Protecting Nearshore Habitat and Functions in Puget Sound

An Interim Guide

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EnviroVision,

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Aquatic Habitat Guidelines Working Group[1]

[1] The Aquatic Habitat Guidelines Working Group is a multi-agency committee within Washington State that receives support and participation from the Departments of Fish and Wildlife, Ecology, Natural Resources, Transportation, Community Trade and Economic Development; the Recreation and Conservation Office, and the Puget Sound Partnership.

TABLE OF CONTENTS

TABLE OF TABLES

SECTION I

SECTION II

SECTION III

TABLE OF FIGURES

SECTION II

SECTION III

TABLE OF FIGURES (CONT.)

Section III

SECTION I

INTRODUCTION

PURPOSE AND NEED

WHY PROVIDE THIS GUIDANCE?

Increasing human population growth combined with the desirability and high value of shoreline properties, means that shoreline modifications will continue to occur in the Puget Sound area. "Shoreline modification" is a broadly used term covering a variety of structures and activities intended to adapt the shoreline environment for human use. These activities can range from installing stairways across bluff faces, to building docks and bulkheads, to dredging. Shoreline modification has been accelerating significantly in recent decades in response to population growth and development of the shoreline for commercial, industrial, residential, and recreational uses. These activities have contributed to wide scale degradation and loss of important habitat in the nearshore environment. The remaining habitat is becoming increasingly fragmented and degraded by ongoing activities.

The Shoreline Management Act (SMA) provides the framework for protection of the nearshore. Adopted in 1971 from a citizen's initiative, the Act's purpose is to protect the state's shorelines from uncoordinated and piecemeal development. This is accomplished through locally prepared and administered Shoreline Master Programs (SMPs). SMPs are currently being updated statewide consistent with new guidelines (WAC 173-26, Part III). The SMP update process requires local governments to evaluate existing nearshore conditions and establish policies and regulations that will protect nearshore ecological functions. During this update process, local planners and officials have the opportunity to determine where, and under what conditions, certain shoreline uses and activities should be permitted or prohibited. In this way, inappropriate modification activities can be prohibited, thereby avoiding future impacts altogether. In those circumstances where modification activities are allowed, local governments have the authority to ensure that policies, regulations and specific standards of local master programs are being met. Shoreline protection is also integrated into many local critical areas ordinances under the Growth Management Act (GMA).

This guidance has been developed as a companion to the Department of Ecology's SMA Guidelines and critical areas protection guidance offered by the Community, Trade, and Economic Development Department. This guidance provides a synthesis of current science on several important nearshore habitats and processes, and directions for where to find data and specific recommendations for moving through the mitigation sequence; from avoidance of new activities and reducing impacts from approved activities, to mitigating for cumulative impacts. In addition to helping local planners prepare SMP updates, this document will also assist Ecology in their review to ensure that SMP updates are based on good science.

The intent of this guidance is to:

◊ Provide basic information on key nearshore habitats and how they are impacted by shoreline modifications, in summary form.

◊ Provide useful approaches to protecting nearshore habitat that are supported by the prevailing science.

◊ Provide recommendations in a form that lays out a decision sequence that begins with avoiding impacts from these activities and moves through mitigating for cumulative impacts.

◊ Provide the information in the form of user-friendly text and graphics with reliance on tools such as flow charts and tables rather than extensive narrative.

WHAT IS THE SCOPE OF THIS GUIDANCE?

This Introduction (section I) includes a description of the relationship of this guidance to SMA and GMA requirements, and a definition of the importance of the Puget Sound nearshore zone. Section II, provides a brief description of some key nearshore habitats in Puget Sound that are often affected by shoreline modifications. These "science briefs" were summarized from recent scientific papers, and provide a framework to put the importance of nearshore habitats into perspective. The goal is to provide planners and regulators with condensed information that shows how shoreline modification can affect Puget Sound nearshore habitat and nearshore ecological functions. The science briefs include:

- Beaches and Bluffs
- Forage Fish Habitat
- Kelp and Eelgrass Habitat
- Marine Riparian Vegetation
- Juvenile Salmon Habitat

Section III, contains recommendations associated with reviewing and permitting three common shoreline modifications. For each activity, an overview of impacts is provided along with recommendations for reducing the level of impact through planning and site specific designs. In this section, narrative and descriptive text were minimized in favor of flow charts, tables, and matrices that would serve as an easy-to-use reference for planners and decision-makers. The following shoreline modifications are addressed:

- Overwater Structures
- Shoreline Armoring
- Riparian Vegetation Alteration

Throughout the document links to websites with supporting or more detailed information have been included. Scientific citations have been minimized within the text but are included as footnotes to tables and references.

WHY IS THE SCOPE LIMITED?

Most local governments are, or will soon be, undertaking ordinance and comprehensive plan amendments and revising their SMPs to meet GMA and SMA requirements. In addition, scientific white papers, draft management recommendations and other science products related to the nearshore environment have recently been released. There was a need to compile this information and provide a portal to access more detailed information in a timely manner.

The recently released white papers (available at: http://www.pugetsoundnearshore.org/technical_reports.htm) and other documents cover much more than the 5 habitat and 3 shoreline modification types addressed in this guidance. The scope of this guidance was limited to these topics because they represent some of the most common habitat concerns and frequently permitted activities in Puget Sound. Additional topics may be integrated into later versions of this guidance or supplemental documents may be developed to address other topics and particular areas of concern.

WHY PROVIDE "INTERIM" GUIDANCE?

The Washington Department of Fish and Wildlife (WDFW), along with other state agencies and others in the scientific community have been developing "best available science (BAS)" for the nearshore environment. This "BAS" for a variety of topics has been synthesized in recently released white papers. This guidance reflects the findings of these papers but is considered "interim" in recognition that science will evolve rapidly especially with the Governor's attention focused on the health of the Puget Sound. Meanwhile, Interim guidance is needed to for many efforts, underway or anticipated, that require local governments to update SMPs and local codes. Although BAS has been used to develop this guidance, full details regarding the science have not been included here. Instead, links to supporting information and citations are provided for those needing more detailed information.

WHO SHOULD USE THIS GUIDANCE?

This guidance was written to assist local planners involved with development of regulations to meet requirements of the GMA and SMA. In recent years many reports have addressed habitat loss and impacts from shoreline modifications. However, it is unrealistic to expect planners and decision-makers to review all of these technical documents. A reference document was needed that contained summary information of the ecological functions of the nearshore, as well as one that provided tools recommendations to inform nearshore management decisions.

How to use This Guidance?

Local planners developing SMP's should review the appropriate scientific brief (Section II) for the habitats of interest. This review may assist planners with identifying where more shoreline inventory information is needed. In addition, the review may help planners better identify critical nearshore habitat and make more informed decisions about applying appropriate shoreline environment designations and activity standards. The recommendations section (Section III) can be used to develop policies for inclusion in revised SMP's and to guide decisions on specific permit requests.

Acknowledgements

The Washington State Department of Ecology and the Puget Sound Action Team (now the Puget Sound Partnership) provided funding for the production of this document.

Relationship to SMA and GMA Requirements

In Washington State, development activities in nearshore environments are regulated by the Shoreline Management Act (RCW 90.58) and the Growth Management Act (RCW 36.70A). Local governments are responsible for meeting the requirements of these Acts through development of SMPs, for SMA, and Comprehensive Plans and Critical Area Ordinances, for GMA.

Elements of the SMA related to the nearshore

Washington State's Shoreline Management Act was first adopted in 1971 "to prevent the inherent harm in an uncoordinated and piecemeal development of the state's shorelines." The SMA has three broad policies that are implemented through administration of locally customized SMPs. These broad policies include: (1) protecting shoreline natural resources, (2) encouraging water-oriented uses, and (3) promoting public access. This guidance has been developed to assist with meeting the first policy of protecting shoreline natural resources.

SMPs include; policies, shoreline environment designations, specific regulations; and permit administration provisions. At the outset of the planning process for updating local SMPs, natural resources and related ecological processes and functions are identified for each stretch of shoreline through a required inventory and characterization process. (Appendix A is a summary of planning steps associated with SMP updates.) As stated in WAC 173-26-201(3)(c), an inventory of shoreline conditions is to be conducted by gathering and incorporating "all pertinent and available information, existing inventory data and materials." The rules clearly state that critical areas are to be included in the inventory as noted below:

> "Local government shall, at a minimum, and to the extent such information is relevant and reasonably available, collect the following information:
>
> (ii) Critical areas, including wetlands, aquifer recharge areas, fish and wildlife conservation areas, geologically hazardous areas, and frequently flooded areas. See also WAC 173-26-221. " (WAC 173-26-201(3)(c))

Critical saltwater habitats are incorporated as critical areas and are defined in WAC 173-26-221 to include:

> "… all kelp beds, eelgrass beds, spawning and holding areas for forage fish, such as herring, smelt and sand lance; subsistence, commercial and recreational shellfish beds; mudflats, intertidal habitats with vascular plants, and areas with which priority species have a primary association. "(WAC 173-26-221(2)(iii)(A)
>
> When the inventory has been completed, the information is used to characterize shoreline functions and ecosystem-wide processes. This consists of three steps (WAC 173-26-201(3)): "(I) Identify the ecosystem-wide processes and ecological functions…
>
> (II) Assess the ecosystem-wide processes to determine their relationship to ecological functions present within the jurisdiction and identify which ecological functions are healthy, which have been significantly altered and/or adversely impacted and which functions may have previously existed and are missing based on the values identified in (d)(i)(D) of this subsection; and

> (III) Identify specific measures necessary to protect and/or restore the ecological functions and ecosystem-wide processes."

Jurisdictions that contain critical saltwater habitats should also implement the principles outlined in WAC 173-26-221(2)(c)(iii)(B).

When the shoreline inventory and characterization has been completed, local jurisdictions begin the planning phase of SMP updates. Each individual shoreline inventory and characterization provides the basis for determining environment designations and developing appropriate policies and regulations. Planning objectives under the SMA guidelines for critical areas state that SMP "regulatory provisions for critical areas shall protect existing ecological functions and ecosystem-wide processes" (WAC 173-26-221(2)(B)(iv). With regard to critical areas:

> "Critical saltwater habitats require a higher level of protection due to the important ecological functions they provide. Ecological functions of marine shorelands can affect the viability of critical saltwater habitats. Therefore, effective protection and restoration of critical saltwater habitats should integrate management of shorelands as well as submerged areas." (RCW 90.58.090(4) and WAC 173-26-221(2)(iii)(A).

Policies and regulations developed for SMPs are to "provide a level of protection to critical areas within the shoreline area that is at least equal to that provided by the local government's existing critical area regulations adopted pursuant to the GMA for comparable areas other than shorelines" (WAC 173-26-221(2)(a) and (c)).

The following table lists WAC section references that relate to the different habitat types and shoreline modifications that are addressed in this guidance document.

Table I.1 Link Between Topics Addressed in this Guidance and the SMA.

HABITAT OR SHORELINE MODIFICATION TYPE	SMA WAC REFERENCE
Forage Fish Habitat	WAC 173-26-221(2)(c)(iii) Critical Saltwater Habitats

Table I.1 Link Between Topics Addressed in this Guidance and the SMA.

HABITAT OR SHORELINE MODIFICATION TYPE	SMA WAC REFERENCE
Beaches and Bluffs Beaches and Bluffs (cont.)	WAC 173-26-221(2)(c)(ii) Geologically Hazardous Areas WAC 173-26-221(2)(c)(iii) Critical Saltwater Habitats
Kelp and Eelgrass	WAC 173-26-221(2)(c)(iii) Critical Saltwater Habitats
Juvenile Salmon	WAC 173-26-221(2)(c)(iii) Critical Saltwater Habitats
Marine Riparian Vegetation	WAC 173-26-221(2)(c)(iii) Critical Saltwater Habitats
Over-Water Structures	WAC 173-26-231(3) (b) Piers and Docks WAC 173-26-231(3)(d) Breakwaters, Jetties, and Weirs WAC 173-26-221(2)(c)(iii) Critical Saltwater Habitats WAC 173-26-211(5)(c) Aquatic Environment Designation
Shoreline Armoring	WAC 173-26-231(3)(a) Shoreline Stabilization WAC 173-26-221(2)(c)(ii) Geologically Hazardous Areas WAC 173-26-221(2)(c)(iii) Critical Saltwater Habitats
Riparian Vegetation Alternation	WAC 173-26-221(5) Vegetation Conservation WAC 173-26-231(3)(a) Shoreline Stabilization WAC 173-26-241(3)(e) Forest Practices

ELEMENTS OF GMA RELATED TO THE NEARSHORE

The GMA requires all cities and counties throughout the State to designate and protect Critical Areas (RCW 36.70A.060 (2)). The five types of critical areas defined by GMA are: 1) wetlands, 2) areas with a critical recharging effect on aquifers used for potable water, 3) fish and wildlife habitat conservation areas, 4) frequently flooded areas, and 5) geologically hazardous areas (RCW 36.70A.030). The areas that relate most directly to the Puget Sound nearshore are geologically hazardous areas and fish and wildlife habitat conservation areas.

The GMA requires that local governments use the best available science in developing policies and development regulations to protect the functions and

values of critical areas" (RCW 36.70A.172(1)). GMA requires the use of "best available science" in designating critical areas, protecting their functions and values, preserving and enhancing anadromous fisheries, and identifying the risks associated with alternative approaches for accomplishing these goals. Until a local government updates its SMP to be consistent with Ecology guidelines, local governments must continue to regulate shoreline areas under critical areas ordinances, as well as SMPs'. After Ecology approves a new SMP, sole jurisdiction of critical areas within shoreline jurisdiction, which will typically include the nearshore environment, will "transfer" exclusively to the SMP. (See Ecology guidance:
http://www.ecy.wa.gov/programs/sea/sma/st_guide/SMP/index.html).

THE PUGET SOUND NEARSHORE

WHAT DO WE MEAN BY "NEARSHORE"?

The nearshore zone in Puget Sound is the aquatic interface between freshwater, air, land, and the marine waters of Puget Sound. It includes areas along the shore that are either influenced by or directly influence marine water. It extends waterward to the maximum depth offshore where sunlight is sufficient to support plant growth (i.e., the photic zone). The nearshore zone also includes upland and backshore areas that directly influence shoreline conditions. It also extends upstream in estuaries to the head of tidal influence. The offshore edge of the nearshore zone will vary depending upon water depth and clarity, and can reach depths of -30 meters. The nearshore zone includes areas commonly known as the shore, beach, intertidal and subtidal zones. For description of nearshore zone processes and the effect of development on those processes see: http://dnr.metrokc.gov/wlr/watersheds/puget/nearshore/index.htm.

WHY IS THE NEARSHORE AREA SO IMPORTANT?

The nearshore zone is where the interplay of physical processes such as wave energy and sediment transport create and maintain shoreline physical features and habitats. It is where biological processes such as sunlight driven photosynthesis, primary productivity, and carbon cycling occur at rates important at a worldwide scale. Puget Sound's nearshore zone also represents three critical "edge" habitats; the edge between upland and aquatic environments, the edge between the shallow productive zone and deep water, and the edge between fresh and marine waters. Variations in wave energy, sediment movement, sunlight, water depth, salinity and location associated with "nearshore edges" creates a wide range of physical environments that support a wide diversity and abundance of life.

The nearshore zone also attracts a lot of human activity. Much of the northwest economy is tied to the Puget Sound and its nearshore environment, including shellfish and salmon industries, ports and refineries, and a variety of recreational activities.

SECTION II

SCIENCE BRIEFS: KEY NEARSHORE HABITATS

Section II provides science briefs that summarize nearshore zone elements important to the Puget Sound region. The five topics included in these briefs provide an overview of Puget Sound nearshore ecology and how it is commonly affected by shoreline modification activities.

BEACHES AND BLUFFS

The information in this brief is summarized from a Puget Sound Nearshore Partnership Report by Jim Johannessen and Andrea MacLennan titled "Beaches and Bluffs of Puget Sound and the Northern Straits Valued Ecosystem Component of Washington State". The full report contains a detailed discussion of the how beaches and bluffs are shaped and formed and how they are affected by shoreline activities. The full report can be viewed at: http://www.pugetsoundnearshore.org/technical_reports.htm.

Beaches and bluffs are important geological features of the Puget Sound nearshore. In Puget Sound, bluff erosion is the primary source of material that replenishes beach substrate. Beaches and bluffs also provide important habitat to numerous species dependant on the nearshore zone of Puget Sound.

Shoreline modifications, including over-water structures, shoreline armoring, and marine riparian vegetation alteration can change natural processes such as erosion and sediment transport associated with beach and bluff formation. Recommendations for minimizing or mitigating impacts from these activities are provided in section five.

BEACHES

Beaches are comprised of materials that accumulate between an upland environment such as a bluff, dune, or bulkhead and a lower limit defined by the area where substrate is still active and mobile. This lower limit extends below the low tide line to depths of -10 feet Mean Lower Low Water (MLLW = 0.0 ft) or greater. Puget Sound beaches generally have two components; a beach face, sometimes called the high-tide beach, that has an abrupt decrease in slope at the waterward extent; and a low tide terrace, a more gently sloped beach extending seaward from the beach face. Some Puget Sound beaches also have a berm or series of berms above ordinary high water. These are formed when material is transported to the backshore during high water windstorms. Salt-tolerant plants such as dunegrass and marsh plants will often grow in sandy backshore areas between a bluff and beach berm. See Figure II.1 below for a cross-section of the nearshore zone.

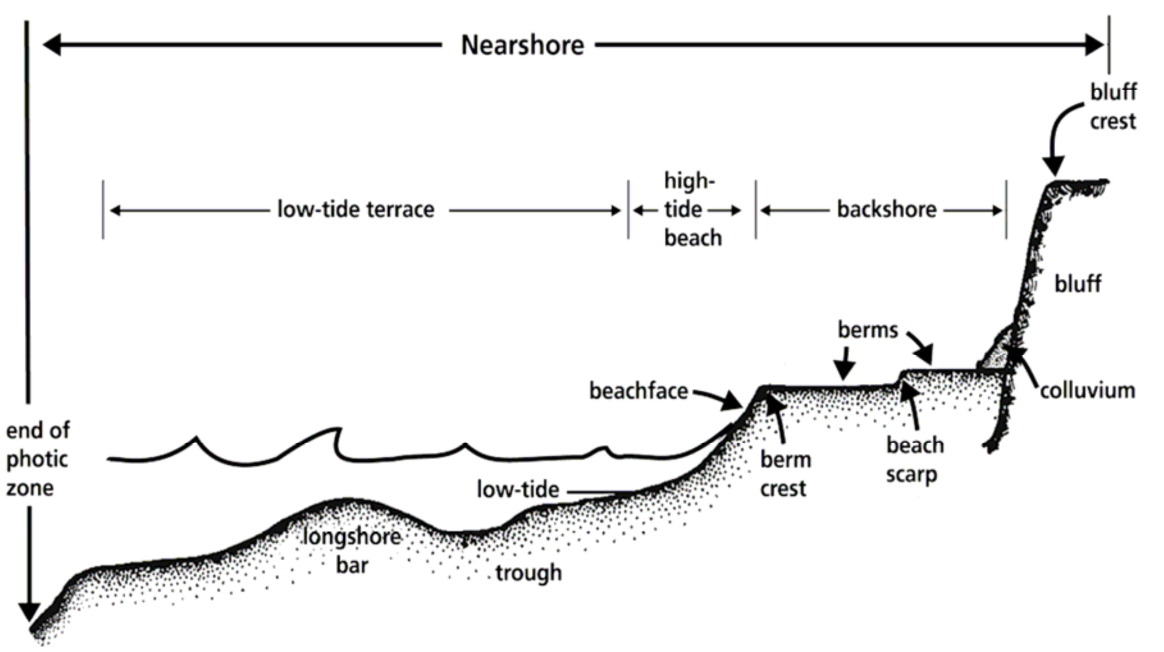


Figure II.1. Diagram of Puget Sound nearshore terminology (Johannessen and MacLennan 2007).

How are Beaches Formed and Maintained?

The source material for Puget Sound beaches is primarily derived from up-drift bluff erosion (e.g., feeder bluffs that supply sediment to the beach system). The composition of contributing bluffs and the amount of wave energy exposure determines the type and size of material that collects on the beach and forms the substrate. The material can be comprised of fine sand or mud or large boulders and woody debris. The size and shape of the beach is primarily a function of the beach substrate, the orientation of the beach in respect to wave energy and the rate of bluff erosion (see beach width examples in Figure II.2). For additional details, see
http://dnr.metrokc.gov/wlr/watersheds/puget/nearshore/index.htm.

The width and slope of the low-tide terrace affects the degree of wave energy dissipation that occurs along a beach. The large amount of gravel eroding from bluffs gives Puget Sound beach faces a much steeper slope than sandy beaches like those found on the outer coast of Washington. Because steeper sloped beaches do not dissipate wave energy as well as gradually sloped beaches, fine material is often moved away from the beach face and larger material is left in place (see Figure II.3 below). As waves transport fine materials away, the remaining boulders and large material can, over time, naturally armor the low tide terrace.

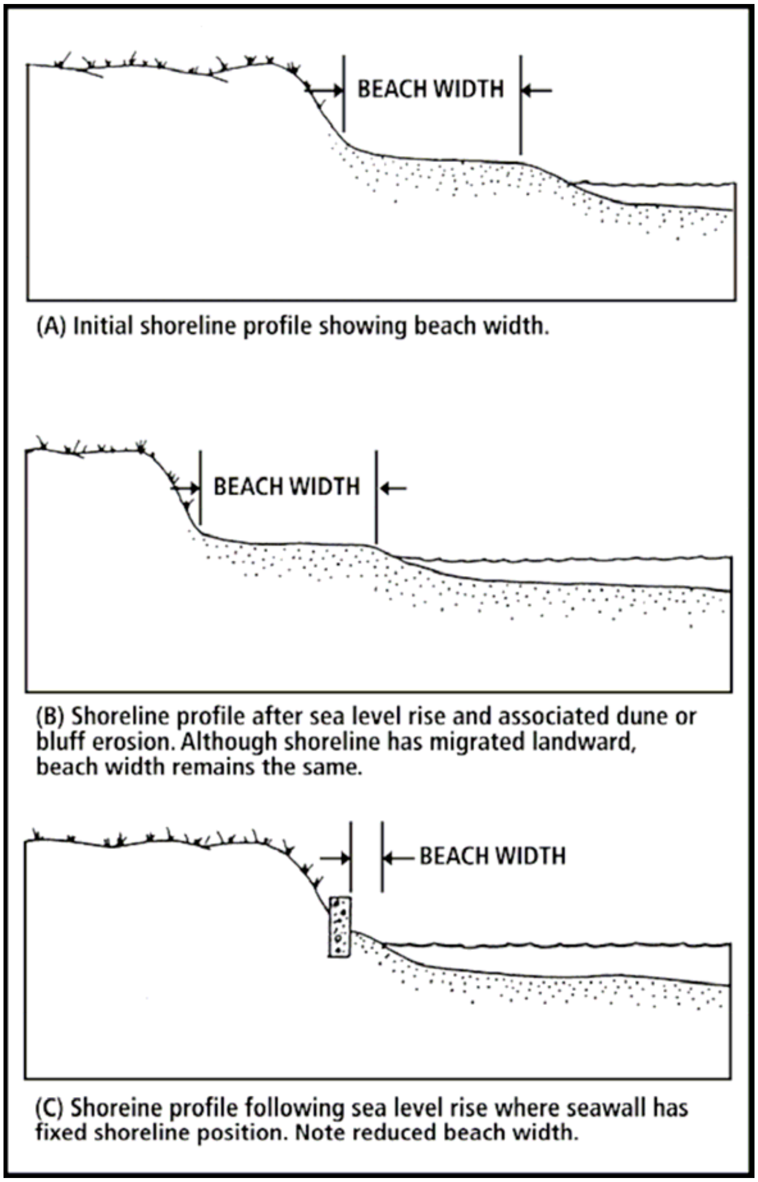


Figure II.2. Example of beach width loss through passive erosion (Griggs et al.1994). .

Figure II.3. Change in sediment size between the upper slope and low tide terrace (Finlayson 2006).

