Steelhead At Risk Report: Assessment of Washington's Steelhead Populations

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Authored by

Jeremy Cram*, Neala Kendall*, Anne Marshall*, Thomas Buehrens, Todd Seamons, Bob Leland, Kris Ryding, and Erik Neatherlin

*these authors contributed equally

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Executive summary

- **Background**: Steelhead trout (hereafter steelhead), the anadromous form of *Oncorhynchus mykiss*, are an important and iconic fish in the Pacific Northwest. Steelhead are the state fish of Washington, they are of cultural and economic value to recreational tribal and non-tribal fishermen and tribal commercial fishermen, and they are an integral part of freshwater ecosystems. Despite this importance, steelhead have declined throughout their native range in North America. In Washington State, anthropogenic activities have pushed steelhead abundances to a fraction of their historical levels. Population declines led to the listing of five of the seven steelhead Distinct Population Segments (DPS) in Washington as "threatened" under the Endangered Species Act (ESA).
- **Purpose and Scope**: In 2008, in response to declining abundance, the Washington Department of Fish and Wildlife (WDFW) Fish Program completed a Statewide Steelhead Management Plan (SSMP) that outlined policies, strategies, and actions for managing steelhead (Washington Department of Fish and Wildlife (WDFW) 2008). The SSMP is intended to direct WDFW activities towards maintaining and restoring abundance, productivity, distribution, and diversity of wild steelhead and their habitats to assure long-term health of populations. A key action stipulated in the SSMP was the production at 5-year intervals of a report on the current status of wild steelhead populations at risk of extinction. This current report fulfills that obligation and in it we 1) analyze available biological data for steelhead populations to assess status, 2) identify focal populations at high risk, 3) identify threats to viability at statewide, DPS, and focal population scales, and 4) recommend actions that can be taken to improve status and reduce extinction risks at each scale.
- **Methods**: We gathered available data on Washington steelhead populations for abundance, harvest, productivity, life history and genetic diversity, and spatial structure—factors that are indicative of extinction risk. We conducted a quantitative risk assessment to identify highest-risk populations using primarily adult escapement (spawner) abundance data because 1) data for other risk factors were inconsistently available and/or sparse and 2) objective methods for quantifying extinction risk based on other factors were unavailable. We used five metrics to produce total risk ratings. Available data on all factors along with the contents of existing status assessments and management and recovery plans were used to identify key threats and associated recovery actions.
- **Key Results: Population Status and Risk**
    - Of the 73 steelhead populations that were or are monitored and had sufficient abundance data, a majority, 38 (52%), showed decreasing trends (abundance change < -10%) since 1980, 30 (41%) showed an increasing trend (change >10%), and 5 (7%) showed a low level of change suggesting no trend. Puget Sound (18%), Olympic Peninsula (20%), and Southwest Washington (38%) DPSs had the lowest proportions of populations with increasing trends. Abundance data were not available for 41 populations.
    - Regarding population productivity, average within-DPS population growth rates (2005-2010 brood years) have been higher for Lower Columbia River, Middle Columbia River, Upper Columbia River, and Snake River Basin populations than for Puget Sound and Olympic Peninsula populations. Population growth rates above replacement for Columbia River Basin populations, which were historically reduced to very low adult abundances, are encouraging and suggest that compensatory juvenile production (increased per capita productivity at low adult abundance) may be sufficient to allow population growth at current smolt-to-adult return rates (< 5 %).

- We report population spatial structure status in terms of habitat loss due to large, impassable dams. The percentage of populations in the following DPSs with 5% or greater habitat loss are: Puget Sound - 19%; Olympic Peninsula - 0%; Southwest Washington - 11%; Lower Columbia - 22%; Middle Columbia - 44%; Upper Columbia - 75%; Snake River Basin - 25%. With a habitat loss of 98.7%, the Baker River population (Puget Sound) is considered extirpated. Grand Coulee Dam on upper Columbia River mainstem extirpated at least six historical Upper Columbia DPS populations. Other fish passage barriers such as culverts and roads reduce a population's spatial extent and it is likely that steelhead habitat loss from these smaller barriers is extensive. However, data were not available statewide to quantify these habitat losses.
- Evaluation of life history diversity status within and among DPSs was limited due to few populations with appropriate data. Freshwater age composition from smolts was available for 17 populations or subpopulations statewide, and the majority of smolts left freshwater after two years, with average outmigration age ranging from 1.6 to 2.4 years. Based on data from 21 winter-run and 15 summer-run populations or subpopulations, winter-run steelhead average ocean age ranged from 2.3 to 2.5 years, and summer-run steelhead average ocean age ranged from 1.4 to 2.0 years. Similarly, evaluation of genetic diversity status was limited statewide due to only 50% of populations having available baseline data. Genetic data availability was lowest for Olympia Peninsula and Southwest Washington DPSs (16.1% and 21.1% of populations, respectively).
- The size and type of hatchery steelhead releases served as indicators of diversity risks from potential gene flow between hatchery and wild steelhead. Total average annual smolt releases for 2009-2013 were lower than those for 2000-2008 in all DPSs except for Southwest Washington. The largest reductions in smolt releases between the two time periods occurred in Puget Sound DPS, followed by Olympic Peninsula and Snake River Basin DPSs. Average percent of off-site hatchery smolt releases was highest in Olympic Peninsula, Middle Columbia, and Snake River Basin DPSs in both time periods. In Puget Sound DPS, average percent of off-site hatchery smolt releases for 2009-2013 was substantially lower (16.4%) than that for 2000-2008 (40.4%).
- Statewide, among populations with available data, the long-term abundance trends of only 10 populations (14%) declined by > 55% (high risk criterion 1). Eight of those populations were in Puget Sound DPS and there was one each in Olympic Peninsula and Lower Columbia DPSs. Regarding risk from short-term (12 year) decline, only five populations (7%) showed a growth rate significantly less than zero (high risk criterion 2). These included one Puget Sound population, two Olympic Peninsula populations, and two Southwest Washington populations.
- Of the 69 populations with abundance data and a defined quasi-extinction threshold (QET), 18 (26%) had a > 20% probability of abundance falling below their QET at least once in the next 20 years (high risk criterion 3). The Lower Columbia DPS had the lowest percentage of populations (17%) that met this extinction risk criterion and the Upper Columbia DPS had the highest percentage (75%).
- Of the 71 populations with defined escapement or recovery goals and appropriate abundance data, 51 (72%) did not have abundance values above their escapement or recovery goal in seven or more of the recent 10 years (high risk criterion 4).
- Out of the 21 populations rated at high risk over all criteria, we selected 15 as focal populations in these DPSs: Puget Sound - 9; Lower Columbia - 2; Middle Columbia - 1; Upper Columbia - 2; Snake River Basin - 1. We provide detailed descriptions of threats and actions for the focal

populations based on existing management and recovery plan documents and highlight WDFW opportunities for actions.

- Historical changes in steelhead abundance have resulted from changes in habitat (freshwater and marine), dams and passage barriers, hatcheries, and harvest. However, the contribution of each factor to recent changes in abundance has been unequal. Recently, variable marine survival has influenced adult abundance trends among DPSs. Additionally, higher juvenile freshwater survival through Columbia Basin hydropower dams in recent years has provided relatively synchronous improvements in adult abundance for Upper Columbia River, Middle Columbia River, and Snake River Basin DPSs. The effects of changes in hatchery management along with freshwater spawning and rearing habitat conditions on short-term abundance trends are less clear because population abundance response rates are likely slower, less synchronous among populations, and/or harder to measure.

- **Key Results: Threats and Actions**
  - **Hatcheries**: Ongoing hatchery reform efforts are focused on reducing threats to wild populations posed by hatcheries. WDFW has designated areas as wild steelhead gene banks in Olympic Peninsula and Lower Columbia DPSs and is working on designations in other DPSs. Statewide risk-reduction action recommendations included: 1) continue hatchery reform efforts to ensure hatcheries are compliant with HSRG recommendations; 2) improve population-scale monitoring of hatchery genetic and ecological impacts; 3) implement volitional steelhead smolt release; and 4) incorporate demographic analysis into conservation hatchery planning to determine whether the demographic boost intended by such programs is actually needed and to facilitate appropriate sizing of these programs.
  - **Harvest:** Long-term average harvest rates have been greatest in the Olympic Peninsula DPS (27%) and lowest in the Lower Columbia DPS (5%), with moderate harvest rates in Puget Sound (7.2%) and Southwest Washington (6.8%) DPSs. However, the population-specific impacts of these harvest rates are difficult to interpret without accompanying demographic analyses, since risks posed by harvest depend on a population's productivity. Harvest threats to wild steelhead are managed through mark-selective sport fisheries that require wild steelhead release, by legal prohibition of non-tribal commercial sale of steelhead, and through tribal treaty fisheries' operations designed to achieve conservation objectives. However, harvest-related threats remain, including 1) the inability to completely account for fishery non-retention mortality in all areas outside the Columbia Basin; 2) existing methods producing inaccurate harvest impact estimates; and 3) unknown levels of mortality from illegal harvest or unreported catch. Recommended threat-reducing actions included: 1) implement the practice of systematically and consistently estimating total harvest mortality on populations statewide; 2) initiate and continue studies to measure non-retention mortality and sub-lethal impacts to steelhead released from fisheries; 3) quantify risks by developing methods to estimate harvest mortality that include measures of precision and bias; and 4) undertake studies to quantify illegal harvest of wild steelhead and work to increase enforcement where necessary.
  - **Dams, barriers, and fish passage**: Dams and other fish passage barriers continue to present some of the greatest threats to steelhead viability statewide. Besides blocking or restricting up- and down-stream migration, barriers interrupt wood and sediment transport, hindering maintenance and creation of critical habitat. WDFW estimated that 18,000-20,000 barriers to salmon and steelhead exist in Washington streams. In the Columbia Basin, threats to all life stages from passage at mainstem dams and reservoirs include longer and delayed migration times, greater exposure to predation, elevated water temperatures, and physical harm. Action

recommendations included: 1) continue to work with all dam operators to ensure adult and juvenile passage survival targets (required by licenses, settlement agreements, and Habitat Conservation Plans) are met; 2) improve downstream passage of pre-spawn adults, kelts, and juveniles at all dams and irrigation diversions, 3) continue active engagement on the Columbia River Technical Management Team, Fish Passage Advisory Committee, and Comparative Survival Study; 4) improve mapping of small fish passage barriers and potential upstream habitat; and 5) complete the statewide removal of all artificial fish passage barriers, including hatchery facility structures, on WDFW-owned lands by 2026. Activities related to many dams, barriers, and fish passage actions described in this document have already begun and we hope that they will be continued.

  - **Habitat:** Freshwater habitat that steelhead depend on is degraded throughout the state due to a legacy of natural resource extraction, agricultural practices, increased surface flow diversion, and development. Habitat loss is a primary factor limiting steelhead abundance and recovery in all DPSs. Actions that would increase freshwater habitat capacity (quality and quantity) may be highly effective for increasing adult abundance if, as suggested by our productivity analysis, the number of smolts per spawner is density limited. Recommended actions include: 1) continue to develop tools to link life stage-specific survival bottlenecks directly to habitat restoration actions; 2) continue to support habitat restoration by expediting Hydraulic Project Approval (HPA) permits, providing environmental engineering expertise, and offering steelhead-specific planning and design assistance; 3) continue to invest, including via acquisition and easement, in instream flow enhancement where feasible including instream water transfers, irrigation or water-use efficiency projects, and fish screens at instream diversions to help achieve adequate streamflow levels, guard against critical temperature exceedance, and prevent fish entrainment; 4) continue to collaborate with habitat restoration and protection efforts statewide, especially cold water refuges, riparian, and nearshore habitats; and 5) continue to protect existing freshwater habitat through HPA program, Forest Practices, Priority Habitats and Species (PHS) riparian management recommendations, and acquisition and easement programs. Activities related to many habitat actions described in this document have already begun and we hope that they will be continued.

- **Key Results: Monitoring and Data Gaps**
  - The lack of abundance, productivity, and diversity data was most the common impediment to conducting wild steelhead status assessments statewide. For example, even basic adult abundance data are unavailable for 33 of 114 (29%) extant populations, and smolt-to-adult survival estimates exist for only 16 of the 114 (7%). Implementing methods that will increase the availability of monitoring data, as well as their accuracy and precision, and improve future evaluations of population status should be prioritized. High-quality monitoring data are needed to measure effectiveness of management actions intended to improve status.
  - Steelhead populations in western Washington are generally less-rigorously monitored than those in the central and eastern part of the state. Monitoring of Columbia Basin populations has improved in the past decade. It is critically important that ESA-listed populations statewide be monitored sufficiently to detect progress towards delisting. Specific recommendations included: 1) initiate comprehensive population-scale monitoring, including adult and juvenile abundance and age composition, for one or more moderate- to large-sized populations in Puget Sound, Olympic Peninsula, and Southwest Washington DPSs and 2) develop improved redd monitoring designs that include representative sampling, estimates of females per redd, observer efficiency, redd life, and methods to account for error in subsequent abundance estimates.

- Harvest monitoring data gaps include few current mortality estimates for wild steelhead released in sport fisheries or from net drop-out in tribal fisheries along with a lack of uncertainty estimates for mortality due to other fisheries. We suggest that modifying the sport catch record card (CRC) system to accommodate unbiased estimation of wild steelhead release mortality would greatly reduce creel survey costs and increase spatial and temporal coverage of sport fishery impacts. We recommend that methods be developed to estimate numbers of wild steelhead released by sport fishers and to incorporate measurement uncertainty in CRC-based harvest estimates. We make additional suggestions, above, about improving our ability to monitor harvest mortality.
- Monitoring hatchery impacts is hindered by currently the low capacity to, and high cost of, estimating gene flow or percent of hatchery-origin steelhead spawning in the wild. Gene flow assessments are possible using genetic stock identification (GSI) for segregated hatchery stocks, but due to high costs this method has only been implemented in a small subset of stocks and years. Gene flow assessment is particularly difficult for integrated hatchery programs due to 1) genetic similarities of hatchery and wild fish, which negates the use of GSI as a monitoring tool, and 2) difficult observational conditions on spawning grounds, which complicate visual identification of fin-clipped hatchery-origin spawners. For most western Washington populations, no methods currently exist to obtain monitoring data required for integrated hatcheries to be in compliance with Hatchery and Genetic Management Plans. For integrated hatcheries, we recommended the development of parentage-based or field methods for quantifying reproductive interactions between wild and hatchery steelhead. Limited efforts have been made to quantify ecological impacts of hatcheries on wild populations, including competition, predation, and disease. We recommend future efforts to better quantify these impacts.
- Improvements are needed in the ways WDFW's monitoring data are stored, managed, and made available to managers and others. Specific data management recommendations include: 1) expand and develop data entry and data analysis capabilities of the WDFW-managed juvenile salmonid database and 2) develop a standardized harvest reporting database where steelhead exploitation rates and supporting metadata are entered and stored.

- **Key Results: Progress since 2008**: Scott and Gill (2008) contained a list of 35 recommendations on eight topics: biology, habitat, artificial production, management, population structure, diversity and spatial structure, and abundance and productivity. We report attention and action directed towards 30 of these recommendations.
- **Intended Use and Relationship to Other Evaluations**: This report is intended as a statewide review of steelhead population status, threats, and recovery actions. Its scope is sufficiently large to encompass goals of population assessments and recovery planning processes conducted at other spatial scales (e.g., NOAA DPS-scale status reviews and watershed/population-scale habitat restoration, fishery, and hatchery management plans). As such, this report does not supersede other efforts but rather complements them by synthesizing their findings and rendering them comparable at a statewide scale. In order to accomplish this we had to develop standardized methods to compare populations statewide regardless of differences in data availability and methods used in previous regional reviews and management processes. The risk assessment is at a relatively coarse scale in order to maintain comparability among populations, and it does not make use of more extensive data available for smaller subsets of populations.

This report presents a high-level synthesis of population status, threats, and recovery actions rather than a detailed recovery or action prioritization plan. We focused on near-term recovery and management actions that 1) could improve status and viability of individual steelhead populations, entire DPSs, and statewide and 2) WDFW has a greater ability to influence or implement over shorter time frames with less dependency on external support. For this second reason, habitat restoration-related actions were not a principal focus of this report.

Chapter 1 Steelhead background information

1.1 Biology and life history

There are certain aspects of steelhead biology and life history that are critical to review for this report. Steelhead display perhaps the most diverse and complicated biology and life history of the Pacific salmon and trout. Spawned in freshwater gravel, steelhead juveniles typically spend 1-4 years in freshwater before undergoing smoltification and migrating to the ocean, where they typically spend another 1–4 years (Busby et al. 1996; Kuzishchin et al. 2007; Quinn and Myers 2004). That is, if they go to sea at all. The species is characterized by partial migration, wherein some individuals in a population undergo marine migrations before returning to freshwater to breed (anadromous steelhead) and others complete their entire life cycle, including maturation and reproduction, within freshwater (resident rainbow trout or precocial parr; Behnke 2002; Kendall et al. 2015). *O. mykiss* is naturally a spring spawning species, however populations vary in their timing of return migration to natal rivers; some enter freshwater in a sexually immature state between 6-12 months before spawning ("summer-run" steelhead; Behnke 2002), while others initiate reproductive migrations the fall, winter, and spring just prior to spawning in a more advanced state of sexual maturation ("winter-run" steelhead).

In coastal areas, winter-run steelhead are generally widely distributed, whereas summer-run steelhead populations are typically found in watersheds with waterfalls that are impassable to salmon and are seasonally impassable to steelhead during winter months (e.g., Withler 1966). In these watersheds, the vast majority of summer-run steelhead spawn upstream of these barriers so they are spatially isolated from winter-run steelhead spawners. Summer-run steelhead are also the dominant form in the upper portions of very large rivers that require long migration distances (e.g., Columbia, Skeena, Fraser). Finally, *O. mykiss* is an iteroparous species in which most fish survive spawning and migrate back out to the ocean. They may spawn up to five times in their lifetime, in consecutive years or alternate years, however most individuals in most populations only survive to spawn once (Behnke 2002; Busby et al. 1996). For more details on the biology and life history of *O. mykiss* in Washington, see the assessment by Scott and Gill (2008; http://wdfw.wa.gov/publications/00150).

The complex biology and life history of *O. mykiss* make monitoring a challenging task. Steelhead smolts are generally larger than those of Pacific salmon (Behnke 2002) and have greater swimming ability. Thus, they are more difficult to trap using equipment that effectively traps salmon smolts, especially during low flows and in low gradient sites, which are usually chosen in order to capture smaller, more abundant juvenile salmon (Kinsel et al. 2013; Topping and Zimmerman 2013; Volkhardt et al. 2007). The protracted return migration of adult steelhead necessitates a long monitoring season to enumerate their abundance. Additionally, the spawn timing of steelhead, in the late winter to spring, occurs during the period of high stream flows, which limits visibility of redds and spawning fish. Because steelhead are iteroparous, few carcasses are present for enumeration of spawners or collection of biological data from carcasses such as scales or otoliths for aging or tissue samples for genetic analysis. While sampling stream-resident juveniles by electrofishing is often the easiest way to sample *O. mykiss*, resident rainbow trout are visually indistinguishable from steelhead at that age. In addition, summer-run and winter-run juveniles may occupy the same freshwater habitat, and they are also visually indistinguishable.

Thus, long spawning seasons, poor visibility during spawning, adult survival post-spawning, cryptic juvenile identity, and low juvenile trapping capacity are the major challenges for collecting adequate data on abundance, productivity, and diversity. These data collection challenges have been met for some Washington populations, and could be overcome in more areas if adequate financial resources were available to support effective monitoring strategies.

1.2 Population structure for management and recovery

Steelhead populations are grouped within a hierarchical management and recovery spatial structure. "Distinct Population Segments" (DPSs) are high-level groupings under the federal Endangered Species Act (ESA; for more details see Ford 2011). The National Oceanic and Atmospheric Administration (NOAA) established DPSs for west coast steelhead (Busby et al. 1996; note that DPSs were originally called Evolutionary Significant Units [ESUs]) and the seven DPSs that include steelhead spawning in Washington are: Puget Sound, Olympic Peninsula, Southwest Washington, Lower Columbia River (LCR), Middle Columbia River (MCR), Upper Columbia River (UCR), and Snake River Basin (SRB; Figure 1). Five of Washington's seven DPSs are listed as threatened under the ESA: Puget Sound, LCR, MCR, UCR, and SRB.

Within these ESA-listed DPSs, lower hierarchical levels, called Major Population Groups (MPGs), have been defined for recovery planning. These are groups of populations with similar biological and ecological characteristics within distinct geographic regions of a DPS. Populations are the lowest hierarchical scale for recovery, and ESA-listed populations have been described as Demographically Independent Populations (DIPs). The Olympic Peninsula and Southwest Washington DPSs currently are not listed under the ESA and thus MPGs and DIPs have not been defined by NOAA. Instead, populations within these two non-listed DPSs were described by WDFW and tribal co-managers for the Salmonid Stock Inventory (SaSI). We organized our evaluation to complement this management hierarchy and we provide information and recommendations at the statewide, DPS, and population levels. When only sub-population-level data were available, we provided information at that level. Sub-populations are regarded as non-independent units within a population.

