Table A-1. HPA HCP Habitat Modification Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Beaver Dam Removal									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
		Visual, physical, and noise related disturbance	During project construction and maintenance activities	Temporary (disturbance) to short-term (displacement, auditory masking, hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Visual and physical disturbance may cause stress and displacement to other suitable habitats. Displaced fish may face increased competition, and increased predation risk. Auditory masking or temporary hearing threshold effects from elevated underwater noise may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Impoundment dewatering	Fish entrainment, stranding, displacement	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from increased flow entrainment as impoundment dewatering. Possible stranding of alevins in impoundment areas. Adults and juveniles: Mortality, injury, or stress from stranding or entrainment in dewatering flows. Juveniles: Increased competition following displacement, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration, resulting in decreased fitness and spawning success.	Manage dam removal to drain impoundment as slowly as practicable. Avoid scouring flows. Use beaver deceivers to limit hydraulic alteration.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Localized alteration in invertebrate abundance	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable. Use beaver deceivers to limit hydraulic alteration.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering.	See effects for related stressors under Water Quality Modification.

Table A-1 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term to long-term	Continuous	Eggs and alevins; Juveniles; Adults	<u>Eggs and alevins</u>: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. <u>Juveniles</u>: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Potential habitat avoidance and/or decreased survival due to suspended sediment loads induced by bank instability as described for related stressor responses under Water Quality Modification. <u>Adults</u>: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate ecological context and consider the magnitude of impact mechanisms produced by the project. Prevent rapid dewatering of impoundments likely to cause scouring flows. Encourage use of beaver deceivers.	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered flow velocity		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Intermediate-term to long-term	Seasonal				
	Altered bank stability		Year round especially during high flows	Intermediate-term to long-term	Seasonal				
	Altered substrate composition (including spawning gravel sedimentation)		Year round	Intermediate-term to long-term	Continuous				
	Altered groundwater-surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Intermediate-term to long-term	Continuous				
	Ecosystem Fragmentation								
	Riverine								
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most extensive)	Permanent	Seasonal	Eggs and alevins	<u>Eggs and alevins</u>: See related stressor responses under Water Quality Modification.	Avoid draining impounded area through use of beaver deceivers.	See effects for related stressors under Water Quality Modification.
		Decreased dissolved oxygen from eutrophication below the impoundment (caused by elevated nutrient export)							
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u>: See related stressor responses under Water Quality Modification.	Avoid draining impounded area through use of beaver deceivers.	May affect survival, growth, and fitness of juveniles and adults.

Table A-1 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered terrestrial/aquatic connectivity	Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of high quality floodplain habitat.	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
		Reduced foraging opportunities and rearing habitat availability							
	Aquatic Vegetation Modification								
	Riverine								
	Altered autochthonous production	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased foraging opportunity due to decreased food web productivity.	Avoid draining impounded area through use of beaver deceivers.	May affect juvenile survival. May affect adult growth and spawning productivity.
	Altered cover and habitat								
	Riparian Vegetation Modification								
	Riverine								
	Altered stream bank and shoreline stability	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Initiate proper erosion control measures both during and after construction. Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
		Spawning gravel sedimentation							
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Long-term to permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	May affect juvenile rearing.
	Altered buffering capability	Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modification.

Table A-1 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
		Decreased dissolved oxygen from eutrophication (caused by elevated nutrient export)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Long-term to permanent	Seasonal	Juveniles	<u>Juveniles</u>: See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modification.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>Eggs and alevins:</u> Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. <u>Juveniles and adults</u>: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u>: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pollutant loading	Increased exposure to toxic substances	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u>: Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel machinery in a controlled environment away from the project area. Avoid reducing hydraulic complexity.	May affect survival, growth, and fitness of juveniles and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u>: Low-oxygen stress leading to physiological injury and/or mortality; behavioral avoidance.	Limit damage to riparian area. Replant former impoundment with native vegetation to discourage invasives and stabilize sediments. Avoid draining impounded area through use of beaver deceivers.	May affect juvenile survival and productivity as well as adult survival, productivity, and spawning success.

Table A-1 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
Large Woody Debris Placement/Movement/Removal (for placement only construction impacts apply)									
	Construction and Maintenance Activities								
	Riverine, Lacustrine, Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u>: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane (from exposure to high intensity noise such as pile driving). • Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.

Table A-1 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.

Table A-1 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered flow velocity		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition		Year round	Permanent	Continuous				
	Altered groundwater-surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				

Table A-1 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	Juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile Chinook salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				

Table A-1 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine								
	Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Juveniles; Adults	Juveniles and adults: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile and migratory habitat for adult Chinook salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduced cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality. Adult Chinook will generally be less sensitive to these stressors. However, increased stress and delayed migration in the migratory corridor may reduce fitness and ultimately reduce spawning success.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival at juvenile life-history stage. Decreased fitness may lead to reduced spawning productivity.
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common				
	Altered sediment supply		Year-round	Permanent	Continuous				
	Altered substrate composition		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Riverine								
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most extensive)	Permanent	Seasonal	Eggs and alevins	Eggs and alevins: See related stressor responses under Water Quality Modification.	Require assessment of the hydraulic effects of the project before permitting.	See effects for related stressors under Water Quality Modification.
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	Juveniles: See related stressor responses under Water Quality Modification.		May affect survival, growth, and fitness of juveniles and adults.

Table A-1 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered lateral (terrestrial/aquatic) habitat connectivity	Reduced availability of off-channel refuge and rearing habitat. Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs. Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition, increased predation, and resulting effects on growth and fitness. Adults: Decreased survival, fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat or longitudinal reach simplification.	May affect survival, growth, and fitness at egg, alevin, and juvenile life-history stages. May affect adult survival and spawning productivity.
	Altered longitudinal habitat connectivity	Reduced availability of suitable habitats along longitudinal gradient.							
	Marine								
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Juveniles	All exposed life-history stages: LWD removal in the marine environment can fragment nearshore rearing habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Avoid permitting LWD removal projects in areas where significant cumulative effects are already prevalent.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered cover and habitat	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.
	Lacustrine								
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	All exposed life-history stages: LWD removal in lacustrine environments can fragment nearshore rearing habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival at juvenile life-history stage. Decreased fitness may lead to reduced spawning productivity.
	Altered cover and habitat	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.

Table A-1 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Aquatic Vegetation Modification								
	Marine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Construction: Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased foraging opportunity due to decreased food web productivity.		May affect juvenile survival. May affect adult growth and spawning productivity.
	Riverine and Lacustrine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Construction: Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.		May affect juvenile survival, growth, and fitness, as well as adult spawning productivity.

Table A-1 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Riparian Vegetation Modification								
	Riverine								
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults	Eggs and alevins: Decreased incubation success. Adults: Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid disturbance of vegetation along stream.	May affect survival of eggs and alevins, as well as adult spawning productivity.

Table A-1 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Marine								
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures)	Year-round, (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles	Juveniles: Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and survival.
	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	Juveniles: Chinook dependence on allochthonous inputs from marine riparian vegetation is a data gap. However, Chinook are known to utilize terrestrial insect resources recruited from the riparian zone. Alteration of vegetation will therefore result in decreased foraging opportunities, decreased growth and fitness, and decreased productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high quality habitat features.	May affect juvenile survival.
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	Juveniles: Chinook dependence on groundwater inflow to nearshore marine habitats is currently a data gap.	Avoid disturbance of vegetation along shoreline.	Effects of the action resulting from this impact mechanism are unknown.

Table A-1 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round, (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles	Juveniles: Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of thermal stratification and wind driven mixing However, juveniles trapped in isolated habitats may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival.
	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs predominantly during spring outmigration period through lakes)	Permanent	Continuous	Juveniles	Juveniles: Chinook are known to use terrestrial insect resources recruited from the riparian zone. Alteration of vegetation will therefore result in decreased foraging opportunities, decreased growth and fitness, and decreased productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Permanent	Continuous	Juveniles	Juveniles: Chinook dependence on groundwater inflow to nearshore lacustrine habitats is currently a data gap.	Avoid disturbance of vegetation along the shoreline.	Effects of the action resulting from this impact mechanism are unknown.

Table A-1 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to long-term (dependent on contributing mechanism of impact)	Continuous to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile survival, growth, and fitness, and adult survival and spawning productivity.
	Altered pollutant loading	Increased pollutant loading	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All life-history stages: Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival, growth, and fitness of juveniles and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen (due to eutrophication caused by elevated nutrient export from dewatered floodplains)	Dependent on contributing mechanism of impact	Temporary to short-term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Low-oxygen stress leading to physiological injury and/or mortality; behavioral avoidance.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect alevin development, juvenile survival, growth, and fitness as well as adult survival, fitness, and spawning success.

Table A-1 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Spawning Substrate Augmentation									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane (from exposure to high intensity noise such as pile driving). • Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.

Table A-1 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
		Burial (during active sediment placement)	During project construction	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from burial during gravel placement.	Restrict in-water work window to periods when incubating eggs and alevins with limited motility are least likely to be present.	May cause direct mortality or injury at egg, alevin, and juvenile life-history stages. Injury and stress may affect survival, growth, and fitness.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids	During project construction	Temporary to short-term	Interannual–decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Reduced refuge habitat (from potential pool filling)	Year-round	Short-term to intermediate-term	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Ensure that project has been designed properly for ecosystem context.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.

Table A-1 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered bank stability (intermediate-term effects from passive augmentation projects)	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in substrate composition and stability may lead to decreased incubation success and alevin survival while augmentation projects stabilize. Juveniles: Altered channel geometry, bank stability, and substrate composition can result in short-term to intermediate-term changes in rearing habitat suitability and changes in food web complexity while augmentation projects stabilize. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology and bank structure may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate stability may lead to decreased spawning success while augmentation projects stabilize. However, adverse effects would be expected to be short-term in nature, while beneficial effects would be expected to persist.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of augmentation projects that minimize adverse effects on channel geometry, bank conditions, and substrate stability to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered substrate composition/stability			Short-term to long-term					
	Aquatic Vegetation Modification								
	Riverine								
	Altered autochthonous production	Reduced foraging opportunities	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Avoid spawning gravel augmentation projects in locations where aquatic vegetation plays a strong role in habitat productivity.	May affect juvenile survival, growth, and fitness.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased foraging opportunity due to decreased food web productivity.		

Table A-1 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
In-Channel/Off-Channel Habitat Creation/Modification									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane (from exposure to high intensity noise such as pile driving). • Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.

Table A-1 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.

Table A-1 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids (during construction or if in-channel project fails)	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
Riparian Planting/Restoration Enhancement									
	Construction and Maintenance Activities								
	Riverine , Lacustrine, Marine								
	Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-1 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
		Increased suspended solids – due to removal of invasive riparian species Spawning gravel sedimentation – due to removal of invasive riparian species	Year-round (with specific stressors prominent during high flow conditions)	Short-term to intermediate (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Minimize disturbance during invasive species removal. Use appropriate erosion control BMPs both during and after construction.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Aquatic Vegetation Modification								
	Riverine, Lacustrine, Marine								
	Altered autochthonous production	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect juvenile growth and fitness

Table A-1 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Riverine, Lacustrine, Marine								
	Altered Shading and solar input	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect juvenile growth and fitness
	Water Quality Modification								
	Altered Temperatures	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered suspended solids	Increased suspended solids – due to removal of invasive riparian species	Dependent on contributing mechanism of impact	Short-term to intermediate (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.

Table A-1 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Wetland Creation Restoration/Enhancement									
	Construction and Maintenance Activities								
	Riverine and Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Juveniles; Adults	All exposed life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane (from exposure to high intensity noise such as pile driving). • Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.

Table A-1 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
	Water Quality Modification								

Table A-1 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids (e.g., during reconnection of fragmented floodplain wetlands, etc.)	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
Beach Nourishment/Contouring									
	Construction and Maintenance Activities								
	Marine and Lacustrine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Juveniles; Adults	All affected life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery/vessel work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended sediment	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project sites which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.

Table A-1 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Marine and Lacustrine								
	Altered sediment supply	Localized alteration in invertebrate abundance from burial	During project construction and maintenance activities	Short-term – long-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project sites which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.
	Aquatic Vegetation Modification								
	Marine and Lacustrine								
	Altered autochthonous production	Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to long-term(dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased foraging opportunity due to decreased food web productivity.	Avoid/minimize disturbance of aquatic vegetation during project construction. Avoid nourishing beaches updrift of productive, vegetated aquatic habitat.	May affect juvenile survival. May affect adult growth and spawning productivity.
	Altered cover and habitat	Reduced cover							
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	During construction and during subsequent high energy periods	Temporary to short-term (dependent on grain size of augmented sediment)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic shoreline instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term (dependent on contributing mechanism of impact)	Interannual to decadal	Juveniles; Adults	All affected life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body.	May affect survival, growth, and fitness of juveniles and adults.

Table A-1 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Reef Creation/Restoration/Enhancement									
	Construction and Maintenance Activities								
	Marine and Lacustrine								
	Equipment operation and materials placement	Elevated noise, visual and physical disturbance	During project construction activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	All life-history stages: Stressor response dependent on magnitude and duration of disturbance, and project-specific environmental conditions; may range from: • Increased predation risk and decreased foraging success due to displacement, auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid construction activities during periods when individuals may be present, particularly juveniles.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. Should exposure occur, direct mortality or injury is probable.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended sediment	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project sites which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.

Table A-1 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles; Adults	Juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile Chinook salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality. Adults: Adult Chinook salmon forage in nearshore environments during return migrations. Alteration of nearshore habitat characteristics through these sub-mechanisms may lead to decreased food web productivity and prey availability. This may lead to decreased growth and decrease spawning fitness.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase. May affect adult growth and fitness, and spawning productivity.
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				

Table A-1 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine								
	Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Juveniles; Adults	Juveniles and adults: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile and migratory habitat for adult Chinook salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduced cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality. Adult Chinook will generally be less sensitive to these stressors. However, increased stress and delayed migration in the migratory corridor may reduce fitness and ultimately reduce spawning success.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival at juvenile life-history stage. Decreased fitness may lead to reduced spawning productivity.
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Continuous				
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal				
	Altered sediment supply		Year-round	Permanent	Continuous				
	Altered substrate composition		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Marine								
	Altered cover and habitat	Increased predation risk	Year-round	Permanent	Continuous	Juveniles	Juveniles: Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid placement of reef projects in proximity to juvenile migratory corridors, such that increased predation exposure may occur.	May affect juvenile survival, growth and fitness.
	Lacustrine								
	Altered cover and habitat	Increased predation by piscivorous fish	Year-round	Permanent	Continuous	Juveniles	Juveniles: Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid placement of reef projects in proximity to juvenile migratory corridors, such that increased predation exposure may occur.	May affect juvenile survival, growth and fitness.

Table A-1 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification								
	Marine								
	Altered cover and habitat	Decreased refuge and forage habitat	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased foraging opportunity due to decreased food web productivity.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile survival. May affect adult growth and spawning productivity.
	Lacustrine								
	Altered autochthonous production Altered cover and habitat	Reduced foraging opportunities	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles;	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile survival, growth, and fitness.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pollutant loading	Leaching of toxic substances (depending on composition of reef material)	Year-round	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Juveniles; Adults	All affected life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Use non-toxic reef material.	May affect survival, growth, and fitness of juveniles and adults.
Eel Grass and Other Aquatic Vegetation Creation/Restoration/Enhancement									
	Construction and Maintenance Activities								
	Marine								

Table A-1 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Planting activities and vessel use	Visual, physical, and noise related disturbance	During project construction	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles: Stress and behavioral avoidance by rearing juveniles and migrating adults exposed to low level noise, physical, and visual disturbance.	Adhere to system-specific in-water work windows.	May cause temporary behavioral avoidance and displacement.
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Vegetation transplantation projects are not likely to cause pulses of suspended sediment sufficient to lead to injury or mortality. Stressor response may include temporary behavioral avoidance and displacement.	Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May cause temporary behavioral avoidance and displacement.

Table A-2. HPA HCP Habitat Modification Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
Beaver Dam Removal/Modification									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of all life stages.
		Visual, physical, and noise related disturbance	During project construction and maintenance activities	Temporary (disturbance) to short-term (displacement, auditory masking, hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Visual and physical disturbance may cause stress and displacement to other suitable habitats. Displaced fish may face increased competition, and increased predation risk. Auditory masking or temporary hearing threshold effects from elevated underwater noise may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Impoundment dewatering	Fish entrainment, stranding, displacement	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from increased flow entrainment as impoundment dewatering. Possible stranding of alevins in impoundment areas. Adults and juveniles: Mortality, injury, or stress from stranding or entrainment in dewatering flows. Juveniles: Increased competition following displacement, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration, resulting in decreased fitness and spawning success.	Manage dam removal to drain impoundment as slowly as practicable. Avoid scouring flows. Use beaver deceivers to limit hydraulic alteration.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Localized alteration in invertebrate abundance	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable. Use beaver deceivers to limit hydraulic alteration.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering.	See effects for related stressors under Water Quality Modification.

Table A-2 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term to long-term	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Potential habitat avoidance and/or decreased survival due to suspended sediment loads induced by bank instability as described for related stressor responses under Water Quality Modification. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate ecological context and consider the magnitude of impact mechanisms produced by the project. Prevent rapid dewatering of impoundments likely to cause scouring flows. Encourage use of beaver deceivers.	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered flow velocity		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Intermediate-term to long-term	Seasonal				
	Altered bank stability		Year round especially during high flows	Intermediate-term to long-term	Seasonal				
	Altered substrate composition (including spawning gravel sedimentation)		Year round	Intermediate-term to long-term	Continuous				
	Altered groundwater-surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Intermediate-term to long-term	Continuous				
	Ecosystem Fragmentation								
	Riverine								
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most extensive)	Permanent	Seasonal	Eggs and alevins	Eggs and alevins: See related stressor responses under Water Quality Modification	Avoid draining impounded area through use of beaver deceivers.	See effects for related stressors under Water Quality Modification.
		Decreased dissolved oxygen from eutrophication below the impoundment (caused by elevated nutrient export)							
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: See related stressor responses under Water Quality Modification.	Avoid draining impounded area through use of beaver deceivers.	May affect survival, growth, and fitness of juveniles and adults.
	Altered terrestrial/aquatic connectivity	Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of high	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.

Table A-2 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Reduced foraging opportunities and rearing habitat availability					Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	quality floodplain habitat.	
	Aquatic Vegetation modification								
	Riverine								
	Altered autochthonous production Altered cover and habitat	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles; Adults	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. <u>Adults</u>: Decreased foraging opportunity due to decreased food web productivity.	Avoid draining impounded area through use of beaver deceivers.	May affect juvenile survival. May affect adult growth and spawning productivity.
	Riparian Vegetation Modification								
	Riverine								
	Altered stream bank and shoreline stability	Increased suspended solids Spawning gravel sedimentation	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	<u>Eggs/alevins:</u> Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. <u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. <u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Initiate proper erosion control measures both during and after construction. Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Long-term to permanent	Continuous	Juveniles	<u>Juveniles:</u> Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	May affect juvenile rearing.
	Altered buffering capability	Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u>: See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modification.
		Decreased dissolved oxygen from eutrophication (caused by elevated nutrient export)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Long-term to permanent	Seasonal	Juveniles	<u>Juveniles</u>: See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modification.

Table A-2 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pollutant loading	Increased exposure to toxic substances	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel machinery in a controlled environment away from the project area. Avoid reducing hydraulic complexity.	May affect survival, growth, and fitness of juveniles and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Low-oxygen stress leading to physiological injury and/or mortality; behavioral avoidance.	Limit damage to riparian area. Replant former impoundment with native vegetation to discourage invasives and stabilize sediments. Avoid draining impounded area through use of beaver deceivers.	May affect alevin development, juvenile survival and productivity as well as adult survival, productivity, and spawning success.
Large Woody Debris Placement/Movement/Removal (for placement only construction impacts apply)									
	Construction and Maintenance Activities								
	Riverine, Lacustrine, Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.

Table A-2 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane (from exposure to high intensity noise such as pile driving). • Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.

Table A-2 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	<u>Eggs/alevins:</u> Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. <u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. <u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>Eggs and alevins</u>: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. <u>Adults and juveniles</u>: Mortality, injury, or stress from capture, handling, and relocation. <u>Juveniles</u>: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. <u>Adults</u>: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	<u>Eggs and alevins, juveniles</u>: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>Eggs and alevins</u>: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. <u>Juveniles</u>: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. <u>Adults</u>: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.

Table A-2 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered flow velocity		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition		Year round	Permanent	Continuous				
	Altered groundwater-surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				

Table A-2 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	Juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile Coho salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				

Table A-2 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine								
	Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Juveniles; Adults	Juveniles and adults: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile and migratory habitat for adult Coho salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduced cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality. Adult Coho will generally be less sensitive to these stressors. However, increased stress and delayed migration in the migratory corridor may reduce fitness and ultimately reduce spawning success.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival at juvenile life-history stage. Decreased fitness may lead to reduced spawning productivity.
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common				
	Altered sediment supply		Year-round	Permanent	Continuous				
	Altered substrate composition		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Riverine								
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most extensive)	Permanent	Seasonal	Eggs and alevins	Eggs and alevins: See related stressor responses under Water Quality Modification	Require assessment of the hydraulic effects of the project before permitting.	See effects for related stressors under Water Quality Modification.
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	Juveniles: See related stressor responses under Water Quality Modification.		May affect survival, growth, and fitness of juveniles and adults.

Table A-2 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered lateral (terrestrial/aquatic) habitat connectivity Altered longitudinal habitat connectivity	Reduced availability of off-channel refuge and rearing habitat. Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs Reduced foraging opportunities and rearing habitat availability Reduced availability of suitable habitats along longitudinal gradient.	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition, increased predation, and resulting effects on growth and fitness. Adults: Decreased survival, fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat or longitudinal reach simplification.	May affect survival, growth, and fitness at egg, alevin, and juvenile life-history stages. May affect adult survival and spawning productivity.
	Marine								
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Juveniles	Juveniles: LWD removal in the marine environment can fragment nearshore rearing habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Avoid permitting LWD removal projects in areas where significant cumulative effects are already prevalent.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered cover and habitat	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.
	Lacustrine								
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	All exposed life-history stages: LWD removal in lacustrine environments can fragment nearshore rearing habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival at juvenile life-history stage. Decreased fitness may lead to reduced spawning productivity.
	Altered cover and habitat	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.

Table A-2 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification								
	Marine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Construction: Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased foraging opportunity due to decreased food web productivity.		May affect juvenile survival. May affect adult growth and spawning productivity.
	Riverine and Lacustrine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Construction: Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.		May affect juvenile survival, growth, and fitness, as well as adult spawning productivity.

Table A-2 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Riverine								
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults	Eggs and alevins: Decreased incubation success. Adults: Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid disturbance of vegetation along stream.	May affect survival of eggs and alevins, as well as adult spawning productivity.

Table A-2 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Marine								
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures)	Year-round, (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles	Juveniles: Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and survival.
	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	Juveniles: Coho dependence on allochthonous inputs from marine riparian vegetation is a data gap. However, Coho are known to utilize terrestrial insect resources recruited from the riparian zone. Alteration of vegetation will therefore result in decreased foraging opportunities, decreased growth and fitness, and decreased productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high quality habitat features.	May affect juvenile survival.
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	Juveniles: Coho dependence on groundwater inflow to nearshore marine habitats is currently a data gap.	Avoid disturbance of vegetation along shoreline.	Effects of the action resulting from this impact mechanism are unknown.
	Lacustrine								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round, (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles	Juveniles: Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of thermal stratification and wind driven mixing However, juveniles trapped in isolated habitats may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival.

Table A-2 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs predominantly during spring outmigration period through lakes)	Permanent	Continuous	Juveniles	Juveniles: Coho are known to use terrestrial insect resources recruited from the riparian zone. Alteration of vegetation will therefore result in decreased foraging opportunities, decreased growth and fitness, and decreased productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.
	Altered groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Permanent	Continuous	Juveniles	Juveniles: Coho dependence on groundwater inflow to nearshore lacustrine habitats is currently a data gap.	Avoid disturbance of vegetation along the shoreline.	Effects of the action resulting from this impact mechanism are unknown.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to long-term (dependent on contributing mechanism of impact)	Continuous to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile survival, growth, and fitness, and adult survival and spawning productivity.
	Altered pollutant loading	Increased pollutant loading	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All life-history stages: Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival, growth, and fitness of juveniles and adults.

Table A-2 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered dissolved oxygen	Decreased dissolved oxygen (due to eutrophication caused by elevated nutrient export from dewatered floodplains)	Dependent on contributing mechanism of impact	Temporary to short-term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Low-oxygen stress leading to physiological injury and/or mortality; behavioral avoidance.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect alevin development, juvenile survival and productivity as well as adult survival, productivity, and spawning success.
Spawning Substrate Augmentation									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane (from exposure to high intensity noise such as pile driving). • Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
		Burial (during active sediment placement)	During project construction	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from burial during gravel placement.	Restrict in-water work window to periods when incubating eggs and alevins with limited motility are least likely to be present.	May cause direct mortality or injury at egg, alevin, and juvenile life-history stages. Injury and stress may affect survival, growth, and fitness.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids,	During project construction	Temporary to short-term	Interannual–decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Reduced refuge habitat (from potential pool filling)	Year-round	Short-term to intermediate-term	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Ensure that project has been designed properly for ecosystem context.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.

Table A-2 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered bank stability (intermediate-term effects from passive augmentation projects)	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in substrate composition and stability may lead to decreased incubation success and alevin survival while augmentation projects stabilize. Juveniles: Altered channel geometry, bank stability, and substrate composition can result in short-term to intermediate-term changes in rearing habitat suitability and changes in food web complexity while augmentation projects stabilize. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology and bank structure may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate stability may lead to decreased spawning success while augmentation projects stabilize. However, adverse effects would be expected to be short-term in nature, while beneficial effects would be expected to persist.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of augmentation projects that minimize adverse effects on channel geometry, bank conditions, and substrate stability to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered substrate composition/stability			Short-term to long-term					
	Aquatic Vegetation Modification								
	Riverine								
	Altered autochthonous production	Reduced foraging opportunities	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Avoid spawning gravel augmentation projects in locations where aquatic vegetation plays a strong role in habitat productivity.	May affect juvenile survival, growth, and fitness.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased foraging opportunity due to decreased food web productivity.		

Table A-2 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>Eggs and alevins:</u> Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. <u>Juveniles and adults</u>: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u>: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
In-Channel/Off-Channel Habitat Creation/Modification									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u>: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.

Table A-2 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane (from exposure to high intensity noise such as pile driving). • Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-2 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids (during construction or if in-channel project fails)	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
Riparian Planting/Restoration Enhancement									
	Construction and Maintenance Activities								
	Riverine , Lacustrine, Marine								
	Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-2 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Increased suspended solids – due to removal of invasive riparian species Spawning gravel sedimentation – due to removal of invasive riparian species	Year-round (with specific stressors prominent during high flow conditions)	Short-term to intermediate (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Minimize disturbance during invasive species removal. Use appropriate erosion control BMPs both during and after construction.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Aquatic Vegetation Modification								
	Riverine, Lacustrine, Marine								
	Altered autochthonous production	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect juvenile growth and fitness

Table A-2 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Riverine, Lacustrine, Marine								
	Altered Shading and solar input	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect juvenile growth and fitness
	Water Quality Modification								
	Altered Temperatures	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered suspended solids	Increased suspended solids – due to removal of invasive riparian species	Dependent on contributing mechanism of impact	Short-term to intermediate (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.

Table A-2 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Wetland Creation Restoration/Enhancement									
	Construction and Maintenance Activities								
	Riverine and Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Juveniles; Adults	<u>Juveniles, adults</u>: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane (from exposure to high intensity noise such as pile driving). • Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.

Table A-2 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
	Water Quality Modification								

Table A-2 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids (e.g., during reconnection of fragmented floodplain wetlands, etc.)	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
Beach Nourishment/Contouring									
	Construction and Maintenance Activities								
	Marine and Lacustrine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Juveniles; Adults	Juveniles, adults: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery/vessel work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended sediment	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project sites which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.

Table A-2 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Marine and Lacustrine								
	Altered sediment supply	Localized alteration in invertebrate abundance from burial	During project construction and maintenance activities	Short-term – long-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.
	Aquatic Vegetation Modification								
	Marine and Lacustrine								
	Altered autochthonous production	Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to long-term(dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased foraging opportunity due to decreased food web productivity.	Avoid/minimize disturbance of aquatic vegetation during project construction. Avoid nourishing beaches updrift of productive, vegetated aquatic habitat.	May affect juvenile survival. May affect adult growth and spawning productivity.
	Altered cover and habitat	Reduced cover							
	Water Quality Modification								
	Marine and Lacustrine								
	Altered suspended solids	Increased suspended solids	During construction and during subsequent high energy periods	Temporary to short-term (dependent on grain size of augmented sediment)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic shoreline instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term (dependent on contributing mechanism of impact)	Interannual to decadal	Juveniles; Adults	Juveniles and adults: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body.	May affect survival, growth, and fitness of juveniles and adults.

Table A-2 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
Reef Creation/Restoration/Enhancement									
	Construction and Maintenance Activities								
	Marine and Lacustrine								
	Equipment operation and materials placement	Elevated noise, visual and physical disturbance	During project construction activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	All life-history stages: Stressor response dependent on magnitude and duration of disturbance, and project-specific environmental conditions; may range from: • Increased predation risk and decreased foraging success due to displacement, auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid construction activities during periods when individuals may be present, particularly juveniles.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. Should exposure occur, direct mortality or injury is probable.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended sediment	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project sites which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.

Table A-2 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Hydraulic and Geomorphic Modification								
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles; Adults	Juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile Coho salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality. Adults: Adult Coho salmon forage in nearshore environments during return migrations. Alteration of nearshore habitat characteristics through these sub-mechanisms may lead to decreased food web productivity and prey availability. This may lead to decreased growth and decrease spawning fitness.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase. May affect adult growth and fitness, and spawning productivity.
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				

Table A-2 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Lacustrine								
	Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Juveniles; Adults	Juveniles and adults: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile and migratory habitat for adult Coho salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduced cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality. Adult Coho will generally be less sensitive to these stressors. However, increased stress and delayed migration in the migratory corridor may reduce fitness and ultimately reduce spawning success.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival at juvenile life-history stage. Decreased fitness may lead to reduced spawning productivity.
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Continuous				
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal				
	Altered sediment supply		Year-round	Permanent	Continuous				
	Altered substrate composition		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Marine								
	Altered cover and habitat	Increased predation risk	Year-round	Permanent	Continuous	Juveniles	Juveniles: Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid placement of reef projects in proximity to juvenile migratory corridors, such that increased predation exposure may occur.	May affect juvenile survival, growth and fitness.
	Lacustrine								
	Altered cover and habitat	Increased predation by piscivorous fish	Year-round	Permanent	Continuous	Juveniles	Juveniles: Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid placement of reef projects in proximity to juvenile migratory corridors, such that increased predation exposure may occur.	May affect juvenile survival, growth and fitness.
	Aquatic Vegetation Modification								
	Marine								
	Altered cover and habitat		Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased foraging opportunity due to decreased food web productivity.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile survival. May affect adult growth and spawning productivity.
	Lacustrine								

Table A-2 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered autochthonous production Altered cover and habitat	Reduced foraging opportunities	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles;	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile survival, growth, and fitness.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pollutant loading	Leaching of toxic substances (depending on composition of reef material)	Year-round	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Juveniles; Adults	All affected life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Use non-toxic reef material.	May affect survival, growth, and fitness of juveniles and adults.
Eel Grass and Other Aquatic Vegetation Creation/Restoration/Enhancement									
	Construction and Maintenance Activities								
	Marine								
	Planting activities and vessel use	Visual, physical, and noise related disturbance	During project construction	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles: Stress and behavioral avoidance by rearing juveniles and migrating adults exposed to low level noise, physical, and visual disturbance.	Adhere to system-specific in-water work windows.	May cause temporary behavioral avoidance and displacement.
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Vegetation transplantation projects are not likely to cause pulses of suspended sediment sufficient to lead to injury or mortality. Stressor response may include temporary behavioral avoidance and displacement.	Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May cause temporary behavioral avoidance and displacement.

Table A-3. HPA HCP Habitat Modification Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Beaver Dam Removal/Modification									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness. May affect survival, growth, and fitness of juveniles and adults.
		Visual, physical, and noise related disturbance	During project construction and maintenance activities	Temporary (disturbance) to short-term (displacement, auditory masking, hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Visual and physical disturbance may cause stress and displacement to other suitable habitats. Displaced fish may face increased competition, and increased predation risk. Auditory masking or temporary hearing threshold effects from elevated underwater noise may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Impoundment dewatering	Fish entrainment, stranding, displacement	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from increased flow entrainment as impoundment dewatering. Possible stranding of alevins in impoundment areas. Adults and juveniles: Mortality, injury, or stress from stranding or entrainment in dewatering flows. Juveniles: Increased competition following displacement, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration, resulting in decreased fitness and spawning success.	Manage dam removal to drain impoundment as slowly as practicable. Avoid scouring flows. Use beaver deceivers to limit hydraulic alteration.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Localized alteration in invertebrate abundance	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Effects on chum salmon will be relatively minimal due to limited dependence on freshwater foraging.	Limit area of dewatering to the greatest extent practicable.	Temporary localized reductions in invertebrate abundance would not be expected to adversely affect juvenile chum salmon.
		Increased suspended solids	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering.	See effects for related stressors under Water Quality Modification.

Table A-3 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term to long-term	Continuous	Eggs and alevins; Juveniles; Adults	<u>Eggs and alevins</u>: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. <u>Juveniles</u>: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Potential habitat avoidance and/or decreased survival due to suspended sediment loads induced by bank instability as described for related stressor responses under Water Quality Modification. <u>Adults</u>: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate ecological context and consider the magnitude of impact mechanisms produced by the project. Prevent rapid dewatering of impoundments likely to cause scouring flows. Encourage use of beaver deceivers.	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered flow velocity		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Intermediate-term to long-term	Seasonal				
	Altered bank stability		Year round especially during high flows	Intermediate-term to long-term	Seasonal				
	Altered substrate composition (including spawning gravel sedimentation)		Year round	Intermediate-term to long-term	Continuous				
	Altered groundwater-surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Intermediate-term to long-term	Continuous				
	Ecosystem Fragmentation								
	Riverine								
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most extensive)	Permanent	Seasonal	Eggs and alevins	<u>Eggs and alevins:</u> See related stressor responses under Water Quality Modification	Avoid draining impounded area through use of beaver deceivers.	See effects for related stressors under Water Quality Modification.
		Decreased dissolved oxygen from eutrophication below the impoundment (caused by elevated nutrient export)							
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u>: See related stressor responses under Water Quality Modification.	Avoid draining impounded area through use of beaver deceivers.	May affect survival, growth, and fitness of juveniles and adults.

Table A-3 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered terrestrial/aquatic connectivity	Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Chum dependence on autochthonous inputs from aquatic vegetation is limited, as this species does not forage in riverine and lacustrine environments. Therefore, effects on juvenile chum growth and fitness will be limited.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of high quality floodplain habitat.	Impact mechanism is unlikely to affect chum salmon.
		Reduced refuge habitat availability	Year-round	Permanent	Continuous	Adults	Adults: This stressor may limit the availability of adult spawning habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density-dependent effects on adult spawning success.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of high quality floodplain habitat.	May affect spawning productivity.
	Aquatic Vegetation Modification								
	Riverine								
	Altered cover and habitat	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles	Juveniles: Decreased refuge habitat, increased predation exposure. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory habitat.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile growth and survival, spawning success, and overall population productivity.
	Riparian Vegetation Modification								
	Riverine								
	Altered stream bank and shoreline stability	Increased suspended solids Spawning gravel sedimentation	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Initiate proper erosion control measures both during and after construction. Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-3 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Long-term to permanent	Continuous	Juveniles	Juveniles: Limited effects from food web alteration due to minimal dependence on freshwater forage resources.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	Unlikely to affect juvenile rearing.
	Altered buffering capability	Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modification.
		Decreased dissolved oxygen from eutrophication (caused by elevated nutrient export)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Long-term to permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modification.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pollutant loading	Increased exposure to toxic substances	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel machinery in a controlled environment away from the project area. Avoid reducing hydraulic complexity.	May affect survival, growth, and fitness of juveniles and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Low-oxygen stress leading to physiological injury and/or mortality; behavioral avoidance.	Limit damage to riparian area. Replant former impoundment with native vegetation to discourage invasives and stabilize sediments. Avoid draining impounded area through use of beaver deceivers.	May affect juvenile survival and productivity as well as adult survival, productivity, and spawning success.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Large Woody Debris Placement/Movement/Removal (for placement only construction impacts apply)									
	Construction and Maintenance Activities								
	Riverine, Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u>: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane (from exposure to high intensity noise such as pile driving). • Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.

Table A-3 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.

Table A-3 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Localized alteration in invertebrate abundance	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Effects on chum salmon will be relatively minimal due to limited dependence on freshwater foraging.	Limit area of dewatering to the greatest extent practicable.	Temporary localized reductions in invertebrate abundance would not be expected to adversely affect juvenile chum salmon.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered flow velocity		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition		Year round	Permanent	Continuous				
	Altered groundwater-surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				

Table A-3 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	Juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile chum salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase. However, this impact pathway has not been well studied.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				
	Lacustrine								
	Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	N/A	N/A	N/A	N/A
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common				
	Altered sediment supply		Year-round	Permanent	Continuous				
	Altered substrate composition		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Riverine								

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most extensive)	Permanent	Seasonal	Eggs and alevins	Eggs and alevins: See related stressor responses under Water Quality Modification	Require assessment of the hydraulic effects of the project before permitting.	See effects for related stressors under Water Quality Modification.
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	Juveniles: See related stressor responses under Water Quality Modification.		May affect survival, growth, and fitness of juveniles and adults.
	Altered lateral (terrestrial/aquatic) habitat connectivity Altered longitudinal habitat connectivity	Reduced refuge habitat availability	Year-round	Permanent	Continuous	Adults	Adults: This stressor may limit the availability of adult spawning habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density-dependent effects on adult spawning success.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of high quality floodplain habitat.	May affect spawning productivity.
	Marine								
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Juveniles	All exposed life-history stages: LWD removal in the marine environment may fragment nearshore rearing habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Avoid permitting LWD removal projects in areas where significant cumulative effects are already prevalent.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase. However, this impact pathway has not been well studied.
	Altered cover and habitat	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival. However, this impact pathway has not been well studied.
	Lacustrine								
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	N/A	N/A	N/A	N/A
	Altered cover and habitat	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	N/A	N/A	N/A	N/A

Table A-3 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification								
	Marine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Construction: Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased foraging opportunity due to decreased food web productivity.		May affect juvenile survival. May affect adult growth and spawning productivity.
	Riverine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Effects on chum salmon will be relatively minimal due to limited dependence on freshwater foraging.	Construction: Avoid/minimize disturbance of aquatic vegetation during project construction.	Impact mechanism is unlikely to affect chum salmon.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability, potentially leading to altered migratory behavior and increased predation exposure.		May affect juvenile survival.

Table A-3 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Riverine								
	Altered shading, solar input and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Potential delays in migration or alterations in migration behavior. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	Should exposure occur, stressor may affect survival. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high-flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Potential delays in migration or alteration in migration behavior, increased predation exposure. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	Should exposure occur, stressor may affect survival. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat, increased predation exposure. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile growth and survival, spawning success, and overall population productivity.
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen; reduced thermal refuge	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Decreased incubation success. Juveniles: Decreased availability of thermal refuge habitat, resulting in increased thermal stress and increased competition for suitable habitats. Adults: Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid permitting of projects in areas with springs, seeps, or other sources of significant groundwater recharge. Limit alteration of riparian vegetation to greatest extent practicable.	May affect survival of eggs and alevins. May affect juvenile survival and growth. May affect adult spawning productivity.

Table A-3 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Marine								
	Altered shading, solar input and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures)	Year-round (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles	Juveniles: Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival and growth. However, this impact pathway has not been well studied.
	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival. However, this impact pathway has not been well studied.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources. Reduced aquatic food web productivity due to reduced organic matter inputs.	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	Juveniles: Chum dependence on allochthonous inputs from marine riparian vegetation is a data gap. However, chum are known to use terrestrial insect resources recruited from the riparian zone. Alteration of vegetation will therefore result in decreased foraging opportunities, decreased growth and fitness, and decreased productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness. However, this impact pathway has not been well studied.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high quality habitat features.	May affect juvenile survival. However, this impact pathway has not been well studied.
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	Juveniles: Chum dependence on groundwater inflow to nearshore marine habitats is currently a data gap.	Avoid disturbance of vegetation along shoreline.	Effects of the action resulting from this impact mechanism are unknown. However, this impact pathway has not been well studied.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round, (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	N/A	N/A	N/A	N/A
	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	N/A	N/A	N/A	N/A
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs predominantly during spring outmigration period through lakes)	Permanent	Continuous	N/A	N/A	N/A	N/A
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Short-term to permanent (dependent on nature of activity)	Continuous	N/A	N/A	N/A	N/A
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Permanent	Continuous	N/A	N/A	N/A	N/A

Table A-3 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to long-term (dependent on contributing mechanism of impact)	Continuous to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile survival, growth, and fitness, and adult survival and spawning productivity.
	Altered pollutant loading	Increased pollutant loading	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All life-history stages: Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival, growth, and fitness of juveniles and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Low-oxygen stress leading to physiological injury and/or mortality; behavioral avoidance.	Limit damage to riparian area. Replant former impoundment with native vegetation to discourage invasives and stabilize sediments. Avoid draining impounded area through use of beaver deceivers.	May affect juvenile survival and productivity as well as adult survival, productivity, and spawning success.

Table A-3 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Spawning Substrate Augmentation									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane (from exposure to high intensity noise such as pile driving). • Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.

Table A-3 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
		Burial (during active sediment placement)	During project construction	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from burial during gravel placement.	Restrict in-water work window to periods when incubating eggs and alevins with limited motility are least likely to be present.	May cause direct mortality or injury at egg, alevin, and juvenile life-history stages. Injury and stress may affect survival, growth, and fitness.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Effects on chum salmon will be relatively minimal due to limited dependence on freshwater foraging.	Limit area of dewatering to the greatest extent practicable.	Temporary localized reductions in invertebrate abundance would not be expected to adversely affect juvenile chum salmon.
		Entrainment of benthic organisms, increased suspended solids,	During project construction	Temporary to short-term	Interannual–decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Reduced refuge habitat (from potential pool filling)	Year-round	Short-term to intermediate-term	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Ensure that project has been designed properly for ecosystem context.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.

Table A-3 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered bank stability (intermediate-term effects from passive augmentation projects)	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, substrate composition, and groundwater inputs can result in decreased refuge habitat suitability, potentially leading to changes in migratory behavior, increased stress, and increased predation exposure. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg and alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered substrate composition/stability			Short-term to long-term					
	Aquatic Vegetation Modification								
	Riverine								
	Altered autochthonous production	Reduced foraging opportunities	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Chum dependence on autochthonous inputs from aquatic vegetation is limited, as this species does not forage in riverine and lacustrine environments. Therefore, effects on juvenile chum growth and fitness will be limited.	Avoid spawning gravel augmentation projects in locations where aquatic vegetation plays a strong role in habitat productivity.	May affect juvenile survival, growth, and fitness.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability, potentially leading to altered migratory behavior and increased predation exposure.		May affect juvenile survival.

Table A-3 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
In-Channel/Off-Channel Habitat Creation/Modification									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.

Table A-3 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane (from exposure to high intensity noise such as pile driving). • Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-3 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Effects on chum salmon will be relatively minimal due to limited dependence on freshwater foraging.	Limit area of dewatering to the greatest extent practicable.	Temporary localized reductions in invertebrate abundance would not be expected to adversely affect juvenile chum salmon.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.

Table A-3 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids (during construction or if in-channel project fails)	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
Riparian Planting/Restoration Enhancement									
	Construction and Maintenance Activities								
	Riverine Marine								
	Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-3 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
		Increased suspended solids – due to removal of invasive riparian species	Year-round (with specific stressors prominent during high flow conditions)	Short-term to intermediate (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Minimize disturbance during invasive species removal. Use appropriate erosion control BMPs both during and after construction.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
		Spawning gravel sedimentation – due to removal of invasive riparian species							
	Aquatic Vegetation Modification								
	Riverine, Marine								
	Altered autochthonous production	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect juvenile growth and fitness in marine environments.

Table A-3 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Riparian Vegetation Modification								
	Riverine, Marine								
	Altered Shading and solar input	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect juvenile growth and fitness
	Water Quality Modification								
	Altered Temperatures	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered suspended solids	Increased suspended solids – due to removal of invasive riparian species	Dependent on contributing mechanism of impact	Short-term to intermediate (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.

Table A-3 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Wetland Creation Restoration/Enhancement									
	Construction and Maintenance Activities								
	Riverine and Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Juveniles; Adults	All exposed life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane (from exposure to high intensity noise such as pile driving). • Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.

Table A-3 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Effects on chum salmon will be relatively minimal due to limited dependence on freshwater foraging.	Limit area of dewatering to the greatest extent practicable.	Temporary localized reductions in invertebrate abundance would not be expected to adversely affect juvenile chum salmon.

Table A-3 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids (e.g., during reconnection of fragmented floodplain wetlands, etc.)	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
Beach Nourishment/Contouring									
	Construction and Maintenance Activities								
	Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Juveniles; Adults	All affected life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery/vessel work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid locating projects in areas which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.
	Riverine								

Table A-3 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Juveniles; Adults	All affected life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery/vessel work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid locating projects in areas which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.
	Hydraulic and Geomorphic Modification								
	Marine								
	Altered sediment supply	Localized alteration in invertebrate abundance from burial	During project construction and maintenance activities	Short-term – long-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid locating projects in areas which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.
	Riverine								
	Altered sediment supply	Localized alteration in invertebrate abundance from burial	During project construction and maintenance activities	Short-term – long-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid locating projects in areas which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.
	Aquatic Vegetation Modification								
	Marine								
	Altered autochthonous production	Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to long-term(dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased foraging opportunity due to decreased food web productivity.	Avoid/minimize disturbance of aquatic vegetation during project construction. Avoid nourishing beaches updrift of productive, vegetated aquatic habitat.	May affect juvenile survival. May affect adult growth and spawning productivity.
	Altered cover and habitat	Reduced cover							
	Riverine								
	Altered autochthonous production	Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to long-term(dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction. Avoid nourishing beaches updrift of productive, vegetated aquatic habitat.	May affect growth and fitness at juvenile life-history stage.
	Altered cover and habitat	Reduced cover							
	Water Quality Modification								

Table A-3 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids	During construction and during subsequent high energy periods	Temporary to short-term (dependent on grain size of augmented sediment)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic shoreline instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term (dependent on contributing mechanism of impact)	Interannual to decadal	Juveniles; Adults	All affected life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body.	May affect survival, growth, and fitness of juveniles and adults.
Reef Creation/Restoration/Enhancement									
	Construction and Maintenance Activities								
	Marine								
	Equipment operation and materials placement	Elevated noise, visual and physical disturbance	During project construction activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	All life-history stages: Stressor response dependent on magnitude and duration of disturbance, and project-specific environmental conditions; may range from: • Increased predation risk and decreased foraging success due to displacement, auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid construction activities during periods when individuals may be present, particularly juveniles.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. Should exposure occur, direct mortality or injury is probable.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.

Table A-3 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.
	Lacustrine								
	Equipment operation and materials placement	Elevated noise, visual and physical disturbance	During project construction activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	All life-history stages: Stressor response dependent on magnitude and duration of disturbance, and project-specific environmental conditions; may range from: • Increased predation risk and decreased foraging success due to displacement, auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid construction activities during periods when individuals may be present, particularly juveniles.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. Should exposure occur, direct mortality or injury is probable.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	Exposure will be minimal because chum salmon do not rear in lakes. Consequently, effects are negligible.

Table A-3 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles; Adults	Juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile Chum salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality. Adults: Adult Chum salmon forage in nearshore environments during return migrations. Alteration of nearshore habitat characteristics through these sub-mechanisms may lead to decreased food web productivity and prey availability. This may lead to decreased growth and decrease spawning fitness.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase. May affect adult growth and fitness, and spawning productivity.
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				

Table A-3 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine								
	Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Juveniles; Adults	Juveniles and adults: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of migratory habitat for adult chum salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduced cover or exposure to deep water habitat, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality. Adult chum will generally be less sensitive to these stressors. However, increased stress and delayed migration in the migratory corridor may reduce fitness and ultimately reduce spawning success.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival at juvenile life-history stage. Decreased fitness may lead to reduced spawning productivity.
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Continuous				
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal				
	Altered sediment supply		Year-round	Permanent	Continuous				
	Altered substrate composition		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Marine								
	Altered cover and habitat	Increased predation by piscivorous fish	Year-round	Permanent	Continuous	Juveniles	Juveniles: Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid placement of reef projects in proximity to juvenile migratory corridors, such that increased predation exposure may occur.	May affect juvenile survival, growth and fitness.
	Lacustrine								
	Altered cover and habitat	Increased predation by piscivorous fish	Year-round	Permanent	Continuous	Juveniles	Juveniles: Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid placement of reef projects in proximity to juvenile migratory corridors, such that increased predation exposure may occur.	May affect juvenile survival, growth and fitness.
	Aquatic Vegetation Modification								
	Marine								
	Altered cover and habitat	Decreased refuge and forage habitat	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased foraging opportunity due to decreased food web productivity.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile survival. May affect adult growth and spawning productivity.
	Lacustrine								

Table A-3 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered cover and habitat	Reduced cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles;	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	Impact mechanism is unlikely to affect chum salmon as they do not rear in lakes.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pollutant loading	Leaching of toxic substances (depending on composition of reef material)	Year-round	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Juveniles; Adults	All affected life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Use non-toxic reef material.	May affect survival, growth, and fitness of juveniles and adults.
Eel Grass and Other Aquatic Vegetation Creation/Restoration/Enhancement									
	Construction and Maintenance Activities								
	Marine								
	Planting activities and vessel use	Visual, physical, and noise related disturbance	During project construction	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles: Stress and behavioral avoidance by rearing juveniles and migrating adults exposed to low level noise, physical, and visual disturbance.	Adhere to system-specific in-water work windows.	May cause temporary behavioral avoidance and displacement.
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Vegetation transplantation projects are not likely to cause pulses of suspended sediment sufficient to lead to injury or mortality. Stressor response may include temporary behavioral avoidance and displacement.	Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May cause temporary behavioral avoidance and displacement.

Table A-4. HPA HCP Habitat Modification Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	**When**	**Duration**	**Frequency**	**Life-history Form**			
Beaver Dam Removal/Modification									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness. May affect survival, growth, and fitness of juveniles and adults.
		Visual, physical, and noise related disturbance	During project construction and maintenance activities	Temporary (disturbance) to short-term (displacement, auditory masking, hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Visual and physical disturbance may cause stress and displacement to other suitable habitats. Displaced fish may face increased competition, and increased predation risk. Auditory masking or temporary hearing threshold effects from elevated underwater noise may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Impoundment dewatering	Fish entrainment, stranding, displacement	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from increased flow entrainment as impoundment dewatering. Possible stranding of alevins in impoundment areas. Adults and juveniles: Mortality, injury, or stress from stranding or entrainment in dewatering flows. Juveniles: Increased competition following displacement, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration, resulting in decreased fitness and spawning success.	Manage dam removal to drain impoundment as slowly as practicable. Avoid scouring flows. Use beaver deceivers to limit hydraulic alteration.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Localized alteration in invertebrate abundance	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Effects on pink salmon will be relatively minimal due to limited dependence on freshwater foraging.	Limit area of dewatering to the greatest extent practicable.	Temporary localized reductions in invertebrate abundance would not be expected to adversely affect juvenile pink salmon.
		Increased suspended solids	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering.	See effects for related stressors under Water Quality Modification.

Table A-4 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term to long-term	Continuous	Eggs and alevins; Juveniles; Adults	<u>Eggs and alevins</u>: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. <u>Juveniles</u>: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Potential habitat avoidance and/or decreased survival due to suspended sediment loads induced by bank instability as described for related stressor responses under Water Quality Modification. <u>Adults</u>: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate ecological context and consider the magnitude of impact mechanisms produced by the project. Prevent rapid dewatering of impoundments likely to cause scouring flows. Encourage use of beaver deceivers.	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered flow velocity		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Intermediate-term to long-term	Seasonal				
	Altered bank stability		Year round especially during high flows	Intermediate-term to long-term	Seasonal				
	Altered substrate composition (including spawning gravel sedimentation)		Year round	Intermediate-term to long-term	Continuous				
	Altered groundwater-surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Intermediate-term to long-term	Continuous				
	Ecosystem Fragmentation								
	Riverine								
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most extensive)	Permanent	Seasonal	Eggs and alevins	<u>Eggs and alevins:</u> See related stressor responses under Water Quality Modification	Avoid draining impounded area through use of beaver deceivers.	See effects for related stressors under Water Quality Modification.
		Decreased dissolved oxygen from eutrophication below the impoundment (caused by elevated nutrient export)							
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u>: See related stressor responses under Water Quality Modification.	Avoid draining impounded area through use of beaver deceivers.	May affect survival, growth, and fitness of juveniles and adults.

Table A-4 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered terrestrial/aquatic connectivity	Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Pink dependence on autochthonous inputs from aquatic vegetation is limited, as this species does not forage in riverine and lacustrine environments. Therefore, effects on juvenile pink growth and fitness will be limited.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of high quality floodplain habitat.	Impact mechanism is unlikely to affect pink salmon.
		Reduced refuge habitat availability	Year-round	Permanent	Continuous	Adults	Adults: This stressor may limit the availability of adult spawning habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density-dependent effects on adult spawning success.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of high quality floodplain habitat.	May affect spawning productivity.
	Aquatic Vegetation Modification								
	Riverine								
	Altered cover and habitat	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles	Juveniles: Decreased refuge habitat, increased predation exposure. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory habitat.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile growth and survival, spawning success, and overall population productivity.
	Riparian Vegetation Modification								
	Riverine								
	Altered stream bank and shoreline stability	Increased suspended solids Spawning gravel sedimentation	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Initiate proper erosion control measures both during and after construction. Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-4 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Long-term to permanent	Continuous	Juveniles	Juveniles: Limited effects from food web alteration due to minimal dependence on freshwater forage resources.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	Unlikely to affect juvenile rearing.
	Altered buffering capability	Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modification.
		Decreased dissolved oxygen from eutrophication (caused by elevated nutrient export)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Long-term to permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modification.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pollutant loading	Increased exposure to toxic substances	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel machinery in a controlled environment away from the project area. Avoid reducing hydraulic complexity.	May affect survival, growth, and fitness of juveniles and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Low-oxygen stress leading to physiological injury and/or mortality; behavioral avoidance.	Limit damage to riparian area. Replant former impoundment with native vegetation to discourage invasives and stabilize sediments. Avoid draining impounded area through use of beaver deceivers.	May affect juvenile survival as well as adult survival, productivity, and spawning success.

Table A-4 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Large Woody Debris Placement/Movement/Removal (for placement only construction impacts apply)									
	Construction and Maintenance Activities								
	Riverine, Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane (from exposure to high intensity noise such as pile driving). • Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.

Table A-4 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.

Table A-4 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Localized alteration in invertebrate abundance	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Effects on pink salmon will be relatively minimal due to limited dependence on freshwater foraging.	Limit area of dewatering to the greatest extent practicable.	Temporary localized reductions in invertebrate abundance would not be expected to adversely affect juvenile pink salmon.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered flow velocity		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition		Year round	Permanent	Continuous				
	Altered groundwater-surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				

Table A-4 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	Juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile pink salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase. However, this impact pathway has not been well studied.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				
	Ecosystem Fragmentation								
	Riverine								
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most extensive)	Permanent	Seasonal	Eggs and alevins	Eggs and alevins: See related stressor responses under Water Quality Modification	Require assessment of the hydraulic effects of the project before permitting.	See effects for related stressors under Water Quality Modification.
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	Juveniles: See related stressor responses under Water Quality Modification.		May affect survival, growth, and fitness of juveniles and adults.

Table A-4 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered lateral (terrestrial/aquatic) habitat connectivity	Reduced refuge habitat availability	Year-round	Permanent	Continuous	Adults	Adults: This stressor may limit the availability of adult spawning habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density-dependent effects on adult spawning success.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of high quality floodplain habitat.	May affect spawning productivity.
	Altered longitudinal habitat connectivity								
	Marine								
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Juveniles	All exposed life-history stages: LWD removal in the marine environment may fragment nearshore rearing habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Avoid permitting LWD removal projects in areas where significant cumulative effects are already prevalent.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase. However, this impact pathway has not been well studied.
	Altered cover and habitat	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival. However, this impact pathway has not been well studied.
	Lacustrine								
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	All exposed life-history stages: LWD removal in lacustrine environments can fragment nearshore rearing habitat, forcing migrating salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival at juvenile life-history stage. Decreased fitness may lead to reduced spawning productivity. However, pink salmon do not rear in lakes so the impact will not be acute.
	Altered cover and habitat	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival. However, pink salmon do not rear in lakes so the impact will not be acute.

Table A-4 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification								
	Marine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Construction: Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased foraging opportunity due to decreased food web productivity.		May affect juvenile survival. May affect adult growth and spawning productivity.
	Riverine and Lacustrine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Effects on pink salmon will be relatively minimal due to limited dependence on freshwater foraging.	Construction: Avoid/minimize disturbance of aquatic vegetation during project construction.	Impact mechanism is unlikely to affect pink salmon.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability, potentially leading to altered migratory behavior and increased predation exposure.		May affect juvenile survival.

Table A-4 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Riverine								
	Altered shading, solar input and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Potential delays in migration or alterations in migration behavior. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	Should exposure occur, stressor may affect survival. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high-flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Potential delays in migration or alteration in migration behavior, increased predation exposure. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	Should exposure occur, stressor may affect survival. May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat, increased predation exposure. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile growth and survival, spawning success, and overall population productivity.
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen; reduced thermal refuge	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Decreased incubation success. Juveniles: Decreased availability of thermal refuge habitat, resulting in increased thermal stress and increased competition for suitable habitats. Adults: Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid permitting of projects in areas with springs, seeps, or other sources of significant groundwater recharge. Limit alteration of riparian vegetation to greatest extent practicable.	May affect survival of eggs and alevins. May affect juvenile survival and growth. May affect adult spawning productivity.