Low wave energy beaches are composed of poorly sorted (i.e., uniformly mixed) substrates with a relatively narrow backshore and intermittent intertidal vegetation. Higher wave energy beaches contain areas with well-sorted substrates forming distinct bands of different sized sediments distributed over a broad intertidal and backshore area, usually devoid of fringing vegetation.

Wave energy causes beaches to continually evolve by affecting sediment erosion, entrainment, and transport (see Figure II.4 below). This dynamic process, called "shore drift", is the combination of materials being transported landward and seaward (beach drift), as well as laterally along the coast (longshore drift). The movement can vary seasonally but, depending on the orientation of the beach to predominant winds and wave energy, sediment ultimately moves in one direction along the shore. Over time, this results in a gradual change in the beach size, shape, and structure.

Figure II.4. Large grain sediment deposits from storm activity caused buildup on the low energy side of this beach (Johannessen and MacLennan 2007).

Approximately 860 cells where net shore-drift occurs, and over 233 separate areas where there is essentially no net shore-drift have been identified within Puget Sound. While the average length of these drift cells is just 1.5 miles, they vary broadly in length from as little as 46 feet to almost 19 miles. The recruitment and movement of sediments within these drift cells are largely responsible for the shoreline configuration we see today. Unique shoreline features, such as spits, are formed by the particular characteristics of individual drift cells and the interactions between them. Spits can be straight, curved, or a complex form of multiple spits. For example, cuspate spits are formed where two drift cells meet from opposite directions and deposit sediment in a formation extending away from the shore to a seaward point. Linear spits can be formed when sediment is carried away from easily eroded bluffs. Other landforms are created from sediment deposits as well; including tombolos, connecting two islands or an island to the mainland; and bars, which are subtidal deposits. These landforms, created by shore drift, are highly dynamic and continue to evolve through the continual deposition and erosion of sediments carried along the shoreline by these natural processes. As these features evolve, new habitats are formed and existing habitats mature and change. For example, two cuspate spits that form where the shore orientation changes at the narrowest part of an inlet or bay, as they often do, can converge to create a coastal wetland in the center. This wetland may persist for some time before the barrier features are naturally breached, forming a shallow marine embayment. Images of beaches, spits, and other habitat features formed by coastal processes can be viewed on the Department of Ecology's Shoreline Aerial Photos web site or Coastal Atlas.

WHY ARE BEACHES IMPORTANT TO THE NEARSHORE ZONE?

Beaches are the primary feature that defines the landward edge of the nearshore zone. They are variable in size, shape, and composition and are continually evolving in response to physical processes. These habitats, as well as their continual process of formation and change, provide important habitat for forage fish, juvenile salmon, shellfish, and aquatic vegetation such as eelgrass and kelp beds. Beach evolution also defines the structure and composition of the marine backshore where marine riparian vegetation grows, which in turn provides a separate unique range of habitat types for both aquatic and terrestrial species. The value of beaches to people for commercial and recreational uses, are also well known.

WHAT DATA ARE AVAILABLE?

The DNR ShoreZone Inventory is a comprehensive source of information about Washington shorelines. It contains information on shoreline and substrate types, drift cell patterns and existing shoreline modifications, as well as other information. The Department of Ecology's Coastal Atlas also provides a delineation of drift cells and information on the direction of net shore drift as well as many other physical, biological, regulatory and landscape features.

Data or research reports on beach formation, including effects of shoreline modifications on beaches is provided as references in Section II of this guidance.

BLUFFS

A bluff is a steep-sloped landform that is similar to a cliff, except that there is soil and vegetation covering most of the underlying rock, whereas a cliff is mostly exposed. The movement of glaciers and the stabilization of sea levels following the end of the last ice age formed bluffs along much of Puget Sound's shorelines. The composition and shape of bluffs depends on how the glacial material was deposited in combination with the affects of ice melt and the resultant sea level rise and geologic uplift. Because conditions and events affected areas on a local scale, bluffs have differing topographies and can be composed of diverse rock or sediment types and sizes.

The bluffs in the Puget Sound region are highly variable in terms of size, shape, and composition (see Figure II.5 below). Physical conditions such as geology, hydrology, orientation and exposure, erosion rates, and vegetation all play a role in determining a bluffs character. Depending on their composition they can be more or less resistant to erosion. Glacial till, for example, can be highly resistant to erosion, whereas bluffs comprised primarily of silt and clay are typically more susceptible to erosion. Glacial till is one of the most common bluff types in Puget Sound. While its resistance to erosion may seem a positive attribute, it can limit a bluff's capacity to replenish down-drift beaches.

Figure II.5. Four examples of common bluff formations found throughout the Puget lowlands (from Shipman 2004).

HOW ARE BLUFFS FORMED AND MAINTAINED?

Puget Sound bluffs are formed by a combination of processes. Wave action at the base of the bluff is an ongoing active process, overlaid upon a natural process of the bluffs receding or "laying back" to achieve a natural equilibrium slope. This process is very slow acting but it plays a dominant role in the evolution of bluffs along our shorelines. See Figure 5 in: "Beaches and Bluffs of Puget Sound and the Northern Straits: Valued Ecosystem Component of Washington State" at http://www.pugetsoundnearshore.org/technical_reports.htm.

The effects of wave action are a more immediate and more visible component of this longer acting process. As wave action works at the base of the bluff it erodes, the face is undercut and material slides down to form colluvium; sediment, sand, rock, and slabs. The colluvial material collects at the base and protects the bluff from further erosion but over decades is gradually eroded and carried away. This leaves the base of the bluff exposed to wave action once more until the cycle repeats.

The combination of these processes causes the bluff to slowly recede over time and to develop a shallower slope. The rate of recession is dependant on a number of factors including; geology of the bluff, beach structure, and wave energy. Development impacts can further affect the rate of recession. Stormwater runoff and vegetation clearing or alteration (e.g., to create views) can have profound effects on bluff recession rates and stability.

WHY ARE BLUFFS IMPORTANT TO THE NEARSHORE ZONE?

These geological features are found along more than 60% of Puget Sound's shoreline and are the primary source of recruitment for the sand, gravel, and larger substrate that make up the region's beaches. Consequently, they have a significant influence on the region's nearshore environment. Bluff erosion plays an important role in shaping nearshore habitat (see Figure II.6 below).

Figure II.6 Example of natural erosion on left, and steep bluff vegetation on right (from Brennan 2007).

Variation in bluff topography, material composition, and orientation in relation to weather and waves can produce a diverse range of nearshore habitat types. The combination of these factors will determine the exposure to wave energy, the rate of erosion, the composition, volume, distance and direction these materials are transported by shore drift, and the type of riparian vegetation on the bluff face. The complex interactions between factors combine to provide the diversity of habitat types that characterize marine shorelines.

Many species that use the Puget Sound nearshore zone are dependent on a particular range of beach substrates. The size and composition of substrate are important factors determining the value of nearshore habitats for juvenile salmon rearing and forage fish spawning. These factors also determine the habitat suitability for the formation of kelp forests and eelgrass beds. These aquatic marine plants form dense canopies below the water surface that provide highly productive refuges for a broad range of species. Again, because bluffs are the primary source of material for replenishing beaches, they indirectly ensure that a variety of habitats continue to exist for species with diverse requirements. Bluffs are therefore vital to the overall health of these populations and, indirectly, to the health of Puget Sound.

WHAT DATA ARE AVAILABLE?

As with beach data, the DNR ShoreZone Inventory is the most comprehensive source of information on shoreline types. The Department of Ecology's Coastal Atlas also contains data on slope stability along Puget Sound shorelines.

Data or research reports on bluffs, including effects of shoreline modifications on bluffs is provided as references in Section III of this guidance.

HOW DO COMMON SHORELINE ACTIVITIES IMPACT THESE FEATURES?

Direct and indirect impacts to beaches and bluffs can occur through any activities that alter erosion or wave energy or change the supply of sediments and other material along the shoreline. Shoreline modifications have been, and continue to be, widespread in Puget Sound. Approximately 34% of the shoreline in the Puget Sound region has been modified by structures such as bulkheads, riprap, dikes and other shoreline armoring.

Shoreline armoring or other energy attenuation devices (e.g., seawalls) are the most significant activity that impacts bluff erosion or more accurately, deters colluvium from being transported. Clearly, since there is a direct relationship between these bluffs and beaches, these activities also affect the size, shape, and substrate character of the down-drift beach (e.g., surf smelt spawning areas that may be present).

Shoreline armoring is also detrimental to the beach area immediately adjacent to the structure. For example, when bulkheads are constructed it causes greater wave energy at the bulkhead face (see Figure II.7 below). The excess turbulence causes downcutting (lowering) of the beach. Ultimately, the beach can cut below the base of the bulkhead causing failure of the bulkhead. Pilings, that support overwater structures, can also impact beach substrate because they attentuate waves energy, causing fine grains to fall out of the water column. In addition, barnacles and other organisms that colonize the pilings result in formation of a different beach substrate than normal, changing the character of the habitat. Groins and jetties also interrupt shore drift, causing sediment starvation that can alter habitat structure, and in turn the species composition.

Figure II.7. Photos contrasting high-tide wind waves (top) versus low-tide wind waves (bottom), from Finlayson 2006.

Riparian vegetation alteration and general shoreline development can result in increased erosion and an increase in the potential for landslides, particularly on steep bluffs. In addition to potentially damaging property and infrastructure, landslides can result in an oversupply of substrate to the beach, which can also alter habitat structure and species composition.

Activities that alter the composition and distribution of shoreline substrates or their contributing physical processes can adversely affect the productivity of spawning habitats for beach spawning forage fish (Pacific herring, sand lance, and surf smelt). These species are fundamental components of the marine foodweb supporting a number of highly valued species, including salmon, rockfish, flatfish, seabirds, and marine mammals.

Cumulative impacts from continued modification of the shoreline and resultant alternation of bluff erosion and beach formation are difficult to quantify. However, they are likely to be exacerbated over time because beaches and bluffs are so closely connected (see Figure II.8 below). For example, erosion caused by shoreline armoring at a specific beach can be accelerated when the bluffs supplying sediment to that beach are armored even though those bluffs may be miles away. The continued propagation of these armoring structures along the shoreline of Puget Sound will continue to adversely affect physical processes and shoreline configuration.

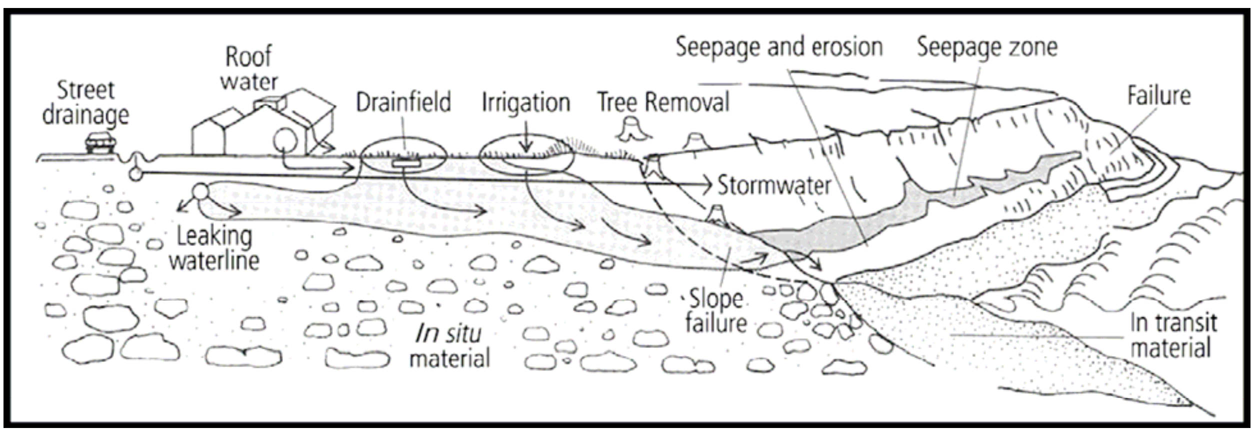


Figure II.8. Illustration of frequent causes of bank stability failure as a result of alterations of hydrology and vegetation (from Marsh 2005).

The cumulative impacts of shoreline modifications are expected to intensify with a rise in sea level associated with climate change. As sea levels rise, extreme storm surges become increasingly higher, exposing more beach and bluff area to erosive wave energy. This will promote a landward migration of beaches, increased coastal flooding, and the gradual loss of salt marshes, wetlands, and low-lying beaches or spits that form the Puget Sound nearshore habitat.

Beaches and bluffs contribute to Puget Sound's dynamic habitat through erosion and shore drift occurring on a landscape scale. As net shore-drift is significantly altered by shoreline modifications, these also affect Puget Sound on a landscape scale. Due to the complexity of the natural process involved, mitigation is unlikely to be a viable solution to reduce impacts. Therefore, avoidance and minimization measures are essential, in addition to the need for restoration actions that remove impacting structures. These impacts and some planning and site design issues are summarized in Table II.2. Section III of this report contains detailed recommendations associated with planning and site design issues.

Table II.2: Common Impacts to Beaches and Bluffs and Key Regulatory and Design Considerations.	
Direct/Indirect Impacts	o Any activity that alters erosion or wave energy and changes the supply or distribution of sediments along the shore can result in impacts such as; ▪ Loss of backshore due to shoreline armoring ▪ Direct loss of beach through downcutting (often caused by shoreline armoring) ▪ Indirect loss of beach through armoring of updrift bluffs, the resultant loss of sediment supply followed by changes in beach substrate character and downcutting o Loss of nearshore vegetation and shading o Simplification of habitat structure due to removal of large wood, overhanging branches, and boulders o Substrate modification due to piling placement (shellhash formation) and grounding of boats and/or structures o Reduced bluff and beach stabilization, and increased erosion due to vegetation removal o Loss or change to beach substrate and conditions that support aquatic and riparian vegetation and spawning habitat for forage fish
Cumulative Impacts	o Landscape scale changes in beach structure and habitat function due to changes in wave energy and geomorphic processes (erosion, transport, and accretion) o Changed/reduced productivity of Puget Sound nearshore zone o Loss of connection between aquatic and upland environment which impacts drainage, wildlife corridors, and loss of unique transitional areas across Puget Sound o Decrease in habitat suitable for eelgrass, kelp and other plants and overall photosynthesis in intertidal and subtidal zones o Landward migration of beaches and loss of some habitats due to sea level rise

Table II.2: Common Impacts to Beaches and Bluffs and Key Regulatory and Design Considerations.	
Regulatory and Design Considerations	o Identify feeder bluffs and protect them (and their functions) through appropriate shoreline designation and SMP regulations o Identify intact beaches and protect them through appropriate shoreline designation and SMP regulations o Avoid and minimize shoreline armoring projects, and require geotechnical assessments, reviewed by a qualified third party, to evaluate problems and analyze potential solutions, including the use of alternative designs o Require proposed bulkhead rebuild projects to evaluate the effectiveness of alternative designs (e.g., soft-shore approaches) as opposed to in-kind replacement o Promote retaining or establishing marine riparian vegetation including large trees by requiring a vegetation conservation plan for activities impacting marine riparian vegetation o If tree removal is unavoidable, leave felled trees or create snags for wildlife habitat o Avoid placement of shoreline armoring or other structures near the beach, especially waterward of OHWM o Minimize displacement of beach area by pilings or other structures. Where such structures are unavoidably necessary, prohibit the use of treated wood in favor of concrete, steel, or recycled plastic o Prohibit grounding of floats, rafts, docks and vessels o Require replacement of all native riparian or aquatic vegetation that is directly or indirectly lost through shoreline activities

FORAGE FISH HABITAT

The following information on forage fish is summarized from a Puget Sound Nearshore Partnership report by Dan Penttila entitled "Valued Ecosystem Component White Paper; Marine Forage Fishes". The full report contains maps and photos of spawning areas and details about spawning timing by location or stock, as well as status and trend information. The full report can be viewed at: http://www.pugetsoundnearshore.org/technical_reports.htm. Forage fish information is also available through WDFW's website.

Impacts on forage fish habitat from common shoreline modification activities (e.g., shoreline armoring, overwater structures, and riparian vegetation alteration) and recommendations for minimizing or mitigating impacts are provided in Section III.

WHAT ARE FORAGE FISH?

Forage fish is a loosely defined term for small, schooling fish that provide a critical food web link in marine environments; they prey upon zooplankton and are in turn preyed upon by larger predatory fish, birds and marine mammals. In addition to being considered a key component of the food base for economically and socially important species such as salmon, some forage fish species in Puget Sound have commercial and recreational importance.

Key forage fish species in Puget Sound include; Pacific herring (*Culpea pallasi*), surf smelt (*Hypomesus pretiosus*), Pacific sand lance (*Ammodytes hexapterus*), northern anchovy (*Engraulis mordax*), and longfin smelt (*Spirinchus thaleichthys*). Pacific herring, surf smelt, and Pacific sand lance are the most common in Puget Sound. For photos and additional information on forage fish see: http://www.wdfw.wa.gov/fish/forage/forage.htm.

WHY IS THE NEARSHORE ZONE CRITICAL TO FORAGE FISH?

Three of these forage fish species, Pacific herring, surf smelt, and Pacific sand lance, spawn in the nearshore (see Figure II.9). Their spawning habitat occupies many of the intertidal and shallow subtidal areas within the Puget Sound basin –

areas most at risk from shoreline modification activities. Further, because these species congregate in large numbers at high densities during spawning they are particularly vulnerable to marine shoreline activities during this critical life history stage. While Northern anchovy and longfin smelt do not spawn in the nearshore, juveniles of these species use nearshore areas for rearing and are thus potentially vulnerable to disturbance of nearshore habitat. See http://www.ecy.wa.gov/programs/sea/pugetsound/species/smelt.html for a description and locations of forage fish spawning habitat.

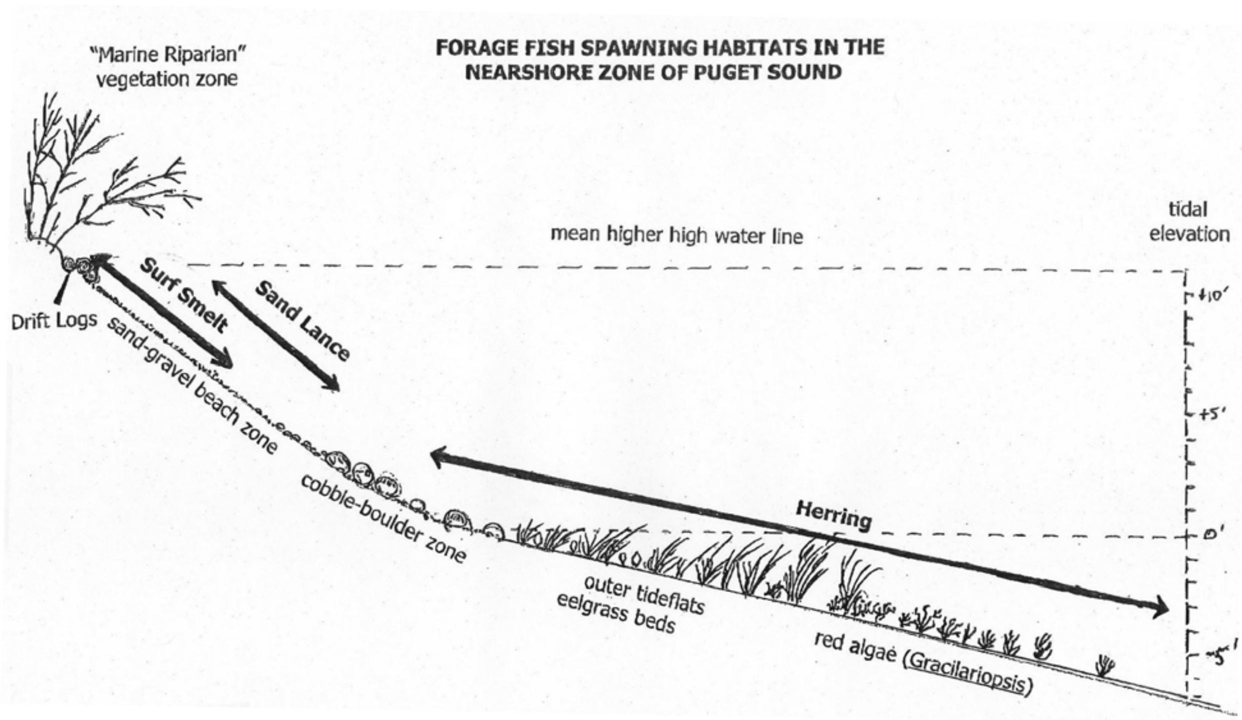


Figure II.9. Forage fish spawning habitats in the nearshore zone of Puget Sound (Penttila, 2005).

Because all forage fish species rely on nearshore habitats during at least some part of their life history, the protection of these habitats is critically important to their long-term sustainability. In addition, because forage fish are a critical prey resource for a number of species, including ESA listed salmon and marine mammals, the protection of forage fish habitat is important to the conservation of these ESA-listed species as well.

Pacific herring, surf smelt, sand lance, and longfin smelt spawning habitats and congregation areas are listed as "marine habitats of special concern". As such, they are considered to be "priority habitats" under WDFW's Priority Habitats and

Species (PHS) program. Washington's Hydraulic Code (Chapter 220-110-250-WAC) that governs hydraulic project review and permitting by WDFW provides "no-net-loss" protection for spawning sites documented through on-site surveys. However, the Puget Sound Management Plan has a goal of "net gain in ecosystem function" to address past degradation of habitat. To meet this goal, beaches with spawning potential should also be identified and protected through local planning efforts. For the purpose of developing local regulations, WDFW forage fish databases and Priority Habitat Species (PHS) maps are considered "best available science". The PHS maps are periodically updated and project proponents are expected to confirm that the information they are relying on is the most recent.

PACIFIC HERRING

The Pacific herring is a widespread, open-water (pelagic) species found throughout marine waters of Washington State. Approximately twenty herring stocks occupy the Puget Sound basin. Each stock is defined by a geographically distinct spawning area and season.

WHEN DO THEY USE THE NEARSHORE ZONE?

Pacific herring congregate offshore in the general area of their spawning grounds several weeks prior to spawning. Subgroups of herring within this larger congregation will mature at slightly different times, moving from deeper water into the shallow nearshore zone to deposit their spawn. The spawning season of any individual spawning ground may be staggered over 6 to 8 weeks, during which time a number of individual spawning events of varying magnitude may occur. While the Pacific herring spawning season in Puget Sound lasts from late January to early June, most spawning takes place in February and March.

Herring eggs take up to two weeks to hatch. After hatching, the free-floating larvae will remain in close to the spawning areas unless they are transported offshore by wind and current. Typically, juvenile herring inhabit nearshore waters of Puget Sound through their first several months of life, moving into deeper water during September-October. Thus, sensitive life history stages of Pacific herring may be found in nearshore areas from late January through October. Subadult herring will remain in open waters until they are ready to spawn, typically in their second or third year of life.

WHAT CHARACTERISTICS OF THE NEARSHORE ARE IMPORTANT?

In Washington State, herring deposit their eggs almost exclusively on marine vegetation (see Figure II.10), and therefore spawning sites are limited to portions of the nearshore zone where there is adequate light for plant growth. The depth at which spawning can occur is largely controlled by water clarity, which in turn controls the maximum depth at which vegetation will grow. This depth corresponds to the shallow subtidal and lower half of the intertidal zone. In areas with especially clear water, the zone where herring can spawn can extend to depths of -10 meters MLLW in tidal elevation.

Figure II.10. Intertidal algae bed with heavy herring spawn, S. Cherry Point, Whatcom County (Penttila 2007).

In Puget Sound the native eelgrass (*Zostera marina*) is the primary herring spawning substrate. In some areas, a combination of red, green, and brown alga referred to as “marine alga turf” is commonly used by spawning herring. In deeper water in areas where native eelgrass is uncommon, the red alga (Gracilariopsis or Gracilaria) is may be used for spawn deposition. Water depth and substrate composition (e.g., mud, gravel, cobble) are the most important factors that determine the composition of vegetation found in spawning ground. In a few of the known herring spawning areas, more unusual substrates are used, including; boulder/cobble rock surfaces, current-swept gravel beds, pilings, and amassed beds of tubes of polychaete worms.