Within the seven DPSs in Washington, there are 115 currently recognized, extant populations of steelhead (Table 1; Figures 2-8). Winter-run populations predominate in the four western Washington DPSs. Only summer-run populations occur in UCR and SRB DPSs. Three populations in the Puget Sound DPS and one population in the MCR DPS are described as summer- and winter-run (Table 1). This designation was made because these populations contain fish of both return-timing life histories and the extent to which the life history types are reproductively isolated either appears insubstantial or is unknown. In Puget Sound summer- and winter-run populations, most of the fish currently are winter-run. Three populations recognized as historically present but that we considered extirpated are Baker River summer- and winter-run (Puget Sound), North Fork Lewis summer-run (Lower Columbia), and White Salmon River summer- and winter-run (Middle Columbia).

Table 1. Summary of the currently recognized 115 extant Washington summer- and winter-run steelhead populations in each Distinct Population Segment (DPS).

DPS	Summer-run populations	Winter-run populations
Puget Sound	5	26[1]
Olympic Peninsula	7	24
Southwest Washington	2	17
Lower Columbia River	4	14
Middle Columbia River	8[2]	0
Upper Columbia River	4	0
Snake River	4	0

[1]Three populations include both summer- and winter-run life histories

[2]One population includes both summer- and winter-run life histories

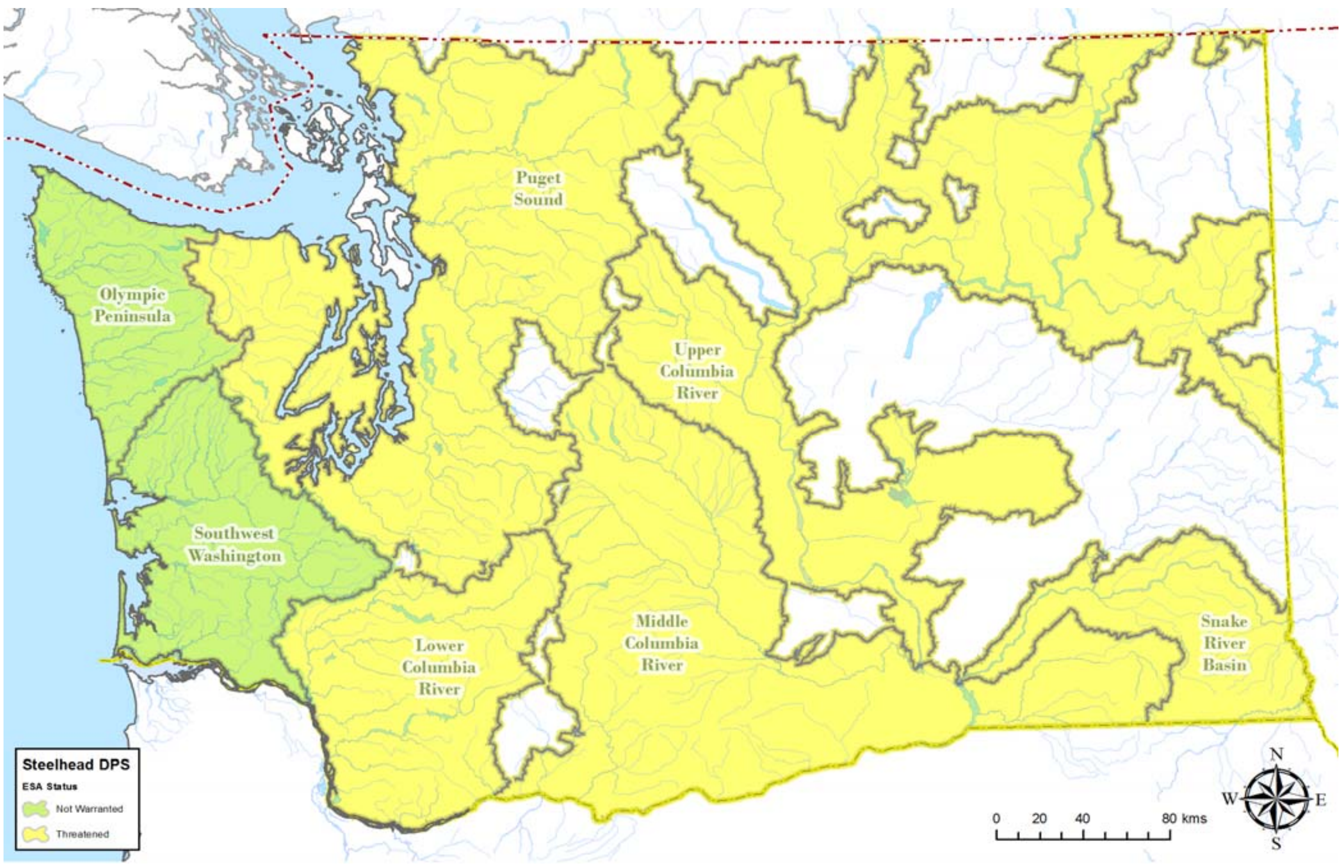

Figure 1. Map of the seven steelhead Distinct Population Segments (DPSs) in Washington State.

Figure 2. Map of the Puget Sound steelhead DPS in Washington. Many of the individual dams that are in the region are labeled (though not all appear on this map).

Figure 3. Map of the Lower Columbia River steelhead DPS in Washington. Many of the individual dams that are in the region are labeled (though not all appear on this map). SRS indicates a sediment retention structure.

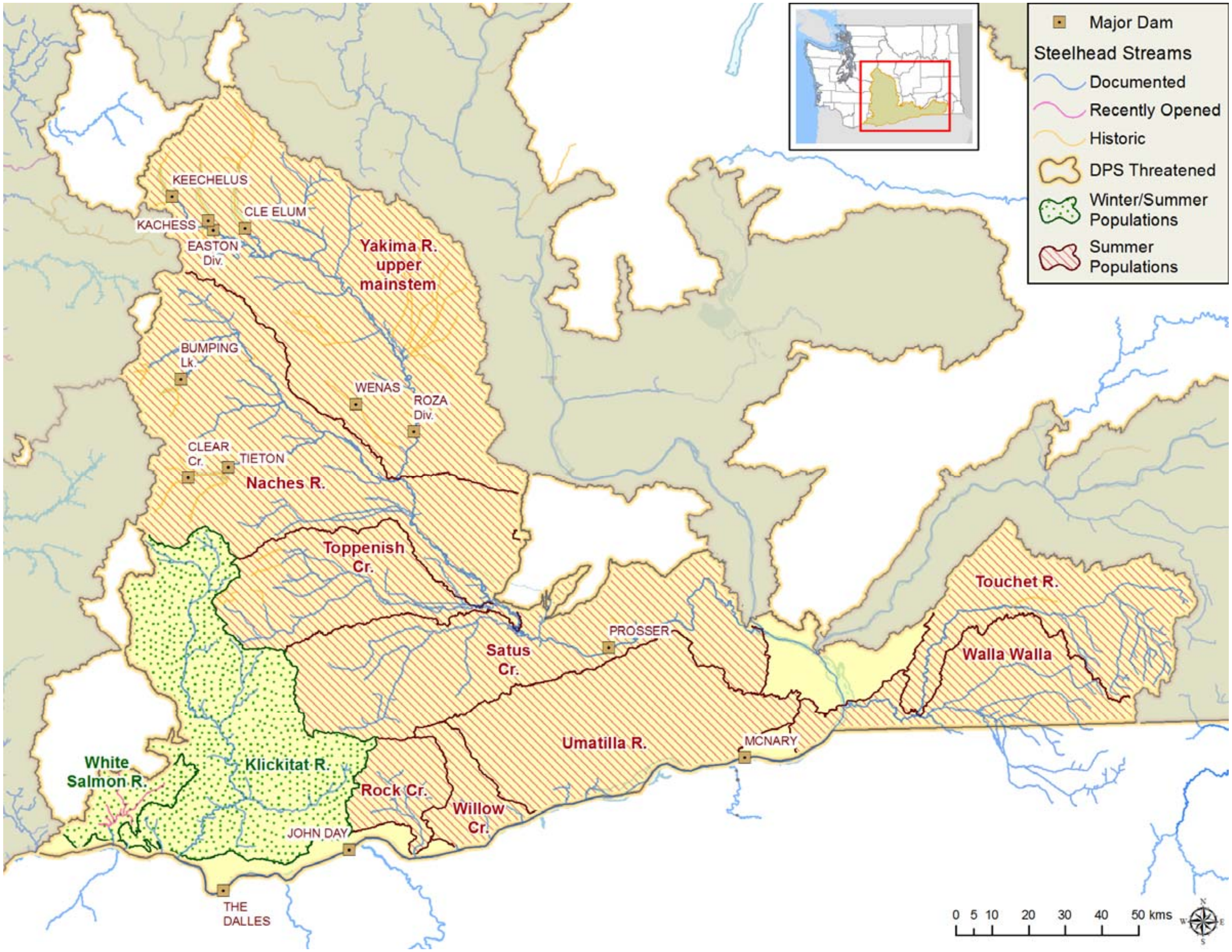

Figure 4. Map of the Middle Columbia River steelhead DPS in Washington. Individual dams are labeled. The Willow Creek and Umatilla River populations are largely in Oregon, with some small Washington streams included in population boundaries; they are not considered Washington populations in this report.

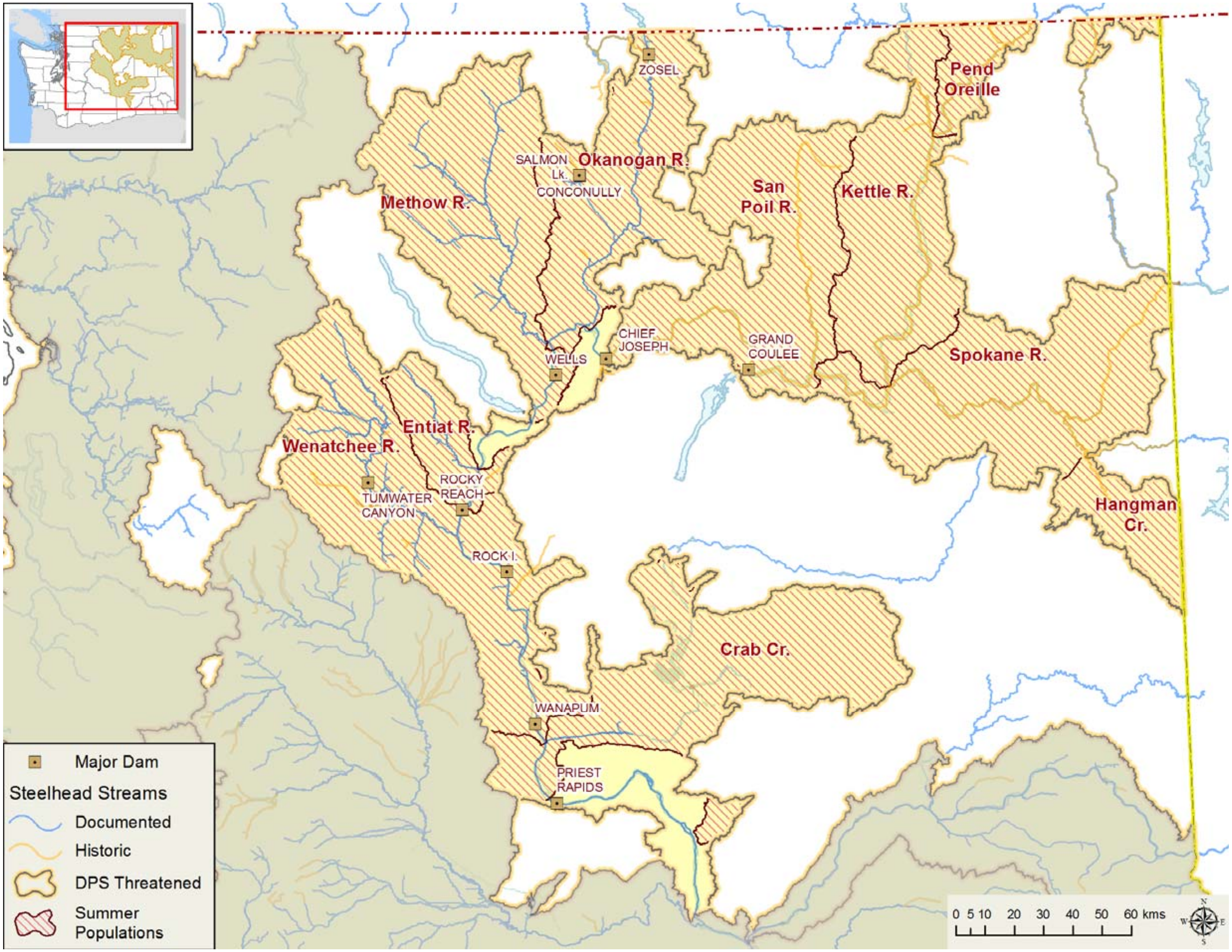

Figure 5. Map of the Upper Columbia River steelhead DPS in Washington. Individual dams are labeled. Populations upstream of Chief Joseph Dam are extirpated.

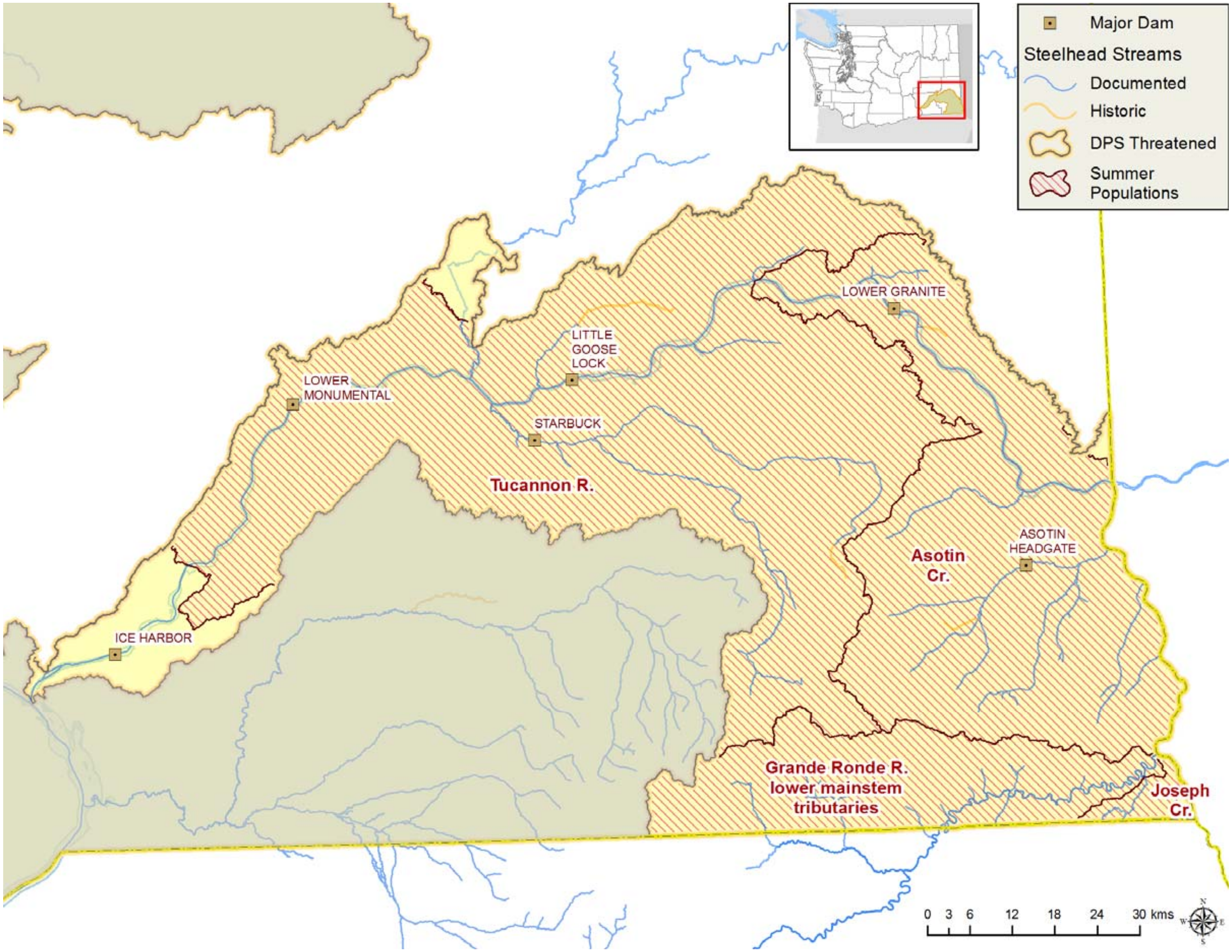

Figure 6. Map of the Snake River Basin steelhead DPS in Washington. Individual dams are labeled.

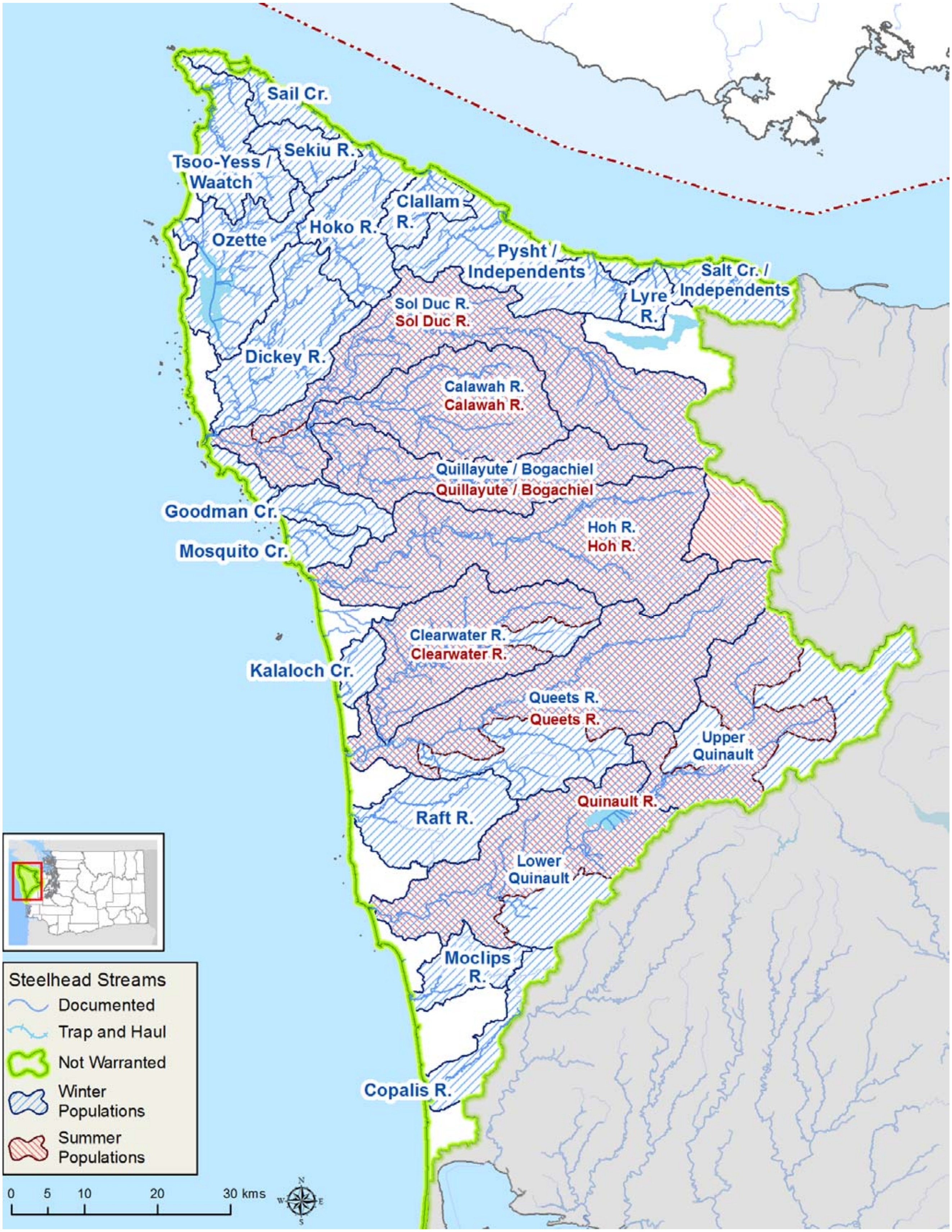

Figure 7. Map of the Olympic Peninsula steelhead DPS in Washington.