Table A-4 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Marine								
	Altered shading, solar input and ambient air temperature regime	Expansion of thermal regime (i.e., increased summer temperatures)	Year-round (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles	Juveniles: Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival and growth. However, this impact pathway has not been well studied.
	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival. However, this impact pathway has not been well studied.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources. Reduced aquatic food web productivity due to reduced organic matter inputs.	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	Juveniles: Pink dependence on allochthonous inputs from marine riparian vegetation is a data gap. However, pink are known to use terrestrial insect resources recruited from the riparian zone. Alteration of vegetation will therefore result in decreased foraging opportunities, decreased growth and fitness, and decreased productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness. However, this impact pathway has not been well studied.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high quality habitat features.	May affect juvenile survival. However, this impact pathway has not been well studied.
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	Juveniles: Pink dependence on groundwater inflow to nearshore marine habitats is currently a data gap.	Avoid disturbance of vegetation along shoreline.	Effects of the action resulting from this impact mechanism are unknown. However, this impact pathway has not been well studied.

Table A-4 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Lacustrine								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round, (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles	Juveniles: Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of thermal stratification and wind driven mixing However, juveniles trapped in isolated may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival. However, pink salmon do not rear in lakes so the impact will not be acute.
	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival. However, pink salmon do not rear in lakes so the impact will not be acute.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs predominantly during spring outmigration period through lakes)	Permanent	Continuous	Juveniles	Juveniles: Alteration of vegetation will result in decreased foraging opportunities.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness. However, pink salmon do not rear in lakes so the impact will not be acute.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival. However, pink salmon do not rear in lakes so the impact will not be acute.
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Permanent	Continuous	Juveniles	Juveniles: Pink dependence on groundwater inflow to nearshore lacustrine habitats is currently a data gap.	Avoid disturbance of vegetation along the shoreline.	Effects of the action resulting from this impact mechanism are unknown.

Table A-4 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to long-term (dependent on contributing mechanism of impact)	Continuous to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile survival, growth, and fitness, and adult survival and spawning productivity.
	Altered pollutant loading	Increased pollutant loading	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All life-history stages: Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival, growth, and fitness of juveniles and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Low-oxygen stress leading to physiological injury and/or mortality; behavioral avoidance.	Limit damage to riparian area. Replant former impoundment with native vegetation to discourage invasives and stabilize sediments. Avoid draining impounded area through use of beaver deceivers.	May affect juvenile survival and productivity as well as adult survival, productivity, and spawning success.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Spawning Substrate Augmentation									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane (from exposure to high intensity noise such as pile driving). • Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.

Table A-4 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
		Burial (during active sediment placement)	During project construction	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from burial during gravel placement.	Restrict in-water work window to periods when incubating eggs and alevins with limited motility are least likely to be present.	May cause direct mortality or injury at egg, alevin, and juvenile life-history stages. Injury and stress may affect survival, growth, and fitness.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Effects on pink salmon will be relatively minimal due to limited dependence on freshwater foraging.	Limit area of dewatering to the greatest extent practicable.	Temporary localized reductions in invertebrate abundance would not be expected to adversely affect juvenile pink salmon.
		Entrainment of benthic organisms, increased suspended solids,	During project construction	Temporary to short-term	Interannual–decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Reduced refuge habitat (from potential pool filling)	Year-round	Short-term to intermediate-term	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Ensure that project has been designed properly for ecosystem context.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.

Table A-4 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered bank stability (intermediate-term effects from passive augmentation projects)	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, substrate composition, and groundwater inputs can result in decreased refuge habitat suitability, potentially leading to changes in migratory behavior, increased stress, and increased predation exposure. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg and alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered substrate composition/stability			Short-term to long-term					
	Aquatic Vegetation Modification								
	Riverine								
	Altered autochthonous production	Reduced foraging opportunities	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Pink dependence on autochthonous inputs from aquatic vegetation is limited, as this species does not forage in riverine and lacustrine environments. Therefore, effects on juvenile pink growth and fitness will be limited.	Avoid spawning gravel augmentation projects in locations where aquatic vegetation plays a strong role in habitat productivity.	May affect juvenile survival, growth, and fitness.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability, potentially leading to altered migratory behavior and increased predation exposure.		May affect juvenile survival.

Table A-4 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
In-Channel/Off-Channel Habitat Creation/Modification									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.

Table A-4 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane (from exposure to high intensity noise such as pile driving). • Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-4 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Effects on pink salmon will be relatively minimal due to limited dependence on freshwater foraging.	Limit area of dewatering to the greatest extent practicable.	Temporary localized reductions in invertebrate abundance would not be expected to adversely affect juvenile pink salmon.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids (during construction or if in-channel project fails)	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
Riparian Planting/Restoration Enhancement									
	Construction and Maintenance Activities								
	Riverine , Lacustrine, Marine								
	Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-4 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Increased suspended solids – due to removal of invasive riparian species Spawning gravel sedimentation – due to removal of invasive riparian species	Year-round (with specific stressors prominent during high flow conditions)	Short-term to intermediate (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Minimize disturbance during invasive species removal. Use appropriate erosion control BMPs both during and after construction.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Aquatic Vegetation Modification								
	Riverine, Lacustrine, Marine								
	Altered autochthonous production	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect juvenile growth and fitness in marine environments.

Table A-4 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Riverine, Lacustrine, Marine								
	Altered Shading and solar input	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect juvenile growth and fitness
	Water Quality Modification								
	Altered Temperatures	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered suspended solids	Increased suspended solids – due to removal of invasive riparian species	Dependent on contributing mechanism of impact	Short-term to intermediate (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.

Table A-4 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
Wetland Creation Restoration/Enhancement									
	Construction and Maintenance Activities								
	Riverine and Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Juveniles; Adults	All exposed life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane (from exposure to high intensity noise such as pile driving). • Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.

Table A-4 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Effects on pink salmon will be relatively minimal due to limited dependence on freshwater foraging.	Limit area of dewatering to the greatest extent practicable.	Temporary localized reductions in invertebrate abundance would not be expected to adversely affect juvenile pink salmon.

Table A-4 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids (e.g., during reconnection of fragmented floodplain wetlands, etc.)	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
Beach Nourishment/Contouring									
	Construction and Maintenance Activities								
	Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Juveniles; Adults	All affected life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery/vessel work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended sediment	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.
	Lacustrine								

Table A-4 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Juveniles; Adults	All affected life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery/vessel work within the project area.	Exposure will be minimal because pink salmon do not rear in lakes. Consequently, effects are negligible.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended sediment	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	Exposure will be minimal because pink salmon do not rear in lakes. Consequently, effects are negligible.
	Hydraulic and Geomorphic Modification								
	Marine								
	Altered sediment supply	Localized alteration in invertebrate abundance from burial.	During project construction and maintenance activities	Short-term – long-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.
	Lacustrine								
	Altered sediment supply	Localized alteration in invertebrate abundance from burial.	During project construction and maintenance activities	Short-term – long-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	Exposure will be minimal because pink salmon do not rear in lakes. Consequently, effects are negligible.
	Aquatic Vegetation Modification								
	Marine								
	Altered autochthonous production	Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to long-term(dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased foraging opportunity due to decreased food web productivity.	Avoid/minimize disturbance of aquatic vegetation during project construction. Avoid nourishing beaches updrift of productive, vegetated aquatic habitat.	May affect juvenile survival. May affect adult growth and spawning productivity.
	Altered cover and habitat	Reduced cover							
	Lacustrine								
	Altered autochthonous production	Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to long-term(dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction. Avoid nourishing beaches updrift of productive, vegetated aquatic habitat.	Exposure will be minimal because pink salmon do not rear in lakes. Consequently, effects are negligible.
	Altered cover and habitat	Reduced cover							
	Water Quality Modification								

Table A-4 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids	During construction and during subsequent high energy periods	Temporary to short-term (dependent on grain size of augmented sediment)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic shoreline instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term (dependent on contributing mechanism of impact)	Interannual to decadal	Juveniles; Adults	All affected life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body.	May affect survival, growth, and fitness of juveniles and adults.
Reef Creation/Restoration/Enhancement									
	Construction and Maintenance Activities								
	Marine								
	Equipment operation and materials placement	Elevated noise, visual and physical disturbance	During project construction activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	All life-history stages: Stressor response dependent on magnitude and duration of disturbance, and project-specific environmental conditions; may range from: • Increased predation risk and decreased foraging success due to displacement, auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid construction activities during periods when individuals may be present, particularly juveniles.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. Should exposure occur, direct mortality or injury is probable.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.

Table A-4 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended sediment	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success.
	Lacustrine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Juveniles; Adults	All affected life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery/vessel work within the project area.	Exposure will be minimal because pink salmon do not rear in lakes. Consequently, effects are negligible.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended sediment	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	Exposure will be minimal because pink salmon do not rear in lakes. Consequently, effects are negligible.

Table A-4 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Hydraulic and Geomorphic Modification								
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles; Adults	Juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile Pink salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality. Adults: Adult Pink salmon forage in nearshore environments during return migrations. Alteration of nearshore habitat characteristics through these sub-mechanisms may lead to decreased food web productivity and prey availability. This may lead to decreased growth and decrease spawning fitness.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase. May affect adult growth and fitness, and spawning productivity.
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				

Table A-4 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine								
	Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Juveniles; Adults	Juveniles and adults: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of migratory habitat for adult pink salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduced cover or exposure to deep water habitat, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality. Adult pink will generally be less sensitive to these stressors. However, increased stress and delayed migration in the migratory corridor may reduce fitness and ultimately reduce spawning success.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival at juvenile life-history stage. Decreased fitness may lead to reduced spawning productivity.
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Continuous				
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal				
	Altered sediment supply		Year-round	Permanent	Continuous				
	Altered substrate composition		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Marine								
	Altered cover and habitat	Increased predation by piscivorous fish	Year-round	Permanent	Continuous	Juveniles	Juveniles: Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid placement of reef projects in proximity to juvenile migratory corridors, such that increased predation exposure may occur.	May affect juvenile survival, growth and fitness.
	Lacustrine								
	Altered cover and habitat	Increased predation by piscivorous fish	Year-round	Permanent	Continuous	Juveniles	Juveniles: Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid placement of reef projects in proximity to juvenile migratory corridors, such that increased predation exposure may occur.	May affect juvenile survival, growth and fitness.
	Aquatic Vegetation Modification								
	Marine								
	Altered cover and habitat	Decreased refuge and forage habitat	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased foraging opportunity due to decreased food web productivity.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile survival. May affect adult growth and spawning productivity.
	Lacustrine								

Table A-4 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered cover and habitat	Reduced cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles;	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	Impact mechanism is unlikely to affect pink salmon as they do not rear in lakes.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pollutant loading	Leaching of toxic substances (depending on composition of reef material)	Year-round	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Juveniles; Adults	All affected life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Use non-toxic reef material.	May affect survival, growth, and fitness of juveniles and adults.
Eel Grass and Other Aquatic Vegetation Creation/Restoration/Enhancement									
	Construction and Maintenance Activities								
	Marine								
	Planting activities and vessel use	Visual, physical, and noise related disturbance	During project construction	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles: Stress and behavioral avoidance by rearing juveniles and migrating adults exposed to low level noise, physical, and visual disturbance.	Adhere to system-specific in-water work windows.	May cause temporary behavioral avoidance and displacement.
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Vegetation transplantation projects are not likely to cause pulses of suspended sediment sufficient to lead to injury or mortality. Stressor response may include temporary behavioral avoidance and displacement.	Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May cause temporary behavioral avoidance and displacement.

Table A-5. HPA HCP Habitat Modification Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Beaver Dam Removal/Modification									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of all life stages.
		Visual, physical, and noise related disturbance	During project construction and maintenance activities	Temporary (disturbance) to short-term (displacement, auditory masking, hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Visual and physical disturbance may cause stress and displacement to other suitable habitats. Displaced fish may face increased competition, and increased predation risk. Auditory masking or temporary hearing threshold effects from elevated underwater noise may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Impoundment dewatering	Fish entrainment, stranding, displacement	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from increased flow entrainment as impoundment dewatering. Possible stranding of alevins in impoundment areas. Adults and juveniles: Mortality, injury, or stress from stranding or entrainment in dewatering flows. Juveniles: Increased competition following displacement, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration, resulting in decreased fitness and spawning success.	Manage dam removal to drain impoundment as slowly as practicable. Avoid scouring flows. Use beaver deceivers to limit hydraulic alteration.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Localized alteration in invertebrate abundance	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable. Use beaver deceivers to limit hydraulic alteration.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering.	See effects for related stressors under Water Quality Modification.

Table A-5 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term to long-term	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased refuge habitat during migration to lacustrine rearing environments, and increased predation exposure. Juvenile river rearing sockeye may also experience decreased foraging opportunity, leading to increased competition and decreased growth and fitness. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival, growth, and fitness at egg, alevin, and juvenile life-history stages (river rearing sockeye). May affect spawning productivity.
	Altered flow velocity		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Intermediate-term to long-term	Seasonal				
	Altered bank stability		Year round especially during high flows	Intermediate-term to long-term	Seasonal				
	Altered substrate composition (including spawning gravel sedimentation)		Year round	Intermediate-term to long-term	Continuous				
	Altered groundwater-surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Intermediate-term to long-term	Continuous				
	Ecosystem Fragmentation								
	Riverine								
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most extensive)	Permanent	Seasonal	Eggs and alevins	Eggs and alevins: See related stressor responses under Water Quality Modification	Avoid draining impounded area through use of beaver deceivers.	See effects for related stressors under Water Quality Modification.
		Decreased dissolved oxygen from eutrophication below the impoundment (caused by elevated nutrient export)							
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: See related stressor responses under Water Quality Modification.	Avoid draining impounded area through use of beaver deceivers.	May affect survival, growth, and fitness of juveniles and adults.
	Altered terrestrial/aquatic connectivity	Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of high quality floodplain habitat.	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
		Reduced foraging opportunities and rearing habitat availability							

Table A-5 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation codification								
	Riverine								
	Altered autochthonous production Altered cover and habitat	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased foraging opportunity due to decreased food web productivity.	Avoid draining impounded area through use of beaver deceivers.	May affect juvenile survival. May affect adult growth and spawning productivity.
	Riparian Vegetation Modification								
	Riverine								
	Altered stream bank and shoreline stability	Increased suspended solids Spawning gravel sedimentation	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Initiate proper erosion control measures both during and after construction. Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Long-term to permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	May affect juvenile rearing.
	Altered buffering capability	Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modification.
		Decreased dissolved oxygen from eutrophication (caused by elevated nutrient export)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Long-term to permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modification.

Table A-5 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pollutant loading	Increased exposure to toxic substances	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel machinery in a controlled environment away from the project area. Avoid reducing hydraulic complexity.	May affect survival, growth, and fitness of juveniles and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Low-oxygen stress leading to physiological injury and/or mortality; behavioral avoidance.	Limit damage to riparian area. Replant former impoundment with native vegetation to discourage invasives and stabilize sediments. Avoid draining impounded area through use of beaver deceivers.	May affect juvenile survival and productivity as well as adult survival, productivity, and spawning success.
Large Woody Debris Placement/Movement/Removal (for placement only construction impacts apply)									
	Construction and Maintenance Activities								
	Riverine, Lacustrine, Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.

Table A-5 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane (from exposure to high intensity noise such as pile driving). • Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.

Table A-5 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	<u>Eggs/alevins:</u> Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. <u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. <u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>Eggs and alevins</u>: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. <u>Adults and juveniles</u>: Mortality, injury, or stress from capture, handling, and relocation. <u>Juveniles</u>: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. <u>Adults</u>: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	<u>Eggs and alevins, juveniles</u>: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>Eggs and alevins</u>: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. <u>Juveniles</u>: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. <u>Adults</u>: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.

Table A-5 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased refuge habitat during migration to lacustrine rearing environments, and increased predation exposure. Juvenile river rearing sockeye may also experience decreased foraging opportunity, leading to increased competition and decreased growth and fitness. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival, growth, and fitness at egg, alevin, and juvenile life-history stages (river rearing sockeye). May affect spawning productivity.
	Altered flow velocity		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition		Year round	Permanent	Continuous				
	Altered groundwater-surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				

Table A-5 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	Juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats. Juvenile sockeye have relatively limited dependence on nearshore marine habitats. However, alteration of habitat productivity in the nearshore may lead to alteration of food web dynamics in offshore environments, potentially affecting foraging opportunities, leading to decreased growth and productivity. Adults: Alteration of nearshore habitat characteristics can demonstrably affect the productivity of forage species preyed upon by returning adult sockeye. Decreased foraging opportunity may lead to decreased growth and productivity.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase. May affect adult growth and productivity.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				
	Lacustrine								
	Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats upon which juvenile sockeye depend. Adults: Alteration of nearshore habitat parameters may alter the suitability of shoreline spawning habitats for beach spawning sockeye, leading to decreased spawning productivity.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selections of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect growth and fitness at juvenile life-history stage. May affect adult spawning productivity.
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common				
	Altered sediment supply		Year-round	Permanent	Continuous				
	Altered substrate composition		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Riverine								

Table A-5 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most extensive)	Permanent	Seasonal	Eggs and alevins	Eggs and alevins: See related stressor responses under Water Quality Modification.	Require assessment of the hydraulic effects of the project before permitting.	See effects for related stressors under Water Quality Modification.
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	Juveniles: See related stressor responses under Water Quality Modification.		May affect survival, growth, and fitness of juveniles and adults.
	Altered lateral (terrestrial/aquatic) habitat connectivity Altered longitudinal habitat connectivity	Reduced availability of off-channel refuge and rearing habitat. Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs Reduced foraging opportunities and rearing habitat availability Reduced availability of suitable habitats along longitudinal gradient.	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition, increased predation, and resulting effects on growth and fitness. Adults: Decreased survival, fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat or longitudinal reach simplification.	May affect survival, growth, and fitness at egg, alevin, and juvenile life-history stages. May affect adult survival and spawning productivity.
	Marine								
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Juveniles	All exposed life-history stages: LWD removal in the marine environment can fragment nearshore rearing habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Avoid permitting LWD removal projects in areas where significant cumulative effects are already prevalent.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect adult survival and productivity during ocean migration life-history phase.
	Altered cover and habitat	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.
	Lacustrine								
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	All exposed life-history stages: LWD removal in lacustrine environments can fragment nearshore rearing and spawning habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival at juvenile life-history stage. Decreased fitness may lead to reduced spawning productivity.

Table A-5 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered cover and habitat	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.
	Aquatic Vegetation Modification								
	Marine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Sockeye dependence on autochthonous inputs from marine littoral vegetation is a data gap but is likely limited due to the lesser dependence of this species on the nearshore marine environment.	Construction: Avoid/minimize disturbance of aquatic vegetation during project construction.	Potential effects resulting from this impact mechanism are unknown.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Sockeye dependence on nearshore marine habitats is limited in comparison to other salmonids. Sockeye response to alteration of nearshore habitat complexity is currently a data gap. Adults: Reduction in nearshore habitat complexity may affect availability of forage for returning adult sockeye, affecting growth and productivity during spawning.		Potential effects on juvenile sockeye resulting from this impact mechanism are unknown. May affect adult growth and productivity.
	Riverine and Lacustrine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Alteration of aquatic vegetation may indirectly affect food web dynamics, potentially leading to decreased foraging opportunities.	Construction: Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile productivity.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Alteration of aquatic vegetation may indirectly affect food web dynamics, potentially leading to decreased foraging opportunities.		May affect juvenile survival.

Table A-5 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Riverine								
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults	Eggs and alevins: Decreased incubation success. Adults: Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid disturbance of vegetation along stream.	May affect survival of eggs and alevins, as well as adult spawning productivity.

Table A-5 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Marine								
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures)	Year-round, (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles	Juveniles: Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. Juvenile sockeye dependence on the nearshore marine environment is relatively limited. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival and growth.
	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival and fitness.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	Juveniles: Sockeye dependence on allochthonous inputs from marine riparian vegetation is a data gap but is likely limited due to the lesser dependence of this species on the nearshore marine environment.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	Potential effects resulting from this impact mechanism are unknown.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Sockeye dependence on nearshore marine habitats is limited in comparison to other salmonids. Sockeye response to alteration of nearshore habitat complexity is currently a data gap. Adults: Reduction in nearshore habitat complexity may affect availability of forage for returning adult sockeye, affecting growth and productivity during spawning.	Encourage project designs that limit permanent alteration of high-quality habitat features.	Potential effects on juvenile sockeye resulting from this impact mechanism are unknown. May affect adult growth and productivity.
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	Juveniles: Sockeye dependence on groundwater inflow to nearshore marine habitats is currently a data gap.	Avoid disturbance of vegetation along shoreline.	Effects of the action resulting from this impact mechanism are unknown.
	Lacustrine								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round, (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles	Juveniles: Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of lake stratification, reservoir current patterns, wind conditions, and other factors. However, shallow littoral habitats may experience increased temperatures due to lack of shade, leading to decreased availability of refuge and forage habitat, increased competition, and increased predation exposure.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival, growth, and fitness.

Table A-5 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	<u>Eggs and alevins</u>: Potential reduction in egg survival and incubation success (for beach spawning sockeye) due to increased sedimentation and turbidity, as described under Water Quality Modification. <u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification. <u>Adults</u>: May affect spawning habitat suitability, leading to decreased spawning productivity as described under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect egg and alevin survival. May affect juvenile survival and productivity. May affect adult spawning productivity.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	<u>Juveniles</u>: Sockeye dependence on autochthonous inputs from lacustrine riparian vegetation is a data gap. Sockeye are primarily planktonic feeders in the photic zone, so direct dependence on allochthonous inputs for prey is likely limited.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	Potential effects resulting from this impact mechanism are unknown.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Intermediate-term to permanent (dependent on nature of activity and time required for recovery)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival, growth, and fitness.
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Eggs and alevins; Juveniles; Adults	<u>Eggs and alevins</u>: Decreased egg and alevin survival (beach-spawning sockeyes) due to lower dissolved oxygen levels in spawning substrate. <u>Juveniles</u>: Sockeye dependence on groundwater inflow to nearshore habitats is currently a data gap. <u>Adults</u>: Decreased suitable spawning habitat, leading to decreased spawning productivity.	Avoid disturbance of vegetation along shoreline.	May affect egg and alevin survival. May affect adult spawning productivity. Effects on juveniles are unknown.

Table A-5 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to long-term (dependent on contributing mechanism of impact)	Continuous to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile survival, growth, and fitness, and adult survival and spawning productivity.
	Altered pollutant loading	Increased pollutant loading	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All life-history stages: Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival, growth, and fitness of juveniles and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen (due to eutrophication caused by elevated nutrient export from dewatered floodplains)	Dependent on contributing mechanism of impact	Temporary to short-term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Low-oxygen stress leading to physiological injury and/or mortality; behavioral avoidance.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect alevin development, juvenile survival, growth, and fitness as well as adult survival, fitness, and spawning success.

Table A-5 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Spawning Substrate Augmentation									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane (from exposure to high intensity noise such as pile driving). • Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.

Table A-5 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
		Burial (during active sediment placement)	During project construction	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from burial during gravel placement.	Restrict in-water work window to periods when incubating eggs and alevins with limited motility are least likely to be present.	May cause direct mortality or injury at egg, alevin, and juvenile life-history stages. Injury and stress may affect survival, growth, and fitness.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids,	During project construction	Temporary to short-term	Interannual–decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Reduced refuge habitat (from potential pool filling)	Year-round	Short-term to intermediate-term	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Ensure that project has been designed properly for ecosystem context.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered bank stability (intermediate-term effects from passive augmentation projects)	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased refuge habitat during migration to lacustrine rearing environments, and increased predation exposure. Juvenile river rearing sockeye may also experience decreased foraging opportunity, leading to increased competition and decreased growth and fitness. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival, growth, and fitness at egg, alevin, and juvenile life-history stages (river rearing sockeye). May affect spawning productivity.
	Altered substrate composition/stability			Short-term to long-term					
	Aquatic Vegetation Modification								
	Riverine								
	Altered autochthonous production	Reduced foraging opportunities	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Avoid spawning gravel augmentation projects in locations where aquatic vegetation plays a strong role in habitat productivity.	May affect juvenile survival, growth, and fitness.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased foraging opportunity due to decreased food web productivity.		

Table A-5 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
In-Channel/Off-Channel Habitat Creation/Modification									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.

Table A-5 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane (from exposure to high intensity noise such as pile driving). • Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-5 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.

Table A-5 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids (during construction or if in-channel project fails)	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
Riparian Planting/Restoration Enhancement									
	Construction and Maintenance Activities								
	Riverine , Lacustrine, Marine								
	Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-5 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Increased suspended solids – due to removal of invasive riparian species Spawning gravel sedimentation – due to removal of invasive riparian species	Year-round (with specific stressors prominent during high flow conditions)	Short-term to intermediate (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Minimize disturbance during invasive species removal. Use appropriate erosion control BMPs both during and after construction.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Aquatic Vegetation Modification								
	Riverine, Lacustrine, Marine								
	Altered autochthonous production	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Sockeye dependence on autochthonous inputs from marine littoral vegetation is a data gap but is likely limited due to the lesser dependence of this species on the nearshore marine environment.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	Potential effects resulting from this impact mechanism are unknown.

Table A-5 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Riverine, Lacustrine, Marine								
	Altered Shading and solar input	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect juvenile growth and fitness
	Water Quality Modification								
	Altered Temperatures	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered suspended solids	Increased suspended solids – due to removal of invasive riparian species	Dependent on contributing mechanism of impact	Short-term to intermediate (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.

Table A-5 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
Wetland Creation Restoration/Enhancement									
	Construction and Maintenance Activities								
	Riverine and Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Juveniles; Adults	All exposed life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane (from exposure to high intensity noise such as pile driving). • Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.

Table A-5 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
	Water Quality Modification								

Table A-5 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids (e.g., during reconnection of fragmented floodplain wetlands, etc.)	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>Eggs and alevins:</u> Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. <u>Juveniles and adults</u>: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u>: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u>: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
Beach Nourishment/Contouring									
	Construction and Maintenance Activities								
	Marine and Lacustrine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Juveniles; Adults	<u>All affected life-history stages</u>: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery/vessel work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids.	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles;	<u>Eggs and alevins:</u> Littoral disturbance in lacustrine areas may lead to direct mortality and decreased survival of eggs and alevins. <u>Juveniles</u>: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community. Avoid lacustrine activities during sockeye spawning periods.	May affect survival of incubating eggs and alevins. May affect growth and fitness at juvenile life-history stage.

Table A-5 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Hydraulic and Geomorphic Modification								
	Marine and Lacustrine								
	Altered sediment supply	Localized alteration in invertebrate abundance from burial	During project construction and maintenance activities	Short-term – long-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles;	Eggs and alevins: Littoral disturbance in lacustrine areas may lead to direct mortality and decreased survival of eggs and alevins. Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect survival of incubating eggs and alevins. May affect growth and fitness at juvenile life-history stage.
	Aquatic Vegetation Modification								
	Marine and Lacustrine								
	Altered autochthonous production	Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to long-term(dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Sockeye dependence on autochthonous inputs from marine littoral vegetation is a data gap but is likely limited due to the lesser dependence of this species on the nearshore marine environment. Adults: Reduction in nearshore habitat complexity may affect availability of forage for returning adult sockeye, affecting growth and productivity during spawning.	Avoid/minimize disturbance of aquatic vegetation during project construction. Avoid nourishing beaches updrift of productive, vegetated aquatic habitat.	Potential affects on juveniles is unknown. May affect adult growth and spawning productivity.
	Altered cover and habitat	Reduced cover							
	Water Quality Modification								
	Marine and Lacustrine								
	Altered suspended solids	Increased suspended solids	During construction and during subsequent high energy periods	Temporary to short-term (dependent on grain size of augmented sediment)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic shoreline instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term (dependent on contributing mechanism of impact)	Interannual to decadal	Juveniles; Adults	All affected life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body.	May affect survival, growth, and fitness of juveniles and adults.

Table A-5 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Reef Creation/Restoration/Enhancement									
	Construction and Maintenance Activities								
	Marine and Lacustrine								
	Equipment operation and materials placement	Elevated noise, visual and physical disturbance	During project construction activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	All life-history stages: Stressor response dependent on magnitude and duration of disturbance, and project-specific environmental conditions; may range from: • Increased predation risk and decreased foraging success due to displacement, auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid construction activities during periods when individuals may be present, particularly juveniles.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. Should exposure occur, direct mortality or injury is probable.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids.	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles;	Eggs and alevins: Littoral disturbance in lacustrine areas may lead to direct mortality and decreased survival of eggs and alevins. Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community. Avoid lacustrine activities during sockeye spawning periods.	May affect survival of incubating eggs and alevins. May affect growth and fitness at juvenile life-history stage.

Table A-5 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles</u>: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile Sockeye salmon. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality. <u>Adults</u>: Adult Sockeye salmon forage in nearshore environments during return migrations. Alteration of nearshore habitat characteristics through these sub-mechanisms may lead to decreased food web productivity and prey availability. This may lead to decreased growth and decrease spawning fitness.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase. May affect adult growth and fitness, and spawning productivity.
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				

Table A-5 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine								
	Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Juveniles; Adults	Juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats upon which juvenile sockeye depend. Adults: Alteration of nearshore habitat parameters may alter the suitability of shoreline spawning habitats for beach spawning sockeye, leading to decreased spawning productivity.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selections of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect growth and fitness at juvenile life-history stage. May affect adult spawning productivity.
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Continuous				
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal				
	Altered sediment supply		Year-round	Permanent	Continuous				
	Altered substrate composition		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Marine								
	Altered cover and habitat	Increased predation risk	Year-round	Permanent	Continuous	Juveniles	Juveniles: Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid placement of reef projects in proximity to juvenile migratory corridors, such that increased predation exposure may occur.	May affect juvenile survival, growth and fitness.
	Lacustrine								
	Altered cover and habitat	Increased predation by piscivorous fish	Year-round	Permanent	Continuous	Juveniles	Juveniles: Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid placement of reef projects in proximity to juvenile migratory corridors, such that increased predation exposure may occur.	May affect juvenile survival, growth and fitness.
	Aquatic Vegetation Modification								
	Marine								
	Altered cover and habitat	Increased predation risk	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased foraging opportunity due to decreased food web productivity.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile survival. May affect adult growth and spawning productivity.
	Lacustrine								
	Altered autochthonous production	Reduced foraging opportunities	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles;	Juveniles: Decreased refuge habitat availability, leading to increased competition and resulting effects on growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile survival, growth, and fitness.
	Altered cover and habitat								
	Water Quality Modification								

Table A-5 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pollutant loading	Leaching of toxic substances (depending on composition of reef material)	Year-round	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Juveniles; Adults	All affected life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Use non-toxic reef material.	May affect survival, growth, and fitness of juveniles and adults.
Eel Grass and Other Aquatic Vegetation Creation/Restoration/Enhancement									
	Construction and Maintenance Activities								
	Marine								
	Planting activities and vessel use	Visual, physical, and noise related disturbance	During project construction	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles: Stress and behavioral avoidance by rearing juveniles and migrating adults exposed to low level noise, physical, and visual disturbance.	Adhere to system-specific in-water work windows.	May cause temporary behavioral avoidance and displacement.
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Vegetation transplantation projects are not likely to cause pulses of suspended sediment sufficient to lead to injury or mortality. Stressor response may include temporary behavioral avoidance and displacement.	Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May cause temporary behavioral avoidance and displacement.

Table A-6. HPA HCP Habitat Modification Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Beaver Dam Removal									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness. May affect survival, growth, and fitness of juveniles and adults.
		Visual, physical, and noise related disturbance	During project construction and maintenance activities	Temporary (disturbance) to short-term (displacement, auditory masking, hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Visual and physical disturbance may cause stress and displacement to other suitable habitats. Displaced fish may face increased competition, and increased predation risk. Auditory masking or temporary hearing threshold effects from elevated underwater noise may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Impoundment dewatering	Fish entrainment, stranding, displacement	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from increased flow entrainment as impoundment dewatering. Possible stranding of alevins in impoundment areas. Adults and juveniles: Mortality, injury, or stress from stranding or entrainment in dewatering flows. Juveniles: Increased competition following displacement, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration, resulting in decreased fitness and spawning success.	Manage dam removal to drain impoundment as slowly as practicable. Avoid scouring flows. Use beaver deceivers to limit hydraulic alteration.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Localized alteration in invertebrate abundance	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable. Use beaver deceivers to limit hydraulic alteration.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering.	See effects for related stressors under Water Quality Modification.

Table A-6 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term to long-term	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Potential habitat avoidance and/or decreased survival due to suspended sediment loads induced by bank instability as described for related stressor responses under Water Quality Modification. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate ecological context and consider the magnitude of impact mechanisms produced by the project. Prevent rapid dewatering of impoundments likely to cause scouring flows. Encourage use of beaver deceivers.	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered flow velocity		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Intermediate-term to long-term	Seasonal				
	Altered bank stability		Year round especially during high flows	Intermediate-term to long-term	Seasonal				
	Altered substrate composition (including spawning gravel sedimentation)		Year round	Intermediate-term to long-term	Continuous				
	Altered groundwater-surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Intermediate-term to long-term	Continuous				
	Ecosystem Fragmentation								
	Riverine								
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most extensive)	Permanent	Seasonal	Eggs and alevins	Eggs and alevins: See related stressor responses under Water Quality Modification.	Avoid draining impounded area through use of beaver deceivers.	See effects for related stressors under Water Quality Modification.
		Decreased dissolved oxygen from eutrophication below the impoundment (caused by elevated nutrient export)							
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: See related stressor responses under Water Quality Modification.	Avoid draining impounded area through use of beaver deceivers.	May affect survival, growth, and fitness of juveniles and adults.

Table A-6 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered terrestrial/aquatic connectivity	Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs Reduced foraging opportunities and rearing habitat availability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of high quality floodplain habitat.	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Aquatic Vegetation Modification								
	Riverine								
	Altered autochthonous production Altered cover and habitat	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased foraging opportunity due to decreased food web productivity.	Avoid draining impounded area through use of beaver deceivers.	May affect juvenile survival. May affect adult growth and spawning productivity.
	Riparian Vegetation Modification								
	Riverine								
	Altered stream bank and shoreline stability	Increased suspended solids Spawning gravel sedimentation	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Initiate proper erosion control measures both during and after construction. Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Long-term to permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	May affect juvenile rearing.

Table A-6 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered buffering capability	Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modification.
		Decreased dissolved oxygen from eutrophication (caused by elevated nutrient export)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Long-term to permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modification.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pollutant loading	Increased exposure to toxic substances	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel machinery in a controlled environment away from the project area. Avoid reducing hydraulic complexity.	May affect survival, growth, and fitness of juveniles and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Low-oxygen stress leading to physiological injury and/or mortality; behavioral avoidance.	Limit damage to riparian area. Replant former impoundment with native vegetation to discourage invasives and stabilize sediments. Avoid draining impounded area through use of beaver deceivers.	May affect juvenile survival and productivity as well as adult survival, productivity, and spawning success.

Table A-6 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Large Woody Debris Placement/Movement/Removal (for placement only construction impacts apply)									
	Construction and Maintenance Activities								
	Riverine, Lacustrine, Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane (from exposure to high intensity noise such as pile driving). • Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.

Table A-6 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.

Table A-6 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered flow velocity		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition		Year round	Permanent	Continuous				
	Altered groundwater-surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				

Table A-6 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles; Adults	Juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile steelhead. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality. Adults: Subadult and returning adult steelhead forage in nearshore environments. Alteration in nearshore ecosystem processes may decrease foraging opportunity, affecting growth and fitness.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at juvenile life-history stage. May affect adult growth and productivity.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				

Table A-6 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine								
	Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Juveniles; Adults	Juveniles and adults: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile and migratory habitat for adult steelhead. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduced cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality. Adult steelhead will generally be less sensitive to these stressors. However, increased stress and delayed migration may reduce fitness and ultimately reduce spawning success.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns. For example:	May affect survival, growth, and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common				
	Altered sediment supply		Year-round	Permanent	Continuous				
	Altered substrate composition		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Riverine								
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most extensive)	Permanent	Seasonal	Eggs and alevins	Eggs and alevins: See related stressor responses under Water Quality Modification.	Require assessment of the hydraulic effects of the project before permitting.	See effects for related stressors under Water Quality Modification.
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	Juveniles: See related stressor responses under Water Quality Modification.		May affect survival, growth, and fitness of juveniles and adults.

Table A-6 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered lateral (terrestrial/aquatic) habitat connectivity Altered longitudinal habitat connectivity	Reduced availability of off-channel refuge and rearing habitat. Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs Reduced foraging opportunities and rearing habitat availability Reduced availability of suitable habitats along longitudinal gradient.	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u>: This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness. <u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition, increased predation, and resulting effects on growth and fitness. <u>Adults:</u> Decreased survival, fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat or longitudinal reach simplification.	May affect survival, growth, and fitness at egg, alevin, and juvenile life-history stages. May affect adult survival and spawning productivity.
	Marine								
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Juveniles	<u>All exposed life-history stages</u>: LWD removal in the marine environment may fragment nearshore rearing habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered cover and habitat	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.
	Lacustrine								
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	<u>All exposed life-history stages</u>: LWD removal in lacustrine environments can fragment nearshore rearing habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival at juvenile life-history stage. Decreased fitness may lead to reduced spawning productivity.
	Altered cover and habitat	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.

Table A-6 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification								
	Marine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Construction: Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased foraging opportunity due to decreased food web productivity.		May affect juvenile survival. May affect adult growth and spawning productivity.
	Riverine and Lacustrine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Construction: Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.		May affect juvenile survival, growth, and fitness, as well as adult spawning productivity.

Table A-6 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Riverine								
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults	Eggs and alevins: Decreased incubation success. Adults: Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid disturbance of vegetation along stream.	May affect survival of eggs and alevins, as well as adult spawning productivity.

Table A-6 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Marine								
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures)	Year-round, (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles	Juveniles: Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. The extent of nearshore habitat use by juvenile steelhead is currently a data gap. However, juveniles trapped by tidal exchange in specific habitats, such as pocket estuaries, may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	The potential effects of this mechanism on juvenile steelhead are generally unknown. However, may affect juvenile survival and growth.
	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. This effect may be limited in magnitude, however, as juvenile steelhead use of littoral habitats is relatively limited. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	The potential effects of this mechanism on juvenile steelhead are generally unknown. However, may affect juvenile survival and fitness.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	Juveniles: Steelhead dependence on allochthonous inputs from marine riparian vegetation is a data gap. However, steelhead are known to use terrestrial insect resources recruited from the riparian zone in freshwater environments, so exploitation of these resources in marine environments is possible.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	The potential effects of this mechanism on juvenile steelhead are generally unknown. However, may affect juvenile survival, growth, and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Steelhead dependence on nearshore habitat complexity is currently a data gap. Altered habitat complexity may lead to decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	The potential effects of this mechanism on juvenile steelhead are generally unknown. However, may affect juvenile survival, growth, and fitness.
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	Juveniles: Steelhead dependence on groundwater inflow to nearshore marine habitats is currently a data gap.	Avoid disturbance of vegetation along shoreline.	Effects of the action resulting from this impact mechanism are unknown.

Table A-6 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round, (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles	Juveniles: Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of lake stratification, reservoir current patterns, wind conditions, and other factors. However, shallow littoral habitats may experience increased temperatures due to lack of shade, leading to decreased availability of refuge and forage habitat, increased competition, and increased predation exposure.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival, growth, and fitness.
	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival and fitness.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs predominantly during spring outmigration period through lakes)	Permanent	Continuous	Juveniles	Juveniles: Steelhead dependence on allochthonous inputs from marine riparian vegetation is a data gap. However, steelhead are known to use terrestrial insect resources recruited from the riparian zone. Alteration of vegetation will result in decreased foraging opportunities, decreased growth and fitness, and decreased productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth, fitness, and productivity.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival and fitness, spawning success, and overall population productivity.
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs predominantly during spring outmigration period through lakes)	Permanent	Continuous	Juveniles	Juveniles: Steelhead dependence on groundwater inflow to littoral lacustrine habitats is currently a data gap. However, loss of groundwater may lead to reduction in shallow water thermal refuge, increased competition, and decreased foraging opportunity.	Avoid disturbance of vegetation along shoreline.	May affect juvenile survival and fitness.

Table A-6 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to long-term (dependent on contributing mechanism of impact)	Continuous to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile survival, growth, and fitness, and adult survival and spawning productivity.
	Altered pollutant loading	Increased pollutant loading	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All life-history stages: Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival, growth, and fitness of juveniles and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen (due to eutrophication caused by elevated nutrient export from dewatered floodplains)	Dependent on contributing mechanism of impact	Temporary to short-term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Low-oxygen stress leading to physiological injury and/or mortality; behavioral avoidance.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect alevin development, juvenile survival, growth, and fitness as well as adult survival, fitness, and spawning success.

Table A-6 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Spawning Substrate Augmentation									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u>: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane (from exposure to high intensity noise such as pile driving). • Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.

Table A-6 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
		Burial (during active sediment placement)	During project construction	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from burial during gravel placement.	Restrict in-water work window to periods when incubating eggs and alevins with limited motility are least likely to be present.	May cause direct mortality or injury at egg, alevin, and juvenile life-history stages. Injury and stress may affect survival, growth, and fitness.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids,	During project construction	Temporary to short-term	Interannual–decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Reduced refuge habitat (from potential pool filling)	Year-round	Short-term to intermediate-term	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Ensure that project has been designed properly for ecosystem context.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.

Table A-6 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered bank stability (intermediate-term effects from passive augmentation projects)	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in substrate composition and stability may lead to decreased incubation success and alevin survival while augmentation projects stabilize. Juveniles: Altered channel geometry, bank stability, and substrate composition can result in short-term to intermediate-term changes in rearing habitat suitability and changes in food web complexity while augmentation projects stabilize. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology and bank structure may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate stability may lead to decreased spawning success while augmentation projects stabilize. However, adverse effects would be expected to be short-term in nature, while beneficial effects would be expected to persist.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of augmentation projects that minimize adverse effects on channel geometry, bank conditions, and substrate stability to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered substrate composition/stability			Short-term to long-term					
	Aquatic Vegetation Modification								
	Riverine								
	Altered autochthonous production	Reduced foraging opportunities	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Avoid spawning gravel augmentation projects in locations where aquatic vegetation plays a strong role in habitat productivity.	May affect juvenile survival, growth, and fitness.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased foraging opportunity due to decreased food web productivity.		

Table A-6 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>Eggs and alevins:</u> Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. <u>Juveniles and adults</u>: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u>: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
In-Channel/Off-Channel Habitat Creation/Modification									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u>: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.

Table A-6 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane (from exposure to high intensity noise such as pile driving). • Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-6 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.

Table A-6 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids (during construction or if in-channel project fails)	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
Riparian Planting/Restoration Enhancement									
	Construction and Maintenance Activities								
	Riverine , Lacustrine, Marine								
	Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-6 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Increased suspended solids – due to removal of invasive riparian species Spawning gravel sedimentation – due to removal of invasive riparian species	Year-round (with specific stressors prominent during high flow conditions)	Short-term to intermediate (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Minimize disturbance during invasive species removal. Use appropriate erosion control BMPs both during and after construction.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Aquatic Vegetation Modification								
	Riverine, Lacustrine, Marine								
	Altered autochthonous production	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect juvenile growth and fitness

Table A-6 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Riverine, Lacustrine, Marine								
	Altered Shading and solar input	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect juvenile growth and fitness
	Water Quality Modification								
	Altered Temperatures	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered suspended solids	Increased suspended solids – due to removal of invasive riparian species	Dependent on contributing mechanism of impact	Short-term to intermediate (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.

Table A-6 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Wetland Creation Restoration/Enhancement									
	Construction and Maintenance Activities								
	Riverine and Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Juveniles; Adults	All exposed life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane (from exposure to high intensity noise such as pile driving). • Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.

Table A-6 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

Table A-6 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids (e.g., during reconnection of fragmented floodplain wetlands, etc.)	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
Beach Nourishment/Contouring									
	Construction and Maintenance Activities								
	Marine and Lacustrine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Juveniles; Adults	All affected life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery/vessel work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.

Table A-6 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Marine and Lacustrine								
	Altered sediment supply	Localized alteration in invertebrate abundance from burial	During project construction and maintenance activities	Short-term – long-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.
	Aquatic Vegetation Modification								
	Marine and Lacustrine								
	Altered autochthonous production	Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to long-term(dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased foraging opportunity due to decreased food web productivity.	Avoid/minimize disturbance of aquatic vegetation during project construction. Avoid nourishing beaches updrift of productive, vegetated aquatic habitat.	May affect juvenile survival. May affect adult growth and spawning productivity.
	Altered cover and habitat	Reduced cover							
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	During construction and during subsequent high energy periods	Temporary to short-term (dependent on grain size of augmented sediment)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic shoreline instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term (dependent on contributing mechanism of impact)	Interannual to decadal	Juveniles; Adults	All affected life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body.	May affect survival, growth, and fitness of juveniles and adults.

Table A-6 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Reef Creation/Restoration/Enhancement									
	Construction and Maintenance Activities								
	Marine and Lacustrine								
	Equipment operation and materials placement	Elevated noise, visual and physical disturbance	During project construction activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	All life-history stages: Stressor response dependent on magnitude and duration of disturbance, and project-specific environmental conditions; may range from: • Increased predation risk and decreased foraging success due to displacement, auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid construction activities during periods when individuals may be present, particularly juveniles.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. Should exposure occur, direct mortality or injury is probable.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.

Table A-6 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles; Adults	Juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile steelhead. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality. Adults: Subadult and returning adult steelhead forage in nearshore environments. Alteration in nearshore ecosystem processes may decrease foraging opportunity, affecting growth and fitness.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at juvenile life-history stage. May affect adult growth and productivity.
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				

Table A-6 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine								
	Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Juveniles; Adults	Juveniles and adults: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile and migratory habitat for adult steelhead. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduced cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality. Adult steelhead will generally be less sensitive to these stressors. However, increased stress and delayed migration may reduce fitness and ultimately reduce spawning success.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns. For example:	May affect survival, growth, and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Continuous				
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal				
	Altered sediment supply		Year-round	Permanent	Continuous				
	Altered substrate composition		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Marine								
	Altered cover and habitat	Increased predation risk	Year-round	Permanent	Continuous	Juveniles	Juveniles: Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid placement of reef projects in proximity to juvenile migratory corridors, such that increased predation exposure may occur.	May affect juvenile survival, growth and fitness.
	Lacustrine								
	Altered cover and habitat	Increased predation by piscivorous fish	Year-round	Permanent	Continuous	Juveniles	Juveniles: Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid placement of reef projects in proximity to juvenile migratory corridors, such that increased predation exposure may occur.	May affect juvenile survival, growth and fitness.

Table A-6 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification								
	Marine								
	Altered cover and habitat	Decreased refuge and forage habitat	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased foraging opportunity due to decreased food web productivity.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile survival. May affect adult growth and spawning productivity.
	Lacustrine								
	Altered autochthonous production Altered cover and habitat	Reduced foraging opportunities	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles;	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile survival, growth, and fitness.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pollutant loading	Leaching of toxic substances (depending on composition of reef material)	Year-round	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Juveniles; Adults	All affected life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Use non-toxic reef material.	May affect survival, growth, and fitness of juveniles and adults.
Eel Grass and Other Aquatic Vegetation Creation/Restoration/Enhancement									
	Construction and Maintenance Activities								
	Marine								

Table A-6 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Steelhead Salmon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Planting activities and vessel use	Visual, physical, and noise related disturbance	During project construction	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles: Stress and behavioral avoidance by rearing juveniles and migrating adults exposed to low level noise, physical, and visual disturbance.	Adhere to system-specific in-water work windows.	May cause temporary behavioral avoidance and displacement.
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Vegetation transplantation projects are not likely to cause pulses of suspended sediment sufficient to lead to injury or mortality. Stressor response may include temporary behavioral avoidance and displacement.	Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May cause temporary behavioral avoidance and displacement.

Table A-7. HPA HCP Habitat Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
Beaver Dam Removal									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness. May affect survival, growth, and fitness of juveniles and adults.
		Visual, physical, and noise related disturbance	During project construction and maintenance activities	Temporary (disturbance) to short-term (displacement, auditory masking, hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Visual and physical disturbance may cause stress and displacement to other suitable habitats. Displaced fish may face increased competition, and increased predation risk. Auditory masking or temporary hearing threshold effects from elevated underwater noise may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Impoundment dewatering	Fish entrainment, stranding, displacement	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from increased flow entrainment as impoundment dewatering. Possible stranding of alevins in impoundment areas. Adults and juveniles: Mortality, injury, or stress from stranding or entrainment in dewatering flows. Juveniles: Increased competition following displacement, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration, resulting in decreased fitness and spawning success.	Manage dam removal to drain impoundment as slowly as practicable. Avoid scouring flows. Use beaver deceivers to limit hydraulic alteration.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Localized alteration in invertebrate abundance	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable. Use beaver deceivers to limit hydraulic alteration.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering.	See effects for related stressors under Water Quality Modification.

Table A-7 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term to long-term	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Potential habitat avoidance and/or decreased survival due to suspended sediment loads induced by bank instability as described for related stressor responses under Water Quality Modification. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate ecological context and consider the magnitude of impact mechanisms produced by the project. Prevent rapid dewatering of impoundments likely to cause scouring flows. Encourage use of beaver deceivers.	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered flow velocity		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Intermediate-term to long-term	Seasonal				
	Altered bank stability		Year round especially during high flows	Intermediate-term to long-term	Seasonal				
	Altered substrate composition (including spawning gravel sedimentation)		Year round	Intermediate-term to long-term	Continuous				
	Altered groundwater-surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Intermediate-term to long-term	Continuous				
	Ecosystem Fragmentation								
	Riverine								
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most extensive)	Permanent	Seasonal	Eggs and alevins	Eggs and alevins: See related stressor responses under Water Quality Modification.	Avoid draining impounded area through use of beaver deceivers.	See effects for related stressors under Water Quality Modification.
		Decreased dissolved oxygen from eutrophication below the impoundment (caused by elevated nutrient export)							
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: See related stressor responses under Water Quality Modification.	Avoid draining impounded area through use of beaver deceivers.	May affect survival, growth, and fitness of juveniles and adults.

Table A-7 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered terrestrial/aquatic connectivity	Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs Reduced foraging opportunities and rearing habitat availability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of high quality floodplain habitat.	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Aquatic Vegetation Modification								
	Riverine								
	Altered autochthonous production Altered cover and habitat	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased foraging opportunity due to decreased food web productivity.	Avoid draining impounded area through use of beaver deceivers.	May affect juvenile survival. May affect adult growth and spawning productivity.
	Riparian Vegetation Modification								
	Riverine								
	Altered stream bank and shoreline stability	Increased suspended solids Spawning gravel sedimentation	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Initiate proper erosion control measures both during and after construction. Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Long-term to permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	May affect juvenile rearing.

Table A-7 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered buffering capability	Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modification.
		Decreased dissolved oxygen from eutrophication (caused by elevated nutrient export)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Long-term to permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modification.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pollutant loading	Increased exposure to toxic substances	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel machinery in a controlled environment away from the project area. Avoid reducing hydraulic complexity.	May affect survival, growth, and fitness of juveniles and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Low-oxygen stress leading to physiological injury and/or mortality; behavioral avoidance.	Limit damage to riparian area. Replant former impoundment with native vegetation to discourage invasives and stabilize sediments. Avoid draining impounded area through use of beaver deceivers.	May affect juvenile survival and productivity as well as adult survival, productivity, and spawning success.

Table A-7 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
Large Woody Debris Placement/Movement/Removal (for placement only construction impacts apply)									
	Construction and Maintenance Activities								
	Riverine, Lacustrine, Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane (from exposure to high intensity noise such as pile driving). • Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.

Table A-7 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.

Table A-7 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered flow velocity		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition		Year round	Permanent	Continuous				
	Altered groundwater-surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				

Table A-7 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	Juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile Coastal cutthroat trout. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				

Table A-7 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine								
	Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u>: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile and migratory habitat for adult Coastal cutthroat trout. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduced cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality. Adult Coastal cutthroat will generally be less sensitive to these stressors. However, increased stress and delayed migration in the migratory corridor may reduce fitness and ultimately reduce spawning success.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival at juvenile life-history stage. Decreased fitness may lead to reduced spawning productivity.
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common				
	Altered sediment supply		Year-round	Permanent	Continuous				
	Altered substrate composition		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Riverine								
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most extensive)	Permanent	Seasonal	Eggs and alevins	<u>Eggs and alevins</u>: See related stressor responses under Water Quality Modification.	Require assessment of the hydraulic effects of the project before permitting.	See effects for related stressors under Water Quality Modification.
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>Juveniles</u>: See related stressor responses under Water Quality Modification.		May affect survival, growth, and fitness of juveniles and adults.

Table A-7 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered lateral (terrestrial/aquatic) habitat connectivity Altered longitudinal habitat connectivity	Reduced availability of off-channel refuge and rearing habitat. Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs Reduced foraging opportunities and rearing habitat availability Reduced availability of suitable habitats along longitudinal gradient.	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition, increased predation, and resulting effects on growth and fitness. Adults: Decreased survival, fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat or longitudinal reach simplification.	May affect survival, growth, and fitness at egg, alevin, and juvenile life-history stages. May affect adult survival and spawning productivity.
	Marine								
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Juveniles	All exposed life-history stages: LWD removal in the marine environment can fragment nearshore rearing habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Avoid permitting LWD removal projects in areas where significant cumulative effects are already prevalent.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered cover and habitat	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.
	Lacustrine								
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	All exposed life-history stages: LWD removal in lacustrine environments can fragment nearshore rearing habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival at juvenile life-history stage. Decreased fitness may lead to reduced spawning productivity.
	Altered cover and habitat	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.

Table A-7 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification								
	Marine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Construction: Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased foraging opportunity due to decreased food web productivity.		May affect juvenile survival. May affect adult growth and spawning productivity.
	Riverine and Lacustrine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Construction: Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.		May affect juvenile survival, growth, and fitness, as well as adult spawning productivity.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Riverine								
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults	Eggs and alevins: Decreased incubation success. Adults: Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid disturbance of vegetation along stream.	May affect survival of eggs and alevins, as well as adult spawning productivity.

Table A-7 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Marine								
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures)	Year-round, (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles	Juveniles: Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and survival.
	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	Juveniles: Coastal cutthroat dependence on allochthonous inputs from marine riparian vegetation is a data gap. However, Coastal cutthroat are known to utilize terrestrial insect resources recruited from the riparian zone. Alteration of vegetation will therefore result in decreased foraging opportunities, decreased growth and fitness, and decreased productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high quality habitat features.	May affect juvenile survival.
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	Juveniles: Coastal cutthroat dependence on groundwater inflow to nearshore marine habitats is currently a data gap.	Avoid disturbance of vegetation along shoreline.	Effects of the action resulting from this impact mechanism are unknown.

Table A-7 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round, (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles	Juveniles: Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of thermal stratification and wind driven mixing However, juveniles trapped in isolated may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival.
	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs predominantly during spring outmigration period through lakes)	Permanent	Continuous	Juveniles	Juveniles: Coastal cutthroat are known to use terrestrial insect resources recruited from the riparian zone. Alteration of vegetation will therefore result in decreased foraging opportunities, decreased growth and fitness, and decreased productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Permanent	Continuous	Juveniles	Juveniles: Coastal cutthroat dependence on groundwater inflow to nearshore lacustrine habitats is currently a data gap.	Avoid disturbance of vegetation along the shoreline.	Effects of the action resulting from this impact mechanism are unknown.

Table A-7 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to long-term (dependent on contributing mechanism of impact)	Continuous to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile survival, growth, and fitness, and adult survival and spawning productivity.
	Altered pollutant loading	Increased pollutant loading	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All life-history stages: Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival, growth, and fitness of juveniles and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen (due to eutrophication caused by elevated nutrient export from dewatered floodplains)	Dependent on contributing mechanism of impact	Temporary to short-term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Low-oxygen stress leading to physiological injury and/or mortality; behavioral avoidance.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect alevin development, juvenile survival, growth, and fitness as well as adult survival, fitness, and spawning success.

Table A-7 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
Spawning Substrate Augmentation									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u>: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane (from exposure to high intensity noise such as pile driving). • Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.

Table A-7 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
		Burial (during active sediment placement)	During project construction	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from burial during gravel placement.	Restrict in-water work window to periods when incubating eggs and alevins with limited motility are least likely to be present.	May cause direct mortality or injury at egg, alevin, and juvenile life-history stages. Injury and stress may affect survival, growth, and fitness.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids,	During project construction	Temporary to short-term	Interannual–decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Reduced refuge habitat (from potential pool filling)	Year-round	Short-term to intermediate-term	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Ensure that project has been designed properly for ecosystem context.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.

Table A-7 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered bank stability (intermediate-term effects from passive augmentation projects)	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in substrate composition and stability may lead to decreased incubation success and alevin survival while augmentation projects stabilize. Juveniles: Altered channel geometry, bank stability, and substrate composition can result in short-term to intermediate-term changes in rearing habitat suitability and changes in food web complexity while augmentation projects stabilize. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology and bank structure may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate stability may lead to decreased spawning success while augmentation projects stabilize. However, adverse effects would be expected to be short-term in nature, while beneficial effects would be expected to persist.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of augmentation projects that minimize adverse effects on channel geometry, bank conditions, and substrate stability to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered substrate composition/stability			Short-term to long-term					
	Aquatic Vegetation Modification								
	Riverine								
	Altered autochthonous production	Reduced foraging opportunities	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Avoid spawning gravel augmentation projects in locations where aquatic vegetation plays a strong role in habitat productivity.	May affect juvenile survival, growth, and fitness.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased foraging opportunity due to decreased food web productivity.		

Table A-7 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
In-Channel/Off-Channel Habitat Creation/Modification									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.

Table A-7 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane (from exposure to high intensity noise such as pile driving). • Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-7 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.

Table A-7 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids (during construction or if in-channel project fails)	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>Eggs and alevins:</u> Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. <u>Juveniles and adults</u>: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u>: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u>: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
Riparian Planting/Restoration Enhancement									
	Construction and Maintenance Activities								
	Riverine , Lacustrine, Marine								
	Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	<u>Eggs and alevins:</u> Direct mortality due to winter ice formation and scour. <u>Juveniles</u>: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. <u>Adults and juveniles</u>: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. <u>Adults</u>: Decreased spawning fitness due to migration delays caused by thermal barriers.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-7 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Increased suspended solids – due to removal of invasive riparian species Spawning gravel sedimentation – due to removal of invasive riparian species	Year-round (with specific stressors prominent during high flow conditions)	Short-term to intermediate (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Minimize disturbance during invasive species removal. Use appropriate erosion control BMPs both during and after construction.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Aquatic Vegetation Modification								
	Riverine, Lacustrine, Marine								
	Altered autochthonous production	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect juvenile growth and fitness

Table A-7 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Riverine, Lacustrine, Marine								
	Altered Shading and solar input	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect juvenile growth and fitness
	Water Quality Modification								
	Altered Temperatures	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered suspended solids	Increased suspended solids – due to removal of invasive riparian species	Dependent on contributing mechanism of impact	Short-term to intermediate (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.