In addition to physical habitat needs for spawning, the larval and juvenile life stages utilize the nearshore zone. Therefore water quality, as well as other conditions that affect food or predator abundance in the nearshore zone, are important.

WHAT DATA ARE AVAILABLE?

Spawning Pacific herring populations have been monitored with sufficient effort to provide annual estimates of relative abundance. Pacific herring information is available through WDFW's website. The locations and seasons of herring spawning in Puget Sound are relatively well known. However, no comprehensive survey of "likely looking" shorelines has been done and new spawning sites are still being discovered.

SURF SMELT

Surf smelt is a common and widespread forage fish species that spawns in the nearshore. However, this species is poorly studied and little is known about its distribution and movement or the number and distribution of distinct stocks.

WHEN DO THEY USE THE NEARSHORE ZONE?

The spawning season for surf smelt is widely variable; timing of spawning for various stocks includes summer (May – October), fall-winter (September – March) or year-around (January – December often with a seasonal peak). Spawning, which occurs at high tide, may occur at irregular, short intervals at any particular site. Once a spawning season begins, an individual beach is likely to experience a continuous deposit of eggs for several months.

The egg incubation period varies with seasonal temperatures. During summer incubation time is about 2 weeks, while during cold winter months it may be 4 to 8 weeks in length.

Little is known about the life history of surf smelt apart from its use of the intertidal areas for spawning. The species is not generally known to form large open-water schools. Surf smelt may reside near the shoreline in the general area of their spawning sites for their entire lives.

For those areas that experience year round spawning, surf smelt eggs may be found in the most vulnerable portion of the nearshore area (upper intertidal zone) during any month of the year.

WHAT CHARACTERISTICS OF THE NEARSHORE ARE IMPORTANT?

Surf smelt require upper intertidal sand-gravel beaches for spawning. The specific mix of small gravel and coarse sand (commonly called "pea gravel") preferred by surf smelt for spawning is usually found in patches or bands along the upper third of the intertidal zone. The physical area of spawning substrate can vary from a discontinuous array of small patches around the high tide line, to broad bands of material several yards wide and several miles long. Within a typical sediment-transport drift cell, spawning habitat may be limited at the two ends of the drift cell where beach substrate is too coarse (upper end of cell) or too sandy (lower end).

Most known beach spawning sites are used annually with other areas only used only during in periods of high smelt abundance. According to WDFW surveys, the majority of Puget Sound beaches that appear to be suitable for spawning are not documented surf smelt spawning sites. This lack of documentation should be interpreted cautiously, due to limitations of the monitoring and the variable nature of spawn timing.

For summer spawning fish, the presence of over-hanging trees along the upper beach area is important for moderating/preventing wind and sun exposure, which can kill eggs. See Figure 13 in VEC Forage Fish White Paper: http://pugetsoundnearshore.org/technical_reports.htm .

In addition to physical habitat needs for spawning, all life stages utilize the nearshore zone. Therefore water quality and other conditions that may affect food or predator abundance in the nearshore zone are important.

WHAT DATA ARE AVAILABLE?

Spawning site inventories for surf smelt have been fairly extensive. WDFW can provide GIS-based charts of known spawning beaches and site-specific surf smelt spawning habitat. The mapped locations are available to those who receive PHS data.

PACIFIC SAND LANCE

The sand lance are common and widespread forage fish in the nearshore marine waters throughout Puget Sound. However, there is little life history information or population data available for this species.

WHEN DO THEY USE THE NEARSHORE ZONE?

Sand lance deposit their eggs in many small individual spawning events scattered over broad reaches of shoreline. Spawning occurs between November and February in Puget Sound, predominantly during the first half of that period. Sand lance spawn during high tides when the upper beach is covered by shallow water, and the spawn is often deposited at the bottom of scattered, shallow pits excavated in the beach (see Figure II.11). Incubation time is approximately one month. Repeated spawning episodes may occur throughout the spawning season.

Figure II.11. Sand lance spawning beach with fresh spawn pits, S. Port Gamble Bay, Kitsap Co. (Penttila 2007).

Planktonic sand lance larvae are common in nearshore waters of Puget Sound in late winter and juveniles are common there through the first summer of life. Sand lance dwell in the very nearshore area even as adults and spend part of their diurnal and seasonal cycles buried in the bottom substrate; probably as a means of avoiding predators and conserving energy. A broad array of marine bird, mammal and fish species feed on sand lance, especially when they are in dense surface schools commonly called “bait balls” by anglers.

Sand lance eggs and larvae are found in the upper intertidal area of spawning beaches during winter; adults are found burrowed into the substrate in subtidal areas at all times of the year, and generally spend their lives in the nearshore zone.

WHAT CHARACTERISTICS OF THE NEARSHORE ARE IMPORTANT?

The spawning habitat of the Pacific sand lance resembles that of surf smelt; they spawn in the upper third of the intertidal zone, in sand-sized substrate. As a result, these two species often use the same beaches and co-occurrence of eggs is common during winter when spawning seasons overlap. Depositional shoreforms such as beaches at the far ends of drift cells and sandy spits, supports sand lance spawning.

In addition to physical habitat needs for spawning, all life stages utilize the nearshore zone. Therefore water quality and other conditions that affect food or predator abundance in the nearshore zone are important to the long-term health of Pacific sand lance populations.

WHAT DATA ARE AVAILABLE?

WDFW, with the help of other entities (North Olympic Salmon Coalition, Friends of the San Juans, and recently the Nisqually Tribe and South Puget Sound Salmon Enhancement Group),has been documenting sand lance spawning sites since 1989, but new sites continue to be documented. WDFW can provide GIS-based charts of known spawning beaches and site-specific sand lance spawning habitat. The mapped locations are available to those who receive PHS data. Little or no stock assessment or population data are available on this species.

NORTHERN ANCHOVY

Northern anchovies commonly occur in Puget Sound and are considered to be a primarily pelagic (open-water) species.

WHEN DO THEY USE THE NEARSHORE ZONE?

Anchovy spawn away from shore, releasing their floating eggs into open water. The larvae are planktonic i.e., they drift freely with the current. Because waterways in Puget Sound are narrow and swept by currents, juvenile anchovy are often transported to nearshore environments. Young-of-the-year anchovies occur in the nearshore zone of Puget Sound during summer months and are also found at midwater depths throughout the Puget Sound basin. Spawning is known to occur in southern Puget Sound and the Strait of Georgia during summer months and anchovy are most likely to be in the nearshore zone during summer.

WHAT CHARACTERISTICS OF THE NEARSHORE ARE IMPORTANT?

Spawning habitat for this species is not associated with the nearshore zone. However, anchovy do rear in the nearshore zone during summer. Therefore, summer period water quality and other conditions that affect food or predator abundance in the nearshore zone are important to this species.

WHAT DATA ARE AVAILABLE?

Northern anchovy populations have not been thoroughly monitored by WDFW and there are no assessments of abundance or population trends. Midwater trawl surveys targeting Pacific herring have contained incidental catches of anchovy, and those data are available by contacting the Marine Resources Division of the Fish Program at WDFW.

LONGFIN SMELT

Unlike the other forage fish species described here, longfin smelt are ananadromous species that spawn in rivers and rear mostly in marine waters. The only well-documented spawning population of longfin smelt in Puget Sound occurs in the Nooksack River. Another population may occur in the Duwamish River, but has not been documented.

WHEN DO THEY USE THE NEARSHORE ZONE?

Longfin smelt are an anadromous species that deposit their adhesive eggs on river-bottom sediments near the upper ranges of tidal influence. After hatching, planktonic larvae are transported by river currents to estuarine waters. During the winter months, young of the year, maturing adults, and spent females appear to occupy open water habitat. Although little is known about their larval/juvenile rearing requirements, it is likely that marine nearshore areas are important during this life stage. Longfin smelt are most likely to be in the nearshore zone during summer.

What Characteristics of the Nearshore are important?

Longfin smelt may have the most geographically restricted and vulnerable spawning habitat of any marine/anadromous species in Puget Sound due to their specific association with only one or two rivers. As described previously, they spawn in the freshwater nearshore zone rather than marine waters.

Although longfin smelt do not have a marine nearshore spawning habitat requirement, they may rear in the nearshore zone in the vicinity of their spawning streams. Therefore, water quality and other conditions that affect food or predator abundance in the nearshore zone are important.

What data are available?

No stock assessment or spawning habitat survey data exist for longfin smelt in Puget Sound. The species has been part of the incidental catch during midwater trawls in Bellingham Bay. They were also identified as a locally common nearshore fish along the Strait of Juan de Fuca, but no adjacent spawning streams have been identified. They have been only rarely encountered elsewhere in Puget Sound.

How do Common Shoreline Activities Impact this Habitat?

Activities that alter the beach, or the nearshore physical processes that form and maintain beaches, have the potential to impact the spawning habitat for Pacific herring, sand lance, and surf smelt. To adequately protect forage fish habitat requires protecting the beaches where spawning occurs in addition to protecting the physical processes that form and maintain habitat conditions that support spawning.

Direct impacts to the beach substrate would include any activity that disturbs the substrate, from installation of footings for dock construction, to grounding a barge on the beach. Such activities can directly impact spawning adults and/or deposited eggs, or impact the substrate in such a way that reduces its suitability for spawning. These impacts can be minimized through avoiding these activities on spawning beaches, conducting activities to avoid the spawning period, and restoring/replacing impacted substrate.

Indirect impacts to the habitat can occur through activities that change the size and shape of the beach or the composition of beach substrate. These impacts can occur through a myriad of activities. Activities that affect the hydraulic character (energy and/or flow patterns) of the drift cell that feeds the beach will affect the beach form and substrate size. Shoreline armoring or other energy attenuation devices (e.g., jetties or seawalls) are the most significant cause of changes to beach size, shape, and substrate character.

Because Pacific herring rely on marine vegetation for spawning, activity that impacts plant growth in the intertidal and subtidal zone is likely to negatively affect habitat quality or quantity for this species. This may include changes to water quality that decrease water clarity and the depth at which plants can grow, changes in wave energy that make the environment less suitable for plant attachment, and shading from construction activities such as overwater structures.

Since some populations of surf smelt spawn high on the beach during summer, they are considered particularly vulnerable to loss of marine riparian vegetation, which provides shade to this region of the beach. These impacts and some planning and site design issues are summarized in Table II.3. Section III of this report contains detailed recommendations associated with planning and site design issues.

Table II.3: Common Impacts to Forage Fish Habitat and Key Regulatory and Design Considerations.	
Direct/Indirect Impacts	o Alteration of wave energy or other shoreline processes that affect beach substrate or morphology through shoreline modification activities o Decreases in terrestrial food supply, shading, and protection from overhead predators due to clearing of marine riparian vegetation o Loss of marine vegetation from shade impacts of boats and floats, and scouring from buoy anchors causing reductions in spawning, rearing, and refugia habitat available to forage fish. Changes to substrate, increased egg mortality, and fish avoidance from prop wash and grounding of boats during low tides Changes to substrate structure/vegetation due to accumulation of shell fragments adjacent to pilings resulting in decreased habitat available for herring spawning o Uptake of contaminants (leading to decreased survival) by herring eggs deposited on chemically treated wood pilings o Decreased survival, due to desiccation, for herring eggs spawned on pilings at high tide elevations
Cumulative Impacts	o Changes in general pattern of upper intertidal sediment distribution and character o Decrease in marine aquatic plant habitat and overall reduction in productivity of the nearshore zone o Accumulation of shell fragments (long term impact from growth on pilings) and subsequent change to substrate structure and vegetation spawning substrate availability.
Regulatory and Design Considerations	o Designate inventoried spawning areas as natural or conservancy shorelines o Avoid and minimize new over-water structures in areas inventoried as forage fish spawning o Minimize displacement of beach area by pilings o Prohibit grounding of floats and rafts on the beach o Promote overwater structure designs that result in improved light levels (e.g., minimize width, use grating, orient north-south to minimize shading resulting from new and rebuilt structures o Minimize the footprint and number of pilings associated with overwater structures and do not allow use of treated wood o Place structures to perpendicularly span the shoreline spawning habitat zone o Do not allow construction activity during egg deposition and incubation periods o Avoid placing docks or piers in tidal flats because these locations require very long structures

KELP AND EELGRASS BEDS

The information in this brief is summarized from a Puget Sound Nearshore Partnership White Paper by Thomas F. Mumford, Jr titled "Kelp and Eelgrass: A Valued Ecosystem Component". The full report provides detailed information on the biology, distribution, and status of kelp and eelgrass populations in Puget Sound. The full report can be viewed at: http://www.pugetsoundnearshore.org/publications.htm.

Kelp and eelgrass are important marine plants that are dependant on specific environmental conditions found in the nearshore zone. Human activities and shoreline modification can adversely affect kelp and eelgrass through direct removal or degradation and indirectly through alteration of the environmental conditions that support them. Overwater structures, shoreline armoring, riparian vegetation alteration, boating, illegal harvesting, shellfish culturing, and water quality impairments all have the potential to affect the health of kelp and eelgrass beds. These activities can alter light and nutrient levels, alter substrate composition, increase toxics and suspended sediments, or cause physical disturbance of the species. Recommendations for minimizing or mitigating impacts are provided in Section III.

WHAT ARE KELP AND EELGRASS AND WHY ARE THEY IMPORTANT?

Kelp and eelgrass are marine aquatic plants that thrive in the nearshore zone. The term kelp refers to a particular group of multicellular marine algae, also known as brown algae, which attach themselves to the surface of marine substrates using a structure called a "holdfast". Puget Sound is home to 23 species of kelp, making it one of the most diverse kelp floras in the world. Kelps are believed to play as significant a role in the marine environment in terms of their forest-like productivity and contribution to carbon cycling. See http://dnr.metrokc.gov/wlr/waterres/marine/photos/vegetation.htm for photos of kelp and eelgrass.

Eelgrass, *Zostera marina*, and its introduced non-native relative *Z. japonica,* are vascular plants that root in the substrate like land plants. Like kelp, eelgrass is a carbon fixer that is important to nearshore primary production.

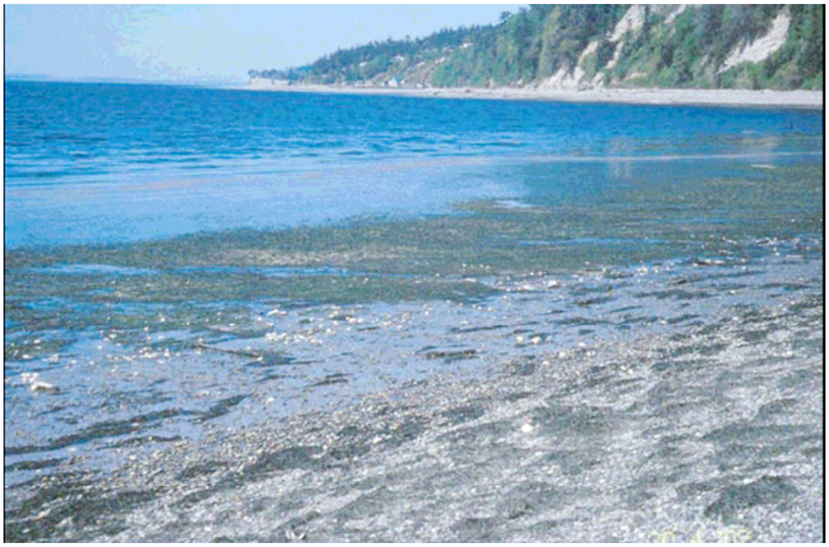


Figure II.12. Low-tide terrace eelgrass bed (*Zostera marina*) Photo by H. Shipman (from Finlayson 2006).

Kelp and eelgrass play a critical role in the marine ecosystem as primary producers, generating nutrients and substrate that form the base of the food chain. The dense and complex structure created by kelp and eelgrass beds also provide refuge and foraging habitat for a wide range of fish, invertebrates and other organisms, many of which are valued from a cultural and economic standpoint. For example, kelp forests and eelgrass meadows are critical to juvenile salmon as they prepare for life in the open ocean. Dense forests and meadows of vegetation provide refuge from current and wave energy, protect juvenile salmon from predation, and support and attract organisms that are important food sources for salmon and other species.

In addition to salmon, kelp and eelgrass in Puget Sound provide important spawning and rearing habitat for a variety of other species. Forage fish, crab, and a variety of other shellfish species are critically reliant on these important habitats. Lastly, kelp and eelgrass have historically supported a range of cultural uses, especially to Puget Sound Indian tribes.

WHY IS THE NEARSHORE ZONE CRITICAL TO KELP AND EELGRASS?

Since kelp and eelgrass are photosynthesizers and dependant on specific sediment types, they require a fairly well defined set of physical conditions; hard, relatively stable substrate in the case of kelp, and sandy substrate in the case of eelgrass (see Figure II.12 above), high ambient light, and clear water free of turbidity that can block light and bury or smother the plants. Since all kelp and eelgrass species begin life on the bottom and require sunlight to grow, they are limited to a relatively narrow band of shallow nearshore area that provides the proper substrate and sufficient light penetration.

As these plants grow they form unique habitats within the nearshore zone that are used by many fish and invertebrate species, including four salmonid species that are currently listed as threatened under the Endangered Species Act (ESA). Due to their role in the health or recovery of these species, eelgrass and kelp are considered key elements of designated critical habitat for the purpose of ESA consultation and recovery planning. Kelp and eelgrass beds are also afforded regulatory protection at the local level through either local Critical Areas Ordinances or through Shoreline Master Programs. With the exception of giant kelp (*Macrocystis integrifolia)*, once important to the commercial herring roe fishery in Puget Sound, commercial harvest of kelp and eelgrass is prohibited. Harvesting of kelp for personal use is currently permitted and is regulated jointly by the Washington Department of Natural Resources (WDNR) and Washington Department of Fish and Wildlife (WDFW).

KELP

Kelps' wide blades form dense canopies that shade the water and substrate. Depending upon the length of the kelp stems (actually known as "stipes") these canopies fall into three groups. There are those with long stipes and blades that float on or near the water surface, such as the familiar bull kelp, those that are raised off the bottom by short, rigid stems, and those that are prostrate and cover the substrate. Of the 23 kelp species found in Puget Sound, the majority (21 species) fall into the second two groups; they are either low growing or prostrate types and are therefore not often visible through boat and aerial surveys. These low growing and prostate types are limited to shallower portions of the nearshore zone than the much longer floating blade types. This is simply due to their inability to extend into the sunlit portion of the water column where light penetration is adequate to support growth and metabolism throughout the year.

Kelps are held to the bottom by holdfasts, which unlike roots do not penetrate the substrate or carry nutrients to the plant. This means the kelp must obtain nutrients directly from the water. This may be one of the reasons that most are found in areas with moderate wave energy or currents, since water movement is needed to keep nutrient rich water circulating past the plant. Because they lack a root system all kelps require a relatively stable solid substrate for attachment. Suitable substrates range from bedrock and boulders, to pebbles, to manmade structures such as sunken vessels, boat bottoms, pilings and docks.

WHERE DO THEY OCCUR IN THE NEARSHORE ZONE?

Floating kelps are found adjacent to approximately 11% of Washington's shoreline. The distribution of non-floating kelps is not as well quantified but they are generally more widely distributed and more abundant (~31%) than the floating varieties. Generally, kelps in Puget Sound prefer water with fairly high salinity (>25psu), low temperature (<15°C), high ambient light, hard substrate, and minimal sedimentation.

Because kelps are dependant on hard substrates and high ambient light levels for growth, areas providing these conditions are likely to support kelp habitat. The lower depth limits of kelp vary by species and by water clarity, but in Puget Sound most occur in the shallow subtidal zone from Mean Lower Low Water (MLLW) to about 20 meters below MLLW. Kelps also prefer high-energy environments in the lower intertidal or subtidal zone where tidal currents renew available nutrients and prevent sediment from covering young plants.

Non-floating species are abundant and cover large areas within the subtidal zone where substrate and water conditions such as temperature, light, and currents provide suitable habitat. These species, which are much less likely to be included in boat or aerial surveys, are those most likely to be impacted by changes to the condition of the nearshore area.

Kelps are vulnerable to a variety of competitor species including the invasive brown algae, *Sargassum muticum*, and are also vulnerable to herbivores like sea urchins and mollusks. An overabundance of urchins can result in barrens where kelp and other fleshy seaweeds have essentially been eradicated. Conversely, depressed abundance of urchins due to the presence of sea otters or human harvesters of sea urchins can greatly mediate their impact on kelp. Due to this vulnerability to grazing, kelps are more likely to become established in areas where sea urchin access is naturally limited, such as cobble beds surrounded by sand.

WHAT DATA ARE AVAILABLE?

Most of the data available on kelps pertains to the floating species as forests of floating kelp species can be easily mapped and monitored using aerial photographs. Data from aerial surveys is included in Ecology's Coastal Atlas, which includes aerial surveys from past years for comparison. The WDNR Puget Sound Assessment and Monitoring Program has been monitoring kelp beds since 1989, using data collected from aerial photographs. Maps produced with the ShoreZone Inventory database illustrate the distribution of floating kelp beds. These data are also available through Department of Ecology's Coastal Atlas. The Coastal Atlas also contains links to county sites that may contain additional data layers of interest.

Because they are not readily visible in aerial photographs under all conditions, the smaller non-floating kelp species are not as easily monitored or mapped. They are expected to be more abundant and have more extensive distribution than floating kelps, meaning that they likely play a larger roll in primary production and carbon cycling in Puget Sound, and support habitat requirements for a broader range of species.

EELGRASS

Eelgrass grows in fine-grained substrates and forms a tangled mat of rhizomes that allow it to spread horizontally to produce new plants. The plant can also reproduce by pollination. Fertile seeds are broadcast into the current and those that are transported to suitable environments form new colonies. Flowering occurs in spring and seeds are broadcast in mid-summer. Germination occurs the following spring. Eelgrass blades are up to 2 meters in length and 2 centimeters wide, with the largest plants occurring in deeper intertidal or subtidal areas. The roots and rhizomes are a large component of the overall mass of the plant. The plant gets the majority of its nutrients through its root system, but adequate light exposure is also required for photosynthesis and growth.

Figure II.13. Underwater view of eelgrass. Photo by S. Simenstad.

WHERE DO THEY OCCUR IN THE NEARSHORE ZONE?

Eelgrass grows in low to moderately high-energy intertidal and shallow subtidal areas with mud/sandy substrate (see Figure II.13). It occurs along roughly 37% of Washington's shoreline. Eelgrass is limited to these substrate types, and is therefore highly sensitive to actions or activities that affect their distribution and availability. Eelgrass persistence is dependent on receiving sufficient light during summer to support growth and nutrient storage necessary for survival during winter when light levels are naturally low. Light attenuation due to propeller-derived bubbles, high turbidity, and sediment loading can limit photosynthesis by reducing the depth of light penetration and/or by settling material on the plant blades, limiting the amount of light available. Conditions that encourage eelgrass growth are often found near the margins of river deltas. These areas are close enough to the river mouths that nutrients are introduced to the tidal zone but they are far enough away that water turbidity is low. Extensive eelgrass beds are also found in large tidal flats. Smaller patches of eelgrass commonly occur in areas where conditions are not ideal, for example, where the substrate may have only small areas of sediment between rocks or where wave energy or other factors restrict growth. These fragmented beds are often located on the fringes of continuous beds and may vary in size and distribution from year to year.

Typically eelgrass beds form near Mean Lower Low Water (MLLW) and extend to depths from about 2 meters above MLLW to almost 9 meters below MLLW. The depth to which eelgrass grows is determined primarily by water clarity. However, factors such as extreme low or high nutrient levels, substrate composition, presence of other species, and toxic pollutants in the water can affect eelgrass abundance and distribution.

Eelgrass is found in all but the southernmost part of Puget Sound; it is not found south of Anderson Island and Carr Inlet. The lack of eelgrass presence in this southern part of the Sound is likely due to the timing of tidal events and to higher temperatures and low nutrient levels that can limit growth. Temperature limitations may also affect the upper depth at which eelgrass grows in other parts of the sound.