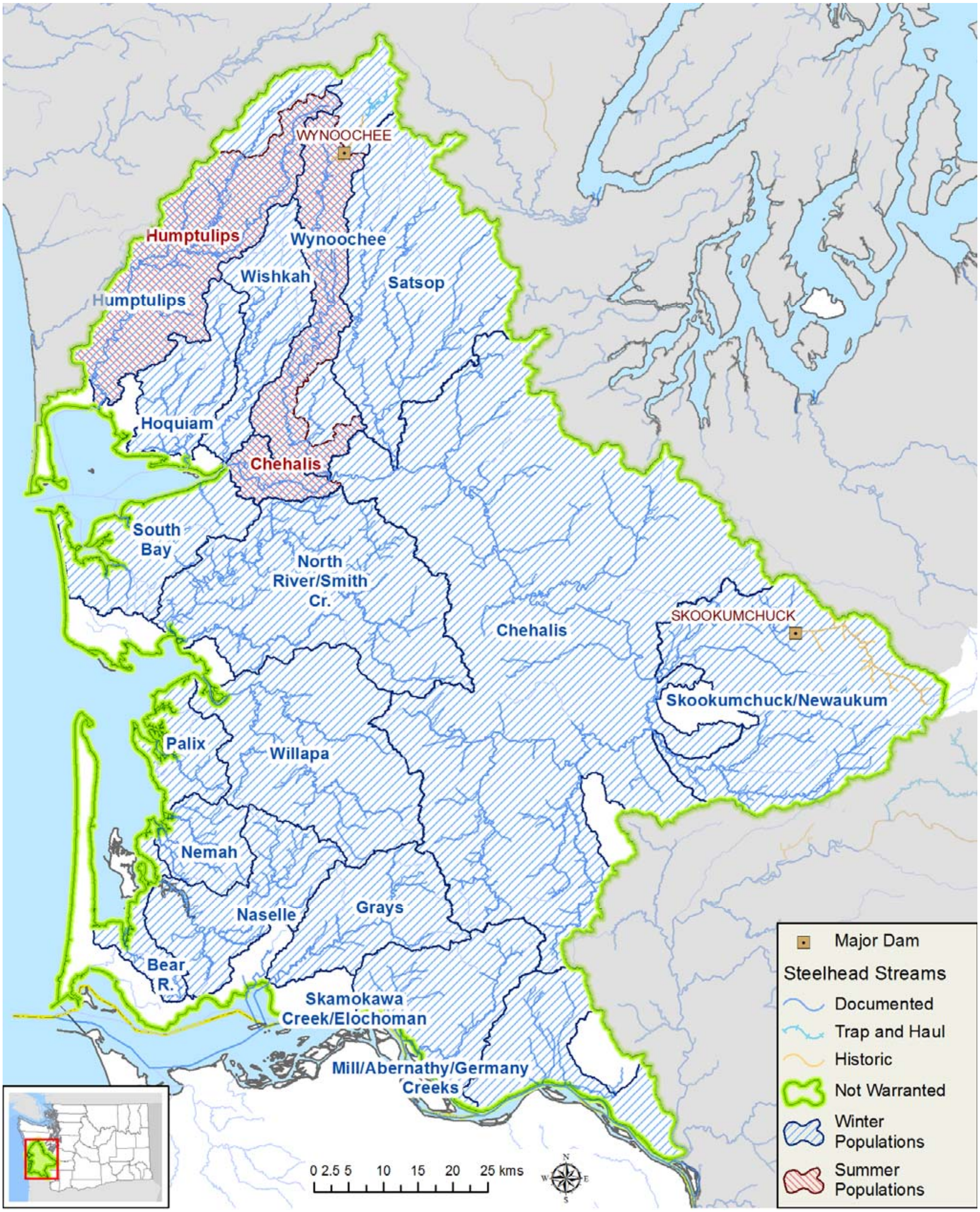

Figure 8. Map of the Southwest Washington steelhead DPS.

Chapter 2 Data availability and status assessment methods

In this chapter we summarize the availability and quality of data for all steelhead populations and describe methods we used to assess population status and trends. We collected and standardized a set of steelhead data for the four viable salmonid population (VSP) parameters—abundance, productivity, spatial structure and diversity (McElhany et al. 2000)—for all years and populations for which data were available. NOAA uses VSP parameter data in their periodic status reviews of ESA-listed steelhead. Some data we use here, such as annual population abundance estimates, are supplied to NOAA for their reviews. Our objectives here are to:

- describe available data and their quality relative to existing data collection methods,
- summarize data availability for measuring status and trend for VSP parameters, and
- describe our methods for assessing current steelhead status for each parameter.

Our status and trend analyses were controlled by the type and extent of data available for population-level abundance, productivity, spatial structure, and diversity. As described in this chapter, adult escapement and total run size abundance data were the only data types widely available and suitable for quantitative analyses. Some data were available for quantitative analyses of productivity but not enough for a state-wide assessment. Data we had for spatial structure and diversity were used as indicators of status for those parameters. Overall, available data for productivity, spatial structure, and diversity were used to qualitatively assess current conditions and identify threats.

2.1 Historical context

Comprehensive steelhead monitoring programs, especially for annual abundance, were initiated in the 1970s as a result of the Belloni (*US v. Oregon*) and Boldt (*US v. Washington*) decisions. The purpose of monitoring in the 1970s was for conservation (i.e., ensure sufficient spawners to maximize harvest benefits) and allocation of harvestable steelhead between tribal and sport fishers. During this time, WDFW developed redd-based adult abundance monitoring programs in western Washington whereas abundance was tracked using dam counts combined with redd surveys in the Columbia River basin. As part of steelhead redd surveys, fish are rarely handled for scale or tissue collection, which would yield age, genetic, and other biological information. Sampling at dams often allows the collection of such information as fish can be handled at dam traps. However, redd surveys can provide spatial structure and spawn timing diversity information, which could help inform VSP parameters.

Total steelhead abundance (escapement to the spawning grounds plus the number of fish that otherwise would have returned had they not been harvested) has been estimated using adult harvest data from various sources. Recreational harvest has been estimated using catch record cards (CRC; http://wdfw.wa.gov/fishing/catch_record_card/), on which anglers are required to record all retained steelhead, and creel surveys. Tribal harvests have been estimated from commercial sales receipts ("fish tickets" completed by buyers). By the mid-1980s hatchery steelhead were mass marked (i.e., all fish were adipose fin clipped), which allowed harvested wild fish to be accurately identified. Subsequently, mark-selective recreational fisheries, which required the release of wild (unclipped) steelhead, were implemented to focus harvest on hatchery steelhead. Beginning in July 2016, all recreational steelhead fisheries require the release of wild steelhead. Some mortality of released wild steelhead does occur and is estimated as a percentage of encounters in recreational fisheries.

These monitoring programs and management actions have provided much of the data we used to evaluate status and trends. Newer monitoring methods or programs have been implemented, such as to address recovery needs for ESA-listed steelhead, and are described below.

2.2 Abundance

2.2.1 Adult spawner abundance

Adult escapement abundance estimates that are available for most populations of winter- or summer-run steelhead outside of the Columbia River Basin are based on redd counts (Gallagher et al. 2007). Spawning areas, or subsets of them, are periodically surveyed by foot, boat, or from the air throughout the spawning season, and redds are counted. The redd counts may be expanded to account for areas that are not surveyed or corrected for water clarity to estimate total redds. To estimate total spawners, final redd count estimates are multiplied by an estimated number of fish per redd. In western Washington, redds counts are multiplied by 1.62 fish per redd, based on data from Snow Creek steelhead studies (US Fish and Wildlife Service (USFWS) and Washington Department of Game (WDG) 1980). Redd-based abundance estimation models require assumptions including: 1) the spatial distribution of spawning areas is known (Stevens et al. 2007), 2) surveyed areas are a representative subset of all spawning areas (Liermann et al. 2014), 3) all redds are detected, 4) the number of redds per female is known and is constant across habitats, and 5) if individual redds are not tracked (e.g. redd census counts), the redd life is known (i.e., how long a redd stays visible is known; Parsons and Skalski 2009). Redd-based abundance estimates rarely included estimates of their uncertainty.

Other methods such as mark-recapture or live spawner and carcass counts have been used successfully to accurately estimate adult abundance for salmon populations, but these methods have proved challenging to implement for steelhead, particularly winter-run fish, due to a protracted migration period, adverse environmental conditions during their migration (high stream flows), modest abundance (relative to other salmonids), and post-spawning emigration from rivers (e.g., kelting behavior). Summer steelhead life-history has enabled collection of more accurate abundance data, particularly in the Columbia River Basin where summer steelhead are typically counted at dams or tagged as part of mark-recapture programs (e.g., Crawford and Herr 2015).

For UCR summer-run steelhead, an old methodology that relied primarily on dam counts is being replaced with passive integrated transponder (PIT)-tag based estimation for more accurate and precise population-scale estimates of abundance over time. Monitoring of LCR summer-run steelhead populations downstream of Bonneville Dam switched from redd-based methods to mark-recapture (re-sight) methods in the 1990s and 2000s. Fish from these populations are externally tagged (e.g., spaghetti tags) during their migration, and then later visually surveyed during their holding period by snorkelers. Abundance estimates are made by using the number of tagged fish relative to snorkel counts of tagged and untagged individuals and applying mathematical abundance models (e.g., Lincoln-Petersen mark-recapture models). Mark-recapture models require assumptions that are easily tested (Parsons and Skalski 2009) and the estimates they generate undergo statistical tests to correct for bias if needed. WDFW's summer-run population estimates made with this method are the only statewide adult abundance estimates that include an estimate of uncertainty (precision).

We acknowledge that available redd-based abundance estimates we used in this report may be biased, inaccurate, or imprecise when assumptions were not met and error was not calculated. We recognize also that if abundance estimates do not accurately approximate abundance, status or viability analyses could be erroneous. We used annual adult escapement estimates for populations that were available in WDFW's SaSI database, and assumed these represented the best available data for abundance. If only subpopulation abundance data were available, they were used to represent a population, and we described results accordingly. In some cases, available abundance data represented only a proportion of a population and we used these data as an index of abundance. Detailed, population-specific information is available at https://fortress.wa.gov/dfw/score/score/species/steelhead.jsp?species=Steelhead.

Abundance data were included in analyses only if they were available for at least three consecutive years since 1980 and data collection is ongoing. The abundance estimates we used (Appendix A) may not be identical to those currently present in SaSI because data may have been updated after our acquisition.

2.2.2 Total abundance and harvest estimates

For many Washington steelhead populations, fishery harvest occurs before fish reach their spawning grounds (as the escapement), so harvest estimates are needed to estimate total annual adult abundance. Total abundance is often referred to as total run size and is a measure of all adult fish that survive their ocean migration and return to freshwater to spawn. Wild steelhead adults are principally affected by three sources of fishery mortality: non-tribal recreational fisheries (hereafter sport fisheries); direct or incidental mortality in tribal fisheries directed at steelhead or other species, including those for commercial, ceremonial, and subsistence purposes; and incidental mortality (bycatch) in non-tribal commercial fisheries for other species, such as Chinook salmon. Impacts on wild steelhead from most sport fisheries and non-tribal commercial fisheries result from mortality due to capture and handling rather than from directed harvest since releasing wild steelhead is required in those fisheries. Directed harvest and retention of wild adult steelhead are currently permitted in all tribal fisheries throughout the state and until 2016 wild harvest was permitted in sport fisheries in eight rivers within the Olympic Peninsula DPS. Historically, retention of sport-caught wild steelhead was permitted in many more rivers.

To calculate total abundance for populations, estimates of wild steelhead harvested or incidentally killed in sport, tribal, and non-tribal commercial fisheries were added to escapement counts. Note that steelhead harvest or mortality estimates typically are point estimates with no estimated uncertainty (variance) due to sampling methodology. In some areas, total annual harvest estimates were available only at a watershed ("system")-wide level (that included multiple populations) instead of the population level. For non-Columbia River populations, we used total harvest estimates that were reported in management plan reports and run reconstructions (R. Leland, WDFW, unpublished data). For Columbia River populations, we used escapement data and back-calculated total run size after accounting for mortality in various fisheries the populations encountered. These totals often included one or more fishery harvest components, and components were estimated as follows.

First, directed harvest estimates for wild steelhead-retention in sport fisheries were derived from CRC data and supplemental information from statistical creel or telephone surveys designed to improve recreational harvest estimate accuracy (Kraig 2013). Second, methods used to estimate incidental bycatch mortality (e.g., 'hooking mortality') of wild steelhead in sport fisheries varied by area. For non-Columbia River populations, we only used population- or system-specific data reported in harvest management plans or run reconstruction reports. In contrast, sport fishery incidental harvest rates of wild steelhead in the Columbia River were reported by season and location in the river—Zones 1-5, Zone 6, mainstem Columbia River upstream of McNary Dam, and spawning tributaries (Table 2c).

Third, tribal fishery harvest estimates for rivers outside of the Columbia Basin were calculated and reported by individual tribes in harvest management plans or run reconstruction reports. For Columbia River populations, we used seasonal Zone 6 harvest estimates (Stuart Ellis, CRITFC, pers. comm.; Joint Columbia River Management Staff 2016). Fourth, non-tribal commercial fishery bycatch mortality estimates were only available for Columbia River populations and were derived by region-specific methods and reported in harvest management documents (Joint Columbia River Management Staff 2016). Puget Sound commercial salmon fisheries have observer programs which report that steelhead are rarely caught in these fisheries (< 1% of the sets observed over the past 25 years encountered a steelhead and the average number of steelhead caught annually was two; WDFW unpublished data) and that most captured steelhead are released alive. However, these programs are not set up to generate bycatch mortality estimates for steelhead. Thus, the steelhead non-tribal commercial fishery bycatch mortality rates in Puget Sound are likely very low but cannot be quantified. Willapa Bay commercial salmon fisheries are monitored for incidental steelhead bycatch only during the earlier part of the steelhead return-time period. Thus, bycatch mortality estimates could only be estimated for earlier-arriving fish (which tend to be hatchery fish). Due to the gap in data on later-returning fish, we do not report non-tribal commercial fishery bycatch mortality estimates for Willapa Bay fisheries.

Finally, in the Columbia River Basin, in addition to reconstructing run size using only harvest rate estimates (including sport and commercial harvest bycatch mortality), we also estimated total run size by expanding escapement estimates for populations above Bonneville Dam to account for total mortality (including harvest and other unidentified sources of mortality) of adults between Bonneville Dam and the last dam they encountered below their natal tributary. Using PIT tag data from DART (Columbia River Data Access in Real Time; http://www.cbr.washington.edu/dart/), we estimated the percent of fish by population or region that survived from Bonneville Dam to a population's spawning grounds (if PIT tag readers were available there) or nearest downstream dam. This analysis assumed 100% PIT tag detection efficiency of adult steelhead moving upstream past mainstem Columbia River dams. The result was a "conversion" rate, defined as the percent of fish that were actually recorded surviving this migration. Thus, a total mortality (or loss) rate included reported harvest, any unreported harvest, non-harvest mortality, and potentially straying. Using these data, we calculated and reported the harvest rate plus the unaccounted-for (undocumented) loss rate experienced by each population.

2.3 Productivity

To calculate productivity indicators, including adult-to-adult productivity (in this case, the population growth rate [lambda]), smolt recruits per spawner, and smolt-to-adult return (SAR) rates, age data for smolts and returning adults as well as annual smolt and adult abundance estimates are needed. Steelhead age data are most often acquired from scale pattern analysis and thus scale sampling must occur. Smolt age data and abundance estimates were available from smolts captured and handled at various trapping locations or facilities statewide. For Puget Sound, coastal, and LCR populations downstream of Bonneville Dam, smolt estimates and scales ages originated from in-river smolt trapping activities (e.g., Topping and Zimmerman 2013) while for other Columbia Basin populations, smolt data were produced from captures at dam trapping facilities and in-river traps. For some populations that lacked data, we used available smolt age data and annual abundance estimates from another representative population or subpopulation.

Scale sampling of spawners occurs infrequently where redd-based spawner surveys are employed because surveys usually do not include live fish capture or carcass recovery. In areas where steelhead are trapped at hydropower dams' or other barriers' upstream passage facilities, adults are often handled and sampled for scales and biological characteristics. Lower Columbia summer-run steelhead that are captured and tagged for mark-resight abundance estimation are scale-sampled. Thus, spawner age data availability for populations varied statewide. In several DPSs, age data were available from scale-sampled harvested wild adult steelhead, especially for years where harvest was allowed in sport fisheries and when tribal harvests were sampled. We used these age data from harvested adults as representative of annual spawner populations. Adult age data included years in freshwater, years in ocean, repeat spawning events, and total age at time of sampling.

First, here we represent adult-to-adult productivity as the number of adults that return to spawn that are produced by adults spawning in prior years (spawners-per-spawner; $\frac{adult\ recruits}{spawner}$). Spawners-per-spawner is a measure of population growth rate (whether the population is replacing itself, growing, or declining; also known as lambda). This estimate is the true measure of productivity from a VSP perspective. Adult-to-adult productivity can also be measured as the total number of adults that return to a population (total run, or catch plus escapement plus any other mortality estimates that are available) that are produced by adults spawning in prior years. Since we do not have long-term data on total run size for all populations, we chose to estimate adult-to-adult productivity as spawners-per-spawner in this report. While some high and some low productivity years are expected, long-term average adult productivity should be at or above replacement (equal to or > 1) for a population to be considered stable or sustainable. Calculating adult-to-adult productivity requires annual adult spawner abundance and total age composition (freshwater plus ocean age) data. Because only adults that survive fisheries may reproduce, we used only spawner escapement data in the denominator of the equation. We used age data to assign adult spawners in the offspring generation to their parents' cohort. These "adult recruits" were the data used in the numerator of the equation. Using available data, we estimated adult-to-adult productivity for 36 populations among all seven DPSs.

Second, smolt recruits per spawner estimates are informative measures of steelhead productivity and portray effects of processes occurring in freshwater. They describe the number of outmigrating smolts (that survived their freshwater rearing stage) produced by a given cohort of spawners. Smolt recruits per spawner estimates require adult abundance estimates, smolt abundance estimates, and smolt age composition in order to match outmigrating smolts of different ages to their parents' cohorts. Only 11 populations or subpopulations statewide (none in the Olympic Peninsula DPS) had sufficient data for calculating smolt productivity measures.

Third, smolt-to-adult return (SAR) rates describe the percent of smolts outmigrating to the ocean that survive to return to their natal environment to spawn as adults. These estimates are generally described as ocean survival estimates. However, steelhead from some populations, especially in the interior Columbia Basin, have a long migration from their natal environment to the ocean and then from the ocean back to that natal system during which freshwater migration mortality also occurs. Thus, productivity measures based on smolt abundance measured at a natal river smolt trap and adult abundance measured on spawning grounds are estimates of both freshwater migration and ocean survival. For a few interior Columbia populations, enough smolts have been PIT-tagged that ocean-specific survival could be estimated, but these data are not yet common across the state and thus we do not report these values. With more tagging data, future analyses could partition mortality into riverine and ocean components, which would allow us to further measure environment-specific productivity impacts.

To estimate SARs, we used smolt abundance, adult total run abundance, and adult ocean-age composition. We estimated the proportion of smolts that outmigrated in a given year (and thus of a given cohort) that returned as adults by matching the adults (who were of different ages) to a given smolt cohort. We were able to estimate SARs from a total of nine Puget Sound and coastal DPS populations/subpopulations and seven Columbia Basin DPS populations/subpopulations. We used the gls package in R, which included a correlation structure (corAR(1)) to account for temporal autocorrelation in SAR time series, to fit a linear model to each time series segment. We estimated the slope of each time series segment and examined whether it was significantly different than zero or whether its values were relatively constant over time (slope not significantly different than zero).

None of the productivity measures we calculated included data for freshwater-resident individuals that were produced by steelhead and/or produced anadromous offspring. We acknowledge that fish with resident life histories may contribute to population productivity (Courter et al. 2013; Ruzycki et al. 2009), but quantitative data on resident life-history components are rarely available for Washington populations.

2.4 Spatial Structure

The spatial structure of DPSs and populations is an important viability parameter because it can influence life history diversity and carrying capacity (abundance), and, in some cases, can be an indicator of habitat quality. For this report, we focused on identifying and quantifying steelhead habitat lost due to blockage by various types of large dams and barriers. Thus, the measure of spatial structure status we present here is an indicator of spatial extent (river or stream kilometers; rkm), not habitat quality or patchiness. A previous study described populations that have been extirpated by dam-related habitat loss (McClure et al. 2008).

Spatial extent is affected by other fish passage barriers (e.g., culverts and roads) and it is likely that steelhead habitat loss from these other barriers is extensive statewide (e.g., see information at http://wdfw.wa.gov/about/advisory/fbrb/ and at http://wdfw.wa.gov/conservation/habitat/fish_passage/data_maps.html). We did not quantify loss of spatial structure due to these other barriers in this report. Efforts to quantify amount of habitat blocked by culverts and other small barriers are underway by the Yakima Tributary Access and Habitat Program (YTAHP) and other groups, and results could be incorporated into future status analyses.

To classify a stream as one supporting steelhead, we used the WDFW fish distribution database (web link available in Appendix B), which characterizes steelhead stream reaches by life stage (e.g., rearing or spawning) and occurrence, outlined briefly below:

- Documented: Streams where steelhead have been observed by a fish biologist or documented in Washington Conservation Commission 'salmonid limiting factors analysis' reports, or the WDFW WRIA Stream Catalog (http://www.streamnetlibrary.org/?page_id=95). Note that neither database is complete nor always updated based on existing conditions.
- Presumed distribution: Streams where the professional opinion of a fish biologist is that there should be steelhead in that stream, but steelhead have not been directly observed.
- Documented historical: Streams that met the definition of Documented more than 20 years ago, but are currently not occupied by steelhead due to large dams without fish passage. The mapped historical distributions mainly consist of mainstem and large tributary habitats. Steelhead almost certainly used some portion of the smaller tributaries also.
- Transported: Streams where the presence of steelhead is maintained by trap-and-haul programs. Where steelhead are transported upstream of dams, river or stream kilometers inundated by a dam's reservoir that were historical habitat and no longer suitable for spawning were included in calculations of percent of habitat lost.
- Artificial: Streams that historically did not support steelhead, but upstream passage has been or still is being provided (e.g., South Fork Skykomish River, Deschutes River).
- Recently opened: This is a new distribution type not currently classified in the existing databases. These are streams upstream of recently removed dams (Elwha River/Elwha Dam/Glines Canyon Dam, White Salmon River/Condit Dam) and dams with new fish passage (Puyallup River/Electron Dam).