Table A-7 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Wetland Creation Restoration/Enhancement									
	Construction and Maintenance Activities								
	Riverine and Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Juveniles; Adults	<u>All exposed life-history stages</u>: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane (from exposure to high intensity noise such as pile driving). • Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.

Table A-7 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

Table A-7 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids (e.g., during reconnection of fragmented floodplain wetlands, etc.)	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
Beach Nourishment/Contouring									
	Construction and Maintenance Activities								
	Marine and Lacustrine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Juveniles; Adults	All affected life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery/vessel work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.

Table A-7 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Marine and Lacustrine								
	Altered sediment supply	Localized alteration in invertebrate abundance from burial	During project construction and maintenance activities	Short-term – long-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.
	Aquatic Vegetation Modification								
	Marine and Lacustrine								
	Altered autochthonous production	Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to long-term(dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased foraging opportunity due to decreased food web productivity.	Avoid/minimize disturbance of aquatic vegetation during project construction. Avoid nourishing beaches updrift of productive, vegetated aquatic habitat.	May affect juvenile survival. May affect adult growth and spawning productivity.
	Altered cover and habitat	Reduced cover							
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	During construction and during subsequent high energy periods	Temporary to short-term (dependent on grain size of augmented sediment)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic shoreline instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term (dependent on contributing mechanism of impact)	Interannual to decadal	Juveniles; Adults	All affected life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body.	May affect survival, growth, and fitness of juveniles and adults.

Table A-7 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Reef Creation/Restoration/Enhancement									
	Construction and Maintenance Activities								
	Marine and Lacustrine								
	Equipment operation and materials placement	Elevated noise, visual and physical disturbance	During project construction activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	All life-history stages: Stressor response dependent on magnitude and duration of disturbance, and project-specific environmental conditions; may range from: • Increased predation risk and decreased foraging success due to displacement, auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid construction activities during periods when individuals may be present, particularly juveniles.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. Should exposure occur, direct mortality or injury is probable.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.

Table A-7 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles; Adults	Juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile Coastal cutthroat trout. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effects of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality. Adults: Adult Coastal cutthroat trout forage in nearshore environments during return migrations. Alteration of nearshore habitat characteristics through these sub-mechanisms may lead to decreased food web productivity and prey availability. This may lead to decreased growth and decrease spawning fitness.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase. May affect adult growth and fitness, and spawning productivity.
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				

Table A-7 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine								
	Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Juveniles; Adults	Juveniles and adults: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile and migratory habitat for adult Coastal cutthroat trout. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduced cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine migration, and direct mortality. Adult Coastal cutthroat will generally be less sensitive to these stressors. However, increased stress and delayed migration in the migratory corridor may reduce fitness and ultimately reduce spawning success.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival at juvenile life-history stage. Decreased fitness may lead to reduced spawning productivity.
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Continuous				
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal				
	Altered sediment supply		Year-round	Permanent	Continuous				
	Altered substrate composition		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Marine								
	Altered cover and habitat	Increased predation risk	Year-round	Permanent	Continuous	Juveniles	Juveniles: Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid placement of reef projects in proximity to juvenile migratory corridors, such that increased predation exposure may occur.	May affect juvenile survival, growth and fitness.
	Lacustrine								
	Altered cover and habitat	Increased predation by piscivorous fish	Year-round	Permanent	Continuous	Juveniles	Juveniles: Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid placement of reef projects in proximity to juvenile migratory corridors, such that increased predation exposure may occur.	May affect juvenile survival, growth and fitness.

Table A-7 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification								
	Marine								
	Altered cover and habitat	Decreased refuge and forage habitat	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased foraging opportunity due to decreased food web productivity.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile survival. May affect adult growth and spawning productivity.
	Lacustrine								
	Altered autochthonous production Altered cover and habitat	Reduced foraging opportunities	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles;	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile survival, growth, and fitness.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pollutant loading	Leaching of toxic substances (depending on composition of reef material)	Year-round	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Juveniles; Adults	All affected life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Use non-toxic reef material.	May affect survival, growth, and fitness of juveniles and adults.
Eel Grass and Other Aquatic Vegetation Creation/Restoration/Enhancement									
	Construction and Maintenance Activities								
	Marine								

Table A-7 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Planting activities and vessel use	Visual, physical, and noise related disturbance	During project construction	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles: Stress and behavioral avoidance by rearing juveniles and migrating adults exposed to low level noise, physical, and visual disturbance.	Adhere to system-specific in-water work windows.	May cause temporary behavioral avoidance and displacement.
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Vegetation transplantation projects are not likely to cause pulses of suspended sediment sufficient to lead to injury or mortality. Stressor response may include temporary behavioral avoidance and displacement.	Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May cause temporary behavioral avoidance and displacement.

Table A-8. HPA HCP Habitat Modification Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Beaver Dam Removal									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness. May affect survival, growth, and fitness of juveniles and adults.
		Visual, physical, and noise related disturbance	During project construction and maintenance activities	Temporary (disturbance) to short-term (displacement, auditory masking, hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Visual and physical disturbance may cause stress and displacement to other suitable habitats. Displaced fish may face increased competition, and increased predation risk. Auditory masking or temporary hearing threshold effects from elevated underwater noise may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Impoundment dewatering	Fish entrainment, stranding, displacement	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from increased flow entrainment as impoundment dewatering. Possible stranding of alevins in impoundment areas. Adults and juveniles: Mortality, injury, or stress from stranding or entrainment in dewatering flows. Juveniles: Increased competition following displacement, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration, resulting in decreased fitness and spawning success.	Manage dam removal to drain impoundment as slowly as practicable. Avoid scouring flows. Use beaver deceivers to limit hydraulic alteration.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Localized alteration in invertebrate abundance	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable. Use beaver deceivers to limit hydraulic alteration.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering.	See effects for related stressors under Water Quality Modification.

Table A-8 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term to long-term	Continuous	Juveniles; Adults	Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selections of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect juvenile survival, growth and fitness. May affect adult spawning fitness.
	Altered flow velocity		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Intermediate-term to long-term	Seasonal				
	Altered bank stability		Year round especially during high flows	Intermediate-term to long-term	Seasonal				
	Altered substrate composition (including spawning gravel sedimentation)		Year round	Intermediate-term to long-term	Continuous				
	Altered groundwater-surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Intermediate-term to long-term	Continuous				
	Ecosystem Fragmentation								
	Riverine								
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most extensive)	Permanent	Seasonal	Eggs and alevins	Eggs and alevins: See related stressor responses under Water Quality Modification.	Avoid draining impounded area through use of beaver deceivers.	See effects for related stressors under Water Quality Modification.
		Decreased dissolved oxygen from eutrophication below the impoundment (caused by elevated nutrient export)							
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: See related stressor responses under Water Quality Modification.	Avoid draining impounded area through use of beaver deceivers.	May affect survival, growth, and fitness of juveniles and adults.
	Altered terrestrial/aquatic connectivity	Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: This stressor may limit the availability of adult spawning and juvenile rearing habitat for trout species dependent on these habitat types. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of high quality floodplain habitat.	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
		Reduced foraging opportunities and rearing habitat availability							

Table A-8 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Aquatic Vegetation Modification								
	Riverine								
	Altered autochthonous production Altered cover and habitat	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased foraging opportunity due to decreased food web productivity.	Avoid draining impounded area through use of beaver deceivers.	May affect juvenile survival. May affect adult growth and spawning productivity.
	Riparian Vegetation Modification								
	Riverine								
	Altered stream bank and shoreline stability	Increased suspended solids Spawning gravel sedimentation	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Initiate proper erosion control measures both during and after construction. Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Long-term to permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	May affect juvenile rearing.
	Altered buffering capability	Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modification.
		Decreased dissolved oxygen from eutrophication (caused by elevated nutrient export)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Long-term to permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modification.
	Water Quality Modification								

Table A-8 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pollutant loading	Increased exposure to toxic substances	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel machinery in a controlled environment away from the project area. Avoid reducing hydraulic complexity.	May affect survival, growth, and fitness of juveniles and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Low-oxygen stress leading to physiological injury and/or mortality; behavioral avoidance.	Limit damage to riparian area. Replant former impoundment with native vegetation to discourage invasives and stabilize sediments. Avoid draining impounded area through use of beaver deceivers.	May affect juvenile survival and productivity as well as adult survival, productivity, and spawning success.
Large Woody Debris Placement/Movement/Removal (for placement only construction impacts apply)									
	Construction and Maintenance Activities								
	Riverine, Lacustrine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.

Table A-8 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane (from exposure to high intensity noise such as pile driving). • Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.

Table A-8 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.

Table A-8 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selections of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect juvenile survival, growth and fitness. May affect adult spawning fitness.
	Altered flow velocity		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition		Year round	Permanent	Continuous				
	Altered groundwater-surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				

Table A-8 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine								
	Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Juveniles; Adults	Adults and juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile and migratory habitat for adult native trout. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduced cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and fitness, and direct mortality. Adults: Adult native trout will generally be less sensitive to these stressors. However, increased stress and inhibited movement may reduce fitness and ultimately reduce spawning success.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns. For example:	May affect survival and productivity at juvenile life-history stage. Decreased fitness may lead to reduced spawning productivity.
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common				
	Altered sediment supply		Year-round	Permanent	Continuous				
	Altered substrate composition		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Riverine								
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most extensive)	Permanent	Seasonal	Eggs and alevins	Eggs and alevins: See related stressor responses under Water Quality Modification.	Require assessment of the hydraulic effects of the project before permitting	See effects for related stressors under Water Quality Modification.
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	Juveniles: See related stressor responses under Water Quality Modification.		May affect survival, growth, and fitness of juveniles and adults.

Table A-8 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered lateral (terrestrial/aquatic) habitat connectivity; Altered longitudinal habitat connectivity	Reduced availability of off-channel refuge and rearing habitat. Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs. Reduced foraging opportunities and rearing habitat availability. Reduced availability of suitable habitats along longitudinal gradient.	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition, increased predation, and resulting effects on growth and fitness. Adults: Decreased survival, fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat or longitudinal reach simplification.	May affect survival, growth, and fitness at egg, alevin, and juvenile life-history stages. May affect adult survival and spawning productivity.
	Lacustrine								
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	All exposed life-history stages: LWD removal in lacustrine environments can fragment nearshore rearing habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival at juvenile life-history stage. Decreased fitness may lead to reduced spawning productivity.
	Altered cover and habitat	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.
	Aquatic Vegetation Modification								
	Riverine and Lacustrine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Construction: Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.

Table A-8 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.		May affect juvenile survival, growth, and fitness, as well as adult spawning productivity.
	Riparian Vegetation Modification								
	Riverine								
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-8 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults	Eggs and alevins: Decreased incubation success. Adults: Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid disturbance of vegetation along stream.	May affect survival of eggs and alevins, as well as adult spawning productivity.
	Lacustrine								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round, (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles	Juveniles: Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of thermal stratification and wind driven mixing However, juveniles trapped in isolated may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival.
	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs predominantly during spring outmigration period through lakes)	Permanent	Continuous	Juveniles	Juveniles: Native trout dependence on allochthonous inputs from riparian vegetation is a data gap. However, native trout are known to use terrestrial insect resources recruited from the riparian zone. Alteration of vegetation will therefore result in decreased foraging opportunities, decreased growth and fitness, and decreased productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth, fitness, and productivity.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.

Table A-8 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Permanent	Continuous	Juveniles	Juveniles: Native trout dependence on groundwater inflow to nearshore habitats is currently a data gap.	Avoid disturbance of vegetation along stream.	Effects of the action resulting from this impact mechanism are unknown.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to long-term (dependent on contributing mechanism of impact)	Continuous to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile survival, growth, and fitness, and adult survival and spawning productivity.
	Altered pollutant loading	Increased pollutant loading	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All life-history stages: Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival, growth, and fitness of juveniles and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen (due to eutrophication caused by elevated nutrient export from dewatered floodplains)	Dependent on contributing mechanism of impact	Temporary to short-term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Low-oxygen stress leading to physiological injury and/or mortality; behavioral avoidance.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect alevin development, juvenile survival, growth, and fitness as well as adult survival, fitness, and spawning success.

Table A-8 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Spawning Substrate Augmentation									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane (from exposure to high intensity noise such as pile driving). • Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.

Table A-8 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
		Burial (during active sediment placement)	During project construction	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from burial during gravel placement.	Restrict in-water work window to periods when incubating eggs and alevins with limited motility are least likely to be present.	May cause direct mortality or injury at egg, alevin, and juvenile life-history stages. Injury and stress may affect survival, growth, and fitness.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids,	During project construction	Temporary to short-term	Interannual–decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Reduced refuge habitat (from potential pool filling)	Year-round	Short-term to intermediate-term	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Ensure that project has been designed properly for ecosystem context.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.

Table A-8 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered bank stability (intermediate-term effects from passive augmentation projects)	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in substrate composition and stability may lead to decreased incubation success and alevin survival while augmentation projects stabilize. Juveniles: Altered channel geometry, bank stability, and substrate composition can result in short-term to intermediate-term changes in rearing habitat suitability and changes in food web complexity while augmentation projects stabilize. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology and bank structure may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate stability may lead to decreased spawning success while augmentation projects stabilize. However, adverse effects would be expected to be short-term in nature, while beneficial effects would be expected to persist.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of augmentation projects that minimize adverse effects on channel geometry, bank conditions, and substrate stability to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered substrate composition/stability			Short-term to long-term					
	Aquatic Vegetation Modification								
	Riverine								
	Altered autochthonous production	Reduced foraging opportunities	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Avoid spawning gravel augmentation projects in locations where aquatic vegetation plays a strong role in habitat productivity.	May affect juvenile survival, growth, and fitness.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased foraging opportunity due to decreased food web productivity.		

Table A-8 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
In-Channel/Off-Channel Habitat Creation/Modification									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.

Table A-8 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane (from exposure to high intensity noise such as pile driving). • Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.

Table A-8 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids (during construction or if in-channel project fails)	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>Eggs and alevins:</u> Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. <u>Juveniles and adults</u>: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u>: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u>: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
Riparian Planting/Restoration Enhancement									
	Construction and Maintenance Activities								
	Riverine , Lacustrine								
	Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	<u>Eggs and alevins:</u> Direct mortality due to winter ice formation and scour. <u>Juveniles</u>: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. <u>Adults and juveniles</u>: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. <u>Adults</u>: Decreased spawning fitness due to migration delays caused by thermal barriers.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Increased suspended solids – due to removal of invasive riparian species Spawning gravel sedimentation – due to removal of invasive riparian species	Year-round (with specific stressors prominent during high flow conditions)	Short-term to intermediate (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Minimize disturbance during invasive species removal. Use appropriate erosion control BMPs both during and after construction.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Aquatic Vegetation Modification								
	Riverine, Lacustrine								
	Altered autochthonous production	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect juvenile growth and fitness

Table A-8 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Riparian Vegetation Modification								
	Riverine, Lacustrine								
	Altered Shading and solar input	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect juvenile growth and fitness
	Water Quality Modification								
	Altered Temperatures	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered suspended solids	Increased suspended solids – due to removal of invasive riparian species	Dependent on contributing mechanism of impact	Short-term to intermediate (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.

Table A-8 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
Wetland Creation Restoration/Enhancement									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Juveniles; Adults	All exposed life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane (from exposure to high intensity noise such as pile driving). • Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.

Table A-8 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

Table A-8 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids (e.g., during reconnection of fragmented floodplain wetlands, etc.)	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
Beach Nourishment/Contouring									
	Construction and Maintenance Activities								
	Lacustrine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Juveniles; Adults	All affected life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery/vessel work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended sediment	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.

Table A-8 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Lacustrine								
	Altered sediment supply	Localized alteration in invertebrate abundance from burial	During project construction and maintenance activities	Short-term – long-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.
	Aquatic Vegetation Modification								
	Lacustrine								
	Altered autochthonous production	Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to long-term(dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased foraging opportunity due to decreased food web productivity.	Avoid/minimize disturbance of aquatic vegetation during project construction. Avoid nourishing beaches updrift of productive, vegetated aquatic habitat.	May affect juvenile survival. May affect adult growth and spawning productivity.
	Altered cover and habitat	Reduced cover							
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	During construction and during subsequent high energy periods	Temporary to short-term (dependent on grain size of augmented sediment)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic shoreline instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term (dependent on contributing mechanism of impact)	Interannual to decadal	Juveniles; Adults	All affected life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body.	May affect survival, growth, and fitness of juveniles and adults.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Reef Creation/Restoration/Enhancement									
	Construction and Maintenance Activities								
	Lacustrine								
	Equipment operation and materials placement	Elevated noise, visual and physical disturbance	During project construction activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	All life-history stages: Stressor response dependent on magnitude and duration of disturbance, and project-specific environmental conditions; may range from: • Increased predation risk and decreased foraging success due to displacement, auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid construction activities during periods when individuals may be present, particularly juveniles.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. Should exposure occur, direct mortality or injury is probable.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended sediment	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.

Table A-8 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Lacustrine								
	Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Juveniles; Adults	Adults and juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile and migratory habitat for adult native trout. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduced cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and fitness, and direct mortality. Adults: Adult native trout will generally be less sensitive to these stressors. However, increased stress and inhibited movement may reduce fitness and ultimately reduce spawning success.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns. For example:	May affect survival and productivity at juvenile life-history stage. Decreased fitness may lead to reduced spawning productivity.
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Continuous				
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal				
	Altered sediment supply		Year-round	Permanent	Continuous				
	Altered substrate composition		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Lacustrine								
	Altered cover and habitat	Increased predation by piscivorous fish	Year-round	Permanent	Continuous	Juveniles	Juveniles: Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid placement of reef projects in proximity to juvenile migratory corridors, such that increased predation exposure may occur.	May affect juvenile survival, growth and fitness.
	Aquatic Vegetation Modification								
	Lacustrine								
	Altered autochthonous production	Reduced foraging opportunities	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles;	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile survival, growth, and fitness.
	Altered cover and habitat								
	Water Quality Modification								

Table A-8 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Native Trout (Westslope Cutthroat and Redband Trout).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pollutant loading	Leaching of toxic substances (depending on composition of reef material)	Year-round	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Juveniles; Adults	All affected life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Use non-toxic reef material.	May affect survival, growth, and fitness of juveniles and adults.
Eel Grass and Other Aquatic Vegetation Creation/Restoration/Enhancement									
	Not applicable								

Table A-9. HPA HCP Habitat Modification Exposure and Response Matrix for Bull Trout and Dolly Varden (Native Char).

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
Beaver Dam Removal									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness. May affect survival, growth, and fitness of juveniles and adults.
		Visual, physical, and noise related disturbance	During project construction and maintenance activities	Temporary (disturbance) to short-term (displacement, auditory masking, hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Visual and physical disturbance may cause stress and displacement to other suitable habitats. Displaced fish may face increased competition, and increased predation risk. Auditory masking or temporary hearing threshold effects from elevated underwater noise may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Impoundment dewatering	Fish entrainment, stranding, displacement	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from increased flow entrainment as impoundment dewatering. Possible stranding of alevins in impoundment areas. Adults and juveniles: Mortality, injury, or stress from stranding or entrainment in dewatering flows. Juveniles: Increased competition following displacement, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration, resulting in decreased fitness and spawning success.	Manage dam removal to drain impoundment as slowly as practicable. Avoid scouring flows. Use beaver deceivers to limit hydraulic alteration.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Localized alteration in invertebrate abundance	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable. Use beaver deceivers to limit hydraulic alteration.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering.	See effects for related stressors under Water Quality Modification.

Table A-9 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Bull Trout and Dolly Varden (Native Char)**.**

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term to long-term	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Potential habitat avoidance and/or decreased survival due to suspended sediment loads induced by bank instability as described for related stressor responses under Water Quality Modification. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate ecological context and consider the magnitude of impact mechanisms produced by the project. Prevent rapid dewatering of impoundments likely to cause scouring flows. Encourage use of beaver deceivers.	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered flow velocity		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Intermediate-term to long-term	Seasonal				
	Altered bank stability		Year round especially during high flows	Intermediate-term to long-term	Seasonal				
	Altered substrate composition (including spawning gravel sedimentation)		Year round	Intermediate-term to long-term	Continuous				
	Altered groundwater-surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Intermediate-term to long-term	Continuous				
	Ecosystem Fragmentation								
	Riverine								
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most extensive)	Permanent	Seasonal	Eggs and alevins	Eggs and alevins: See related stressor responses under Water Quality Modification.	Avoid draining impounded area through use of beaver deceivers.	See effects for related stressors under Water Quality Modification.
		Decreased dissolved oxygen from eutrophication below the impoundment (caused by elevated nutrient export)							
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: See related stressor responses under Water Quality Modification.	Avoid draining impounded area through use of beaver deceivers.	May affect survival, growth, and fitness of juveniles and adults.

Table A-9 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Bull Trout and Dolly Varden (Native Char)**.**

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered terrestrial/aquatic connectivity	Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs Reduced foraging opportunities and rearing habitat availability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of high quality floodplain habitat.	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Aquatic Vegetation Modification								
	Riverine								
	Altered autochthonous production Altered cover and habitat	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased foraging opportunity due to decreased food web productivity.	Avoid draining impounded area through use of beaver deceivers.	May affect juvenile survival. May affect adult growth and spawning productivity.
	Riparian Vegetation Modification								
	Riverine								
	Altered stream bank and shoreline stability	Increased suspended solids Spawning gravel sedimentation	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Initiate proper erosion control measures both during and after construction. Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Long-term to permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	May affect juvenile rearing.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered buffering capability	Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modification.
		Decreased dissolved oxygen from eutrophication (caused by elevated nutrient export)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Long-term to permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modification.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pollutant loading	Increased exposure to toxic substances	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel machinery in a controlled environment away from the project area. Avoid reducing hydraulic complexity.	May affect survival, growth, and fitness of juveniles and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Low-oxygen stress leading to physiological injury and/or mortality; behavioral avoidance.	Limit damage to riparian area. Replant former impoundment with native vegetation to discourage invasives and stabilize sediments. Avoid draining impounded area through use of beaver deceivers.	May affect juvenile survival and productivity as well as adult survival, productivity, and spawning success.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Large Woody Debris Placement/Movement/Removal (for placement only construction impacts apply)									
	Construction and Maintenance Activities								
	Riverine, Lacustrine, Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u>: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane (from exposure to high intensity noise such as pile driving). • Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.

Table A-9 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Bull Trout and Dolly Varden (Native Char)**.**

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	<u>Eggs/alevins:</u> Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. <u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. <u>Adults:</u> Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>Eggs and alevins</u>: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. <u>Adults and juveniles</u>: Mortality, injury, or stress from capture, handling, and relocation. <u>Juveniles</u>: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. <u>Adults</u>: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	<u>Eggs and alevins, juveniles</u>: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>Eggs and alevins</u>: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. <u>Juveniles</u>: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. <u>Adults</u>: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.

Table A-9 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Bull Trout and Dolly Varden (Native Char)**.**

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered flow velocity		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition		Year round	Permanent	Continuous				
	Altered groundwater-surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				

Table A-9 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Bull Trout and Dolly Varden (Native Char)**.**

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles; Adults	Juveniles and adults: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of foraging habitats for adult char. This may occur through a number of specific stressors, including change in current and wave energy patterns, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and fitness, and potentially decreased survival due to predation exposure.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selections of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect juvenile and adult survival and growth.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				
	Lacustrine								
	Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Juveniles: Adults	Juveniles and adults: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats. Use of these habitats by adult char is limited, as these species tend to utilize cold, deepwater habitats in the photic and profundal zone. However, reduction in nearshore habitat productivity may affect abundance of potential prey species, reducing adult foraging opportunity and leading to decreased growth and fitness.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect juveniles and adult growth and fitness.
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common				
	Altered sediment supply		Year-round	Permanent	Continuous				
	Altered substrate composition		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Riverine								

Table A-9 (continued). **HPA HCP Habitat Modification Exposure and Response Matrix for** Bull Trout and Dolly Varden (Native Char)**.**

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most extensive)	Permanent	Seasonal	Eggs and alevins	Eggs and alevins: See related stressor responses under Water Quality Modification.	Require assessment of the hydraulic effects of the project before permitting.	See effects for related stressors under Water Quality Modification.
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and alevins; Juveniles; Adults	Juveniles: See related stressor responses under Water Quality Modification.		May affect survival, growth, and fitness of juveniles and adults.
	Altered lateral (terrestrial/aquatic) habitat connectivity	Reduced availability of off-channel refuge and rearing habitat. Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: This stressor may limit the availability of adult spawning and juvenile rearing habitat for salmonid species dependent on these habitat types. Decreased habitat availability may lead to density-dependent effects on adult spawning success, as well as juvenile survival, growth, and fitness. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition, increased predation, and resulting effects on growth and fitness. Adults: Decreased survival, fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat or longitudinal reach simplification.	May affect survival, growth, and fitness at egg, alevin, and juvenile life-history stages. May affect adult survival and spawning productivity.
	Altered longitudinal habitat connectivity	Reduced availability of suitable habitats along longitudinal gradient.							
	Marine								
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Juveniles	All exposed life-history stages: LWD removal in the marine environment can fragment nearshore rearing habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Avoid permitting LWD removal projects in areas where significant cumulative effects are already prevalent.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered cover and habitat	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.
	Lacustrine								

Table A-9 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Bull Trout and Dolly Varden (Native Char)**.**

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	All exposed life-history stages: LWD removal in lacustrine environments can fragment nearshore rearing habitat, forcing migrating and foraging salmonids to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival at juvenile life-history stage. Decreased fitness may lead to reduced spawning productivity.
	Altered cover and habitat	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.
	Aquatic Vegetation Modification								
	Marine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Construction: Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased foraging opportunity due to decreased food web productivity.		May affect juvenile survival. May affect adult growth and spawning productivity.
	Riverine and Lacustrine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	Adults and juveniles: Char dependence on littoral lacustrine vegetation is relatively limited as this species tends to occupy cold water river habitats and deepwater lacustrine habitats in the photic or profundal zone where aquatic vegetation is limited or non-existent. Therefore, modification of aquatic vegetation may have limited direct effects on this species. However, such alterations may limit the productivity of prey species for native char, leading to decreased foraging opportunity and decreased growth and fitness.	Design: Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. Construction: Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect growth and fitness of juveniles and adults. Reduced adult fitness may lead to decreased spawning success.

Table A-9 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Bull Trout and Dolly Varden (Native Char)**.**

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.		May affect juvenile survival, growth, and fitness, as well as adult spawning productivity.
	Riparian Vegetation Modification								
	Riverine								
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-9 (continued). **HPA HCP Habitat Modification Exposure and Response Matrix for** Bull Trout and Dolly Varden (Native Char)**.**

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults	Eggs and alevins: Decreased incubation success. Adults: Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid disturbance of vegetation along stream.	May affect survival of eggs and alevins, as well as adult spawning productivity.
	Marine								
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures)	Year-round, (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles; Adults	Adults and juveniles: Riparian shade and ambient temperature have a relatively minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, adult char trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence have been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system appropriate riparian buffer widths to the greatest extent possible.	May affect growth and fitness of juveniles and adults. Reduced adult fitness may lead to decreased spawning success.
	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles; Adults	Adults and juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect growth and fitness of juveniles and adults. Reduced adult fitness may lead to decreased spawning success.

Table A-9 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Bull Trout and Dolly Varden (Native Char)**.**

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Adults and juveniles: Char dependence on allochthonous inputs from marine riparian vegetation is a data gap. However, the dependence on terrestrial insect fall as a food source may be limited as adult char are primarily piscivorous. Indirect effects on food web productivity may decrease foraging opportunities, leading to decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect growth and fitness of juveniles and adults. Reduced adult fitness may lead to decreased spawning success.
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles; Adults	Juveniles: Char dependence on groundwater inflow to nearshore marine habitats is currently a data gap.	Avoid disturbance of vegetation along shoreline.	Effects of the action resulting from this impact mechanism are unknown.
	Lacustrine								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round, (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles	Juveniles: Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of thermal stratification and wind driven mixing However, juveniles trapped in isolated may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival.
	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs predominantly during spring outmigration period through lakes)	Permanent	Continuous	Juveniles	Reduced foraging opportunities due to decreased food web productivity, decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness of juveniles.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Permanent	Continuous	Juveniles	Juveniles: Char dependence on groundwater inflow to nearshore lacustrine habitats is currently a data gap.	Avoid disturbance of vegetation along the shoreline.	Effects of the action resulting from this impact mechanism are unknown.

Table A-9 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Bull Trout and Dolly Varden (Native Char)**.**

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to long-term (dependent on contributing mechanism of impact)	Continuous to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile survival, growth, and fitness, and adult survival and spawning productivity.
	Altered pollutant loading	Increased pollutant loading	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All life-history stages: Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival, growth, and fitness of juveniles and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen (due to eutrophication caused by elevated nutrient export from dewatered floodplains)	Dependent on contributing mechanism of impact	Temporary to short-term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Low-oxygen stress leading to physiological injury and/or mortality; behavioral avoidance.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect alevin development, juvenile survival, growth, and fitness as well as adult survival, fitness, and spawning success.

Table A-9 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Bull Trout and Dolly Varden (Native Char)**.**

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Spawning Substrate Augmentation									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u>: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	<u>All life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane (from exposure to high intensity noise such as pile driving). • Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.

Table A-9 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Bull Trout and Dolly Varden (Native Char)**.**

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
		Burial (during active sediment placement)	During project construction	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from burial during gravel placement.	Restrict in-water work window to periods when incubating eggs and alevins with limited motility are least likely to be present.	May cause direct mortality or injury at egg, alevin, and juvenile life-history stages. Injury and stress may affect survival, growth, and fitness.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids,	During project construction	Temporary to short-term	Interannual–decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Reduced refuge habitat (from potential pool filling)	Year-round	Short-term to intermediate-term	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Ensure that project has been designed properly for ecosystem context.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.

Table A-9 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Bull Trout and Dolly Varden (Native Char)**.**

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered bank stability (intermediate-term effects from passive augmentation projects)	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in substrate composition and stability may lead to decreased incubation success and alevin survival while augmentation projects stabilize. Juveniles: Altered channel geometry, bank stability, and substrate composition can result in short-term to intermediate-term changes in rearing habitat suitability and changes in food web complexity while augmentation projects stabilize. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology and bank structure may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate stability may lead to decreased spawning success while augmentation projects stabilize. However, adverse effects would be expected to be short-term in nature, while beneficial effects would be expected to persist.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of augmentation projects that minimize adverse effects on channel geometry, bank conditions, and substrate stability to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered substrate composition/stability			Short-term to long-term					
	Aquatic Vegetation Modification								
	Riverine								
	Altered autochthonous production	Reduced foraging opportunities	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Avoid spawning gravel augmentation projects in locations where aquatic vegetation plays a strong role in habitat productivity.	May affect juvenile survival, growth, and fitness.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased foraging opportunity due to decreased food web productivity.		

Table A-9 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Bull Trout and Dolly Varden (Native Char)**.**

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
In-Channel/Off-Channel Habitat Creation/Modification									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.

Table A-9 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Bull Trout and Dolly Varden (Native Char)**.**

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane (from exposure to high intensity noise such as pile driving). • Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-9 (continued). **HPA HCP Habitat Modification Exposure and Response Matrix for** Bull Trout and Dolly Varden (Native Char)**.**

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.

Table A-9 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Bull Trout and Dolly Varden (Native Char)**.**

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids (during construction or if in-channel project fails)	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
Riparian Planting/Restoration Enhancement									
	Construction and Maintenance Activities								
	Riverine , Lacustrine, Marine								
	Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-9 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Bull Trout and Dolly Varden (Native Char)**.**

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Increased suspended solids – due to removal of invasive riparian species Spawning gravel sedimentation – due to removal of invasive riparian species	Year-round (with specific stressors prominent during high flow conditions)	Short-term to intermediate (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Minimize disturbance during invasive species removal. Use appropriate erosion control BMPs both during and after construction.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Aquatic Vegetation Modification								
	Riverine, Lacustrine, Marine								
	Altered autochthonous production	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness. Char dependence on littoral lacustrine vegetation is relatively limited as this species tends to occupy cold water river habitats and deepwater lacustrine habitats in the photic or profundal zone where aquatic vegetation is limited or non-existent. Therefore, modification of aquatic vegetation may have limited direct effects on this species in lacustrine environments.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect juvenile growth and fitness

Table A-9 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Bull Trout and Dolly Varden (Native Char)**.**

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Riverine, Lacustrine, Marine								
	Altered Shading and solar input	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect juvenile growth and fitness
	Water Quality Modification								
	Altered Temperatures	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered suspended solids	Increased suspended solids – due to removal of invasive riparian species	Dependent on contributing mechanism of impact	Short-term to intermediate (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.

Table A-9 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Bull Trout and Dolly Varden (Native Char)**.**

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
Wetland Creation Restoration/Enhancement									
	Construction and Maintenance Activities								
	Riverine and Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Juveniles; Adults	All exposed life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane (from exposure to high intensity noise such as pile driving). • Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.

Table A-9 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Bull Trout and Dolly Varden (Native Char)**.**

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	Eggs/alevins: Decreased incubation success due to decreased redd dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

Table A-9 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Bull Trout and Dolly Varden (Native Char)**.**

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids (e.g., during reconnection of fragmented floodplain wetlands, etc.)	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs and alevins; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
Beach Nourishment/Contouring									
	Construction and Maintenance Activities								
	Marine and Lacustrine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Juveniles; Adults	All affected life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery/vessel work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended sediment	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.

Table A-9 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Bull Trout and Dolly Varden (Native Char)**.**

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Marine and Lacustrine								
	Altered sediment supply	Localized alteration in invertebrate abundance from burial	During project construction and maintenance activities	Short-term – long-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.
	Aquatic Vegetation Modification								
	Marine								
	Altered autochthonous production	Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to long-term(dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased foraging opportunity due to decreased food web productivity.	Avoid/minimize disturbance of aquatic vegetation during project construction. Avoid nourishing beaches updrift of productive, vegetated aquatic habitat.	May affect juvenile survival. May affect adult growth and spawning productivity.
	Altered cover and habitat	Reduced cover							
	Lacustrine								
	Altered autochthonous production	Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to long-term(dependent on nature of activity)	Continuous	Juveniles; Adults	Adults and juveniles: Char dependence on littoral lacustrine vegetation is relatively limited as this species tends to occupy cold water river habitats and deepwater lacustrine habitats in the photic or profundal zone where aquatic vegetation is limited or non-existent. Therefore, modification of aquatic vegetation may have limited direct effects on this species. However, such alterations may limit the productivity of prey species for native char, leading to decreased foraging opportunity and decreased growth and fitness.	Design: Limit project structural footprint to minimize shading of aquatic vegetation to the greatest extent practicable. Construction: Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect growth and fitness of juveniles and adults. Reduced adult fitness may lead to decreased spawning success.
	Altered cover and habitat	Reduced cover							
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	During construction and during subsequent high energy periods	Temporary to short-term (dependent on grain size of augmented sediment)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic shoreline instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.

Table A-9 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Bull Trout and Dolly Varden (Native Char)**.**

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	**When**	**Duration**	**Frequency**	**Life-history Form**			
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term (dependent on contributing mechanism of impact)	Interannual to decadal	Juveniles; Adults	All affected life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body.	May affect survival, growth, and fitness of juveniles and adults.
Reef Creation/Restoration/Enhancement									
	Construction and Maintenance Activities								
	Marine and Lacustrine								
	Equipment operation and materials placement	Elevated noise, visual and physical disturbance	During project construction activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	All life-history stages: Stressor response dependent on magnitude and duration of disturbance, and project-specific environmental conditions; may range from: • Increased predation risk and decreased foraging success due to displacement, auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid construction activities during periods when individuals may be present, particularly juveniles.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. Should exposure occur, direct mortality or injury is probable.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended sediment	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles; Adults	Juveniles and adults: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of foraging habitats for adult char. This may occur through a number of specific stressors, including change in current and wave energy patterns, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and fitness, and potentially decreased survival due to predation exposure.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selections of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect juvenile and adult survival and growth.
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				

Table A-9 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Bull Trout and Dolly Varden (Native Char)**.**

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine								
	Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Juveniles; Adults	Juveniles and adults: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats. Use of these habitats by adult char is limited, as these species tend to utilize cold, deepwater habitats in the photic and profundal zone. However, reduction in nearshore habitat productivity may affect abundance of potential prey species, reducing adult foraging opportunity and leading to decreased growth and fitness.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect juveniles and adult growth and fitness.
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Continuous				
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal				
	Altered sediment supply		Year-round	Permanent	Continuous				
	Altered substrate composition		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Marine								
	Altered cover and habitat	Increased predation risk	Year-round	Permanent	Continuous	Juveniles	Juveniles: Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid placement of reef projects in proximity to juvenile migratory corridors, such that increased predation exposure may occur.	May affect juvenile survival, growth and fitness.
	Lacustrine								
	Altered cover and habitat	Increased predation by piscivorous fish	Year-round	Permanent	Continuous	Juveniles	Juveniles: Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid placement of reef projects in proximity to juvenile migratory corridors, such that increased predation exposure may occur.	May affect juvenile survival, growth and fitness.
	Aquatic Vegetation Modification								
	Marine								
	Altered cover and habitat	Decreased refuge and forage habitat	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased foraging opportunity due to decreased food web productivity.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile survival. May affect adult growth and spawning productivity.
	Lacustrine								
	Altered autochthonous production	Reduced foraging opportunities	Year-round	Short-term to permanent	Continuous	Juveniles;	Adults and juveniles: Char dependence on littoral lacustrine vegetation is relatively	Design: Limit project structural footprint to minimize shading of	May affect growth and fitness of juveniles and adults. Reduced adult

Table A-9 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Bull Trout and Dolly Varden (Native Char)**.**

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered cover and habitat			(dependent on nature of activity)		Adults	limited as this species tends to occupy cold water river habitats and deepwater lacustrine habitats in the photic or profundal zone where aquatic vegetation is limited or non-existent. Therefore, modification of aquatic vegetation may have limited direct effects on this species. However, such alterations may limit the productivity of prey species for native char, leading to decreased foraging opportunity and decreased growth and fitness.	aquatic vegetation to the greatest extent practicable. Construction: Avoid/minimize disturbance of aquatic vegetation during project construction.	fitness may lead to decreased spawning success.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pollutant loading	Leaching of toxic substances (depending on composition of reef material)	Year-round	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Juveniles; Adults	All affected life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Use non-toxic reef material.	May affect survival, growth, and fitness of juveniles and adults.
Eel Grass and Other Aquatic Vegetation Creation/Restoration/Enhancement									
	Construction and Maintenance Activities								
	Marine								
	Planting activities and vessel use	Visual, physical, and noise related disturbance	During project construction	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles: Stress and behavioral avoidance by rearing juveniles and migrating adults exposed to low level noise, physical, and visual disturbance.	Adhere to system-specific in-water work windows.	May cause temporary behavioral avoidance and displacement.

Table A-9 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Bull Trout and Dolly Varden (Native Char)**.**

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Vegetation transplantation projects are not likely to cause pulses of suspended sediment sufficient to lead to injury or mortality. Stressor response may include temporary behavioral avoidance and displacement.	Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May cause temporary behavioral avoidance and displacement.

Table A-10. HPA HCP Habitat Modification Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Beaver Dam Removal									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness. May affect survival, growth, and fitness of juveniles and adults.
		Visual, physical, and noise related disturbance	During project construction and maintenance activities	Temporary (disturbance) to short-term (displacement, auditory masking, hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Visual and physical disturbance may cause stress and displacement to other suitable habitats. Displaced fish may face increased competition, and increased predation risk. Auditory masking or temporary hearing threshold effects from elevated underwater noise may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Impoundment dewatering	Fish entrainment, stranding, displacement	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Mortality, injury, or stress from increased flow entrainment as impoundment dewatering. Possible stranding of larvae in impoundment areas. Adults and juveniles: Mortality, injury, or stress from stranding or entrainment in dewatering flows. Juveniles: Increased competition following displacement, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration, resulting in decreased fitness and spawning success.	Manage dam removal to drain impoundment as slowly as practicable. Avoid scouring flows. Use beaver deceivers to limit hydraulic alteration.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Localized alteration in invertebrate abundance	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable. Use beaver deceivers to limit hydraulic alteration.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering.	See effects for related stressors under Water Quality Modification.

Table A-10 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term to long-term	Continuous	Eggs-larvae Juveniles Adults	Eggs-larvae: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased egg incubation success and survival. Pygmy whitefish dependence on groundwater inflow for incubation success is currently a data gap. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of spawning areas) if potential spawning habitat is affected	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival and productivity at egg, larvae, and juvenile life-history stages. May affect spawning productivity.
	Altered flow velocity		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Intermediate-term to long-term	Seasonal				
	Altered bank stability		Year round especially during high flows	Intermediate-term to long-term	Seasonal				
	Altered substrate composition (including spawning gravel sedimentation)		Year round	Intermediate-term to long-term	Continuous				
	Altered groundwater-surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Intermediate-term to long-term	Continuous				
	Ecosystem Fragmentation								
	Riverine								
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most extensive)	Permanent	Seasonal	Eggs and larvae	Eggs and larvae: See related stressor responses under Water Quality Modification.	Avoid draining impounded area through use of beaver deceivers.	See effects for related stressors under Water Quality Modification.
		Decreased dissolved oxygen from eutrophication below the impoundment (caused by elevated nutrient export)							
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: See related stressor responses under Water Quality Modification.	Avoid draining impounded area through use of beaver deceivers.	May affect survival, growth, and fitness of juveniles and adults.

Table A-10 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered terrestrial/aquatic connectivity	Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs Reduced foraging opportunities and rearing habitat availability	Year-round	Permanent	Continuous	Larvae; Adults	Larvae and adults: Beaver dam removal can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor is unlikely to significantly affect pygmy whitefish, which spawn in the mainstems of small, swift rivers and the larvae are transported to oligotrophic lakes for rearing to adulthood.	Require assessment of the hydraulic effects of the project before permitting and avoid permitting designs that lead to disconnection of floodplain habitat.	Stressor may affect larval and adult pygmy whitefish, but is unlikely to adversely affect these species.
	Aquatic Vegetation Modification								
	Riverine								
	Altered autochthonous production Altered cover and habitat	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Avoid draining impounded area through use of beaver deceivers.	May affect juvenile survival and adult spawning productivity
	Riparian Vegetation Modification								
	Riverine								
	Altered stream bank and shoreline stability	Increased suspended solids Spawning gravel sedimentation	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	Eggs-larvae: Decreased incubation success due to decreased dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival during incubation, rearing, and spawning.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Long-term to permanent	Continuous				

Table A-10 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered buffering capability	Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modification.
		Decreased dissolved oxygen from eutrophication (caused by elevated nutrient export)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Long-term to permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modification.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pollutant loading	Increased exposure to toxic substances	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel machinery in a controlled environment away from the project area. Avoid reducing hydraulic complexity.	May affect survival, growth, and fitness of juveniles and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: Low-oxygen stress leading to physiological injury and/or mortality; behavioral avoidance.	Limit damage to riparian area. Replant former impoundment with native vegetation to discourage invasives and stabilize sediments. Avoid draining impounded area through use of beaver deceivers.	May affect juvenile survival and productivity as well as adult survival, productivity, and spawning success.

Table A-10 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Large Woody Debris Placement/Movement/Removal (for placement only construction impacts apply)									
	Construction and Maintenance Activities								
	Riverine, Lacustrine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and larvae; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane (from exposure to high intensity noise such as pile driving). • Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.

Table A-10 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	Eggs/larvae: Decreased incubation success due to decreased dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles	Eggs and larvae, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Potential decreased egg incubation success and larvae survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs-larvae Juveniles Adults	Eggs-larvae: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased egg incubation success and survival. Pygmy whitefish dependence on groundwater inflow for incubation success is currently a data gap. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of spawning areas) if potential spawning habitat is affected	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival and productivity at egg, larvae, and juvenile life-history stages. May affect spawning productivity.
	Altered flow velocity		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition		Year round	Permanent	Continuous				
	Altered groundwater-surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine								
	Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Juveniles; Adults	Juveniles and adults: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile and adult whitefish. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduced cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth, fitness, and productivity, as well as direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival and productivity at juvenile life-history stage. Decreased adult fitness may lead to reduced spawning productivity.
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common				
	Altered sediment supply		Year-round	Permanent	Continuous				
	Altered substrate composition		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Riverine								
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most extensive)	Permanent	Seasonal	Eggs and larvae	Eggs and larvae: See related stressor responses under Water Quality Modification.	Require assessment of the hydraulic effects of the project before permitting	See effects for related stressors under Water Quality Modification.
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and larvae; Juveniles; Adults	Juveniles: See related stressor responses under Water Quality Modification.		May affect survival, growth, and fitness of juveniles and adults.
	Altered lateral (terrestrial/aquatic) habitat connectivity	Reduced availability of off-channel refuge and rearing habitat. Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Larvae; Adults	Larvae and adults: LWD removal can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor is unlikely to significantly affect pygmy whitefish, which spawn in the mainstems of small, swift rivers and the larvae are transported to oligotrophic lakes for rearing to adulthood.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat or longitudinal reach simplification.	Stressor may affect larval and adult pygmy whitefish, but is unlikely to adversely affect these species.
	Altered longitudinal habitat connectivity	Reduced availability of suitable habitats along longitudinal gradient.							
	Lacustrine								

Table A-10 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	Juveniles: LWD removal can fragment nearshore lacustrine habitats. Larval and juvenile pygmy whitefish are known to occur in these habitat types, but knowledge of dependence on these habitats is limited. Given prevalence in these habitat types, however, stressor exposure may affect juvenile survival, growth, and fitness if habitat access is impaired.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect juvenile survival, growth, and fitness.
	Altered cover and habitat	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.
	Aquatic Vegetation Modification								
	Riverine and Lacustrine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Construction: Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.		May affect juvenile survival, growth, and fitness, as well as adult spawning productivity.

Table A-10 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Riverine								
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs-larvae; Juveniles; Adults	Eggs-larvae: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and productivity caused by temperatures outside optimal growth range, and alteration of food web patterns (optimal range 50°F or less). Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect larval, juvenile, and adult growth and fitness.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	Eggs-larvae: Decreased incubation success due to decreased dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival during incubation, rearing, and spawning.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Larvae; Juveniles; Adults	Larvae and juveniles: Decreased foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased pool availability and availability of suitable spawning habitat.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect larval and juvenile survival, growth, and productivity. May affect adult spawning productivity.

Table A-10 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and larvae; Adults	Eggs-larvae: Decreased incubation success. Adults: Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid disturbance of vegetation along stream.	May affect survival of eggs-larvae and adult spawning productivity.
	Lacustrine								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures). Pygmy whitefish depend on cold water of 50°F or less. Therefore, increased temperatures will limit suitable habitat.	Year-round, (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles	Juveniles: Riparian shade and ambient temperature have a relatively minor effect on nearshore water temperatures relative to the dominant influence of currents, wind conditions, and other factors. However, juveniles trapped in habitats with isolated water level changes may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival.
	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs predominantly during spring outmigration period through lakes)	Permanent	Continuous	Juveniles	Juveniles: Pygmy whitefish are known to use terrestrial insect resources recruited from the riparian zone. Alteration of vegetation will result in decreased foraging opportunities, decreased growth and fitness, and decreased productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Permanent	Continuous	Juveniles	Juveniles: Whitefish dependence upon groundwater inflow is currently a data gap.	Avoid disturbance of vegetation along shoreline.	Effects of the action resulting from this impact mechanism are unknown.

Table A-10 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to long-term (dependent on contributing mechanism of impact)	Continuous to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and larvae. May affect juvenile survival, growth, and fitness, and adult survival and spawning productivity.
	Altered pollutant loading	Increased pollutant loading	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	All life-history stages: Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival, growth, and fitness of juveniles and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen (due to eutrophication caused by elevated nutrient export from dewatered floodplains)	Dependent on contributing mechanism of impact	Temporary to short-term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: Low-oxygen stress leading to physiological injury and/or mortality; behavioral avoidance.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect larvae development, juvenile survival, growth, and fitness as well as adult survival, fitness, and spawning success.

Table A-10 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Spawning Substrate Augmentation									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and larvae; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude; project-specific environmental conditions may range from: ▪ Egg mortality due to membrane rupture. ▪ Barotraumas causing fatality or permanent auditory tissue damage leading to impairment limiting to survival. ▪ Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey. ▪ Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. • Note that specific data on the noise sensitivity of these species are limited; therefore, the effects of stressor exposure are uncertain.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	Activity may cause direct mortality at all life-history stages. May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise intensity and receptor exposure.

Table A-10 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	Eggs/larvae: Decreased incubation success due to decreased dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
		Burial (during active sediment placement)	During project construction	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles	Eggs and larvae, juveniles: Injury or mortality from burial during gravel placement.	Restrict in-water work window to periods when incubating eggs and larvae with limited motility are least likely to be present.	May cause direct mortality or injury at egg, larvae, and juvenile life-history stages. Injury and stress may affect survival, growth, and fitness.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids,	During project construction	Temporary to short-term	Interannual–decadal	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Reduced refuge habitat (from potential pool filling)	Year-round	Short-term to intermediate-term	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Ensure that project has been designed properly for ecosystem context.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.

Table A-10 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered bank stability (intermediate-term effects from passive augmentation projects)	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term	Continuous	Eggs-larvae Juveniles Adults	Eggs-larvae: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased egg incubation success and survival. Pygmy whitefish dependence on groundwater inflow for incubation success is currently a data gap. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of spawning areas) if potential spawning habitat is affected	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival and productivity at egg, larvae, and juvenile life-history stages. May affect spawning productivity.
	Altered substrate composition/stability			Short-term to long-term					
	Aquatic Vegetation Modification								
	Riverine								
	Altered autochthonous production	Reduced foraging opportunities	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Avoid spawning gravel augmentation projects in locations where aquatic vegetation plays a strong role in habitat productivity.	May affect juvenile survival, growth, and fitness.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased foraging opportunity due to decreased food web productivity.		

Table A-10 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
In-Channel/Off-Channel Habitat Creation/Modification									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.

Table A-10 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and larvae; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude; project-specific environmental conditions may range from: ▪ Egg mortality due to membrane rupture. ▪ Barotraumas causing fatality or permanent auditory tissue damage leading to impairment limiting to survival. ▪ Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey. ▪ Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. • Note that specific data on the noise sensitivity of these species are limited; therefore, the effects of stressor exposure are uncertain.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	Activity may cause direct mortality at all life-history stages. May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise intensity and receptor exposure.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	Eggs/larvae: Decreased incubation success due to decreased dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-10 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles	Eggs and larvae, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Potential decreased egg incubation success and larvae survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.

Table A-10 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids (during construction or if in-channel project fails)	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
Riparian Planting/Restoration Enhancement									
	Construction and Maintenance Activities								
	Riverine , Lacustrine								
	Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-10 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
		Increased suspended solids – due to removal of invasive riparian species Spawning gravel sedimentation – due to removal of invasive riparian species	Year-round (with specific stressors prominent during high flow conditions)	Short-term to intermediate (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	Eggs/larvae: Decreased incubation success due to decreased dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Minimize disturbance during invasive species removal. Use appropriate erosion control BMPs both during and after construction.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Aquatic Vegetation Modification								
	Riverine, Lacustrine								
	Altered autochthonous production	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect juvenile growth and fitness

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Riverine, Lacustrine								
	Altered Shading and solar input	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect juvenile growth and fitness
	Water Quality Modification								
	Altered Temperatures	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures). Pygmy whitefish depend on cold water of 50°F or less. Therefore, increased temperatures will limit suitable habitat.	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Direct mortality due to winter ice formation and scour. Juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered suspended solids	Increased suspended solids – due to removal of invasive riparian species	Dependent on contributing mechanism of impact	Short-term to intermediate (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.

Table A-10 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Wetland Creation Restoration/Enhancement									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Juveniles; Adults	All exposed life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and larvae; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude; project-specific environmental conditions may range from: ▪ Egg mortality due to membrane rupture. ▪ Barotraumas causing fatality or permanent auditory tissue damage leading to impairment limiting to survival. ▪ Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey. ▪ Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. • Note that specific data on the noise sensitivity of these species are limited; therefore, the effects of stressor exposure are uncertain.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	Activity may cause direct mortality at all life-history stages. May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise intensity and receptor exposure.

Table A-10 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	Eggs/larvae: Decreased incubation success due to decreased dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Potential decreased egg incubation success and larvae survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

Table A-10 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids (e.g., during reconnection of fragmented floodplain wetlands, etc.)	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs and larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
Beach Nourishment/Contouring									
	Construction and Maintenance Activities								
	Lacustrine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Juveniles; Adults	All affected life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery/vessel work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended sediment	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.

Table A-10 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Lacustrine								
	Altered sediment supply	Localized alteration in invertebrate abundance from burial	During project construction and maintenance activities	Short-term – long-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.
	Aquatic Vegetation Modification								
	Lacustrine								
	Altered autochthonous production	Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to long-term(dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased foraging opportunity due to decreased food web productivity.	Avoid/minimize disturbance of aquatic vegetation during project construction. Avoid nourishing beaches updrift of productive, vegetated aquatic habitat.	May affect juvenile survival. May affect adult growth and spawning productivity.
	Altered cover and habitat	Reduced cover							
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	During construction and during subsequent high energy periods	Temporary to short-term (dependent on grain size of augmented sediment)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic shoreline instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term (dependent on contributing mechanism of impact)	Interannual to decadal	Juveniles; Adults	All affected life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body.	May affect survival, growth, and fitness of juveniles and adults.

Table A-10 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Reef Creation/Restoration/Enhancement									
	Construction and Maintenance Activities								
	Lacustrine								
	Equipment operation and materials placement	Elevated noise, visual and physical disturbance	During project construction activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	All life-history stages: Stressor response dependent on magnitude and duration of disturbance, and project-specific environmental conditions; may range from: • Increased predation risk and decreased foraging success due to displacement, auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid construction activities during periods when individuals may be present, particularly juveniles.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. Should exposure occur, direct mortality or injury is probable.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended sediment	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.

Table A-10 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Lacustrine								
	Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Juveniles; Adults	Juveniles and adults: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile and adult whitefish. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduced cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth, fitness, and productivity, as well as direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns	May affect survival and productivity at juvenile life-history stage. Decreased adult fitness may lead to reduced spawning productivity.
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Continuous				
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal				
	Altered sediment supply		Year-round	Permanent	Continuous				
	Altered substrate composition		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Lacustrine								
	Altered cover and habitat	Increased predation by piscivorous fish	Year-round	Permanent	Continuous	Juveniles	Juveniles: Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid placement of reef projects in proximity to juvenile migratory corridors, such that increased predation exposure may occur.	May affect juvenile survival, growth and fitness.
	Aquatic Vegetation Modification								
	Lacustrine								
	Altered autochthonous production	Reduced foraging opportunities	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile survival, growth, and fitness.
	Altered cover and habitat								
	Water Quality Modification								

Table A-10 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u>: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u>: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pollutant loading	Leaching of toxic substances (depending on composition of reef material)	Year-round	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Juveniles; Adults	<u>All affected life-history stages</u>: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Use non-toxic reef material.	May affect survival, growth, and fitness of juveniles and adults.
Eel Grass and Other Aquatic Vegetation Creation/Restoration/Enhancement									
	Not applicable								

Table A-11. HPA HCP Habitat Modification Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
Beaver Dam Removal									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness. May affect survival, growth, and fitness of juveniles and adults.
		Visual, physical, and noise related disturbance	During project construction and maintenance activities	Temporary (disturbance) to short-term (displacement, auditory masking, hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Impoundment dewatering	Fish entrainment, stranding, displacement	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Risk of mortality from stranding if fish cannot be captured and relocated successfully. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.
		Localized alteration in invertebrate abundance	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Increased suspended solids	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering.	See effects for related stressors under Water Quality Modifications.

Table A-11 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term to long-term	Continuous	Eggs and larvae; Juveniles Adults	<u>All exposed life history stages</u>: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. Mudminnow are dependent on habitats with low or zero flow velocity, loose silt substrate, and abundant aquatic vegetation for survival. Any alterations in hydraulic and geomorphic conditions that affect flow and substrate characteristics are likely to affect habitat suitability for this species. This in turn is likely to affect survival, growth, and fitness at all life history stages, spawning productivity, and distribution and abundance.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival, growth, and fitness at all life history stages, spawning productivity. May affect distribution and abundance.
	Altered flow velocity		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Intermediate-term to long-term	Seasonal				
	Altered bank stability		Year round especially during high flows	Intermediate-term to long-term	Seasonal				
	Altered substrate composition (including spawning gravel sedimentation)		Year round	Intermediate-term to long-term	Continuous				
	Altered groundwater-surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Intermediate-term to long-term	Continuous				
	Ecosystem Fragmentation								
	Riverine								
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most extensive)	Permanent	Seasonal	Eggs and larvae; Juveniles; Adults	<u>Eggs and larvae</u>: Decreased hyporheic exchange in downstream reaches may lead to decreased incubation success (i.e., decreased survival) due to decreased intragravel DO levels. <u>Adults and juveniles</u>: Decreased availability of thermal refuge habitat provided by groundwater upwelling may lead to decreased survival, growth, and fitness. <u>Adults</u>: Decreased availability of desirable spawning sites (due to lack of groundwater induced upwelling) may lead to decreased spawning productivity.	Avoid draining impounded area through use of beaver deceivers.	May affect egg and larvae survival, may affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
		Decreased dissolved oxygen from eutrophication below the impoundment (caused by elevated nutrient export)							
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u>: See related stressor responses under Water Quality Modification.	Avoid draining impounded area through use of beaver deceivers.	May affect survival, growth, and fitness of juveniles and adults.

Table A-11 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered terrestrial/aquatic connectivity	Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs Reduced foraging opportunities and rearing habitat availability	Year-round	Permanent	Continuous	Larvae; Adults	Larvae and adults: Beaver dam removal can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. Reduced organic matter input and terrestrially derived prey may lead to decreased survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting and avoid permitting designs that lead to disconnection of floodplain habitat.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
	Aquatic Vegetation Modification								
	Riverine								
	Altered autochthonous production Altered cover and habitat	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles; Adults	Juveniles, Adults: Extensive modification of aquatic vegetation can alter habitat complexity and food web productivity, which may in turn affect survival, growth, and fitness of juveniles. This is particularly true for mudminnow, which are dependent on aquatic vegetation for habitat.	Avoid draining impounded area through use of beaver deceivers.	May affect juvenile and adult survival, growth, and fitness. May affect spawning productivity, abundance and distribution.
	Riparian Vegetation Modification								
	Riverine								
	Altered stream bank and shoreline stability	Increased suspended solids Spawning gravel sedimentation	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	Eggs/larvae: Decreased incubation success due to decreased dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.