As a perennial plant, eelgrass beds form and reemerge in the spring, with bed areas varying only slightly (typically less than 10%) from year to year. However, impacts from human activities and shoreline modifications have contributed to loss of eelgrass beds.

Since the plants die back during the fall, for planning purposes it is important that inventory and survey work be done during summer months, including project specific surveys required for permit activities.

WHAT DATA ARE AVAILABLE?

WDNR Puget Sound Assessment and Monitoring Program have collected the most comprehensive data on eelgrass presence. Surveys began in 2000 and the agency continues to monitor eelgrass distribution and abundance on a regional scale. These data are part of WDNRs' ShoreZone Inventory datasets and maps can also be obtained through Department of Ecology's Coastal Atlas. WDFW has collected data on eelgrass presence while conducting herring roe surveys. Known eelgrass areas are mapped in the WDFW PHS data system. Eelgrass surveys are also conducted in the process of obtaining Hydraulic Project Approvals and Shoreline Permits and may be collected through other local programs, although most of this information is unpublished.

How do Common Shoreline Activities Impact this Habitat?

Kelp beds and eelgrass meadows can be adversely affected by a number of shoreline modifications. Direct impacts can occur on a local or site-specific scale through impacts to substrate and light levels. Dredging, filling, and grading, or otherwise altering the substrate can make a site uninhabitable for these plants and the numerous species dependent on them. Boat propellers and anchors can physically damage plants, disturb sediments, and alter the habitat by creating high-energy wakes. Overwater structures such as piers, docks, and floats, and moored boats decrease the amount of light available, and cause physical habitat changes that can result in a substantial reduction in the size and diversity of the plant community. Reduced light levels have been shown to be detrimental to eelgrass even during the winter dormant season.

Shoreline development can cause a multitude of indirect effects that can adversely impact kelp and eelgrass habitat. For example, shoreline armoring can alter wave energy patterns and change the composition of nearshore substrates. Removal of marine riparian vegetation can alter the temperature and nutrient regime of the nearshore environment, and increase the amount of sediments and pollutants entering the intertidal zone. Elevated nutrient levels associated with stormwater runoff and septic systems can cause excessive growth of macroalgae, phytoplankton, or invasive competitors that reduce the amount of light and substrate available. Increased boat use may affect eelgrass meadows through light attenuation caused by propeller-generated bubbles. Oil products, metals, and other pollutants from stormwater runoff and industrial or agricultural land uses can damage kelp and eelgrass or affect their growth and reproduction.

The broad patterns of development and shoreline modification around the Puget Sound basin have caused small, incremental effects that have become cumulatively significant. For example, there are areas that have experienced rapid reductions in the extent of eelgrass beds and where beds are now virtually eliminated. Significant losses have also occurred in major river deltas. Local observations indicate that the physical extent of kelp and eelgrass beds in the Puget Sound region is in decline, as is the amount of suitable habitat for these important marine plant communities. Successful eelgrass restoration has been difficult to achieve in Puget Sound, and costs associated with restoration have been uneconomical. Since they do represent a unique habitat that is critical to many species, their deterioration or loss is expected to affect the marine food web. Impacts to kelp and eelgrass and some planning and site design issues are summarized in Table II.4. Section III of this report contains detailed recommendations associated with regulation and design.

Table II.4: Common Impacts to Kelp and Eelgrass and Key Regulatory and Design Considerations.

Direct/Indirect Impacts	o Reduction or loss of beds due to shading by over-water structures o Loss of substrate appropriate for attachment or growth due to beach loss or substrate change from changes in wave energy and other physical processes o Loss of appropriate habitat or direct vegetation impacts due to pilings (shellhash), dredging, prop wash, buoy anchor chain scour, and grounding of boats or structures o Habitat reduction due to reduced light levels from short and long term increases in turbidity o Loss of vegetation (eelgrass) due to increased shading from ulvoids and epiphytes (due to eutrophication)
Cumulative Impacts	o Puget Sound wide decrease in nearshore photosynthesis and productivity o Puget Sound wide reduction in kelp and eelgrass and domino affect on numerous species that are directly and indirectly dependent upon them o Increased release of carbon dioxide and potential climatic impacts o Loss in nearshore habitat complexity
Regulatory and Site Design Considerations	o Identify all marine vegetation within intertidal and subtidal zones and protect them through appropriate shoreline designation and SMP regulations o Require survey of intertidal and shallow subtidal areas prior to permitting any structures or activities that could impact existing beds o Prohibit placement of overwater structures over marine vegetation o Require structure designs that minimize shading and disturbance of the substrate including from prop wash o Prohibit grounding of floats and rafts o Avoid placement of shoreline armor or other structures that may result in downcutting of the beach, substrate change, or alteration of shoreline physical processes o Require replacement or mitigation for all riparian or aquatic vegetation directly or indirectly lost through shoreline activities

MARINE RIPARIAN VEGETATION

"Marine riparian vegetation" includes both upland forested plant communities occurring on the Puget Sound shoreline that function similarly to freshwater riparian communities, as well as unique vegetation found only in the marine nearshore. Much of the information in this brief is summarized from a Puget Sound Nearshore Partnership Report by James S. Brennan titled "Marine Riparian Vegetation Communities". The full report contains a detailed discussion of how vegetation communities in the Puget Sound area evolve over long periods of time, and how they are impacted by human activities. The full report can be viewed at: http://www.pugetsoundnearshore.org/publications.htm.

Riparian vegetation is an important aspect of nearshore habitat in Puget Sound. Riparian areas can be directly impacted by vegetation alteration (removal, topping, trimming), or indirectly impacted by changing the physical conditions required by plants that make up the community. For example, shoreline armoring, or other modification can impact natural erosion and soil composition. Development along the shoreline can change surface water runoff patterns, increasing soil erosion or risk of landslides. By disturbing riparian vegetation directly, or by altering the physical conditions that determine the type of plants that grow in the nearshore zone, shoreline modification can affect numerous culturally, commercially, and ecologically important species. Recommendations for minimizing or mitigating impacts are provided in Section III.

WHAT IS MARINE RIPARIAN VEGETATION?

The marine riparian area of Puget Sound's shoreline consists of many different plant community types. These communities vary in structure and composition, ranging from salt-tolerant vegetation on beaches or tidal flood plains, to forest communities that grow along the shoreline and on adjacent bluffs. Despite this variability, these communities share two common characteristics; they are directly influenced by the marine environment, and they directly or indirectly influence nearshore aquatic habitat. Specifically, tree and understory species are influenced by the specific microclimate produced by the nearshore environment. Riparian vegetation in turn influences the marine nearshore environment in ways similar to its function in freshwater environments- by stabilizing bluffs, filtering surface runoff, and providing shade, organic litter, and large woody debris. Upland marine riparian communities are often continuous with and closely linked to freshwater riparian communities where streams enter the sound and freshwater wetlands border estuarine marshlands. Maintaining the diversity of these communities and continuity between them is critical to species that depend on these areas. The diversity that exists today is in part due to environmental conditions but also reflects natural disturbance and succession processes.

VEGETATION IN THE NEARSHORE ZONE

Prior to European colonization, the Puget Sound lowlands and riparian forest communities were largely dense coniferous forests primarily of Douglas fir with a diverse understory that may include Oregon grape, salal, red huckleberry, trailing blackberry, and sword fern. However, natural and human alterations of the landscape have changed the vegetation in many areas. Natural disturbance of riparian vegetation includes episodic events such as fire, disease, seismic activity, and landslides. Human disturbance is generally more continuous over long periods of time and includes forest harvesting, agriculture, clearing and development. After a disturbance the area is first populated by plant species that are tolerant of the altered conditions. Disturbed areas may support shrubs and deciduous trees such as alder and maple. Conditions gradually change until the area is again capable of supporting climax forest communities that include Douglas fir, western hemlock and western red cedar.

There are other unique forest communities found throughout Puget Sound as well. Dry sunny locations with relatively nutrient-poor soils may support forest communities of madrone and associated plants. Aspen is a common species found on San Juan Island and Sucia Island that is relatively rare elsewhere in Puget Sound.

Forest and prairie communities have developed in the rain shadow of the Olympic Mountains. South facing slopes of islands can be uncommonly dry and exposed to heavy wind and salt spray. The conditions are the basis for unique vegetation communities including open forests comprised of Douglas fir, madrone, shore pine, and juniper; dense forests of Douglas fir, grand fir and western red cedar; or grass prairies with few trees (see Figure II.14 below).

Interspersed among the forested bluffs of Puget Sound are numerous plant communities

Common plant species of marine riparian areas:

- Vine maple
- Red alder
- Bigleaf maple
- Pacific madrone
- Western hemlock
- Western redcedar
- Douglas-fir
- Sword fern
- Salal
- Oregon grape
- Oceanspray
- Indian plum
- Salmonberry
- Huckleberry
- Snowberry
- Nootka rose
- Beach pea
- Shore lupine
- Tufted hairgrass
- Saltweed
- Saltgrass
- Fleshy jaumea
- Seaside arrowgrass
- Seaside plantain
- Pickleweed
- Dune wildrye
- Gumweed

associated with beaches, sand dunes, and salt marshes. These environments support plant communities that are tolerant of specific conditions. For example, marshes are composed of plants that are tolerant of saltwater inundation and soils with high organic matter. Beaches and dunes support salt tolerant plants that can also survive nutrient poor soils and exposure to waves. Unique communities occur on the narrow strip of the backshore or beach berms, on large spits, or in the lower portions of river estuaries. The type of soil, amount of sediment, local climate, and topography, degree of saltwater and salt spray exposure, and other factors determine the type of vegetation that grows in these areas.

Figure II.14. Example of shoreline prairie (from Brennan 2007)

As distance inland from the shore increases, tidal influence gradually decreases making the habitat suitable for plant species less tolerant of salt and tidal disturbance. Areas further from the open shoreline typically have more sediment accumulation and less wave energy. The vegetation communities that develop in flood plains or tidal surge plains closer to river mouths can be considerably different than those communities along open shorelines.

Why is Riparian Vegetation Important to the Nearshore Zone?

A diverse number of communities comprise the vegetated area around Puget Sound's marine waters. These plant communities create a gradient in environmental conditions and form transitional areas connecting aquatic and terrestrial habitat (see Figure II.15). This transitional habitat is important to the Puget Sound ecosystem and many species depend on its unique characteristics.

Riparian vegetation contributes to the foodweb by providing large woody debris and organic matter, important to many species, and creates habitat for insects and marine invertebrates that are important food sources for fish and other aquatic life. Vegetation in tidal plains provides refuge for juvenile salmon and shades shallow water to maintain cooler temperatures that are necessary for the survival of salmon and other species. Large trees, which shade the upper intertidal zone is especially important for maintaining forage fish spawning habitat.

Marine riparian vegetation also protects water quality and reduces surface erosion by slowing run off. Terrestrial and shoreline vegetation acts as a filter for runoff, while submerged vegetation causes sediments to settle out of the water column. By slowing erosion and retaining sediments, riparian vegetation reduces pollutants including nitrogen, phosphorus, hydrocarbons, PCBs, metals, and pesticides. It also prevents excessive turbidity, which can smother eggs and aquatic vegetation.

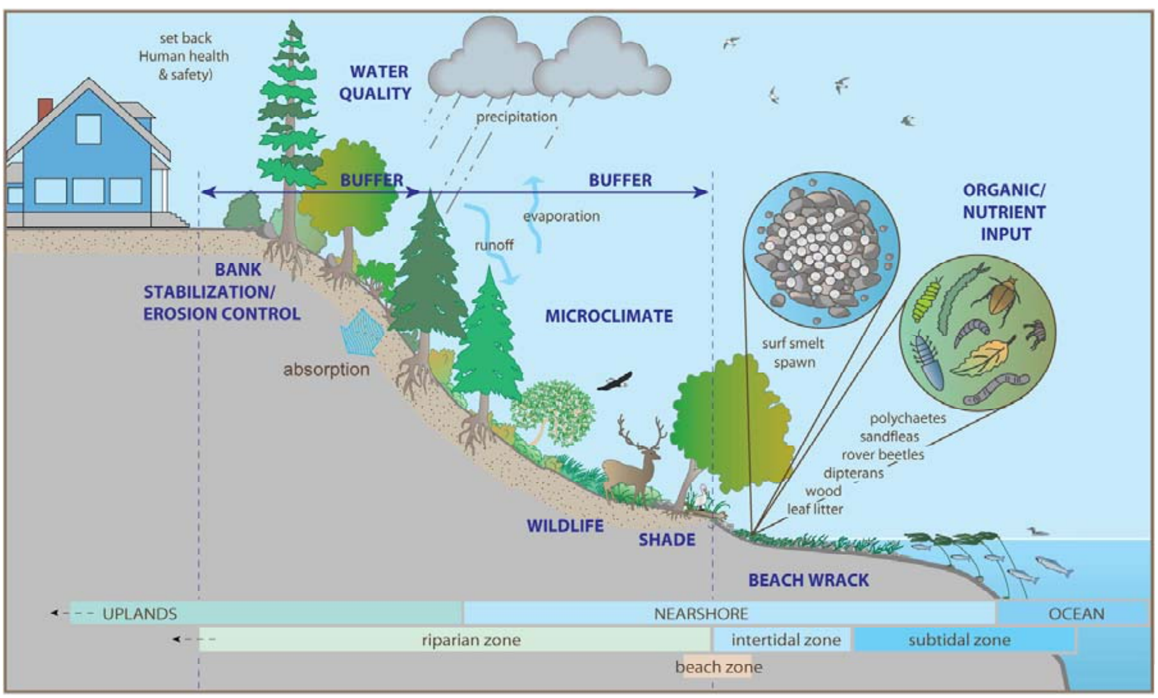


Figure II.15. Conceptual Model of Marine Riparian Functions (from Brennan and Culverwell 2004).

WHAT DATA ARE AVAILABLE?

Digital map data on important plant associations in Washington State have been developed by DNR's Natural Heritage Program (NHP). This information can be useful for understanding distribution, status, environmental characteristics, and succession patterns of vegetation communities. However, the NHP is focused primarily on terrestrial plant species and does not characterize all communities found along Puget Sound shorelines. Wildlife species occurrence data for marine riparian areas is available from Washington Department of Fish and Wildlife's PHS program. The DNR Nearshore Habitat Program maintains the ShoreZone Inventory database, which provides information on the locations of saltmarsh vegetation and common nearshore vegetation such as surfgrass, seagrass, dune grass, kelp and eelgrass. It also provides data for geology, soils and forest disturbance, which can influence vegetation communities and habitat characteristics. Department of Ecology's Coastal Atlas also provides mapped information on vegetation and habitat types found along Puget Sound shorelines.

HOW DO COMMON SHORELINE ACTIVITIES IMPACT THIS HABITAT?

The composition of Puget Sound marine riparian communities is determined by environmental conditions specific to the nearshore area. Because of this, riparian vegetation is particularly susceptible to disturbance by common shoreline modifications.

Probably the most common activity that has directly impacted riparian vegetation along the shoreline is clearing. Historic forest harvesting and clearing of vegetation for agriculture, docks, roads, residential development and other uses has substantially altered the Puget Sound nearshore riparian zone. Many of these activities continue today.

Figure II.16. Unaltered riparian vegetation (left photo by R. Carman), and an example of bluff erosion following riparian vegetation removal (right photo, Brennan 2007).

Clearing vegetation can destabilize slopes (see Figure II.16). This leads to increased erosion, risk of landslides, and elevated levels of suspended sediments and turbidity in the nearshore environment. As a result, clearing vegetation reduces the amount of pollutants that are removed from the water and creates conditions harmful to aquatic species. Shade, organic litter, large woody debris and other benefits provided by riparian vegetation are also reduced.

Clearing is commonly followed by additional development or agricultural use of the land, which reduces and fragments available habitat. Even where cleared areas have been replanted, they were often replaced by single species stands that have little habitat diversity. Cleared areas are also much more vulnerable to colonization by invasive plant species. These plants do not provide the same habitat conditions that native species provide, and further contribute to the degradation of riparian conditions.

Nearshore riparian areas are transitions zones between the aquatic environment and upland forest. These zones are characterized by sharp environmental gradients that tend to support relatively diverse plant and animal communities. Altering shorelines, beaches, and bluffs with armoring, over-water structures, fill, or other types of development typically results in the alteration or removal of vegetation. Shoreline alteration and vegetation removal can alter environmental gradients (e.g., by changing topography, soil composition, salt spray exposure, the amount of saltwater inundation, etc.). As a consequence, highly modified areas lose habitat diversity.

In the Puget Sound region, the cumulative impacts of human disturbance are the result of activity that has occurred over a relatively brief period since European settlement. The net result of these impacts is that tidal wetland and riparian habitat in Puget Sound has been reduced to less than 30% of its historic extent. Urban areas have less than 10% of their estuarine wetlands remaining. A DNR survey of Puget Sound (ShoreZone Inventory) showed that, currently, vegetation overhanging the intertidal zone covers less than 18% of the shoreline. The cumulative effects of shoreline modification and development have led to a reduction in riparian vegetation, habitat fragmentation, and simplification of vegetation communities on a landscape and regional scale. The functional vegetation that remains is threatened by human development. The effective management and conservation of remaining marine riparian vegetation is critical to a healthy Puget Sound. These impacts and some planning and site design issues are summarized in Table II.5. Section III of this report contains detailed recommendations associated with planning and site design issues.

Table II.5: Common Impacts to Marine Riparian Vegetation and Key Regulatory and Design Considerations.	
Direct/Indirect Impacts	o Loss of function due to direct removal or disturbance during clearing and grading activities o Reduction in functional value due to decreases in vegetated riparian area width and plant diversity or density o Reduction or loss of riparian function through pruning overhanging pieces and/or removal of large trees o Increased pollutant load due to change from established native community to non native landscaping requiring use of fertilizers and pesticides o Increased incidence of invasive species due to site disruption o Increased beach substrate temperatures during low tide in summer due to removal of overhanging vegetation o Reduction or loss of localized terrestrial insect input from shoreline vegetation due to vegetation removal
Cumulative Impacts	o Loss of marine riparian area and associated ecological function throughout the Puget Sound basin due to vegetation removal and modification o Fragmentation of remaining habitat and simplification of vegetation communities on a landscape and regional scale have resulted in greatly reduced functional value o Loss of large tracts of shaded nearshore area throughout Puget Sound has reduced organic matter and large woody debris recruitment o Reduced level of pollutant removal due to decreased riparian areas resulting in deteriorating water quality throughout Puget Sound o Increased substrate temperatures at low tide due to loss of overhanging riparian vegetation

Regulatory and Design Considerations	o Require site surveys of existing conditions including vegetation function analysis o Avoid and minimize area disturbed during nearshore construction activities by establishing standards for equipment use within riparian areas, and require replacement of damaged vegetation with native species, including long term maintenance provisions o Identify marine riparian protection areas that support existing functions through no-touch buffers in undeveloped areas and enhancement and mitigation requirements related to expansions or redevelopment of developed areas o Require development of vegetation conservation plans, including replanting and maintenance standards focused on native species, for any project that impacts marine riparian vegetation o Promote off-site mitigation to address cumulative impacts using the restoration component of the shoreline master program

JUVENILE SALMON HABITAT

The information summarized below is from a Puget Sound Nearshore Partnership report by Kurt L. Fresh titled "Juvenile Pacific Salmon and the Nearshore Ecosystem of Puget Sound". The full report provides detailed information on the nearshore habitat requirements of juvenile salmon, and the status, distribution and trends of the populations. The full report can be viewed at: http://www.pugetsoundnearshore.org/publications.htm

Juvenile salmon are dependent upon the nearshore estuarine and marine environments in Puget Sound. The nearshore area provides food, a migration corridor, protection from predators, and a transitional environment that supports the physiological changes that occur as they transition from a freshwater to a marine environment. Shoreline modification activities (e.g., shoreline armoring, placement of over-water structures, and riparian vegetation alteration) can degrade these nearshore habitats, reducing the quantity and quality of habitat available. Habitat impacts from common types of shoreline modification, the related effects on juvenile salmon from common types of shoreline modification, and recommendations for avoiding, minimizing, or mitigating these impacts are provided in Section III.

WHAT ARE JUVENILE SALMON?

Juvenile salmon in Puget Sound are young salmon that have migrated from their natal streams to the marine environment. Salmon migrating from fresh to salt water undergo a process called "smoltification," a physiological transformation that allows them to survive in the marine environment. This life history stage is particularly sensitive because these physiological changes are demanding, young salmon are small and vulnerable to predation, and their food requirements are large. These combined factors make juvenile salmon sensitive to even small changes in habitat condition.

There are eight species of salmonids that use Puget Sound during their juvenile life history stage: chinook (*Oncorhynchus tshawytscha*), coho (*O. kisutch*), chum (*O. keta*), pink (*O. gorbuscha*), sockeye (*O. nerka*), sea-run cutthroat trout (*O. clarkii*), steelhead trout (*O. mykiss*), and bull trout (*Salvelinus confluentus*).

Four salmonid species are currently listed as threatened under the Endangered

Species Act in Puget Sound: Chinook, Hood Canal summer-run chum, steelhead, and coastal-Puget Sound bull trout. Puget Sound steelhead was recently listed as threatened, while Puget Sound-Strait of Georgia coho, is listed as a Species of Concern.

WHY IS THE NEARSHORE ZONE CRITICAL TO JUVENILE SALMON?

The range of unique habitat characteristics provided by the nearshore environment is critical to juvenile salmon development as they prepare for and undertake their migration to the open ocean. Nearshore habitat provides food, refuge from predation, a shallow water migration corridor, and the distinctive environmental conditions that support the physiological changes necessary to move from freshwater to saltwater as juveniles, and back to freshwater as mature adults. It is essential to the success and long term viability of the species that nearshore habitat in Puget Sound continues to provide the conditions necessary to support these needs.

The agencies responsible for recovery of ESA-listed populations recognize the critical role nearshore habitat will play in the recovery of listed populations. Critical Habitat designations for listed chinook, chum, steelhead, and bull trout stocks include the Puget Sound nearshore environment. Critical habitat designation incurs special management considerations and protections intended to ensure that the habitat will function as necessary to provide for the survival and recovery of listed populations in areas with a Federal nexus. However, these protections are limited in scope and many areas of the Puget Sound shoreline do not receive adequate protection under Section 7 of ESA (e.g., proposed new bulkheads most often do not undergo Section 7 review).

WHEN DO THEY USE THE NEARSHORE ZONE

The life histories of northwest salmon are widely diverse and complex. Spawn timing, migration timing, and utilization of different habitats vary greatly between species such as between Chinook and coho, as well as between stocks or subpopulations of the same species. For example, Chinook salmon originating from different rivers or from different segments of the same river may have very different life cycles in terms of when they spawn, when they migrate downstream, etc. The wide variations between species and populations equates to wide variations in habitat use within a population.

While the physical or behavioral traits of Puget Sound salmon populations can be generally summarized, variations within these populations make it difficult to predict how and when these fish use the nearshore zone. Factors such as spawning timing, variability in stream flows and temperatures, the distance upstream to where the fish were hatched, and the time spent rearing in their natal streams determine the timing, size and age at which juvenile salmon arrive in the nearshore environment. Age and size, food abundance, weather conditions, and other factors determine how long they remain in the nearshore zone and the type of habitat they require. Ultimately these variations affect the overall success and abundance of a population on a seasonal or annual scale.

There is a high level of stock mixing that occurs in Puget Sound as juvenile salmon migrate through their natal estuaries and deltas to nearshore habitats. All of these fish are essentially heading toward the same place and along the same Puget Sound shoreline. They forage and grow as they move along the nearshore environment toward the open ocean. As they do so, their survival depends on connectivity among diverse habitats. This mixing and reliance on similar habitat ensures that juvenile salmon representing a number of species and stocks will be present in the Puget Sound nearshore throughout the year.

Salmonid use of the Puget Sound nearshore is not restricted to juvenile fish. Bull trout and sea-run cutthroat use nearshore marine habitats as both juveniles and foraging adults, and all species of salmonids forage along these nearshore environments as adults returning to freshwater systems to spawn.

WHAT CHARACTERISTICS OF THE NEARSHORE ARE MOST IMPORTANT?