For this analysis we limited the mapping of current and historical distributions to only documented and documented historical classifications. Artificial and presumed distributions were excluded, the latter because they were not consistently mapped across the state. For a consistent comparison with the currently occupied habitat, we also did not include presumed distributions upstream of major dams in the mapping of historical distributions. Distributions were mapped and reviewed by authors who have direct knowledge of some areas and in consultation with several local WDFW and tribal biologists. When appropriate, we also performed reviews of primary and unpublished literature including Technical Recovery Team (TRT) reports, WCC LFA reports, and other documents.

Culverts and other small anthropogenic fish passage barriers are an important component of steelhead habitat loss, as evidenced by the US v Washington “culvert case” (United States vs. Washington 2013). However, as mentioned above, we did not include habitat above blocking culverts as lost habitat because quantification work is ongoing and incomplete. To quantify amounts of occupied, lost (historical), transported, and recently opened habitat by population, we overlaid the steelhead stream distributions with the NOAA and WDFW population boundary polygons made up of aggregations of HUC12 sub-watersheds (Appendix B). Each steelhead stream record was assigned to the population that it intersected. The habitat quantities were then summed by population, MPG, and DPS. The percentage of habitat lost for a given population was estimated as the amount of habitat presently blocked divided by the documented historical habitat amount.

2.5 Diversity

Life history and genetic diversity are important indicators of diversity because they can buffer populations against risks associated with environmental change or stochasticity. Low abundance, habitat loss, hatchery practices, and harvest impacts may influence steelhead genetic and life history diversity. To evaluate change or loss of life history diversity or genetic diversity and subsequently assess risk or status, baseline data are required. We complied and summarized available data for two life history characteristics (smolt/freshwater age and adult/ocean age compositions) and for genetic diversity at the population level where possible. These data would serve as baseline data for future evaluation of diversity status.

Hatchery programs are known to have the potential for impacts on diversity of wild populations (Christie et al. 2014; Hindar et al. 1991; Naish and Hard 2008; Waples 1991; Washington Department of Fish and Wildlife (WDFW) 2008). To reduce hatchery programs’ risks to wild populations, including diversity risks such as increased gene flow between hatchery and wild fish, the SSMP (Washington Department of Fish and Wildlife (WDFW) 2008) recommended actions such as releasing juveniles only at locations where returning adults can be captured, and reducing number of fish released. These actions were expected to reduce rates of gene flow. To evaluate progress on these risk-reduction actions, we compiled data available on sites and sizes of annual hatchery releases and compared them over two time periods. This information serves as an indicator of where diversity risks may occur and where direct data collection on diversity status may be beneficial.

We note here that WDFW’s Hatchery Genetic Management Plans (HGMPs) fully address diversity risks to wild populations and have been developed for hatchery programs affecting ESA-listed steelhead DPSs. As of December 2016, WDFW has submitted HGMPs for nearly all of these hatchery programs for NOAA’s approval. At the time of their submission, based on data available and modeling, hatchery releases were sized in order to be in compliance with laws.

2.5.1 Life history diversity

We gathered data on age structure of steelhead smolts and adults from populations across Washington to examine variability among regions and long-term trends. Age structure is an important indicator of environmental conditions and genetic variation among populations. Changes over time that are detected within or among populations can indicate shifting environments or anthropogenic influences. Diversity in age composition can buffer salmonid populations against population abundance fluctuations just as diverse financial portfolios provide more stable returns (Moore et al. 2014). We gathered total counts of fish by age and used these data to calculate the yearly average age values presented in this report.

Although year-specific total count data could shed light on age variation in a given year, we do not present those data here.

Size- or age-selective harvest can lead to changes in diversity traits of salmonid populations, including heritable life history characteristics (Hard et al. 2008). Size-selective harvest has been shown to reduce length at maturity and reduce or increase age at maturity (Fukuwaka and Morita 2008; Kendall et al. 2014). Studies on the effects of size- or age-selective harvest on steelhead, especially in Washington State, are lacking. However, populations subject to relatively high harvest rates and in fisheries conducted with gear that is known to be size selective (e.g., gillnet fisheries) can be more affected by harvest than populations harvested at lower rates with less size-selective gear (Kendall and Quinn 2012). Other heritable life history traits, such as adult return or spawn timing, may also be affected by harvest selectivity. Many steelhead fisheries have historically been structured to harvest early returning hatchery stocks and therefore have resulted in variable harvest rates across the return period of wild steelhead, implying the potential for selection on run timing. We did not compile information in this report that could serve as indicators of harvest risks to diversity due to the lack of data on size-, age-, and run-timing-selective harvest of Washington steelhead.

2.5.2 Genetic diversity

We assessed current availability of genetic data for steelhead populations that were derived from microsatellite DNA and single nucleotide polymorphism (SNP) DNA markers and that were already processed and publicly available in published journal papers and unpublished agency reports at the time this report was completed. Although the best baseline data are those that represent an entire population, we included in our counts of available data those that represented a major population component, such as a subpopulation (e.g., major tributary) or large portion of population's geographic range. We summarized these data in terms of the extent and distribution of baseline genetic data availability.

2.5.3 Hatchery programs and diversity indicators

We compiled data on steelhead hatcheries operating in Washington to evaluate diversity risks and address SSMP recommended actions as described above. We counted the number of hatchery programs operating as of 2014 within a wild steelhead population's watershed and per DPS, and we reported them by ownership (WDFW or 'other,' such as tribal or federal ownership). We calculated average annual number of smolts released between 2000 and 2008 and between 2009 and 2013 per population and DPS along with the average percent of smolts released at locations away ('off-site') from hatcheries where they were reared in the same time periods. An action recommended in the SSMP was to release juveniles only at locations where returning adults can be captured, which typically are hatchery sites. Off-site releases may pose greater genetic risks (e.g., through interbreeding of hatchery and wild adults) than hatchery on-site releases due to the propensity for adults from off-site releases to return to their release sites instead of their hatchery-of-origin (Schroeder et al. 2001). This recommended action was especially targeted at segregated hatchery programs. We evaluate progress on this action by comparing off-site release numbers between the two time periods.

Other recommended actions in the SSMP included reducing the number of juveniles released relative to risks imposed by segregated or integrated hatchery programs. We report average annual total number of smolts released per program during the two time periods so that progress where this recommended action has been implemented can be reviewed. Finally, to control hatchery programs' risks to wild populations, HGMPs (see Chapter 5, section 5.2.1 for further description) for each program prescribe an allowable proportion of hatchery-origin fish that may spawn naturally (pHOS). However, there are currently few empirical pHOS estimates available, so we were not able to provide a statewide evaluation of the status of this risk-management indicator.

2.6 Data use in status and trend analyses

The type and extent of data available to inform the four VSP parameters guided our use of them in status and trend analyses. Adult escapement and total run size abundance data were the only data types that were widely available and suitable for a quantitative analysis of status and trends. Thus, we used abundance data exclusively for our risk assessment, in which we calculated percent change in abundance over time, population viability estimators of growth rate and extinction risk, and the frequency that annual abundance met an escapement or recovery goal. We describe our abundance-based risk assessment methods completely in Chapter 4.

Though not used for quantitative risk assessment, we used productivity, spatial structure, and diversity data and analysis to inform status and threats assessments. We used available productivity, spatial structure, and diversity information to qualitatively describe current conditions and threats, which was particularly useful when population abundance data were not available.

Chapter 3 VSP parameter results

In this chapter, we present our findings that pertain to the four VSP parameters—abundance, productivity, spatial structure and diversity. We summarize the availability of data for the four parameters for steelhead throughout the state, and present results of our analyses of these data.

We used these results to inform our threats assessments and action recommendations at the statewide and DPS levels (Chapter 5). We also used the results to assess threats and select actions for focal populations (section 5.4), which were identified in our abundance-based risk assessment process (Chapter 4).

3.1 Abundance and harvest rate results

3.1.1 Abundance data availability and harvest rates statewide

Only 64% of extant populations (73 of 114) had sufficient adult escapement data available for abundance status and trend analyses (Figure 9; Appendix A). Upper Cowlitz and Cispus populations (Lower Columbia) were counted as one population in this calculation because only combined abundance data were available. We provide details on population abundance data available in each DPS below. We used these data to calculate our abundance-based risk assessment metrics and those results are described in Chapter 4.

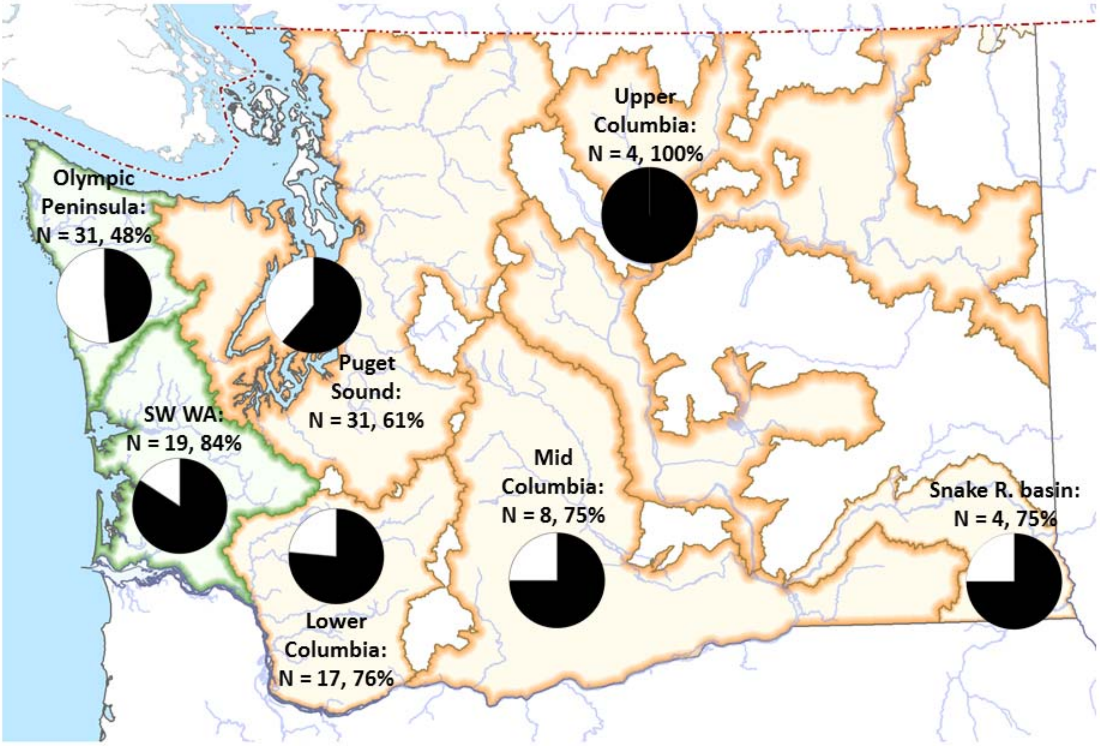

Figure 9. The number of extant Washington steelhead populations in each DPS (N) and the percent for which escapement abundance data have been collected for at least 3 years since 1980 and data collection is ongoing. In the pie charts, black represents the portion of populations with data and white represents the portion without. For Lower Columbia, N=17 (not 18 as in Table 1) because Upper Cowlitz and Cispus populations were combined due to data availability.

Harvest rate estimates were available for 55 of the 76 populations (72%) that had escapement abundance data (Tables 2a and 2b). Harvest rate estimates were available for five river systems instead of the individual populations in those systems (Table 2a). Annual total run sizes were thus estimated for the 55 populations and the five river systems. Since 1980, an average of 19 years of harvest rate estimates was available for populations with escapement data, with a minimum of eight years and a maximum of 34 years of available harvest estimates. Harvest data and harvest rate estimates generally were available in at least half of the years in which populations or systems had available escapement data.

All four Columbia Basin DPSs had harvest rate data for 100% of their populations with escapement data (Tables 2a and 2b). In Olympic Peninsula DPS harvest rate estimates were available for 33% of populations with escapement data and for three river systems (Table 2a) in which population escapement data could be combined for a system total. Puget Sound DPS and Southwest Washington DPS had harvest rate estimates available for 68% and 69%, respectively, of populations with escapement data, and for one system in each.

The average annual estimated harvest rate among all populations was 11.5% during time periods with data. Individual years' harvest rates ranged from 0% to 71.3%. Olympic Peninsula DPS populations have sustained the highest harvest rates among all DPSs over time with an average annual harvest rate of

25.6% (Table 2a). The Lower Columbia DPS had the lowest average harvest rate (5.0%) among the seven DPSs (Table 2a). The other DPSs had estimated average annual harvest rates ranging from 6.8% to 11.5% (Table 2a and b).

Table 2a. Average annual harvest rates and total run size reconstruction sources (numbers and code descriptions in Tables 2c and 2d) by DPS (in italics) and population for years for which data were available for natural-origin steelhead in Puget Sound, the Washington Pacific coast, and below Bonneville Dam in the lower Columbia River. Populations for which data were not available are not listed. Populations or systems for which sport harvest rate includes wild fish bycatch release mortality in at least a fraction of years are Skagit summer and winter, Hoh winter, Humptulips winter, Chehalis system winter, and all populations harvested by a Columbia River fishery. Populations or systems for which tribal harvest rate includes net drop-out mortality in at least a fraction of years are Hoh winter, Humptulips winter, and Chehalis system winter.

DPS	Population	Run	Average harvest rate	Years	Run reconstruction number	Non-tribal harvest data code	Tribal harvest data code
Puget Sound			*7.2%*				
Puget Sound	Cedar	W	6.5%	1987-2013	1	B2	C1
Puget Sound	East Hood Canal	W	0.4%	1989-2013	1	B2	N/A
Puget Sound	Green	W	18.9%	1978-2013	1	B3	C2
Puget Sound	Nisqually	W	16.4%	1987-2013	1	B2	C1
Puget Sound	Pilchuck	W		see Snohomish system			
Puget Sound	Puyallup/Carbon	W	10.4%	1983-2013	1	B2	C1
Puget Sound	Samish & Belligham Bay tribs.	W	7.2%	1979-2013	1	B2	C1
Puget Sound	Sequim and Discovery Bays Tributarie	W	0.0%	1987-2013	1	B2	N/A
Puget Sound	Skagit	S & W	10.9%	1978-2013	1	B2	C1
Puget Sound	Skokomish	W	0.3%	1995-2006	1	B2	C1
Puget Sound	Snohomish/Skykomish	W		see Snohomish system			
Puget Sound	Snohomish system	S & W	7.8%	1987-2013	1	B2	C1
Puget Sound	Snoqualmie	W		see Snohomish system			
Puget Sound	South Hood Canal	W	1.6%	1988-2013	1	B2	N/A
Puget Sound	Stillaguamish	W	4.0%	2000-2013	1	B3	C2
Puget Sound	Strait of Juan de Fuca Ind. Tribs.	W	4.6%	1991-2009	1	B2	N/A
Puget Sound	Tolt	S		see Snohomish system			
Puget Sound	West Hood Canal	W	0.0%	2003-2013	1	B2	N/A
Puget Sound	White River (Puyallup)	W	1.5%	1986-2013	1	B2	C1
Olympic Peninsula			*25.6%*				
Olympic Peninsula	Calawah	W		see Quillayute system			
Olympic Peninsula	Clallam	W	0.7%	1999-2013	1	B2	N/A
Olympic Peninsula	Clearwater	W		see Queets system			
Olympic Peninsula	Dickey	W		see Quillayute system			
Olympic Peninsula	Goodman	W	6.8%	1995-2009	1	B1	N/A
Olympic Peninsula	Hoh	W	36.7%	1980-2013	1	B2	C1
Olympic Peninsula	Lower Quinault	W		see Quinault system			
Olympic Peninsula	Pysht/Independents	W	14.0%	1995-2013		B2	C1
Olympic Peninsula	Queets	W		see Queets system			
Olympic Peninsula	Queets system	W	35.5%	1981-2011	1	B2	C1
Olympic Peninsula	Quillayute/Bogachiel	W		see Quillayute system			
Olympic Peninsula	Quillayute system	W	29.6%	1978-2013	1	B3	C2
Olympic Peninsula	Quinault system	W	48.2%	1991-2013	1	B2	C1
Olympic Peninsula	Salt/Independents	W	3.9%	1995-2013	1	B2	N/A
Olympic Peninsula	Sol Duc	W		see Quillayute system			
Olympic Peninsula	Upper Quinault	W		see Quinault system			

DPS	Population	Run	Average harvest rate	Years	Run reconstruction number	Non-tribal harvest data code	Tribal harvest data code
SW Washington			*6.8%*				
SW Washington	Bear	W	0.6%	1996-2010	1	B1	N/A
SW Washington	Chehalis	W		see Chehalis system			
SW Washington	Chehalis system	W	15.8%	1983-2013	1	B3	C2
SW Washington	Grays	W	5.3%	2001-2013	2		
SW Washington	Hoquiam	W	0.7%	1987-2013	1	B1	N/A
SW Washington	Humptulips	W	16.9%	1979-2013	1	B3	C2
SW Washington	Mill/Abernathy/Germany	W	5.3%	2001-2013	2		
SW Washington	Naselle	W	4.4%	1993-2013	1	B1	N/A
SW Washington	Nemah	W	1.5%	1993-2013	1	B1	N/A
SW Washington	North/Smith	W	4.2%	1996-2013	1	B1	N/A
SW Washington	Palix	W	1.4%	1996-2013	1	B1	N/A
SW Washington	Satsop	W		see Chehalis system			
SW Washington	Skamokawa/Elochoman	W	5.4%	2001-2013	2		
SW Washington	Skookumchuck/Newaukum	W		see Chehalis system			
SW Washington	Willapa	W	6.5%	1993-2013	1	B1	N/A
SW Washington	Wishkah	W		see Chehalis system			
SW Washington	Wynoochee	W		see Chehalis system			
Lower Columbia			*5.0%*				
Lower Columbia	Coweeman	W	5.3%	2001-2013	2		
Lower Columbia	East Fork Lewis	S	4.0%	2001-2013	3		
Lower Columbia	East Fork Lewis	W	5.3%	2001-2013	2		
Lower Columbia	Kalama	S	6.0%	2001-2013	3		
Lower Columbia	Kalama	W	7.3%	2001-2013	2		
Lower Columbia	North Fork Toutle	W	1.4%	2001-2013	2		
Lower Columbia	South Fork Toutle	W	5.3%	2001-2013	2		
Lower Columbia	Tilton	W	5.3%	2001-2013	2		
Lower Columbia	Upper Cowlitz & Cispus	W	5.3%	2001-2013	2		
Lower Columbia	Upper Gorge	W	4.3%	2001-2013	2		
Lower Columbia	Washougal	S	4.0%	2000-2013	3		
Lower Columbia	Washougal	W	6.4%	2001-2012	2		

Table 2b. Average harvest rates and harvest rates plus unaccounted-for loss rates between Bonneville Dam and a population's natal system averaged across DPS (in italics) and population for years for which data were available. Total run size reconstruction sources (number and code descriptions) for summer-run, natural-origin steelhead above Bonneville Dam in the Columbia River are in Tables 2c and 2d. Conversion rate is survival rate estimated to upriver detection site using PIT tag data. Populations for which data were not available are not listed. For all populations, sport harvest rate includes release mortality, but tribal harvest rate does not include net drop-out mortality.

DPS	Population	Harvest rate run reconstruction number	Average harvest rate	Harvest rate years	Harvest rate + unaccounted-for loss run reconstruction number	Conversion rate measured to (upriver detection site)	Average harvest rate + unaccounted-for loss from Bonneville Dam to nearest upstream dam	Harvest rate + unaccounted-for loss years
Lower Columbia								
Lower Columbia	Wind	4	9.5%	2001-2013	6	Shipherd Falls	38.6%	2001-2013
Middle Columbia			*10.0%*				*28.9%*	
Middle Columbia	Naches	5	9.9%	2000-2013	6	Prosser Dam	32.7%	2001-2013
Middle Columbia	Satus	5	9.9%	2000-2013	6	Prosser Dam	32.7%	2001-2013
Middle Columbia	Toppenish	5	9.9%	2000-2013	6	Prosser Dam	32.7%	2001-2013
Middle Columbia	Touchet	5	10.1%	2000-2013	6	McNary Dam	19.7%	2001-2013
Middle Columbia	Upper Yakima	5	9.9%	2000-2013	6	Prosser Dam	32.7%	2001-2013
Middle Columbia	Walla Walla	5	10.1%	2000-2013	6	McNary Dam	22.8%	2001-2013
Upper Columbia			*10.3%*				*26.8%*	
Upper Columbia	Entiat	5	9.7%	2000-2013	6	Rocky Reach Dam	26.6%	2001-2013
Upper Columbia	Methow	5	10.8%	2000-2013	6	Wells Dam	24.2%	2001-2013
Upper Columbia	Okanogan	5	10.7%	2000-2013	6	Wells Dam	24.2%	2001-2013
Upper Columbia	Wenatchee	5	9.9%	2000-2013	6	Rock Island Dam	32.3%	2001-2013
Snake River Basin			*11.5%*				*31.6%*	
Snake River Basin	Asotin	5	10.3%	2000-2013	6	Lower Granite Dam	31.6%	2001-2013
Snake River Basin	Joseph	5	10.3%	2000-2013	6	Lower Granite Dam	31.6%	2001-2013
Snake River Basin	Tucannon	5	13.9%	2000-2013	6	Ice Harbor Dam	31.5%	2001-2013

Table 2c. Run reconstruction numbers (referenced in Tables 2a and 2b), applicable areas and their formulas to estimate total run size for various Washington steelhead populations.