Table A-11 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Long-term to permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile rearing.
	Altered buffering capability	Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modification.
		Decreased dissolved oxygen from eutrophication (caused by elevated nutrient export)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Long-term to permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modification.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pollutant loading	Increased exposure to toxic substances	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel machinery in a controlled environment away from the project area. Avoid reducing hydraulic complexity.	May affect survival, growth, and fitness of juveniles and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles and adults: Behavioral alteration resulting in increased predation exposure (mudminnows are tolerant of wide variations in DO levels due to the ability to absorb atmospheric oxygen).	Limit damage to riparian area. Replant former impoundment with native vegetation to discourage invasives and stabilize sediments. Avoid draining impounded area through use of beaver deceivers.	May affect egg and larval survival. May affect juvenile and adult behavior.

Table A-11 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Large Woody Debris Placement/Movement/Removal (for placement only construction impacts apply)									
	Construction and Maintenance Activities								
	Riverine, Lacustrine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and larvae; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane (from exposure to high intensity noise such as pile driving). • Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.

Table A-11 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modifications.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Risk of mortality from stranding if fish cannot be captured and relocated successfully. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles	Eggs and larvae, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.

Table A-11 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Potential decreased egg incubation success and larvae survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles Adults	All exposed life history stages: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. Mudminnow are dependent on habitats with low or zero flow velocity, loose silt substrate, and abundant aquatic vegetation for survival. Any alterations in hydraulic and geomorphic conditions that affect flow and substrate characteristics are likely to affect habitat suitability for this species. This in turn is likely to affect survival, growth, and fitness at all life history stages, spawning productivity, and distribution and abundance.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival, growth, and fitness at all life history stages, spawning productivity. May affect distribution and abundance.
	Altered flow velocity		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition		Year round	Permanent	Continuous				
	Altered groundwater-surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				

Table A-11 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine								
	Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Eggs and larvae; Juveniles Adults	All exposed life history stages: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. Mudminnow are dependent on habitats with low or zero flow velocity, loose silt substrate, and abundant aquatic vegetation for survival. Any alterations in hydraulic and geomorphic conditions that affect flow and substrate characteristics are likely to affect habitat suitability for this species. This in turn is likely to affect survival, growth, and fitness at all life history stages, spawning productivity, and distribution and abundance.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival, growth, and fitness at all life history stages, spawning productivity. May affect distribution and abundance.
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common				
	Altered sediment supply		Year-round	Permanent	Continuous				
	Altered substrate composition		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Riverine								
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most extensive)	Permanent	Seasonal	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Decreased hyporheic exchange in downstream reaches may lead to decreased incubation success (i.e., decreased survival) due to decreased intragravel DO levels. Adults and juveniles: Decreased availability of thermal refuge habitat provided by groundwater upwelling may lead to decreased survival, growth, and fitness. Adults: Decreased availability of desirable spawning sites (due to lack of groundwater induced upwelling) may lead to decreased spawning productivity.	Require assessment of the hydraulic effects of the project before permitting	May affect egg and larvae survival, may affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and larvae; Juveniles; Adults	Juveniles: See related stressor responses under Water Quality Modification.		May affect survival, growth, and fitness of juveniles and adults.

Table A-11 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered lateral (terrestrial/aquatic) habitat connectivity	Reduced availability of off-channel refuge and rearing habitat. Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs. Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Eggs and larvae; Juveniles; Adults	Larvae and adults: LWD removal can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. Reduced organic matter input and terrestrially derived prey may lead to decreased survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat or longitudinal reach simplification.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered longitudinal habitat connectivity	Reduced availability of suitable habitats along longitudinal gradient.							
	Lacustrine								
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	Juveniles: LWD removal can fragment nearshore lacustrine habitats. Olympic Mudminnow are known to occur in these habitat types. Consequently, stressor exposure may affect survival, growth, and fitness if habitat access is impaired.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect juvenile survival, growth, and fitness.
	Altered cover and habitat	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	Juveniles: See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.
	Aquatic Vegetation Modification								
	Riverine and Lacustrine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	Juveniles and adults: Extensive modification of aquatic vegetation can alter habitat complexity and food web productivity, which may in turn affect survival growth, and fitness of juveniles. This is particularly true for mudminnow, which are dependent on aquatic vegetation for habitat.	Construction: Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile and adult survival, growth, and fitness. May affect spawning productivity, abundance and distribution.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.

Table A-11 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Riparian Vegetation Modification								
	Riverine								
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	Juveniles and adults: This species has a wide temperature tolerance range. May result in behavioral alteration.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile and adult behavior.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	Eggs/larvae: Decreased incubation success due to decreased dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Larvae; Juveniles; Adults	Larvae and juveniles: Decreased foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased pool availability and availability of suitable spawning habitat.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect larval and juvenile survival, growth, and productivity. May affect adult spawning productivity.
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and larvae; Adults	Eggs-larvae: Decreased incubation success. Adults: Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid disturbance of vegetation along stream.	May affect survival of eggs-larvae and adult spawning productivity.

Table A-11 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round, (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	Juveniles and adults: This species has a wide temperature tolerance range. May result in behavioral alteration.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile and adult behavior.
	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs predominantly during spring outmigration period through lakes)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile rearing.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition, and resulting effects on growth and fitness. Adults: Increased mortality, decreased fitness, and spawning success due to decreased availability of suitable spawning and rearing habitat.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile growth and survival, spawning success, and overall population productivity.
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Decreased incubation success. Juveniles: Decreased availability of thermal refuge habitat, resulting in increased thermal stress, increased competition for suitable habitats. Adults: Decrease in suitable spawning habitat, increased competition, decreased spawning fitness and success.	Avoid disturbance of vegetation along shoreline.	May affect survival of eggs and larvae. May affect juvenile survival and growth. May affect adult spawning productivity.

Table A-11 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to long-term (dependent on contributing mechanism of impact)	Continuous to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pollutant loading	Increased pollutant loading	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	All life-history stages: Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival, growth, and fitness of juveniles and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen (due to eutrophication caused by elevated nutrient export from dewatered floodplains)	Dependent on contributing mechanism of impact	Temporary to short-term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles and adults: Behavioral alteration resulting in increased predation exposure (mudminnows are tolerant of wide variations in DO levels due to the ability to absorb atmospheric oxygen).	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect egg and larval survival. May affect juvenile and adult behavior.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Spawning Substrate Augmentation									
	Not applicable.								
In-Channel/Off-Channel Habitat Creation/Modification									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and larvae; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude; project-specific environmental conditions may range from: ▪ Egg mortality due to membrane rupture. ▪ Barotraumas causing fatality or permanent auditory tissue damage leading to impairment limiting to survival. ▪ Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey. ▪ Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. • Note that specific data on the noise sensitivity of these species are limited; therefore, the effects of stressor exposure are uncertain.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	Activity may cause direct mortality at all life-history stages. May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise intensity and receptor exposure.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modifications.

Table A-11 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Risk of mortality from stranding if fish cannot be captured and relocated successfully. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles	Eggs and larvae, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Potential decreased egg incubation success and larvae survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Mortality or injury from entrainment. Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids (during construction or if in-channel project fails)	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
Riparian Planting/Restoration Enhancement									
	Construction and Maintenance Activities								
	Riverine , Lacustrine								
	Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	Juveniles and adults: This species has a wide temperature tolerance range. May result in behavioral alteration.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect juvenile and adult behavior.

Table A-11 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
		Increased suspended solids – due to removal of invasive riparian species	Year-round (with specific stressors prominent during high flow conditions)	Short-term to intermediate (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	Eggs/larvae: Decreased incubation success due to decreased benthic dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality	Minimize disturbance during invasive species removal. Use appropriate erosion control BMPs both during and after construction.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Aquatic Vegetation Modification								
	Riverine, Lacustrine								
	Altered autochthonous production	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	Juveniles, adults: Extensive modification of aquatic vegetation can alter habitat complexity and food web productivity, which may in turn affect survival growth, and fitness of juveniles. This is particularly true for mudminnow, which are dependent on aquatic vegetation for habitat.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect juvenile and adult growth and fitness

Table A-11 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Riverine, Lacustrine								
	Altered Shading and solar input	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	Extensive modification of aquatic vegetation can alter habitat complexity and food web productivity, which may in turn affect survival growth, and fitness of juveniles. This is particularly true for mudminnow, which are dependent on aquatic vegetation for habitat.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect juvenile and adult growth and fitness
	Water Quality Modification								
	Altered Temperatures	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	Juveniles and adults: This species has a wide temperature tolerance range. May result in behavioral alteration.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect juvenile and adult behavior.
	Altered suspended solids	Increased suspended solids – due to removal of invasive riparian species	Dependent on contributing mechanism of impact	Short-term to intermediate (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.

Table A-11 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Wetland Creation Restoration/Enhancement									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Juveniles; Adults	All exposed life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and larvae; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude; project-specific environmental conditions may range from: ▪ Egg mortality due to membrane rupture. ▪ Barotraumas causing fatality or permanent auditory tissue damage leading to impairment limiting to survival. ▪ Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey. ▪ Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. • Note that specific data on the noise sensitivity of these species are limited; therefore, the effects of stressor exposure are uncertain.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	Activity may cause direct mortality at all life-history stages. May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise intensity and receptor exposure.

Table A-11 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	Eggs/larvae: Decreased incubation success due to decreased benthic dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Potential decreased egg incubation success and larvae survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

Table A-11 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids (e.g., during reconnection of fragmented floodplain wetlands, etc.)	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs and larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
Beach Nourishment/Contouring									
	Construction and Maintenance Activities								
	Lacustrine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and larvae; Juveniles; Adults	All affected life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery/vessel work within the project area.	May affect survival, growth, and fitness of all life history stages.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended sediment	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	All affected life-history stages: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect survival, growth, and fitness of all life history stages.

Table A-11 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Lacustrine								
	Altered sediment supply	Localized alteration in invertebrate abundance from burial	During project construction and maintenance activities	Short-term – long-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	All affected life-history stages: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect survival, growth, and fitness of all life history stages.
	Aquatic Vegetation Modification								
	Lacustrine								
	Altered autochthonous production	Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to long-term(dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles and adults: Extensive modification of aquatic vegetation can alter habitat complexity and food web productivity, which may in turn affect survival growth, and fitness of juveniles. This is particularly true for mudminnow, which are dependent on aquatic vegetation for habitat.	Avoid/minimize disturbance of aquatic vegetation during project construction. Avoid nourishing beaches updrift of productive, vegetated aquatic habitat.	May affect juvenile and adult survival, growth, and fitness. May affect spawning productivity, abundance and distribution.
	Altered cover and habitat	Reduced cover							
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	During construction and during subsequent high energy periods	Temporary to short-term (dependent on grain size of augmented sediment)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic shoreline instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term (dependent on contributing mechanism of impact)	Interannual to decadal	Juveniles; Adults	All affected life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body.	May affect survival, growth, and fitness of juveniles and adults.

Table A-11 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Reef Creation/Restoration/Enhancement									
	Construction and Maintenance Activities								
	Lacustrine								
	Equipment operation and materials placement	Elevated noise, visual and physical disturbance	During project construction activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane. Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival. Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid construction activities during periods when individuals may be present, particularly juveniles.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. May cause direct mortality or injury.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended sediment	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.

Table A-11 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Lacustrine								
	Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Juveniles; Adults	Juveniles and adults: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile and adult Olympic Mudminnow. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduced cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth, fitness, and productivity, as well as direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns	May affect survival and productivity at juvenile life-history stage. Decreased adult fitness may lead to reduced spawning productivity.
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Continuous				
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal				
	Altered sediment supply		Year-round	Permanent	Continuous				
	Altered substrate composition		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Lacustrine								
	Altered cover and habitat	Increased predation by piscivorous fish	Year-round	Permanent	Continuous	Juveniles	Juveniles: Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid placement of reef projects in proximity to juvenile migratory corridors, such that increased predation exposure may occur.	May affect juvenile survival, growth and fitness.
	Aquatic Vegetation Modification								
	Lacustrine								
	Altered autochthonous production	Localized reduced foraging opportunities	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles;	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile survival, growth, and fitness.
	Altered cover and habitat								
	Water Quality Modification								

Table A-11 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pollutant loading	Leaching of toxic substances (depending on composition of reef material)	Year-round	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Juveniles; Adults	All affected life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Use non-toxic reef material.	May affect survival, growth, and fitness of juveniles and adults.
Eel Grass and Other Aquatic Vegetation Creation/Restoration/Enhancement									
	Not applicable								

Table A-12. HPA HCP Habitat Modification Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
Beaver Dam Removal									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness. May affect survival, growth, and fitness of juveniles and adults.
		Visual, physical, and noise related disturbance	During project construction and maintenance activities	Temporary (disturbance) to short-term (displacement, auditory masking, hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude; project-specific environmental conditions may range from: ▪ Egg mortality due to membrane rupture. ▪ Barotraumas causing fatality or permanent auditory tissue damage leading to impairment limiting to survival. ▪ Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey. ▪ Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. Note that specific data on the noise sensitivity of these species are limited; therefore, the effects of stressor exposure are uncertain.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	Activity may cause direct mortality at all life-history stages. May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise intensity and receptor exposure.
	Impoundment dewatering	Fish entrainment, stranding, displacement	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles; Adults	Eggs: Mortality, injury, or stress from increased flow entrainment as impoundment dewatering. Possible stranding of larvae in impoundment areas. Adults and juveniles: Mortality, injury, or stress from stranding or entrainment in dewatering flows. Juveniles: Increased competition following displacement, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration, resulting in decreased fitness and spawning success.	Manage dam removal to drain impoundment as slowly as practicable. Avoid scouring flows. Use beaver deceivers to limit hydraulic alteration.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth and fitness, and adult spawning productivity.
		Localized alteration in invertebrate abundance	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable. Use beaver deceivers to limit hydraulic alteration.	May affect growth and fitness at juvenile life-history stage.

Table A-12 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Increased suspended solids	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering.	See effects for related stressors under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term to long-term	Continuous	Eggs; Juveniles; Adults	Eggs: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased egg incubation success and survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability and changes in food web complexity. Dace are associated with low to moderate flows, which may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations, egg burial, etc.) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival, growth, and fitness at egg and juvenile life-history stages. May affect spawning productivity.
	Altered flow velocity		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Intermediate-term to long-term	Seasonal				
	Altered bank stability		Year round especially during high flows	Intermediate-term to long-term	Seasonal				
	Altered substrate composition (including spawning gravel sedimentation)		Year round	Intermediate-term to long-term	Continuous				
	Altered groundwater-surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Intermediate-term to long-term	Continuous				
	Ecosystem Fragmentation								
	Riverine								
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most extensive)	Permanent	Seasonal	Eggs	Eggs and larvae: See related stressor responses under Water Quality Modification.	Avoid draining impounded area through use of beaver deceivers.	See effects for related stressors under Water Quality Modification.
		Decreased dissolved oxygen from eutrophication below the impoundment (caused by elevated nutrient export)							
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs; Juveniles; Adults	All exposed life-history stages: See related stressor responses under Water Quality Modification.	Avoid draining impounded area through use of beaver deceivers.	May affect survival, growth, and fitness of juveniles and adults.

Table A-12 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered terrestrial/aquatic connectivity	Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs Reduced foraging opportunities and rearing habitat availability	Year-round	Permanent	Continuous	Eggs (dace); Juveniles; Adults	Eggs: Adult dace spawning habitat availability may be limited by lateral disconnection. Increased egg density may in turn increase potential egg losses from predation, localized water quality impacts, or other mechanisms, limiting egg survival and/or incubation success. Juveniles: Disconnection of floodplain habitats can lead to decreased availability and suitability of rearing habitat, and changes in food web complexity. Moderate gradient stream systems preferred by sculpins may limit the extent of suitable habitat area. Disconnection of sloughs and similar slow-flowing floodplain habitats in lower gradient systems may limit habitat area preferred by dace and juvenile suckers. These stressors may thereby result in decreased foraging opportunities and increased competition for suitable habitats, affecting survival, growth, and fitness. Adults: Disconnection of sloughs and similar slow-water rearing habitats may limit the availability of suitable foraging and spawning habitat for dace. In moderate gradient habitats, disconnection of floodplain habitats may limit the availability and suitability of spawning habitat for mountain sucker, and foraging and spawning habitat for margined sculpins. These stressors may thereby result in decreased foraging opportunities, and increased competition for suitable habitats, affecting survival, growth, fitness, and by extension, spawning productivity.	Require assessment of the hydraulic effects of the project before permitting and avoid permitting designs that lead to disconnection of floodplain habitat.	May affect egg survival. May affect juvenile and adult survival, growth, and fitness. May affect adult spawning productivity.
	Aquatic Vegetation Modification								
	Riverine								
	Altered autochthonous production Altered cover and habitat	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles; Adults	Juveniles and adults: Decreased refuge habitat availability and foraging opportunities, leading to increased competition, increased predation exposure, and resulting effects on survival, growth, and fitness.	Avoid draining impounded area through use of beaver deceivers.	May affect survival, growth, and productivity of juvenile and adult life-history stages.
	Riparian Vegetation Modification								
	Riverine								

Table A-12 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered stream bank and shoreline stability	Increased suspended solids Spawning gravel sedimentation	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs; Juveniles; Adults	Eggs: Decreased incubation success due to turbidity effects as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness at all life-history stages
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Long-term to permanent	Continuous	Juveniles; Adults	Juveniles and adults: Dace feed on terrestrial insects. While less dependent, suckers are opportunistic feeders dependent on overall food web productivity. Reduced allochthonous inputs may affect food web productivity, leading to decreased foraging opportunities and decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect growth and fitness at juvenile and adult life-history stages.
	Altered buffering capability	Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs; Juveniles; Adults	All exposed life-history stages: See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modification.
		Decreased dissolved oxygen from eutrophication (caused by elevated nutrient export)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Long-term to permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modification.
	Water Quality Modification								

Table A-12 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs; Juveniles; Adults	Eggs: Turbidity sufficient to cause fine sediment embeddedness may lead to egg burial, causing decreased survival. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses), leading to increased territoriality, reduced foraging opportunity, increased predation exposure.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs. May affect juvenile and adult survival, growth, and fitness.
	Altered pollutant loading	Increased exposure to toxic substances	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel machinery in a controlled environment away from the project area. Avoid reducing hydraulic complexity.	May affect survival, growth, and fitness of juveniles and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: Low-oxygen stress leading to physiological injury and/or mortality; behavioral avoidance.	Limit damage to riparian area. Replant former impoundment with native vegetation to discourage invasives and stabilize sediments. Avoid draining impounded area through use of beaver deceivers.	May affect juvenile survival and productivity as well as adult survival, productivity, and spawning success.
Large Woody Debris Placement/Movement/Removal (for placement only construction impacts apply)									
	Construction and Maintenance Activities								
	Riverine, Lacustrine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.

Table A-12 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs, Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude; project-specific environmental conditions may range from: ▪ Egg mortality due to membrane rupture. ▪ Barotraumas causing fatality or permanent auditory tissue damage leading to impairment limiting to survival. ▪ Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey. ▪ Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. • Note that specific data on the noise sensitivity of these species are limited; therefore, the effects of stressor exposure are uncertain.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by these species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work-areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Activity may cause direct mortality at all life-history stages. May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise intensity and receptor exposure.

Table A-12 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	Eggs/larvae: Decreased incubation success due to decreased dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles; Adults	Eggs: Mortality due to dewatering. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Small juvenile dace may be difficult to capture and relocate, leading to higher incidence of mortality. Increased competition once relocated, and reduced growth and fitness; increased predation exposure.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct mortality and injury. May affect survival, growth, and fitness at juvenile and adult life-history stages.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles	Eggs and juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May cause direct mortality or injury.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles; Adults	Eggs: Potential decreased survival due to turbidity exposure and substrate disturbance. Juveniles and adults: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, reduced foraging opportunities, and increased predation risk, leading to decreased survival, growth, and fitness. See responses to related stressors under Water Quality Modification.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect egg survival. May affect juvenile and adult survival, growth, and fitness. See effects of related stressor exposure under Water Quality Modification.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles and adults: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect juvenile and adult growth and fitness.
	Hydraulic and Geomorphic Modification								

Table A-12 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs; Juveniles; Adults	Eggs: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased egg incubation success and survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability and changes in food web complexity. Dace are associated with low to moderate flows, which may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations, egg burial, etc.) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival, growth, and fitness at egg and juvenile life-history stages. May affect spawning productivity.
	Altered flow velocity		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition		Year round	Permanent	Continuous				
	Altered groundwater-surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				

Table A-12 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine								
	Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Eggs (dace); Juveniles; Adults	All exposed life-history stages: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for juveniles and adults. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduced cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness, or mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selections of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at all exposed life-history stages. Decreased fitness may lead to reduced spawning productivity.
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common				
	Altered sediment supply		Year-round	Permanent	Continuous				
	Altered substrate composition		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Riverine								
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most extensive)	Permanent	Seasonal	Eggs and larvae	Eggs and larvae: See related stressor responses under Water Quality Modification.	Require assessment of the hydraulic effects of the project before permitting	See effects for related stressors under Water Quality Modification.
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and larvae; Juveniles; Adults	Juveniles: See related stressor responses under Water Quality Modification.		May affect survival, growth, and fitness of juveniles and adults.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered lateral (terrestrial/aquatic) habitat connectivity Altered longitudinal habitat connectivity	Reduced availability of off-channel refuge and rearing habitat. Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs Reduced foraging opportunities and rearing habitat availability Reduced availability of suitable habitats along longitudinal gradient.	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Eggs (dace); Juveniles; Adults	Eggs: Adult dace spawning habitat availability may be limited by lateral disconnection, and by limitations on movement in the nearshore zone. Increased egg density may in turn increase potential egg losses from predation, localized water quality impacts, or other mechanisms, limiting egg survival and/or incubation success. Juveniles: Disconnection of floodplain habitats can lead to decreased availability and suitability of rearing habitat, and changes in food web complexity. Moderate gradient stream systems preferred by sculpins may limit the extent of suitable habitat area. Disconnection of sloughs and similar slow-flowing floodplain habitats in lower gradient systems may limit habitat area preferred by dace and juvenile suckers. These stressors may thereby result in decreased foraging opportunities and increased competition for suitable habitats, affecting survival, growth, and fitness. Adults: Disconnection of sloughs and similar slow-water rearing habitats may limit the availability of suitable foraging and spawning habitat for dace. In moderate gradient habitats, disconnection of floodplain habitats may limit the availability and suitability of spawning habitat for mountain sucker, and foraging and spawning habitat for margined sculpins. These stressors may thereby result in decreased foraging opportunities, and increased competition for suitable habitats, affecting survival, growth, fitness, and by extension, spawning productivity.	Require assessment of the hydraulic effects of the project before permitting and avoid permitting designs that lead to disconnection of floodplain habitat.	May affect egg survival. May affect juvenile and adult survival, growth, and fitness. May affect adult spawning productivity.
	Lacustrine								

Table A-12 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Eggs (dace); Juveniles (dace and mountain suckers); Adults (dace and mountain suckers)	Eggs: Adult dace spawning habitat availability may be limited by latteral disconnection, and by limitations on movement in the nearshore zone. Increased egg density may in turn increase potential egg losses from predation, localized water quality impacts, or other mechanisms, limiting egg survival and/or incubation success. Juveniles and adults: LWD removal can fragment nearshore habitats, forcing juvenile fish moving along the shoreline to migrate into deeper water. Dace, which prefer shallow water habitats, would experience increased predation exposure and increased stress and exertion as a result. Concentration in nearshore habitats due to restricted movement may limit foraging opportunities. Exposure to these stressors may limit survival, growth, and fitness. Reduced adult fitness may affect spawning productivity. Juvenile and adult suckers will experience similar stressor exposure but are less prone to the resulting effects due to their benthic orientation. Margined sculpins are found predominantly in small rivers and streams in the Tucannon and Walla Walla River drainages. The likelihood of occurrence in lakes is limited, which in turn limits the potential for stressor exposure in lacustrine environments.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect juvenile and adult survival, growth, and fitness. May affect egg survival and/or incubation success.
	Altered cover and habitat	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.
	Aquatic Vegetation Modification								
	Riverine and Lacustrine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Construction: Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.

Table A-12 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.		May affect juvenile survival, growth, and fitness, as well as adult spawning productivity.

Table A-12 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Riverine								
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs; Juveniles; Adults	Eggs: High water temperatures may decrease egg survival. Juveniles: Reduced growth and fitness caused by temperatures outside optimal growth range, and alteration of food web patterns. Adults and juveniles: May reduce the availability of suitable refuge and foraging habitat, leading to reduced survival, growth, and fitness. Adults: Spawning is temperature dependent; alteration of nearshore temperature may affect spawning success and productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness at all life-history stages. Mountain sucker prefer deeper water environments and are likely to be less sensitive to these effects.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs; Juveniles; Adults	Eggs: Decreased incubation success due to turbidity effects as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness at all life-history stages
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles and adults: Decreased availability of suitable foraging and refuge habitat, leading to decreased foraging opportunities, increased competition, increased predation exposure, collectively affecting survival, growth, and fitness. Reduction in suitable spawning habitat area may affect spawning productivity.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile and adult survival, growth, and fitness. May affect adult spawning productivity.

Table A-12 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs; Juveniles; Adults	All exposed life-history stages: Dace and sucker dependency on groundwater is currently a data gap. However, decreased availability of thermal refuge may affect survival during temperature extremes.	Avoid disturbance of vegetation along stream.	Effects resulting from this impact mechanism are uncertain, as dace and sucker sensitivity to stressor exposure is currently a data gap. However, lack of suitable thermal refuge habitat may affect dace survival.
	Lacustrine								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures).	Year-round, (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles	Juveniles: Riparian shade and ambient temperature have a relatively minor effect on deep lacustrine water temperatures relative to the dominant influence of currents, wind conditions, and other factors. However, protected nearshore habitats favored by dace may be sensitive to temperature extremes. Lack of suitable thermal refuge habitat may lead to decreased survival.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness at all life-history stages. Mountain sucker prefer deeper water environments and are likely to be less sensitive to these effects.
	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs (dace); Juveniles; Adults	Eggs: Dace may experience decreased egg survival in lacustrine spawning environments due to turbidity effects. Juveniles and adults: Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect dace egg survival. See effects for related stressors under Water Quality Modification.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs predominantly during spring outmigration period through lakes)	Permanent	Continuous	Juveniles; Adults	Juveniles and adults: Dace and suckers prey upon terrestrial insects recruited from riparian zone. Alteration of vegetation will result in decreased foraging opportunities, decreased growth and fitness, and decreased productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect growth, fitness, and productivity.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles and adults: Alteration of habitat complexity may affect the suitability of spawning, rearing, and refuge habitat for dace and suckers, leading to reduced survival, growth, and fitness. Reduced habitat complexity may affect the availability of suitable spawning habitats for dace and sucker.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect survival, growth, and fitness during juvenile and adult life-history stages. Reduced habitat complexity may affect spawning productivity.
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Permanent	Continuous	Juveniles	Juveniles: Dependence on groundwater–surface water exchange by these fish species is a data gap. However, lack of suitable thermal refuge habitat may lead to decreased survival during temperature extremes.	Avoid/minimize disturbance of riparian vegetation. Maintain system appropriate riparian buffer widths to the greatest extent possible.	Effects resulting from this impact mechanism are uncertain, as dace and sucker sensitivity to stressor exposure is currently a data gap. However, lack of suitable thermal refuge habitat may affect dace survival.

Table A-12 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to long-term (dependent on contributing mechanism of impact)	Continuous to interannual–decadal (dependent on contributing mechanism of impact)	Eggs; Juveniles; Adults	<u>Eggs:</u> Turbidity sufficient to cause fine sediment embeddedness may lead to egg burial, causing decreased survival. <u>Juveniles and adults:</u> Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses), leading to increased territoriality, reduced foraging opportunity, increased predation exposure.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs. May affect juvenile and adult survival, growth, and fitness.
	Altered pollutant loading	Increased pollutant loading	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs; Juveniles; Adults	<u>All life-history stages</u>: Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival, growth, and fitness of juveniles and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen (due to eutrophication caused by elevated nutrient export from dewatered floodplains)	Dependent on contributing mechanism of impact	Temporary to short-term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs; Juveniles; Adults	<u>All exposed life-history stages</u>: Low-oxygen stress leading to physiological injury and/or mortality; behavioral avoidance.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect juvenile survival, growth, and fitness as well as adult survival, fitness, and spawning success.

Table A-12 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
Spawning Substrate Augmentation									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and larvae; Juveniles; Adults	<u>All life-history stages</u>: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>All life-history stages</u>: Stressor response dependent on magnitude and duration of disturbance, and project-specific environmental conditions; may range from: • Increased predation risk and decreased foraging success due to displacement, auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid construction activities during periods when individuals may be present, particularly juveniles.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. Should exposure occur, direct mortality or injury is probable.

Table A-12 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	Eggs/larvae: Decreased incubation success due to decreased dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles; Adults	Eggs: Mortality due to dewatering. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Small juvenile dace may be difficult to capture and relocate, leading to higher incidence of mortality. Increased competition once relocated, and reduced growth and fitness; increased predation exposure.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct mortality and injury. May affect survival, growth, and fitness at juvenile and adult life-history stages.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles	Eggs and juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May cause direct mortality or injury.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles; Adults	Eggs: Potential decreased survival due to turbidity exposure and substrate disturbance. Juveniles and adults: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, reduced foraging opportunities, and increased predation risk, leading to decreased survival, growth, and fitness. See responses to related stressors under Water Quality Modification.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect egg survival. May affect juvenile and adult survival, growth, and fitness. See effects of related stressor exposure under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Riverine								

Table A-12 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered channel geometry	Reduced refuge habitat (from potential pool filling)	Year-round	Short-term to intermediate-term	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Ensure that project has been designed properly for ecosystem context.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.
	Altered bank stability (intermediate-term effects from passive augmentation projects) Altered substrate composition/stability	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term Short-term to long-term	Continuous	Eggs; Juveniles; Adults	Eggs: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased egg incubation success and survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability and changes in food web complexity. Dace are associated with low to moderate flows, which may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations, egg burial, etc.) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival, growth, and fitness at egg and juvenile life-history stages. May affect spawning productivity.
	Aquatic Vegetation Modification								
	Riverine								
	Altered autochthonous production	Reduced foraging opportunities	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles and adults: Reduced foraging opportunities due to decreased food web productivity, leading to decreased growth and fitness. Primary forage for suckers includes algae and aquatic invertebrates, which may be affected by decreased autochthonous production.	Avoid spawning gravel augmentation projects in locations where aquatic vegetation plays a strong role in habitat productivity.	May affect juvenile survival, growth, and fitness.

Table A-12 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles and adults: Decreased refuge habitat availability and foraging opportunities, leading to increased competition, increased predation exposure, and resulting effects on survival, growth, and fitness.		
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs; Juveniles; Adults	Eggs: Turbidity sufficient to cause fine sediment embeddedness may lead to egg burial, causing decreased survival. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses), leading to increased territoriality, reduced foraging opportunity, increased predation exposure.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs. May affect juvenile and adult survival, growth, and fitness.
In-Channel/Off-Channel Habitat Creation/Modification									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	All life-history stages: Stressor response dependent on magnitude and duration of disturbance, and project-specific environmental conditions; may range from: • Increased predation risk and decreased foraging success due to displacement, auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid construction activities during periods when individuals may be present, particularly juveniles.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. Should exposure occur, direct mortality or injury is probable.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	Eggs/larvae: Decreased incubation success due to decreased dissolved oxygen as described for related stressor responses under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	May affect survival, growth, and fitness during juvenile rearing. May affect adult survival and spawning productivity.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles; Adults	Eggs: Mortality due to dewatering. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Small juvenile dace may be difficult to capture and relocate, leading to higher incidence of mortality. Increased competition once relocated, and reduced growth and fitness; increased predation exposure.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct mortality and injury. May affect survival, growth, and fitness at juvenile and adult life-history stages.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles	Eggs and juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May cause direct mortality or injury.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles; Adults	Eggs: Potential decreased survival due to turbidity exposure and substrate disturbance. Juveniles and adults: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, reduced foraging opportunities, and increased predation risk, leading to decreased survival, growth, and fitness. See responses to related stressors under Water Quality Modification.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect egg survival. May affect juvenile and adult survival, growth, and fitness. See effects of related stressor exposure under Water Quality Modification.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles and adults: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect juvenile and adult growth and fitness.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids (during construction or if in-channel project fails)	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs; Juveniles; Adults	Eggs: Turbidity sufficient to cause fine sediment embeddedness may lead to egg burial, causing decreased survival. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses), leading to increased territoriality, reduced foraging opportunity, increased predation exposure.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs. May affect juvenile and adult survival, growth, and fitness.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
Riparian Planting/Restoration Enhancement									
	Construction and Maintenance Activities								
	Riverine , Lacustrine								
	Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs; Juveniles; Adults	All exposed life-history stages: Alteration of water temperatures leading to increases or decreases beyond optimal ranges may affect growth and fitness of dace and sucker. Optimal temperatures range from 59–64°F for dace and 55–70°F for mountain sucker. Exposure to higher temperatures may lead to direct mortality or sufficient stress to affect survival. Juveniles and adults may exhibit temporary avoidance behavior, increased stress, increased predation exposure, and decreased foraging opportunities.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect survival of incubating eggs. May affect juvenile and adult survival, growth, and fitness.
		Increased suspended solids – due to removal of invasive riparian species	Year-round (with specific stressors prominent during high flow conditions)	Short-term to intermediate (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs; Juveniles; Adults	Eggs: Turbidity sufficient to cause fine sediment embeddedness may lead to egg burial, causing decreased survival. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high	Minimize disturbance during invasive species removal. Use appropriate erosion control BMPs both during and after construction.	May affect survival of incubating eggs. May affect juvenile and adult survival, growth, and fitness.

Table A-12 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
		Spawning gravel sedimentation – due to removal of invasive riparian species					turbidity may cause behavioral alteration (e.g., avoidance responses), leading to increased territoriality, reduced foraging opportunity, increased predation exposure.		
	Aquatic Vegetation Modification								
	Riverine, Lacustrine								
	Altered autochthonous production	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	Juveniles and adults: Reduced foraging opportunities due to decreased food web productivity, leading to decreased growth and fitness. Primary forage for suckers includes algae and aquatic invertebrates, which may be affected by decreased autochthonous production.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect survival, growth, and productivity of juvenile and adult life-history stages.

Table A-12 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Riparian Vegetation Modification								
	Riverine, Lacustrine								
	Altered Shading and solar input	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	Juveniles and adults: Reduced foraging opportunities due to decreased food web productivity, leading to decreased growth and fitness. Primary forage for suckers includes algae and aquatic invertebrates, which may be affected by decreased autochthonous production.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect survival, growth, and productivity of juvenile and adult life-history stages.
	Water Quality Modification								
	Altered Temperatures	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures).	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs; Juveniles; Adults	All exposed life-history stages: Alteration of water temperatures leading to increases or decreases beyond optimal ranges may affect growth and fitness of dace and sucker. Optimal temperatures range from 59–64°F for dace and 55–70°F for mountain sucker. Exposure to higher temperatures may lead to direct mortality or sufficient stress to affect survival. Juveniles and adults may exhibit temporary avoidance behavior, increased stress, increased predation exposure, and decreased foraging opportunities.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect survival of incubating eggs. May affect juvenile and adult survival, growth, and fitness.
	Altered suspended solids	Increased suspended solids – due to removal of invasive riparian species	Dependent on contributing mechanism of impact	Short-term to intermediate (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs; Juveniles; Adults	Eggs: Turbidity sufficient to cause fine sediment embeddedness may lead to egg burial, causing decreased survival. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses), leading to increased territoriality, reduced foraging opportunity, increased predation exposure.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs. May affect juvenile and adult survival, growth, and fitness.

Table A-12 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Wetland Creation Restoration/Enhancement									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	All life-history stages: Stressor response dependent on magnitude and duration of disturbance, and project-specific environmental conditions; may range from: • Increased predation risk and decreased foraging success due to displacement, auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid construction activities during periods when individuals may be present, particularly juveniles.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. Should exposure occur, direct mortality or injury is probable.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids (e.g., during reconnection of fragmented floodplain wetlands, etc.)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs; Juveniles; Adults	Eggs: Potential decreased survival due to turbidity exposure and substrate disturbance. Juveniles and adults: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, reduced foraging opportunities, and increased predation risk, leading to decreased survival, growth, and fitness. See responses to related stressors under Water Quality Modification.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect egg survival. May affect juvenile and adult survival, growth, and fitness. See effects of related stressor exposure under Water Quality Modification.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles; Adults	Eggs: Mortality due to dewatering. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Small juvenile dace may be difficult to capture and relocate, leading to higher incidence of mortality. Increased competition once relocated, and reduced growth and fitness; increased predation exposure.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct mortality and injury. May affect survival, growth, and fitness at juvenile and adult life-history stages.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles	Eggs and juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May cause direct mortality or injury.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles; Adults	Eggs: Potential decreased survival due to turbidity exposure and substrate disturbance. Juveniles and adults: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, reduced foraging opportunities, and increased predation risk, leading to decreased survival, growth, and fitness. See responses to related stressors under Water Quality Modification.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect egg survival. May affect juvenile and adult survival, growth, and fitness. See effects of related stressor exposure under Water Quality Modification.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles and adults: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect juvenile and adult growth and fitness.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids (e.g., during reconnection of fragmented floodplain wetlands, etc.)	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs; Juveniles; Adults	Eggs: Turbidity sufficient to cause fine sediment embeddedness may lead to egg burial, causing decreased survival. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses), leading to increased territoriality, reduced foraging opportunity, increased predation exposure.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs. May affect juvenile and adult survival, growth, and fitness.

Table A-12 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
Beach Nourishment/Contouring									
	Construction and Maintenance Activities								
	Lacustrine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	All life-history stages: Stressor response dependent on magnitude and duration of disturbance, and project-specific environmental conditions; may range from: • Increased predation risk and decreased foraging success due to displacement, auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid construction activities during periods when individuals may be present, particularly juveniles.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. Should exposure occur, direct mortality or injury is probable.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended sediment	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles; Adults	Eggs: Potential decreased survival due to turbidity exposure and substrate disturbance. Juveniles and adults: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, reduced foraging opportunities, and increased predation risk, leading to decreased survival, growth, and fitness. See responses to related stressors under Water Quality Modification.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect egg survival. May affect juvenile and adult survival, growth, and fitness. See effects of related stressor exposure under Water Quality Modification.

Table A-12 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Lacustrine								
	Altered sediment supply	Localized alteration in invertebrate abundance from burial	During project construction and maintenance activities	Short-term – long-term	Interannual to decadal (depending on activity frequency)	Eggs (dace); Juveniles; Adults	<u>All exposed life-history stages</u>: Alteration in sediment supply can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for juveniles and adults. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduced cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness, or mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selections of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at all exposed life-history stages. Decreased fitness may lead to reduced spawning productivity.
	Aquatic Vegetation Modification								
	Lacustrine								
	Altered cover and habitat	Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles and adults:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition, increased predation exposure, and resulting effects on survival, growth, and fitness.		May affect survival, growth, and productivity of juvenile and adult life-history stages.
	Altered autochthonous production	Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to long-term(dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles and adults</u>: Reduced foraging opportunities due to decreased food web productivity, leading to decreased growth and fitness. Primary forage for suckers includes algae and aquatic invertebrates, which may be affected by decreased autochthonous production.	Avoid/minimize disturbance of aquatic vegetation during project construction. Avoid nourishing beaches updrift of productive, vegetated aquatic habitat.	May affect juvenile survival. May affect adult growth and spawning productivity.
	Water Quality Modification								

Table A-12 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids	During construction and during subsequent high energy periods	Temporary to short-term (dependent on grain size of augmented sediment)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs; Juveniles; Adults	Eggs: Turbidity sufficient to cause fine sediment embeddedness may lead to egg burial, causing decreased survival. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses), leading to increased territoriality, reduced foraging opportunity, increased predation exposure.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs. May affect juvenile and adult survival, growth, and fitness.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
Reef Creation/Restoration/Enhancement									
	Construction and Maintenance Activities								
	Lacustrine								
	Equipment operation and materials placement	Elevated noise, visual and physical disturbance	During project construction activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	All life-history stages: Stressor response dependent on magnitude and duration of disturbance, and project-specific environmental conditions; may range from: • Increased predation risk and decreased foraging success due to displacement, auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid construction activities during periods when individuals may be present, particularly juveniles.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. Should exposure occur, direct mortality or injury is probable.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.

Table A-12 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended sediment	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Juveniles; Adults	Eggs: Potential decreased survival due to turbidity exposure and substrate disturbance. Juveniles and adults: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, reduced foraging opportunities, and increased predation risk, leading to decreased survival, growth, and fitness. See responses to related stressors under Water Quality Modification.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect egg survival. May affect juvenile and adult survival, growth, and fitness. See effects of related stressor exposure under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Lacustrine								
	Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Eggs (dace); Juveniles; Adults	All exposed life-history stages: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for juveniles and adults. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduced cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness, or mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selections of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at all exposed life-history stages. Decreased fitness may lead to reduced spawning productivity.
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Continuous				
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal				
	Altered sediment supply		Year-round	Permanent	Continuous				
	Altered substrate composition		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Lacustrine								
	Altered cover and habitat	Increased predation by piscivorous fish	Year-round	Permanent	Continuous	Juveniles	Juveniles: Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid placement of reef projects in proximity to juvenile migratory corridors, such that increased predation exposure may occur.	May affect juvenile survival, growth and fitness.
	Aquatic Vegetation Modification								
	Lacustrine								
	Altered autochthonous production	Reduced foraging opportunities	Year-round	Short-term to permanent	Continuous	Juveniles;	Juveniles and adults: Reduced foraging opportunities due to decreased food web	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile survival. May affect adult growth and spawning

Table A-12 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Umatilla Dace, Leopard Dace, Lake Chub, Margined Sculpin, and Mountain Sucker.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered cover and habitat			(dependent on nature of activity)		Adults	productivity, leading to decreased growth and fitness. Primary forage for suckers includes algae and aquatic invertebrates, which may be affected by decreased autochthonous production.	Avoid nourishing beaches updrift of productive, vegetated aquatic habitat.	productivity.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs; Juveniles; Adults	<u>Eggs:</u> Turbidity sufficient to cause fine sediment embeddedness may lead to egg burial, causing decreased survival. <u>Juveniles and adults</u>: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses), leading to increased territoriality, reduced foraging opportunity, increased predation exposure.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs. May affect juvenile and adult survival, growth, and fitness.
	Altered pollutant loading	Leaching of toxic substances (depending on composition of reef material)	Year-round	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs; Juveniles; Adults	<u>All life-history stages</u>: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
Eel Grass and Other Aquatic Vegetation Creation/Restoration/Enhancement									
	Not applicable								

Table A-13. HPA HCP Habitat Modification Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
Beaver Dam Removal/Modification									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and ammocoetes; Transforming adults; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of all life stages.
		Visual, physical, and noise related disturbance	During project construction and maintenance activities	Temporary (disturbance) to short-term (displacement, auditory masking, hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and ammocoetes; Transforming adults; Adults	All life-history stages: Very little is known of the effects of pile-driving sounds on lamprey at any life-history stage.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	Little is known about the effects of anthropogenic sounds on lamprey.
	Impoundment dewatering	Fish entrainment, stranding, displacement	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Ammocoetes; Transforming adults; Adults	Ammocoetes: Mortality, injury, and stress, during dewatering (when buried in riverine sediments). Adults and transforming adults: Mortality, injury, or stress from capture, handling, and relocation. Transforming adults: Increased competition once relocated, and reduced growth and fitness; increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Manage dam removal to drain impoundment as slowly as practicable. Avoid scouring flows. Use beaver deceivers to limit hydraulic alteration.	May affect survival, growth, and fitness at ammocoete, transforming adult, and adult life-history stages.
		Localized alteration in invertebrate abundance	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Transforming adults	Transforming adults: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable. Use beaver deceivers to limit hydraulic alteration.	May affect growth and fitness of Transforming adults.
		Increased suspended solids	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and ammocoetes; Transforming adults; Adults	All life-history-stages: See responses to related stressors under Water Quality Modification. Water quality effects to ammocoetes are a data gap. However, as Pacific and river lamprey feed on host fish, effects of suspended solids on host fish could affect them. As western brook lamprey are filter feeders, this may not be a stressor for transforming adults and adults.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering.	See effects for related stressors under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term to long-term	Continuous	Eggs and ammocoetes; Transforming adults;	Eggs and ammocoetes: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project	May affect survival, growth, and fitness at egg and ammocoete stages and egg and transforming adult life-history stages for host fish of Pacific

Table A-13 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered flow velocity		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Intermediate-term to long-term	Seasonal	Adults	success and ammocoete survival. Pacific and river lamprey ammocoetes are particularly vulnerable to impact mechanisms that cause scour, deposition, or other forms of substrate modification when buried in fine substrates during rearing periods, which can last for several years. Transforming adults: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, as well as changes in food web complexity. These may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of s) if potential spawning habitat is affected	designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	and river lamprey. May also affect spawning productivity.
	Altered bank stability		Year round especially during high flows	Intermediate-term to long-term	Seasonal				
	Altered substrate composition (including spawning gravel sedimentation)		Year round	Intermediate-term to long-term	Continuous				
	Altered groundwater-surface water exchange		Year-round (with stressor exposure occurring during egg incubation)	Intermediate-term to long-term	Continuous				
	Ecosystem Fragmentation								
	Riverine								
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most extensive)	Permanent	Seasonal	Eggs and ammocoetes	Eggs and ammocoetes: See related stressor responses under Water Quality Modification	Avoid draining impounded area through use of beaver deceivers.	See effects for related stressors under Water Quality Modification.
		Decreased dissolved oxygen from eutrophication below the impoundment (caused by elevated nutrient export)							
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and ammocoetes; Transforming adults; Adults	All exposed life-history stages: See related stressor responses under Water Quality Modification.	Avoid draining impounded area through use of beaver deceivers.	May affect survival, growth, and fitness of all life history stages
	Altered terrestrial/aquatic connectivity	Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs	Year-round	Permanent	Continuous	Eggs and ammocoetes; Transforming adults; Adults	All exposed life-history stages: This stressor may limit the availability of adult spawning and transforming adult rearing habitat for lamprey species dependent on these habitat types.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of high quality floodplain habitat.	May affect survival at egg, ammocete, and transforming adult life-history stages. May affect spawning productivity.
		Reduced foraging opportunities and rearing habitat availability							
	Aquatic Vegetation codification								
	Riverine								
	Altered autochthonous production	Reduced food web productivity, reduced foraging opportunity,	Year-round	Permanent	Continuous	Ammocoetes; Transforming	Ammocoetes and transforming adults: Reduced foraging opportunities due to	Avoid draining impounded area through use of beaver deceivers.	May affect ammocoete and transforming adult growth and fitness.

Table A-13 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered cover and habitat	reduction in available cover				adults	decreased food web productivity, decreased growth and fitness of Pacific and river lamprey host fish, and decreased prey resources for filter-feeding Western brook lamprey and ammocoete stages of Pacific and river lamprey. Altered prey resource effects to lamprey ammocoete life-history stages are a data gap. Although effects of altered autochthonous inputs for western brook lamprey are a data gap, alterations could be expected to affect prey resource availability.		
	Riparian Vegetation Modification								
	Riverine								
	Altered stream bank and shoreline stability	Increased suspended solids Burial of benthic ammocoetes or eggs.	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and ammocoetes; Transforming adults; Adults	Eggs/ammocoetes: Decreased incubation success due to burial or scour of eggs and rearing ammocoetes. Decreased availability of host fish for Pacific and river lamprey. Transforming adults: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness for Pacific and river lamprey host fish. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: Potential effects on migration and spawning productivity as described for related stressor responses under Water Quality Modification.	Initiate proper erosion control measures both during and after construction. Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	May affect survival, growth, and fitness during incubation and transforming adult and adult fitness of host fish for Pacific and river lamprey.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Long-term to permanent	Continuous	Ammocoetes; Transforming adults	Transforming adults and ammocoetes: Reduced foraging opportunities due to decreased food web productivity, decreased growth and fitness.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	May affect growth and fitness of ammocoetes and transforming adults.
	Altered buffering capability	Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and ammocoetes; Transforming adults; Adults	All exposed life-history stages: See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	May affect survival, growth, and fitness of all life history stages
		Decreased dissolved oxygen from eutrophication (caused by elevated nutrient export)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Long-term to permanent	Seasonal	Transforming adults; Adults	Transforming adults and adults: See related stressor responses under Water Quality Alteration. Effects are related to host fish effects for both Pacific and river lamprey.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modification.
	Water Quality Modification								

Table A-13 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: Turbidity sufficient to cause fine sediment embeddedness or increased burial depth may lead to direct mortality and decreased survival of eggs and ammocoetes. Transforming adults and adults: Not a direct stressor to the lamprey. For Pacific and river lamprey, responses depend on stressor magnitude to host fish, which may include the following: unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and ammocoetes. May affect transforming adult growth and fitness, as well as adult fitness and spawning success.
	Altered pollutant loading	Increased exposure to toxic substances	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and ammocoetes; Transforming adults; Adults	All exposed life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness for Pacific and river lamprey. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel machinery in a controlled environment away from the project area. Avoid reducing hydraulic complexity.	May affect survival, growth, and fitness of all exposed life-history stages.
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and ammocoetes; Transforming adults; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Effects on host fish are stressors to Pacific and river lamprey. Transforming adults and adults: A physiological response to exposure at toxic levels causing mortality or injury leading to reduced fitness is a data gap. However, effects on host fish are known and would affect Pacific and river lamprey. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality. This is a data gap.	Limit damage to riparian area. Replant former impoundment with native vegetation to discourage invasives and stabilize sediments. Avoid draining impounded area through use of beaver deceivers.	May affect survival of incubating eggs and ammocoetes. May affect transforming adult survival, growth, and fitness, as well as adult survival, productivity, and spawning success.
Large Woody Debris Placement/Movement/Removal (for placement only construction impacts apply)									
	Construction and Maintenance Activities								
	Riverine, Lacustrine, Marine								

Table A-13 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and ammocoetes; Transforming adults; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of all life stages.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Transforming adults, Adults	Adults and transforming adults: Very little is known of the effects of anthropogenic sounds on lamprey at any life-history stage.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	Little is known about the effects of anthropogenic sounds on lamprey.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and ammocoetes; Transforming adults; Adults	All life-history-stages: See responses to related stressors under Water Quality Modification. Water quality effects to ammocoetes are a data gap. However, as Pacific and river lamprey feed on host fish, effects of suspended solids on host fish could affect them. As western brook lamprey are filter feeders, this may not be a stressor for transforming adults and adults.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Ammocoetes; Transforming adults; Adults	Ammocoetes: Mortality, injury, and stress, during dewatering (when buried in riverine sediments). Adults and transforming adults: Mortality, injury, or stress from capture, handling, and relocation. Transforming adults: Increased competition once relocated, and reduced growth and fitness; increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect survival, growth, and fitness at ammocoete, transforming adult, and adult life-history stages.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Transforming adults	Transforming adults: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when transforming adults are present.	May affect survival and fitness at transforming adult life-history stage.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and ammocoetes; Transforming adults; Adults	Ammocoetes: Ammocoetes of Pacific and river lamprey mature buried in fine substrates in the lower reaches and estuaries of larger rivers for extended periods and are therefore vulnerable to direct injury and mortality from benthic disturbance. Transforming adults: Decreased foraging opportunity due to short-term reduction in prey availability. All life-history stages: See responses described for related stressors under Water Quality Modification.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May cause direct mortality or injury to ammocoetes. May affect transforming adult growth and fitness. See effects for related stressors under Water Quality Modification.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Transforming adults	Transforming adults: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness of Transforming adults.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: Mortality or injury from entrainment. Transforming adults: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect Transforming adults growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and ammocoete survival. Pacific and river lamprey ammocoetes are particularly vulnerable to impact mechanisms that cause scour, deposition, or other forms of substrate modification when buried in fine substrates during rearing periods, which can last for several years. Transforming adults: Altered channel geometry, flow velocity, and substrate	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival, growth, and fitness at egg and ammocoete stages and egg and transforming adult life-history stages for host fish of Pacific and river lamprey. May also affect spawning productivity.
	Altered flow velocity		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition		Year round	Permanent	Continuous				

Table A-13 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered groundwater-surface water exchange		Year-round (with stressor exposure occurring during egg incubation)	Permanent	Continuous		composition can result in decreased rearing habitat suitability, as well as changes in food web complexity. These may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. <u>Adults</u>: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of s) if potential spawning habitat is affected		
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer)	Permanent	Continuous	Transforming adults; Adults (river lamprey)	<u>Transforming adults and adults</u>: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of rearing habitat for lamprey host fish, leading to decreased foraging opportunities for transforming adult Pacific and river lamprey, and adult river lamprey.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect growth and fitness at transforming adult life-history stages through effects on host fish. River lamprey are also known to use nearshore habitats during the adult life-history stage and will be subject to these effects during this period. Direct dependence on nearshore habitat characteristics for both species is a data gap. Decreased growth and fitness may affect survival and productivity during ocean migration life-history phase for both species. Western brook lamprey are non-anadromous and will not be exposed to these stressors.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				
	Lacustrine								
	Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Ammocoetes; Transforming adults; Adults	<u>Ammocoetes</u>: Rearing lamprey ammocoetes are found buried in nearshore lacustrine sediments. Modification of hydraulic and geomorphic conditions may alter habitat suitability, leading to limitations on the amount of available habitat and affecting	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selections of project designs that minimize effects on sediment supply, longshore drift	May affect survival, growth, and fitness at ammocoete life-history stage. Effects on host fish may decrease survival, growth, and fitness of transforming adult and adult lamprey, and spawning productivity of adult

Table A-13 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common		survival, growth, and fitness at this life-history stage. <u>Transforming adults and adults</u>: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for host fish, leading to decreased foraging opportunities for adults and transforming adults. Decreased foraging opportunities may cause decreased growth and fitness, affecting survival during marine migration and spawning productivity.	patterns, and wave energy and current patterns.	lamprey.
	Altered sediment supply		Year-round	Permanent	Continuous				
	Altered substrate composition		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Riverine								
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most extensive)	Permanent	Seasonal	Eggs and ammocoetes	<u>Eggs and ammocoetes:</u> See related stressor responses under Water Quality Modification	Require assessment of the hydraulic effects of the project before permitting.	See effects for related stressors under Water Quality Modification.
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs and ammocoetes; Transforming adults; Adults	<u>All exposed life-history stages</u>: See related stressor responses under Water Quality Modification.		May affect survival, growth, and fitness of all life history stages
	Altered lateral (terrestrial/aquatic) habitat connectivity	Reduced availability of off-channel refuge and rearing habitat. Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs Reduced foraging opportunities and rearing habitat availability Reduced availability of suitable habitats along longitudinal gradient.	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Eggs and ammocoetes; Transforming adults; Adults	<u>All exposed life-history stages</u>: : LWD removal can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of adult spawning and larval rearing habitat for lamprey species. LWD removal may also affect the transport of lamprey ammocoetes to suitable rearing habitats, potentially affecting ammocoete survival. Decreased habitat availability may lead to density-dependent effects on adult spawning success. Adult brook lamprey may also be affected by decreased availability of suitable foraging habitat.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat or longitudinal reach simplification.	May affect survival at egg, ammocete, and transforming adult life-history stages. May affect spawning productivity.
	Altered longitudinal habitat connectivity								
	Marine								
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Transforming adults Adults	<u>Transforming adults and adults</u>: LWD removal in the marine environment can fragment nearshore rearing habitat, forcing migrating and foraging XXX to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Avoid permitting LWD removal projects in areas where significant cumulative effects are already prevalent.	May affect survival and productivity at XXX life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered cover and habitat	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round	Permanent	Continuous	Transforming adults; Adults	See responses to altered habitat complexity under Riparian Vegetation Modification.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect transforming adult and adult survival.
	Lacustrine								
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Adults	All exposed life-history stages: LWD removal in lacustrine environments can fragment nearshore rearing and spawning habitat, forcing migrating and foraging XXX to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival at XXX life-history stage. Decreased fitness may lead to reduced spawning productivity.
	Altered cover and habitat	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Transforming adults; Adults	See responses to altered habitat complexity under Riparian Vegetation Modification.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect transforming adult and adult survival.
	Aquatic Vegetation Modification								
	Marine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Transforming adults; Adults	Transforming adults and adults: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness of Pacific and river lamprey host fish. Effects on host fish in nearshore habitats would also affect adult river lamprey forage opportunities.	Construction: Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect river lamprey transforming adult and adult growth and fitness, as well as productivity of Pacific and river lamprey host fish.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Transforming adults; Adults	Transforming adults and adults: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Transforming adults; Adults	Transforming adults: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure resulting in decreased survival, growth, and fitness of Pacific and river lamprey host fish. Adults: Decreased foraging opportunity due to decreased food web productivity, with resulting decreased growth and reproductive fitness of Pacific and river lamprey. River lamprey use nearshore habitats during this life-history phase, but dependence on habitat complexity remains a data gap.		May affect transforming adult survival and productivity. May affect adult growth and spawning productivity of Pacific and river lamprey host fish. Other effects on adult river lamprey are a data gap.
	Riverine and Lacustrine								

Table A-13 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Ammocoetes; Transforming adults	Ammocoetes and transforming adults: Reduced foraging opportunities due to decreased food web productivity, decreased growth and fitness of Pacific and river lamprey host fish, and decreased prey resources for filter-feeding Western brook lamprey and ammocoete stages of Pacific and river lamprey. Altered prey resource effects to lamprey ammocoete life-history stages are a data gap. Although effects of altered autochthonous production for western brook lamprey are a data gap, alterations could be expected to affect prey resource availability.	Construction: Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect ammocoete and transforming adult growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Transforming adults; Adults	Transforming adults and adults: See related stressor responses under Water Quality Alteration. Effects are related to host fish effects for both Pacific and river lamprey.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Ammocoetes; Transforming adults; Adults	All exposed life-history stages: Reduced foraging opportunities due to decreased food web productivity, decreased growth and fitness of Pacific and river lamprey host fish, and decreased prey resources for filter feeding Western brook lamprey and ammocoete stages of Pacific and river lamprey. Altered prey resource effects to lamprey ammocoete life-history stages are a data gap. Although effects of altered autochthonous inputs on Western brook lamprey are a data gap, alterations could be expected to affect prey resource availability.		Lamprey dependence on habitat complexity provided by freshwater aquatic vegetation is a data gap.
	Riparian Vegetation Modification								
	Riverine								
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: Direct mortality when exposed to temperatures over 68°F for continuous periods. Transforming adults: Altered growth and fitness when exposed to temperatures outside optimal growth range, and alteration of food web patterns, including food web supporting Pacific and river lamprey host fish. Adults and transforming adults: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds. Adults: Decreased spawning fitness due to migration delays caused by thermal barriers.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible	May affect survival, growth, and fitness during incubation, rearing, and spawning.