The variations that occur between species and populations of salmon are complex and are not completely understood in relation to nearshore habitat characteristics. However, some fundamental characteristics have been identified.

Juvenile salmon typically utilize shallow water habitat with low wave energy and fine-grained silt or mud substrate. These characteristics are associated with marsh and wetland areas and pocket estuaries (connected lagoons and stream mouths). These areas can provide food and protection for juvenile salmon.

Food in the form of prey species is often abundant in vegetated shallow water areas such as eelgrass or macroalgae beds. The vegetation also provides cover and protection from predation.

As salmon feed and grow they are likely to utilize different habitats with different characteristics (deeper water, higher salinity, different food sources). Connectivity between these habitats is critical to foraging success, refuge from predation and successful physiological adaptation to the marine environment as fish grow and migrate towards the ocean. Connected habitats provide gradual transitions between estuarine and marine waters, along shallow water environments adjacent to the shoreline, and between shallow and deeper water environments. Habitat fragmentation caused by shoreline modification limits the amount of suitable habitat available and creates unproductive zones where prey and cover are limited and exposure to predation, strong waves and currents, and other factors detrimental to survival is more likely.

Due to these diverse habitat requirements and the need for connectivity, it is essential to recognize that habitat protection cannot be considered solely at the project or site-specific scale. Effective habitat protection must be implemented at a landscape-scale that considers the broad range of habitat requirements necessary for survival and productivity, and recognizes the need for connectivity between the habitats that meet these requirements.

WHAT DATA ARE AVAILABLE?

Information has been collected on various Puget Sound salmon stocks over the past 40 years. Field surveys conducted by WDFW, tribes, and other agencies provide data on stock presence in Puget Sound streams. Priority Fish presence is included in WDFW Priority Habitats and Species maps. SalmonScape, a web-based mapping application, is a useful tool for identifying stock presence in specific streams. WDFW biologists can often provide more detailed information on a site-specific scale and should be contacted to confirm that the information is complete and accurate to the most recent surveys and available data.

Although there are still some gaps in the data available much has been learned through field research where migration and survival is monitored through the use of smolt traps and various tagging methods. Since 1992, WDFW has compiled data into the Salmonid Stock Inventory (SaSI). This inventory provides a method for identifying and monitoring the status of salmonid stocks.

HOW DO COMMON SHORELINE ACTIVITIES IMPACT THIS HABITAT?

The habitat functions provided by the nearshore environment are defined by the specific physical, chemical, and biological conditions present. These conditions are not easily replicated, meaning that alterations cannot be readily mitigated. This makes the Puget Sound nearshore unique in the landscape and particularly susceptible to impacts by development and human activity.

Any activity that alters the wave energy along the shoreline or causes other physical changes will change habitat conditions for juvenile salmon. The most common causes for wave energy change are through shoreline armoring (e.g. bulkheads and riprap) and other energy attenuation devices (e.g., jetties or seawalls). However removal of marine or shoreline vegetation will also affect how wave energy is dissipated before it reaches the upper shore. These localized changes in wave energy alter the supply and movement of sediment and therefore can also impact downdrift shorelines that may be far removed from the site of a planned activity.

Another important area of impact is from overwater structures that create a "light barrier" to salmon. Juvenile salmon have been shown to avoid moving under a structure if there is insufficient light. Instead, they react by migrating into deeper water and around the offshore edge of the structure. This migration pathway is in a water depth zone where predators are more likely, travel distances are greater and currents are stronger. While one dock is not a significant obstacle, the cumulative effect of numerous structures along the Puget Sound shoreline can be significant in terms of the total distance a fish must travel and the additional time and energy it requires.

Other common impacts associated with human activities include alterations in erosion and sediment transport, and loss of riparian vegetation as well as increases in pollutants. These alterations may directly impact juvenile salmon or indirectly impact them by impacting their habitat or prey. These impacts and some planning and site design issues are summarized in Table II.6. Section III of this report contains detailed recommendations associated with regulation and design issues.

Table II.6: Common Impacts to Juvenile Salmonids and Key Regulatory and Design Considerations.

Direct/Indirect Impacts	o Decreases in terrestrial food source due to loss of nearshore vegetation o Changes in prey diversity and abundance due to alterations in beach substrate and structure o Disruption of nearshore migration and feeding areas due to noise and turbidity associated with construction activity o Substrate change and fish use impacts (avoidance) during low tides from prop wash and grounding o Increased wave energy due to armoring modifies habitat form and function o Loss of nearshore habitat structure and function due to removal or large wood, boulders, and vegetation o Substrate modification due to accumulation of shell fragments adjacent to pilings o Altered migration behavior and potentially increased predation due to shading from overwater structures o Increased water temperatures and bird predation due to loss of overhanging riparian vegetation o Increased injury risk (lesions, tumors) and reduced prey and habitat due to water quality degradation from increased stormwater runoff and wastewater discharges o Reduced prey and habitat due to loss of marine vegetation
Cumulative Impacts	o Puget Sound wide increase in pollutant loading from stormwater and wastewater o Increased travel distance and time, extended time in deeper water, and increased energy expenditures for juvenile salmon migrating around overwater structures and other obstacles (groins, breakwaters, moored vessels) o Fragmentation and loss of connectivity between habitats reducing migration efficiency o Alternation in prey base decreasing foraging efficiency o Changes in wave energy, geomorphic processes, and nearshore habitat structure and function

Table II.6: Common Impacts to Juvenile Salmonids and Key Regulatory and Design Considerations.	
Regulatory and Design Considerations	o Provide protected shallow water migration corridors, especially between estuaries and marine waters through shoreline designations o Minimize and limit over-water structures and improve light conditions under these structures through design specifications (width, grating, etc.) Minimize pilings, avoid use of treated wood, and eliminate grounding of boats and structures o Protect marine riparian areas and require mitigation for lost habitat elements such as trees, logs, and boulders o Protect all native marine vegetation, including kelp, eelgrass, and wetland plants o Avoid and minimize shoreline armoring projects o Require analysis of alternative approaches to shoreline protection when armoring projects are proposed

SECTION III RECOMMENDATIONS FOR REGULATING COMMON SHORELINE MODIFICATION ACTIVITIES

This guidance addresses three general categories of shoreline modification: overwater structures; shoreline armoring; and riparian vegetation alteration. While there are other types of potential shoreline modification, these three categories represent the most common types of activities and account for the vast majority of adverse environmental impacts.

The guidance provided in this Section is supported by the best available science (BAS) and current information for managing the shoreline modification activities. This Section is not intended to provide detailed information on the environmental impacts of shoreline modification activities. Instead, it provides planners responsible for regulating these activities with the tools and guidance necessary to avoid and minimize adverse impacts where possible, and to mitigate these impacts where necessary. Links to additional information on specific topics and citations for supporting scientific studies are provided for those desiring additional background.

Finally, projected changes in local sea levels are an important consideration for long term planning. Sea levels in Puget Sound are expected to change over the coming century as a result of global climate change. While this document does not provide explicit guidance on how to incorporate sea level rise into planning and permit review, planners and regulators should familiarize themselves with projected trends in their area and incorporate a long-term perspective into marine shoreline management decisions. For example, a proposed bulkhead above the current ordinary high water (OHW) may cause an increasing level of adverse effects if sea level rise brings the structure within OHW. Planners should take this into consideration now to avoid adverse impacts in the future.

USING THE SMP TO ENHANCE HABITAT PROTECTION

The required updates to local SMPs provide a unique opportunity to plan for, anticipate, and manage, future shoreline development in a manner that avoids impacts from necessary shoreline modification activities. The development of an SMP requires obtaining and developing information necessary to protect important shoreline physical processes and the habitats that depend on them. SMP updates will include conducting or updating inventories of important habitat features and shoreline characteristics, such as:

◊ Known forage fish spawning habitat
◊ Beach area providing substrate and wave energy characteristics suitable for potential support of forage fish spawning habitat
◊ Aquatic vegetation communities
◊ Steep and/or eroding bluffs that recruit substrate and riparian vegetation to the beach
◊ Identified drift cells and their configuration
◊ Habitat types (e.g., protected embayment's, spits, etc.) that likely provide critical nearshore habitat for juvenile salmon
◊ Riparian vegetation communities that provide shade, large woody debris, and organic material recruitment to the nearshore environment

Where possible, the preferred management approach is to designate critical habitat features such as forage fish spawning habitat, aquatic vegetation communities, nearshore salmon habitat, and marine riparian communities under a Natural or other type of conservancy shoreline environment designation. Protected status designation provides some additional leverage to deny permits for projects that are unnecessary or to compel proponents to consider design alternatives that are less damaging to the environment.

Where protective shoreline designations cannot be applied or in cases where a project is deemed necessary to protect property or critical infrastructure, it may be necessary to permit activities that will cause unavoidable degradation. In such cases, planners and regulators should search for opportunities to minimize and mitigate both the site-specific and cumulative impacts that result.

Jurisdictions should consider maintaining a database of mitigation opportunities from their shoreline restoration plan so that searching is easier, and highest priority mitigation opportunities are considered first.

In many areas the detailed information necessary to determine potential effects on shoreline processes and habitat types may not be readily available. In such cases, it is incumbent on planners and regulators to require project proponents to conduct the surveys and studies necessary to support the permitting process. The guidance and recommendations provided in the following sections are consistent with this perspective.

This Section provides guidance for evaluating and permitting three types of shoreline modification activities: overwater structures, such as docks, piers, floats and mooring buoys; shoreline armoring, such as bulkheads, jetties, and seawalls; and riparian vegetation alterations, including the removal, alteration, or selective pruning of shoreline vegetation.

The following information and guidance are provided for each activity:

- ◊ A general description of the type of ecological impacts associated with the activity and links to, or citations for, additional sources of information
- ◊ A table describing direct, indirect, and cumulative impacts and their effects on the following key ecosystem components:
    - o Forage fish habitat
    - o Beaches and bluffs
    - o Kelp and eelgrass beds
    - o Marine riparian vegetation
    - o Nearshore habitat for juvenile salmon
- ◊ A "decision tree" flow chart to guide the permit review process
- ◊ A table providing design guidance and methods for avoiding and/or minimizing adverse impacts
- ◊ A table describing strategies for mitigating unavoidable impacts. (Due to the similarity in mitigation needs, one table is provided that addresses all three activities.)

This guidance is based to the greatest extent possible on the BAS for ecological impacts, design methods, and impact avoidance and mitigation strategies. For ease of use and reference, this document does not provide a detailed description of the BAS on each of these topics. Rather, it incorporates supporting BAS by reference and links to supporting documents.

OVERWATER STRUCTURES

HOW DO OVERWATER STRUCTURES IMPACT THE SHORELINE?

Piers, docks, mooring floats and other types of overwater structures have the potential to alter the physical characteristics of nearshore environments both at the site and beyond the footprint of the structure. By altering the physical processes that operate in the nearshore environment, such as light penetration, wave energy, and sediment transport, overwater structures can promote changes in habitats. Once habitats are altered, the species using those habitats and the way those habitats are used may also change, affecting the biological community in a number of ways. For example, the shaded, deep-water environment under piers can create a favorable habitat for predatory fish. Juvenile salmonids tend to migrate around structures that shade the water column and into deeper water where they can be exposed to predation as they migrate near the edges of the piers. Overwater structures can also impair habitat function. For example, by shading the nearshore environment and altering wave energy and sediment transport characteristics, overwater structures can degrade eelgrass habitat, which is an important refuge for a variety of important marine species. Table III.1 provides a summary of the impacts of overwater structures on a few key species or habitat types. Additional discussion on these key species or habitat types and how they can be impacted by shoreline modification activities was provided in the previous section of this document.

Table III.1. Impacts from over-water structures (piers, docks and floats) and natural functions that may be affected.

Impact	Supporting Technical Studies	Forage fish habitat	Beaches and bluffs	Kelp and eelgrass beds	Marine riparian vegetation	Juvenile salmon nearshore habitat
Direct & Indirect Impacts						
Short-term (site-preparation and construction activities)						
Increased turbidity and possibly release of pollutants ◊ Reduced light and photosynthesis ◊ Fine sediment deposition/substrate change ◊ Increased contaminant levels in the water ◊ Avoidance by fish and other aquatic life	(Norris et al. 1997), (Thom et al. 2001), (Nightingale and Simenstad 2001)	X		X		X
Noise (especially from pile driving) ◊ Avoidance by fish and other aquatic life ◊ Fish mortality due to bladder eruption	(WSDOT 2006), (Hastings and Popper 2005), (Popper 2006)	X				X
Beach and nearshore disturbance from heavy equipment use, materials placement, etc. ◊ Avoidance by fish and other aquatic life ◊ Loss of fish eggs and other substrate dependent life ◊ Aquatic vegetation loss ◊ Riparian vegetation loss	(Kelty and Bliven 2003)	X	X	X	X	X

Table III.1. Impacts from over-water structures (piers, docks and floats) and natural functions that may be affected.

Impact	Supporting Technical Studies	Forage fish habitat	Beaches and bluffs	Kelp and eelgrass beds	Marine riparian vegetation	Juvenile salmon nearshore habitat
Alteration of substrate characteristics ◊ Removal of existing habitat features such as large woody debris from the intertidal zone ◊ Loss of habitat features in the structural footprint ◊ Accumulation of shell hash underneath the structure, alteration of substrate characteristics	(Kelty and Bliven 2003), (Nightingale and Simenstad 2001), (Haas et al. 2002)	X	X	X		X
Shading from dock and adjacent area where boats and rafts may be tied ◊ Forced migration of juvenile salmon away from the intertidal zone and into deeper waters ◊ Loss of plants and the habitat they create ◊ Reduction in substrate cohesion ◊ Reduction in shoreline energy dissipation through plant loss	(Nightingale and Simenstad 2001), (Fresh et al. 2006), (Fresh 2006), (Williams et al. 2003)	X	X	X		X
Pilings impact on substrate and aquatic life ◊ Establishment of herring eggs on pilings and desiccation of eggs at low tides ◊ Uptake of contaminants and mortality for herring eggs deposited on treated wood pilings ◊ Development of "shellhash" and resultant substrate change ◊ Release of contaminants associated with wood piles or associated with piling maintenance	(Poston 2001), (Nightingale and Simenstad 2001), (Ecologic 2003)	X		X		X

Table III.1. Impacts from over-water structures (piers, docks and floats) and natural functions that may be affected.

Impact	Supporting Technical Studies	Forage fish habitat	Beaches and bluffs	Kelp and eelgrass beds	Marine riparian vegetation	Juvenile salmon nearshore habitat
Boat Operations Impacts ◊ Prop wash impacts to substrate and substrate dependent life ◊ Petrochemical discharge and other maintenance related contaminants (e.g. zinc) ◊ Noise and lighting ◊ Possible continual impact to habitat during low and lowering tides from grounding, anchor chain scour, etc.	(Kelty and Bliven 2003), (Ecologic 2003), (Nightingale and Simenstad 2001)	X		X		X
Cumulative Impacts						
Increase in pollutants and habitat disturbance associated with boat operations and dock and piling maintenance	(Poston 2001), (Kelty and Bliven 2003), (Ecologic 2003), (Nightingale and Simenstad 2001), (Williams et al. 2003)	X		X		X
Increased travel distance and time for juvenile salmon and extended time in deeper water, increasing predation risk	(Redman et al. 2005), (Williams et al. 2003)					X
Decrease in eelgrass and plant habitat and overall photosynthesis in intertidal zone	(Nightingale and Simenstad 2001), (Kelty and Bliven 2003), (Haas et al. 2002), (Norris et al. 1997)	X		X		X
Alteration in juvenile salmon prey base and predation pressure	(Haas et al. 2002), (Williams et al. 2003), (Redman et al. 2005)	X				X
Change in wave energy and longshore drift patterns, and resulting changes in upper intertidal sediment distribution	(Kelty and Bliven 2003), (Nightingale and Simenstad 2001)	X	X	X	X	X

Over-water structures of any kind will result in loss of some habitat functions due to short-term (construction activities) and long-term (permanent structure features) impacts. Most, but not all, habitat impacts can be avoided or minimized through proper design, and compensated for through mitigation. However, small incremental impacts are essentially unavoidable where these types of projects are permitted. As a consequence, despite efforts to avoid, minimize, and mitigate ecological impacts, the cumulative effects of over-water structures will gradually increase over time. The ecological implications of this fact are potentially broad and have other regulatory implications. For example, juvenile salmonids from ESA listed populations are dependent on a variety of nearshore habitats that are broadly distributed throughout the Puget Sound nearshore. Permitting activities that will unavoidably cause cumulative incremental degradation of these habitats will ultimately have implications for the conservation and recovery of these highly valued species.

Regulating Overwater Structures

Due to the clear adverse impacts on the nearshore environment from overwater structures, local planners and regulators must first manage the shoreline to avoid (not permit) the impacts and then to minimize impacts through careful review of permit applications. This guidance provides the tools and information necessary to determine if a proposed project avoids and minimizes ecological impacts to the greatest extent possible, and mitigates for unavoidable impacts consistent with regulatory standards.

The Shoreline Management Act (SMA) and related guidance for updating local Shoreline Master Programs (SMPs) provides a basis for developing more specific guidance for planning and permitting these activities. Because the SMA allows for the development of certain types of overwater structures to support water-dependent uses, it follows that permitting of some activities known to cause harm will take place. However, the SMA also mandates that permitted shoreline activities result in “No Net Loss” of habitats and habitat function. To remain consistent with this mandate, SMPs must provide a clear sequence of steps for avoiding and minimizing these impacts to the greatest extent possible, and for mitigating unavoidable impacts.

A key first step is to identify conditions when new structures should not be approved based on the potential to impact sensitive habitats. For example, Island County's' SMP prohibits new piers and docks on one of their bays in order to protect surf smelt spawning area. Because even carefully designed projects will produce some incremental loss of habitat functions, some limits on the total number of new structures allowed will be necessary to control cumulative effects. The SMA provides useful guidance in this regard, recommending alternative approaches such as using moorage buoys and shared facilities that limit the number of new facilities while providing equivalent access. Useful elements of the broad regulatory guidance provided by the SMA include the development of local policies and requirements that:

a. State a clear preference for use of mooring buoys and shared facilities rather than individual private docks and piers. This policy addresses the potential cumulative impacts of multiple individual docks. If a shoreline inventory has already indicated that certain sensitive areas of the shoreline have a high number of overwater structures, a policy or regulation to restrict new structures in that area or require a higher level of scrutiny for those areas could also be adopted.

b. Regardless of shoreline designation, applicants must demonstrate conclusively that use of a moorage buoy, nearby marina, public boat ramp, or other existing shared facility is not possible. This includes providing evidence of contact with abutting property owners and evidence that they are not willing to share an existing dock or develop a shared moorage. For commercial/industrial facilities, this would include evidence that existing commercial facilities can't be shared or are inadequate for the proposed use.

c. New residential subdivisions must provide shared moorage if and when moorage is desired by the residents. A joint use agreement should be developed to ensure future shared use of the facility. If appropriate, an agreement to allow public use of the structure may be required. This information should be recorded on the face of the plat and/or as part of covenants.

d. Avoid locating docks, piers and mooring buoys, including those auxiliary to single family residences, in areas where they will adversely impact shoreline ecological functions or processes, including currents and littoral drift.

e. Docks, piers, and mooring buoys should not be located in areas containing sensitive, unique, or high-value fish and shellfish habitat.

f. When permitted, these structures must be the minimum size and length to accommodate the intended use.

g. Docks and piers should not be located on shallowly sloped beach areas because of the large footprint required to attain adequate water depths for launching.

h. Prohibit new private or commercial docks in the Natural Shoreline Environment Designation, except as related to science and environmental education facilities that may be permitted in that designation. A conditional use permit should be required for docks in the conservancy environment.

A second key step in creating specific planning and permitting guidance is to employ innovative design standards for new and replacement structures. These design standards, which are based on BAS, are intended to produce overwater structures that avoid and minimize adverse impacts to the greatest extent possible. Finally, the guidance should also provide a means for determining when mitigation for unavoidable impacts should be required, and what form this mitigation should take.

The following “decision tree” tool has been developed with these key steps in mind. It is intended to guide local planners in making initial determinations about conditions where overwater structures should or should not be approved, providing design recommendations, and indicating situations where mitigation should be required. The decision tree is linked by reference to design standards and other recommendations for impact avoidance and mitigation provided in the following sections.

How to minimize impacts from approved Overwater Structures

Corps of Engineers permitting requirements and local shoreline management regulations provide extensive design guidance for overwater structures. This guidance has evolved from numerous studies of the effects of these structures on the nearshore environment, and experimental approaches for minimizing these impacts. A summary of this design guidance and the supporting environmental documentation this guidance is based upon is provided in Table III.2.

Table III.2. Recommendations for construction, design, and operation of overwater structures, buoys, and other forms of watercraft moorage.

Regulatory issues	Recommendations
General	
Materials selection	Treated Wood: The use of treated wood should be avoided altogether; there are many alternative materials that can be used (i.e., concrete, steel, plastic, and in some cases, untreated wood). ◊ Regulatory requirements do not allow for creosote, pentachlorophenol, CCA, or comparably toxic compounds not approved for marine use, to be used on any component of the over water structure. ACZA treated wood must meet Post-Treatment Procedures (Poston 2001), (Nightingale and Simenstad 2001). Floatation: ◊ Enclose or contain floatation material within a durable shell to prevent disintegration (Corps 2006), (Ecology 1994). Transparent materials: ◊ Use transparent or partially transparent (e.g., grating) materials in ramp and pier/float decking (Shafer 2002). ◊ Corps of Engineers permitting requirements (Corps 2006) for functional grating used in docks, piers, floats and ramps state that the grating must have at least 60% open area, oriented to maximize light penetration and without any solid objects above or below the grating (Shafer 2002) (Fresh et al. 2006). ◊ Use transparent roofing materials where roofing is required (e.g., watercraft lifts).

Table III.2. Recommendations for construction, design, and operation of overwater structures, buoys, and other forms of watercraft moorage.

Regulatory issues	Recommendations
Equipment operation	Site access: ◊ Confine equipment use to a single access point and limited to a 12-foot corridor on either side of the proposed work (Corps 2006). ◊ Operate equipment from the top of the bank, a temporary work platform, barge or similar out-of-water location to the maximum extent practicable (Corps 2006). Barges: ◊ When using barges, do not ground on the substrate at any time (Corps 2006). Water quality: ◊ Operate equipment in a manner that minimizes suspended particulates entering the water (Corps 2006).
Habitat and process protection	Watercraft moorage: ◊ Corps of Engineers permitting requirements state that structures must be designed to avoid watercraft resting on the substrate at all times (Corps 2006). Protection of geomorphic processes: ◊ Design for minimal interference with geomorphic and littoral drift processes (Ecology 1994). Habitat protection: ◊ Construction of new overwater structures within 25 feet (horizontally) of macroalgae or eelgrass beds is not allowed under Corps of Engineers permitting regulations (Corps 2006). ◊ For floats or support pilings for replacement structures installed where macroalgae or eelgrass beds and/or documented Pacific herring habitat are present within 25 feet of the float in any direction, allow a minimum of four feet depth between the top of the float stopper and the top of the habitat feature (Corps 2006). ◊ If piers and ramps need to be constructed over documented surf smelt and/or sand lance spawning habitat, they should span that habitat to the maximum extent practicable (Corps 2006).
Survey requirements	Eelgrass/macroalgae: ◊ Surveys are required for all new construction. Surveys are not required for replacement of existing structures within their original footprint (Corps 2006). Substrate types: ◊ Summary information about substrate types in project area must be submitted with Corps permit application. If undocumented Pacific herring, surf smelt, or sand lance spawning habitat is present, additional survey information may be requested from the applicant (Corps 2006). Surf smelt/sand lance habitat: ◊ If the project site contains documented surf smelt and/or sand lance habitat and there is no approved in-water work window for the site, obtain confirmation in writing from a WDFW certified biologist that these species are not spawning in the area when construction occurs. Once certification has been obtained, the permittee has 48 hours from the date of the inspection to begin and two weeks to complete all construction activities in contact with the substrate waterward of ordinary high water (Corps 2006).