Number	Areas of applicability	Formula
1	All populations outside the Columbia River Basin	Run size = A + B + C
2	Columbia River winter steelhead	Run size = A / ((1-D)/(1-M))
3	Columbia R. summer steelhead below Bonneville Dam (BON)	Run size = A / ((1-E)/(1-M))
4	Columbia R. summer steelhead above BON and below McNary Dam (MCN)	Run size = A / ((1-(F+G+I+J))/(1-M))
5	Columbia R. summer steelhead above MCN	Run size = A / ((1-(F+G+I+J+L))/(1-M))
6	Columbia R. summer steelhead above BON (PIT-tagged populations)	Run size = A / (1-(K-H)/(1-M))

Table 2d. Description and sources of Washington steelhead population abundance and fishery harvest metrics and their codes (referenced in Tables 2a, 2b and 2c), including those associated with conversion (survival) rates.

Code	Units	Area	Fishers	Season	Source
A	Wild escapement (total fish)	entire population	N/A	Annual	SCoRE (https://fortress.wa.gov/dfw/score/score/species/steelhead.jsp?species=Steelhead)
B1	Harvest (total wild fish)	entire population	non-tribal sport	Annual	CRC (WDFW Catch Record Card database: http://wdfw.wa.gov/fishing/catch_record_card/)
B2	Harvest (total wild fish)	entire population	non-tribal sport	Annual	Run reconstructions (R. Leland, WDFW, unpublished data)
B3	Harvest (total wild fish)	entire population	non-tribal sport	Annual	Harvest management plans (WDFW and tribal co-managers, unpublished reports)
C1	Harvest (total wild fish)	entire population	tribal	Annual	Run reconstructions (R. Leland, WDFW, unpublished data)
C2	Harvest (total wild fish)	entire population	tribal	Annual	Harvest management plans (WDFW and tribal co-managers, unpublished reports)
D	Harvest rate (wild, winter-run)	Columbia River mouth-McNary Dam	non-tribal sport and commercial	Nov.-Apr.	Table 11; 2016 Joint Staff Report (JSR) for 2015 Winter, Spring, and Summer Fisheries (http://wdfw.wa.gov/fishing/crc/)
E	Harvest rate (wild, Skamania)	Columbia River mouth-McNary Dam	non-tribal sport and commercial	May-June	Table 12; 2016 JSR for 2015 Summer Fisheries (http://wdfw.wa.gov/fishing/crc/)
F	Harvest rate (wild, A-run)	Columbia River mouth-McNary Dam	non-tribal sport and commercial	July	Table 13; 2016 JSR for 2015 Summer Fisheries (http://wdfw.wa.gov/fishing/crc/)
G	Harvest rate (wild, A-run)	Columbia River mouth-McNary Dam	non-tribal sport and commercial	Aug.-Oct.	Table 33; 2015 JSR for Fall 2014 Fisheries (http://wdfw.wa.gov/fishing/crc/)
H	Harvest rate (wild, A-run)	Columbia River mouth-Bonneville Dam	non-tribal sport and commercial	May-Oct.	Table 13; 2016 JSR for 2015 Summer Fisheries and Table 32; 2015 JSR for Fall 2014 Fisheries (http://wdfw.wa.gov/fishing/crc/). Rate calculated by subtracting above BON portion of impacts and adding summer and fall fisheries. Fall impacts were assumed to be 50% above and below BON.
I	Harvest rate (wild, A-run)	Bonneville Dam-McNary Dam	tribal	July	Stuart Ellis, CRITFC, pers. comm.
J	Harvest rate (wild, A-run)	Bonneville Dam-McNary Dam	tribal	Aug.-Oct.	Table 32; 2015 JSR for Fall 2014 Fisheries (http://wdfw.wa.gov/fishing/crc/)
K	Conversion rate based on PIT tags (wild)	Bonneville Dam-upriver detection site	tribal, non-tribal, and other mortality	Annual	Columbia River Data Access in Real Time (DART; http://www.cbr.washington.edu/dart/)
L	Harvest rate (wild)	McNary Dam to tributary mouth	non-tribal sport	Annual	Upper Columbia River ESA Take Reports by WDFW to NOAA Fisheries
M	Harvest rate (wild)	Tributary non-tribal (sport)	non-tribal sport	Annual	Lower and Middle Columbia Fisheries Management And Evaluation Plans (FMEP) and 2007-2015 Steelhead Fishery ESA Take Reports

3.1.2 Abundance data availability and harvest rates by DPS

3.1.2.1 Puget Sound

Sufficient escapement abundance data were available for 61% of extant populations (19 of 31; Figure 9); plots of those data are shown in Figure 10. Only sub-population-level data were available for East Hood Canal and West Hood Canal populations. We computed total escapement abundance for one system (Snohomish; Figure 10) so that we could compute total run size using available harvest data. The Snohomish system total annual escapement included escapement data for Snohomish/Skykomish winter-run, Pilchuck winter-run, Snoqualmie winter-run, and Tolt summer-run populations. Populations with very limited or no data included Drayton Harbor tributaries winter-run, South Fork Nooksack summer-run, Nookachamps Creek winter-run, Sauk River summer- and winter-run, Deer Creek summer-run, Canyon Creek summer-run, North Fork Skykomish summer-run, North Lake Washington and Lake Sammamish winter-run, South Sound Tributaries winter-run, East Kitsap Tributaries winter-run, Dungeness summer- and winter-run, and Elwha winter-run steelhead. Elwha steelhead abundance is currently being estimated so multi-year data series should be available in the future.

Abundance has declined in most populations since the early- to mid-1990s (negative % change values, Figure 10). Populations in rivers that drain to central and south Puget Sound (e.g., Cedar, Green, Puyallup/Carbon, Nisqually) all showed relatively large declines in that time period. Pilchuck winter-run and Tolt summer-run had the smallest percent declines (-12 and -19%, respectively) since 1980. Abundance in nearly all populations has been well-below the TRT's interim abundance viability goals. Only the Strait of Juan de Fuca Tributaries population has had annual abundance at or above its interim abundance viability goal several times during the period with data (Figure 10). Note, however, that this is a small population.

Average annual harvest rates, calculated over various time periods per population, varied from 0.0% to 18.9% (Table 2a). Since approximately 2003, when fisheries were greatly curtailed throughout Puget Sound, annual harvest rates on wild steelhead have been generally < 10%. To put this in perspective, historical harvest records document annual harvest rates of generally > 20% for the Green, Puyallup/Carbon, and Samish rivers prior to 1993, > 40% for Nisqually River prior to 1994, > 10% for Skagit River prior to 1998, > 12% for Snohomish system and Strait of Juan de Fuca independent tributaries prior to 1993, and > 20% for Stillaguamish River prior to 2001. Estimated total run sizes, based on harvest rate estimates for populations or systems with data, are also shown in Figure 10.

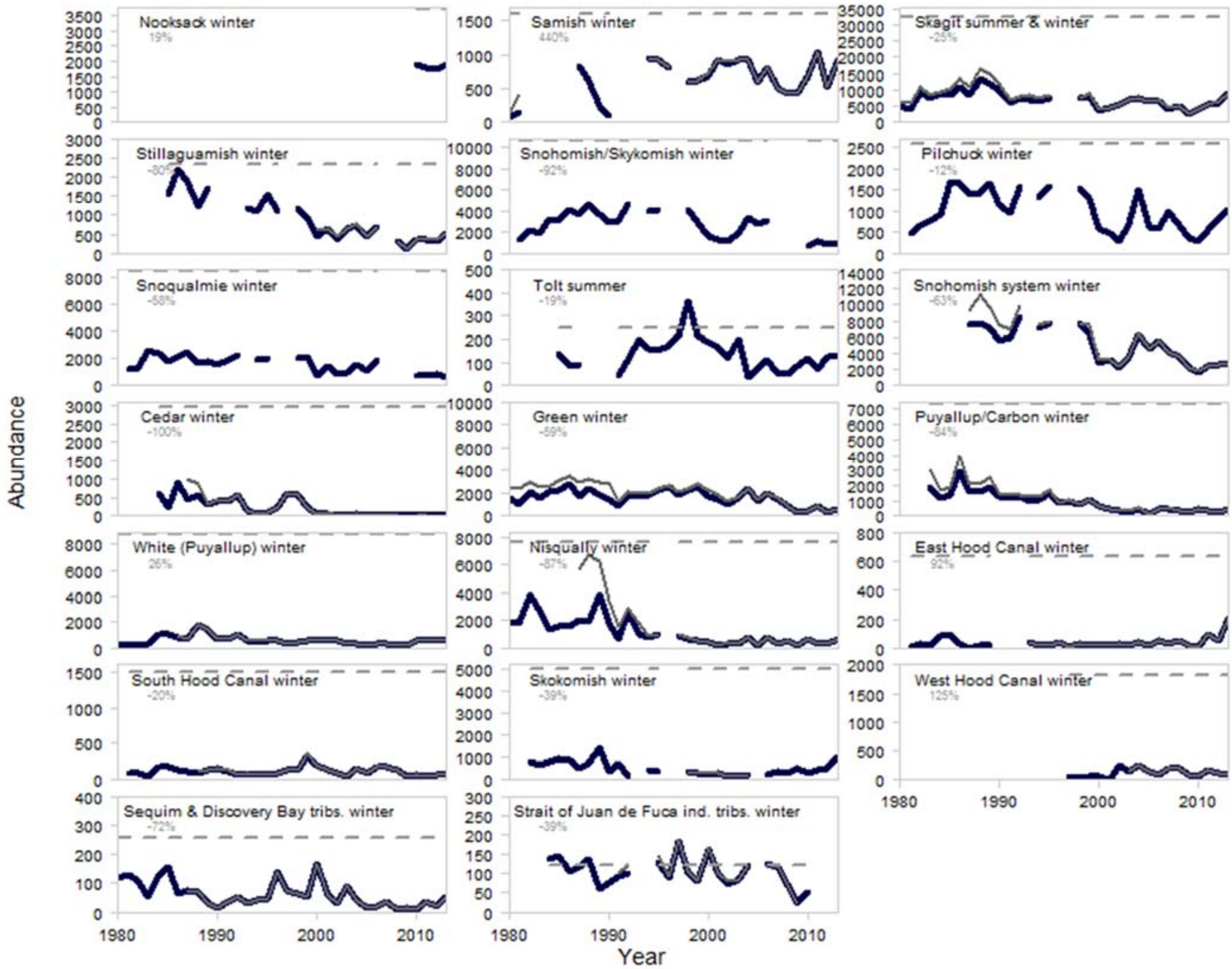

Figure 10. Abundance data for Puget Sound DPS steelhead populations and one system (Snohomish) available from the 1980s to 2013. The thick black line represents the total escapement (for the population or a portion of it, based on data availability), the thin grey line represents total run size (escapement plus reported sport and tribal harvest plus, for Skagit population only, estimated non-tribal bycatch mortality), and the dashed grey line is the PSSTRT interim abundance viability goal. The light grey number is the percent change in abundance (increase or decrease) over the time period with data.

3.1.2.2 Olympic Peninsula

Sufficient escapement abundance data were available for 48% (15 of 31) of populations (Figure 9), and plots of those data are shown in Figure 11. We computed total escapement abundance for three river systems (Quillayute [Dickey, Quillayute/Bogachiel, Sol Duc and Calawah populations], Queets [Queets and Clearwater populations], and Quinault [Lower and Upper Quinault populations]; Figure 11) so that we could compute total run size using available harvest data. Populations with very limited or no data included Lyre winter-run, Sekiu winter-run, Sail winter-run, Tsoo-yess/Waatch winter-run, Ozette winter-run, Quillayute/Bogachiel summer-run, Sol Duc summer-run, Calawah summer-run, Mosquito

Creek winter-run, Hoh summer-run, Kalaloch Creek winter-run, Queets summer-run, Clearwater summer-run, Raft winter-run, Quinault summer-run, and Copalis winter-run steelhead.

Despite declining abundance trends in most Olympic Peninsula DPS populations, most populations have met their escapement goals in recent years (Figure 11). Calawah and Upper Quinault populations showed increasing abundance trends since 1980. The Quillayute system supports the highest steelhead abundance in the DPS with spawner abundance ranging from about 5000 to over 16,000 fish (Figure 11). The Queets system supports relatively high abundance with average annual spawner abundance of about 5000 fish. This DPS is not ESA-listed and as such it has not undergone the same rigorous evaluation of population structure as the listed DPSs. We believe it is likely that a re-evaluation of population structure would consolidate populations in small streams (e.g., Goodman Creek, Mosquito Creek) with nearby populations to form single, larger, aggregate populations, and thus abundance status and trend could be different than presented here.

Steelhead in this DPS have been subject to the highest harvest rates in the state, with an average annual DPS-wide harvest rate of 25.6% over time periods evaluated (Table 2a). Wild steelhead harvest is currently allowed for tribal fisheries in the Quillayute, Queets, and Quinault systems and the Hoh River, where average harvest rates of winter-run steelhead ranged between 29.6% and 48.2% (Table 2a). Estimated total run sizes, based on harvest rate estimates for populations or systems with data, are also shown in Figure 11.

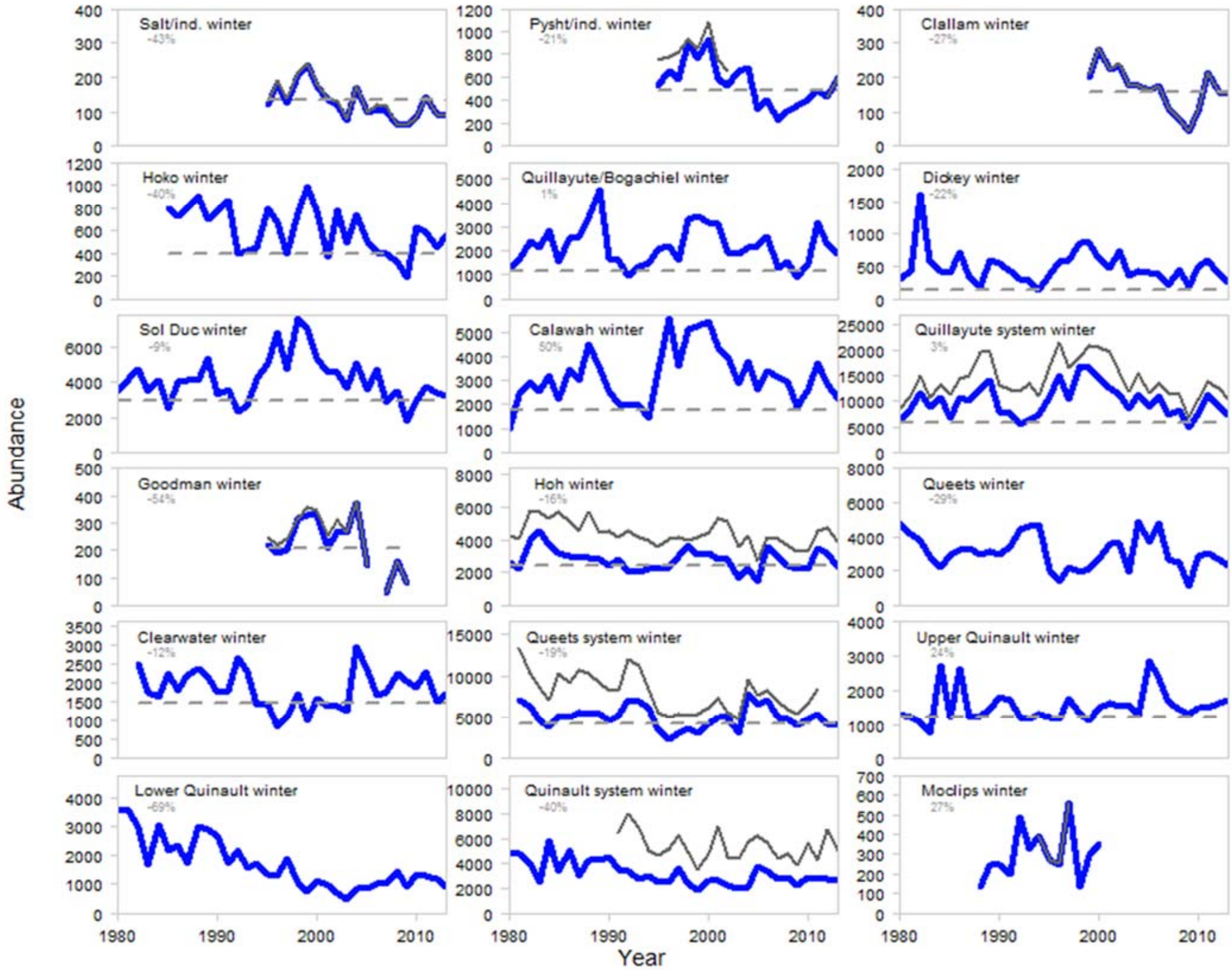

Figure 11. Abundance data for Olympic Peninsula DPS steelhead populations and three river systems available from the 1980s to 2013. The thick blue line represents the total escapement (for the population or a portion of it, based on data availability), the thin grey line represents total run size (escapement plus reported sport and tribal harvest plus, for Hoh population only, estimated non-tribal and tribal bycatch mortality), and the dashed grey line is the escapement goal. The light grey number is the percent change in abundance (increase or decrease) over the time period with data.

3.1.2.3 Southwest Washington

Abundance data were available for 84% (16 of 19) of populations (Figure 9), and plots of those data are shown in Figure 12. We computed total escapement abundance for one river system (Chehalis [Chehalis, Satsop, Skookumchuck/Newaukum, Wishkah, and Wynoochee populations]; Figure 12) so that we could compute total run size using available harvest data. Populations with very limited or no data included Humptulips summer-run, Chehalis summer-run, and South Bay winter-run steelhead.

In this DPS, 10 of 16 populations showed declining trends in abundance over time periods with data (Figure 12). The largest declines were for Hoquiam (-48%) and Wishkah (-46%). Of the populations with increasing abundance trends, the largest increases were for Skookumchuck/Newaukum (+57%) and Mill/Abernathy/Germany (+50%; Figure 12). Despite declining abundance trends, some populations often still met escapement goals (e.g., Humptulips, Wishkah, Bear, and Nemah). Populations in Willapa Bay rivers showed long-term abundance trends similar to those of Grays Harbor and Chehalis Basin populations. Steelhead populations in rivers that drain to Lower Columbia River did not often meet abundance goals in recent years (Figure 12). As with the Olympic Peninsula DPS, population structure of Southwest Washington DPS may change if a rigorous evaluation is conducted in future.

Wild steelhead in watersheds that drain into Grays Harbor and the lower Columbia River have been and continue to be caught incidentally and subject to release mortality in non-tribal and tribal fisheries. The highest average annual harvest rates occurred in the Humptulips River winter-run population (16.9%) and the Chehalis system (15.8%) for time periods analyzed (Table 2a). Within those periods, annual harvest rates averaged 25% for the Humptulips and 22% for the Chehalis prior to 1998 and since then have averaged about 10%. Average annual harvest rates among other populations in the DPS ranged from 0.6% to 6.5% over time periods with data (Table 2a). Estimated total run sizes, based on harvest rate estimates for populations or systems with data, are also shown in Figure 12.

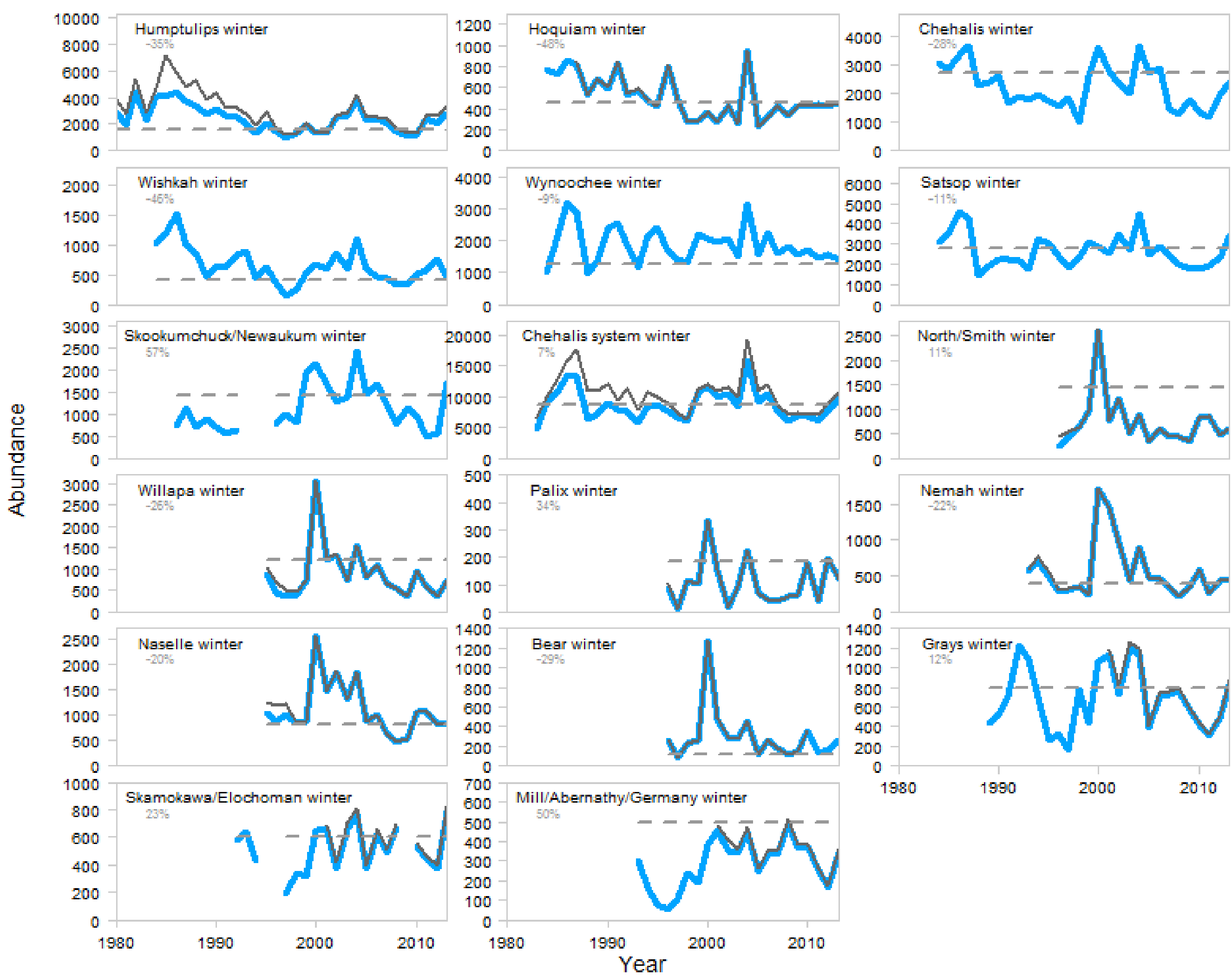

Figure 12. Abundance data for Southwest Washington DPS steelhead populations and one river system available from the 1980s to 2013. The thick light blue line represents the total escapement (for the population or a portion of it, based on data availability), the thin grey line represents total run size (escapement plus reported sport and tribal harvest plus, for Chehalis system and three populations as shown in Table 2a only, estimated tribal and/or non-tribal bycatch mortality), and the dashed grey line is the escapement goal. The light grey number is the percent change in abundance (increase or decrease) over the time period with data.