Table A-13 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered stream bank and shoreline stability	Increased suspended solids; decreased dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and ammocoetes; Transforming adults; Adults	<u>Eggs/ammocoetes:</u> Decreased incubation success due to burial or scour of eggs and rearing ammocoetes. Decreased availability of host fish for Pacific and river lamprey. <u>Transforming adults:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness for Pacific and river lamprey host fish. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. <u>Adults</u>: Potential effects on migration and spawning productivity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness during incubation and transforming adult and adult fitness of host fish for Pacific and river lamprey.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Transforming adults; Adults	<u>Transforming adults:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness of host fish for Pacific and river lamprey. <u>Adults:</u> Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat for host fish of Pacific and river lamprey. Decreased suitable lamprey spawning habitat.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect growth and fitness of transforming adults. May affect adult spawning success.
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and ammocoetes; Adults	Lamprey responses to groundwater exchange are a data gap.	Avoid disturbance of vegetation along stream.	Lamprey dependence on groundwater exchange is currently a data gap. Therefore, the effects of stressor exposure are unknown.
	Marine								
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures)	Year-round, (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Transforming adults; Adults	<u>Transforming adults</u>: Riparian shade and ambient temperature have a relatively minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, transforming adult Pacific and river lamprey trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress. Similar effects on Pacific and river lamprey host fish may affect foraging success. <u>Adults</u>: River lamprey adults are found in nearshore environments and may experience similar effects as described above. Similar effects on river lamprey host fish may affect foraging success, leading to decreased growth and spawning fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness of transforming adult Pacific and river lamprey, as well as adult river lamprey.

Table A-13 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Transforming adults; Adults	Transforming adults: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness of Pacific and river lamprey host fish. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification. Adults: River lamprey adults are found in nearshore environments and may experience similar effects as described above. Similar effects on river lamprey host fish may affect foraging success, leading to decreased growth and spawning fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness of transforming adult Pacific and river lamprey, as well as adult river lamprey.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Transforming adults; Adults	Transforming adults: Pacific and river lamprey host fish depend on allochthonous inputs from marine riparian vegetation. Effects on host fish survival growth and fitness may in turn affect lamprey growth and fitness. Those host fish that feed on benthic organisms (such as mollusks and amphipods) are likely linked to allochthonous material inputs. Adults: Adult river lamprey experience same effects as above.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	For Pacific and river lamprey, effects would be related only to host fish dependence on allochthonous inputs. Western brook lamprey have no marine life-history stage.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Transforming adults; Adults	Transforming adults: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness of host fish for Pacific and river lamprey. Adults: Adult river lamprey experience same effects as above.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect transforming adult survival, growth, and fitness; adult spawning success; and overall population productivity.
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Transforming adults; Adults	Transforming adults and adults (river lamprey): Lamprey dependence on groundwater inflow to nearshore marine habitats is currently a data gap.	Avoid disturbance of vegetation along shoreline.	Effects of the action resulting from this impact mechanism are unknown.
	Lacustrine								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round, (pronounced in winter/summer during solar radiation and ambient temperature	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Ammocoetes; Transforming adults; Adults	Ammocoetes: Larval western brook, river, and potentially Pacific lamprey are found in sheltered nearshore lacustrine habitats, buried in substrates. Altered water temperatures due to riparian modification could limit habitat	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect ammocoete survival, growth, and fitness. May affect growth and fitness of adults and transforming adults.

Table A-13 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
			extremes)				suitability, affecting survival, growth, and fitness. Adults and transforming adults: Adult lamprey dependence on nearshore lacustrine habitats is currently a data gap. However, transforming adult host fish of Pacific and river lamprey may become trapped in isolated habitats, which may increase temperatures and potentially lead to mortality or increased thermal stress and decreased fitness of host fish, affecting foraging opportunities for adults and transforming adults.		
	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Ammocoetes; Transforming adults; Adults	Ammocoetes: Larval western brook, river, and potentially Pacific lamprey are found in sheltered nearshore lacustrine habitats, buried in substrates. Alteration of shoreline stability could lead to increased sedimentation and burial, affecting larval survival. Adults and transforming adults: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness for Pacific and river lamprey host fish. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect ammocoete survival. May affect growth and fitness of adults and transforming adults.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Ammocoetes; Transforming adults; Adults	All life-history stages: Lamprey dependence on allochthonous inputs from shoreline riparian vegetation is a data gap. However, Pacific and river lamprey ammocoete benthic filter feeding stage and the filter feeding of the western brook lamprey could be affected. This could be a stressor to the extent the host fish is stressed by this mechanism of impact.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect ammocoete, transforming adult, and adult growth and fitness, depending on species.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Intermediate-term to permanent (dependent on nature of activity and time required for recovery)	Continuous	Ammocoetes; Transforming adults; Adults	Ammocoetes: Decrease in availability of suitable rearing habitat, leading to decreased survival, growth, and fitness. Transforming adults and adults: Decreased refuge habitat availability and foraging opportunities for host fish, potentially leading to decreased foraging opportunities for Pacific and river lamprey with resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect ammocoete survival, growth, and fitness. May affect adult growth, fitness, and spawning productivity due to effects on host fish.
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Ammocoetes; Transforming adults; Adults	All life-history stages: Lamprey dependence on groundwater inflow in lacustrine habitats is currently a data gap.	Avoid/minimize disturbance of riparian vegetation. Maintain system appropriate riparian buffer widths to the greatest extent possible.	Effects of the action resulting from this impact mechanism are unknown.
	Water Quality Modification								

Table A-13 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to long-term (dependent on contributing mechanism of impact)	Continuous to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: Turbidity sufficient to cause fine sediment embeddedness or increased burial depth may lead to direct mortality and decreased survival of eggs and ammocoetes. Transforming adults and adults: Not a direct stressor to the lamprey. For Pacific and river lamprey, responses depend on stressor magnitude to host fish, which may include the following: unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior.	Ensure that project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and ammocoetes. May affect transforming adult growth and fitness, as well as adult fitness and spawning success.
	Altered pollutant loading	Increased pollutant loading	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and ammocoetes; Transforming adults; Adults	All exposed life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness for Pacific and river lamprey. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival, growth, and fitness of transforming adults and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen (due to eutrophication caused by elevated nutrient export from dewatered floodplains)	Dependent on contributing mechanism of impact	Temporary to short-term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and ammocoetes; Transforming adults; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Effects on host fish are stressors to Pacific and river lamprey. Transforming adults and adults: A physiological response to exposure at toxic levels causing mortality or injury leading to reduced fitness is a data gap. However, effects on host fish are known and would affect Pacific and river lamprey. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality. This is a data gap.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival of incubating eggs and ammocoetes. May affect transforming adult survival, growth, and fitness, as well as adult survival, productivity, and spawning success.
Spawning Substrate Augmentation									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and ammocoetes; Transforming adults; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of all life stages.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and ammocoetes; Transforming adults; Adults	All life-history stages: Very little is known of the effects of pile-driving sounds on lamprey at any life-history stage.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible. Avoid dumping gravel from high banks.	Little is known about the effects of anthropogenic sounds on lamprey.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and ammocoetes; Transforming adults; Adults	All life-history-stages: See responses to related stressors under Water Quality Modification. Water quality effects to ammocoetes are a data gap. However, as Pacific and river lamprey feed on host fish, effects of suspended solids on host fish could affect them. As western brook lamprey are filter feeders, this may not be a stressor for transforming adults and adults.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification.
		Burial (during active sediment placement)	During project construction	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and ammocoetes; Transforming adults;	Eggs and ammocoetes, transforming adults: Injury or mortality from burial during gravel placement.	Restrict in-water work window to periods when incubating eggs and ammocoetes with limited motility are least likely to be present.	May cause direct mortality or injury at egg, ammocete, and transforming adult life-history stages. Injury and stress may affect survival, growth, and fitness.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Transforming adults	Transforming adults: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering and benthic disturbance to the greatest extent practicable.	May affect growth and fitness of Transforming adults.
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Reduced refuge habitat (from potential pool filling)	Year-round	Short-term to intermediate-term	Continuous	Transforming adults; Adults	Transforming Adults: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Ensure that project has been designed properly for ecosystem context.	May affect transforming adult growth and survival, as well as reproductive success and overall population productivity.
	Altered bank stability (intermediate-term effects from passive augmentation projects)	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term	Continuous	Eggs and ammocoetes; Transforming adults;	Eggs and ammocoetes: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and ammocoete survival. Pacific and	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on	May affect survival, growth, and fitness at egg and ammocoete stages and egg and transforming adult life-history stages for host fish of Pacific and river lamprey. May also affect

Table A-13 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered substrate composition/stability			Short-term to long-term		Adults	river lamprey ammocoetes are particularly vulnerable to impact mechanisms that cause scour, deposition, or other forms of substrate modification when buried in fine substrates during rearing periods, which can last for several years. Transforming adults: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, as well as changes in food web complexity. These may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of s) if potential spawning habitat is affected	channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	spawning productivity.
	Aquatic Vegetation Modification								
	Riverine								
	Altered autochthonous production	Reduced foraging opportunities	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Ammocoetes; Transforming adults	Ammocoetes and transforming adults: Reduced foraging opportunities due to decreased food web productivity, decreased growth and fitness of Pacific and river lamprey host fish, and decreased prey resources for filter-feeding Western brook lamprey and ammocoete stages of Pacific and river lamprey. Altered prey resource effects to lamprey ammocoete life-history stages are a data gap. Although effects of altered autochthonous inputs for western brook lamprey are a data gap, alterations could be expected to affect prey resource availability.	Avoid spawning gravel augmentation projects in locations where aquatic vegetation plays a strong role in habitat productivity.	May affect ammocoete and transforming adult growth and fitness.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Ammocoetes; Transforming adults; Adults	All exposed life-history stages: Reduced foraging opportunities due to decreased food web productivity, decreased growth and fitness of Pacific and river lamprey host fish, and decreased prey resources for filter feeding Western brook lamprey and ammocoete stages of Pacific and river lamprey. Altered prey resource effects to lamprey ammocoete life-history stages are a data gap. Although effects of altered autochthonous inputs on Western brook lamprey are a data gap, alterations could be expected to affect prey resource availability.		Lamprey dependence on habitat complexity provided by freshwater aquatic vegetation is a data gap.
	Water Quality Modification								

Table A-13 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: Turbidity sufficient to cause fine sediment embeddedness or increased burial depth may lead to direct mortality and decreased survival of eggs and ammocoetes. Transforming adults and adults: Not a direct stressor to the lamprey. For Pacific and river lamprey, responses depend on stressor magnitude to host fish, which may include the following: unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and ammocoetes. May affect transforming adult growth and fitness, as well as adult fitness and spawning success.
In-Channel/Off-Channel Habitat Creation/Modification									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and ammocoetes; Transforming adults; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of all life stages.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and ammocoetes; Transforming adults; Adults	Adults and transforming adults: Very little is known of the effects of anthropogenic sounds on lamprey at any life-history stage.	Avoid noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit work to in-water work windows. . Limit in-water use of heavy machinery.	Little is known about the effects of anthropogenic sounds on lamprey.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and ammocoetes; Transforming adults; Adults	All life-history-stages: See responses to related stressors under Water Quality Modification. Water quality effects to ammocoetes are a data gap. However, as Pacific and river lamprey feed on host fish, effects of suspended solids on host fish could affect them. As western brook lamprey are filter feeders, this may not be a stressor for transforming adults and adults.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification.

Table A-13 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Ammocoetes; Transforming adults; Adults	Ammocoetes: Mortality, injury, and stress, during dewatering (when buried in riverine sediments). Adults and transforming adults: Mortality, injury, or stress from capture, handling, and relocation. Transforming adults: Increased competition once relocated, and reduced growth and fitness; increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect survival, growth, and fitness at ammocoete, transforming adult, and adult life-history stages.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Transforming adults	Transforming adults: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when transforming adults are present.	May affect survival and fitness at transforming adult life-history stage.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and ammocoetes; Transforming adults; Adults	Ammocoetes: Ammocoetes of Pacific and river lamprey mature buried in fine substrates in the lower reaches and estuaries of larger rivers for extended periods and are therefore vulnerable to direct injury and mortality from benthic disturbance. Transforming adults: Decreased foraging opportunity due to short-term reduction in prey availability. All life-history stages: See responses described for related stressors under Water Quality Modification.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May cause direct mortality or injury to ammocoetes. May affect transforming adult growth and fitness. See effects for related stressors under Water Quality Modification.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Transforming adults	Transforming adults: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering and benthic disturbance to the greatest extent practicable.	May affect growth and fitness of Transforming adults.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: Mortality or injury from entrainment. Transforming adults: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect Transforming adults growth and fitness. See effects for related stressors on all life-history stages under Water Quality Modification.
	Water Quality Modification								

Table A-13 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids (during construction or if in-channel project fails)	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: Turbidity sufficient to cause fine sediment embeddedness or increased burial depth may lead to direct mortality and decreased survival of eggs and ammocoetes. Transforming adults and adults: Not a direct stressor to the lamprey. For Pacific and river lamprey, responses depend on stressor magnitude to host fish, which may include the following: unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure that project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and ammocoetes. May affect transforming adult growth and fitness, as well as adult fitness and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and ammocoetes; Transforming adults; Adults	All exposed life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness for Pacific and river lamprey. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of all exposed life-history stages.
Riparian Planting/Restoration Enhancement									
	Construction and Maintenance Activities								
	Riverine , Lacustrine, Marine								
	Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Ammocoetes; Transforming adults; Adults	Ammocoetes: Larval western brook, river, and potentially Pacific lamprey are found in sheltered nearshore lacustrine habitats, buried in substrates. Altered water temperatures due to riparian modification could limit habitat suitability, affecting survival, growth, and fitness. Adults and transforming adults: Adult lamprey dependence on nearshore lacustrine habitats is currently a data gap. However, transforming adult host fish of Pacific and river lamprey may become trapped in isolated habitats, which may increase temperatures and potentially lead to mortality or increased thermal stress and decreased fitness of host fish, affecting foraging opportunities for adults and transforming adults.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect ammocoete survival, growth, and fitness. May affect growth and fitness of adults and transforming adults.

Table A-13 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Increased suspended solids – due to removal of invasive riparian species Benthic sedimentation – due to removal of invasive riparian species	Year-round (with specific stressors prominent during high flow conditions)	Short-term to intermediate (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and ammocoetes; Transforming adults; Adults	<u>All life-history-stages</u>: See responses to related stressors under Water Quality Modification. Water quality effects to ammocoetes are a data gap. However, as Pacific and river lamprey feed on host fish, effects of suspended solids on host fish could affect them. As western brook lamprey are filter feeders, this may not be a stressor for transforming adults and adults.	Minimize disturbance during invasive species removal. Use appropriate erosion control BMPs both during and after construction.	See effects for related stressors under Water Quality Modification.
	Aquatic Vegetation Modification								
	Riverine, Lacustrine, Marine								
	Altered autochthonous production	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Eggs and ammocoetes; Transforming adults; Adults	<u>All life-history-stages</u>: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness of Pacific and river lamprey host fish. Effects on host fish in nearshore habitats would also affect adult river lamprey forage opportunities.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the aqueous environment.	May affect river lamprey transforming adult and adult growth and fitness, as well as productivity of Pacific and river lamprey host fish.
	Riparian Vegetation Modification								
	Riverine, Lacustrine, Marine								
	Altered Shading and solar input	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Eggs and ammocoetes; Transforming adults; Adults	<u>All life-history-stages</u>: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness of Pacific and river lamprey host fish. Effects on host fish in nearshore habitats would also affect adult river lamprey forage opportunities.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the aqueous environment.	May affect river lamprey transforming adult and adult growth and fitness, as well as productivity of Pacific and river lamprey host fish.
	Water Quality Modification								
	Altered Temperatures	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Ammocoetes; Transforming adults; Adults	<u>Ammocoetes</u>: Larval western brook, river, and potentially Pacific lamprey are found in sheltered nearshore lacustrine habitats, buried in substrates. Altered water temperatures due to riparian modification could limit habitat suitability, affecting survival, growth, and fitness. <u>Adults and transforming adults</u>: Adult lamprey dependence on nearshore lacustrine habitats is currently a data gap. However, transforming adult host fish of Pacific and river lamprey may become trapped in isolated habitats, which may increase temperatures and potentially lead to mortality or increased thermal stress and decreased fitness of host fish, affecting foraging opportunities for adults and transforming adults.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect ammocoete survival, growth, and fitness. May affect growth and fitness of adults and transforming adults.

Table A-13 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids – due to removal of invasive riparian species	Dependent on contributing mechanism of impact	Short-term to intermediate (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: Turbidity sufficient to cause fine sediment embeddedness or increased burial depth may lead to direct mortality and decreased survival of eggs and ammocoetes. Transforming adults and adults: Not a direct stressor to the lamprey. For Pacific and river lamprey, responses depend on stressor magnitude to host fish, which may include the following: unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and ammocoetes. May affect transforming adult growth and fitness, as well as adult fitness and spawning success.
Wetland Creation Restoration/Enhancement									
	Construction and Maintenance Activities								
	Riverine and Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and ammocoetes; Transforming adults; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of all life stages.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and ammocoetes; Transforming adults; Adults	All life-history stages: Very little is known of the effects of pile-driving sounds on lamprey at any life-history stage.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible. Avoid dumping gravel from high banks.	Little is known about the effects of anthropogenic sounds on lamprey.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and ammocoetes; Transforming adults; Adults	All life-history-stages: See responses to related stressors under Water Quality Modification. Water quality effects to ammocoetes are a data gap. However, as Pacific and river lamprey feed on host fish, effects of suspended solids on host fish could affect them. As western brook lamprey are filter feeders, this may not be a stressor for transforming adults and adults.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification.

Table A-13 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Ammocoetes; Transforming adults; Adults	Ammocoetes: Mortality, injury, and stress, during dewatering (when buried in riverine sediments). Adults and transforming adults: Mortality, injury, or stress from capture, handling, and relocation. Transforming adults: Increased competition once relocated, and reduced growth and fitness; increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May affect survival, growth, and fitness at ammocoete, transforming adult, and adult life-history stages.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Transforming adults	Transforming adults: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when transforming adults are present.	May affect survival and fitness at transforming adult life-history stage.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and ammocoetes; Transforming adults; Adults	Ammocoetes: Ammocoetes of Pacific and river lamprey mature buried in fine substrates in the lower reaches and estuaries of larger rivers for extended periods and are therefore vulnerable to direct injury and mortality from benthic disturbance. Transforming adults: Decreased foraging opportunity due to short-term reduction in prey availability. All life-history stages: See responses described for related stressors under Water Quality Modification.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May cause direct mortality or injury to ammocoetes. May affect transforming adult growth and fitness. See effects for related stressors under Water Quality Modification.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Transforming adults	Transforming adults: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering and benthic disturbance to the greatest extent practicable.	May affect growth and fitness of Transforming adults.
	Water Quality Modification								

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids (e.g., during reconnection of fragmented floodplain wetlands, etc.)	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: Turbidity sufficient to cause fine sediment embeddedness or increased burial depth may lead to direct mortality and decreased survival of eggs and ammocoetes. Transforming adults and adults: Not a direct stressor to the lamprey. For Pacific and river lamprey, responses depend on stressor magnitude to host fish, which may include the following: unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure that project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and ammocoetes. May affect transforming adult growth and fitness, as well as adult fitness and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs and ammocoetes; Transforming adults; Adults	All exposed life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness for Pacific and river lamprey. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival, growth, and fitness of transforming adults and adults.
Beach Nourishment/Contouring									
	Construction and Maintenance Activities								
	Marine and Lacustrine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and ammocoetes; Transforming adults; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of all life stages.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids.	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: Littoral disturbance in lacustrine areas may lead to direct mortality and decreased survival of eggs and ammocoetes. Transforming adults: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect survival of incubating eggs and ammocoetes. May affect growth and fitness at transforming adult life-history stage.
	Hydraulic and Geomorphic Modification								
	Marine and Lacustrine								

Table A-13 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered sediment supply	Localized alteration in invertebrate abundance from burial	During project construction and maintenance activities	Short-term – long-term	Interannual to decadal (depending on activity frequency)	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: Littoral disturbance in lacustrine areas may lead to direct mortality and decreased survival of eggs and ammocoetes. Transforming adults: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect survival of incubating eggs and ammocoetes. May affect growth and fitness at Transforming adult life-history stage.
	Aquatic Vegetation Modification								
	Marine and Lacustrine								
	Altered autochthonous production	Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to long-term(dependent on nature of activity)	Continuous	Ammocoetes; Transforming adults	Ammocoetes and transforming adults: Reduced foraging opportunities due to decreased food web productivity, decreased growth and fitness of Pacific and river lamprey host fish, and decreased prey resources for filter-feeding Western brook lamprey and ammocoete stages of Pacific and river lamprey. Altered prey resource effects to lamprey ammocoete life-history stages are a data gap. Although effects of altered autochthonous production for western brook lamprey are a data gap, alterations could be expected to affect prey resource availability.	Avoid/minimize disturbance of aquatic vegetation during project construction. Avoid nourishing beaches updrift of productive, vegetated aquatic habitat.	May affect ammocoete and transforming adult growth and fitness.
	Altered cover and habitat	Reduced cover							
	Water Quality Modification								
	Marine and Lacustrine								
	Altered suspended solids	Increased suspended solids	During construction and during subsequent high energy periods	Temporary to short-term (dependent on grain size of augmented sediment)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: Turbidity sufficient to cause fine sediment embeddedness or increased burial depth may lead to direct mortality and decreased survival of eggs and ammocoetes. Transforming adults and adults: Not a direct stressor to the lamprey. For Pacific and river lamprey, responses depend on stressor magnitude to host fish, which may include the following: unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic shoreline instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and ammocoetes. May affect transforming adult growth and fitness, as well as adult fitness and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs and ammocoetes; Transforming adults; Adults	All exposed life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness for Pacific and river lamprey. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival, growth, and fitness of transforming adults and adults.

Table A-13 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
Reef Creation/Restoration/Enhancement									
	Construction and Maintenance Activities								
	Marine and Lacustrine								
	Equipment operation and materials placement	Elevated noise, visual and physical disturbance	During project construction activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and ammocoetes; Transforming adults; Adults	All life-history stages: Very little is known of the effects of pile-driving sounds on lamprey at any life-history stage.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible. Avoid dumping gravel from high banks.	Little is known about the effects of anthropogenic sounds on lamprey.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction)	Transforming adults; Adults	All life-history stages: Very little is known of the effects of pile-driving sounds on lamprey at any life-history stage.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	Little is known about the effects of anthropogenic sounds on lamprey.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids.	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and ammocoetes; Transforming adults; Adults	All life-history-stages: See responses to related stressors under Water Quality Modification. Water quality effects to ammocoetes are a data gap. However, as Pacific and river lamprey feed on host fish, effects of suspended solids on host fish could affect them. As western brook lamprey are filter feeders, this may not be a stressor for transforming adults and adults.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer)	Permanent	Continuous	Transforming adults; Adults	Transforming adults and adults: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for host fish, leading to decreased foraging opportunities for adults and transforming adults. Decreased foraging opportunities may cause decreased growth and fitness, affecting survival during marine migration and spawning productivity.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	Effects on host fish may decrease survival, growth, and fitness of transforming adult and adult lamprey, and spawning productivity of adult lamprey.
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				

Table A-13 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				
	Lacustrine								
	Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Ammocoetes; Transforming adults; Adults	Ammocoetes: Rearing lamprey ammocoetes are found buried in nearshore lacustrine sediments. Modification of hydraulic and geomorphic conditions may alter habitat suitability, leading to limitations on the amount of available habitat and affecting survival, growth, and fitness at this life-history stage. Transforming adults and adults: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for host fish, leading to decreased foraging opportunities for adults and transforming adults. Decreased foraging opportunities may cause decreased growth and fitness, affecting survival during marine migration and spawning productivity.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at ammocoete life-history stage. Effects on host fish may decrease survival, growth, and fitness of transforming adult and adult lamprey, and spawning productivity of adult lamprey.
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Continuous				
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal				
	Altered sediment supply		Year-round	Permanent	Continuous				
	Altered substrate composition		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Marine								
	Altered cover and habitat	Increased predation risk	Year-round	Permanent	Continuous	Transforming adults	Transforming adults: Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid placement of reef projects in proximity to Transforming adults migratory corridors, such that increased predation exposure may occur.	May affect Transforming adults survival, growth and fitness.
	Lacustrine								
	Altered cover and habitat	Increased predation risk	Year-round	Permanent	Continuous	Transforming adults	Transforming adults: Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid placement of reef projects in proximity to Transforming adults migratory corridors, such that increased predation exposure may occur.	May affect Transforming adults survival, growth and fitness.
	Aquatic Vegetation Modification								
	Marine								

Table A-13 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered cover and habitat	Increased predation risk	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Transforming adults; Adults	Transforming adults: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased foraging opportunity due to decreased food web productivity.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect Transforming adult survival. May affect adult growth and reproductive productivity.
	Lacustrine								
	Altered autochthonous production; Altered cover and habitat	Reduced foraging opportunities	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Transforming adults; Adults	Transforming adults and adults: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness of Pacific and river lamprey host fish. Effects on host fish in nearshore habitats would also affect adult river lamprey forage opportunities.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect river lamprey transforming adult and adult growth and fitness, as well as productivity of Pacific and river lamprey host fish.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: Turbidity sufficient to cause fine sediment embeddedness or increased burial depth may lead to direct mortality and decreased survival of eggs and ammocoetes. Transforming adults and adults: Not a direct stressor to the lamprey. For Pacific and river lamprey, responses depend on stressor magnitude to host fish, which may include the following: unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival of incubating eggs and ammocoetes. May affect transforming adult growth and fitness, as well as adult fitness and spawning success.
	Altered pollutant loading	Leaching of toxic substances (depending on composition of reef material)	Year-round	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Transforming adults; Adults	All affected life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Use non-toxic reef material.	May affect survival, growth, and fitness of transforming adults and adults.
Eel Grass and Other Aquatic Vegetation Creation/Restoration/Enhancement									
	Construction and Maintenance Activities								
	Marine								

Table A-13 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Planting activities and vessel use	Visual, physical, and noise related disturbance	During project construction	Temporary	Interannual to decadal (depending on activity frequency)	Transforming adults; Adults	Transforming adults and adults: Very little is known of the effects of pile-driving sounds on lamprey at any life-history stage.	Adhere to system-specific in-water work windows.	Little is known about the effects of anthropogenic sounds on lamprey.
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Transforming adults; Adults	Transforming adults and adults: Vegetation transplantation projects are not likely to cause pulses of suspended sediment sufficient to lead to injury or mortality. Stressor response may include temporary behavioral avoidance and displacement.	Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May cause temporary behavioral avoidance and displacement.

Table A-14. HPA HCP Habitat Modification Exposure and Response Matrix for Green and White Sturgeon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
Beaver Dam Removal									
Sturgeon do not inhabit areas where beaver are active, thus beaver dam removal will not significantly affect Sturgeon									
Large Woody Debris Placement/Movement/Removal (for placement only construction impacts apply)									
	Construction and Maintenance Activities								
	Riverine, Lacustrine, Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	All life-history stages: See responses described for related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of all life history stages.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Juveniles: Auditory masking may affect ability to avoid predators, leading to effects on survival. Behavioral responses may lead to habitat avoidance, affecting growth and fitness. Adults: May cause avoidance behavior. Note: While these responses are possible, very little is known of the effects of anthropogenic sounds on sturgeon at any life-history stage, so the actual effects of stressor exposure are uncertain.	Although, little is known about the effects of anthropogenic sounds on sturgeon, it is prudent to avoid/ minimize noise intensity during in-water work.	May affect juvenile survival due to avoidance behavior, decreased foraging success, and increased predation risk. May cause adult avoidance behavior. Actual effects are unknown as stressor sensitivity is currently a data gap.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification

Table A-14 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Green and White Sturgeon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	<u>Juveniles and larvae</u>: Mortality, injury, or stress from capture, handling, and relocation. Sturgeon larvae may be too small to capture effectively, leading to mortality or injury from asphyxiation.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct mortality or injury to larvae and juveniles. Stress from relocation may affect survival, growth, and fitness.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	<u>Larvae and juveniles</u>: Injury or mortality from pump entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May cause direct mortality of larvae and juveniles.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	<u>Eggs and larvae</u>: Potential decreased egg incubation success and larval survival due to turbidity exposure and substrate disturbance. Green sturgeon eggs lack thick jelly coat of other sturgeon species and develop more rapidly, indicating greater sensitivity to acute turbidity. <u>Juveniles</u>: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. <u>Adults</u>: May cause avoidance behavior, potentially delaying migration.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect survival during egg and larval life-history stages. May affect juvenile survival, growth, and productivity. May cause adult avoidance behavior, potentially delaying migration and limiting spawning productivity; however, actual sensitivity to these stressors is a data gap.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u>: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Eggs and larvae; Juveniles; Adults	<u>Eggs and larvae:</u> Non-mobile eggs and larvae may experience injury or mortality from dredge entrainment. <u>Juveniles and adults</u>: Decreased growth and fitness due to stress and exertion caused by avoidance behavior and decreased foraging opportunity caused by short-term reduction in prey availability. <u>All life-history stages</u>: See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May cause direct injury or mortality of eggs and larvae. May affect juvenile growth and fitness. See effects for related stressors under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles Adults	<u>Eggs and larvae</u>: Sturgeon are believed to spawn in swift current environments in part because the high velocities protect eggs from predation. Changes in channel morphology, flow velocity, and substrate	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on	May affect survival at egg and larval life-history stages. May affect juvenile growth and fitness. May affect adult spawning productivity.

Table A-14 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Green and White Sturgeon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered flow velocity		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		composition can alter substrate composition and stability, leading to decreased incubation success, and potentially increased predation exposure. Changes in flow regime may cause larvae to be transported to environments unfavorable for survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Juvenile dependence on groundwater exchange is a data gap; however, loss of thermal refuge may decrease the availability of suitable rearing habitat, leading to decreased growth and fitness. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations) if potential spawning habitat is affected	channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	
	Altered substrate composition		Year round	Permanent	Continuous				
	Altered groundwater-surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Adults	Adults: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing marine food web productivity and availability of prey species. This could lead to decreased adult growth and fitness, however incremental effects may not be significant considering the wide ranging marine habitats of adult sturgeon.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selections of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect adult growth and fitness.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				

Table A-14 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Green and White Sturgeon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				
	Lacustrine								
	Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Larvae; Juveniles; Adults	Larvae and juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of juvenile rearing habitat. This may occur through increased predation exposure, food web alterations, and decreased foraging opportunity. Alteration of current and circulation patterns may prevent larvae transport to suitable rearing environments. The combined effect of these stressors can result in decreased survival, growth, and fitness at larval and juvenile life-history stages. Adults: Adult sturgeon are generally less sensitive to these stressors. However, food web productivity in large reservoir environments may be affected by these impact mechanisms. This could lead to reduced adult foraging opportunities in residualized populations, and decreased growth, fitness, and spawning productivity.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selections of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival at larval life-history stage. May affect growth and fitness at juvenile life-history stage. May affect adult growth and fitness, and adult spawning productivity.
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common				
	Altered sediment supply		Year-round	Permanent	Continuous				
	Altered substrate composition		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Riverine								
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most extensive)	Permanent	Seasonal	Larvae; Juveniles;	Larvae and juveniles: See related stressor responses under Water Quality Modification.	Require assessment of the hydraulic effects of the project before permitting.	See effects for related stressors under Water Quality Modification.

Table A-14 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Green and White Sturgeon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Larvae; Juveniles; Adults	All exposed life-history stages: See related stressor responses under Water Quality Modification.		May affect survival, growth, and fitness of juveniles and adults.
	Altered lateral (terrestrial/aquatic) habitat connectivity	Reduced availability of off-channel refuge and rearing habitat. Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: LWD removal can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor may limit the availability of larval sturgeon rearing habitat. Decreased habitat availability may lead to density-dependent effects on larval and juvenile survival, growth, and fitness.	Require assessment of the hydraulic effects of the project before permitting, and avoid permitting designs that lead to disconnection of floodplain habitat.	May affect survival at egg, larvae, and juvenile life-history stages. May affect spawning productivity.
	Altered longitudinal habitat connectivity	Reduced availability of suitable habitats along longitudinal gradient.							
	Marine								
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Juveniles	All exposed life-history stages: LWD removal in the marine environment could possibly fragment nearshore habitat. Sturgeon dependence on these habitat types is currently a data gap; therefore, the effects of this stressor are unknown.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered cover and habitat	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.
	Lacustrine								
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	All exposed life-history stages: LWD removal in lacustrine environments can fragment nearshore habitat, forcing foraging larval and juvenile sturgeon to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion, affecting survival, growth, and fitness.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival at juvenile life-history stage. Decreased fitness may lead to reduced spawning productivity
	Altered cover and habitat	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.
	Aquatic Vegetation Modification								
	Marine								
	Altered autochthonous	Reduced food web productivity	Year-round (most	Permanent	Continuous	Adults	Adults: Adult sturgeon dependence on	Construction: Avoid/minimize	May affect adult growth and fitness.

Table A-14 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Green and White Sturgeon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	production		pronounced in spring and summer when vegetation growth is most extensive)				nearshore aquatic vegetation is a data gap. However, this species feeds on mollusks, fish, and invertebrate species dependent on nearshore food web productivity. Therefore, this stressor could indirectly affect adult growth and fitness.	disturbance of aquatic vegetation during project construction.	However, localized effects are likely to be insignificant.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Adults	Adults: Adult sturgeon dependence on nearshore habitat complexity is limited. However, effects on habitat complexity may limit the availability and productivity of prey species; therefore, this stressor could indirectly affect adult growth and fitness. Given the extended marine foraging habitats used by sturgeon, localized effects are likely to be insignificant.		
	Riverine and Lacustrine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Juvenile sturgeon are known to feed opportunistically upon benthic prey organisms and fish dependent upon autochthonous material; reducing autochthonous production may decrease foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Construction: Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile productivity.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Reduced aquatic habitat complexity may limit the availability of suitable refuge and foraging habitat, leading to increased predation exposure and decreased foraging opportunities, affecting survival, growth, and fitness.		May affect juvenile survival, growth, and fitness.
	Riparian Vegetation Modification								
	Riverine								
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Direct mortality of embryos at temperatures in excess of 68°F (20°C). Juveniles: Altered growth and productivity caused by temperatures outside optimal growth range, and alteration of food web patterns. Decreased growth when exposed to temperatures in excess of 75°F (24°C). Adults: Exposure to thermal barriers is unlikely as spawning migrations occur in mid- to late-winter and spawning occurs in turbulent river mainstems.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible	May affect survival, growth, and fitness during incubation, rearing, and spawning.

Table A-14 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Green and White Sturgeon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered stream bank and shoreline stability	Increased suspended solids; decreased dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles;	Eggs and larvae: Decreased incubation success and larval survival due to effects of turbidity exposure as described above under Water Quality Modification. Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival during incubation larval dispersal, as well as survival, growth, and fitness during juvenile rearing.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival, growth, and fitness.
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Juveniles	Juveniles: Sturgeon dependence on groundwater exchange is currently a data gap. However, juveniles are dependent on water temperatures less than 75°F (24°C) for optimal growth. Reduction in thermal refuge habitat may lead to avoidance behavior, decreased growth, and decreased fitness.	Avoid disturbance of vegetation along stream.	Effects of action resulting from this impact mechanism are unknown, as sturgeon dependence on groundwater-surface water exchange is a data gap. However, loss of thermal refuge habitat may affect juvenile growth and fitness.
	Marine								
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures)	Year-round, (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Adults	Adults: Riparian shade and ambient temperature have a relatively minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. Adult use of nearshore marine habitats is limited; therefore, stressor exposure is unlikely to occur.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	Effects of stressor exposure on adult sturgeon are expected to be insignificant and discountable.
	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Adults	Adults: Adult use of nearshore marine habitats is limited; therefore, stressor exposure is unlikely to occur.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	Effects of stressor exposure on adult sturgeon are expected to be insignificant and discountable.

Table A-14 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Green and White Sturgeon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Adults	Adults: Sturgeon dependence on allochthonous inputs from marine riparian vegetation is a data gap.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	Sensitivity to stressor exposure is currently a data gap; therefore, the effects of the action from this impact mechanism are unknown.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Adults	Adults: Adult use of nearshore marine habitats is limited; therefore, stressor exposure is unlikely to occur.	Encourage project designs that limit permanent alteration of high-quality habitat features.	Effects of stressor exposure on adult sturgeon are expected to be insignificant and discountable.
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Adults	Adult: Sturgeon dependence on groundwater inflow to nearshore marine habitats is currently a data gap. However, adult use of nearshore marine habitats is limited; therefore, stressor exposure is unlikely to occur.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	Sensitivity to stressor exposure is currently a data gap; therefore, the effects of the action from this impact mechanism are unknown.
	Lacustrine								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round, (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles	Juveniles: Riparian shade and ambient temperature have a relatively minor effect on nearshore water temperatures relative to the dominant influence of turnover time, stratification patterns, wind conditions, and other factors. However, the suitability of some protected habitats such as isolated embayments may be affected, leading to decreased rearing habitat availability and increased competition, leading to decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness.
	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs predominantly during spring outmigration period through lakes)	Permanent	Continuous	Juveniles	Juveniles: Sturgeon dependence on allochthonous inputs from lacustrine riparian vegetation is a data gap. However, juvenile sturgeon are opportunistic feeders. Loss of terrestrial insect-fall could lead to decreased foraging opportunities, affecting growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness.

Table A-14 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Green and White Sturgeon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile growth and fitness.
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Permanent	Continuous	Juveniles	<u>Juveniles</u>: Sturgeon dependence on groundwater inflow to nearshore lacustrine habitats is currently a data gap. However, juveniles are dependent on water temperatures less than 75°F (24°C) for optimal growth. Reduction in thermal refuge habitat may lead to avoidance behavior, decreased growth, and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system appropriate riparian buffer widths to the greatest extent possible.	Effects of action resulting from this impact mechanism are unknown, as sturgeon dependence on lacustrine groundwater inflow is a data gap. However, loss of thermal refuge habitat may affect juvenile growth and fitness.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to long-term (dependent on contributing mechanism of impact)	Continuous to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	<u>Eggs and larvae:</u> Turbidity may lead to direct mortality and decreased survival of eggs and larvae. Green sturgeon eggs lack thick jelly coat of other sturgeon species and develop more rapidly, indicating greater sensitivity to acute turbidity. <u>Juveniles and adults</u>: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to reduced foraging opportunity, increased predation exposure, and altered migration behavior.	Ensure that project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of eggs and larvae. May affect juvenile productivity and adult productivity and spawning success. May cause direct mortality or injury in acute events.

Table A-14 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Green and White Sturgeon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered pollutant loading	Increased pollutant loading	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality. Due to their long lifespan and high age at maturity, adult sturgeon are at risk from adverse effects from bioaccumulation of contaminants. Chronic exposure to contaminants may affect adult survival, growth, fitness, and spawning productivity.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival, growth, and fitness of all exposed life-history stages.
	Altered dissolved oxygen	Decreased dissolved oxygen (due to eutrophication caused by elevated nutrient export from dewatered floodplains)	Dependent on contributing mechanism of impact	Temporary to short-term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles and adults: Physiological responses to exposure at levels exceeding tolerance thresholds, causing mortality or injury leading to reduced fitness. Avoidance behavior during subacute events.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival of incubating eggs and larvae. May affect juvenile and adult survival, growth, and fitness.
Spawning Substrate Augmentation									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	All life-history stages: See responses described for related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of all life history stages.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Juveniles: Auditory masking may affect ability to avoid predators, leading to effects on survival. Behavioral responses may lead to habitat avoidance, affecting growth and fitness. Adults: May cause avoidance behavior. Note: While these responses are possible, very little is known of the effects of anthropogenic sounds on sturgeon at any life-history stage, so the actual effects of stressor exposure are uncertain.	Although, little is known about the effects of anthropogenic sounds on sturgeon, it is prudent to avoid/ minimize noise intensity during in-water work.	May affect juvenile survival due to avoidance behavior, decreased foraging success, and increased predation risk. May cause adult avoidance behavior. Actual effects are unknown as stressor sensitivity is currently a data gap.

Table A-14 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Green and White Sturgeon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification
		Burial (during active sediment placement)	During project construction	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles;	Eggs and larvae, juveniles: Injury or mortality from burial during gravel placement.	Restrict in-water work window to periods when incubating eggs and larvae with limited motility are least likely to be present.	May cause direct mortality or injury at egg, larvae, and juvenile life-history stages. Injury and stress may affect survival, growth, and fitness.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
	Hydraulic and Geomorphic Modification								
	Riverine								

Table A-14 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Green and White Sturgeon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered channel geometry	Reduced refuge habitat (from potential pool filling)	Year-round	Short-term to intermediate-term	Continuous	Eggs and larvae; Juveniles Adults	Eggs and larvae: Sturgeon are believed to spawn in swift current environments in part because the high velocities protect eggs from predation. Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success, and potentially increased predation exposure. Changes in flow regime may cause larvae to be transported to environments unfavorable for survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Juvenile dependence on groundwater exchange is a data gap; however, loss of thermal refuge may decrease the availability of suitable rearing habitat, leading to decreased growth and fitness. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations) if potential spawning habitat is affected	Ensure that project has been designed properly for ecosystem context.	May affect survival at egg and larval life-history stages. May affect juvenile growth and fitness. May affect adult spawning productivity.
	Altered bank stability (intermediate-term effects from passive augmentation projects)	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term	Continuous	Eggs and larvae; Juveniles Adults	Eggs and larvae: Changes in substrate composition and stability may lead to decreased incubation success and larvae survival while augmentation projects stabilize. Juveniles: Altered channel geometry, bank	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of augmentation projects that minimize	May affect survival at egg, larvae, and juvenile life-history stages. May affect spawning productivity.

Table A-14 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Green and White Sturgeon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered substrate composition/stability			Short-term to long-term			stability, and substrate composition can result in short-term to intermediate-term changes in rearing habitat suitability and changes in food web complexity while augmentation projects stabilize. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology and bank structure may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate stability may lead to decreased spawning success while augmentation projects stabilize. However, adverse effects would be expected to be short-term in nature, while beneficial effects would be expected to persist.	adverse effects on channel geometry, bank conditions, and substrate stability to the greatest extent practicable.	
	Aquatic Vegetation Modification								
	Riverine								
	Altered autochthonous production	Reduced foraging opportunities	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Juvenile sturgeon are known to feed opportunistically upon benthic prey organisms and fish dependent upon autochthonous material; reducing autochthonous production may decrease foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Avoid spawning gravel augmentation projects in locations where aquatic vegetation plays a strong role in habitat productivity.	May affect juvenile survival, growth, and fitness.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Reduced aquatic habitat complexity may limit the availability of suitable refuge and foraging habitat, leading to increased predation exposure and decreased foraging opportunities, affecting survival, growth, and fitness.		
	Water Quality Modification								

Table A-14 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Green and White Sturgeon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity may lead to direct mortality and decreased survival of eggs and larvae. Green sturgeon eggs lack thick jelly coat of other sturgeon species and develop more rapidly, indicating greater sensitivity to acute turbidity. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to reduced foraging opportunity, increased predation exposure, and altered migration behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of eggs and larvae. May affect juvenile productivity and adult productivity and spawning success. May cause direct mortality or injury in acute events.
In-Channel/Off-Channel Habitat Creation/Modification									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	All life-history stages: See responses described for related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of all life history stages.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Juveniles: Auditory masking may affect ability to avoid predators, leading to effects on survival. Behavioral responses may lead to habitat avoidance, affecting growth and fitness. Adults: May cause avoidance behavior. Note: While these responses are possible, very little is known of the effects of anthropogenic sounds on sturgeon at any life-history stage, so the actual effects of stressor exposure are uncertain.	Although, little is known about the effects of anthropogenic sounds on sturgeon, it is prudent to avoid/ minimize noise intensity during in-water work.	May affect juvenile survival due to avoidance behavior, decreased foraging success, and increased predation risk. May cause adult avoidance behavior. Actual effects are unknown as stressor sensitivity is currently a data gap.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification

Table A-14 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Green and White Sturgeon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	Juveniles and larvae: Mortality, injury, or stress from capture, handling, and relocation. Sturgeon larvae may be too small to capture effectively, leading to mortality or injury from asphyxiation.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct mortality or injury to larvae and juveniles. Stress from relocation may affect survival, growth, and fitness.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	Larvae and juveniles: Injury or mortality from pump entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May cause direct mortality of larvae and juveniles.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Potential decreased egg incubation success and larval survival due to turbidity exposure and substrate disturbance. Green sturgeon eggs lack thick jelly coat of other sturgeon species and develop more rapidly, indicating greater sensitivity to acute turbidity. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: May cause avoidance behavior, potentially delaying migration.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect survival during egg and larval life-history stages. May affect juvenile survival, growth, and productivity. May cause adult avoidance behavior, potentially delaying migration and limiting spawning productivity; however, actual sensitivity to these stressors is a data gap.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Non-mobile eggs and larvae may experience injury or mortality from dredge entrainment. Juveniles and adults: Decreased growth and fitness due to stress and exertion caused by avoidance behavior and decreased foraging opportunity caused by short-term reduction in prey availability. All life-history stages: See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May cause direct injury or mortality of eggs and larvae. May affect juvenile growth and fitness. See effects for related stressors under Water Quality Modification.
	Water Quality Modification								

Table A-14 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Green and White Sturgeon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered suspended solids	Increased suspended solids (during construction or if in-channel project fails)	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity may lead to direct mortality and decreased survival of eggs and larvae. Green sturgeon eggs lack thick jelly coat of other sturgeon species and develop more rapidly, indicating greater sensitivity to acute turbidity. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to reduced foraging opportunity, increased predation exposure, and altered migration behavior.	Ensure that project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of eggs and larvae. May affect juvenile productivity and adult productivity and spawning success. May cause direct mortality or injury in acute events.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality. Due to their long lifespan and high age at maturity, adult sturgeon are at risk from adverse effects from bioaccumulation of contaminants. Chronic exposure to contaminants may affect adult survival, growth, fitness, and spawning productivity.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of all exposed life-history stages.
Riparian Planting/Restoration Enhancement									
	Construction and Maintenance Activities								
	Riverine , Lacustrine, Marine								

Table A-14 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Green and White Sturgeon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Direct mortality of embryos at temperatures in excess of 68°F (20°C). Juveniles: Altered growth and productivity caused by temperatures outside optimal growth range, and alteration of food web patterns. Decreased growth when exposed to temperatures in excess of 75°F (24°C). Adults: Exposure to thermal barriers is unlikely as spawning migrations occur in mid- to late-winter and spawning occurs in turbulent river mainstems.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible	May affect survival, growth, and fitness during incubation, rearing, and spawning.
		Increased suspended solids – due to removal of invasive riparian species Spawning gravel sedimentation – due to removal of invasive riparian species	Year-round (with specific stressors prominent during high flow conditions)	Short-term to intermediate (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification
	Aquatic Vegetation Modification								
	Riverine and Lacustrine								
	Altered autochthonous production	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Juvenile sturgeon are known to feed opportunistically upon benthic prey organisms and fish dependent upon autochthonous material; reducing autochthonous production may decrease foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect juvenile productivity.
	Marine								

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered autochthonous production	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Adults	Adults: Adult sturgeon dependence on nearshore aquatic vegetation is a data gap. However, this species feeds on mollusks, fish, and invertebrate species dependent on nearshore food web productivity. Therefore, this stressor could indirectly affect adult growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect adult growth and fitness. However, localized effects are likely to be insignificant.
	Riparian Vegetation Modification								
	Riverine and Lacustrine								
	Altered Shading and solar input	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Juvenile sturgeon are known to feed opportunistically upon benthic prey organisms and fish dependent upon allochthonous material; reducing allochthonous production may decrease foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect juvenile productivity.
	Marine								
	Altered Shading and solar input	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Adults	Adults: Adult sturgeon dependence on nearshore aquatic vegetation is a data gap. However, this species feeds on mollusks, fish, and invertebrate species dependent on nearshore food web productivity. Therefore, this stressor could indirectly affect adult growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect adult growth and fitness. However, localized effects are likely to be insignificant.
	Water Quality Modification								
	Altered Temperatures	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Direct mortality of embryos at temperatures in excess of 68°F (20°C). Juveniles: Altered growth and productivity caused by temperatures outside optimal growth range, and alteration of food web patterns. Decreased growth when exposed to temperatures in excess of 75°F (24°C). Adults: Exposure to thermal barriers is unlikely as spawning migrations occur in mid- to late-winter and spawning occurs in turbulent river mainstems.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible	May affect survival, growth, and fitness during incubation, rearing, and spawning.

Table A-14 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Green and White Sturgeon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids – due to removal of invasive riparian species	Dependent on contributing mechanism of impact	Short-term to intermediate (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity may lead to direct mortality and decreased survival of eggs and larvae. Green sturgeon eggs lack thick jelly coat of other sturgeon species and develop more rapidly, indicating greater sensitivity to acute turbidity. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to reduced foraging opportunity, increased predation exposure, and altered migration behavior.	Ensure that project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of eggs and larvae. May affect juvenile productivity and adult productivity and spawning success. May cause direct mortality or injury in acute events.
Wetland Creation Restoration/Enhancement									
	Construction and Maintenance Activities								
	Riverine and Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	All life-history stages: See responses described for related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of all life history stages.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Juveniles: Auditory masking may affect ability to avoid predators, leading to effects on survival. Behavioral responses may lead to habitat avoidance, affecting growth and fitness. Adults: May cause avoidance behavior. Note: While these responses are possible, very little is known of the effects of anthropogenic sounds on sturgeon at any life-history stage, so the actual effects of stressor exposure are uncertain.	Although, little is known about the effects of anthropogenic sounds on sturgeon, it is prudent to avoid/ minimize noise intensity during in-water work.	May affect juvenile survival due to avoidance behavior, decreased foraging success, and increased predation risk. May cause adult avoidance behavior. Actual effects are unknown as stressor sensitivity is currently a data gap.

Table A-14 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Green and White Sturgeon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	Juveniles and larvae: Mortality, injury, or stress from capture, handling, and relocation. Sturgeon larvae may be too small to capture effectively, leading to mortality or injury from asphyxiation.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct mortality or injury to larvae and juveniles. Stress from relocation may affect survival, growth, and fitness.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	Larvae and juveniles: Injury or mortality from pump entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May cause direct mortality of larvae and juveniles.
		Benthic disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Potential decreased egg incubation success and larval survival due to turbidity exposure and substrate disturbance. Green sturgeon eggs lack thick jelly coat of other sturgeon species and develop more rapidly, indicating greater sensitivity to acute turbidity. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: May cause avoidance behavior, potentially delaying migration.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect survival during egg and larval life-history stages. May affect juvenile survival, growth, and productivity. May cause adult avoidance behavior, potentially delaying migration and limiting spawning productivity; however, actual sensitivity to these stressors is a data gap.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
	Water Quality Modification								

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered suspended solids	Increased suspended solids (e.g., during reconnection of fragmented floodplain wetlands, etc.)	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity may lead to direct mortality and decreased survival of eggs and larvae. Green sturgeon eggs lack thick jelly coat of other sturgeon species and develop more rapidly, indicating greater sensitivity to acute turbidity. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to reduced foraging opportunity, increased predation exposure, and altered migration behavior.	Ensure that project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of eggs and larvae. May affect juvenile productivity and adult productivity and spawning success. May cause direct mortality or injury in acute events.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality. Due to their long lifespan and high age at maturity, adult sturgeon are at risk from adverse effects from bioaccumulation of contaminants. Chronic exposure to contaminants may affect adult survival, growth, fitness, and spawning productivity.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival, growth, and fitness of all exposed life-history stages.
Beach Nourishment/Contouring									
	Construction and Maintenance Activities								
	Lacustrine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	All life-history stages: See responses described for related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of all life history stages.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.

Table A-14 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Green and White Sturgeon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Lacustrine								
	Altered sediment supply	Localized alteration in invertebrate abundance from burial	During project construction and maintenance activities	Short-term – long-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.
	Aquatic Vegetation Modification								
	Lacustrine								
	Altered autochthonous production	Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to long-term(dependent on nature of activity)	Continuous	Juveniles	Juveniles: Juvenile sturgeon are known to feed opportunistically upon benthic prey organisms and fish dependent upon autochthonous material; reducing autochthonous production may decrease foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction. Avoid nourishing beaches updrift of productive, vegetated aquatic habitat.	May affect juvenile productivity.
	Altered cover and habitat	Reduced cover							
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	During construction and during subsequent high energy periods	Temporary to short-term (dependent on grain size of augmented sediment)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity may lead to direct mortality and decreased survival of eggs and larvae. Green sturgeon eggs lack thick jelly coat of other sturgeon species and develop more rapidly, indicating greater sensitivity to acute turbidity. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to reduced foraging opportunity, increased predation exposure, and altered migration behavior.	Ensure that project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of eggs and larvae. May affect juvenile productivity and adult productivity and spawning success. May cause direct mortality or injury in acute events.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality. Due to their long lifespan and high age at maturity, adult sturgeon are at risk from adverse effects from bioaccumulation of contaminants. Chronic exposure to contaminants may affect adult survival, growth, fitness, and spawning productivity.	Refuel and service machinery in a controlled environment away from the water body.	May affect survival, growth, and fitness of all exposed life-history stages.
Reef Creation/Restoration/Enhancement									
	Construction and Maintenance Activities								
	Marine and Lacustrine								
	Equipment operation and materials placement	Elevated noise, visual and physical disturbance	During project construction activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Juveniles: Auditory masking may affect ability to avoid predators, leading to effects on survival. Behavioral responses may lead to habitat avoidance, affecting growth and fitness. Adults: May cause avoidance behavior. Note: While these responses are possible, very little is known of the effects of anthropogenic sounds on sturgeon at any life-history stage, so the actual effects of stressor exposure are uncertain.	Although, little is known about the effects of anthropogenic sounds on sturgeon, it is prudent to avoid/ minimize noise intensity during in-water work.	May affect juvenile survival due to avoidance behavior, decreased foraging success, and increased predation risk. May cause adult avoidance behavior. Actual effects are unknown as stressor sensitivity is currently a data gap.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.
	Hydraulic and Geomorphic Modification								
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Adults	Adults: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selections of project designs that minimize effects on	May affect adult growth and fitness. Actual effects are unknown as stressor sensitivity is currently a data gap.

Table A-14 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Green and White Sturgeon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal		parameters can fundamentally alter marine littoral habitats, potentially decreasing marine food web productivity and availability of prey species. This could lead to decreased adult growth and fitness, however incremental effects may not be significant considering the wide ranging marine habitats of adult sturgeon.	sediment supply, longshore drift patterns, and wave energy and current patterns.	
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				
	Lacustrine								
	Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Larvae; Juveniles; Adults	Larvae and juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of juvenile rearing habitat. This may occur through increased predation exposure, food web alterations, and decreased foraging opportunity. Alteration of current and circulation patterns may prevent larvae transport to suitable rearing environments. The combined effect of these stressors can	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selections of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival at larval life-history stage. May affect growth and fitness at juvenile life-history stage. May affect adult growth and fitness, and adult spawning productivity.
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Continuous				
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal				
	Altered sediment supply		Year-round	Permanent	Continuous				

Table A-14 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Green and White Sturgeon.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered substrate composition		Year-round	Permanent	Continuous		result in decreased survival, growth, and fitness at larval and juvenile life-history stages. Adults: Adult sturgeon are generally less sensitive to these stressors. However, food web productivity in large reservoir environments may be affected by these impact mechanisms. This could lead to reduced adult foraging opportunities in residualized populations, and decreased growth, fitness, and spawning productivity.		
	Ecosystem Fragmentation								
	Lacustrine								
	Altered cover and habitat	Increased predation by piscivorous fish	Year-round	Permanent	Continuous	Juveniles	Juveniles: Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid placement of reef projects in proximity to juvenile migratory corridors, such that increased predation exposure may occur.	May affect juvenile survival, growth and fitness.
	Aquatic Vegetation Modification								
	Marine								
	Altered cover and habitat	Decreased refuge and forage habitat	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Adults	Adults: Adult sturgeon dependence on nearshore aquatic vegetation is a data gap. However, this species feeds on mollusks, fish, and invertebrate species dependent on nearshore food web productivity. Therefore, this stressor could indirectly affect adult growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect adult growth and fitness. However, localized effects are likely to be insignificant.
	Lacustrine								
	Altered autochthonous production Altered cover and habitat	Reduced foraging opportunities	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Juvenile sturgeon are known to feed opportunistically upon benthic prey organisms and fish dependent upon autochthonous material; reducing autochthonous production may decrease foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile productivity.
	Water Quality Modification								

Table A-14 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Green and White Sturgeon.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity may lead to direct mortality and decreased survival of eggs and larvae. Green sturgeon eggs lack thick jelly coat of other sturgeon species and develop more rapidly, indicating greater sensitivity to acute turbidity. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to reduced foraging opportunity, increased predation exposure, and altered migration behavior.	Ensure that project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of eggs and larvae. May affect juvenile productivity and adult productivity and spawning success. May cause direct mortality or injury in acute events.
	Altered pollutant loading	Leaching of toxic substances (depending on composition of reef material)	Year-round	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality. Due to their long lifespan and high age at maturity, adult sturgeon are at risk from adverse effects from bioaccumulation of contaminants. Chronic exposure to contaminants may affect adult survival, growth, fitness, and spawning productivity.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival, growth, and fitness of all exposed life-history stages.
Eel Grass and Other Aquatic Vegetation Creation/Restoration/Enhancement									
	No negative impacts.								