<table>
<tr><th colspan="2">Table III.2. Recommendations for construction, design, and operation of overwater structures, buoys, and other forms of watercraft moorage.</th></tr>
<tr><th>Regulatory issues</th><th>Recommendations</th></tr>
<tr><td>Site restoration</td><td>Substrate disturbance:
◊ Restore depressions or trenches in beach substrate created by construction equipment waterward of OHW to pre-project conditions. Where beach hardpan or clay is exposed by construction activities, restore to pre-project conditions immediately upon completion of construction (Corps 2006).
Vegetation disturbance:
◊ Develop a planting plan that provides for the replacement of disturbed vegetation with equivalent site-appropriate native species (Corps 2006).
◊ Do not remove existing habitat features (e.g., logs, aquatic vegetation) from the aquatic environment (Corps 2006).
◊ Limit disturbance of bank vegetation to a work area strip no wider than twice the width of the pier (Corps 2006).
◊ Obtain prior approval from the Corps before removing vegetation greater than 4 inches diameter at breast height within the work area strip (Corps 2006).
◊ Keep removed trees on site securely anchored on the beach (Corps 2006).</td></tr>
<tr><th colspan="2">Piles</th></tr>
<tr><td>Installation</td><td>Material selection:
◊ Replacement or proposed new piling can be steel, concrete, plastic or untreated wood (Corps 2006).
◊ When using existing treated wood pilings, incorporate design features like plastic rub strips or metal bands that minimize contact abrasion to limit the release of toxic chemicals into the environment (Corps 2006), (Poston 2001).
Configuration and placement:
◊ Avoid placing pilings closer than 20 feet apart, or otherwise space to limit shading and dissipate wave energy and sediment transport (Corps 2006), (Shafer 2002), (Fresh et al. 1995).
Minimizing construction related noise impacts:
◊ Steel pilings cannot exceed a 12-inch diameter for residential docks (Corps 2006), (WSDOT 2006).
◊ Vibratory hammers should be used for pile installation where possible (Corps 2006), (WSDOT 2006).
Where impact hammers are necessary:
◊ Limit pile driving to periods when water depth is less than 3 feet (WSDOT 2006).
◊ Use approved sound attenuation devices (e.g., bubble curtains) per Corps of Engineers requirements as follows (Corps 2006):
▪ Piles 10 inches diameter or less, one approved device or measure
▪ Piles >10 to 12 inches diameter, two approved devices or measure</td></tr>
<tr><td>Habitat impact minimization</td><td>When piles must be placed in documented surf smelt and/or sand lance habitat (Corps 2006):
◊ Limit the number of piles to the minimum practicable
◊ Use piles of 8 inches in diameter or less</td></tr>
</table>

Table III.2. Recommendations for construction, design, and operation of overwater structures, buoys, and other forms of watercraft moorage.

Regulatory issues	Recommendations
Habitat impact minimization (cont.)	◊ Do not use treated wood (Poston 2001)
Removal	Encourage complete removal of treated piles using the following methods of removal in preferred order (WDNR SPM 2005), (Poston 2001): ◊ Complete removal using vibratory extraction. ◊ If the use of vibratory extraction is not feasible, complete removal using puller buncher, choker cables, and/or lift bag extraction. Proponent should be required to demonstrate that use of vibratory extraction is not feasible. ◊ Complete removal by excavating a pit sufficiently large to grasp and extract the piling (potentially contaminated spoils must be disposed of at an approved hazardous waste handling facility; hydraulic jetting, which can suspend and scatter contaminated sediments, should not be permitted). ◊ If complete removal is not feasible, perform partial removal by breaking or cutting the piling at a minimum depth of 2 feet below the surface (sawdust and fragments should be collected and disposed of at an approved hazardous waste handling facility). Proponent should be required to demonstrate that complete removal is not feasible. ◊ Other removal methods evaluated on a case-by-case basis.
Piers and Docks	
Size and configuration	Configuration: ◊ The Corps of Engineers will only authorize linear configurations; finger, "T" or "L" piers are not permitted (Corps 2006), (Fresh et al.2006). ◊ Designs that allow the structure to move with tides (e.g., chained between pilings) are desirable over static structures (Corps 2006). Height: Recommend designing piers and docks for the maximum height practicable to maintain light transmission: ◊ Minimum height of 6 feet over the substrate bed is desirable to maintain light transmission (Nightingale and Simenstad 2001), (Shafer 2002). Length: Limit to the minimum length necessary, consistent with regulatory requirements: ◊ Whatcom County: Private docks up to 40 feet, shared moorage up to 80 feet (under special exceptions, docks up to 60 feet and 100 feet may be approved, respectively, where special conditions apply) (Whatcom SMP). Width: Limit to the minimum necessary consistent with regulatory requirements per jurisdiction: ◊ Corps of Engineers: Up to 6 feet width (Corps 2006), (Shafer 2002). ◊ Whatcom County: Up to 4 feet width, wider piers with functional grating may be allowable (Whatcom SMP). Railing: Limit to 36 inches in height with an open framework (Whatcom SMP).
Deck	Functional grating %: ◊ 30% of area along entire length for N/S oriented pier (338 to 22 north, or 158 to 202 south) greater than 4 feet in width (Fresh et al. 2006).

Table III.2. Recommendations for construction, design, and operation of overwater structures, buoys, and other forms of watercraft moorage.

Regulatory issues	Recommendations
Deck (cont.)	◊ 50% of area along entire length for NE/SW, NW/SE and E/W oriented piers (23 to 157 east, 203 to 337 west) for all piers regardless of width (Fresh et al. 2006).
Ramps	Ramp width: ◊ Must not exceed 4 feet (Corps 2006), (Shafer 2002). Grating: ◊ Use functional grating (i.e., 60% minimum open area) for entire ramp surface (Corps 2006) (Fresh et al.2006).
Floats	
Size and configuration	Configuration: ◊ Use square or rectangular configuration (Corps 2006), (Fresh et al. 2006). Size limitations: ◊ Limit float size to the minimum width necessary as dictated by regulatory limits per jurisdiction. For example: Corps of Engineers: Up to 8 feet width and up to 20 feet length (Corps 2006). Siting: ◊ Do not build the structure in shallow areas such as tidal flats because the structure would need to be very long in order to reach a depth where boats can be moored. Orientation: ◊ Place float with largest dimension oriented north-south to the maximum extent practicable (Corps 2006), (Shafer 2002), (Nightingale and Simenstad 2001), (Fresh et al. 2006).
Design	Deck grating: ◊ Corps of Engineers: Functional grating over 30% of surface for floats up to 6 feet in width, and over 50% of surface for floats from 6 to 8 feet in width (Corps 2006), (Shafer 2002), (Fresh et al.2006). Suspension: ◊ Design float with stoppers or support pilings that keep the bottom of the floats at least 1 foot above the substrate so that the structure will not rest on the bottom (Corps 2006), (Shafer 2002), (Fresh et al.2006). Anchoring: ◊ Corps of Engineers: Limit floatation anchoring to a maximum of four helical screw anchors, piles, piling with stoppers, and/or float support/stub piles (Corps 2006).
Habitat impact minimization	◊ Per Corps of Engineers permitting restrictions, floats, float support piling, and helical anchors cannot be placed in documented Pacific herring, surf smelt and/or sand lance habitat (Corps 2006). ◊ Remove seasonal floats when not in use, ideally between October and April (Fresh et al. 2006).

Table III.2. Recommendations for construction, design, and operation of overwater structures, buoys, and other forms of watercraft moorage.

Regulatory issues	Recommendations
Water Craft Moorage and Lifts	
Permit limitations	Number of structures: ◊ Corps of Engineers permit applicants are limited to one uncovered watercraft grid or lift per single use overwater structure, and two uncovered watercraft grids or lifts per joint use structure (Corps 2006).
Design	Configuration: ◊ Design grid/lift so that the bottom of the grid rests at least 1 foot from the tidal substrate and does not rest on the substrate at any time (Corps 2006), (Shafer 2002), (Fresh et al.2006). Support piling: ◊ Use the minimum number of additional piles necessary to support the watercraft grid/lift (e.g., two additional piles per lift) (Corps 2006). Walls/roofing: ◊ Limit wall materials to the minimum open structural framework needed for roof support to limit shading effects (Whatcom SMP). ◊ Limit roof area to less than 200 square feet and 15 feet height above the ordinary high water mark (OHWM) (Whatcom SMP). ◊ Use translucent roofing materials, or use clear skylights covering at least 50% of roof area (Whatcom SMP).
Habitat protection	◊ Watercraft grids or lifts cannot be placed in documented Pacific herring, surf smelt and/or sand lance habitat (Corps 2006).
Mooring Buoys	
Equipment	Buoy size: ◊ Corps of Engineers: maximum 3- feet in diameter (Corps 2000). Materials: ◊ Hollow plastic, hard plastic-encapsulated styrofoam, aluminum kegs or other approved materials. Anchor: Helix or Manta Ray -style anchors: ◊ Nylon rope or chain and rope combination, with appropriate line "scope" (i.e. length to depth ratio) for location as per U.S. Coast Guard or local boating association guidance (typically 7:1 ratio of line length to depth) (Corps 2000), (Simenstad and Nightingale 2001). ◊ Chain with a mid-line float (no counterweight) that fully suspends the chain off the bottom at all tidal elevations (Simenstad and Nightingale 2001).
Configuration, placement and use	Placement: ◊ Corps of Engineers: Locate buoy so that anchor, buoy and moored vessels will not shade or otherwise impact vegetated shallows (Corps 2000).

Table III.2. Recommendations for construction, design, and operation of overwater structures, buoys, and other forms of watercraft moorage.

Regulatory issues	Recommendations
Configuration, placement and use (cont.)	Vessel size: ◊ Corps of Engineers: Limit vessels using mooring buoys to less than 65 feet total length (Corps 2000) wrong bullet type here, match with above. Density of buoys: ◊ Corps of Engineers: Limit buoys to no more than four per acre (Corps 2000). Moorage limits: ◊ Corps of Engineers: Limit buoy use to 6 months/year or less to extent practicable and avoid use during winter months and stormy weather to avoid dragging anchors across substrate (Corps 2000).

Strategies for Mitigating Unavoidable Impacts

Construction of overwater structures will in many cases result in unavoidable environmental impacts, affecting a range of habitat types and ecological functions. Many of these impacts can be avoided or minimized with proper planning and design, and mitigation for several of the remaining impacts can be applied to compensate for impacts that are unavoidable. It should be recognized, however, that not all impacts can be adequately mitigated. Therefore, serious consideration should be given to denying such projects to avoid losses of habitat functions and continued cumulative impacts. Off site mitigation and restoration projects should also be considered to address unavoidable and cumulative impacts. Suggested impact avoidance and minimization measures, and various mitigation strategies are described in Table III.3.

Table III.3. Mitigation strategies for habitat losses due to development of overwater structures, shoreline armoring, and riparian vegetation management.

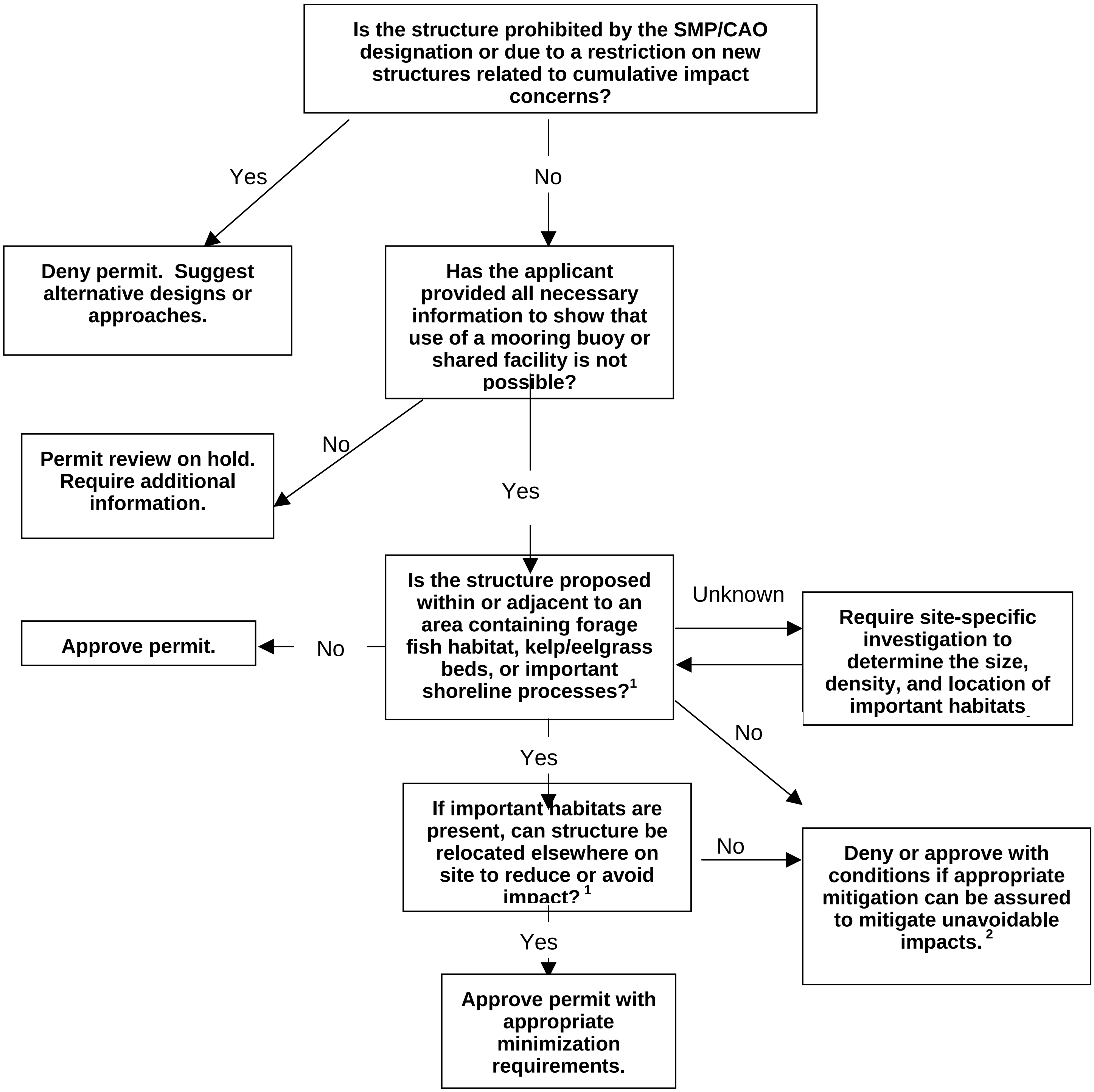
Impact	Mitigation Strategies
General	Mitigation should emphasize on-site and in-kind rehabilitation or replacement of degraded habitats and ecological functions to the greatest extent possible. For example, loss of eelgrass habitat should be mitigated by the restoration of degraded eelgrass habitat in the immediate vicinity of the project, or the creation of new habitat. Replacement of lost eelgrass habitat by

Table III.3. Mitigation strategies for habitat losses due to development of overwater structures, shoreline armoring, and riparian vegetation management.	
Impact	**Mitigation Strategies**
General (cont.)	replanting marine riparian vegetation or by creating macroalgae habitat is not in-kind mitigation and would be inappropriate. Similarly, creation of new marine riparian vegetation in Hood Canal to mitigate for losses occurring on the east side of the Kitsap Peninsula would be considered off-site and thereby inappropriate. In some circumstances, however, off-site mitigation may be desirable and should be allowed, particularly as a way to mitigate for cumulative impacts. Mitigation plans should be developed and implemented by qualified professionals. Planners evaluating mitigation plans should consider the following: ◊ Is the mitigation plan sufficiently detailed to evaluate eventual success (e.g., does it include a plan view of the planting scheme, identify replacement species and methods, provide as built schematics, etc.)? ◊ Does the plan provide sufficient performance criteria and monitoring (a minimum of 5 years for most projects) to establish that mitigation was successful? Have sufficient reporting requirements been established? ◊ Does the mitigation site provide the ecological characteristics necessary to support the desired habitat? ◊ Does the proposed mitigation provide, at minimum, 1 to 1 replacement of the lost habitat area? ◊ Does the plan provide contingencies if performance criteria are not met?
Aquatic vegetation alteration	Impact avoidance and minimization is the most effective means of maintaining aquatic vegetation habitat functions. When unavoidable degradation occurs, mitigation of lost eelgrass and macroalgae habitat can sometimes be achieved by allowing for natural regrowth, or by using transplant methods (Thom et al. 2001). In addition to the general issues identified above, mitigation plans for aquatic vegetation losses should consider the following: ◊ Is there historical/baseline information indicating vegetation presence at the site before the disturbance or development? ◊ Does the proposed mitigation site provide suitable depth, substrate, wave energy, and water quality conditions to support the desired species? ◊ Does the plan provide clear performance criteria for vegetation establishment and survival? ◊ Does the plan include at least five years of monitoring, and contingency provisions if performance criteria are not met?
Riparian vegetation alteration	Disturbed marine riparian vegetation should be replaced with equivalent native species appropriate for the site. Mitigation should provide 100 % replacement of lost vegetation, and provide for an equal amount of vegetative function. The following factors should be considered when replacing lost ecological functions: ◊ Does the affected vegetation overhang the beach or provide organic litter and prey recruitment? ◊ Does the site contain large trees (>4” dbh) that provide shade and potential LWD recruitment? ◊ Would upland runoff from surface streets or residential properties run across exposed bluff areas (i.e., could reduced vegetative filtration negatively impact water quality)?

Table III.3. Mitigation strategies for habitat losses due to development of overwater structures, shoreline armoring, and riparian vegetation management.

Impact	Mitigation Strategies
Riparian vegetation alteration (cont.)	In addition to the general issues identified above, mitigation plans for riparian vegetation alteration should consider the following: ◊ Does the mitigation plan replace the full range of vegetation types that were lost (e.g., trees, shrubs, understory)? ◊ Will the replaced vegetation provide equivalent functions? o Runoff filtration o LWD, prey and litter recruitment o Shade and microhabitat conditions o Terrestrial habitat functions ◊ Will revegetation occur during the appropriate time of year for the selected species? ◊ Have minimum survival criteria been established for all planting types? ◊ Does the plan include monitoring and maintenance, and contingency provisions if performance criteria are not met? The mitigation plan should provide clear performance criteria for survival of plantings until they are fully established.
Forage fish spawning habitat	Several aspects of mitigation for forage fish habitat are addressed by mitigation for degradation of aquatic vegetation (herring spawning substrate) and riparian vegetation (shade for surf smelt and sand lance spawning beaches). However, any project which results in the loss of suitable spawning substrate for surf smelt and sand lance (i.e., sand and fine gravel substrate high in the intertidal zone), either directly within the project footprint or through effects on sediment recruitment and longshore drift processes, has created an impact that should be mitigated. Mitigation plans for lost beach spawning habitat (e.g., substrate placement) should consider the following: ◊ Is placement of suitable substrate on the beach an adequate approach to mitigating project impacts? ◊ What is the appropriate location for substrate enhancement (on site, off site)? ◊ Does the mitigation site provide suitable wave energy and sediment transport characteristics to maintain the necessary substrate characteristics over time? ◊ Can spawning substrates be maintained at the correct intertidal elevation? ◊ Does the mitigation site provide sufficient spawning area and/or microhabitat characteristics to ensure equivalent spawning productivity?
Unavoidable impacts from approved structures	In certain cases, planners may have to approve overwater structures or shoreline armoring projects to support approved shoreline uses or to protect property, infrastructure, or public safety. In cases where these activities cause unavoidable degradation, appropriate mitigation may include the removal of an existing structure or structures followed by site restoration sufficient to replace lost habitats and ecological functions. These types of mitigation activities are complex and qualified professionals should develop the related plans.

Figure III.1. Recommended Review Steps for Overwater Structures.



1 See design and impact avoidance recommendations, Table III.2
2 See mitigation recommendations, Table III.3

SHORELINE ARMORING

HOW DOES SHORELINE ARMORING IMPACT THE SHORELINE?

Riprap, retaining walls (i.e., bulkheads), and other forms of shoreline armoring structures can have a number of adverse impacts on the marine shoreline environment. The adverse effects of these structures can occur through a variety of mechanisms that have been well documented. These adverse effects are particularly evident in areas where these structures have been constructed below the OHW elevation.

The construction of these types of structures promotes loss of terrestrial, shallow-water, and benthic habitat. The physical disturbance and damage to fish and wildlife habitat caused by the construction of bulkheads can vary, and is dependent on several factors including:

- ◊ type of habitat present prior to construction;
- ◊ location and elevation of the structure on the shoreline;
- ◊ size and configuration of the structure;
- ◊ construction methods used to create it;
- ◊ geomorphic setting;
- ◊ exposure and orientation to waves, and;
- ◊ erosion rates.

The construction of bulkheads and associated activities also cause local erosion, new sediment deposits in the vicinity of the structure, turbidity, and hence water quality degradation. New sediment deposits are often silty and thus can degrade forage fish spawning areas, smother benthic organisms and vegetation, and reduce bottom habitat diversity

Bulkheads promote erosion of the foreshore because waves can reflect off the face of these structures with sufficient energy to transport fine sediments along the shoreline or offshore. This erosion can be severe in many cases, leading to downcutting of the beach and the eventual loss of the higher elevation portion of the intertidal zone. Downcutting may eventually undermine the bulkhead itself, leading to its eventual failure. Bulkheads can also interfere with the recruitment of sediment from bluffs and the transport of sediment within drift cells, starving adjacent beaches of sediment. These two mechanisms can lead to the gradual loss of fine sediments in the nearshore environment and lowering of the beach profile, leading to a loss of shallow water habitat. The recent development of "soft" erosion protection techniques, such as vegetated berms and natural wood structures designed to emulate natural drift wood accumulations are preferable to vertical bulkheads because they effectively attenuate wave energy and reduce beach erosion. But even soft structures can reduce sediment recruitment by limiting feeder bluff erosion. Over time, decreased inputs of sand and gravel size sediment within an active drift cell can result in coarsening of nearshore substrate, potentially degrading forage fish spawning habitat.

There are several additional mechanisms through which shoreline armoring can impact the nearshore environment, and they can be complex in nature. Many of these impacts can be minimized through proper design, but they cannot be avoided entirely. As with overwater structures, the cumulative impacts from multiple shoreline armoring projects are potentially significant. Where extensive shoreline armoring has resulted in significant cumulative impacts, it may be difficult or impossible to maintain desirable ecological functions. These factors must be considered when reviewing proposed projects, and when developing mitigation requirements.

Table III.4 provides a summary of the impacts from shoreline armoring and some of the habitats that may be affected. Additional discussion of the environmental impacts on these components is provided in Section II.

Table III.4. Impacts from shoreline armoring and the natural functions that may be affected.

Impact	Supporting Studies	Forage fish habitat	Beaches and bluffs	Kelp and eelgrass beds	Marine riparian vegetation	Juvenile salmon nearshore habitat
Direct and Indirect						
Short-term site preparation and construction activities)						
Increased turbidity and possible release of pollutants ◊ Reduced light and photosynthesis ◊ Fine sediment deposition/substrate change ◊ Possible spills from construction equipment, aquatic habitat and species exposure ◊ Noise and activity related disturbance, avoidance by fish and other aquatic life	(Norris et al. 1997), (Williams and Thom 2001)	X		X		X
Beach disruption from equipment access, materials staging and placement, etc ◊ Avoidance by fish and other aquatic life ◊ Loss of fish eggs and other substrate dependent life ◊ Vegetation loss	(Kelty and Bliven 2003), (Williams and Thom 2001)	X	X	X	X	X

Table III.4. Impacts from shoreline armoring and the natural functions that may be affected.