3.1.2.4 Lower Columbia River

Sufficient escapement abundance data were available for 76% (13 of 17) of extant populations (Figure 9), and plots of those data are shown in Figure 13. We show two data series for North Fork Toutle population due to data collection methods. We combined upper Cowlitz and Cispus populations into one operational population due to the way abundance data are currently collected. Populations with very limited or no data included Lower Cowlitz winter-run, North Fork Lewis summer-run, North Fork Lewis winter-run, Salmon Creek winter-run, and Columbia Lower Gorge Tributaries winter-run.

Among LCR summer-run populations, large percent increases in abundance occurred in East Fork Lewis (299%) and Washougal (167%) over time periods with data (Figure 13). Both of these populations often met their abundance recovery goals in the last 10 years of the data set. Wind River summer-run population increased in abundance by 21% from 1989-2013 but has not often met its abundance recovery goal. Among winter-run populations (excluding North Fork Toutle), four showed an increasing abundance trend, three had a declining trend, and one (Kalama) showed no directional trend over time periods with data. The Kalama winter-run population met its abundance recovery goal every year of last 10 in the data set (Figure 13).

Average annual harvest rates for LCR DPS populations ranged from 1.4% to 9.5%, and average harvest rates for almost all populations were consistently < 7% from 2001-2013 (Tables 2a and 2b). The Wind River summer-run population, which is upstream of Bonneville Dam, had a high average harvest plus unaccounted-for loss rate (38.6%; Table 2b). Estimated total run sizes, based on harvest rate estimates for populations with data, are also shown in Figure 13.

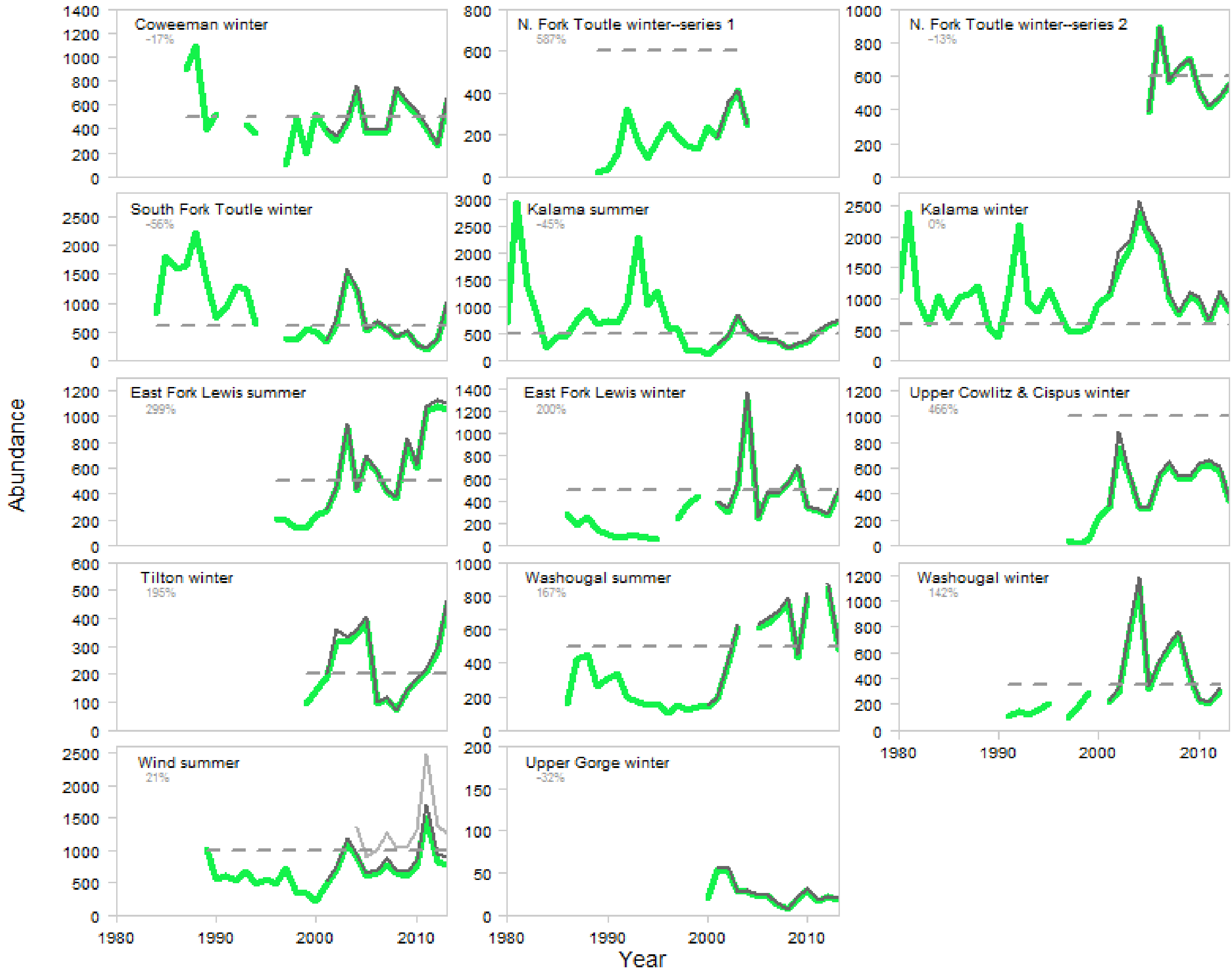

Figure 13. Abundance data for Lower Columbia River DPS steelhead populations available from the 1980s to 2013. The thick green line represents the total escapement (for the population or a portion of it, based on data availability), the thin dark grey line represents total run size (escapement plus reported non-tribal harvest plus estimated non-tribal bycatch mortality), the thin light grey line (Wind summer only) represents the total run size calculated as escapement plus reported harvest plus unaccounted-for loss upstream of Bonneville Dam, and the dashed grey line is the recovery goal. The light grey number is the percent change in abundance (increase or decrease) over the time period with data. For North Fork Toutle: series 1 is North Fork Toutle subpopulation trap count at the Sediment Retention Structure and series 2 is total of North Fork Toutle trap count and Green River subpopulation estimate.

3.1.2.5 Middle Columbia River

Sufficient escapement abundance data were available for 75% (6 of 8) of extant populations (Figure 9), and plots of those data are shown in Figure 14. Populations with limited or no data included White Salmon summer- and winter-run (extirpated prior to dam removal in 2011), Klickitat summer- and winter-run, and Rock Creek summer-run steelhead.

Five of six MCR DPS populations showed increases in abundance over time periods with data, and percent increases were very high for Toppenish (471%) and Naches (332%; Figure 14). Annual abundance in recent years for three of the Yakima populations (Toppenish, Satus, and Naches) exceeded minimum abundance recovery goals, but Upper Yakima population annual abundance, although increasing recently, has been well below the minimum abundance goal. The Walla Walla population had a positive abundance trend but annual values varied widely from 1993-2013. Touchet steelhead annual abundance had a 4% decline and was well-below the abundance goal in most years (Figure 14).

Average harvest rates were 9.9-10.1% (Table 2b). Average harvest plus unaccounted-for loss rates for adult PIT-tagged steelhead from MCR populations ranged from 19.7-32.7% (Table 2b). The highest loss rate was estimated for Yakima populations and indicated a 67.3% conversion (survival) rate from Bonneville to Prosser Dam (Table 2b). Loss above and beyond reported harvest was likely due to some combination of unreported harvest, natural mortality, and straying. Estimated total run sizes, based on harvest rate and on harvest plus unaccounted-for loss rate estimates, are also shown in Figure 14.

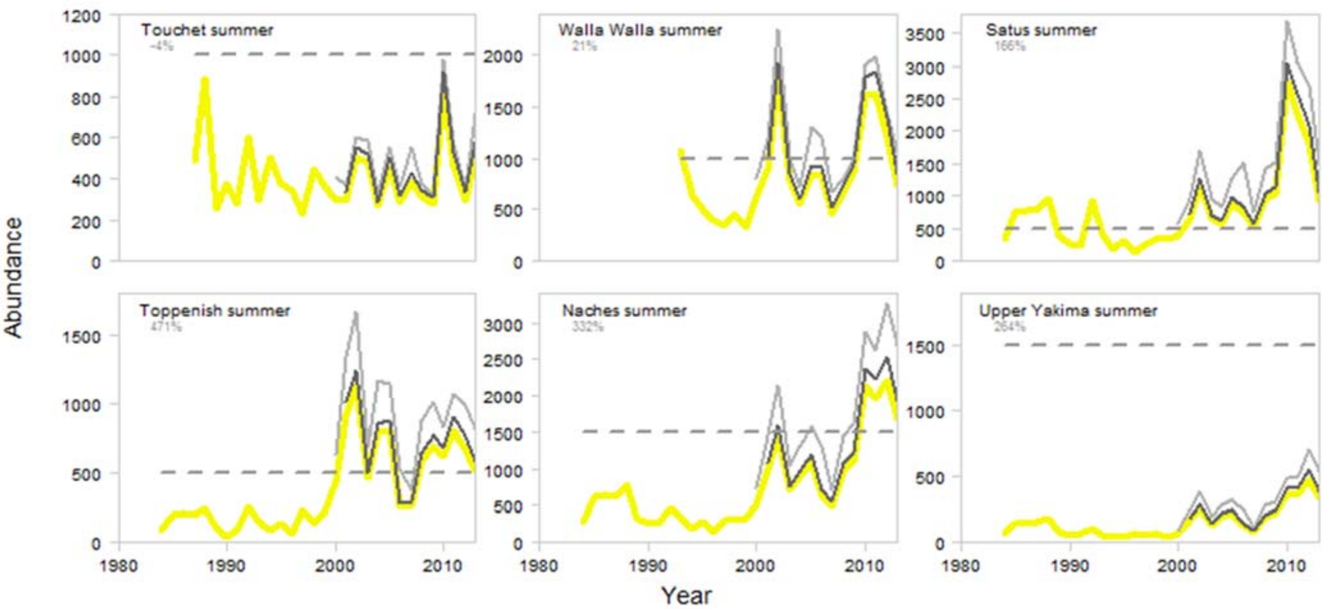

Figure 14. Abundance data for Middle Columbia River DPS steelhead populations available from the 1980s to 2013. The thick yellow line represents the total escapement (for the population or a portion of it, based on data availability), the thin dark grey line represents total run size (escapement plus reported non-tribal and tribal harvest plus estimated non-tribal bycatch mortality), the thin light grey line represents the total run size calculated as escapement plus harvest plus unaccounted-for loss, and the dashed grey line is the recovery goal. The light grey number is the percent change in abundance (increase or decrease) over the time period with data.

3.1.2.6 Upper Columbia River

Sufficient escapement abundance data were available for 100% (4 of 4) of populations (Figure 9), and plots of those data are shown in Figure 15. Currently, population abundance is estimated based on dam counts at Rock Island, Rocky Reach, and Wells dams, and then allocating fish to their respective populations based on a previously-conducted radio telemetry study (English et al. 2001; 2003) and redd surveys. A transition to abundance estimation based on PIT tags applied at Priest Rapids Dam is underway, and thus future abundance estimates may differ from those presented here.

In the UCR DPS wild steelhead abundance trends in all populations have been positive in recent years, with increases ranging from 50-89% (Figure 15). Despite upward abundance trend since 2000, abundance in three of the four populations has remained below minimum abundance recovery goals in most years. The Wenatchee population has had the highest abundance, often exceeding its goal.

These populations have been harvested (including tribal and incidental sport harvest) at average annual rates ranging from 9.7-10.8% between 2000 and 2013 (Table 2b). Average harvest plus unaccounted-for loss rates for adult PIT-tagged steelhead from UCR populations ranged from 24.2-32.2% (Table 2b). This estimated loss rate was higher for Wenatchee steelhead than rates for Methow and Okanogan steelhead, which must pass two more mainstem Columbia dams (Table 2b). Based on the loss rates, conversion rates averaged 67.8% for Wenatchee steelhead and 75.8% for Methow and Okanogan populations. Estimated total run sizes, based on harvest rate and on harvest plus unaccounted-for loss rate estimates, are also shown in Figure 15.

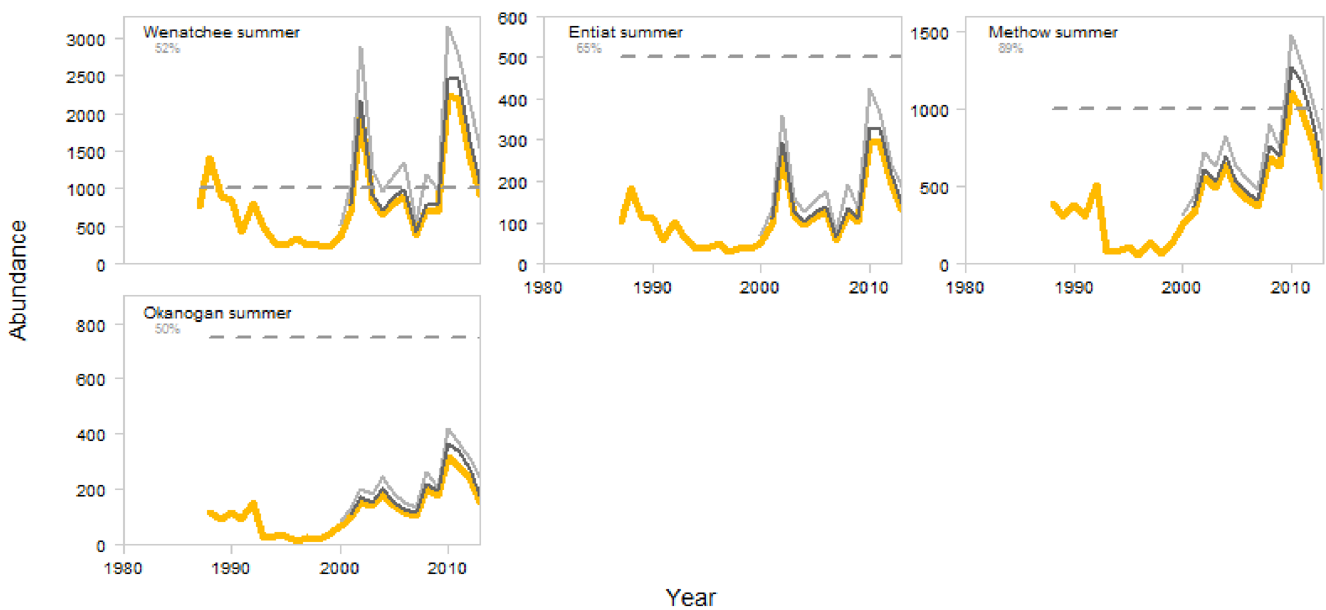

Figure 15. Abundance data for Upper Columbia River DPS steelhead populations available from the 1980s to 2013. The thick orange line represents the total escapement (for the population or a portion of it, based on data availability), the thin dark grey line represents total run size (escapement plus reported non-tribal and tribal harvest plus estimated non-tribal bycatch mortality), the thin light grey line represents the total run size calculated as escapement plus reported harvest plus unaccounted-for loss, and the dashed grey line is the recovery goal. The light grey number is the percent change in abundance (increase or decrease) over the time period with data.

3.1.2.7 Snake River Basin

Sufficient escapement abundance data were available for 75% (3 of 4) of populations (Figure 9), and plots of those data are shown in Figure 16. Adequate abundance monitoring was lacking for the Lower Grande Ronde population. Consistent with the two other interior Columbia Basin DPSs, abundance trends showed increases in most Washington steelhead populations of the Snake River Basin DPS. The Asotin population showed the largest percent increase (94%) and has often been above its minimum abundance recovery goal since 2000 (Figure 16). Tucannon population abundance was far below its minimum abundance goal. Annual abundance varied widely in the Joseph Creek population but was nearly always above the recovery goal (Figure 16).

Average annual harvest rates for the three populations ranged from 10.3-13.9% (Table 2b). Average harvest plus unaccounted-for loss rate for adult PIT-tagged steelhead over all SRB populations was 31.6% (Table 2b). Based on this loss rate, conversion rates averaged 68.4%. This was the lowest overall DPS-level rate for survival relative to harvest and mainstem dam passage among the three interior Columbia Basin DPSs. Estimated total run sizes, based on harvest rate and on harvest plus unaccounted-for loss rate estimates, are also shown in Figure 16.

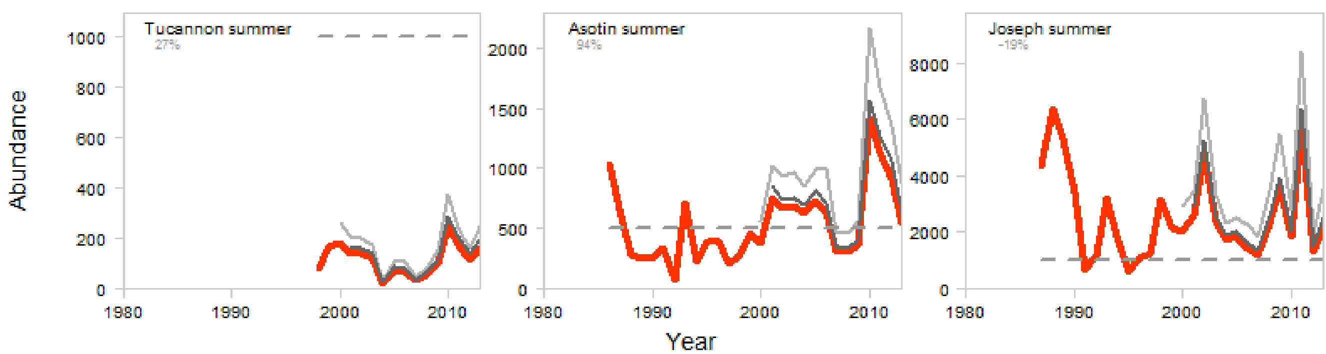

Figure 16. Abundance data for Snake River Basin DPS steelhead populations available from the 1980s to 2013. The thick red line represents the total escapement (for the population or a portion of it, based on data availability), the thin dark grey line represents total run size (escapement plus reported non-tribal and tribal harvest plus estimated non-tribal bycatch mortality), the thin light grey line represents total run size calculated as escapement plus reported harvest plus unaccounted-for loss, and the dashed grey line is the recovery goal. The light grey number is the percent change in abundance (increase or decrease) over the time period with data.

3.2 Productivity results

3.2.1 Adult-to-adult productivity (population growth rate)

Trends in population growth rate, measured as estimates of spawners produced per spawner, mirrored those of adult abundance. For many years, average population growth rate in all DPSs has been less than 1; individuals were not replacing themselves and populations were declining (Figure 17). In recent brood years (2005-2010), average within-DPS population growth rates have been higher for LCR, MCR, UCR, and SRB basin populations than for Puget Sound and Olympic Peninsula populations. Population growth rate values above replacement (> 1) for Columbia River Basin populations, which were historically reduced to very low adult abundances, are encouraging and suggest that compensatory juvenile production (increased per capita productivity at low adult abundance) may be sufficient to allow population growth at current SARs (section 3.2.3), low as they may be.