Table A-15. HPA HCP Habitat Modification Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Beaver Dam Removal									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness. May affect survival, growth, and fitness of juveniles and adults.
		Visual, physical, and noise related disturbance	During project construction and maintenance activities	Temporary (disturbance) to short-term (displacement, auditory masking, hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	Unlikely to affect smelt populations when activities are conducted in prescribed in-water work windows, avoiding spawning disruptions. Exposure to stressor may affect survival and productivity due to avoidance behavior, decreased foraging success, and increased predation risk.
	Impoundment dewatering	Fish entrainment, stranding, displacement	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Juveniles (Lake Washington longfin smelt); Adults	Eggs and larvae: Channel dewatering will cause egg mortality. Juveniles: Juvenile smelt are generally believed to migrate offshore and will therefore not likely be exposed to dewatering. Lake Washington longfin smelt are an exception; potential nearshore habitat use by this population is currently a data gap. Adults: Capture, handling, and relocation are likely to cause mortality or injury and stress leading to mortality or decreased spawning fitness. Delayed migration resulting in decreased fitness and spawning success.	Manage dam removal to drain impoundment as slowly as practicable. Avoid scouring flows. Use beaver deceivers to limit hydraulic alteration.	Unlikely to affect eggs, larvae, and adults if activities are conducted during in-water work windows. Capture and removal of eggs, larvae, and juveniles is impractical, meaning that activities occurring during incubation and emigration periods may affect survival during these life-history stages. Capture and removal of adults are likely to affect survival and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: With the exception of the Lake Washington longfin population, smelt do not feed on benthic organisms in freshwater systems and will be unaffected by this stressor. In Lake Washington and in marine systems, smelt are planktonic feeders that are not likely to be affected by temporary decreases in benthic invertebrate abundance.	Limit area of dewatering to the greatest extent practicable. Use beaver deceivers to limit hydraulic alteration.	Not likely to affect smelt at any life-history stage.
		Increased suspended solids	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering.	See effects for related stressors under Water Quality Modification.

Table A-15 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term to long-term	Continuous	Eggs; Larvae; Juveniles; Adults	Eggs: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and larval survival. Larvae and juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of XXX) if potential spawning habitat is affected.	Carefully evaluate ecological context and consider the magnitude of impact mechanisms produced by the project. Prevent rapid dewatering of impoundments likely to cause scouring flows. Encourage use of beaver deceivers.	May affect survival at egg and larval life-history stages. May affect spawning productivity.
	Altered flow velocity		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Intermediate-term to long-term	Seasonal				
	Altered bank stability		Year round especially during high flows	Intermediate-term to long-term	Seasonal				
	Altered substrate composition (including spawning gravel sedimentation)		Year round	Intermediate-term to long-term	Continuous				
	Altered groundwater-surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Intermediate-term to long-term	Continuous				
	Ecosystem Fragmentation								
	Riverine								
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most extensive)	Permanent	Seasonal	Eggs; Larvae;	Eggs and larvae: See related stressor responses under Water Quality Modification.	Avoid draining impounded area through use of beaver deceivers.	See effects for related stressors under Water Quality Modification.
		Decreased dissolved oxygen from eutrophication below the impoundment (caused by elevated nutrient export)							
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs; Larvae; Juveniles; Adults	All exposed life-history stages: See related stressor responses under Water Quality Modification.	Avoid draining impounded area through use of beaver deceivers.	May affect survival, growth, and fitness of juveniles and adults.

Table A-15 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered terrestrial/aquatic connectivity	Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs Reduced foraging opportunities and rearing habitat availability	Year-round	Permanent	Continuous	Larvae; Adults	Adults: LWD removal can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor is unlikely to significantly affect mainstem spawning eulachon and longfin smelt. Planktonic larvae are carried downstream to estuarine habitats, and are not dependent on floodplain habitats.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of high quality floodplain habitat.	May affect survival at egg, larvae, and juvenile life-history stages. May affect spawning productivity.
	Aquatic Vegetation Modification								
	Riverine								
	Altered autochthonous production Altered cover and habitat	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Eggs; Larvae; Adults	All exposed life-history stages: Smelt dependence on freshwater submerged aquatic vegetation is currently a data gap. Therefore, the potential for exposure to these stressors is unknown.	Avoid draining impounded area through use of beaver deceivers.	Sensitivity to stressor exposure is currently a data gap for these species; therefore, the potential effects resulting from this impact mechanism are unknown.
	Riparian Vegetation Modification								
	Riverine								
	Altered stream bank and shoreline stability	Increased suspended solids Spawning gravel sedimentation	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs; Larvae; Adults	Eggs and larvae: Decreased incubation success due to smothering of eggs as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential, migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Initiate proper erosion control measures both during and after construction. Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	May affect survival during egg incubation; may affect spawning fitness and productivity.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Long-term to permanent	Continuous	Larvae	Larvae: Larval longfin smelt and eulachon feed on forage on riverine plankton following emergence and transport to estuarine and marine habitats. Reduced allochthonous inputs may affect food web productivity, leading to decreased growth and fitness.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	May affect larval growth and fitness.

Table A-15 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered buffering capability	Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs; Larvae; Juveniles; Adults	All exposed life-history stages: See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modification.
		Decreased dissolved oxygen from eutrophication (caused by elevated nutrient export)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Long-term to permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modification.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause burial or coating of eggs may lead to direct mortality. Increased turbidity may decrease larval foraging success, resulting in decreased growth and fitness. Juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs. May affect juvenile productivity, adult productivity, and spawning success.
	Altered pollutant loading	Increased exposure to toxic substances	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles	Eggs and larvae, juveniles: Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel machinery in a controlled environment away from the project area. Avoid reducing hydraulic complexity.	May affect survival and productivity of eggs, larvae, and juveniles
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved events due to asphyxiation. Juveniles and adults: Avoidance behavior and increased stress, leading to reduced growth and fitness.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival of incubating eggs. May affect juvenile survival and productivity and adult survival, productivity, and spawning success.
Large Woody Debris Placement/Movement/Removal (for placement only construction impacts apply)									

Table A-15 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Construction and Maintenance Activities								
	Riverine, Lacustrine, Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness. May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs; Larvae; Juveniles; Adults	Eggs and larvae: Noise of sufficient magnitude may cause direct mortality of eggs and larval smelt or permanent injury leading to decreased survival and fitness. Adults and juveniles: Stressor response, depending on noise magnitude and project-specific environmental conditions, may range from: • Fatal injury or permanent auditory tissue damage limiting to survival. • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey. • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to system-specific in-water work windows to avoid stressor exposure during spawning, incubation, and larval dispersal (November to April, depending on system). If pile driving is necessary during spawning period, use double-confined bubble curtain to attenuate sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Unlikely to affect smelt populations when activities are conducted in prescribed in-water work windows, avoiding spawning, incubation, and larval dispersal. The potential for juvenile exposure is less well known. Except for the landlocked Lake Washington population of longfin smelt, juvenile habitat use by these species is poorly understood. Subadults are known to migrate to offshore areas on the continental shelf.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs; Larvae; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification.

Table A-15 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Juveniles (Lake Washington longfin smelt); Adults	Eggs and larvae: Channel dewatering will cause egg mortality. Juveniles: Juvenile smelt are generally believed to migrate offshore and will therefore not likely be exposed to dewatering. Lake Washington longfin smelt are an exception; potential nearshore habitat use by this population is currently a data gap. Adults: Capture, handling, and relocation are likely to cause mortality or injury and stress leading to mortality or decreased spawning fitness. Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	Unlikely to affect eggs, larvae, and adults if activities are conducted during in-water work windows. Capture and removal of eggs, larvae, and juveniles is impractical, meaning that activities occurring during incubation and emigration periods may affect survival during these life-history stages. Capture and removal of adults are likely to affect survival and spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Eggs, larvae, and juveniles: Pump entrainment is highly likely to cause mortality of larvae and drifting eggs. This effect cannot be avoided by pump screening. Entrainment and impingement are likely to cause mortality of juveniles. Adults: Impingement is likely to cause adult mortality.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	Unlikely to affect survival and productivity during egg and larvae and adult life-history stages if activities are conducted outside in-water work windows. If activities are permitted during in-water work windows, activity may affect adult and egg and larval survival. The potential for effects on juvenile smelt survival in marine habitats and Lake Washington are unknown because habitat use by this life-history stage is a data gap.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Adults	Eggs and larvae: Potential decreased egg incubation success and larval survival due to turbidity exposure and substrate disturbance. Adults: Stress and behavioral modifications by adult spawners exposed to sediment pulses, migration delay, increased predation exposure, decreased spawning habitat suitability.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	Unlikely to affect egg survival and adult spawning productivity when activities are conducted during in-water work windows. May affect these parameters if activities occur during spawning and incubation.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: With the exception of the Lake Washington longfin population, smelt do not feed on benthic organisms in freshwater systems and will be unaffected by this stressor. In Lake Washington and in marine systems, smelt are planktonic feeders that are not likely to be affected by temporary decreases in benthic invertebrate abundance.	Limit area of dewatering to the greatest extent practicable.	Not likely to affect smelt at any life-history stage.
	Hydraulic and Geomorphic Modification								
	Riverine								

Table A-15 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs; Larvae; Juveniles; Adults	Eggs: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and larval survival. Larvae and juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of XXX) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg and larval life-history stages. May affect spawning productivity.
	Altered flow velocity		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition		Year round	Permanent	Continuous				
	Altered groundwater-surface water exchange		Year-round (with stressor exposure occurring during egg incubation and juvenile rearing)	Permanent	Continuous				
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Larvae; Juveniles; Adults	Larvae and juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats. Longfin smelt and eulachon dependence on these habitats is currently a data gap. However, alteration of current velocities and circulation patterns may cause transportation of planktonic larvae to unfavorable habitats for growth and development. Alteration of nearshore habitat productivity may also	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at the larval and juvenile life-history stages. Decreased fitness may affect survival and productivity during ocean migration life-history phase, and may affect spawning productivity.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				

Table A-15 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous		have concomitant effects on food web relationships in the offshore environment. Adults: Alteration of nearshore habitat parameters may affect survival and foraging opportunities at larval and juvenile life-history stages, leading to decreased adult fitness, decreased survival, and decreased spawning productivity.		
	Lacustrine								
	Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Lake Washington longfin smelt. Larvae; Juveniles; Adults	Larvae, juveniles, and adults: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, with concomitant food web effects throughout the lacustrine ecosystem. Therefore, alteration of these parameters may affect foraging opportunities for longfin smelt at larval and juvenile life-history stages, leading to decreased adult fitness and decreased spawning success.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect productivity at larval and juvenile life-history stage. Decreased fitness may lead to reduced spawning productivity.
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common				
	Altered sediment supply		Year-round	Permanent	Continuous				
	Altered substrate composition		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Riverine								
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most extensive)	Permanent	Seasonal	Unknown	Longfin smelt and eulachon dependence on groundwater exchange is currently a data gap.	Require assessment of the hydraulic effects of the project before permitting.	Sensitivity to stressor exposure is currently a data gap for these species; therefore, the potential effects resulting from this impact mechanism are unknown..
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Eggs; Larvae; Juveniles; Adults	All exposed life-history stages: See related stressor responses under Water Quality Modification.		May affect survival, growth, and fitness of juveniles and adults.

Table A-15 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered lateral (terrestrial/aquatic) habitat connectivity	Reduced availability of off-channel refuge and rearing habitat. Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs. Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Larvae; Adults	Adults: LWD removal can force channel incision, leading to disconnection of side channel and floodplain habitats under lower flow conditions. This stressor is unlikely to significantly affect mainstem spawning eulachon and longfin smelt. Planktonic larvae are carried downstream to estuarine habitats, and are not dependent on floodplain habitats.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat or longitudinal reach simplification.	May affect survival at egg, larvae, and juvenile life-history stages. May affect spawning productivity.
	Altered longitudinal habitat connectivity	Reduced availability of suitable habitats along longitudinal gradient.							
	Marine								
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Larvae; Juvenile; Adult	All exposed life-history stages: LWD removal in the marine environment can fragment nearshore habitat. Eulachon and longfin smelt are known to use these habitat types during juvenile and adult life-history stages, and are likely to occur as larvae as well. LWD removal may alter migration of adults toward spawning habitats, larval dispersal, and juvenile foraging, affecting survival, growth, and fitness at all life-history stages.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival and productivity at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered cover and habitat	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.
	Lacustrine								
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Lake Washington longfin smelt. Larvae; Juveniles; Adults	All exposed life-history stages: Longfin smelt dependence on nearshore habitats in Lake Washington is currently a data gap. Therefore the effects of this stressor are unknown.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival at juvenile life-history stage. Decreased fitness may lead to reduced spawning productivity.
	Altered cover and habitat	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Lake Washington longfin smelt. Larvae; Juveniles; Adults	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.
	Aquatic Vegetation Modification								
	Marine								

Table A-15 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Larvae; Juveniles; Adults	All exposed life-history stages: Longfin smelt and eulachon dependence on marine littoral vegetation and the nearshore marine environment is currently a data gap. Therefore, the potential for exposure to these stressors is unknown.	Construction: Avoid/minimize disturbance of aquatic vegetation during project construction.	Sensitivity to stressor exposure is currently a data gap for these species; therefore, the potential effects resulting from this impact mechanism are unknown.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Larvae; Juveniles; Adults	All exposed life-history stages: Longfin smelt and eulachon dependence on marine littoral vegetation and the nearshore marine environment is currently a data gap. Therefore, the potential for exposure to these stressors is unknown.		Sensitivity to stressor exposure is currently a data gap for these species; therefore, the potential effects resulting from this impact mechanism are unknown.
	Riverine and Lacustrine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Eggs; Larvae; Adults	All exposed life-history stages: Smelt dependence on freshwater submerged aquatic vegetation is currently a data gap. Therefore, the potential for exposure to these stressors is unknown.	Construction: Avoid/minimize disturbance of aquatic vegetation during project construction.	Sensitivity to stressor exposure is currently a data gap for these species; therefore, the potential effects resulting from this impact mechanism are unknown.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	Juveniles and adults: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Eggs; Larvae; Adults	All exposed life-history stages: Smelt dependence on freshwater submerged aquatic vegetation is currently a data gap. Therefore, the potential for exposure to these stressors is unknown.		Sensitivity to stressor exposure is currently a data gap for these species; therefore, the potential effects resulting from this impact mechanism are unknown.
	Riparian Vegetation Modification								
	Riverine								

Table A-15 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Adults	Adults: Decreased spawning productivity and fitness due to migration delays caused by low water temperatures.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible	May affect spawning productivity.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs; Larvae; Adults	Eggs and larvae: Decreased incubation success due to smothering of eggs as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential, migration delay, habitat avoidance, and/or injury and mortality caused by excessive turbidity as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival during egg incubation; may affect spawning fitness and productivity.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Adults	Adults: Reduced habitat complexity may affect the availability of suitable spawning habitat leading to decreased spawning productivity.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect adult spawning productivity.
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Unknown	Longfin smelt and eulachon dependence on groundwater exchange is currently a data gap.	Avoid disturbance of vegetation along stream.	Sensitivity to stressor exposure is currently a data gap for these species; therefore, the potential effects resulting from this impact mechanism are unknown.
	Marine								
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures)	Year-round, (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Larvae; Juveniles	Larvae and juveniles: Riparian shade and ambient temperature have a relatively minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. Dependence of larval and juvenile longfin smelt and eulachon on these habitats is currently a data gap. Therefore, the potential for exposure to these stressors is unknown.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	Sensitivity to stressor exposure is currently a data gap for these species; therefore, the potential effects resulting from this impact mechanism are unknown.

Table A-15 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Larvae; Juveniles	Larvae and juveniles: Dependence of larval and juvenile longfin smelt and eulachon on these habitats is currently a data gap. Therefore, the potential for exposure to these stressors is unknown.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	Sensitivity to stressor exposure is currently a data gap for these species; therefore, the potential effects resulting from this impact mechanism are unknown.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Larvae; Juveniles	Larvae and juveniles: Longfin smelt and eulachon dependence on allochthonous inputs from marine riparian vegetation is a data gap.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	Sensitivity to stressor exposure is currently a data gap for these species; therefore, the potential effects resulting from this impact mechanism are unknown.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Larvae; Juveniles	Larvae and juveniles: Dependence of larval and juvenile smelt on these habitats is currently a data gap. Therefore, the potential for exposure to these stressors is unknown.	Encourage project designs that limit permanent alteration of high-quality habitat features.	Sensitivity to stressor exposure is currently a data gap for these species; therefore, the potential effects resulting from this impact mechanism are unknown.
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Larvae; Juveniles	Larvae and juveniles: Dependence of larval and juvenile smelt on surface water and groundwater exchange in nearshore habitats is currently a data gap. Therefore, the potential for exposure to these stressors is unknown.	Avoid disturbance of vegetation along shoreline.	Sensitivity to stressor exposure is currently a data gap for these species; therefore, the potential effects resulting from this impact mechanism are unknown.
	Lacustrine								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round, (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Lake Washington longfin smelt. Larvae; Juveniles; Adults	Larvae, juveniles, and adults: Riparian shade and ambient temperature has a relatively minor effect on nearshore water temperatures relative to the dominant influence of lake stratification, reservoir current patterns, wind conditions and other factors. However, shallow littoral habitats may experience increased temperatures due to lack of shade. Dependence of juvenile longfin smelt on these habitats is currently a data gap Therefore the potential for exposure to these stressors is unknown.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	Potential effects resulting from this impact mechanism are unknown.
	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Lake Washington longfin smelt. Larvae; Juveniles; Adults	Larvae, juveniles, and adults: Potential habitat avoidance and/or injury/mortality caused by excessive turbidity, potential for decreased foraging success leading to decreased growth and fitness as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile and adult survival and productivity.

Table A-15 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs predominantly during spring outmigration period through lakes)	Permanent	Continuous	Lake Washington longfin smelt. Larvae; Juveniles; Adults	Larvae, juveniles, and adults: Longfin smelt dependence on allochthonous inputs from lacustrine riparian vegetation is a data gap. Therefore the potential for exposure to these stressors is unknown.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	Potential effects resulting from this impact mechanism are unknown.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Short-term to permanent (dependent on nature of activity)	Continuous	Lake Washington longfin smelt. Larvae; Juveniles; Adults	Larvae, juveniles, and adults: Dependence of larval, juvenile, and adult longfin smelt on these habitats is currently a data gap, Therefore the potential for exposure to these stressors is unknown.	Encourage project designs that limit permanent alteration of high-quality habitat features.	Potential effects resulting from this impact mechanism are unknown.
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Permanent	Continuous	Lake Washington longfin smelt. Larvae; Juveniles; Adults	Larvae, juveniles, and adults: Longfin smelt dependence on groundwater inflow to nearshore lacustrine habitats is currently a data gap. Therefore the potential for exposure to these stressors is unknown.	Avoid disturbance of vegetation along shoreline.	Effects of the action resulting from this impact mechanism are unknown.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to long-term (dependent on contributing mechanism of impact)	Continuous to interannual–decadal (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause burial or coating of eggs may lead to direct mortality. Increased turbidity may decrease larval foraging success, resulting in decreased growth and fitness. Juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs. May affect juvenile productivity, adult productivity, and spawning success.

Table A-15 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered pollutant loading	Increased pollutant loading	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles	Eggs and larvae, juveniles: Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival, growth, and fitness of juveniles and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen (due to eutrophication caused by elevated nutrient export from dewatered floodplains)	Dependent on contributing mechanism of impact	Temporary to short-term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved events due to asphyxiation. Juveniles and adults: Avoidance behavior and increased stress, leading to reduced growth and fitness.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival of incubating eggs. May affect juvenile survival and productivity and adult survival, productivity, and spawning success.
Spawning Substrate Augmentation									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness. May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	Unlikely to affect smelt populations when activities are conducted in prescribed in-water work windows, avoiding spawning disruptions. Exposure to stressor may affect survival and productivity due to avoidance behavior, decreased foraging success, and increased predation risk.

Table A-15 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs; Larvae; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification.
		Burial (during active sediment placement)	During project construction	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Juveniles;	Eggs and larvae, juveniles: Injury or mortality from burial during gravel placement.	Restrict in-water work window to periods when incubating eggs and larvae with limited motility are least likely to be present.	May cause direct mortality or injury at egg, larvae, and juvenile life-history stages. Injury and stress may affect survival, growth, and fitness.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Reduced refuge habitat (from potential pool filling)	Year-round	Short-term to intermediate-term	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality; decreased fitness and spawning success due to decreased availability of suitable migratory and spawning habitat.	Ensure that project has been designed properly for ecosystem context.	May affect juvenile growth and survival, as well as spawning success and overall population productivity.
	Altered bank stability (intermediate-term effects from passive augmentation projects)	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Intermediate-term	Continuous	Eggs; Larvae; Juveniles; Adults	Eggs: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and larval survival.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of augmentation projects that minimize	May affect survival at egg and larval life-history stages. May affect spawning productivity.

Table A-15 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered substrate composition/stability			Short-term to long-term			Larvae and juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of XXX) if potential spawning habitat is affected.	adverse effects on channel geometry, bank conditions, and substrate stability to the greatest extent practicable.	
	Aquatic Vegetation Modification								
	Riverine								
	Altered autochthonous production	Reduced foraging opportunities	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Eggs; Larvae; Adults	All exposed life-history stages: Smelt dependence on freshwater submerged aquatic vegetation is currently a data gap. Therefore, the potential for exposure to these stressors is unknown.	Avoid spawning gravel augmentation projects in locations where aquatic vegetation plays a strong role in habitat productivity.	Sensitivity to stressor exposure is currently a data gap for these species; therefore, the potential effects resulting from this impact mechanism are unknown.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Eggs; Larvae; Adults	All exposed life-history stages: Smelt dependence on freshwater submerged aquatic vegetation is currently a data gap. Therefore, the potential for exposure to these stressors is unknown.		
	Water Quality Modification								

Table A-15 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause burial or coating of eggs may lead to direct mortality. Increased turbidity may decrease larval foraging success, resulting in decreased growth and fitness. Juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs. May affect juvenile productivity, adult productivity, and spawning success.
In-Channel/Off-Channel Habitat Creation/Modification									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness. May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	Unlikely to affect smelt populations when activities are conducted in prescribed in-water work windows, avoiding spawning disruptions. Exposure to stressor may affect survival and productivity due to avoidance behavior, decreased foraging success, and increased predation risk.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs; Larvae; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification.

Table A-15 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Juveniles (Lake Washington longfin smelt); Adults	Eggs and larvae: Channel dewatering will cause egg mortality. Juveniles: Juvenile smelt are generally believed to migrate offshore and will therefore not likely be exposed to dewatering. Lake Washington longfin smelt are an exception; potential nearshore habitat use by this population is currently a data gap. Adults: Capture, handling, and relocation are likely to cause mortality or injury and stress leading to mortality or decreased spawning fitness. Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	Unlikely to affect eggs, larvae, and adults if activities are conducted during in-water work windows. Capture and removal of eggs, larvae, and juveniles is impractical, meaning that activities occurring during incubation and emigration periods may affect survival during these life-history stages. Capture and removal of adults are likely to affect survival and spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Eggs, larvae, and juveniles: Pump entrainment is highly likely to cause mortality of larvae and drifting eggs. This effect cannot be avoided by pump screening. Entrainment and impingement are likely to cause mortality of juveniles. Adults: Impingement is likely to cause adult mortality.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	Unlikely to affect survival and productivity during egg and larvae and adult life-history stages if activities are conducted outside in-water work windows. If activities are permitted during in-water work windows, activity may affect adult and egg and larval survival. The potential for effects on juvenile smelt survival in marine habitats and Lake Washington are unknown because habitat use by this life-history stage is a data gap.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Adults	Eggs and larvae: Potential decreased egg incubation success and larval survival due to turbidity exposure and substrate disturbance. Adults: Stress and behavioral modifications by adult spawners exposed to sediment pulses, migration delay, increased predation exposure, decreased spawning habitat suitability.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	Unlikely to affect egg survival and adult spawning productivity when activities are conducted during in-water work windows. May affect these parameters if activities occur during spawning and incubation.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: With the exception of the Lake Washington longfin population, smelt do not feed on benthic organisms in freshwater systems and will be unaffected by this stressor. In Lake Washington and in marine systems, smelt are planktonic feeders that are not likely to be affected by temporary decreases in benthic invertebrate abundance.	Limit area of dewatering to the greatest extent practicable.	Not likely to affect smelt at any life-history stage.
	Water Quality Modification								

Table A-15 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids (during construction or if in-channel project fails)	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause burial or coating of eggs may lead to direct mortality. Increased turbidity may decrease larval foraging success, resulting in decreased growth and fitness. Juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs. May affect juvenile productivity, adult productivity, and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs; Larvae; Juveniles	Eggs and larvae, juveniles: Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel machinery in a controlled environment away from the project area. Avoid reducing hydraulic complexity.	May affect survival and productivity of eggs, larvae, and juveniles
Riparian Planting/Restoration Enhancement									
	Construction and Maintenance Activities								
	Riverine , Lacustrine, Marine								
	Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Adults	Adults: Decreased spawning productivity and fitness due to migration delays caused by low water temperatures.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect spawning productivity.
		Increased suspended solids – due to removal of invasive riparian species	Year-round (with specific stressors prominent during high flow conditions)	Short-term to intermediate (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs; Larvae; Adults	Eggs and larvae: Decreased incubation success due to smothering of eggs as described for related stressor responses under Water Quality Modification. Adults: Decreased spawning success due to decreased availability of suitable spawning habitat. Potential, migration delay, habitat avoidance, and/or injury and mortality caused by excessive	Minimize disturbance during invasive species removal. Use appropriate erosion control BMPs both during and after construction.	May affect survival during egg incubation; may affect spawning fitness and productivity.

Table A-15 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Spawning gravel sedimentation – due to removal of invasive riparian species					turbidity as described for related stressor responses under Water Quality Modification.		
	Aquatic Vegetation Modification								
	Riverine, Lacustrine, Marine								
	Altered autochthonous production	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Larvae; Juveniles; Adults	All exposed life-history stages: Longfin smelt and eulachon dependence on marine littoral vegetation and the nearshore marine environment is currently a data gap. Therefore, the potential for exposure to these stressors is unknown.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	Sensitivity to stressor exposure is currently a data gap for these species; therefore, the potential effects resulting from this impact mechanism are unknown.
	Riparian Vegetation Modification								
	Riverine, Lacustrine, Marine								
	Altered Shading and solar input	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Larvae	Larvae: Larval longfin smelt and eulachon feed on forage on riverine plankton following emergence and transport to estuarine and marine habitats. Reduced allochthonous inputs may affect food web productivity, leading to decreased growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect larval growth and fitness.
	Water Quality Modification								
	Altered Temperatures	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Adults	Adults: Decreased spawning productivity and fitness due to migration delays caused by low water temperatures.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect spawning productivity.

Table A-15 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids – due to removal of invasive riparian species	Dependent on contributing mechanism of impact	Short-term to intermediate (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause burial or coating of eggs may lead to direct mortality. Increased turbidity may decrease larval foraging success, resulting in decreased growth and fitness. Juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs. May affect juvenile productivity, adult productivity, and spawning success.
Wetland Creation Restoration/Enhancement									
	Construction and Maintenance Activities								
	Riverine and Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness. May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	Unlikely to affect smelt populations when activities are conducted in prescribed in-water work windows, avoiding spawning disruptions. Exposure to stressor may affect survival and productivity due to avoidance behavior, decreased foraging success, and increased predation risk.

Table A-15 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs; Larvae; Adults	<u>All life-history stages</u>: See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Juveniles (Lake Washington longfin smelt); Adults	<u>Eggs and larvae</u>: Channel dewatering will cause egg mortality. <u>Juveniles</u>: Juvenile smelt are generally believed to migrate offshore and will therefore not likely be exposed to dewatering. Lake Washington longfin smelt are an exception; potential nearshore habitat use by this population is currently a data gap. <u>Adults</u>: Capture, handling, and relocation are likely to cause mortality or injury and stress leading to mortality or decreased spawning fitness. Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	Unlikely to affect eggs, larvae, and adults if activities are conducted during in-water work windows. Capture and removal of eggs, larvae, and juveniles is impractical, meaning that activities occurring during incubation and emigration periods may affect survival during these life-history stages. Capture and removal of adults are likely to affect survival and spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	<u>Eggs, larvae, and juveniles</u>: Pump entrainment is highly likely to cause mortality of larvae and drifting eggs. This effect cannot be avoided by pump screening. Entrainment and impingement are likely to cause mortality of juveniles. <u>Adults</u>: Impingement is likely to cause adult mortality.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	Unlikely to affect survival and productivity during egg and larvae and adult life-history stages if activities are conducted outside in-water work windows. If activities are permitted during in-water work windows, activity may affect adult and egg and larval survival. The potential for effects on juvenile smelt survival in marine habitats and Lake Washington are unknown because habitat use by this life-history stage is a data gap.

Table A-15 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Adults	Eggs and larvae: Potential decreased egg incubation success and larval survival due to turbidity exposure and substrate disturbance. Adults: Stress and behavioral modifications by adult spawners exposed to sediment pulses, migration delay, increased predation exposure, decreased spawning habitat suitability.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	Unlikely to affect egg survival and adult spawning productivity when activities are conducted during in-water work windows. May affect these parameters if activities occur during spawning and incubation.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: With the exception of the Lake Washington longfin population, smelt do not feed on benthic organisms in freshwater systems and will be unaffected by this stressor. In Lake Washington and in marine systems, smelt are planktonic feeders that are not likely to be affected by temporary decreases in benthic invertebrate abundance.	Limit area of dewatering to the greatest extent practicable.	Not likely to affect smelt at any life-history stage.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids (e.g., during reconnection of fragmented floodplain wetlands, etc.)	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause burial or coating of eggs may lead to direct mortality. Increased turbidity may decrease larval foraging success, resulting in decreased growth and fitness. Juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs. May affect juvenile productivity, adult productivity, and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs; Larvae; Juveniles	Eggs and larvae, juveniles: Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival, growth, and fitness of juveniles and adults.
Beach Nourishment/Contouring									

Table A-15 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Construction and Maintenance Activities								
	Marine and Lacustrine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness. May affect survival, growth, and fitness of juveniles and adults.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.
	Hydraulic and Geomorphic Modification								
	Marine and Lacustrine								
	Altered sediment supply	Localized alteration in invertebrate abundance from burial	During project construction and maintenance activities	Short-term – long-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.
	Aquatic Vegetation Modification								
	Marine								
	Altered autochthonous production	Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to long-term(dependent on nature of activity)	Continuous	Larvae; Juveniles; Adults	All exposed life-history stages: Longfin smelt and eulachon dependence on marine littoral vegetation and the nearshore marine environment is currently a data gap. Therefore, the potential for exposure to these stressors is unknown.	Avoid/minimize disturbance of aquatic vegetation during project construction. Avoid nourishing beaches updrift of productive, vegetated aquatic habitat.	Sensitivity to stressor exposure is currently a data gap for these species; therefore, the potential effects resulting from this impact mechanism are unknown.
	Altered cover and habitat	Reduced cover							
	Lacustrine								
	Altered autochthonous production	Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to long-term(dependent on nature of activity)	Continuous	Eggs; Larvae; Adults	All exposed life-history stages: Smelt dependence on freshwater submerged aquatic vegetation is currently a data gap. Therefore, the potential for exposure to these stressors is unknown.	Avoid/minimize disturbance of aquatic vegetation during project construction. Avoid nourishing beaches updrift of productive, vegetated aquatic habitat.	Sensitivity to stressor exposure is currently a data gap for these species; therefore, the potential effects resulting from this impact mechanism are unknown.
	Altered cover and habitat	Reduced cover							
	Water Quality Modification								

Table A-15 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids	During construction and during subsequent high energy periods	Temporary to short-term (dependent on grain size of augmented sediment)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause burial or coating of eggs may lead to direct mortality. Increased turbidity may decrease larval foraging success, resulting in decreased growth and fitness. Juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic shoreline instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs. May affect juvenile productivity, adult productivity, and spawning success.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs; Larvae; Juveniles	Eggs and larvae, juveniles: Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body.	May affect survival and productivity of eggs, larvae, and juveniles
Reef Creation/Restoration/Enhancement									
	Construction and Maintenance Activities								
	Marine and Lacustrine								
	Equipment operation and materials placement	Elevated noise, visual and physical disturbance	During project construction activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	Unlikely to affect smelt populations when activities are conducted in prescribed in-water work windows, avoiding spawning disruptions. Exposure to stressor may affect survival and productivity due to avoidance behavior, decreased foraging success, and increased predation risk.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize propeller cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/ antivibration technology where practicable. Limit activities to system-specific in-water work windows where practicable to avoid effects on spawning adults.	Unlikely to affect smelt populations when activities are conducted in prescribed in-water work windows, avoiding spawning disruptions. Exposure to stressor may affect survival and productivity due to avoidance behavior, decreased foraging success, and increased predation risk.

Table A-15 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.
	Hydraulic and Geomorphic Modification								
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Larvae; Juveniles; Adults	Larvae and juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats. Longfin smelt and eulachon dependence on these habitats is currently a data gap. However, alteration of current velocities and circulation patterns may cause transportation of planktonic larvae to unfavorable habitats for growth and development. Alteration of nearshore habitat productivity may also have concomitant effects on food web relationships in the offshore environment. Adults: Alteration of nearshore habitat parameters may affect survival and foraging opportunities at larval and juvenile life-history stages, leading to decreased adult fitness, decreased survival, and decreased spawning productivity.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at the larval and juvenile life-history stages. Decreased fitness may affect survival and productivity during ocean migration life-history phase, and may affect spawning productivity.
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				
	Lacustrine								
	Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Lake Washington longfin smelt. Larvae; Juveniles;	Larvae, juveniles, and adults: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift	May affect productivity at larval and juvenile life-history stage. Decreased fitness may lead to reduced spawning productivity.

Table A-15 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Continuous	Adults	or more of these parameters can fundamentally alter lacustrine littoral habitats, with concomitant food web effects throughout the lacustrine ecosystem. Therefore, alteration of these parameters may affect foraging opportunities for longfin smelt at larval and juvenile life-history stages, leading to decreased adult fitness and decreased spawning success.	patterns, and wave energy and current patterns. For example:	
	Altered nearshore circulation patterns		Year-round (with variable effects by season [e.g., circulation patterns])	Permanent	Seasonal				
	Altered sediment supply		Year-round	Permanent	Continuous				
	Altered substrate composition		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Marine								
	Altered cover and habitat	Increased predation risk	Year-round	Permanent	Continuous	Juveniles	Juveniles: Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid placement of reef projects in proximity to juvenile migratory corridors, such that increased predation exposure may occur.	May affect juvenile survival, growth and fitness.
	Lacustrine								
	Altered cover and habitat	Increased predation by piscivorous fish	Year-round	Permanent	Continuous	Juveniles	Juveniles: Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid placement of reef projects in proximity to juvenile migratory corridors, such that increased predation exposure may occur.	May affect juvenile survival, growth and fitness.
	Aquatic Vegetation Modification								
	Marine								
	Altered cover and habitat	Decreased refuge and forage habitat	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Larvae; Juveniles; Adults	All exposed life-history stages: Longfin smelt and eulachon dependence on marine littoral vegetation and the nearshore marine environment is currently a data gap. Therefore, the potential for exposure to these stressors is unknown.	Avoid/minimize disturbance of aquatic vegetation during project construction.	Sensitivity to stressor exposure is currently a data gap for these species; therefore, the potential effects resulting from this impact mechanism are unknown.
	Lacustrine								
	Altered autochthonous production	Reduced foraging opportunities	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Eggs; Larvae; Adults	All exposed life-history stages: Smelt dependence on freshwater submerged aquatic vegetation is currently a data gap. Therefore, the potential for exposure to these stressors is unknown.	Avoid/minimize disturbance of aquatic vegetation during project construction.	Sensitivity to stressor exposure is currently a data gap for these species; therefore, the potential effects resulting from this impact mechanism are unknown.
	Altered cover and habitat								
	Water Quality Modification								

Table A-15 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Longfin Smelt and Eulachon (Smelt).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause burial or coating of eggs may lead to direct mortality. Increased turbidity may decrease larval foraging success, resulting in decreased growth and fitness. Juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival of incubating eggs. May affect juvenile productivity, adult productivity, and spawning success.
	Altered pollutant loading	Leaching of toxic substances (depending on composition of reef material)	Year-round	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs; Larvae; Juveniles	Eggs and larvae, juveniles: Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Use non-toxic reef material.	May affect survival and productivity of eggs, larvae, and juveniles
Eel Grass and Other Aquatic Vegetation Creation/Restoration/Enhancement									
	Construction and Maintenance Activities								
	Marine								
	Planting activities and vessel use	Visual, physical, and noise related disturbance	During project construction	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles: Stress and behavioral avoidance by rearing juveniles and migrating adults exposed to low level noise, physical, and visual disturbance.	Adhere to system-specific in-water work windows.	May cause temporary behavioral avoidance and displacement.
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Vegetation transplantation projects are not likely to cause pulses of suspended sediment sufficient to lead to injury or mortality. Stressor response may include temporary behavioral avoidance and displacement.	Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May cause temporary behavioral avoidance and displacement.

Table A-16. HPA HCP Habitat Modification Exposure and Response Matrix for Surf Smelt and Sand Lance.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Beaver Dam Removal									
	Not applicable								
Large Woody Debris Placement/Movement/Removal (for placement only construction impacts apply)									
	Construction and Maintenance Activities								
	Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs; Larvae; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane (from exposure to high intensity noise such as pile driving). • Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.

Table A-16 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Surf Smelt and Sand Lance.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Larvae and juveniles: These life-history stages will be difficult to capture and relocate effectively. Adults: Capture, handling, and relocation is likely to cause mortality, or injury and stress leading to mortality or decreased spawning fitness. Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	Capture/removal of larvae and juveniles is impractical, meaning that these activities are likely to affect larval and juvenile survival. Capture and removal of adults is likely to affect survival and spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Larvae and juveniles: Pump entrainment is likely to cause mortality of drifting larvae. This effect cannot be avoided by pump screening. Entrainment and impingement are likely to cause mortality of juveniles. Adults: Impingement is likely to cause adult mortality.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause injury and mortality of larvae, juveniles, and adults. Effects are less likely to occur if activities are conducted outside of spawning season
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	All life-history stages: Surf smelt and sand lance dependence on benthic invertebrates for forage is likely limited but is currently a data gap. Therefore, the potential effects of stressor exposure are unknown.	Limit area of dewatering to the greatest extent practicable.	Potential effects resulting from this impact mechanism are unknown.
	Hydraulic and Geomorphic Modification								

Table A-16 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Surf Smelt and Sand Lance.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u>: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats. Egg incubation success may be affected by alteration in wave energy patterns and groundwater inputs. Alteration of current velocities and circulation patterns may cause transportation of planktonic larvae to unfavorable habitats for growth and development. Alteration of nearshore habitat productivity may also have concomitant effects on food web relationships in the offshore environment. Therefore, alteration of these parameters may affect foraging opportunities for at larval and juvenile life-history stages, leading to decreased adult fitness, decreased survival, and decreased spawning productivity.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival at the larval and juvenile life-history stages. May affect juvenile and adult growth and fitness. Decreased fitness may affect spawning productivity.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				
	Ecosystem Fragmentation								
	Marine								
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Larvae; Juveniles; Adults	<u>Larvae and juveniles</u>: LWD removal in the marine environment can fragment nearshore rearing habitat, forcing larval and juvenile surf-smelt and sandlance to navigate away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion. These stressors may affect survival, growth, and fitness. <u>Adults</u>: The geomorphic effect of LWD removal on the upper intertidal zone may eliminate or decrease the suitability of spawning habitat, potentially limiting the spawning productivity of affected populations.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect larval and juvenile survival, growth, and fitness. May affect adult survival, fitness, and spawning productivity.

Table A-16 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Surf Smelt and Sand Lance.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered cover and habitat	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.
	Aquatic Vegetation Modification								
	Marine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Eggs; Larvae; Juveniles; Adults	<u>Eggs</u>: Alteration or reduction of submerged aquatic vegetation component of beach wrack may affect microclimate conditions in spawning substrates, decreasing egg survival (particularly during spring and summer spawning). <u>All life-history stages</u>: Altered autochthonous production and habitat complexity are likely to affect food web dynamics and available foraging opportunities, potentially resulting in decreased growth and fitness.	<u>Construction</u>: Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect growth and fitness at egg, larval, juvenile, and adult life-history stages.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	<u>Juveniles</u>: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Eggs; Larvae; Juveniles; Adults	<u>Eggs</u>: Alteration or reduction of submerged aquatic vegetation component of beach wrack may affect microclimate conditions in spawning substrates, decreasing egg survival (particularly during spring and summer spawning). <u>All life-history stages</u>: Altered autochthonous production and habitat complexity are likely to affect food web dynamics and available foraging opportunities, potentially resulting in decreased growth and fitness.		May affect growth and fitness at egg, larval, juvenile, and adult life-history stages.

Table A-16 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Surf Smelt and Sand Lance.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Riparian Vegetation Modification								
	Marine								
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures)	Year-round, (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Eggs	Eggs: Surf smelt and sand lance incubation success is demonstrably affected by microclimate conditions in the nearshore environment that are influenced by riparian vegetation. Alteration of riparian vegetation has been demonstrated to reduce egg survival and incubation success.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect egg survival, decreasing population productivity.
	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs; Larvae; Juveniles; Adults	Eggs: Smothering of incubating eggs or alteration of substrate composition may decrease egg survival. Larvae and juveniles: See responses to increased turbidity exposure described under Water Quality Modification. Adults: Potential reduction of suitable spawning habitat, leading to decreased spawning productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect egg survival. May affect growth and fitness at larval and juvenile life-history stages. May affect adult spawning fitness and productivity.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Eggs; Larvae; Juveniles; Adults	Eggs: Leaf litter and other detritus may influence microclimate conditions in spawning substrates. Reduction in leaf litter may cause reduced incubation success. Larvae, juveniles, and adults: Dependence on allochthonous inputs from marine riparian vegetation is a data gap.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of incubating eggs. Potential effects resulting from this impact mechanism on remaining life-history stages are unknown.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Larvae; Juveniles; Adults	All life-history stages: Altered habitat complexity is likely to affect food web dynamics and available foraging opportunities, potentially resulting in decreased growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	Sensitivity to stressor exposure is currently a data gap for these species; the potential effects resulting from this impact mechanism are unknown.

Table A-16 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Surf Smelt and Sand Lance.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Eggs; Larvae; Juveniles; Adults	Eggs: Groundwater inflow demonstrably affects substrate temperatures, creating favorable conditions for egg incubation. Larvae and juveniles: Dependence of larval and juvenile forage fish on surface water and groundwater exchange in nearshore habitats is currently a data gap; the potential for exposure to these stressors is unknown. Adults: Altered groundwater inflow may affect spawning habitat suitability, leading to decreased spawning success.	Avoid disturbance of vegetation along shoreline.	May affect egg survival and adult spawning productivity. Potential effects resulting from this impact mechanism on larvae and juveniles are unknown.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to long-term (dependent on contributing mechanism of impact)	Continuous to interannual–decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	Larvae: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. Adults and juveniles: Same effects as above, as well as increased stress and decreased foraging opportunity due to avoidance behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival and productivity at larval, juvenile, and adult life-history stages.
	Altered pollutant loading	Increased pollutant loading	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival and productivity of larvae, juveniles, and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen (due to eutrophication caused by elevated nutrient export from dewatered floodplains)	Dependent on contributing mechanism of impact	Temporary to short-term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	All exposed life-history stages: Low-oxygen stress leading to physiological injury and/or mortality; behavioral avoidance.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect larvae development, juvenile survival, growth, and fitness as well as adult survival, fitness, and spawning success.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Spawning Substrate Augmentation									
	Not applicable								
In-Channel/Off-Channel Habitat Creation/Modification									
	Not applicable								
Riparian Planting/Restoration Enhancement									
	Construction and Maintenance Activities								
	Marine								
	Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs	Eggs: Surf smelt and sand lance incubation success is demonstrably affected by microclimate conditions in the nearshore environment that are influenced by riparian vegetation. Alteration of riparian vegetation has been demonstrated to reduce egg survival and incubation success.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect egg survival, decreasing population productivity.
		Increased suspended solids – due to removal of invasive riparian species	Year-round (with specific stressors prominent during high flow conditions)	Short-term to intermediate (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Minimize disturbance during invasive species removal. Use appropriate erosion control BMPs both during and after construction.	See effects for related stressors under Water Quality Modification.
	Aquatic Vegetation Modification								
	Marine								
	Altered autochthonous production	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the water surface.	May affect juvenile growth and fitness, data gap.

Table A-16 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Surf Smelt and Sand Lance.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Marine								
	Altered Shading and solar input	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	<u>Juveniles</u>: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the water surface.	May affect juvenile growth and fitness, data gap.
	Water Quality Modification								
	Altered Temperatures	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs	<u>Eggs</u>: Surf smelt and sand lance incubation success is demonstrably affected by microclimate conditions in the nearshore environment that are influenced by riparian vegetation. Alteration of riparian vegetation has been demonstrated to reduce egg survival and incubation success.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect egg survival, decreasing population productivity.
	Altered suspended solids	Increased suspended solids – due to removal of invasive riparian species	Dependent on contributing mechanism of impact	Short-term to intermediate (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	<u>Larvae</u>: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. <u>Adults and juveniles</u>: Same effects as above, as well as increased stress and decreased foraging opportunity due to avoidance behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic erosion. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival and productivity at larval, juvenile, and adult life-history stages.

Table A-16 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Surf Smelt and Sand Lance.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Wetland Creation Restoration/Enhancement									
	Construction and Maintenance Activities								
	Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: May cause avoidance behavior leading to increased stress and decreased foraging opportunity. Auditory masking or temporary hearing threshold effects may increase risk of predation due to decreased ability to sense predators.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival and productivity due to avoidance behavior, decreased foraging success, and increased predation risk.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification.

Table A-16 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Surf Smelt and Sand Lance.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Larvae and juveniles: These life-history stages will be difficult to capture and relocate effectively. Adults: Capture, handling, and relocation is likely to cause mortality, or injury and stress leading to mortality or decreased spawning fitness. Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	Capture/removal of larvae and juveniles is impractical, meaning that these activities are likely to affect larval and juvenile survival. Capture and removal of adults is likely to affect survival and spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Larvae and juveniles: Pump entrainment is likely to cause mortality of drifting larvae. This effect cannot be avoided by pump screening. Entrainment and impingement are likely to cause mortality of juveniles. Adults: Impingement is likely to cause adult mortality.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause injury and mortality of larvae, juveniles, and adults. Effects are less likely to occur if activities are conducted outside of spawning season.
		Benthic disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Larvae: Potential decreased larval foraging success due to turbidity exposure and substrate disturbance, leading to decreased growth and fitness. Adults and juveniles: Stress caused by avoidance behavior; decreased foraging success due to increased turbidity levels.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect larval productivity. May affect juvenile and adult survival and productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	All life-history stages: Surf smelt and sand lance dependence on benthic invertebrates for forage is likely limited but is currently a data gap. Therefore, the potential effects of stressor exposure are unknown.	Limit area of dewatering to the greatest extent practicable.	Potential effects resulting from this impact mechanism are unknown.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids (e.g., during reconnection of fragmented floodplain wetlands, etc.)	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	Larvae: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. Adults and juveniles: Same effects as above, as well as increased stress and decreased foraging opportunity due to avoidance behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival and productivity at larval, juvenile, and adult life-history stages.

Table A-16 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Surf Smelt and Sand Lance.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit in-water heavy machinery use.	May affect survival, growth, and fitness of juveniles and adults.
Beach Nourishment/Contouring									
	Construction and Maintenance Activities								
	Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids, Burial of eggs and larvae	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Juveniles;	Eggs and Larvae: Direct mortality from smothering Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage. Reduced in reproductive success from destruction of eggs.
	Hydraulic and Geomorphic Modification								
	Marine								
	Altered sediment supply	Localized alteration in invertebrate abundance from burial, burial of eggs and larvae	During project construction and maintenance activities	Short-term – long-term	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Juveniles;	Eggs and Larvae: Direct mortality from smothering Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage. Reduced in reproductive success from destruction of eggs.
	Aquatic Vegetation Modification								
	Marine								
	Altered autochthonous production	Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to long-term(dependent on nature of activity)	Continuous	Eggs; Larvae;	Eggs: Alteration or reduction of submerged aquatic vegetation component of beach wrack may affect microclimate	Avoid/minimize disturbance of aquatic vegetation during project construction. Avoid nourishing beaches updrift of	May affect growth and fitness at egg, larval, juvenile, and adult life-history stages.

Table A-16 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Surf Smelt and Sand Lance.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered cover and habitat	Reduced cover				Juveniles; Adults	conditions in spawning substrates, decreasing egg survival (particularly during spring and summer spawning). <u>All life-history stages</u>: Altered autochthonous production and habitat complexity are likely to affect food web dynamics and available foraging opportunities, potentially resulting in decreased growth and fitness.	productive, vegetated aquatic habitat.	
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	During construction and during subsequent high energy periods	Temporary to short-term (dependent on grain size of augmented sediment)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	<u>Larvae</u>: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. <u>Adults and juveniles</u>: Same effects as above, as well as increased stress and decreased foraging opportunity due to avoidance behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic shoreline instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival and productivity at larval, juvenile, and adult life-history stages.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u>: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body.	May affect survival, growth, and fitness of juveniles and adults.

Table A-16 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Surf Smelt and Sand Lance.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Reef Creation/Restoration/Enhancement									
	Construction and Maintenance Activities								
	Marine								
	Equipment operation and materials placement	Elevated noise, visual and physical disturbance	During project construction activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	All life-history stages: Stressor response dependent on magnitude and duration of disturbance, and project-specific environmental conditions; may range from: • Increased predation risk and decreased foraging success due to displacement, auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid construction activities during periods when individuals may be present, particularly juveniles.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. Should exposure occur, direct mortality or injury is probable.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction)	Juveniles; Adults	Adults and juveniles: May cause avoidance behavior leading to increased stress and decreased foraging opportunity. Auditory masking or temporary hearing threshold effects may increase risk of predation due to decreased ability to sense predators.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival and productivity due to avoidance behavior, decreased foraging success, and increased predation risk.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.

Table A-16 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Surf Smelt and Sand Lance.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u>: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats. Egg incubation success may be affected by alteration in wave energy patterns and groundwater inputs. Alteration of current velocities and circulation patterns may cause transportation of planktonic larvae to unfavorable habitats for growth and development. Alteration of nearshore habitat productivity may also have concomitant effects on food web relationships in the offshore environment. Therefore, alteration of these parameters may affect foraging opportunities for at larval and juvenile life-history stages, leading to decreased adult fitness, decreased survival, and decreased spawning productivity.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival at the larval and juvenile life-history stages. May affect juvenile and adult growth and fitness. Decreased fitness may affect spawning productivity.
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				
	Ecosystem Fragmentation								
	Marine								
	Altered cover and habitat	Increased predation risk	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles:</u> Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid placement of reef projects in proximity to juvenile migratory corridors, such that increased predation exposure may occur.	May affect juvenile survival, growth and fitness.

Table A-16 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Surf Smelt and Sand Lance.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification								
	Marine								
	Altered cover and habitat	Decreased refuge and forage habitat	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Eggs; Larvae; Juveniles; Adults	<u>Eggs</u>: Alteration or reduction of submerged aquatic vegetation may affect microclimate conditions in spawning substrates, decreasing egg survival (particularly during spring and summer spawning). <u>All life-history stages</u>: Altered autochthonous production and habitat complexity are likely to affect food web dynamics and available foraging opportunities, potentially resulting in decreased growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect growth and fitness at egg, larval, juvenile, and adult life-history stages.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	<u>Larvae</u>: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. <u>Adults and juveniles</u>: Same effects as above, as well as increased stress and decreased foraging opportunity due to avoidance behavior.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival and productivity at larval, juvenile, and adult life-history stages.
	Altered pollutant loading	Leaching of toxic substances (depending on composition of reef material)	Year-round	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u>: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Use non-toxic reef material.	May affect survival and productivity of larvae, juveniles, and adults.
Eel Grass and Other Aquatic Vegetation Creation/Restoration/Enhancement									
	Construction and Maintenance Activities								
	Marine								

Table A-16 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Surf Smelt and Sand Lance.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Planting activities and vessel use	Visual, physical, and noise related disturbance	During project construction	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Adults and juveniles: May cause avoidance behavior leading to increased stress and decreased foraging opportunity. Auditory masking or temporary hearing threshold effects may increase risk of predation due to decreased ability to sense predators.	Adhere to system-specific in-water work windows.	May affect survival and productivity due to avoidance behavior, decreased foraging success, and increased predation risk.
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Vegetation transplantation projects are not likely to cause pulses of suspended sediment sufficient to lead to injury or mortality. Stressor response may include temporary behavioral avoidance and displacement.	Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May cause temporary behavioral avoidance and displacement.

Table A-17. HPA HCP Habitat Modification Exposure and Response Matrix for Pacific Herring.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
Beaver Dam Removal									
	Not applicable								
Large Woody Debris Placement/Movement/Removal (for placement only construction impacts apply)									
	Construction and Maintenance Activities								
	Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs; Larvae; Juveniles; Adults	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: • Rupture of egg membrane (from exposure to high intensity noise such as pile driving). • Fatal injury or permanent auditory tissue damage limiting to survival (from exposure to high intensity noise such as pile driving). • Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness at all life-history stages, depending on project-specific noise or disturbance intensity and receptor exposure. Exposure to intense underwater noise sources (e.g., pile driving) may lead to direct mortality or injury limiting to survival.

Table A-17 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pacific Herring.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification.
	Channel/work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Larvae and juveniles: These life-history stages will be difficult to capture and relocate effectively. Adults: Capture, handling, and relocation is likely to cause mortality, or injury and stress leading to mortality or decreased spawning fitness. Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	Capture/removal of larvae and juveniles is impractical, meaning that these activities are likely to affect larval and juvenile survival. Capture and removal of adults is likely to affect survival and spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Larvae and juveniles: Pump entrainment is likely to cause mortality of drifting larvae. This effect cannot be avoided by pump screening. Entrainment and impingement are likely to cause mortality of juveniles. Adults: Impingement is likely to cause adult mortality.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause injury and mortality of larvae, juveniles, and adults. Effects are less likely to occur if activities are conducted outside of spawning season
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	All life-history stages: Herring dependence on benthic invertebrates for forage is likely limited but is currently a data gap. Therefore, the potential effects of stressor exposure are unknown.	Limit area of dewatering to the greatest extent practicable.	Potential effects resulting from this impact mechanism are unknown.
	Hydraulic and Geomorphic Modification								

Table A-17 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pacific Herring.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Eggs; Larvae; Juveniles; Adults	All exposed life-history stages: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats. Alteration in the aerial extent and composition of the submerged aquatic vegetation community resulting from these mechanisms may reduce available spawning habitat, leading to reduced spawning productivity. Egg incubation success may be affected by alteration in wave energy patterns. Alteration of current velocities and circulation patterns may cause transportation of planktonic larvae to unfavorable habitats for growth and development. Alteration of nearshore habitat productivity may also have concomitant effects on food web relationships in the offshore environment. Therefore, alteration of these parameters may affect foraging opportunities at the juvenile life-history stage, over time leading to decreased adult fitness, decreased survival, and decreased spawning productivity.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect egg and larval survival and larval fitness. Decreased larval fitness may affect survival and productivity during juvenile and adult life-history phases in offshore and open ocean environments, and may affect spawning productivity. Loss or alteration of suitable spawning habitat may affect spawning productivity.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				
	Ecosystem Fragmentation								
	Marine								
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Larvae; Juveniles; Adults	Larvae and juveniles: LWD removal in the marine environment can fragment nearshore rearing habitat, potentially forcing planktonic herring away from nearshore habitats. This stressor may increase exposure to predation, as well as stress and exertion. Adults: LWD removal and the resultant geomorphic effects on the middle and lower intertidal zone may eliminate or decrease the suitability of spawning habitat, potentially limiting the spawning productivity of affected populations.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect larval and juvenile survival, growth, and fitness. May affect adult survival, fitness, and spawning productivity.

Table A-17 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pacific Herring.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered cover and habitat	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.
	Aquatic Vegetation Modification								
	Marine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Eggs; Larvae; Juveniles; Adults	All life-history stages: Altered habitat complexity is likely to affect food web dynamics and available foraging opportunities, potentially resulting in decreased growth and fitness. Adults: Reductions in available submerged aquatic vegetation or alteration of submerged aquatic vegetation community composition may limit spawning productivity.	Construction: Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect growth and fitness at egg, larval, juvenile, and adult life-history stages.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Eggs; Larvae; Juveniles; Adults	All life-history stages: Altered habitat complexity is likely to affect food web dynamics and available foraging opportunities, potentially resulting in decreased growth and fitness. Adults: Reductions in available submerged aquatic vegetation or alteration of submerged aquatic vegetation community composition may limit spawning productivity.		May affect growth and fitness at egg, larval, juvenile, and adult life-history stages.

Table A-17 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pacific Herring.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Marine								
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures)	Year-round, (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Eggs	Eggs: The influence of marine riparian shading on herring incubation is likely limited due to the typical elevation of herring spawn in the upper subtidal zone. However, the effects of this stressor are currently a data gap.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	Potential effects resulting from this impact mechanism are unknown.
	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs; Larvae; Juveniles; Adults	Eggs, larvae, and juveniles: See responses to increased turbidity exposure described under Water Quality Modification. Adults: Potential reduction of suitable spawning habitat, leading to decreased spawning productivity.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect egg survival. May affect productivity at larval and juvenile life-history stages. May affect adult spawning productivity.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles; Adults	Juveniles and adults: Dependence on allochthonous inputs from marine riparian vegetation is a data gap.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	Potential effects resulting from this impact mechanism on remaining life-history stages are unknown.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Larvae; Juveniles; Adults	All life-history stages: Altered habitat complexity is likely to affect food web dynamics and available foraging opportunities, potentially resulting in decreased growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect larval, juvenile, and adult productivity. May affect adult spawning productivity.
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Eggs; Larvae; Adults	Eggs and larvae: Herring egg and larval development is demonstrably affected by surface water salinities beyond tolerance thresholds. Alteration of salinity characteristics may limit egg survival or cause larval abnormalities limiting to survival, growth, and fitness. Adults: The influence of surface water and groundwater exchange on spawning habitat suitability is currently a data gap. However, alteration of this habitat parameter that affect submerged aquatic vegetation may decrease availability and/or suitability of spawning habitat.	Avoid disturbance of vegetation along shoreline.	May affect egg and larval survival and productivity. May affect adult spawning productivity.

Table A-17 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pacific Herring.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to long-term (dependent on contributing mechanism of impact)	Continuous to interannual–decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	Larvae: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. Adults and juveniles: Same effects as above, as well as increased stress and decreased foraging opportunity due to avoidance behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival and productivity at larval, juvenile, and adult life-history stages.
	Altered pollutant loading	Increased pollutant loading	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival and productivity of larvae, juveniles, and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen (due to eutrophication caused by elevated nutrient export from dewatered floodplains)	Dependent on contributing mechanism of impact	Temporary to short-term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	All exposed life-history stages: Low-oxygen stress leading to physiological injury and/or mortality; behavioral avoidance.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect larvae development, juvenile survival, growth, and fitness as well as adult survival, fitness, and spawning success.
Spawning Substrate Augmentation									
	Not applicable								
In-Channel/Off-Channel Habitat Creation/Modification									
	Not applicable								
Riparian Planting/Restoration Enhancement									
	Construction and Maintenance Activities								
	Marine								
	Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs	Eggs: The influence of marine riparian shading on herring incubation is likely limited due to the typical elevation of herring spawn in the upper subtidal zone. However, the effects of this stressor are currently a data gap.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	Potential effects resulting from this impact mechanism are unknown.