Impact	Supporting Studies	Forage fish habitat	Beaches and bluffs	Kelp and eelgrass beds	Marine riparian vegetation	Juvenile salmon nearshore habitat
Long-term (ongoing impacts from permanent features)						
Morphologic alteration of shoreline ◊ Changes in wave energy and longshore drift patterns ◊ Change in beach profile ◊ Direct burial of the upper beach	(MacDonald et al. 1994), (Williams and Thom 2001)	X	X	X	X	X
Substrate alteration (sediment/wood) ◊ Coarsening of substrate (vertical bulkheads) ◊ Accumulation of fines (jetties or other structures that block longshore drift) ◊ Loss of sediment supply on downdrift side of jetties and groins	(Erstad 2006), (MacDonald et al. 1994), (Williams and Thom 2001), (Mulvihill et al. 1980), (Herrara 2005)	X	X	X		X
Aquatic vegetation alteration ◊ Loss of substrate cohesion ◊ Loss of fine substrate recruitment, coarsening of substrate, and change in beach profile ◊ Loss of habitat complexity ◊ Shifts in vegetation community types	(Erstad 2006), (MacDonald et al. 1994), (Williams and Thom 2001), (Williams and Thom 2001), (Mulvihill et al. 1980)	X		X		X

Table III.4. Impacts from shoreline armoring and the natural functions that may be affected.

Impact	Supporting Studies	Forage fish habitat	Beaches and bluffs	Kelp and eelgrass beds	Marine riparian vegetation	Juvenile salmon nearshore habitat
Riparian vegetation alteration ◊ Removal of riparian vegetation within structure footprint	See Table III.6	X	X		X	X
Cumulative						
Change in wave energy and longshore drift patterns, resulting in changes to upper intertidal sediment characteristics	(Williams and Thom 2001)	X	X	X	X	X
Reduced nearshore habitat suitability for juvenile salmonids	(Redman et al. 2005), (Fresh 2006), (Williams and Thom 2001)		X			X

REGULATING SHORELINE ARMORING ACTIVITIES

As described above, shoreline armoring projects will often produce unavoidable adverse impacts, and numerous, small, incremental impacts can produce significant cumulative effects over time. Therefore, a logical first step toward meeting the SMAs "No Net Loss" mandate is to avoid permitting new shoreline armoring, in cases where it is not necessary. In many cases a structural approach may not be necessary for property or infrastructure protection, and may cause unacceptable environmental impacts. In such cases, alternative means of achieving the desired goal should be recommended. Where shoreline armoring is necessary for erosion control, planners should enforce or encourage the use of alternative design methods that avoid and minimize environmental impacts to the greatest extent possible, and require that unavoidable impacts be fully mitigated. Planners should consider whether the source of the erosion is from a feeder bluff, supplying sediment to downdrift beaches. During SMP development, planners should require that traditional, hard armoring be placed landward of the OHWM elevation, except in special circumstances where this may not be possible. Planners should also consider the future impact of sea level rise on the OHWM when developing SMP regulations.

Recently released SMPs incorporate guidance for protecting habitat from loss through shoreline armoring. For example, the draft Whatcom County SMP includes the following language pertinent to regulating the development of shoreline stabilization structures (Section 23.100.13): (Whatcom SMP)

a. Alternatives to structures for shore protection should be used whenever possible. Such alternatives may include; no action (allow the shoreline to retreat naturally), increased building setbacks, building relocation, drainage controls, and bioengineering, including vegetative stabilization, and beach nourishment.

b. New or expanded structural shore stabilization for new primary structures should be avoided. Instead, structures should be located and designed to avoid the need for future shoreline stabilization where feasible. Land subdivisions should be designed to assure that future development of the created lots will not require structural shore stabilization for reasonable development to occur.

c. New or expanded structural shore stabilization should only be permitted where demonstrated to be necessary to protect an existing primary structure that is in danger of loss or substantial damage, and where mitigation of impacts would not cause a net loss of shoreline ecological functions and processes.

d. New or expanded structural shore stabilization for enhancement, restoration, or hazardous substance remediation projects should only be allowed when non-structural measures, vegetation planting, or on-site drainage improvements would be insufficient to achieve enhancement, restoration or remediation objectives.

e. Shore stabilization should be developed in a coordinated manner among affected property owners and public agencies for a whole drift sector (net shore-drift cell) or reach where feasible, particularly those that cross jurisdictional boundaries, to address ecological and geo-hydraulic processes, sediment conveyance and beach management issues. Where beach erosion threatens existing development, a comprehensive program for shoreline management should be established.

f. In addition to conformance with the regulations in this section, non-regulatory methods to protect, enhance, and restore shoreline ecological functions and other shoreline resources should be encouraged for shore stabilization. Non-regulatory methods may include public facility and resource planning, technical assistance, education, voluntary enhancement and restoration projects, or other incentive programs.

g. Shore stabilization should be located, designed, and maintained to protect and maintain shoreline ecological functions, ongoing shore processes, and the integrity of shore features. Ongoing stream, lake or marine processes and the probable effects of proposed shore stabilization on other properties and shore features should be considered. Shore stabilization should not be developed for the purpose of filling shorelines.

h. Failing, harmful, unnecessary, or ineffective structures should be removed, and shoreline ecological functions and processes should be restored using non-structural methods or less harmful long-term stabilization measures.

i. Structural shoreline stabilization measures should only be used when more natural, flexible, non-structural methods such as vegetative stabilization, beach nourishment and bioengineering have been determined infeasible. Alternatives for shoreline stabilization should be based on the following hierarchy of preference:

   1) No action (allow the shoreline to retreat naturally), increase building setbacks, and relocate structures.

   2) Flexible defense works[2] constructed of natural materials including soft shore protection, bioengineering, including beach nourishment, protective berms, or vegetative stabilization.

   3) Rigid works [structures] constructed of artificial materials such as riprap or concrete. Materials used for construction of shoreline stabilization should be selected for long-term durability, ease of maintenance, compatibility with local shore features, including aesthetic values and flexibility for future uses.

   4) Larger works such as jetties, breakwaters, weirs or groin systems should be permitted only for water-dependent uses when the benefits to the region outweigh resource losses from such works, and only where mitigated to provide no net loss of shoreline ecological functions and processes.

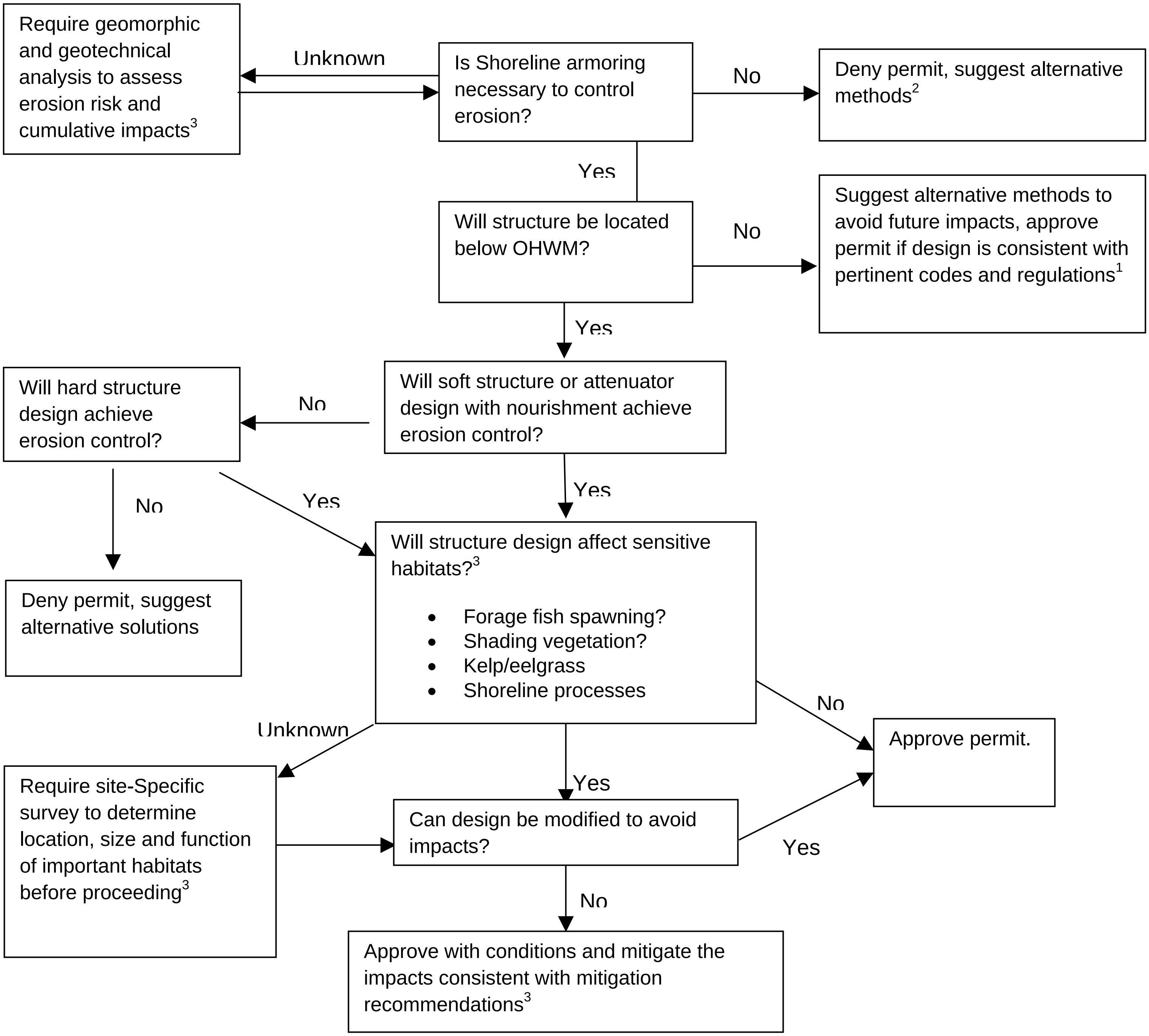
   5) Alternative structures, including floating, portable or submerged breakwater structures, or several smaller

[2] E.g.; bulkheads or other shoreline armoring.

discontinuous structures, should be considered where physical conditions make such alternatives with less impact feasible.

The following decision tree tool is consistent with these directives. It provides guidance for determining whether a proposed activity is necessary to protect property and infrastructure, describes design recommendations for avoiding and minimizing ecological impacts, and discusses the need for environmental mitigation. The decision tree is linked by reference to design standards and other recommendations for impact avoidance and mitigation provided in the following sections.

Figure III.2. Recommended Review Steps for Shoreline Armoring Projects.



1 Suggest using alternative methods such as soft shore or wave attenuator designs, unless the structure is also intended to provide foundation support or some other function subject to separate design codes and regulations
2 See design and impact avoidance recommendations, Table III.4
3 See mitigation recommendations, Table III.5

HOW TO MINIMIZE IMPACTS OF SHORELINE ARMORING

Currently there is little explicit guidance on which type of shoreline armoring is "best" in any given situation. Recent research has shown the value of "soft shore" designs that deform naturally and attenuate wave energy, in comparison to hard vertical structures that cause fragmentation of the intertidal environment. Attenuator designs, which incorporate features like large rock and/or logs that dissipate wave energy, are also preferable to hard vertical bulkheads in many cases. However, these designs require a larger area of beach and may not be suitable in cases where the construction footprint would displace sensitive habitats. As a general rule, planners should require project applicants to provide the site-specific surveys and information necessary to determine the most appropriate design to lessen impacts. This information should be produced by qualified experts, and should be used as a basis for design and for identifying mitigation requirements. Design guidance recommendations and survey requirements are presented in Table III.5.

Table III.5. Recommendations for design and construction of shoreline armoring structures.

Regulatory issues	Recommendations
Need for erosion control	Has geomorphic/geotechnical analysis established that shoreline armoring is needed for erosion control? No - Use alternative methods where hardened structures are not necessary to achieve erosion control Yes – Evaluate shoreline armoring design using criteria listed below
Design to avoid/minimize impact	Use alternatives to hard vertical structures wherever possible. Consider the following design approaches in descending order of preference (Williams and Thom 2001): <u>Non-structural alternatives</u>: Alternative methods applicable for areas where shoreline armoring is not necessary to achieve erosion control or provide property/infrastructure protection. Pros: Relatively minimal environmental impacts on the shoreline environment Cons: Applicable only in limited circumstances Examples include: ◊ Building setbacks: Require placement of new homes or other structures at a safe distance from erodable bluffs or shorelines to reduce/eliminate the need for shoreline armoring. ◊ Surface and groundwater drainage management (where applicable) (Ecology 2007a): o Direct surface drainage to the toe of bluff slopes as appropriate, design discharge to avoid point erosion. o Limit excessive irrigation or other sources of excessive runoff and/or infiltration. o Direct sanitary drain fields away from bluffs to the greatest extent possible.

Table III.5. Recommendations for design and construction of shoreline armoring structures.	
Regulatory issues	**Recommendations**
Design to avoid/minimize impact (cont.)	◊ Improve vegetation management (where applicable): Encourage growth/regrowth of site appropriate native vegetation to increase shoreline stability (Ecology 2007b), (Ecology 1993). Soft shore designs: Shoreline armoring that relies on natural materials in configurations that deform and adjust over time. A more desirable method for providing erosion protection where sufficient footprint area is available without damaging sensitive habitats (Williams and Thom 2001), (Johannesen 2001), (Gerstel and Brown 2006), (Shipman 2001), (Zelo et al. 2000). Pros: Provide erosion protection while minimizing ecological impacts. Cons: Require larger footprints than hard vertical structures leading to more extensive construction impacts and permanent habitat modification (therefore less desirable if sensitive habitats will be impacted). Require ongoing maintenance to maintain function (e.g., replacement of eroded beach nourishment, vegetation management). Examples include: ◊ Anchoring of untreated logs and large woody material to the shoreline to mimic the natural accumulation of downed and drift wood. ◊ Biotechnical approaches using the root cohesion provided by native vegetation to stabilize shorelines. ◊ Beach nourishment with sand and gravel substrates. ◊ Combinations of the above designs. Bulkheads, Seawalls and Revetments: Hard structures placed at the toe of bluff slopes or erodable shorelines to deflect wave energy. In general, these are less desirable design options that should only be permitted where erosion protection is absolutely essential and other methods are not applicable. Structures must be designed to allow groundwater drainage to prevent saturation induced slope failures (Gerstel et al. 1997), (Williams and Thom 2001), (Gerstel and Brown 2006), (Erstad 2006). Pros: Relatively small footprint limits construction impacts and immediate loss of intertidal habitats. Effective erosion protection in high wave energy settings with limited available space for project footprint. Cons: Hard vertical structures fragment the beach from sediment source areas. Reflected wave energy transports fine substrates offshore, causing a change in intertidal elevation in front of the structure and armoring of the nearshore substrate. Examples include: ◊ Concrete bulkheads ◊ Vertical log or pile bulkheads ◊ Rock bulkheads/seawalls (vertical and sloping) Jetties and groins: Hard structures placed perpendicular to the shoreline to trap sediments and create wave shadows protected from storm energy. Pros: None obvious. Cons: Depending on configuration, these types of structures can effectively block or alter longshore transport of sediments along the shoreline. This leads to sediment starvation on the downdrift side of the structure over time, coarsening of substrates, and alteration of beach profile and habitat structure. Jetties also alter circulation patterns, affecting water quality in the project vicinity. Examples include: Riprap jetties and groins

Table III.5. Recommendations for design and construction of shoreline armoring structures.

Regulatory issues	Recommendations
Equipment operation	Site access: ◊ Operate equipment from the top of the bank, a temporary work platform, barge or similar out-of-water location to the maximum extent practicable to avoid beach impacts (Corps 2006). ◊ Where equipment use on the beach is required, confine the project to a single access point with a 12 foot wide work corridor on the seaward side of the structure (Corps 2006). Barges: ◊ When using barges, do not ground on the substrate at any time (Corps 2006). Water quality: ◊ Operate equipment in a manner that minimizes suspended particulates entering the water (Corps 2006).
Survey requirements for impact avoidance	Geomorphic/geotechnical analysis (Erstad 2006): ◊ Require surveys/analyses of beach geomorphology and geotechnical conditions (slope stability) for all shoreline armoring projects. These analyses are critical for determining the causes of shoreline erosion and the potential need for shoreline armoring to control this erosion, and provide critical information for selecting the most appropriate design for a site. Eelgrass/macroalgae (Erstad 2006): ◊ Require surveys for all new and replacement construction to support environmental design. ◊ Select design footprint that avoids or minimizes eelgrass impacts. ◊ Require post-construction monitoring of vegetation for up to 10 years to investigate potential project impacts. Surf smelt/sand lance habitat (Erstad 2006), (Penttila 2007): ◊ Select design that limits short-term and long-term impacts on beach profile and substrate characteristics in documented or potential forage fish spawning areas. ◊ Avoid removal of riparian vegetation that provides shade or overhanging cover for forage fish spawning beds. ◊ If the project site contains documented surf smelt and/or sand lance habitat and there is no approved in-water work window for the site, obtain confirmation in writing from a WDFW certified biologist that these species are not spawning in the area when construction occurs. Once certification has been obtained, the permittee has 48 hours from the date of the inspection to begin and two weeks to complete all construction activities in contact with the substrate waterward of OHW.
Site restoration	Substrate disturbance: ◊ Immediately restore depressions or trenches in beach substrate created by construction equipment waterward of OHW to pre-project conditions (e.g., elevation and substrate material type). ◊ Where beach hardpan or clay is exposed by construction activities, restore to pre-project conditions immediately upon completion of construction (e.g., elevation and substrate material type) (Corps 2006). Vegetation disturbance: ◊ Develop a planting plan that provides for the replacement of disturbed vegetation with equivalent site-appropriate native species (Corps 2006).

Table III.5. Recommendations for design and construction of shoreline armoring structures.

Regulatory issues	Recommendations
Site restoration (cont.)	◊ Do not remove existing habitat features (e.g., logs, aquatic vegetation) from the aquatic environment (Corps 2006). ◊ Limit disturbance of bank vegetation to as small a work area as practicable (Corps 2006). ◊ Obtain prior approval from the Corps before removing vegetation greater than 4 inches diameter at breast height within the work area (Corps 2006). ◊ Anchor removed trees to the beach onsite (Corps 2006).
Removal and/or replacement	Replacement structures: Permitting approval for replacement structures should consider the following recommendations (Penttila 2007): ◊ Replacement structures for shoreline armoring should be placed landward of existing structures. ◊ Existing structures should be completely removed. ◊ Emphasize replacement of existing hard structures with soft shore designs. Removal of treated pile revetments: Encourage complete removal of treated piles using the following methods of removal in preferred order (WDNR SPM 2005) (Poston 2001): ◊ Complete removal using vibratory extraction (first priority). ◊ Complete removal using puller buncher, choker cables, and/or lift bag extraction. ◊ Complete removal by excavating a pit sufficiently large to grasp and extract the piling (potentially contaminated spoils must be disposed of at an approved hazardous waste handling facility; hydraulic jetting, which can suspend and scatter contaminated sediments, should not be permitted). ◊ Partial removal by breaking or cutting the piling at a minimum depth of 2 feet below the surface (sawdust and fragments should be collected and disposed of at an approved hazardous waste handling facility). ◊ Other removal methods evaluated on a case by case basis.

STRATEGIES FOR MITIGATING UNAVOIDABLE IMPACTS

Where shoreline-armoring activities are determined to be necessary and will result in unavoidable adverse impacts, project applicants should be required to develop a mitigation plan. The mitigation plan should compensate for the types of habitats impacted and the ecological processes that have been affected. The same survey data and planning information used to avoid and minimize impacts should be used to assess the nature and extent of unavoidable habitat impacts. Off site mitigation and restoration projects should also be considered to address unavoidable and cumulative impacts. Mitigation strategies for potentially affected habitat types are described in Table III.3.

RIPARIAN VEGETATION ALTERATION

HOW DOES MARINE RIPARIAN VEGETATION ALTERATION IMPACT THE SHORELINE?

Marine riparian vegetation plays a number of important roles in the nearshore environment, including providing habitat structure, shade, and cover for intertidal habitats; fish prey; large wood and organic debris recruitment; habitat for numerous riparian dependent species; and corridors for wildlife movement and migration. Riparian vegetation also provides a number of well-documented ecological benefits, including the filtering of surface water runoff and associated sediments, nutrients and other pollutants, and providing soil stability and stabilization of erosion prone bluffs and shorelines. Removal or modification of riparian vegetation can result in both short and long-term impacts on nearshore processes. These impacts are summarized in Table III.6.

Table III.6. Impacts from marine riparian alterations and the natural functions that may be affected.

Impact	Supporting Studies	Forage fish habitat	Beaches and bluffs	Kelp and eelgrass beds	Marine riparian vegetation	Juvenile salmon nearshore habitat
Short-term (site preparation and construction activities)						
Increased turbidity and possibly release of pollutants ◊ Reduced light and photosynthesis ◊ Deposition of fine sediment /substrate change ◊ Increased contaminant levels in the water ◊ Avoidance by fish and other aquatic life	(Desbonnet et al. 1994), (Brennan and Culverwell 2004), (Lemieux et al. 2004)	X		X	X	
Disruption of beach from tree felling, anchoring on beach, etc ◊ Avoidance by fish and other aquatic life ◊ Loss of fish eggs and other substrate dependent life	(Williams and Thom 2001)	X			X	X
Long-term (ongoing impacts from permanent features)						
Vegetation clearing ◊ Loss of soil cohesion, increased erosion, related turbidity	(Penttila 2007), (Penttila 2001), (Ecology 2007b), (Ecology 1993), (Lemieux et al. 2004), (Brennan and Culverwell 2004), (Romanuk and Levings 2006)	X	X	X	X	X

Table III.6. Impacts from marine riparian alterations and the natural functions that may be affected.

Impact	Supporting Studies	Forage fish habitat	Beaches and bluffs	Kelp and eelgrass beds	Marine riparian vegetation	Juvenile salmon nearshore habitat
Vegetation clearing (cont.) ◊ Loss of organic debris and large woody debris recruitment ◊ Increased surface runoff and turbidity ◊ Loss of fish habitat						
Alteration of microhabitat conditions ◊ Increased temperature ◊ Decreased humidity ◊ Increased solar exposure	(Rice 2006), (Penttila 2001), (Penttila 2007)	X		X	X	X
Loss of slope stability ◊ Increased landslide risk	(Gerstel et al. 1997)	X	X		X	
Loss of food source for fish	(Brennan and Culverwell 2004), (Sobocinski et al. 2004), (Romanuk and Levings 2006)	X			X	X

PROTECTING MARINE RIPARIAN VEGETATION

Many impacts associated with alterations to marine riparian vegetation can be avoided or minimized through careful planning (e.g., applying appropriate shoreline environment designations and use standards), and some lost habitat functions can be recovered through mitigation or restoration actions. However, even with these measures, the removal or substantial modification of riparian vegetation is likely to result in the temporal loss of some level of habitat function. This is particularly true at restoration or mitigation sites before vegetation can (re)grow to the point where it provides a full suite of ecological functions. Consequently, permitting multiple vegetation alteration or clearing activities within a given area will result in incremental cumulative effects that may increase over time. Therefore, it is important that planners and regulators establish clear, protective standards, and work with project applicants to avoid and minimize adverse impacts to the greatest extent possible.

MARINE RIPARIAN PROTECTED AREAS

Establishing "marine riparian protection areas" is an important regulatory mechanism that can help minimize the impact of development and re-development and trigger mitigation sequencing when projects impact riparian vegetation. Marine riparian protected areas are different from buffers and may be applied in different circumstances. The term "buffer" is typically used to denote a border set aside and managed to protect a relatively sensitive area from the effects of surrounding land-use or human activities. Buffers may work best when applied to undeveloped or partially undeveloped areas (e.g., where homes or other human activities uses are already set sufficiently back from the shoreline). Establishing buffers becomes less effective as the sole mechanism to protect the nearshore in more developed areas. On more developed shorelines, or shorelines designated for future development under the SMP, placing buffers on the landscape may simply create situations where existing landowners become immediately noncompliant, which often results in local resistance to the whole idea of regulation. Local ordinances provide variances and exemptions to deal with noncompliance but this is often done without considering impacts to marine riparian vegetation functions. Further, these exemptions often exclude enhancement (e.g., replanting denuded areas with native vegetation) or mitigation that implements the local shoreline restoration plan. The result is ongoing, incremental degradation of the nearshore, even though buffers have been "theoretically" applied. Marine riparian protected areas, however, can be effectively applied as a regulatory overlay even on developed shorelines. In these circumstances, location-appropriate habitat protection regulations can be implemented where needed. These could include function- and area-specific buffers, structural setbacks, riparian enhancement requirements (e.g., native vegetation replanting) and other on-site or off-site mitigation requirements triggered when those areas redevelop, expand, or intensify over time. Landscape-based planning (e.g., the shoreline inventory and analysis component of an SMP) should dictate what protections are triggered within the marine riparian protected area overlay. Variances and exemptions should be limited and tied to mitigation and enhancement, including implementation of the restoration plan.