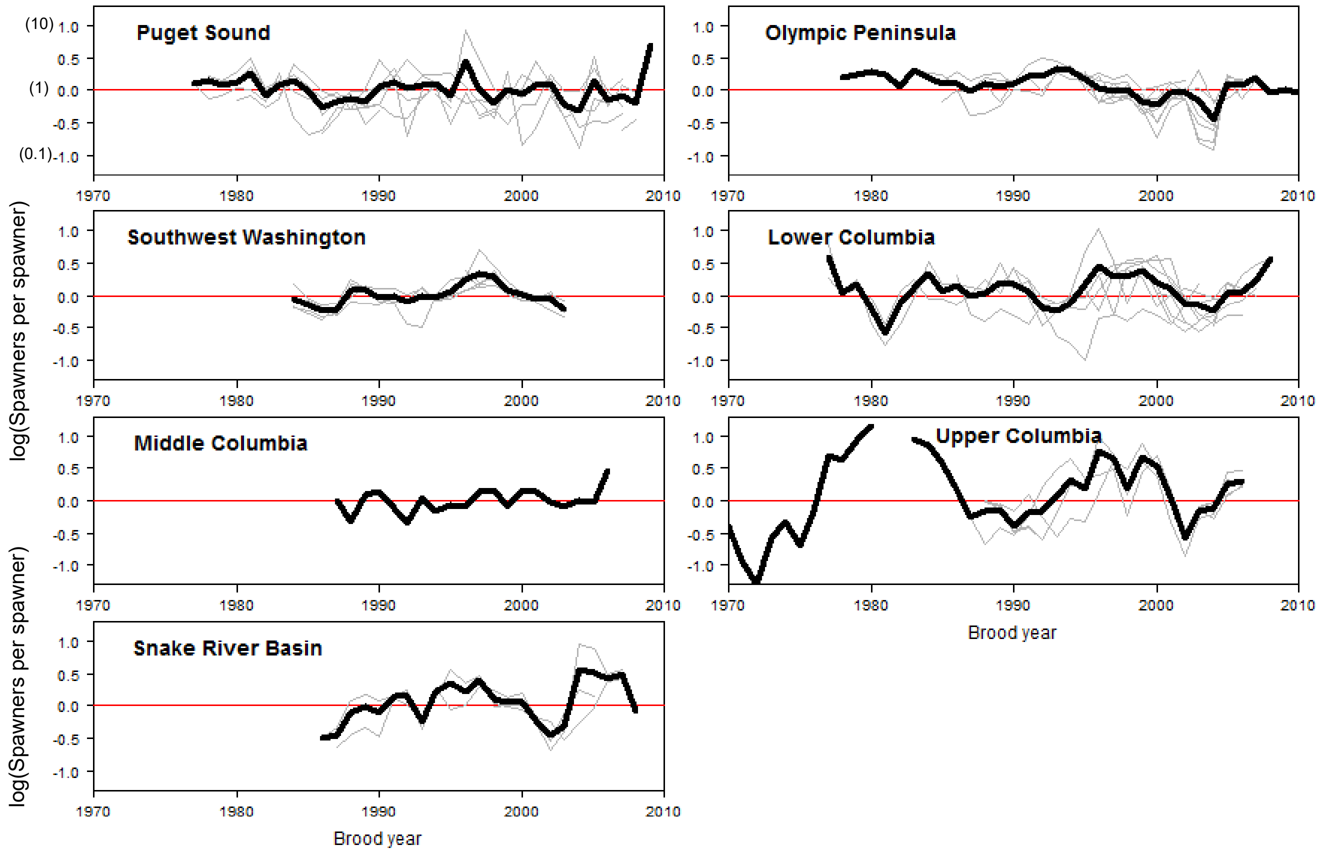

Figure 17. For each DPS, population growth rates represented as the log of the numbers of natural-origin adult spawners produced per spawner for all populations with suitable data for brood years 1970 to 2010. The thick black line represents the average value for each DPS while the thin lines represent data from individual populations within each DPS. The y-axis numbers in parentheses for the Puget Sound figure are the non-transformed values for reference. A log productivity of 0, shown by the red lines, corresponds to an untransformed productivity of 1 spawner per spawner (replacement). Data are available for 7 populations in the Puget Sound DPS, 8 in the Olympic Peninsula DPS, 5 in Southwest Washington, 8 in LCR, 1 in MCR, 4 in UCR, and 3 in the SRB DPS.

3.2.2 Freshwater productivity

We plotted freshwater productivity, measured as the average number of smolts produced per spawner, relative to spawner abundance for 11 populations with varying number of spawners (Figure 18). The results indicated variation in freshwater productivity among populations along with universally declining per-capita productivity as abundance increased. This relationship suggests that freshwater survival may be density dependent, which has been documented in other studies (Alldredge et al. 2015; Atlas et al. 2015; Walters et al. 2013). This potential density-dependence suggests that freshwater habitat may be limiting populations or, due to decreased numbers of spawners in the past few decades, the distribution of these spawners has been contracted (Atlas et al. 2015) and needs time to expand. Further evaluation of available habitat and smolt productivity relationships is needed to understand density dependence limitations.

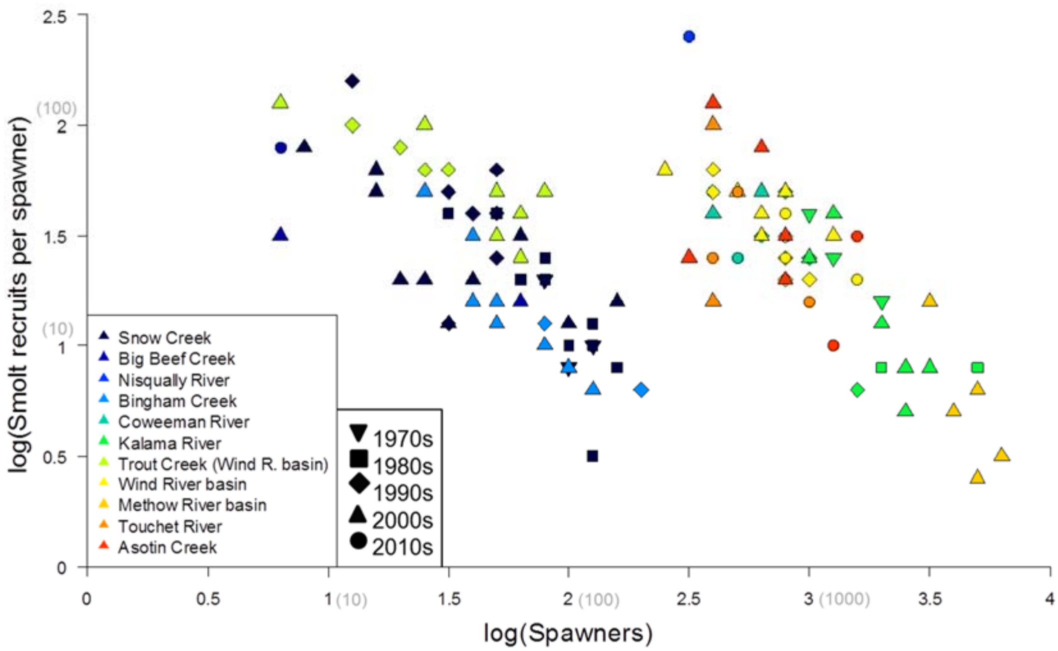

Figure 18. Annual numbers of natural-origin smolts produced per spawner compared to the numbers of spawners for all Washington populations/subpopulations with data between spawning year 1977 and 2012. Colors indicate populations/subpopulations and shapes identify decades.

3.2.3 Smolt to adult return productivity

Smolt-to-adult productivity estimates exist for 16 of the 114 extant steelhead populations, including at least one population from each DPS. For the Puget Sound and coastal DPSs, SARs (smolt survival in the ocean to return as adult recruits or spawners) from outmigration cohorts in 1978 to 2013 ranged from 0.1% to 35.6%. Average values for the LCR and Olympic Peninsula DPSs declined significantly over time (Figure 19). In recent years, SARs of steelhead in Bingham Creek (the only population with data in the Southwest Washington DPS) and in the Olympic Peninsula DPS populations have been consistently higher than those from the Puget Sound DPS (Figure 19). Until 2005, the only Puget Sound DPS subpopulation for which SARs could be estimated was Snow Creek in the Sequim and Discovery Bays Tributaries DIP. Because Snow Creek steelhead enter marine waters in the Strait of Juan de Fuca, this population's marine survival may not be representative of that for populations entering marine waters in more interior locations of Puget Sound. Snake River Basin DPS smolt survival values, which include both riverine migration and marine survival, have not shown an upward or downward trend. Only very recent data were available for MCR and UCR DPSs.

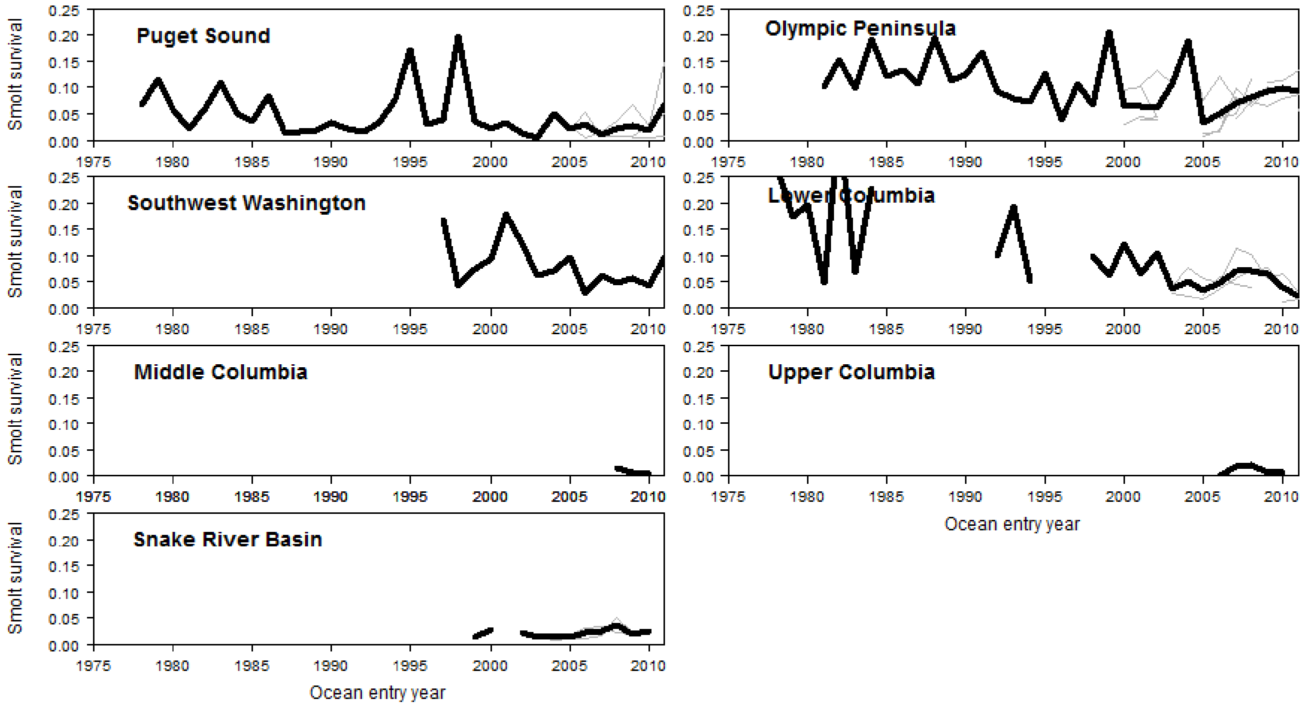

Figure 19. For each DPS, smolt survival, estimated as smolt to adult return (SAR) rates, of natural-origin steelhead spawners from smolt outmigration year 1975 to 2011 (16 populations represented: 2 populations and 1 sub-population in Puget Sound; 4 sub-populations and 1 population in Olympic Peninsula; 1 population each in Southwest Washington, MCR, UCR; 3 populations in LCR; and 2 populations in SRB DPS). The thick black line represents the average SAR value for each DPS and the thin grey lines represent data from individual populations therein.

3.3 Spatial structure results

Our results are limited to habitat losses due to large, impassable dams and irrigation-related barriers. As described in Chapter 2, data were not available statewide to quantify habitat loss due to smaller passage barriers, such as culverts and road crossings. Across the state, population-level habitat loss due to large dams and barriers was highly variable (Appendix C). In the Puget Sound DPS, six of 32 populations (19%) had lost greater than approximately 5% of their original habitat to large dams and barriers, with Baker River summer/winter-run steelhead (now considered extirpated) having lost 98.7% (Table 3). Two of 19 (11%) Southwest Washington DPS populations, four of 18 (22%) LCR DPS populations (Upper Cowlitz and Cispus combined), four of 9 (44%) MCR DPS populations, three of four (75%) UCR DPS populations, and one of four (25%) SRB DPS populations have lost more than about 5% of their habitat (Table 3). No Olympic Peninsula DPS populations have lost habitat to large dams or barriers.

Table 3. Spatial structure indicator results for populations with approximately 5% or greater loss of historical habitat due to the presence of large impassable dams, including irrigation diversion dams.

DPS	Population	Run-timing	Percent of habitat lost to large dams
Puget Sound	Baker	S & W	98.7%
Puget Sound	Green	W	33.2%
Puget Sound	Nooksack	W	4.9%
Puget Sound	Sequim & Discovery Bays tribs.	W	6.4%
Puget Sound	Skokomish	W	17.8%
Puget Sound	West Hood Canal	W	5.3%
SW Washington	Skookumchuck/Newaukum	W	16.4%
SW Washington	Wynoochee	W	6.4%
Lower Columbia	Lower Cowlitz	W	4.7%
Lower Columbia	North Fork Lewis	S	78.2%
Lower Columbia	North Fork Lewis	W	30.7%
Lower Columbia	Upper Cowlitz & Cispus	W	19.4%
Middle Columbia River	Naches	S	15.1%
Middle Columbia River	Toppenish	S	11.0%
Middle Columbia River	Touchet	S	4.5%
Middle Columbia River	Upper Yakima	S	45.2%
Snake River Basin	Tucannon	S	6.0%
Upper Columbia River	Entiat	S	10.0%
Upper Columbia River	Okanogan	S	18.3%
Upper Columbia River	Wenatchee	S	10.9%

3.4 Diversity results

3.4.1 Life History Diversity

3.4.1.1 Freshwater age composition

Freshwater age composition data, collected from outmigrating summer- and winter-run smolts, were available for a total of 17 populations or subpopulations from across all DPSs except for the Olympic Peninsula (Appendix C and Figure 20). Freshwater age composition varied within and among populations and DPSs. The majority of steelhead smolts in Washington leave freshwater after two years (average age at outmigration for a given population of 1.6 – 2.4).

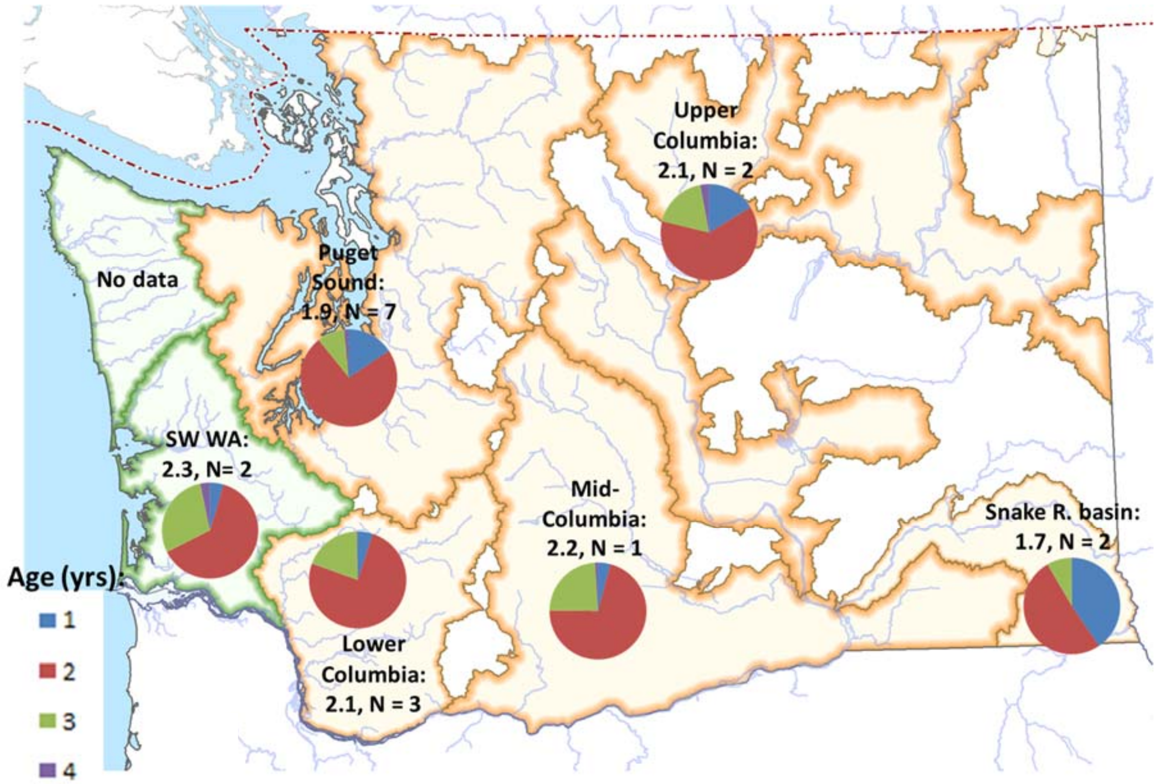

Figure 20. The number of Washington steelhead populations in each DPS (N) that have data on freshwater age composition (smolt age assessed using smolt scales). The pie charts show the average fraction of fish across populations and years in that DPS that have migrated to the ocean at ages 1-4.

3.4.1.2 Ocean age composition

Ocean age data were available from 21 winter-run and 15 summer-run steelhead populations or subpopulations across the state (Appendix C; Figures 21 and 22). The average ocean age of winter-run steelhead returning to freshwater ranged from 2.3 years in the LCR DPS to 2.5 years in Southwest Washington DPS. Summer-run steelhead were younger than winter-run fish when they returned to freshwater (Figure 22), though they spend up to a year in freshwater before spawning. Summer-run average ocean age ranged from 1.4 years for MCR steelhead to 2.0 years for LCR steelhead. We did not observe noteworthy trends in ocean age composition over time for any individual steelhead populations that suggested loss of diversity, though this may be due to the lack of available long-term data

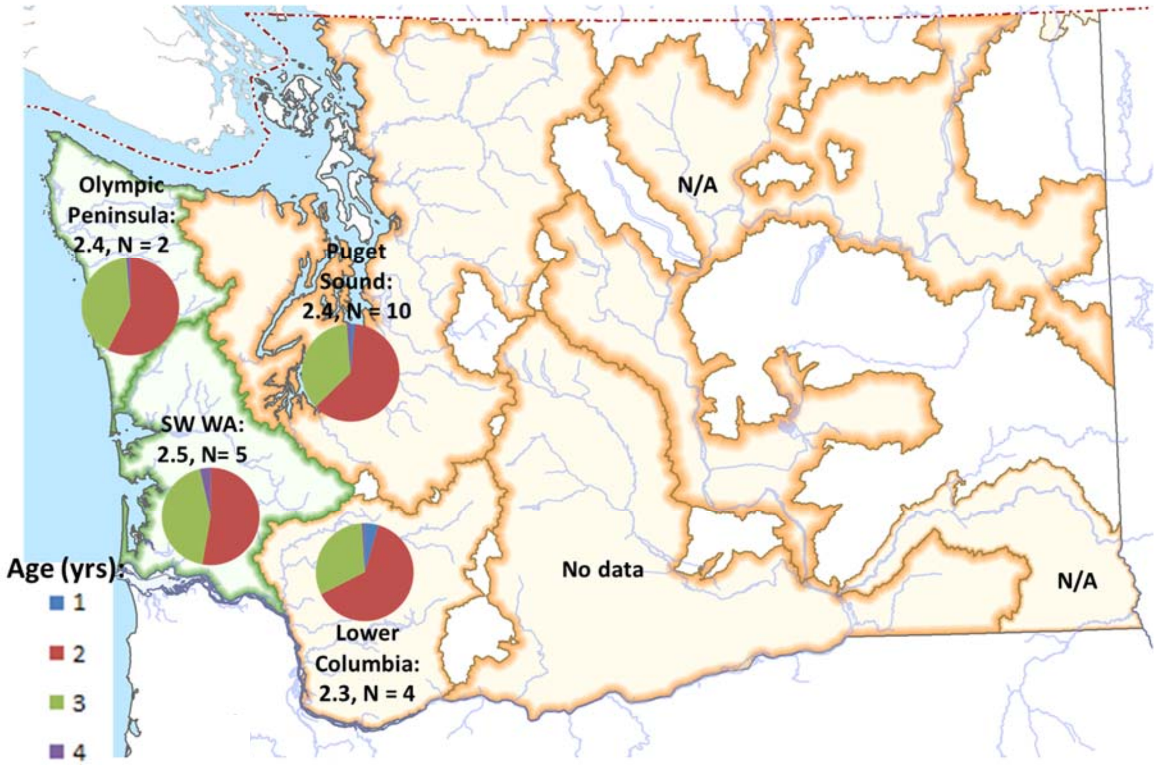

Figure 21. The number of Washington winter-run steelhead populations in each DPS (N) that have data on ocean age composition and the associated average ocean age. The pie charts show the average fraction of fish across populations and years in that DPS that have spent 1-4 years in the ocean. N/A = not applicable.