Table A-17 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pacific Herring.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
		Increased suspended solids – due to removal of invasive riparian species	Year-round (with specific stressors prominent during high flow conditions)	Short-term to intermediate (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Minimize disturbance during invasive species removal. Use appropriate erosion control BMPs both during and after construction.	See effects for related stressors under Water Quality Modification.
	Aquatic Vegetation Modification								
	Marine								
	Altered autochthonous production	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the water surface.	May affect juvenile growth and fitness, data gap.

Table A-17 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pacific Herring.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Marine								
	Altered Shading and solar input	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity and decreased growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the water surface.	May affect juvenile growth and fitness, data gap.
	Water Quality Modification								
	Altered Temperatures	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Eggs	Eggs: The influence of marine riparian shading on herring incubation is likely limited due to the typical elevation of herring spawn in the upper subtidal zone. However, the effects of this stressor are currently a data gap.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	Potential effects resulting from this impact mechanism are unknown.
	Altered suspended solids	Increased suspended solids – due to removal of invasive riparian species	Dependent on contributing mechanism of impact	Short-term to intermediate (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	Eggs: Effects of suspended sediments on incubating herring eggs is currently a data gap. Larvae: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. Adults and juveniles: Same effects as above, as well as increased stress and decreased foraging opportunity due to avoidance behavior.	Minimize disturbance during invasive species removal. Use appropriate erosion control BMPs both during and after construction.	May affect survival and productivity at egg, larval, juvenile, and adult life-history stages.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Wetland Creation Restoration/Enhancement									
	Construction and Maintenance Activities								
	Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: May cause avoidance behavior leading to increased stress and decreased foraging opportunity. Auditory masking or temporary hearing threshold effects may increase risk of predation due to decreased ability to sense predators.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect growth, fitness, and survival due to avoidance behavior, decreased foraging success, and increased predation risk.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs; Larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification.

Table A-17 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pacific Herring.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Work area dewatering	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Juveniles; Adults	Eggs: Extended dewatering may lead to egg desiccation or thermal exposure, causing mortality, or larval abnormalities limiting to survival. Larvae and juveniles: Dewatering is likely to lead to mortality, as larval and juvenile herring will be difficult to capture and relocate effectively. Adults: Capture, handling, and relocation are likely to cause mortality, or injury and stress, leading to mortality or decreased spawning fitness.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	Dewatering and fish removal in marine habitats is an unlikely requirement for LWD projects. However, in the event that such activities are required, adverse effects on exposed life-history stages should be expected. Capture and removal of larvae and juveniles is impractical, meaning that these activities are likely to affect larval and juvenile survival. Capture and removal of adults is likely to affect survival and spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Larvae and juveniles: Pump entrainment is likely to cause mortality of drifting larvae. This effect cannot be avoided by pump screening. Entrainment and impingement are likely to cause mortality of juveniles. Adults: Impingement is likely to cause adult mortality.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows, avoid use when juveniles are present.	May cause injury and mortality of larvae, juveniles, and adults. Effects are less likely to occur if activities are conducted outside of spawning season.
		Benthic disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Juveniles; Adults	Larvae: Potential decreased larval foraging success due to turbidity exposure and substrate disturbance, leading to decreased growth and fitness. Adults and juveniles: Stress caused by avoidance behavior; decreased foraging success due to increased turbidity levels. Adults: Decreased availability of spawning substrate due to sedimentation effects on submerged aquatic vegetation. All life-history stages: See responses to related stressors under Water Quality Modification.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	The likely stressor is increased suspended solids. May affect larval growth and survival. May affect juvenile and adult survival. May affect adult spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	All life-history stages: Herring dependence on benthic invertebrates for forage is likely limited but is currently a data gap. Therefore, the potential effects of stressor exposure are unknown.	Limit area of dewatering to the greatest extent practicable.	Potential effects resulting from this impact mechanism are unknown.
	Water Quality Modification								

Table A-17 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pacific Herring.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered suspended solids	Increased suspended solids (e.g., during reconnection of fragmented floodplain wetlands, etc.)	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	Eggs: Effects of suspended sediments on incubating herring eggs is currently a data gap. Larvae: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. Adults and juveniles: Same effects as above, as well as increased stress and decreased foraging opportunity due to avoidance behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival and productivity at egg, larval, juvenile, and adult life-history stages.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit in-water heavy machinery use.	May affect survival, growth, and fitness of juveniles and adults.
Beach Nourishment/Contouring									
	Construction and Maintenance Activities								
	Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids, Burial of eggs and larvae	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Juveniles;	Eggs and Larvae: Direct mortality from smothering Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage. Reduced in reproductive success from destruction of eggs.

Table A-17 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pacific Herring.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Marine								
	Altered sediment supply	Localized alteration in invertebrate abundance from burial, burial of eggs and larvae	During project construction and maintenance activities	Short-term – long-term	Interannual to decadal (depending on activity frequency)	Eggs; Larvae; Juveniles;	Eggs and Larvae: Direct mortality from smothering Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage. Reduced in reproductive success from destruction of eggs.
	Aquatic Vegetation Modification								
	Marine								
	Altered autochthonous production	Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to long-term(dependent on nature of activity)	Continuous	Eggs; Larvae; Juveniles; Adults	All life-history stages: Reductions in available submerged aquatic vegetation is likely to affect food web dynamics and available foraging opportunities, potentially resulting in decreased growth and fitness. Adults: Reductions in available submerged aquatic vegetation or alteration of submerged aquatic vegetation community composition may limit spawning productivity.	Avoid/minimize disturbance of aquatic vegetation during project construction. Avoid nourishing beaches updrift of productive, vegetated aquatic habitat.	May affect productivity at larval, juvenile, and adult life-history stages.
	Altered cover and habitat	Reduced cover							
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	During construction and during subsequent high energy periods	Temporary to short-term (dependent on grain size of augmented sediment)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	Eggs: Effects of suspended sediments on incubating herring eggs is currently a data gap. Larvae: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. Adults and juveniles: Same effects as above, as well as increased stress and decreased foraging opportunity due to avoidance behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic shoreline instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival and productivity at egg, larval, juvenile, and adult life-history stages.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body.	May affect survival, growth, and fitness of juveniles and adults.

Table A-17 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pacific Herring.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
Reef Creation/Restoration/Enhancement									
	Construction and Maintenance Activities								
	Marine								
	Equipment operation and materials placement	Elevated noise, visual and physical disturbance	During project construction activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	All life-history stages: Stressor response dependent on magnitude and duration of disturbance, and project-specific environmental conditions; may range from: • Increased predation risk and decreased foraging success due to displacement, auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid construction activities during periods when individuals may be present, particularly juveniles.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. Should exposure occur, direct mortality or injury is probable.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction)	Juveniles; Adults	Adults and juveniles: May cause avoidance behavior leading to increased stress and decreased foraging opportunity. Auditory masking or temporary hearing threshold effects may increase risk of predation due to decreased ability to sense predators.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival and productivity due to avoidance behavior, decreased foraging success, and increased predation risk.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.

Table A-17 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pacific Herring.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Eggs; Larvae; Juveniles; Adults	All exposed life-history stages: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats. Alteration in the aerial extent and composition of the submerged aquatic vegetation community resulting from these mechanisms may reduce available spawning habitat, leading to reduced spawning productivity. Egg incubation success may be affected by alteration in wave energy patterns. Alteration of current velocities and circulation patterns may cause transportation of planktonic larvae to unfavorable habitats for growth and development. Alteration of nearshore habitat productivity may also have concomitant effects on food web relationships in the offshore environment. Therefore, alteration of these parameters may affect foraging opportunities at the juvenile life-history stage, over time leading to decreased adult fitness, decreased survival, and decreased spawning productivity.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect egg and larval survival and larval fitness. Decreased larval fitness may affect survival and productivity during juvenile and adult life-history phases in offshore and open ocean environments, and may affect spawning productivity. Loss or alteration of suitable spawning habitat may affect spawning productivity.
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				
	Ecosystem Fragmentation								
	Marine								
	Altered cover and habitat	Increased predation risk	Year-round	Permanent	Continuous	Juveniles	Juveniles: Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid placement of reef projects in proximity to juvenile migratory corridors, such that increased predation exposure may occur.	May affect juvenile survival, growth and fitness.

Table A-17 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pacific Herring.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification								
	Marine								
	Altered cover and habitat	Decreased refuge and forage habitat	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Eggs; Larvae; Juveniles; Adults	Eggs: Alteration or reduction of submerged aquatic vegetation may affect microclimate conditions in spawning substrates, decreasing egg survival (particularly during spring and summer spawning). All life-history stages: Altered autochthonous production and habitat complexity are likely to affect food web dynamics and available foraging opportunities, potentially resulting in decreased growth and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect growth and fitness at egg, larval, juvenile, and adult life-history stages.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	Eggs: Effects of suspended sediments on incubating herring eggs is currently a data gap. Larvae: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may decrease foraging success, resulting in decreased growth and fitness. Adults and juveniles: Same effects as above, as well as increased stress and decreased foraging opportunity due to avoidance behavior.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival and productivity at egg, larval, juvenile, and adult life-history stages.
	Altered pollutant loading	Leaching of toxic substances (depending on composition of reef material)	Year-round	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs; Larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Use non-toxic reef material.	May affect survival and productivity of larvae, juveniles, and adults.
Eel Grass and Other Aquatic Vegetation Creation/Restoration/Enhancement									
	Construction and Maintenance Activities								
	Marine								

Table A-17 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pacific Herring.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Planting activities and vessel use	Visual, physical, and noise related disturbance	During project construction	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Adults and juveniles: May cause avoidance behavior leading to increased stress and decreased foraging opportunity. Auditory masking or temporary hearing threshold effects may increase risk of predation due to decreased ability to sense predators.	Adhere to system-specific in-water work windows.	May affect survival and productivity due to avoidance behavior, decreased foraging success, and increased predation risk.
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Vegetation transplantation projects are not likely to cause pulses of suspended sediment sufficient to lead to injury or mortality. Stressor response may include temporary behavioral avoidance and displacement.	Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May cause temporary behavioral avoidance and displacement.

Table A-18. HPA HCP Habitat Modification Exposure and Response Matrix for Lingcod.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	**When**	**Duration**	**Frequency**	**Life-history Form**			
Beaver Dam Removal									
	Not applicable								
Large Woody Debris Placement/Movement/Removal (for placement only construction impacts apply)									
	Construction and Maintenance Activities								
	Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Juveniles and adults: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: ▪ Fatal injury or permanent auditory tissue damage limiting to survival. 1) Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey. 2) Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	Activity may cause direct mortality or otherwise affect survival, growth, and fitness at all life-history stages, depending on project-specific noise intensity and receptor exposure.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification.
	Hydraulic and Geomorphic Modification								

Table A-18 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Lingcod.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Larvae; Juveniles	<u>Larvae and juveniles</u>: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the likelihood of larval lingcod settlement in nearshore areas favorable for rearing, as well as the overall suitability of rearing habitat for juveniles. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth, decreased fitness, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at larval and juvenile life-history stages.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				
	Ecosystem Fragmentation								
	Marine								
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Larvae; Juveniles; Adults	<u>Larvae and juveniles</u>: LWD removal in the marine environment can fragment nearshore rearing habitat, potentially affecting settlement of larval lingcod. LWD removal May decrease nearshore habitat suitability for juvenile lingcod by removing interstitial cover; however, the resulting potential effects on lingcod populations are a data gap. <u>Adults</u>: LWD removal in the marine environment may remove three-dimensional habitat suitable for adult lingcod in the nearshore environment, encouraging occupation. The resulting potential effects on lingcod populations are a data gap.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect larval survival. Potential effects on juvenile and adult lingcod are a data gap.

Table A-18 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Lingcod.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered cover and habitat	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.
	Aquatic Vegetation Modification								
	Marine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Construction: Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased foraging opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.		May affect juvenile survival. May affect adult growth and fitness.

Table A-18 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Lingcod.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Marine								
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures)	Year-round, (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles	Juveniles: Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival and productivity. Currently a data gap.
	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival. Currently a data gap.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	Juveniles: Lingcod dependence on allochthonous inputs from marine riparian vegetation is a data gap. However, juveniles are known to use shallow vegetated habitats and pocket estuaries which contain food sources that depend on marine riparian allochthonous input. Decreased food web productivity may result in reduced foraging opportunities.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival, growth, and fitness.

Table A-18 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Lingcod.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	Juveniles: Juvenile lingcod are known to selectively settle and rear in areas with reduced salinities; therefore, groundwater inflow may provide increased habitat suitability. Reduction in suitable habitat area may affect survival, growth, and fitness.	Avoid disturbance of vegetation along shoreline.	May affect survival, growth, and fitness of juveniles.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to long-term (dependent on contributing mechanism of impact)	Continuous to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Increased suspended solids in microlayer habitat may lead to direct mortality and decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered movement behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival, growth, and fitness at larval, juvenile, and adult life-history stages.
	Altered pollutant loading	Increased pollutant loading	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival and productivity of larvae, juveniles, and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen (due to eutrophication caused by elevated nutrient export from dewatered floodplains)	Dependent on contributing mechanism of impact	Temporary to short-term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Mortality due to asphyxiation in acute low microlayer dissolved oxygen events. (Egg exposure may occur in rare circumstances if nests are located close to shore.) Juveniles and adults: Avoidance behavior or asphyxiation during acute events.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival of incubating eggs and larvae. May affect juvenile and adult survival. May cause temporary avoidance behavior, potentially leading to decreased growth and fitness.

Table A-18 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Lingcod.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Spawning Substrate Augmentation									
	Not applicable								
In-Channel/Off-Channel Habitat Creation/Modification									
	Not applicable								
Riparian Planting/Restoration Enhancement									
	Construction and Maintenance Activities								
	Marine								
	Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Juveniles	Juveniles: Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect juvenile survival and productivity. Currently a data gap.
		Increased suspended solids – due to removal of invasive riparian species	Year-round (with specific stressors prominent during high flow conditions)	Short-term to intermediate (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Minimize disturbance during invasive species removal. Use appropriate erosion control BMPs both during and after construction.	See effects for related stressors under Water Quality Modification.
	Aquatic Vegetation Modification								
	Marine								

Table A-18 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Lingcod.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered autochthonous production	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the water surface.	May affect juvenile growth and fitness, data gap.
	Riparian Vegetation Modification								
	Marine								
	Altered Shading and solar input	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the water surface.	May affect juvenile growth and fitness, data gap.
	Water Quality Modification								
	Altered Temperatures	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Juveniles	Juveniles: Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect juvenile survival and productivity. Currently a data gap.
	Altered suspended solids	Increased suspended solids – due to removal of invasive riparian species	Dependent on contributing mechanism of impact	Short-term to intermediate (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Increased suspended solids in microlayer habitat may lead to direct mortality and decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered movement behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Minimize disturbance during invasive species removal. Use appropriate erosion control BMPs both during and after construction.	May affect survival, growth, and fitness at larval, juvenile, and adult life-history stages.

Table A-18 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Lingcod.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Wetland Creation Restoration/Enhancement									
	Construction and Maintenance Activities								
	Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: May cause avoidance behavior leading to increased stress and decreased foraging opportunity. Auditory masking or temporary hearing threshold effects may increase risk of predation due to decreased ability to sense predators.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect growth, fitness, and survival due to avoidance behavior, decreased foraging success, and increased predation risk.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs; Larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification.
	Water Quality Modification								

Table A-18 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Lingcod.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids (e.g., during reconnection of fragmented floodplain wetlands, etc.)	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Increased suspended solids in microlayer habitat may lead to direct mortality and decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered movement behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival, growth, and fitness at larval, juvenile, and adult life-history stages.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit in-water heavy machinery use.	May affect survival, growth, and fitness of juveniles and adults.
Beach Nourishment/Contouring									
	Construction and Maintenance Activities								
	Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids, Burial of juveniles	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles;	Juveniles: Post-settlement, juveniles may suffer injury or mortality as they are insufficiently mobile to avoid burial. Juveniles may experience temporary decrease in foraging opportunity due to short-term reduction in prey availability leading to decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.

Table A-18 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Lingcod.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Marine								
	Altered sediment supply	Localized alteration in invertebrate abundance from burial, burial of juveniles	During project construction and maintenance activities	Short-term – long-term	Interannual to decadal (depending on activity frequency)	Juveniles;	Juveniles: Post-settlement, juveniles may suffer injury or mortality as they are insufficiently mobile to avoid burial. Juveniles may experience temporary decrease in foraging opportunity due to short-term reduction in prey availability leading to decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.
	Aquatic Vegetation Modification								
	Marine								
	Altered autochthonous production	Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to long-term(dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased foraging opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction. Avoid nourishing beaches updrift of productive, vegetated aquatic habitat.	May affect juvenile survival. May affect adult growth and fitness.
	Altered cover and habitat	Reduced cover							
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	During construction and during subsequent high energy periods	Temporary to short-term (dependent on grain size of augmented sediment)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Increased suspended solids in microlayer habitat may lead to direct mortality and decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered movement behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic shoreline instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival, growth, and fitness at larval, juvenile, and adult life-history stages.

Table A-18 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Lingcod.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	<u>All life-history stages</u>: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body.	May affect survival, growth, and fitness of juveniles and adults.
Reef Creation/Restoration/Enhancement									
	Construction and Maintenance Activities								
	Marine								
	Equipment operation and materials placement	Elevated noise, visual and physical disturbance	During project construction activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>All life-history stages</u>: Stressor response dependent on magnitude and duration of disturbance, and project-specific environmental conditions; may range from: • Increased predation risk and decreased foraging success due to displacement, auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid construction activities during periods when individuals may be present, particularly juveniles.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. Should exposure occur, direct mortality or injury is probable.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction)	Juveniles; Adults	<u>Adults and juveniles</u>: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival and productivity due to avoidance behavior, decreased foraging success, and increased predation risk. Actual effects are unknown as stressor sensitivity is currently a data gap.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u>: Post-settlement, juveniles may suffer injury or mortality as they are insufficiently mobile to avoid entrainment. Juveniles may experience temporary decrease in foraging opportunity due to short-term reduction in prey availability leading to decreased growth and fitness. <u>All exposed life-history stages</u>: See responses described for related stressors under Water Quality Modification.	Avoid project site which are productive and have a healthy benthic community.	May cause direct mortality or injury to juveniles. May affect juvenile growth and fitness. See effects for related stressors under Water Quality Modification.

Table A-18 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Lingcod.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Larvae; Juveniles	<u>Larvae and juveniles</u>: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the likelihood of larval lingcod settlement in nearshore areas favorable for rearing, as well as the overall suitability of rearing habitat for juveniles. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth, decreased fitness, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at larval and juvenile life-history stages.
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				
	Ecosystem Fragmentation								
	Marine								
	Altered cover and habitat	Increased predation risk	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles:</u> Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid placement of reef projects in proximity to juvenile migratory corridors, such that increased predation exposure may occur.	May affect juvenile survival, growth and fitness.

Table A-18 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Lingcod.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification								
	Marine								
	Altered cover and habitat	Decreased refuge and forage habitat	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased foraging opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile survival. May affect adult growth and fitness.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Increased suspended solids in microlayer habitat may lead to direct mortality and decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered movement behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at larval, juvenile, and adult life-history stages.
	Altered pollutant loading	Leaching of toxic substances (depending on composition of reef material)	Year-round	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs; Larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Use non-toxic reef material.	May affect survival and productivity of larvae, juveniles, and adults.
Eel Grass and Other Aquatic Vegetation Creation/Restoration/Enhancement									
	Construction and Maintenance Activities								

Table A-18 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Lingcod.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Marine								
	Planting activities and vessel use	Visual, physical, and noise related disturbance	During project construction	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Adhere to system-specific in-water work windows.	May affect survival and productivity due to avoidance behavior, decreased foraging success, and increased predation risk. Actual effects are unknown as stressor sensitivity is currently a data gap.
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Vegetation transplantation projects are not likely to cause pulses of suspended sediment sufficient to lead to injury or mortality. Stressor response may include temporary behavioral avoidance and displacement.	Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May cause temporary behavioral avoidance and displacement.

Table A-19. HPA HCP Habitat Modification Exposure and Response Matrix for Pacific Cod, Hake, and Walleye Pollock.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Beaver Dam Removal									
	Not applicable								
Large Woody Debris Placement/Movement/Removal (for placement only construction impacts apply)									
	Construction and Maintenance Activities								
	Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs; Larvae; Juveniles	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Larvae; Juveniles	All life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: ▪ Barotraumas causing fatal injury or permanent auditory tissue damage in larvae, juveniles, and adults limiting to survival. 1) Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey. 2) Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	Activity may cause direct mortality or otherwise affect survival, growth, and fitness and at all life-history stages, depending on project-specific noise intensity and receptor exposure.

Table A-19 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pacific Cod, Hake, and Walleye Pollock.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Larvae; Juveniles	All life-history stages: See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Larvae; Juveniles	Larvae and juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the likelihood of larval settlement in nearshore areas favorable for rearing, as well as the overall suitability of juvenile rearing habitat. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth, decreased fitness, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at larval and juvenile life-history stages.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				

Table A-19 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pacific Cod, Hake, and Walleye Pollock.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation								
	Marine								
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Larvae; Juveniles	Larvae and juveniles: LWD removal in the marine environment can fragment nearshore rearing habitat, potentially affecting settlement of larval cod, pollock, and hake.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect larval survival, growth, and fitness.
	Altered cover and habitat	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.
	Aquatic Vegetation Modification								
	Marine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Construction: Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness.		May affect juvenile growth and fitness.

Table A-19 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pacific Cod, Hake, and Walleye Pollock.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Marine								
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures)	Year-round, (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles	Juveniles: Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival and productivity. Currently a data gap.
	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival and productivity.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	Juveniles: Pacific cod, hake and walleye pollock dependence on allochthonous inputs from marine riparian vegetation is a data gap. However, juvenile Pacific cod, hake, and walleye pollock are known to use shallow vegetated habitats that could have marine riparian allochthonous input. Decreased food web productivity may result in reduced foraging opportunities.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival, growth, and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival, growth, and fitness.
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	Juveniles: Pacific cod, hake, and walleye pollock dependence on groundwater inflow to nearshore marine habitats is currently a data gap.	Avoid disturbance of vegetation along shoreline.	Effects of action are unknown as receptor sensitivity to this stressor is currently a data gap.

Table A-19 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pacific Cod, Hake, and Walleye Pollock.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to long-term (dependent on contributing mechanism of impact)	Continuous to interannual–decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles	Larvae: Increased suspended solids in microlayer habitat may lead to direct mortality and decreased larval survival. Juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered movement behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival, growth, and fitness at larval and juvenile life-history stages.
	Altered pollutant loading	Increased pollutant loading	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs; Larvae; Juveniles	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival and productivity of larvae, juveniles, and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen (due to eutrophication caused by elevated nutrient export from dewatered floodplains)	Dependent on contributing mechanism of impact	Temporary to short-term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Larvae; Juveniles	Larvae: Mortality due to asphyxiation in acute low microlayer dissolved oxygen events. Juveniles: Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Avoidance behavior leading to increased competition, predation exposure, and decreased foraging opportunity.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May cause direct mortality of larvae and juveniles. May affect juvenile survival, growth, and fitness.
Spawning Substrate Augmentation									
	Not applicable								
In-Channel/Off-Channel Habitat Creation/Modification									
	Not applicable								
Riparian Planting/Restoration Enhancement									
	Construction and Maintenance Activities								
	Marine								

Table A-19 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pacific Cod, Hake, and Walleye Pollock.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Juveniles	Juveniles: Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect juvenile survival and productivity. Currently a data gap.
		Increased suspended solids – due to removal of invasive riparian species	Year-round (with specific stressors prominent during high flow conditions)	Short-term to intermediate (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Larvae; Juveniles;	All life-history stages: See responses to related stressors under Water Quality Modification.	Minimize disturbance during invasive species removal. Use appropriate erosion control BMPs both during and after construction.	See effects for related stressors under Water Quality Modification.
	Aquatic Vegetation Modification								
	Marine								
	Altered autochthonous production	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the water surface.	May affect juvenile growth and fitness, data gap.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Marine								
	Altered Shading and solar input	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the water surface.	May affect juvenile growth and fitness, data gap.
	Water Quality Modification								
	Altered Temperatures	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Juveniles	Juveniles: Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect juvenile survival and productivity. Currently a data gap.
	Altered suspended solids	Increased suspended solids – due to removal of invasive riparian species	Dependent on contributing mechanism of impact	Short-term to intermediate (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles	Larvae: Increased suspended solids in microlayer habitat may lead to direct mortality and decreased larval survival. Juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered movement behavior.	Minimize disturbance during invasive species removal. Use appropriate erosion control BMPs both during and after construction.	May affect survival, growth, and fitness at larval and juvenile life-history stages.

Table A-19 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pacific Cod, Hake, and Walleye Pollock.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Wetland Creation Restoration/Enhancement									
	Construction and Maintenance Activities								
	Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs; Larvae; Juveniles	All life-history stages: See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification.
	Water Quality Modification								

Table A-19 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pacific Cod, Hake, and Walleye Pollock.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids (e.g., during reconnection of fragmented floodplain wetlands, etc.)	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles	Larvae: Increased suspended solids in microlayer habitat may lead to direct mortality and decreased larval survival. Juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered movement behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival, growth, and fitness at larval and juvenile life-history stages.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit in-water heavy machinery use.	May affect survival, growth, and fitness of juveniles and adults.
Beach Nourishment/Contouring									
	Construction and Maintenance Activities								
	Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids, Burial of juveniles	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	Juveniles: Post-settlement juveniles may suffer injury or mortality as they are insufficiently mobile to avoid entrainment. Juveniles may experience temporary decrease in foraging opportunity due to short-term reduction in prey availability leading to decreased growth and fitness. All exposed life-history stages: See responses described for related stressors under Water Quality Modification.	Avoid project site which are productive and have a healthy benthic community.	May cause direct mortality of juveniles. May affect juvenile survival, growth, and fitness. See effects for related stressors under Water Quality Modification.

Table A-19 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pacific Cod, Hake, and Walleye Pollock.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Marine								
	Altered sediment supply	Localized alteration in invertebrate abundance from burial, burial of juveniles	During project construction and maintenance activities	Short-term – long-term	Interannual to decadal (depending on activity frequency)	Juveniles;	Juveniles: Post-settlement, juveniles may suffer injury or mortality as they are insufficiently mobile to avoid burial. Juveniles may experience temporary decrease in foraging opportunity due to short-term reduction in prey availability leading to decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.
	Aquatic Vegetation Modification								
	Marine								
	Altered autochthonous production	Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to long-term(dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction. Avoid nourishing beaches updrift of productive, vegetated aquatic habitat.	May affect juvenile survival growth and fitness.
	Altered cover and habitat	Reduced cover	Year-round	Short-term to long-term(dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction. Avoid nourishing beaches updrift of productive, vegetated aquatic habitat.	May affect juvenile survival growth and fitness.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	During construction and during subsequent high energy periods	Temporary to short-term (dependent on grain size of augmented sediment)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles	Larvae: Increased suspended solids in microlayer habitat may lead to direct mortality and decreased larval survival. Juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered movement behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic shoreline instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival, growth, and fitness at larval and juvenile life-history stages.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term (dependent on contributing mechanism of impact)	Interannual to decadal	Eggs; Larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body.	May affect survival, growth, and fitness of juveniles and adults.

Table A-19 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pacific Cod, Hake, and Walleye Pollock.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Reef Creation/Restoration/Enhancement									
	Construction and Maintenance Activities								
	Marine								
	Equipment operation and materials placement	Elevated noise, visual and physical disturbance	During project construction activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	All life-history stages: Stressor response dependent on magnitude and duration of disturbance, and project-specific environmental conditions; may range from: • Increased predation risk and decreased foraging success due to displacement, auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid construction activities during periods when individuals may be present, particularly juveniles.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. Should exposure occur, direct mortality or injury is probable.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival and productivity due to avoidance behavior, decreased foraging success, and increased predation risk. Actual effects are unknown as stressor sensitivity is currently a data gap.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	Juveniles: Post-settlement juveniles may suffer injury or mortality as they are insufficiently mobile to avoid entrainment. Juveniles may experience temporary decrease in foraging opportunity due to short-term reduction in prey availability leading to decreased growth and fitness. All exposed life-history stages: See responses described for related stressors under Water Quality Modification.	Avoid project site which are productive and have a healthy benthic community.	May cause direct mortality of juveniles. May affect juvenile survival, growth, and fitness. See effects for related stressors under Water Quality Modification.

Table A-19 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pacific Cod, Hake, and Walleye Pollock.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Larvae; Juveniles	Larvae and juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the likelihood of larval settlement in nearshore areas favorable for rearing, as well as the overall suitability of juvenile rearing habitat. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth, decreased fitness, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at larval and juvenile life-history stages.
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				
	Ecosystem Fragmentation								
	Marine								
	Altered cover and habitat	Increased predation risk	Year-round	Permanent	Continuous	Juveniles	Juveniles: Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid placement of reef projects in proximity to juvenile migratory corridors, such that increased predation exposure may occur.	May affect juvenile survival, growth and fitness.

Table A-19 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pacific Cod, Hake, and Walleye Pollock.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification								
	Marine								
	Altered cover and habitat	Decreased refuge and forage habitat	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles	Larvae: Increased suspended solids in microlayer habitat may lead to direct mortality and decreased larval survival. Juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered movement behavior.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at larval and juvenile life-history stages.
	Altered pollutant loading	Leaching of toxic substances (depending on composition of reef material)	Year-round	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Eggs; Larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Use non-toxic reef material.	May affect survival and productivity of larvae, juveniles, and adults.
Eel Grass and Other Aquatic Vegetation Creation/Restoration/Enhancement									
	Construction and Maintenance Activities								
	Marine								
	Planting activities and vessel use	Visual, physical, and noise related disturbance	During project construction	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Adhere to system-specific in-water work windows.	May affect survival and productivity due to avoidance behavior, decreased foraging success, and increased predation risk. Actual effects are unknown as stressor sensitivity is currently a data gap.

Table A-19 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Pacific Cod, Hake, and Walleye Pollock.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Vegetation transplantation projects are not likely to cause pulses of suspended sediment sufficient to lead to injury or mortality. Stressor response may include temporary behavioral avoidance and displacement.	Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May cause temporary behavioral avoidance and displacement.

Table A-20. HPA HCP Habitat Modification Exposure and Response Matrix for Group 20—Rockfish Species.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Beaver Dam Removal									
	Not applicable								
Large Woody Debris Placement/Movement/Removal (for placement only construction impacts apply)									
	Construction and Maintenance Activities								
	Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Larvae; Juveniles	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Juveniles and adults: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: ▪ Fatal injury or permanent auditory tissue damage limiting to survival. 1) Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey. 2) Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	Activity may cause direct mortality or injury affecting juvenile and adult survival, depending on project-specific noise intensity and receptor exposure.

Table A-20 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Group 20—Rockfish Species.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Larvae; Juveniles	All life-history stages: See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Larvae; Juveniles	Larvae and juveniles: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the likelihood of larval rockfish settlement in nearshore areas favorable for rearing, as well as the overall suitability of rearing habitat. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth, decreased fitness, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at larval and juvenile life-history stages.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				

Table A-20 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Group 20—Rockfish Species.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation								
	Marine								
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Larvae; Juveniles	Larvae and juveniles: LWD removal in the marine environment can fragment nearshore rearing habitat, potentially affecting settlement of larval rockfish.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect larval survival. Potential effects on juvenile and adult rockfish are a data gap.
	Altered cover and habitat	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round	Permanent	Continuous	Juveniles	See responses to altered habitat complexity under Riparian Vegetation Modification.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.
	Aquatic Vegetation Modification								
	Marine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Construction: Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure resulting in decreased survival, growth, and fitness. Adults: Decreased refuge habitat availability. Decreased foraging opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.		May affect juvenile survival. May affect adult growth and fitness.

Table A-20 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Group 20—Rockfish Species.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Marine								
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures)	Year-round, (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles	Juveniles: Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival. Currently a data gap.
	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness. Potential habitat avoidance and/or injury and mortality caused by excessive turbidity, as described for related stressor responses under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile survival. Currently a data gap.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	Juveniles: Rockfish dependence on allochthonous inputs from marine riparian vegetation is a data gap. However, juvenile rockfish are known to use shallow vegetated habitats and pocket estuaries which contain food sources that depend on marine riparian allochthonous input. Decreased food web productivity may result in reduced foraging opportunities.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile growth and fitness.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival, growth, and fitness.
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles	Juveniles: Rockfish dependence on groundwater inflow to nearshore marine habitats is currently a data gap.	Avoid disturbance of vegetation along shoreline.	Effects of the action resulting from this impact mechanism are unknown.

Table A-20 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Group 20—Rockfish Species.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to long-term (dependent on contributing mechanism of impact)	Continuous to interannual–decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles	Larvae: Increased suspended solids in microlayer habitat may lead to direct mortality and decreased survival of larvae. Juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered movement behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival, growth, and fitness at larval and juvenile life-history stages.
	Altered pollutant loading	Increased pollutant loading	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival and productivity of larvae, juveniles, and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen (due to eutrophication caused by elevated nutrient export from dewatered floodplains)	Dependent on contributing mechanism of impact	Temporary to short-term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Larvae; Juveniles	Larvae: Mortality due to asphyxiation in acute low microlayer dissolved oxygen events. Juveniles: Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Avoidance behavior leading to increased competition, predation exposure, and decreased foraging opportunity.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May cause direct mortality of larvae and juveniles. May affect juvenile survival, growth, and fitness.
Spawning Substrate Augmentation									
	Not applicable								
In-Channel/Off-Channel Habitat Creation/Modification									
	Not applicable								
Riparian Planting/Restoration Enhancement									
	Construction and Maintenance Activities								
	Marine								

Table A-20 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Group 20—Rockfish Species.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Juveniles	Juveniles: Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect juvenile survival and productivity. Currently a data gap.
		Increased suspended solids – due to removal of invasive riparian species	Year-round (with specific stressors prominent during high flow conditions)	Short-term to intermediate (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Larvae; Juveniles;	All life-history stages: See responses to related stressors under Water Quality Modification.	Minimize disturbance during invasive species removal. Use appropriate erosion control BMPs both during and after construction.	See effects for related stressors under Water Quality Modification.
	Aquatic Vegetation Modification								
	Marine								
	Altered autochthonous production	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure resulting in decreased survival, growth, and fitness. Adults: Decreased refuge habitat availability. Decreased foraging opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the water surface.	May affect juvenile survival. May affect adult growth and fitness.

Table A-20 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Group 20—Rockfish Species.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Marine								
	Altered Shading and solar input	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the water surface.	May affect juvenile growth and fitness, data gap.
	Water Quality Modification								
	Altered Temperatures	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Juveniles	Juveniles: Riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors. However, juveniles trapped in habitats isolated by tidal exchange (e.g., pocket estuaries) may experience increased temperatures where shade and buffer influence has been altered, potentially leading to mortality or increased thermal stress and decreased fitness.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect juvenile survival and productivity. Currently a data gap.
	Altered suspended solids	Increased suspended solids – due to removal of invasive riparian species	Dependent on contributing mechanism of impact	Short-term to intermediate (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles	Larvae: Increased suspended solids in microlayer habitat may lead to direct mortality and decreased survival of larvae. Juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered movement behavior.	Minimize disturbance during invasive species removal. Use appropriate erosion control BMPs both during and after construction.	May affect survival, growth, and fitness at larval and juvenile life-history stages.

Table A-20 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Group 20—Rockfish Species.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Wetland Creation Restoration/Enhancement									
	Construction and Maintenance Activities								
	Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Larvae; Juveniles	All life-history stages: See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification.
	Water Quality Modification								

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids (e.g., during reconnection of fragmented floodplain wetlands, etc.)	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles	Larvae: Increased suspended solids in microlayer habitat may lead to direct mortality and decreased survival of larvae. Juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered movement behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival, growth, and fitness at larval and juvenile life-history stages.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term (dependent on contributing mechanism of impact)	Interannual to decadal	Larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit in-water heavy machinery work.	May affect survival, growth, and fitness of juveniles and adults.
Beach Nourishment/Contouring									
	Construction and Maintenance Activities								
	Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids, Burial of juveniles	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	Juveniles: Post-settlement juveniles may suffer injury or mortality as they are insufficiently mobile to avoid entrainment. Juveniles may experience temporary decrease in foraging opportunity due to short-term reduction in prey availability leading to decreased growth and fitness. All exposed life-history stages: See responses described for related stressors under Water Quality Modification.	Avoid project site which are productive and have a healthy benthic community.	May cause direct mortality of juveniles. May affect juvenile survival, growth, and fitness. See effects for related stressors under Water Quality Modification.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Marine								
	Altered sediment supply	Localized alteration in invertebrate abundance from burial, burial of juveniles	During project construction and maintenance activities	Short-term – long-term	Interannual to decadal (depending on activity frequency)	Juveniles;	Juveniles: Post-settlement, juveniles may suffer injury or mortality as they are insufficiently mobile to avoid burial. Juveniles may experience temporary decrease in foraging opportunity due to short-term reduction in prey availability leading to decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.
	Aquatic Vegetation Modification								
	Marine								
	Altered autochthonous production	Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to long-term(dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction. Avoid nourishing beaches updrift of productive, vegetated aquatic habitat.	May affect juvenile survival growth and fitness.
	Altered cover and habitat	Reduced cover							
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	During construction and during subsequent high energy periods	Temporary to short-term (dependent on grain size of augmented sediment)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles	Larvae: Increased suspended solids in microlayer habitat may lead to direct mortality and decreased survival of larvae. Juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered movement behavior.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic shoreline instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival, growth, and fitness at larval and juvenile life-history stages.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term (dependent on contributing mechanism of impact)	Interannual to decadal	Larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body.	May affect survival, growth, and fitness of juveniles and adults.

Table A-20 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Group 20—Rockfish Species.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Reef Creation/Restoration/Enhancement									
	Construction and Maintenance Activities								
	Marine								
	Equipment operation and materials placement	Elevated noise, visual and physical disturbance	During project construction activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	All life-history stages: Stressor response dependent on magnitude and duration of disturbance, and project-specific environmental conditions; may range from: • Increased predation risk and decreased foraging success due to displacement, auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey • Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid construction activities during periods when individuals may be present, particularly juveniles.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. Should exposure occur, direct mortality or injury is probable.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	May affect survival and productivity due to avoidance behavior, decreased foraging success, and increased predation risk. Actual effects are unknown as stressor sensitivity is currently a data gap.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	Juveniles: Post-settlement juveniles may suffer injury or mortality as they are insufficiently mobile to avoid entrainment. Juveniles may experience temporary decrease in foraging opportunity due to short-term reduction in prey availability leading to decreased growth and fitness. All exposed life-history stages: See responses described for related stressors under Water Quality Modification.	Avoid project site which are productive and have a healthy benthic community.	May cause direct mortality of juveniles. May affect juvenile survival, growth, and fitness. See effects for related stressors under Water Quality Modification.

Table A-20 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Group 20—Rockfish Species.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Hydraulic and Geomorphic Modification								
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Larvae; Juveniles	<u>Larvae and juveniles</u>: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the likelihood of larval rockfish settlement in nearshore areas favorable for rearing, as well as the overall suitability of rearing habitat. This may occur through a number of specific stressors, including increased exertion and stress due to change in current and wave energy patterns, increased predation exposure due to reduction in available cover or exposure to deep water habitat, food web alterations and decreased foraging opportunity, and increased competition for suitable habitats. The combined effect of these stressors can result in decreased growth, decreased fitness, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at larval and juvenile life-history stages.
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				
	Ecosystem Fragmentation								
	Marine								
	Altered cover and habitat	Increased predation risk	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles:</u> Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid placement of reef projects in proximity to juvenile migratory corridors, such that increased predation exposure may occur.	May affect juvenile survival, growth and fitness.

Table A-20 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Group 20—Rockfish Species.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification								
	Marine								
	Altered cover and habitat	Decreased refuge and forage habitat	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles	Larvae: Increased suspended solids in microlayer habitat may lead to direct mortality and decreased survival of larvae. Juveniles: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered movement behavior.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at larval and juvenile life-history stages.
	Altered pollutant loading	Leaching of toxic substances (depending on composition of reef material)	Year-round	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Larvae; Juveniles; Adults	All affected life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Use non-toxic reef material.	May affect survival and productivity of larvae, juveniles, and adults.
Eel Grass and Other Aquatic Vegetation Creation/Restoration/Enhancement									
	Construction and Maintenance Activities								
	Marine								

Table A-20 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Group 20—Rockfish Species.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Planting activities and vessel use	Visual, physical, and noise related disturbance	During project construction	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Adhere to system-specific in-water work windows.	May affect survival and productivity due to avoidance behavior, decreased foraging success, and increased predation risk. Actual effects are unknown as stressor sensitivity is currently a data gap.
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Vegetation transplantation projects are not likely to cause pulses of suspended sediment sufficient to lead to injury or mortality. Stressor response may include temporary behavioral avoidance and displacement.	Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May cause temporary behavioral avoidance and displacement.

Table A-21. HPA HCP Habitat Modification Exposure and Response Matrix for Olympia Oyster.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Beaver Dam Removal									
	Not applicable								
Large Woody Debris Placement/Movement/Removal (for placement only construction impacts apply)									
	Construction and Maintenance Activities								
	Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Veliger larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Veliger larvae; Juveniles, Adults	All life-history stages: Effect of anthropogenic sound is a data gap.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	Effect of increased ambient noise level on Olympic oyster is a data gap.

Table A-21 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Olympia Oyster.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Veliger larvae; Juveniles; Adults;	All life-history stages: See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Veliger larvae; Juveniles; Adults	All life-history stages: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of settling and rearing habitat for Olympia oyster. This may occur through a number of specific stressors, including food web alterations and decreased prey resources, introduced non-native species, and increased competition for suitable habitats. Alteration of circulation patterns may also affect spawn timing and the transport and settlement of veliger larvae. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine movement, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at all life-history stages.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				

Table A-21 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Olympia Oyster.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation								
	Marine								
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Veliger larvae; Juveniles; Adults	All exposed life-history stages: LWD removal in the marine environment can fragment nearshore habitat and may limit the area suitable for larval settlement, decreasing overall juvenile and adult abundance.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect larval survival, in turn affecting juvenile and adult population abundance.
	Altered cover and habitat	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round	Permanent	Continuous	Juveniles; Adults	See responses to altered habitat complexity under Riparian Vegetation Modification.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.
	Aquatic Vegetation Modification								
	Marine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	Juveniles and adults: Reduced feeding opportunities due to decreased food web productivity; decreased growth and fitness.	Construction: Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased habitat availability and feeding opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased feeding opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.		May affect juvenile survival. May affect adult growth and fitness.

Table A-21 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Olympia Oyster.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Marine								
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures)	Year-round, (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles; Adults	Juveniles and adults: Although, riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors, Olympia oysters along the intertidal zone can gain benefits from extreme cold or heat that are known to cause mortality in other species.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival, growth, and fitness of juvenile and adult oysters (effects may be beneficial).
	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	Juveniles and adults: Burial can smother Olympia oysters. Siltation is a known limiting factor causing injury or mortality. See turbidity effects described in Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile and adult survival.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles; Adults	Juveniles and adults: Olympia oyster dependence on allochthonous and autochthonous inputs from marine riparian vegetation is a data gap.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	Effects of this impact mechanism and related stressors are currently a data gap.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles and adults: Decreased food resources, leading to adverse effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival, adult spawning success, and overall population productivity.
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Veliger larvae; Juveniles: Adults	All life history stages: Olympia oyster are known to prefer areas where freshwater seepage into the intertidal zone likely limits extremes in temperature.	Avoid disturbance of vegetation along shoreline.	Effects from this impact mechanism may also include protection from predators unable to tolerate low salinity habitats.

Table A-21 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Olympia Oyster.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to long-term (dependent on contributing mechanism of impact)	Continuous to interannual–decadal (dependent on contributing mechanism of impact)	Veliger larvae; Juveniles; Adults	All life-history stages: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause mortality.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating larvae and juveniles. May affect juvenile productivity and adult productivity.
	Altered pollutant loading	Increased pollutant loading	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Veliger larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival and productivity of larvae, juveniles, and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen (due to eutrophication caused by elevated nutrient export from dewatered floodplains)	Dependent on contributing mechanism of impact	Temporary to short-term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Veliger larvae; Juveniles; Adults	All life-history stages: Olympia oyster dissolved oxygen effect thresholds are currently a data gap. Sensitivity to dissolved oxygen levels appears to be low, however.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival of incubating larvae, juveniles, and adults. May affect juvenile and adult survival, growth, and fitness, including adult spawning success. Actual effects are unknown, as sensitivity to this stressor and effects thresholds are currently data gaps.
Spawning Substrate Augmentation									
	Not applicable								
In-Channel/Off-Channel Habitat Creation/Modification									
	Not applicable								
Riparian Planting/Restoration Enhancement									
	Construction and Maintenance Activities								
	Marine								
	Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	Juveniles and adults: Although, riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors, Olympia oysters along the intertidal zone can gain benefits from extreme cold or heat that are known to cause mortality in other species.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect survival, growth, and fitness of juvenile and adult oysters (effects may be beneficial).

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Increased suspended solids – due to removal of invasive riparian species	Year-round (with specific stressors prominent during high flow conditions)	Short-term to intermediate (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Veliger larvae; Juveniles;	All life-history stages: See responses to related stressors under Water Quality Modification.	Minimize disturbance during invasive species removal. Use appropriate erosion control BMPs both during and after construction.	See effects for related stressors under Water Quality Modification.
	Aquatic Vegetation Modification								
	Marine								
	Altered autochthonous production	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	Juveniles: Decreased habitat availability and feeding opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased feeding opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the water surface.	May affect juvenile survival. May affect adult growth and spawning productivity.

Table A-21 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Olympia Oyster.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Riparian Vegetation Modification								
	Marine								
	Altered Shading and solar input	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	Juveniles: Decreased habitat availability and feeding opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased feeding opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the water surface.	May affect juvenile survival. May affect adult growth and spawning productivity.
	Water Quality Modification								
	Altered Temperatures	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	Juveniles and adults: Although, riparian shade and ambient temperature have a minor effect on nearshore water temperatures relative to the dominant influence of marine tidal and current patterns, wind conditions, and other factors, Olympia oysters along the intertidal zone can gain benefits from extreme cold or heat that are known to cause mortality in other species.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect survival, growth, and fitness of juvenile and adult oysters (effects may be beneficial).
	Altered suspended solids	Increased suspended solids – due to removal of invasive riparian species	Dependent on contributing mechanism of impact	Short-term to intermediate (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Veliger larvae; Juveniles; Adults	All life-history stages: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause mortality.	Minimize disturbance during invasive species removal. Use appropriate erosion control BMPs both during and after construction.	May affect survival of incubating larvae and juveniles. May affect juvenile productivity and adult productivity.

Table A-21 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Olympia Oyster.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Wetland Creation Restoration/Enhancement									
	Construction and Maintenance Activities								
	Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Veliger larvae Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Veliger larvae; Juveniles, Adults	All life-history stages: Effect of anthropogenic sound is a data gap.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	Effect of increased ambient noise level on Olympic oyster is a data gap.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Veliger larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification.
	Water Quality Modification								

Table A-21 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Olympia Oyster.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids (e.g., during reconnection of fragmented floodplain wetlands, etc.)	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Veliger larvae; Juveniles; Adults	All life-history stages: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause mortality.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating larvae and juveniles. May affect juvenile productivity and adult productivity.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term (dependent on contributing mechanism of impact)	Interannual to decadal	Veliger larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
Beach Nourishment/Contouring									
	Construction and Maintenance Activities								
	Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Veliger larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Veliger larvae; Juveniles; Adults	All life-history stages: Mortality from burial. Decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May cause direct mortality of all life history stages. May affect juvenile survival, growth, and fitness.
	Hydraulic and Geomorphic Modification								
	Marine								
	Altered sediment supply	Localized alteration in invertebrate abundance from burial, burial of juveniles	During project construction and maintenance activities	Short-term – long-term	Interannual to decadal (depending on activity frequency)	Veliger larvae; Juveniles; Adults	All life-history stages: Mortality from burial. Decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May cause direct mortality of all life history stages. May affect juvenile survival, growth, and fitness.
	Aquatic Vegetation Modification								
	Marine								
	Altered autochthonous production	Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to long-term(dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased habitat availability and feeding opportunities, leading to increased competition and predation	Avoid/minimize disturbance of aquatic vegetation during project construction. Avoid nourishing beaches updrift of	May affect juvenile survival. May affect adult growth and spawning productivity.

Table A-21 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Olympia Oyster.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered cover and habitat	Reduced cover					exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased feeding opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.	productive, vegetated aquatic habitat.	
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	During construction and during subsequent high energy periods	Temporary to short-term (dependent on grain size of augmented sediment)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Veliger larvae; Juveniles; Adults	All life-history stages: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause mortality.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic shoreline instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect juvenile and adult survival.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term (dependent on contributing mechanism of impact)	Interannual to decadal	Veliger larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body.	May affect survival, growth, and fitness of juveniles and adults.
Reef Creation/Restoration/Enhancement									
	Construction and Maintenance Activities								
	Marine								
	Equipment operation and materials placement	Elevated noise, visual and physical disturbance	During project construction activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Veliger larvae; Juveniles, Adults	All life-history stages: Effect of anthropogenic sound is a data gap.	Avoid construction activities during periods when individuals may be present, particularly juveniles.	Effect of increased ambient noise level on Olympic oyster is a data gap.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction)	Veliger larvae; Juveniles, Adults	All life-history stages: Effect of anthropogenic sound is a data gap.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	Effect of increased ambient noise level on Olympic oyster is a data gap.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Veliger larvae; Juveniles; Adults;	All life-history stages: Mortality from burial. Decreased growth and fitness. See responses described for related stressors under Water Quality Modification.	Avoid project site which are productive and have a healthy benthic community.	May affect veliger larvae productivity and fitness. See effects for related stressors under Water Quality Modification.

Table A-21 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Olympia Oyster.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Veliger larvae; Juveniles; Adults	All life-history stages: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of settling and rearing habitat for Olympia oyster. This may occur through a number of specific stressors, including food web alterations and decreased prey resources, introduced non-native species, and increased competition for suitable habitats. Alteration of circulation patterns may also affect spawn timing and the transport and settlement of veliger larvae. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine movement, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at all life-history stages.
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				
	Ecosystem Fragmentation								
	Marine								
	Altered cover and habitat	Increased predation risk	Year-round	Permanent	Continuous	Juveniles	Juveniles: Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid placement of reef projects in proximity to juvenile migratory corridors, such that increased predation exposure may occur.	May affect juvenile survival, growth and fitness.

Table A-21 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Olympia Oyster.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification								
	Marine								
	Altered cover and habitat	Decreased refuge and forage habitat	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	<u>Juveniles:</u> Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Veliger larvae; Juveniles; Adults	<u>All life-history stages</u>: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect juvenile and adult survival.
	Altered pollutant loading	Leaching of toxic substances (depending on composition of reef material)	Year-round	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Veliger larvae; Juveniles; Adults	<u>All affected life-history stages</u>: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Use non-toxic reef material.	May affect survival and productivity of larvae, juveniles, and adults.
Eel Grass and Other Aquatic Vegetation Creation/Restoration/Enhancement									
	Construction and Maintenance Activities								
	Marine								
	Planting activities and vessel use	Visual, physical, and noise related disturbance	During project construction	Temporary	Interannual to decadal (depending on activity frequency)	Veliger larvae; Juveniles, Adults	<u>All life-history stages</u>: Effect of anthropogenic sound is a data gap.	Adhere to system-specific in-water work windows.	Effect of increased ambient noise level on Olympic oyster is a data gap.
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u>: Vegetation transplantation projects are not likely to cause pulses of suspended sediment sufficient to lead to injury or mortality.	Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating larvae and juveniles. May affect juvenile productivity and adult productivity.

Table A-22. HPA HCP Habitat Modification Exposure and Response Matrix for Northern Abalone.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Beaver Dam Removal									
	Not applicable								
Large Woody Debris Placement/Movement/Removal (for placement only construction impacts apply)									
	Construction and Maintenance Activities								
	Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Juveniles and adults: Effect of anthropogenic sound on northern abalone is a data gap.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	Effect of anthropogenic sound on northern abalone is a data gap.

Table A-22 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Northern Abalone.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Larvae; Juveniles; Adults	All life-history stages: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of settling and rearing habitat for northern abalone. This may occur through a number of specific stressors, including food web alterations and decreased prey resources, introduced non-native species, and increased competition for suitable habitats. Loss of marine macroalgae may increase the visibility of the northern abalone to predators. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine movement, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival at all life-history stages.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				

Table A-22 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Northern Abalone.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation								
	Marine								
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Larvae; Juveniles; Adults	All exposed life-history stages: The structural footprint of groins and bank barbs may eliminate suitable habitat for larval settlement and juvenile and adult foraging. Over time, increased hard surface area associated with structures may increase the amount of surface area available for abalone foraging, but these beneficial effects may be offset by stressors related to hydraulic and geomorphic modification.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect larval survival, in turn affecting juvenile and adult population abundance.
	Altered cover and habitat	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round	Permanent	Continuous	Juveniles; Adults	See responses to altered habitat complexity under Riparian Vegetation Modification.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.
	Aquatic Vegetation Modification								
	Marine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	Juveniles and adults: Northern abalone dependence on allochthonous and autochthonous inputs from marine aquatic vegetation is a data gap. Northern abalone are known to use intertidal and subtidal vegetation and phytoplankton that could be a product of aquatic vegetation autochthonous input.	Construction: Avoid/minimize disturbance of aquatic vegetation during project construction.	Effect from this impact mechanism is currently a data gap.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles	Juveniles: See related stressor responses under Water Quality Modification.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge and rearing habitat availability and food resource availability, leading to increased competition and predation exposure and resulting in decreased survival, growth, and fitness. Adults: Decreased feeding opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.		May affect juvenile growth, fitness, and survival. May affect adult growth and spawning productivity.

Table A-22 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Northern Abalone.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Riparian Vegetation Modification								
	Marine								
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures)	Year-round, (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Juveniles; Adults	<u>Juveniles and adults</u>: The effect of riparian shading on abalone is currently a data gap.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	Effects of this impact mechanism and related stressors are currently a data gap.
	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	<u>Juveniles and adults:</u> Burial can smother northern abalones if large pulses of landslide debris were to enter Puget Sound waters. Siltation is a known limiting factor causing injury or mortality. See turbidity effects described under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile and adult survival.
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u>: Northern abalone dependence on allochthonous and autochthonous inputs from marine riparian vegetation is a data gap.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	Effects of this impact mechanism and related stressors are currently a data gap.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	<u>Juveniles and adults:</u> Northern abalone dependence on LWD related habitat complexity is currently a data gap.	Encourage project designs that limit permanent alteration of high-quality habitat features.	Effects of this impact mechanism and related stressors are currently a data gap.
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Larvae; Juveniles: Adults	<u>All life history stages</u>: Northern abalone dependence nearshore groundwater input is currently a data gap.	Avoid disturbance of vegetation along shoreline.	Effects of this impact mechanism and related stressors are currently a data gap.

Table A-22 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Northern Abalone.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to long-term (dependent on contributing mechanism of impact)	Continuous to interannual–decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	All life-history stages: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause mortality or hinder feeding.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival and productivity of all life-history stages.
	Altered pollutant loading	Increased pollutant loading	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Larvae; Juveniles	All exposed life history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival and productivity of larvae and juveniles.
	Altered dissolved oxygen	Decreased dissolved oxygen (due to eutrophication caused by elevated nutrient export from dewatered floodplains)	Dependent on contributing mechanism of impact	Temporary to short-term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Juveniles and adults: Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival of all life-history stages.
Spawning Substrate Augmentation									
	Not applicable								
In-Channel/Off-Channel Habitat Creation/Modification									
	Not applicable								
Riparian Planting/Restoration Enhancement									
	Construction and Maintenance Activities								
	Marine								
	Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	Juveniles and adults: The effect of riparian shading on abalone is currently a data gap.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	Effects of this impact mechanism and related stressors are currently a data gap.

Table A-22 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Northern Abalone.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	**When**	**Duration**	**Frequency**	**Life-history Form**			
		Increased suspended solids – due to removal of invasive riparian species	Year-round (with specific stressors prominent during high flow conditions)	Short-term to intermediate (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Minimize disturbance during invasive species removal. Use appropriate erosion control BMPs both during and after construction.	See effects for related stressors under Water Quality Modification.
	Aquatic Vegetation Modification								
	Marine								
	Altered autochthonous production	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	Juveniles and adults: Northern abalone dependence on allochthonous and autochthonous inputs from marine aquatic vegetation is a data gap. Northern abalone are known to use intertidal and subtidal vegetation and phytoplankton that could be a product of aquatic vegetation autochthonous input.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the water surface.	Effect from this impact mechanism is currently a data gap.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Marine								
	Altered Shading and solar input	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	Juveniles: Decreased refuge and rearing habitat availability and food resource availability, leading to increased competition and predation exposure and resulting in decreased survival, growth, and fitness. Adults: Decreased feeding opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the water surface.	May affect juvenile growth, fitness, and survival. May affect adult growth and spawning productivity.
	Water Quality Modification								
	Altered Temperatures	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	Juveniles and adults: The effect of riparian shading on abalone is currently a data gap.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	Effects of this impact mechanism and related stressors are currently a data gap.
	Altered suspended solids	Increased suspended solids – due to removal of invasive riparian species	Dependent on contributing mechanism of impact	Short-term to intermediate (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	All life-history stages: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause mortality or hinder feeding.	Minimize disturbance during invasive species removal. Use appropriate erosion control BMPs both during and after construction.	May affect survival and productivity of all life-history stages.