RECOMMENDED WIDTHS FOR PROTECTED AREAS AND BUFFERS

Most of the current science on riparian management areas and buffers comes from studies of freshwater systems. However, where the freshwater riparian area function is similar to functions in the marine system (e.g., large woody debris recruitment, shade, nesting and migration habitat for wildlife) these studies are appropriate to apply to planning and regulatory decisions and reflect BAS.

> There is no consensus in the literature recommending a single vegetated buffer width to protect a particular function or to protect all functions. The following tables (Tables III.7 to III.9) summarize recent findings from work in the freshwater environment on the relationship of habitat functions to buffer widths. Table III.7 and III.8 provide summaries from two scientific literature reviews recommending single buffer widths associated with particular functions. Clearly there is large variability in the findings and recommendations. The tables also indicate some of the methods used to resolve this variability. In Table III.7 (May 2003) minimum buffer widths are recommended. In Table III.8 average buffer

widths are listed.

Table III.7. Riparian buffer functions and appropriate widths identified by May (2003).

Riparian Function	Range of Effective Buffer Widths (feet)	Minimum Recommended Widths (feet)	Notes on Function
Sediment Removal/Erosion Control	26 – 600	98	For 80% sediment removal
Pollutant Removal	13 – 860	98	For 80% nutrient removal
LWD Recruitment	33 – 328	164	1 SPTH based on long-term natural levels
Water Temperature	36 – 141	98	Based on adequate shade
Wildlife Habitat	36 – 141	328	Coverage not inclusive
Microclimate	148 – 656	328	Optimum long-term support

SPTH: site potential tree height

Table III.8. Riparian functions and appropriate widths identified by Knutson and Naef (1997).		
Function	Range of Effective Buffer Widths (feet)	Average of Reported Widths (feet)
Sediment filtration	26 – 300	138
Erosion Control	100 – 125	112
Pollutant Removal	13 – 600	78
LWD Recruitment	100 – 200	147
Water Temperature Protection	35 – 151	90
Wildlife Habitat	25 – 984	287
Microclimate	200 – 525	412

Some of the work regarding adequate riparian buffer widths has been based on site-potential tree height (SPTH), defined as the heights that mature trees in a climax forest will reach given local conditions. This actual height is dependent upon the tree species, climate, and other variables (Sedell et al. 1993). The Federal Ecosystem Management Team (FEMAT) first proposed the STPH concept while assessing riparian protection strategies for national forest lands (FEMAT 1993). It was reasoned that tree height is a good scaling factor for buffers because they are a dominant factor determining habitat conditions and their heights reflect inherent productivity and constraints of a site when left unmanaged. When buffer widths equivalent to one SPTH are established, a variety of ecological functions are protected including shade, litter fall, root strength and a potential LWD recruitment (FEMAT 1993). Additionally, it was proposed that a buffer width equivalent to three SPTH would fully protect microclimate functions (soil moisture, radiation, soil temperature, air temperature, wind speed, and relative humidity). Table III.9 is a summary of buffer width recommendations based on SPTH.

Table III.9. Riparian function and appropriate widths identified from FEMAT (1993).

Function	Number of SPTH	Equivalent Based on SPTH of 200 (feet)
Shade	0.75	150
Microclimate	Up to 3	Up to 600
LWD Recruitment	1.0	200
Organic Litter	0.5	100
Sediment Control	1.0	200
Bank Stabilization	0.5	100
Wildlife Habitat	0.5 to 3.0	98-600

Variable width buffer approaches have also been proposed (Forman 1995). Variable width buffers can allow for greater flexibility, account for variation in site conditions and land management practices, and potentially achieve desired ecological goals while minimizing undue losses to landowners.

In fact, a variable width approach based on site-specific conditions has been proposed to managing the marine riparian area (Levings and Jamieson 2001). Levings and Jamieson (2001) proposed the use of an interim measure consisting of site-specific buffer zones to protect nearshore ecological functions such as food production, temperature regulation, wave energy absorption, and provision of structure as well as indirect ecological value.

When applied properly, variable width buffers can be more ecologically sound because they have the potential to reflect the true complexity of the environment and management goals (Haberstock et al. 2000; IMST 2002). However, there are no generally accepted criteria for the establishment of variable width buffers. To ensure no net loss of function, variable buffers must be closely linked to the shoreline inventory and an analysis so that the most important shoreline processes and habitat areas receive the greatest protection via buffers. Where buffers will be smaller, other enhancements may be necessary to avoid cumulative loss of function.

There is consensus in the literature that buffers or protected riparian areas are critical to sustaining many ecological functions. As stated previously, much of the current science on buffers is from freshwater systems. However, the ecological functions provided by marine riparian areas are similar to freshwater riparian areas, therefore it is appropriate to apply this information until more directly applicable studies are completed. In the meantime, a precautionary approach toward regulating this habitat is recommended. A precautionary approach would rely on using the high end of the ranges required to protect specific functions. And, where there is opportunity (e.g., in areas of undeveloped or low-density shorelines with high habitat value), maximum protection would help compensate for unavoidable and cumulative impacts from development and redevelopment elsewhere in the landscape.

CONSISTENCY WITH OTHER REGULATIONS

Planners should ensure that the SMP links to other regulatory mechanisms that protect marine riparian vegetation. For example, the Growth Management Act requires protection of the following types of critical areas that are pertinent to the management of the marine riparian zone:

- Landslide hazard zones
- Steep slope/erosion hazard zones
- Fish and wildlife habitat conservation areas, including:
    - Kelp and eelgrass beds
    - Commercial and recreational shellfish beds
    - Herring, sand lance, and surf smelt spawning areas
    - Endangered, threatened, and sensitive species
    - Locally important habitats and species (e.g., Great blue heron rookeries)
- Wetlands please fix margins here

Plans to modify vegetation should be supported by appropriate surveys and assessments. It is important to consider the types of habitat areas and hazard zones that could be affected by an activity, and to prevent activities that would be destructive of marine riparian habitat in high priority areas, and minimize the impacts of otherwise allowed activities in or near the marine riparian area. Evolving SMPs have recognized the importance of these habitats and incorporate guidance for protecting these habitats. For example, the draft Whatcom County SMP includes the following language pertinent to regulating marine riparian vegetation (Whatcom SMP).

Under the section on Vegetation conservation (section 23.90.06.A):

a. Where new developments and/or uses are proposed, native shoreline vegetation should be conserved to maintain shoreline ecological functions and/or processes and mitigate the direct, indirect and/or cumulative impacts of shoreline development, wherever feasible. Important functions of shoreline vegetation include, but are not limited to:

    1) Providing shade necessary to maintain water temperatures required by salmonids, forage fish, and other aquatic biota. [Note this relates more to freshwater systems, in marine environments, shoreline vegetation will affect the substrate temperatures more than water temperatures due to the overriding influence of large volumes of cool marine water.]

    2) Regulating microclimate in riparian and nearshore areas.

    3) Providing organic inputs necessary for aquatic life, including providing food in the form of various insects and other benthic macroinvertebrates.

    4) Stabilizing banks, minimizing erosion and sedimentation, and reducing the occurrence/severity of landslides.

    5) Reducing fine sediment input into the aquatic environment by minimizing erosion, aiding infiltration, and retaining runoff.

    6) Improving water quality through filtration and vegetative uptake of nutrients and pollutants.

    7) Providing a source of large woody debris to moderate flows, create hydraulic roughness, form pools, and increase aquatic diversity for salmonids and other species. [As above, this relates to freshwater environments. In marine environments large woody debris primarily provides stability to the beach, facilitates accumulation of fine-grained substrate, and adds

habitat complexity to the upper beach area.]

8) Providing habitat for wildlife, including connectivity for travel and migration corridors.

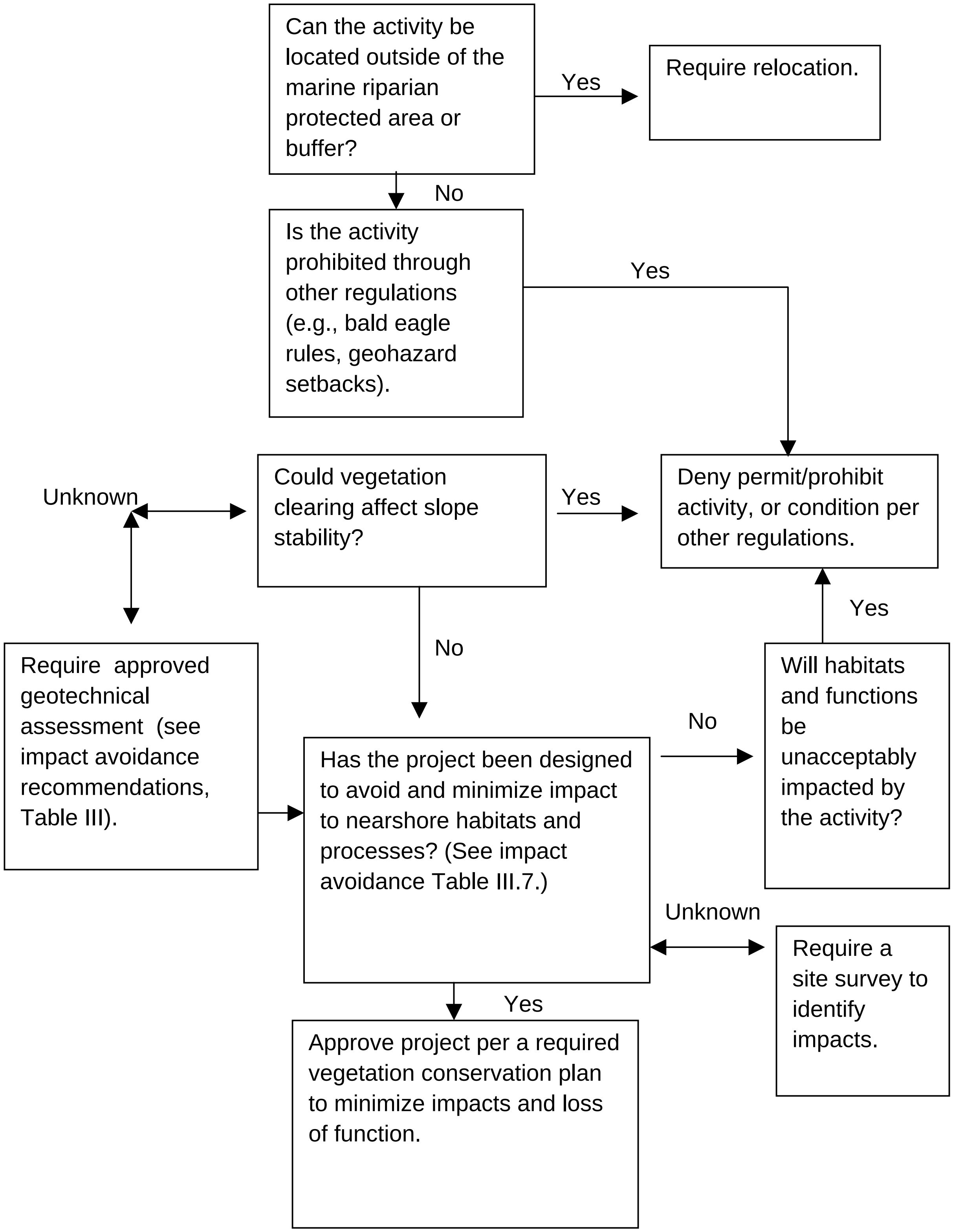
b. New residential development (section 23.100.11.B.1):

1) New residential development shall assure that the development will not require shoreline stabilization. Prior to approval, geotechnical analysis of the site and shoreline characteristics shall demonstrate that shoreline stabilization is unlikely to be necessary during the life of the structure; setbacks from steep slopes, bluffs, landslide hazard areas, seismic hazard areas, riparian and marine shoreline erosion areas shall be sufficient to protect structures during the life of the structure (100 years); and impacts to adjacent, downslope or down current properties are not likely to occur.

2) All new subdivisions shall provide for vegetation conservation to mitigate cumulative impacts of intensification of use within or adjacent to the shoreline that shall include compliance with vegetation conservation requirements of SMP 23.90.06, together with replanting and control of invasive species within setbacks and open space to assure establishment and continuation of a vegetation community characteristic of a native climax community.

The following decision tree provides guidance for regulating riparian vegetation that is consistent with SMP regulatory language. The decision tree is linked by reference to regulatory guidance, vegetation management practices, and other recommendations for impact avoidance and mitigation provided in the following sections.

Figure III.3. Recommended Review Steps in Riparian Vegetation Alteration/Clearing Projects.



MINIMIZING IMPACTS OF MARINE RIPARIAN VEGETATION ALTERATIONS

Establishing local land use regulations for marine riparian protection, should begin with formation of development regulations linked to "marine riparian protection areas". During the permit application process, project proponents should be asked to produce a vegetation conservation plan and supporting surveys that provide sufficient information to guide the approval process. Planners should use this information to assess and approve permissible projects, deny approval for projects that have unacceptable impacts, and to provide recommendations for alternative approaches where such approaches can achieve desired results with less impact. As always, the goal should be to avoid or minimize the impacts of these activities on the nearshore environment to the greatest extent possible. Design guidance recommendations are presented in Table III.10.

Table III.10. Recommendations for riparian vegetation alteration.

Regulatory issue	Recommendations
Site-specific limitations	Require surveys of the existing site and a description of functions the vegetation is providing. Identify minimum widths for marine riparian management areas that support the existing functions. Determine effect on bank stability: ◊ Require geotechnical assessment for vegetation clearing and removal projects to determine if planned activity will negatively affect slope stability (Ecology 2007b). Require maximum protection to existing marine riparian area: ◊ Disallow clearing and other vegetation management activities that could lead to increased instability. ◊ Avoid and minimize area disturbed during nearshore construction activities. ◊ Require development of vegetation management and replanting plans for any project that impacts marine riparian vegetation. Any management strategy should aim at maintaining all natural processes and functions, determined by an evaluation of the specific requirements for maintaining individual and collective functions over space and time (e.g., LWD recruitment; life history requirements of multiple species of fishes and wildlife) (Brennan and Culverwell 2004). ◊ Use a multidisciplinary approach to develop riparian management strategy. Promote off-site mitigation to address cumulative impacts. Increase public education and outreach.
Riparian protection area (buffer) requirements	The marine riparian protection area should include a "no-touch zone" or buffer tailored to protect the ecological processes and nearshore habitats. For developed areas, a protection area should act as an overlay that also requires habitat enhancement and mitigation as sites redevelop or intensify.

Table III.10. Recommendations for riparian vegetation alteration.	
Regulatory issue	**Recommendations**
Riparian protection area (buffer) requirements (cont.)	Administrative variances and exemptions should be strictly limited, and be evaluated for cumulative impacts. Enforce requirements codified in local CAOs (Ecology 1994). Pertinent CAO ordinance categories include: ◊ Landslide hazard ◊ Steep slope/erosion hazard ◊ Fish and wildlife habitat conservation areas ◊ Wetlands
Structural setback requirements	Enforce building setback requirements codified in local CAOs (Ecology 1994). Structure setbacks provide protection to aquatic area processes and riparian functions and values by increasing the distance between human activities and riparian areas. Riparian protection areas (buffers) sustain riparian functions and nearshore processes while the structural setbacks protect buffers from urban encroachment. Structure setbacks are areas adjacent to buffers where buildings and other facilities are not constructed; however, these areas may allow low impact activities such as gardening and lawns.
Impact minimization through a vegetation conservation plan	Recommend project applicants to consult with a qualified professional arborist to develop a vegetation management plan will provide desired outcomes while promoting desired ecological functions (Ecology 1993). Tree pruning and thinning: Discourage "topping" of conifers and broadleaf deciduous trees, which may lead to illness and eventual tree death. Instead, encourage alternative methods such as: ◊ Windowing ◊ Interlimbing ◊ Skirting-up Retain a minimum of 60% of the original crown to maintain tree health and vigor. Thinning and pruning activities should be conducted during the late fall to early spring dormant season. Limit pruning activities to a frequency of once every five years or less. Tree removal: Where tree removal is absolutely necessary, encourage leaving the stump or snag in place to maintain ground stability and reduce erosion. If removed trees are a potential source of LWD recruitment, they should be anchored on the beach on site. Shrub and understory: Promote retention of native understory within and adjacent to riparian buffer areas to control erosion, maintain slope stability, and provide water quality protection.

Table III.10 identifies survey and planning requirements and provides design considerations to assist planners in this regard. The information in this table is organized for consistency with the decision tree in Figure III.3.

The vegetation conservation plan and supporting professional surveys/assessments submitted by the project applicant should address the following information needs:

- Geotechnical and slope stability conditions
- Presence of hazard zones and habitat types protected under CAOs
- Shoreline characteristics (natural or developed)
- Beach substrate characteristics, presence of forage fish spawning habitat
- Presence of eelgrass or macroalgae in adjacent nearshore habitat
- Wildlife use and identified wildlife corridors
- Beach aspect and shading provided by affected vegetation
- Amount of affected vegetation overhanging the beach, providing litter and prey recruitment
- Number of affected trees greater than 4 inches in diameter at breast height that could reach the beach when downed
- Topography and relationship of the site to streets and developed properties and potential for stormwater input

The first logical step towards avoiding impacts to marine riparian habitats is to determine if the proposed vegetation alteration activity is allowable under current regulations or otherwise undesirable. If so, the project should not proceed. The following key questions should be posed:

- Are there hazard areas, critical habitat features, or priority species present that qualify for protection under local CAOs?
- Would the proposed activity affect slope stability or create an erosion hazard?

In general, CAOs and SMPs provide planners with a basis for denying large-scale alteration of vegetation within defined critical areas or shorelines, particularly where such activities would impact protected critical habitats or increase potential landslide or erosion hazards. Landowners should be dissuaded from proceeding with the activity if the geotechnical analysis indicates that a vegetation-clearing project would decrease slope stability. It is expected that most landowners will not wish to proceed with an activity that might lead to future property loss.

If the planned activity is permissible, planners should review the vegetation conservation plan, related surveys, and geotechnical analyses to determine if the activity has the potential to adversely impact sensitive habitats. If such impacts are identified, the planner should direct the applicant towards alternative approaches for achieving the desired results that avoid or minimize these impacts. Finally, if a permitted project will produce unavoidable impacts, appropriate mitigation should be identified.

STRATEGIES FOR MITIGATING UNAVOIDABLE IMPACTS

Mitigation strategies for addressing unavoidable impacts on marine riparian vegetation are identified in Table III.3.

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APPENDIX A – SHORELINE MASTER PROGRAM PLANNING PROCESS

SHORELINE MASTER PROGRAM PLANNING PROCESS

SMP UPDATE PROCESS	SPECIFIC PLANNING TASKS	PRODUCTS
Phase 1: Preliminary Shoreline Jurisdiction, Public Participation Plan & Shoreline Inventory	Task 1.1: Identify preliminary shoreline jurisdiction - shore<u>lines</u> & shore<u>lands</u> Task 1.2: Develop public participation program (citizen, technical, Ecology, other stakeholders) Task 1.3: Conduct shoreline inventory – existing land uses, public access, environmental conditions Task 1.4: Demonstrate how Phase 1 complies with Guidelines	Product 1.1: Preliminary map of local shorelines subject to the SMP Product 1.2: Public participation plan Product 1.3: Complete shoreline inventory Product 1.3.1: Draft list of inventory data sources Product 1.3.2: Digital working maps of inventory information Product 1.4 Documentation in SMP submittal checklist
Phase 2: Shoreline Analysis & Characterization	Task 2.1: Conduct preliminary shoreline inventory analysis Task 2.1.1: Characterize ecosystem-wide processes Task 2.1.2: Characterize shoreline functions; reach analysis Task 2.1.3: Analyze shoreline use and public access Task 2.1.4: Conduct visioning process to develop recommendations based on SMA policy & the characterization Task 2.2: Prepare final shoreline characterization Task 2.3: Prepare draft recommendations report Task 2.4: Demonstrate how Phase 2 complies with Guidelines	Product 2.1 (Tasks 2.1.1 & 2.1.2): Draft characterization of ecosystem-wide processes & functions; reaches Product 2.1.3: Draft shoreline use & public access analysis Product 2.1.4: Shoreline strategy for shoreline uses, public access, resource protection & restoration Product 2.2: Final shoreline characterization; accompanying map portfolio & GIS data Product 2.3: Draft report with recommended actions for translating inventory findings into policies & regulations Product 2.4: Documentation in SMP submittal checklist
Phase 3: Shoreline Environment Designation, Policy & Regulation Development	Task 3.1: Develop general goals & policies (optional regulations) Task 3.2: Develop environment designations & environment-specific policies & regulations Task 3.3: Develop shoreline use policies, regulations & standards Task 3.4 Develop shoreline modification activity policies, regulations & standards Task 3.5: Develop administration provisions Task 3.6: Demonstrate how Phase 3 complies with Guidelines	Product 3.1: Draft goals & policies (optional general regulations) Product 3.2: Draft environment designations & environment-specific policies & regulations Product 3.3: Draft shoreline use policies, regulations & standards Product 3.4 Draft shoreline modification policies, regulations & standards Product 3.5: Draft administration provisions Product 3.6: Final report demonstrating how characterization is reflected in updated SMP policies, regulations, environment designations & restoration strategies; documentation in SMP submittal checklist

SHORELINE MASTER PROGRAM PLANNING PROCESS

SMP UPDATE PROCESS	SPECIFIC PLANNING TASKS	PRODUCTS
Phase 4: Cumulative Impacts Analysis & Restoration Plan; Revisiting Phase 3 Products as Necessary	Task 4.1: Prepare cumulative impacts analysis demonstrating how SMP provides environmental protection & no net loss of ecological functions Task 4.2: Prepare restoration policies, objectives, priorities & timelines Task 4.3: Revisit environment designation, policies & regulations as necessary to achieve no net loss of ecological functions; finalize shoreline jurisdiction Task 4.4: Demonstrate how Phase 4 complies with Guidelines	Product 4.1: Cumulative impacts analysis showing how the SMP will achieve no net loss through its policies, regulations & mitigation standards Product 4.2: Restoration plan Product 4.3: Revised designations, policies & regulations to address findings of cumulative impacts analysis; a report indicating how revisions achieve no net loss of ecological functions; finalized jurisdiction, including map(s) Product 4.4: Documentation in SMP submittal checklist
Phase 5: Local Approval	Task 5.1: Assemble complete draft SMP Task 5.2: Informal Ecology review of draft SMP documents Task 5.3: Complete SEPA review, documentation Task 5.4: Provide GMA 60-day notice of intent to adopt Task 5.5: Hold public hearing Task 5.6: Prepare responsiveness summary Task 5.7: Locally adopt the draft SMP & prepare submittal to Ecology Task 5.8: Demonstrate how Phase 5 complies with Guidelines	Product 5.1: Final draft SMP Product 5.2: Ecology response following informal review Product 5.3: SEPA products (checklist, MDNS,/EIS; SEPA notice) Product 5.4: Evidence of compliance with GMA notice requirements Product 5.5: Public hearing record Product 5.6: Responsiveness summary responding to comments received during public review period Product 5.7: Complete Ecology submittal package Product 5.8: Documentation in SMP submittal checklist
Phase 6: State Approval	Task 6.1: Provide public notice & opportunity for comment; respond to comments received Task 6.2: Prepare decision packet to include: findings & conclusions; transmittal letter; conditions of approval (if any); & responsiveness summary Task 6.3: Work with local government to finalize local adoption	Product 6.1: Responsiveness summary Product 6.2: Decision package submitted to local government Product 6.3: Adoption of Final SMP incorporating any Ecology conditions of approval; updated SMP takes effect