Table A-22 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Northern Abalone.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Wetland Creation Restoration/Enhancement									
	Construction and Maintenance Activities								
	Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Juveniles and adults: Effect of anthropogenic sound on northern abalone is a data gap.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	Effect of anthropogenic sound on northern abalone is a data gap.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification.
	Water Quality Modification								

Table A-22 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Northern Abalone.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered suspended solids	Increased suspended solids (e.g., during reconnection of fragmented floodplain wetlands, etc.)	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	All life-history stages: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause mortality or hinder feeding.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival and productivity of all life-history stages.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term (dependent on contributing mechanism of impact)	Interannual to decadal	Larvae; Juveniles	All exposed life history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival and productivity of larvae and juveniles.
Beach Nourishment/Contouring									
	Construction and Maintenance Activities								
	Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	All life-history stages: Mortality from burial. Decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May cause direct mortality of all life history stages. May affect juvenile survival, growth, and fitness.
	Hydraulic and Geomorphic Modification								
	Marine								
	Altered sediment supply	Localized alteration in invertebrate abundance from burial, burial of juveniles	During project construction and maintenance activities	Short-term – long-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	All life-history stages: Mortality from burial. Decreased growth and fitness.	Avoid project site which are productive and have a healthy benthic community.	May cause direct mortality of all life history stages. May affect juvenile survival, growth, and fitness.
	Aquatic Vegetation Modification								
	Marine								
	Altered autochthonous production	Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to long-term(dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge and rearing habitat availability and food resource availability, leading to increased	Avoid/minimize disturbance of aquatic vegetation during project construction. Avoid nourishing beaches updrift of	May affect juvenile growth, fitness, and survival. May affect adult growth and spawning

Table A-22 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Northern Abalone.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered cover and habitat	Reduced cover					competition and predation exposure and resulting in decreased survival, growth, and fitness. Adults: Decreased feeding opportunity due to decreased food web productivity. Decreased growth and reproductive fitness.	productive, vegetated aquatic habitat.	productivity.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	During construction and during subsequent high energy periods	Temporary to short-term (dependent on grain size of augmented sediment)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	All life-history stages: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause mortality or hinder feeding.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic shoreline instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival and productivity of all life-history stages.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term (dependent on contributing mechanism of impact)	Interannual to decadal	Larvae; Juveniles	All exposed life history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body.	May affect survival and productivity of larvae and juveniles.
Reef Creation/Restoration/Enhancement									
	Construction and Maintenance Activities								
	Marine								
	Equipment operation and materials placement	Elevated noise, visual and physical disturbance	During project construction activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Larvae; Juveniles; Adults	All life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Avoid construction activities during periods when individuals may be present, particularly juveniles.	May affect survival, growth, and fitness of juveniles and adults.
	Construction vessel operation	Increased or altered ambient noise levels	During project construction	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction)	Juveniles; Adults	Juveniles and adults: Effect of anthropogenic sound on northern abalone is a data gap.	Avoid/minimize cavitation to limit noise intensity. Promote use of vessels equipped with antinoise/antivibration technology where practicable.	Effect of anthropogenic sound on northern abalone is a data gap.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	All life-history stages: Mortality from burial. Decreased growth and fitness. See responses described for related stressors under Water Quality Modification.	Avoid project site which are productive and have a healthy benthic community.	May affect larvae productivity and fitness. See effects for related stressors under Water Quality Modification.

Table A-22 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Northern Abalone.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic and Geomorphic Modification								
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Larvae; Juveniles; Adults	<u>All life-history stages</u>: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially decreasing the suitability of settling and rearing habitat for northern abalone. This may occur through a number of specific stressors, including food web alterations and decreased prey resources, introduced non-native species, and increased competition for suitable habitats. Loss of marine macroalgae may increase the visibility of the northern abalone to predators. The combined effect of these stressors can result in decreased growth and productivity, decreased fitness for marine movement, and direct mortality.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival at all life-history stages.
	Altered nearshore circulation patterns		Year-round (with seasonally variable effects depending on site-specific geography and bathymetry, and project configuration)	Permanent	Seasonal				
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				
	Ecosystem Fragmentation								
	Marine								
	Altered cover and habitat	Increased predation risk	Year-round	Permanent	Continuous	Juveniles	<u>Juveniles:</u> Decreased survival due to increased predation exposure. Increased stress (from predation avoidance) leading to decreased growth and fitness.	Avoid placement of reef projects in proximity to juvenile migratory corridors, such that increased predation exposure may occur.	May affect juvenile survival, growth and fitness.

Table A-22 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Northern Abalone.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification								
	Marine								
	Altered cover and habitat	Decreased refuge and forage habitat	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness.	Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile growth and fitness.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	All life-history stages: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause mortality or hinder feeding.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival and productivity of all life-history stages.
	Altered pollutant loading	Leaching of toxic substances (depending on composition of reef material)	Year-round	Intermediate-term	Continuous with seasonal pulses (dependent on current velocity)	Larvae; Juveniles; Adults	All affected life-history stages: Physiological responses to exposure at toxic levels, causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Use non-toxic reef material.	May affect survival and productivity of larvae, juveniles, and adults.
Eel Grass and Other Aquatic Vegetation Creation/Restoration/Enhancement									
	Construction and Maintenance Activities								
	Marine								
	Planting activities and vessel use	Visual, physical, and noise related disturbance	During project construction	Temporary	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles, Adults	All life-history stages: Effect of anthropogenic sound is a data gap.	Adhere to system-specific in-water work windows.	Effect of anthropogenic sound on northern abalone is a data gap.
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Vegetation transplantation projects are not likely to cause pulses of suspended sediment sufficient to lead to injury or mortality.	Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating larvae and juveniles. May affect juvenile productivity and adult productivity.

Table A-23. HPA HCP Habitat Modification Exposure and Response Matrix for Newcomb's Littorine Snail.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
Beaver Dam Removal									
	Not applicable								
Large Woody Debris Placement/Movement/Removal (for placement only construction impacts apply)									
	Construction and Maintenance Activities								
	Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Unknown	Unknown	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	Unknown
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Unknown	Unknown	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	Unknown
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Unknown	Unknown	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	Unknown
	Hydraulic and Geomorphic Modification								

Table A-23 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Newcomb's Littorine Snail.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Unknown	All life-history stages: Wave energy, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter marine littoral habitats, potentially altering the extent and composition of *Salicornia* habitat for Newcomb's littorine snail. In particular, alteration of littoral wave energy and sediment characteristics could lead to reductions in the amount of *Salicornia* habitat, or more frequent inundation leading to reduced habitat suitability. These alterations could lead to reduced survival, growth, and fitness; however, life-history specific sensitivity to these stressors is currently a data gap. As Newcomb's littorine snail is not a truly aquatic species and spends little time below the water surface, it is not affected by changes in current and circulation patterns.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at all life-history stages. However, actual effects are uncertain as life-history specific sensitivity to these impact mechanisms and related stressors is currently a data gap.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered sediment supply		Year-round (beginning with project installation and becoming more pronounced over time)	Permanent	Continuous				
	Altered substrate composition		Year-round (beginning with project installation and becoming more pronounced over time [e.g., due to accumulation of shell hash, sediment settling due to altered wave and/or current regime, routine grounding, anchor trenching])	Permanent	Continuous				
	Ecosystem Fragmentation								
	Marine								
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, as well as reduced food web complexity, habitat availability, and suitability	Year-round	Permanent	Continuous	Unknown	The importance of LWD to Newcomb's littorine snail is currently a data gap, therefore the effects of stressor exposure are unknown. However, except for the potential effects of this impact mechanism on the quantity and quality of available *Salicornia* habitat, the effects of this stressor are likely limited.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	The effects of exposure to this stressor are unknown, but are likely to be insignificant.
	Altered cover and habitat	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round	Permanent	Continuous	Unknown	The importance of LWD to Newcomb's littorine snail is currently a data gap, therefore the effects of stressor exposure are unknown. However, except for the potential effects of this impact mechanism on the quantity and quality of available *Salicornia* habitat, the effects of this stressor are likely limited.	Encourage project designs that limit permanent alteration of high-quality habitat features.	The effects of exposure to this stressor are unknown, but are likely to be insignificant.

Table A-23 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Newcomb's Littorine Snail.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Aquatic Vegetation Modification								
	Marine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Unknown	Unknown	Construction: Avoid/minimize disturbance of aquatic vegetation during project construction.	Unknown
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Unknown	Unknown		Unknown
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Unknown	Unknown		Unknown
	Riparian Vegetation Modification								
	Marine								
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures)	Year-round, (pronounced in summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts)	Seasonal	Unknown	Newcomb's littorine snail it is an intertidal mollusk species that lives under and on the stems of glasswort (*Salicornia virginica*), which occurs in narrow bands on the fringes of salt marshes. Little is known of the life-history of this species, although its limited distribution and dependence on specific vegetation types increases sensitivity to specific types of riparian impacts. *Salicornia* fringe habitats are typically less influenced by riparian shade, but the actual shade requirements and life-history specific temperature requirements of this species are unknown. While tolerant of both salt and fresh water, it avoids immersion for long periods and will drown if trapped. Actual dependence on freshwater inflow is a data gap. However, salt marsh habitats in general are shaped by combined surface and ground water flows; therefore, alteration of freshwater	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	Riparian vegetation modification leading to the alteration of *Salicornia* habitat in salt marsh environments where this species occurs is likely to lead to reduced survival, growth, and fitness at one or more life-history stages. Effects resulting from exposure to specific impact mechanisms are unknown, however, as sensitivity to stressor exposure and life-history requirements are a data gap.
	Altered shoreline and bluff stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Unknown		Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduced organic matter inputs	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Unknown		Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	

Table A-23 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Newcomb's Littorine Snail.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate; reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Short-term to permanent (dependent on nature of activity)	Continuous	Unknown	inflow may lead to reduction in suitable habitat area.	Encourage project designs that limit permanent alteration of high-quality habitat features.	
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during nearshore rearing period in spring and summer)	Permanent	Continuous	Unknown		Avoid disturbance of vegetation along shoreline.	
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to long-term (dependent on contributing mechanism of impact)	Continuous to interannual–decadal (dependent on contributing mechanism of impact)	Unknown	Unknown	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	Unknown
	Altered pollutant loading	Increased pollutant loading	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Unknown	Unknown	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	Unknown
	Altered dissolved oxygen	Decreased dissolved oxygen (due to eutrophication caused by elevated nutrient export from dewatered floodplains)	Dependent on contributing mechanism of impact	Temporary to short-term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Unknown	Unknown	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	Unknown
Spawning Substrate Augmentation									
	Not applicable								
In-Channel/Off-Channel Habitat Creation/Modification									
	Not applicable								
Riparian Planting/Restoration Enhancement									
	Construction and Maintenance Activities								
	Marine								

Table A-23 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Newcomb's Littorine Snail.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Unknown	Unknown	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	Unknown
		Increased suspended solids – due to removal of invasive riparian species	Year-round (with specific stressors prominent during high flow conditions)	Short-term to intermediate (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Unknown	Unknown	Minimize disturbance during invasive species removal. Use appropriate erosion control BMPs both during and after construction.	Unknown
	Aquatic Vegetation Modification								
	Marine								
	Altered autochthonous production	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Unknown	Unknown	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the water surface.	Unknown

Table A-23 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Newcomb's Littorine Snail.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Marine								
	Altered Shading and solar input	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Unknown	Unknown	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the water surface.	Unknown
	Water Quality Modification								
	Altered Temperatures	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Unknown	Unknown	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	Unknown
	Altered suspended solids	Increased suspended solids – due to removal of invasive riparian species	Dependent on contributing mechanism of impact	Short-term to intermediate (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Unknown	Unknown	Minimize disturbance during invasive species removal. Use appropriate erosion control BMPs both during and after construction.	Unknown

Table A-23 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Newcomb's Littorine Snail.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Wetland Creation Restoration/Enhancement									
	Construction and Maintenance Activities								
	Marine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Unknown	Unknown	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	Unknown
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Unknown	Unknown	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	Unknown
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Unknown	Unknown	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	Unknown
	Water Quality Modification								

Table A-23 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Newcomb's Littorine Snail.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids (e.g., during reconnection of fragmented floodplain wetlands, etc.)	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Unknown	Unknown	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	Unknown
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term (dependent on contributing mechanism of impact)	Interannual to decadal	Unknown	Unknown	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	Unknown
Beach Nourishment/Contouring									
	Not applicable								
Reef Creation/Restoration/Enhancement									
	Not applicable								
Eel Grass and Other Aquatic Vegetation Creation/Restoration/Enhancement									
	Construction and Maintenance Activities								
	Marine								
	Planting activities and vessel use	Visual, physical, and noise related disturbance	During project construction	Temporary	Interannual to decadal (depending on activity frequency)	Unknown	Unknown	Adhere to system-specific in-water work windows.	Unknown
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Unknown	Unknown	Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	Unknown

Table A-24. HPA HCP Habitat Modification Exposure and Response Matrix for Giant Columbia River Limpet and Great Columbia River Spire Snail.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	**When**	**Duration**	**Frequency**	**Life-history Form**			
Beaver Dam Removal									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
		Visual, physical, and noise related disturbance	During project construction and maintenance activities	Temporary (disturbance) to short-term (displacement, auditory masking, hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	All life-history stages: The effects of elevated levels of anthropogenic noise on the Columbia River limpet and Columbia River spire snail are a data gap.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	The effects of pile-driving sounds and other anthropogenic sounds to Columbia River limpet and Columbia River spire snail are a data gap.
	Impoundment dewatering	Stranding, displacement	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	All life-history stages: Mortality from dewatering.	Manage dam removal to drain impoundment as slowly as practicable. Avoid scouring flows. Use beaver deceivers to limit hydraulic alteration.	Mortality and reduced survival and productivity at affected life-history stages.
		Localized decrease in periphyton coverage	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	All life-history stages: Decreased growth and fitness due to loss a food resources (scouring of periphyton caused by bed disturbance).	Limit area of dewatering to the greatest extent practicable. Use beaver deceivers to limit hydraulic alteration.	May affect growth and productivity at juvenile life-history stage.
		Increased suspended solids	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering.	See effects for related stressors under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Intermediate-term to long-term	Continuous	Juveniles; Adults	All life-history stages: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased habitat suitability and changes in food web complexity. This may limit prey resource availability and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect all life-history stages; decreased growth, survival, and productivity.
	Altered flow velocity		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Intermediate-term to long-term	Seasonal				
	Altered bank stability		Year round especially during high flows	Intermediate-term to long-term	Seasonal				
	Altered substrate composition (including gravel sedimentation)		Year round	Intermediate-term to long-term	Continuous				

Table A-24 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Giant Columbia River Limpet and Great Columbia River Spire Snail.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered groundwater-surface water exchange		Year-round	Intermediate-term to long-term	Continuous		may lead to habitat alteration, leading to increased stress and predation rate. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity.		
	Ecosystem Fragmentation								
	Riverine								
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen Decreased dissolved oxygen from eutrophication below the impoundment (caused by elevated nutrient export)	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and Adults: See related stressor responses under Water Quality Modification.	Avoid draining impounded area through use of beaver deceivers.	See effects for related stressors under Water Quality Modification.
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Juveniles; Adults	All exposed life-history stages: See related stressor responses under Water Quality Modification.	Avoid draining impounded area through use of beaver deceivers.	May affect survival, growth, and fitness of juveniles and adults.
	Altered terrestrial/aquatic connectivity	Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs	Year-round	Permanent	Continuous	Juveniles; Adults	Juveniles and adults: Decreased prey resource availability leading to increased competition, and resulting effects on growth and fitness. Adults: Increased mortality and decreased fitness	Require assessment of the hydraulic effects of the project before permitting and avoid permitting designs that lead to disconnection of floodplain habitat.	May affect juvenile and adult survival and productivity.
	Aquatic Vegetation Modification								
	Riverine								
	Altered autochthonous production Altered cover and habitat	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles; Adults	Juveniles and adults: Decreased prey resource availability leading to increased competition, and resulting effects on growth and fitness. Adults: Increased mortality and decreased fitness	Avoid draining impounded area through use of beaver deceivers.	May affect juvenile and adult survival and productivity.
	Riparian Vegetation Modification								
	Riverine								

Table A-24 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Giant Columbia River Limpet and Great Columbia River Spire Snail.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered stream bank and shoreline stability	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	All life-history stages: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and burial. Responses vary depending on stressor magnitude. Reduction in suitable settling habitat (due to substrate embeddedness) and reduced dissolved oxygen could limit growth and survival.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival and productivity.
		Increased sedimentation							
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Long-term to permanent	Continuous	Juveniles	Juveniles: Reduced prey resource availability due to decreased food web productivity; decreased growth and fitness.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile and adult life-history stages.
	Altered buffering capability	Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Juveniles; Adults	All exposed life-history stages: See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modification.
		Decreased dissolved oxygen from eutrophication (caused by elevated nutrient export)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Long-term to permanent	Seasonal	Juveniles; Adults	Juveniles: See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modification.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	All life-history stages: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and burial. Responses vary depending on stressor magnitude. Reduction in suitable settling habitat (due to substrate embeddedness) and reduced dissolved oxygen could limit growth and survival.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May decrease survival and productivity.
	Altered pollutant loading	Increased exposure to toxic substances	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Juveniles; Adults	All exposed life-history stages: Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel machinery in a controlled environment away from the project area. Avoid reducing hydraulic complexity.	May affect survival, growth, and fitness of juveniles and adults.

Table A-24 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Giant Columbia River Limpet and Great Columbia River Spire Snail.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Juveniles; Adults	All life-history stages: Requires high dissolved oxygen content. Mortality, decreased fitness, growth, and survival.	Limit damage to riparian area. Replant former impoundment with native vegetation to discourage invasives and stabilize sediments. Avoid draining impounded area through use of beaver deceivers.	May affect productivity and survival of all life-history stages.
Large Woody Debris Placement/Movement/Removal (for placement only construction impacts apply)									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	All life-history stages: The effects of pile-driving sounds and other anthropogenic sounds to Columbia River limpet and Columbia River spire snail are a data gap.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	The effects of pile-driving sounds and other anthropogenic sounds to Columbia River limpet and Columbia River spire snail are a data gap.

Table A-24 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Giant Columbia River Limpet and Great Columbia River Spire Snail.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification.
	Channel/work area dewatering	Species removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	All life-history stages: Mortality from dewatering.	Perform channel work on areas where these species do not occur (these species are rarely found in sandy substrate).	Mortality and reduced survival and productivity at affected life-history stages.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	These species' potential for entrainment in pumps or impingement on pump screens is a data gap.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows. Perform channel work on areas where these species do not occur (these species are rarely found in sandy substrate).	These species' potential for entrainment in pumps or impingement on pump screens is a data gap.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	All life-history stages: Decreased prey resource availability, decreased dissolved oxygen, decreased suitable settling habitat; resulting in decreased fitness, growth, and survival.	Adhere to system-specific in-water work windows. Perform channel work on areas where these species do not occur (these species are rarely found in sandy substrate).	May affect growth and productivity at all life-history stages.
		Localized decrease in periphyton coverage	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	All life-history stages: Decreased growth and fitness due to loss a food resources (scouring of periphyton caused by bed disturbance).	Limit area of dewatering to the greatest extent practicable. Use beaver deceivers to limit hydraulic alteration.	May affect growth and productivity at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Juveniles; Adults	All life-history stages: Mortality from entrainment and decreased prey availability resulting in decreased growth and fitness. See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect all life-history stages; decreased fitness, growth and survival of affected stages. See effects for related stressors under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Riverine								

Table A-24 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Giant Columbia River Limpet and Great Columbia River Spire Snail.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	All life-history stages: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased habitat suitability and changes in food web complexity. This may limit prey resource availability and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to habitat alteration, leading to increased stress and predation rate. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect all life-history stages; decreased growth, survival, and productivity.
	Altered flow velocity		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition		Year round	Permanent	Continuous				
	Altered groundwater-surface water exchange		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Riverine								
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and Adults: See related stressor responses under Water Quality Modification.	Require assessment of the hydraulic effects of the project before permitting	See effects for related stressors under Water Quality Modification.
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Juveniles; Adults	Juveniles: See related stressor responses under Water Quality Modification.		May affect survival, growth, and fitness of juveniles and adults.
	Altered lateral (terrestrial/aquatic) habitat connectivity	Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs Reduced availability of suitable habitats along longitudinal gradient.	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juvenile and adults: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat or longitudinal reach simplification.	May affect juvenile and adult productivity and survival.
	Altered longitudinal habitat connectivity								
	Aquatic Vegetation Modification								
	Riverine								

Table A-24 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Giant Columbia River Limpet and Great Columbia River Spire Snail.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	Juvenile and adults: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Construction: Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect juvenile and adult productivity and survival.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: See related stressor responses under Water Quality Alteration.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased foraging opportunity due to decreased food web productivity.		May affect juvenile and adult survival and productivity.
	Riparian Vegetation Modification								
	Riverine								
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	All life-history stages: Prefers cool water and temperature regulation form shading. Altered growth and productivity caused by temperatures outside optimal growth range and alteration of food web patterns. Wide tolerance range but prefers cooler waters. Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival and productivity.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased benthic dissolved oxygen; decreased area of suitable habitat; reduced habitat complexity	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	All life-history stages: Prefers high levels of dissolved oxygen and cool water. Altered growth and productivity caused by temperatures outside optimal growth range and alteration of food web patterns. Wide tolerance range but prefers cooler waters. Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival and productivity.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover.	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased prey resource availability, leading to increased competition and resulting effects on growth and fitness. Adults: Increased mortality and decreased fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival and overall population productivity.

Table A-24 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Giant Columbia River Limpet and Great Columbia River Spire Snail.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered groundwater–surface water exchange	Reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Juveniles; Adults	All life-history stages: See related stressor responses under Water Quality Alteration.	Avoid disturbance of vegetation along stream.	See effects for related stressors under Water Quality Modification.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to long-term (dependent on contributing mechanism of impact)	Continuous to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	All life-history stages: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and burial. Responses vary depending on stressor magnitude. Reduction in suitable settling habitat (due to substrate embeddedness) and reduced dissolved oxygen could limit growth and survival.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May decrease survival and productivity.
	Altered pollutant loading	Increased pollutant loading	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Juveniles; Adults	All life-history stages: Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival, growth, and fitness of juveniles and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen (due to eutrophication caused by elevated nutrient export from dewatered floodplains)	Dependent on contributing mechanism of impact	Temporary to short-term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Juveniles; Adults	All life-history stages: Requires high dissolved oxygen content. Mortality, decreased fitness, growth, and survival.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect productivity and survival of all life-history stages.
Spawning Substrate Augmentation									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	All life-history stages: The effects of elevated levels of anthropogenic noise on the Columbia River limpet and Columbia River spire snail are a data gap.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	The effects of pile-driving sounds and other anthropogenic sounds to Columbia River limpet and Columbia River spire snail are a data gap.

Table A-24 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Giant Columbia River Limpet and Great Columbia River Spire Snail.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification.
		Burial (during active sediment placement)	During project construction	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	All life-history stages: Injury or mortality from burial during gravel placement.	Restrict in-water work window to periods when with limited motility are least likely to be present.	May cause direct mortality or injury at all life-history stages. Injury and stress may affect survival, growth, and fitness.
		Localized decrease in periphyton coverage	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	All life-history stages: Decreased growth and fitness due to loss a food resources (scouring of periphyton caused by bed disturbance).	Limit area of dewatering to the greatest extent practicable. Use beaver deceivers to limit hydraulic alteration.	May affect growth and productivity at juvenile life-history stage.
		Entrainment of benthic organisms, increased suspended solids,	During project construction	Temporary to short-term	Interannual–decadal	Juveniles; Adults	All life-history stages: Mortality from entrainment and decreased prey availability resulting in decreased growth and fitness. See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect all life-history stages; decreased fitness, growth and survival of affected stages. See effects for related stressors under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered bank stability (intermediate-term effects from passive augmentation projects)	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Intermediate-term	Continuous	Juveniles; Adults	All life-history stages: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project.	May affect all life-history stages; decreased growth, survival, and productivity.

Table A-24 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Giant Columbia River Limpet and Great Columbia River Spire Snail.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered substrate composition/stability			Short-term to long-term			decreased survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased habitat suitability and changes in food web complexity. This may limit prey resource availability and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to habitat alteration, leading to increased stress and predation rate. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity.	Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	
	Aquatic Vegetation Modification								
	Riverine								
	Altered autochthonous production	Reduced foraging opportunities	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juvenile and adults: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Avoid spawning gravel augmentation projects in locations where aquatic vegetation plays a strong role in habitat productivity.	May affect juvenile and adult productivity and survival.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and predation exposure, resulting in decreased survival, growth, and fitness. Adults: Decreased foraging opportunity due to decreased food web productivity.		
	Water Quality Modification								
	Altered pollutant loading	Increased exposure to toxic substances	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Juveniles; Adults	All exposed life-history stages: Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel machinery in a controlled environment away from the project area. Avoid reducing hydraulic complexity.	May affect survival, growth, and fitness of juveniles and adults.

Table A-24 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Giant Columbia River Limpet and Great Columbia River Spire Snail.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	All life-history stages: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and burial. Responses vary depending on stressor magnitude. Reduction in suitable settling habitat (due to substrate embeddedness) and reduced dissolved oxygen could limit growth and survival.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May decrease survival and productivity.
In-Channel/Off-Channel Habitat Creation/Modification									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	All life-history stages: The effects of elevated levels of anthropogenic noise on the Columbia River limpet and Columbia River spire snail are a data gap.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	The effects of pile-driving sounds and other anthropogenic sounds to Columbia River limpet and Columbia River spire snail are a data gap.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification.
	Channel/work area dewatering	Species removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	All life-history stages: Mortality from dewatering.	Perform channel work on areas where these species do not occur (these species are rarely found in sandy substrate).	Mortality and reduced survival and productivity at affected life-history stages.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	These species' potential for entrainment in pumps or impingement on pump screens is a data gap.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows. Perform channel work on areas where these species do not occur (these species are rarely found in sandy substrate).	These species' potential for entrainment in pumps or impingement on pump screens is a data gap.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	All life-history stages: Decreased prey resource availability, decreased dissolved oxygen, decreased suitable settling habitat; resulting in decreased fitness, growth, and survival.	Adhere to system-specific in-water work windows. Perform channel work on areas where these species do not occur (these species are rarely found in sandy substrate).	May affect growth and productivity at all life-history stages.
		Localized decrease in periphyton coverage	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	All life-history stages: Decreased growth and fitness due to loss a food resources (scouring of periphyton caused by bed disturbance).	Limit area of dewatering to the greatest extent practicable. Use beaver deceivers to limit hydraulic alteration.	May affect growth and productivity at juvenile life-history stage.

Table A-24 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Giant Columbia River Limpet and Great Columbia River Spire Snail.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	**When**	**Duration**	**Frequency**	**Life-history Form**			
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Juveniles; Adults	All life-history stages: Mortality from entrainment and decreased prey availability resulting in decreased growth and fitness. See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect all life-history stages; decreased fitness, growth and survival of affected stages. See effects for related stressors under Water Quality Modification.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids (if in-channel project fails)	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	All life-history stages: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and burial. Responses vary depending on stressor magnitude. Reduction in suitable settling habitat (due to substrate embeddedness) and reduced dissolved oxygen could limit growth and survival.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May decrease survival and productivity.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Juveniles; Adults	All life-history stages: Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival, growth, and fitness of juveniles and adults.
Riparian Planting/Restoration Enhancement									
	Construction and Maintenance Activities								
	Riverine								
	Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	All life-history stages: Prefers cool water and temperature regulation form shading. Altered growth and productivity caused by temperatures outside optimal growth range and alteration of food web patterns. Wide tolerance range but prefers cooler waters. Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect survival and productivity.
		Increased suspended solids – due to removal of invasive riparian species	Year-round (with specific stressors prominent during high flow conditions)	Short-term to intermediate (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	All life-history stages: Injury or mortality from burial during gravel placement. See responses to increased suspended solids described for related stressors under Water Quality Modification.	Minimize disturbance during invasive species removal. Use appropriate erosion control BMPs both during and after construction.	May affect survival and productivity.

Table A-24 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Giant Columbia River Limpet and Great Columbia River Spire Snail.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Benthic sedimentation – due to removal of invasive riparian species							
	Aquatic Vegetation Modification								
	Riverine								
	Altered autochthonous production	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	Juvenile and adults: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect juvenile and adult productivity and survival.
	Riparian Vegetation Modification								
	Riverine								
	Altered Shading and solar input	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles; Adults	Juvenile and adults: Reduced foraging opportunities due to decreased food web productivity; decreased growth and fitness.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect juvenile and adult productivity and survival.
	Water Quality Modification								
	Altered Temperatures	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	All life-history stages: Prefers cool water and temperature regulation form shading. Altered growth and productivity caused by temperatures outside optimal growth range and alteration of food web patterns. Wide tolerance range but prefers cooler waters. Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect survival and productivity.
	Altered suspended solids	Increased suspended solids – due to removal of invasive riparian species	Dependent on contributing mechanism of impact	Short-term to intermediate (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	All life-history stages: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and burial. Responses vary depending on stressor magnitude. Reduction in suitable settling habitat (due to substrate embeddedness) and reduced dissolved oxygen could limit growth and survival.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May decrease survival and productivity.

Table A-24 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Giant Columbia River Limpet and Great Columbia River Spire Snail.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Wetland Creation Restoration/Enhancement									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	All life-history stages: The effects of elevated levels of anthropogenic noise on the Columbia River limpet and Columbia River spire snail are a data gap.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	The effects of pile-driving sounds and other anthropogenic sounds to Columbia River limpet and Columbia River spire snail are a data gap.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification.
	Channel/work area dewatering	Species removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	All life-history stages: Mortality from dewatering.	Perform channel work on areas where these species do not occur (these species are rarely found in sandy substrate).	Mortality and reduced survival and productivity at affected life-history stages.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	These species' potential for entrainment in pumps or impingement on pump screens is a data gap.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows. Perform channel work on areas where these species do not occur (these species are rarely found in sandy substrate).	These species' potential for entrainment in pumps or impingement on pump screens is a data gap.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	All life-history stages: Decreased prey resource availability, decreased dissolved oxygen, decreased suitable settling habitat; resulting in decreased fitness, growth, and survival.	Adhere to system-specific in-water work windows. Perform channel work on areas where these species do not occur (these species are rarely found in sandy substrate).	May affect growth and productivity at all life-history stages.

Table A-24 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for Giant Columbia River Limpet and Great Columbia River Spire Snail.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Localized decrease in periphyton coverage	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	All life-history stages: Decreased growth and fitness due to loss a food resources (scouring of periphyton caused by bed disturbance).	Limit area of dewatering to the greatest extent practicable. Use beaver deceivers to limit hydraulic alteration.	May affect growth and productivity at juvenile life-history stage.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids (e.g., during reconnection of fragmented floodplain wetlands, etc.)	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	All life-history stages: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and burial. Responses vary depending on stressor magnitude. Reduction in suitable settling habitat (due to substrate embeddedness) and reduced dissolved oxygen could limit growth and survival.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May decrease survival and productivity.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term (dependent on contributing mechanism of impact)	Interannual to decadal	Juveniles; Adults	All life-history stages: Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
Beach Nourishment/Contouring									
	Not Applicable								
Reef Creation/Restoration/Enhancement									
	Not Applicable								
Eel Grass and Other Aquatic Vegetation Creation/Restoration/Enhancement									
	Not applicable								

Table A-25. HPA HCP Habitat Modification Exposure and Response Matrix for Giant California Floater and Western Ridged Mussel.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
Beaver Dam Removal									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Glochidia larvae; Juveniles, Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
		Visual, physical, and noise related disturbance	During project construction and maintenance activities	Temporary (disturbance) to short-term (displacement, auditory masking, hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Glochidia larvae; Juveniles, Adults	All life-history stages: The effect of elevated anthropogenic noise on California floater and western ridged mussels is a data gap.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	Very little is known of the effects of elevated anthropogenic noise on California floater and western ridged mussels at any life-history stage.
	Impoundment dewatering	Stranding, displacement	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia larvae; Juveniles, Adults	All life-history stages: Mortality from dewatering.	Manage dam removal to drain impoundment as slowly as practicable. Avoid scouring flows. Use beaver deceivers to limit hydraulic alteration.	Mortality and reduced survival and productivity at affected life-history stages.
		Increased suspended solids	During project construction activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering.	See effects for related stressors under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Intermediate-term to long-term	Continuous	Glochidia larvae; Juveniles; Adults	Glochidia larvae: Changes in channel morphology, flow velocity, and substrate composition can affect host fish. Juveniles and adults: As filter feeders, constant water flow is required. Altered channel geometry, flow velocity, and substrate composition can result in decrease habitat suitability and changes in food web complexity. This may limit prey resource availability and foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at all life-history stages and affect life-history stages and productivity of host-fish.
	Altered flow velocity		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Intermediate-term to long-term	Seasonal				
	Altered bank stability		Year round especially during high flows	Intermediate-term to long-term	Seasonal				
	Altered substrate composition (including gravel sedimentation)		Year round	Intermediate-term to long-term	Continuous				
	Altered groundwater-surface water exchange		Year-round	Intermediate-term to long-term	Continuous				
	Ecosystem Fragmentation								
	Riverine								

Table A-25 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for California Floater and Western Ridged Mussel.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most extensive)	Permanent	Seasonal	Glochidia larvae; Juveniles; Adults	Glochidia larvae: See related stressor responses under Water Quality Modification.	Avoid draining impounded area through use of beaver deceivers.	See effects for related stressors under Water Quality Modification.
		Decreased dissolved oxygen from eutrophication below the impoundment (caused by elevated nutrient export)							
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Glochidia larvae; Juveniles; Adults	All exposed life-history stages: See related stressor responses under Water Quality Modification.	Avoid draining impounded area through use of beaver deceivers.	May affect survival, growth, and fitness of Glochidia larvae, juveniles and adults.
	Altered terrestrial/aquatic connectivity	Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs	Year-round	Long-term	Continuous	Glochidia larvae; Juveniles; Adults	Glochidia larvae: Changes in habitat availability may indirectly affect survival through effects on host fish. Juveniles and adults: Beaver dam removal may modify habitat suitable for juveniles and adults, affecting survival and overall population abundance.	Require assessment of the hydraulic effects of the project before permitting and avoid permitting designs that lead to disconnection of floodplain habitat.	May affect survival at all life-history stages and affect life-history stages and productivity of host-fish.
	Aquatic Vegetation Modification								
	Riverine								
	Altered autochthonous production	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Permanent	Continuous	Juveniles; Adults	Juveniles and adults: Reduced prey resources due to decreased food web productivity, decreased growth and fitness of the California floater and Western ridged mussel prey and host fish. Altered autochthonous production could be expected to affect prey resource availability.	Avoid draining impounded area through use of beaver deceivers.	May affect juvenile and adult survival and productivity.
	Altered cover and habitat								
	Riparian Vegetation Modification								
	Riverine								
	Altered stream bank and shoreline stability	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Glochidia larvae; Juveniles; Adults	All life-history stages: Decreased food resource availability, leading to increased competition and resulting effects on growth and fitness for mussels and host fish. Decreased suitable habitat, injury, or mortality caused by excessive turbidity or resulting smothering by burial.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile and adult fitness and survival of mussels and host fish.

Table A-25 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for California Floater and Western Ridged Mussel.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Increased sedimentation							
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Long-term to permanent	Continuous	Glochidia larvae	Mussel dependence upon allochthonous input is a data gap. However, could affect host fish.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect productivity.
	Altered buffering capability	Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Glochidia larvae; Juveniles; Adults	<u>All exposed life-history stages</u>: See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modification.
		Decreased dissolved oxygen from eutrophication (caused by elevated nutrient export)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Long-term to permanent	Seasonal	Glochidia larvae; Juveniles; Adults	<u>Juveniles</u>: See related stressor responses under Water Quality Modification.	Replant former impoundment with native vegetation to discourage invasives and stabilize sediments.	See effects for related stressors under Water Quality Modification.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults:</u> Effects depend on the magnitude of increased suspended solids. Turbidity sufficient to cause fine sediment embeddedness may bury these mussels and lead to direct mortality and decreased population survival.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect juvenile and adult survival.
	Altered pollutant loading	Increased exposure to toxic substances	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Glochidia larvae; Juveniles; Adults	<u>All exposed life-history stages</u>: Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel machinery in a controlled environment away from the project area. Avoid reducing hydraulic complexity.	May affect survival, growth, and fitness of juveniles and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen	Dependent on contributing mechanism of impact	Temporary to short-term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Glochidia larvae; Juveniles; Adults	<u>All life-history stages</u>: Mortality in acute low dissolved oxygen events due to asphyxiation. Effects to host-fish could be stressor to these mussels. <u>Juveniles and adults</u>: A physiological response to exposure at toxic levels, causing mortality or injury leading to reduced fitness is a data gap.	Limit damage to riparian area. Replant former impoundment with native vegetation to discourage invasives and stabilize sediments. Avoid draining impounded area through use of beaver deceivers.	May affect survival of larvae. May affect juvenile survival and adult survival, productivity, and reproductive success.

Table A-25 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for California Floater and Western Ridged Mussel.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Large Woody Debris Placement/Movement/Removal (for placement only construction impacts apply)									
	Construction and Maintenance Activities								
	Riverine and Lacustrine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Glochidia larvae; Juveniles, Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Glochidia larvae; Juveniles; Adults	All life-history stages: The effect of pile-driving sound pressure on California floater and western ridged mussels at any life-history stage is a data gap. Any potential impact would likely occur on the host fish species for the glochidia larvae (California floater= native minnows; western ridge = coldwater stream fish such as trout and salmon).	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Limit in-water use of heavy machinery.	Very little is known of the effects of pile-driving sounds on California floater and western ridged mussels at any life-history stage.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification.
	Channel/work area dewatering	Species removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles and adults: Mortality from dewatering.	Perform channel work on areas where these species do not occur (these species are rarely found in sandy substrate).	May affect survival at juvenile and adult life-history stages.

Table A-25 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for California Floater and Western Ridged Mussel.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia larvae	Glochidia larvae: Any potential impact would only occur if the glochidia fish host is entrained or impinged.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows. Perform channel work on areas where these species do not occur (these species are rarely found in sandy substrate).	Any potential impact would only occur if the glochidia fish host is entrained or impinged.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles and adults: Mortality from increased sedimentation.	Adhere to system-specific in-water work windows. Perform channel work on areas where these species do not occur (these species are rarely found in sandy substrate).	May affect survival at juvenile and adult life-history stages.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Glochidia larvae; Juveniles; Adults;	All life-history stages: See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors under Water Quality Modification.
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Glochidia larvae; Juveniles; Adults	Glochidia larvae: Changes in channel morphology, flow velocity, and substrate composition can affect host fish. Juveniles and adults: As filter feeders, constant water flow is required. Altered channel geometry, flow velocity, and substrate composition can result in decrease habitat suitability and changes in food web complexity. This may limit prey resource availability and foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at all life-history stages and affect life-history stages and productivity of host-fish.
	Altered flow velocity		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition		Year round	Permanent	Continuous				
	Altered groundwater-surface water exchange		Year-round	Permanent	Continuous				

Table A-25 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for California Floater and Western Ridged Mussel.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Lacustrine								
	Altered wave energy (short-period waves)	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with predominant effects from fall through spring when wind-driven waves are most pronounced)	Permanent	Continuous	Glochidia larvae; Juveniles; Adults	All life-history stages: Wave energy, current velocity, sediment supply, substrate composition, and groundwater inputs are core ecosystem processes and characteristics that compose the nearshore ecosystem. Alteration in one or more of these parameters can fundamentally alter lacustrine littoral habitats, potentially decreasing the suitability of rearing habitat for juvenile and adult fish. This may occur through increased predation exposure, food web alterations and decreased foraging opportunity. Effects to host fish affect these mussels.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival at all life-history stages. Decreased fitness may lead to reduced productivity.
	Altered current velocities		Year-round (with effects more predominant in reservoirs versus natural lakes)	Permanent	Common				
	Altered sediment supply		Year-round	Permanent	Continuous				
	Altered substrate composition		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Riverine								
	Altered hyporheic flow/exchange	Decreased benthic dissolved oxygen	Year-round (most pronounced in summer and autumn when vegetation growth and decay is most extensive)	Permanent	Seasonal	Glochidia larvae; Juveniles; Adults	Glochidia larvae: See related stressor responses under Water Quality Modification.	Require assessment of the hydraulic effects of the project before permitting	See effects for related stressors under Water Quality Modification.
		Increased pollutant loading	Year-round	Long-term to permanent	Continuous	Glochidia larvae; Juveniles; Adults	Juveniles: See related stressor responses under Water Quality Modification.		May affect survival, growth, and fitness of juveniles and adults.
	Altered lateral (terrestrial/aquatic) habitat connectivity	Reduced recruitment of terrestrially derived prey resources; reduced aquatic productivity due to reduction of organic matter inputs Reduced availability of suitable habitats along longitudinal gradient.	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Glochidia larvae; Juveniles; Adults	Glochidia larvae: Changes in habitat availability may indirectly affect survival through effects on host fish. Juveniles and adults: LWD removal may permanently modify habitat suitable for juveniles and adults, affecting survival and overall population abundance.	Require assessment of the hydraulic effects of the project before permitting; avoid permitting designs that lead to disconnection of floodplain habitat or longitudinal reach simplification.	May affect juvenile and adult productivity and survival.
	Altered longitudinal habitat connectivity								
	Lacustrine								
	Altered terrestrial/aquatic connectivity	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Permanent	Continuous	Glochidia larvae; Juveniles; Adults	Glochidia larvae: Changes in habitat availability may indirectly affect survival through effects on host fish. Juveniles and adults: LWD removal may permanently modify habitat suitable for juveniles and adults, affecting survival and overall population abundance.	Require structures with the minimal footprint necessary to achieve project objectives. Avoid permitting projects in areas where significant cumulative effects are already prevalent.	May affect survival at all life-history stages and affect life-history stages and productivity of host-fish.

Table A-25 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for California Floater and Western Ridged Mussel.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered cover and habitat	Reduced availability of LWD from drift. See altered allochthonous inputs and altered habitat complexity stressors under Riparian Vegetation Modification	Year-round	Permanent	Continuous	Juveniles; Adults	See responses to altered allochthonous inputs and altered habitat complexity under Riparian Vegetation Modification.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival.
	Aquatic Vegetation Modification								
	Riverine and Lacustrine								
	Altered autochthonous production	Reduced food web productivity	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced prey availability due to decreased food web productivity, decreased growth and fitness of host fish. Although effects specific to altered autochthonous inputs for the California floater and Western ridged mussels are a data gap, alterations could be expected to affect prey resource availability.	Construction: Avoid/minimize disturbance of aquatic vegetation during project construction.	May affect all life-history stages.
		Altered dissolved oxygen levels due to reduced photosynthesis	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Seasonal	Juveniles; Adults	Juveniles and adults: Require high levels of dissolved oxygen. See related stressor responses under Water Quality Alteration.		See effects for related stressors under Water Quality Modification.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles and adults: Reduced prey resources due to decreased food web productivity, decreased growth and fitness of the California floater and Western ridged mussel prey and host fish. Altered autochthonous production could be expected to affect prey resource availability.		May affect all life stages.

Table A-25 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for California Floater and Western Ridged Mussel.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modification								
	Riverine								
	Altered shading, solar input and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Glochidia larvae; Juveniles; Adults	All life-history stages: Altered growth and productivity caused by temperatures outside optimal growth range, and alteration of food web patterns (including food web supporting host fish). Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile and adult fitness and survival of mussels and host fish.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased benthic dissolved oxygen; decreased area of suitable habitat; reduced habitat complexity	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Glochidia larvae; Juveniles; Adults	All life-history stages: Decreased food resource availability, leading to increased competition and resulting effects on growth and fitness for mussels and host fish. Decreased suitable habitat, injury, or mortality caused by excessive turbidity or resulting smothering by burial.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile and adult fitness and survival of mussels and host fish.
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover.	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles and adults: Decreased habitat availability and food availability, leading to increased competition and resulting effects on growth and fitness, including health of host fish.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile and adult fitness and survival of mussels and host fish.
	Altered groundwater–surface water exchange	Reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Glochidia larvae; Juveniles; Adults	Mussel responses to groundwater exchange are a data gap.	Avoid disturbance of vegetation along stream.	Effect of groundwater exchange to mussel health and fitness is a data gap.
	Lacustrine								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round, (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Glochidia larvae; Juveniles; Adults	Glochidia larvae: Host-fish of the California floater and Western ridged mussel may be affected by increased temperatures, which may lead to mortality or increased thermal stress and decreased fitness of host fish. Juveniles and adults: Mortality due to increased temperatures.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect survival of all life-history stages.
	Altered shoreline stability	Increased suspended solids; secondary effects on habitat complexity (e.g., through change in substrate composition, smothering of aquatic vegetation)	Year-round (with primary stressor prominent during high wave energy conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	Juveniles and adults: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness for mussel host-fish.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile and adult survival.

Table A-25 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for California Floater and Western Ridged Mussel.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction of organic matter inputs	Year-round (stressor exposure occurs predominantly during spring outmigration period through lakes)	Permanent	Continuous	Glochidia larvae; Juveniles; Adults	All life-history stages: Mussel dependence on allochthonous inputs from shoreline riparian vegetation is a data gap. This could be a stressor to host fish.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May affect juvenile and adult growth, fitness, and productivity.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Short-term to permanent (dependent on nature of activity)	Continuous	Glochidia larvae; Juveniles; Adult	All life-history stages: Decreased refuge habitat availability and foraging opportunities, leading to increased competition and resulting effects on growth and fitness.	Encourage project designs that limit permanent alteration of high-quality habitat features.	May affect juvenile survival and productivity, as well as reproductive success and overall population productivity.
	Loss of groundwater input	Reduced aquatic food web productivity; secondary effects on habitat complexity (e.g., through alteration of aquatic vegetation)	Year-round (stressor exposure occurs during predominantly during spring outmigration period through lakes)	Permanent	Continuous	Juveniles; Adults	Juveniles and adults: Mussel dependence on groundwater inflow is currently a data gap.	Avoid disturbance of vegetation along shoreline.	Effects of the action resulting from this impact mechanism are unknown.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to long-term (dependent on contributing mechanism of impact)	Continuous to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Effects depend on the magnitude of increased suspended solids. Turbidity sufficient to cause fine sediment embeddedness may bury these mussels and lead to direct mortality and decreased population survival.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect juvenile and adult survival.
	Altered pollutant loading	Increased pollutant loading	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Glochidia larvae; Juveniles; Adults	All life-history stages: Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival, growth, and fitness of juveniles and adults.
	Altered dissolved oxygen	Decreased dissolved oxygen (due to eutrophication caused by elevated nutrient export from dewatered floodplains)	Dependent on contributing mechanism of impact	Temporary to short-term to seasonal (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Glochidia larvae; Juveniles; Adults	All life-history stages: Mortality in acute low dissolved oxygen events due to asphyxiation. Effects to host-fish could be stressor to these mussels. Juveniles and adults: A physiological response to exposure at toxic levels, causing mortality or injury leading to reduced fitness is a data gap.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival of larvae. May affect juvenile survival and adult survival, productivity, and reproductive success.

Table A-25 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for California Floater and Western Ridged Mussel.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Spawning Substrate Augmentation									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Glochidia larvae; Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Glochidia larvae; Juveniles, Adults	All life-history stages: The effect of elevated anthropogenic noise on California floater and western ridged mussels is a data gap.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	Very little is known of the effects of elevated anthropogenic noise on California floater and western ridged mussels at any life-history stage.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification.
		Burial (during active sediment placement)	During project construction	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	All life-history stages: Injury or mortality from burial during gravel placement.	Restrict in-water work window to periods when larvae with limited motility are least likely to be present.	May cause direct mortality or injury at juvenile and adult life-history stages. Injury and stress may affect survival, growth, and fitness.
	Hydraulic and Geomorphic Modification								
	Riverine								
	Altered bank stability (intermediate-term effects from passive augmentation projects)	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced habitat availability and suitability	Year-round	Intermediate-term	Continuous	Glochidia larvae; Juveniles; Adults	Glochidia larvae: Changes in channel morphology, flow velocity, and substrate composition can affect host fish. Juveniles and adults: As filter feeders,	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project.	May affect survival at all life-history stages and affect life-history stages and productivity of host-fish.

Table A-25 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for California Floater and Western Ridged Mussel.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered substrate composition/stability			Short-term to long-term			constant water flow is required. Altered channel geometry, flow velocity, and substrate composition can result in decrease habitat suitability and changes in food web complexity. This may limit prey resource availability and foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival.	Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	
	Aquatic Vegetation Modification								
	Riverine								
	Altered autochthonous production	Reduced food resources	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles	Juveniles: Reduced prey availability due to decreased food web productivity, decreased growth and fitness of host fish. Although effects specific to altered autochthonous inputs for the California floater and Western ridged mussels are a data gap, alterations could be expected to affect prey resource availability.	Avoid spawning gravel augmentation projects in locations where aquatic vegetation plays a strong role in habitat productivity.	May affect juvenile and adult productivity and survival.
	Altered habitat complexity	Reduced food web productivity, reduced foraging opportunity, reduction in available cover	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles and adults: Reduced prey resources due to decreased food web productivity, decreased growth and fitness of the California floater and Western ridged mussel prey and host fish. Altered autochthonous production could be expected to affect prey resource availability.		
	Water Quality Modification								
	Altered pollutant loading	Increased exposure to toxic substances	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to permanent (dependent on contributing mechanism of impact)	Glochidia larvae; Juveniles; Adults	All exposed life-history stages: Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel machinery in a controlled environment away from the project area. Avoid reducing hydraulic complexity.	May affect survival, growth, and fitness of juveniles and adults.

Table A-25 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for California Floater and Western Ridged Mussel.

Sub-activity Type	Mechanism of Impact	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered suspended solids	Increased suspended solids	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Effects depend on the magnitude of increased suspended solids. Turbidity sufficient to cause fine sediment embeddedness may bury these mussels and lead to direct mortality and decreased population survival.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect juvenile and adult survival.
In-Channel/Off-Channel Habitat Creation/Modification									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Glochidia larvae; Juveniles, Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Glochidia larvae; Juveniles, Adults	All life-history stages: The effect of elevated anthropogenic noise on California floater and western ridged mussels is a data gap.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	Very little is known of the effects of elevated anthropogenic noise on California floater and western ridged mussels at any life-history stage.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification.
	Channel/work area dewatering	Species removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles and adults: Mortality from dewatering.	Perform channel work on areas where these species do not occur (these species are rarely found in sandy substrate).	May affect survival at juvenile and adult life-history stages.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia larvae	Glochidia larvae: Any potential impact would only occur if the glochidia fish host is entrained or impinged.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows. Perform channel work on areas where these species do not occur (these species are rarely found in sandy substrate).	Any potential impact would only occur if the glochidia fish host is entrained or impinged.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles and adults: Mortality from increased sedimentation.	Adhere to system-specific in-water work windows. Perform channel work on areas where these species do not occur (these species are rarely found in sandy substrate).	May affect survival at juvenile and adult life-history stages.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Glochidia larvae; Juveniles; Adults;	All life-history stages: See responses described for related stressors under Water Quality Modification.	Avoid turbidity effects above background levels.	May affect juvenile growth and fitness. See effects for related stressors under Water Quality Modification.

Table A-25 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for California Floater and Western Ridged Mussel.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids (if in-channel project fails)	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Effects depend on the magnitude of increased suspended solids. Turbidity sufficient to cause fine sediment embeddedness may bury these mussels and lead to direct mortality and decreased population survival.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect juvenile and adult survival.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Glochidia larvae; Juveniles; Adults	All life-history stages: Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Ensure project design does not drastically reduce hydraulic complexity or impact riparian buffers.	May affect survival, growth, and fitness of juveniles and adults.
Riparian Planting/Restoration Enhancement									
	Construction and Maintenance Activities								
	Riverine and Lacustrine								
	Bank, Channel, Shoreline Disturbance	Expansion of thermal regime – due to removal of invasive riparian species (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Glochidia larvae; Juveniles; Adults	All life-history stages: Altered growth and productivity caused by temperatures outside optimal growth range, and alteration of food web patterns (including food web supporting host fish). Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect survival and productivity during incubation, and rearing.
		Increased suspended solids – due to removal of invasive riparian species Benthic sedimentation – due to removal of invasive riparian species	Year-round (with specific stressors prominent during high flow conditions)	Short-term to intermediate (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Minimize disturbance during invasive species removal. Use appropriate erosion control BMPs both during and after construction.	May affect survival and productivity.

Table A-25 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for California Floater and Western Ridged Mussel.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Aquatic Vegetation Modification								
	Riverine and Lacustrine								
	Altered autochthonous production	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced prey availability due to decreased food web productivity, decreased growth and fitness of host fish. Although effects specific to altered autochthonous inputs for the California floater and Western ridged mussels are a data gap, alterations could be expected to affect prey resource availability.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect all life-history stages.
	Riparian Vegetation Modification								
	Riverine and Lacustrine								
	Altered Shading and solar input	Decreased productivity (locally due to increased shading)	Year-round (most pronounced in spring and summer when vegetation growth is most extensive)	Permanent	Continuous	Juveniles	Juveniles: Reduced prey availability due to decreased food web productivity, decreased growth and fitness of host fish. Although effects specific to altered autochthonous inputs for the California floater and Western ridged mussels are a data gap, alterations could be expected to affect prey resource availability.	Design riparian patches with variable canopy coverage so that sunlight will continue to reach the channel.	May affect all life-history stages.
	Water Quality Modification								
	Altered Temperatures	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Short-term to intermediate (dependent on nature of riparian impacts).	Seasonal	Glochidia larvae; Juveniles; Adults	All life-history stages: Altered growth and productivity caused by temperatures outside optimal growth range, and alteration of food web patterns (including food web supporting host fish). Adults and juveniles: Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.	Minimize disturbance during invasive species removal. Use measures to assure rapid establishment of planted species.	May affect survival and productivity during incubation, and rearing.
	Altered suspended solids	Increased suspended solids – due to removal of invasive riparian species	Dependent on contributing mechanism of impact	Short-term to intermediate (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Effects depend on the magnitude of increased suspended solids. Turbidity sufficient to cause fine sediment embeddedness may bury these mussels and lead to direct mortality and decreased population survival.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect juvenile and adult survival.

Table A-25 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for California Floater and Western Ridged Mussel.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Wetland Creation Restoration/Enhancement									
	Construction and Maintenance Activities								
	Riverine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Glochidia larvae; Juveniles, Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the project area.	May affect survival, growth, and fitness of juveniles and adults.
		Elevated noise, visual, physical disturbance	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Glochidia larvae; Juveniles, Adults	All life-history stages: The effect of elevated anthropogenic noise on California floater and western ridged mussels is a data gap.	Limit in-water equipment use where practicable. Adhere to in-water work windows to avoid effects on multiple life history stages where possible.	Very little is known of the effects of elevated anthropogenic noise on California floater and western ridged mussels at any life-history stage.
	Bank, Channel, Shoreline Disturbance	Increased suspended solids	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Avoid/minimize disturbance of riparian vegetation. Limit bank, shoreline and benthic disturbance. Use proper erosion control BMPs.	See effects for related stressors under Water Quality Modification.
	Channel/work area dewatering	Species removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles and adults: Mortality from dewatering.	Perform channel work on areas where these species do not occur (these species are rarely found in sandy substrate).	May affect survival at juvenile and adult life-history stages.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia larvae	Glochidia larvae: Any potential impact would only occur if the glochidia fish host is entrained or impinged.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows. Perform channel work on areas where these species do not occur (these species are rarely found in sandy substrate).	Any potential impact would only occur if the glochidia fish host is entrained or impinged.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	Exposure: When	Exposure: Duration	Exposure: Frequency	Exposure: Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles and adults: Mortality from increased sedimentation.	Adhere to system-specific in-water work windows. Perform channel work on areas where these species do not occur (these species are rarely found in sandy substrate).	May affect survival at juvenile and adult life-history stages.
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids (e.g., during reconnection of fragmented floodplain wetlands, etc.)	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Effects depend on the magnitude of increased suspended solids. Turbidity sufficient to cause fine sediment embeddedness may bury these mussels and lead to direct mortality and decreased population survival.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect juvenile and adult survival.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term (dependent on contributing mechanism of impact)	Interannual to decadal	Glochidia larvae; Juveniles, Adults	All life-history stages: Bioaccumulation of contaminants at subacute levels, resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
Beach Nourishment/Contouring									
	Construction and Maintenance Activities								
	Lacustrine								
	Equipment Operation	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term	Interannual to decadal	Glochidia larvae; Juveniles, Adults	All life-history stages: See responses to related stressors under Water Quality Modification.	Refuel and service machinery in a controlled environment away from the water body. Limit heavy machinery work within the channel.	May affect survival, growth, and fitness of juveniles and adults.
	Bank, channel, shoreline disturbance	Localized alteration in invertebrate abundance from burial, increased suspended solids	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles, Adults	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness. Mortality from burial.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.
	Hydraulic and Geomorphic Modification								
	Lacustrine								
	Altered sediment supply	Localized alteration in invertebrate abundance from burial	During project construction and maintenance activities	Short-term – long-term	Interannual to decadal (depending on activity frequency)	Juveniles, Adults	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness. Mortality from burial.	Avoid project site which are productive and have a healthy benthic community.	May affect growth and fitness at juvenile life-history stage.
	Aquatic Vegetation Modification								
	Lacustrine								

Table A-25 (continued). HPA HCP Habitat Modification Exposure and Response Matrix for California Floater and Western Ridged Mussel.

Sub-activity Type	Mechanism of Impact	Exposure: Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered autochthonous production	Reduced foraging opportunities and rearing habitat availability	Year-round	Short-term to long-term(dependent on nature of activity)	Continuous	Juveniles; Adults	Juveniles and adults: Reduced prey resources due to decreased food web productivity, decreased growth and fitness of the California floater and Western ridged mussel prey and host fish. Altered autochthonous production could be expected to affect prey resource availability.	Avoid/minimize disturbance of aquatic vegetation during project construction. Avoid nourishing beaches updrift of productive, vegetated aquatic habitat.	May affect all life stages.
	Altered cover and habitat	Reduced cover							
	Water Quality Modification								
	Altered suspended solids	Increased suspended solids	During construction and during subsequent high energy periods	Temporary to short-term (dependent on grain size of augmented sediment)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Effects depend on the magnitude of increased suspended solids. Turbidity sufficient to cause fine sediment embeddedness may bury these mussels and lead to direct mortality and decreased population survival.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic shoreline instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect juvenile and adult survival.
	Altered Pollutant Loading	Elevated Hydrocarbons (associated with potential fuel and oil spills)	During project construction activities	Temporary to short-term (dependent on contributing mechanism of impact)	Interannual to decadal	Glochidia larvae; Juveniles, Adults	All life-history stages: Physiological responses to exposure at toxic levels causing mortality or injury leading to reduced fitness. Bioaccumulation of contaminants at subacute levels resulting in chronic physiological effects leading to reduced fitness and/or mortality.	Refuel and service machinery in a controlled environment away from the water body.	May affect survival and productivity of Glochidia larvae, juveniles, and adults.
Reef Creation/Restoration/Enhancement									
	Not Applicable								
Eel Grass and Other Aquatic Vegetation Creation/Restoration/Enhancement									
	Not applicable								