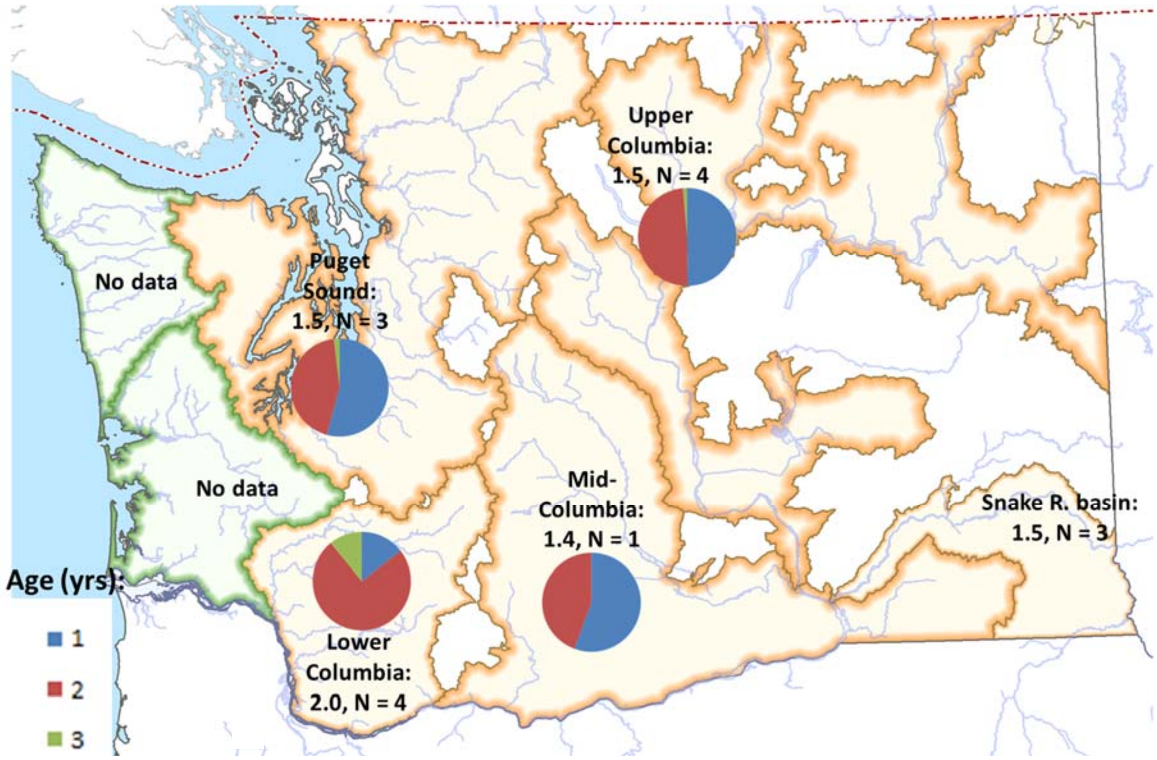

Figure 22. Number of Washington summer-run steelhead populations (N) in each DPS that have data on ocean age composition and the associated average ocean age. The pie charts show the average fraction of fish across populations and years in that DPS that have spent 1-3 years in the ocean.

3.4.2 Genetic diversity

Our potential to evaluate genetic diversity was limited statewide, with genetic baseline data available for only 50% of all populations (59 of 117, includes those considered extirpated; Appendix C). Coverage of populations varied among DPSs with genetic data available for 71.9% of Puget Sound populations, 16.1% of Olympia Peninsula populations, 21.1% of Southwest Washington populations, 63.2% of LCR populations, 88.9% of MCR populations, 100% of UCR populations, and 75% of SRB populations.

3.4.3 Hatchery programs and diversity indicators

As described in Chapter 2, we compiled information and data about hatchery programs that serve as indicators of diversity risks, in accordance with SSMP recommended actions focused on reducing rates of gene flow. There were 72 steelhead hatchery programs operating statewide in 2014, with 59 operated by WDFW. The remaining programs were operated by federal, tribal, or other entities. Steelhead programs occurred in all DPSs (Table 4). Lower Columbia and UCR DPSs had the highest numbers of hatchery programs per number of populations (18 hatchery programs and 19 populations for LCR DPS, 7 hatchery programs and 4 populations UCR DPS; Table 4). Fifty-eight percent of Washington steelhead hatchery programs were segregated programs, which use only hatchery-produced adults for broodstock (Appendix D). The UCR DPS was the only DPS where integrated programs outnumbered segregated programs (five of seven total hatchery programs; Appendix D).

From 2000 to 2013, the highest total average annual smolt releases occurred in Puget Sound and LCR DPSs (Table 4). Total average annual smolt releases for 2009-2013 were lower than those for 2000-2008 in all DPSs except for Southwest Washington DPS (Table 4). The largest reductions in total average annual smolt releases between the two time periods occurred in the Puget Sound DPS, followed by Olympic Peninsula and SRB DPSs (Table 4). Average percent of off-site hatchery smolt releases was highest in Olympic Peninsula, MCR, and SRB DPSs in both time periods (Table 4). In Puget Sound DPS, average percent of off-site hatchery smolt releases for 2009-2013 was substantially lower (16.4%) than that for 2000-2008 (40.4%; Table 4).

Table 4. Summary statistics for Washington steelhead hatchery programs in each DPS, including number of programs, total average annual number of smolts released, and average percent of off-site smolt releases. Values are based on population-level data, and some Snake River Basin and Upper Columbia DPS-level releases included in Appendix D. Extirpated populations are included in number of populations; one each in Puget Sound, Lower Columbia and Middle Columbia DPSs.

DPS	Number of Populations	Total number of hatchery programs as of 2014	Number of WDFW hatchery programs as of 2014	Number of other hatchery programs as of 2014	Total average annual number of smolts released (2000-2008)	Total average annual number of smolts released (2009-2013)	Average % of off-site hatchery smolt releases (2000-2008)	Average % of off-site hatchery smolt releases (2009-2013)
Puget Sound	32	16	14	2	2,170,572	1,562,771	40.4%	16.4%
Olympic Peninsula	31	11	3	8	1,383,022	1,072,781	65.0%	61.1%
SW Washington	19	13	12	1	909,644	941,664	38.4%	28.7%
Lower Columbia	19	18	18	0	2,309,976	2,160,426	22.7%	31.6%
Middle Columbia River	9	4	4	0	392,211	361,455	83.3%	83.3%
Snake River Basin	4	3	3	0	411,025	389,981	75.0%	75.0%
Upper Columbia River	4	7	5	2	1,073,830	996,831	0.0%	0.0%

Chapter 4 Risk assessment and determination of focal populations

In this chapter we:

- analyze available abundance data to calculate four risk metrics,
- assess current risk status (high, moderate, low) for Washington steelhead populations, and
- develop a list of high-priority focal populations based on estimated risk status.

Although NOAA uses the four VSP parameters to assess the viability and status of individual salmonid populations and their progress towards recovery (Ford 2011; McElhany et al. 2000), sufficient data for VSP parameters other than abundance were not widely available for most Washington steelhead populations, as described above. Therefore, we chose to perform a uniform, quantitative risk assessment based on available abundance data and developed a set of scoring criteria to rate population risk. When sufficient data on productivity, spatial structure, and diversity become available, they will be used in future risk assessments.

We assessed population viability risk for all 114 extant steelhead populations in Washington using several measures of abundance trends and, when available, a NOAA-determined risk rating in order to identify and highlight "at-risk" populations that were 1) in precipitous decline; 2) at chronically low abundance; 3) not meeting recovery or escapement goals; or 4) at high probability of falling below a quasi-extinction threshold. For ESA-listed populations, we incorporated NOAA's viability assessment ratings from their 2010 status review and Technical Recovery Team (TRT) reports (Ford 2011; Hard et al. 2015; McElhany et al. 2000) in our risk scoring as described below. In these NOAA documents, staff considered all VSP parameters when developing risk levels for populations, but they aggregated VSP parameter data differently for each DPS.

4.1 Risk assessment methods

The time period for which abundance data were available for populations varied greatly. For consistency, we assessed data during a common time period, 1980 to 2013. The year 1980 was chosen as a starting point because many (but not all) populations had data series from this year forward and few populations had data before this year. We analyzed four abundance-based metrics and chose a risk-rating criterion for each, as described below. For ESA-listed populations, we used a fifth metric based on NOAA's 2010 Status Review (Ford 2011) in order to include risk assessment results derived from all VSP parameters. See Appendix E for a summary table of the risk assessment methods described in detail below.

4.1.1 Risk rating metrics

The first metric was abundance change over time. We estimated the percent change in abundance (increase or decrease) over time periods with data using log-linear regression considering temporal autocorrelation to fit a line through each population's data series. Based on each population's regression model, we estimated the percent change in abundance (Equation 1).

Eq. 1 $$\text{Percent change} = \frac{\overline{A}_{latest\,5} - \overline{A}_{earliest\,5}}{\overline{A}_{earliest\,5}},$$

where $\overline{A}_{lastest\,5}$ is the mean of modeled abundance at the latest five years and $\overline{A}_{earliest\,5}$ is the mean of modeled abundance at the earliest five years. Our risk-rating criterion was a > 55% decline in abundance over the time period with data (criterion 1). Populations that met this decline criterion received one point for their risk score. This metric and risk-rating criterion were selected to track long-term changes in adult abundance and highlight particularly large changes.

The second metric was recent, short-term population growth rate trend, which we used to identify populations that had experienced a significant recent decline. To calculate this metric, we conducted a population viability assessment (PVA) on all steelhead populations with available data, as described in the earlier Washington steelhead assessment in Scott and Gill (Chapter 8, pgs. 9-11; 2008). By using the same PVA methodology, which is based on the Dennis et al. (1991) exponential growth model with random walk, our updated PVA results can be directly compared to those in the assessment by Scott and Gill (2008). We used the PVA to estimate trends using the instantaneous population growth rate, μ, defined as:

Eq. 2 $$ln(N_t) = ln(N_0) + \mu t,$$

where N_0 and N_t represent abundance at the initial year and at a following year, respectively. The instantaneous growth rate was estimated for the most recent 12 years of escapement abundance data for each population. We decided that it was more important to detect declines in population abundance instead of increases and thus we tested for the presence of a decline with a one-tailed significance test using the following hypotheses: $H_0: \mu \geq 0$ $H_a: \mu < 0$. T-tests were conducted at a significance level of α = 0.10 (i.e., μ = 0.10), consistent with previous analyses in the assessment by Scott and Gill (2008). Our risk-rating criterion was an estimated value of μ that was statistically significantly less than zero (criterion 2). Populations that met this short-term growth rate criterion were classified as "in decline" and received one point for their risk score.

We note that the Dennis et al. (1991) model requires few population demographic data (such as age composition) and performs well for populations that experience little or no density dependence (Holmes 2001). However, its results are sensitive to assumptions about population dynamic functional relationships (e.g., density-independent vs. density-dependent growth). The model overestimates risk when populations are experiencing considerable density dependence, which has recently been demonstrated in ESA-listed salmonid populations with severely reduced adult abundance (Alldredge et al. 2015; Walters et al. 2013), and underestimates risk for populations that experience density-dependent survival as their abundance increases above existing ranges (Holmes 2001).

The third metric was population extinction risk. We used the PVA-estimated instantaneous growth rates to estimate a population's extinction risk. We defined extinction risk in terms of the probability that a population would fall below a quasi-extinction threshold (QET) at least once in a specified number of years. We chose a 20-year time period for the risk analysis to be consistent with the metric defined in Allendorf et al. (1997). Population-specific QETs have been set for Puget Sound populations by NOAA (Hard et al. 2015). For all other populations we used a QET of 50 individuals based on the Interior Columbia TRT methods (Cooney et al. 2007). Our risk-rating criterion was an estimate of > 20% probability of falling below the population's QET once in 20 years (criterion 3; *c.f.* Allendorf et al. (1997). Populations that met this extinction risk criterion received one point for their risk score.

The fourth metric was frequency of meeting escapement or recovery goals. We compared each population's annual escapement abundance data in last ten years to its escapement or recovery goal. In the two non-ESA-listed DPSs (Olympia Peninsula and Southwest Washington) we used escapement goals set by WDFW and tribal co-managers. In the five ESA-listed DPSs, we used abundance recovery goals (developed in NOAA Fisheries-approved recovery plans) or interim abundance viability goals (developed by Puget Sound steelhead Technical Recovery Team (PSSTRT); Hard et al. 2015). We calculated the percentage of years that annual population escapement abundance met or exceeded its goal. Our risk-rating criterion was meeting the goal in only six or fewer years of the 10-year period, or, failure to meet goal ≥ 40% of the time (criterion 4). Populations that met this goal frequency criterion received one point for their risk score. A 70% threshold for meeting goals in order to be at low risk was considered conservative because goals we used are minimum escapement or recovery goals.

It is important to note that abundance goals (i.e., escapement, recovery, and interim viability) were developed with disparate methods among DPSs and populations. The escapement goals for non-listed DPSs (Olympia Peninsula and Southwest Washington) were, for the most part, developed based on the Parr Production Potential Model (Gibbons et al. 1985) before population-specific spawner-recruit data were available. Puget Sound interim viability goals ("low", "viable", and "capacity") were developed based on the modeled historical intrinsic smolt capacity using a population's habitat area, estimated smolt densities per area, and one of three levels of marine survival depending on the goal type (similar to Gibbons et al. 1985; Hard et al. 2015). For this report, we compared Puget Sound escapement data with the "viable abundance" interim goals, which are based on smolt capacity and 5% marine survival. Lower Columbia River Basin recovery goals were established by Lower Columbia Fish Recovery Board (Lower Columbia Fish Recovery Board (LCFRB) 2010) based on PVA analyses and designations of a population’s level of importance for DPS-wide recovery. Goals for Interior Columbia River DPSs were developed by the Interior Columbia Technical Recovery Team (2007) using viability curves to evaluate minimum abundance and productivity for each population. Spatial structure and diversity were also integrated differently across regions.

Using these different goal types results in an inconsistent evaluation of risk and thus comparisons of risk among DPSs may not be appropriate. However, criterion 4 (percentage of years in last ten that a goal was met) more accurately captures the risk facing populations whose dramatic decline occurred prior to 1980 (e.g., Interior Columbia populations) and was followed by increase in abundance. Populations with these characteristics would not meet risk criterion 1 or 2, but they would meet criterion 4. Additionally, large populations are inherently less likely to reach QETs that are set equal to 50, thus many large populations may be at high risk of extinction but, because of their size, they would not meet criteria 3 but they may meet criterion 4. This goal metric criterion also provides an early warning for populations that repeatedly miss their abundance goals but are not considered to be at high risk of extinction.

The fifth metric, applied only to ESA-listed populations, was NOAA’s 2010 Status Review (Ford 2011) or more recently comparable risk rating. The purpose of using this risk rating was to include an independent risk evaluation by multiple stakeholders using all VSP parameters. Inclusion of this metric elevates the potential risk score for populations in ESA-listed DPSs that should be most at risk. When feasible, we updated the 2010 rating with comparable or more recent data as follows. For interior Columbia River populations, we used raw abundance and productivity (AP) and spatial structure and diversity (SSD) risk scores from the 2010 Status Review (Ford 2011). For LCR populations we used AP/SSD scores updated with data through 2013 incorporating abundance thresholds published in LCFRB 2010, Appendix E, Ch. 12, and chose the lower of the separate AP and SSD scores. For Puget Sound populations with adequate adult abundance data we used the TRT’s PVA QET risk rating or AP/SSD viability rating, whichever was lower. Each ESA-listed population identified as at high risk (criterion 5) in the 2010 NOAA Status Review or comparable analyses received one point for their risk score.

4.1.2 Total risk scoring

We calculated each population’s total risk score by adding up points received for meeting criteria at all five metrics. An extinction risk rating of “high” was given to populations with total risk scores of 3 or higher, or when insufficient data were available to estimate a score for the first four metrics but the NOAA Status Review or TRT-evaluated risk level was high. We assigned a “moderate” risk rating to populations when total risk score was 1 or 2 or when insufficient data were available but the NOAA or TRT risk level was moderate or maintained. We assigned a “low” risk rating to populations that received no points for any metric or when insufficient data were available but the NOAA or TRT-assigned risk level was low. For any population that had missing abundance data and risk had not been defined by NOAA or a TRT, the risk was called “undetermined.”

4.1.3 Focal population selection

From the list of populations with high total risk scores, we selected “focal populations”. We defined focal populations as populations at high extinction risk, important for recovery and delisting, and for which actions can be taken to mitigate at least some of the risk factors. The purpose of designating focal populations was to identify populations of top priority for actions that could lower extinction risks. In selecting focal populations, we assumed resources more likely would be put towards the recovery of large- and medium-sized populations, which must attain a high level of viability for overall DPS viability to be high, as opposed to smaller populations that may be deemed less important to overall DPS viability. Thus, except for some populations in the Puget Sound DPS, focal populations were chosen among moderate-, large-, or very large-sized populations or primary or contributing populations as defined by NOAA TRT reports or recovery plan documents (Ford 2011; Interior Columbia Technical Recovery Team (ICTRT) 2007; Lower Columbia Fish Recovery Board (LCFRB) 2010).

4.2 Risk assessment results

4.2.1 Statewide and DPS-level results

Of the steelhead populations that were or are monitored and had sufficient population-level data, a majority, 38 (52%), showed decreasing abundance trends (abundance change < -10%) since 1980, 30 (41%) showed an increasing trend (change >10%), and 5 (7%) showed a low level of change suggesting no trend. Puget Sound (18%), Olympic Peninsula (20%), and Southwest Washington (38%) DPSs had the lowest proportions of populations with increasing trends (Figure 23). Populations in the three interior Columbia Basin DPSs showed mostly increasing trends. Populations in these three DPSs were predominantly at very low abundance in the 1980s, so their positive trend in abundance is an important improvement.

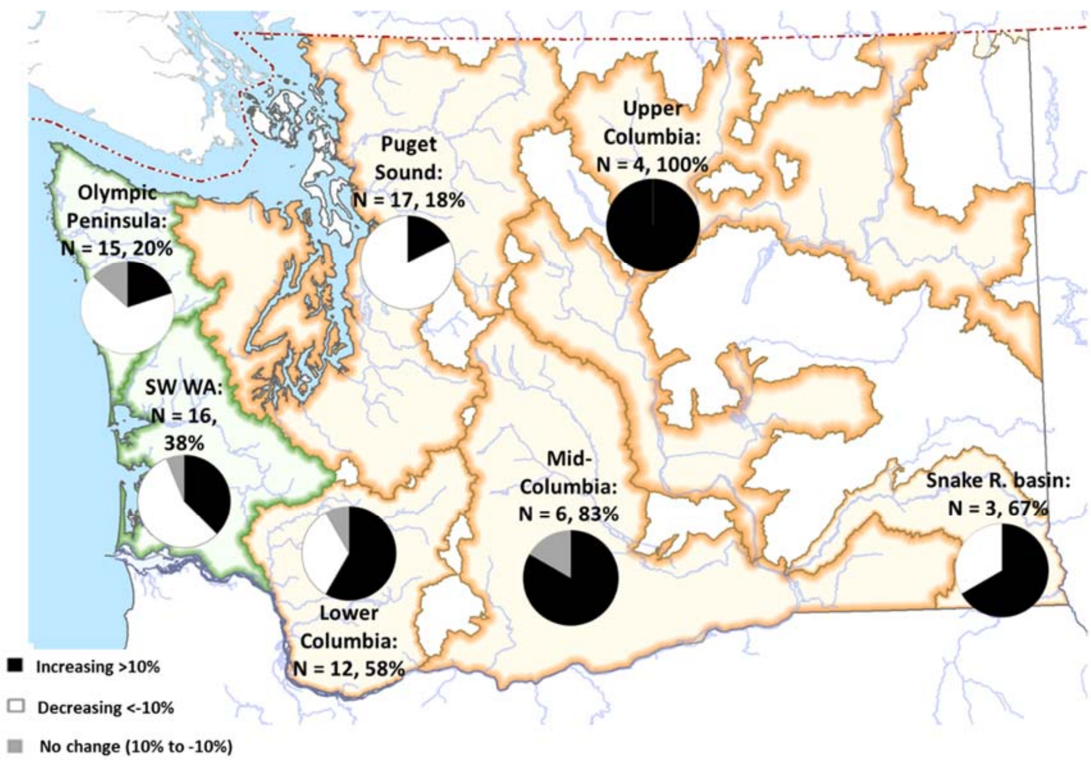

Figure 23. Washington steelhead population escapement abundance trends in each DPS in time periods from 1980-2013. N represents in the number of populations in each DPS that had suitable abundance data for trend analysis and the percentage indicates the proportion of populations that have increased in abundance since 1980.

Statewide, among populations with available data, only 10 populations (14%) met the high risk criterion (> 55% decline) for long-term abundance trend (metric 1; Table 5). Eight of those populations were in Puget Sound DPS and there was one each in Olympic Peninsula and Lower Columbia DPSs. Regarding risk from short-term (12 year) decline (metric 2), only five populations (7%) showed such declines that met the high risk criterion of a growth rate significantly less than zero. These included one Puget Sound DPS population, two Olympic Peninsula DPS populations, and two Southwest Washington DPS populations (Table 5).

Of the 69 populations with appropriate abundance data and a defined quasi-extinction threshold (QET; metric 3), 18 (26%) had a > 20% probability of abundance falling below their QET at least once in the next 20 years, thus meeting high risk criterion 3. The Lower Columbia DPS had the lowest percentage of populations (17%) that met this extinction risk criterion, and the Upper Columbia DPS had the highest percentage (75%; Figure 24). In all other DPSs, 33% or fewer of the populations had met this extinction risk criterion (Figure 24).

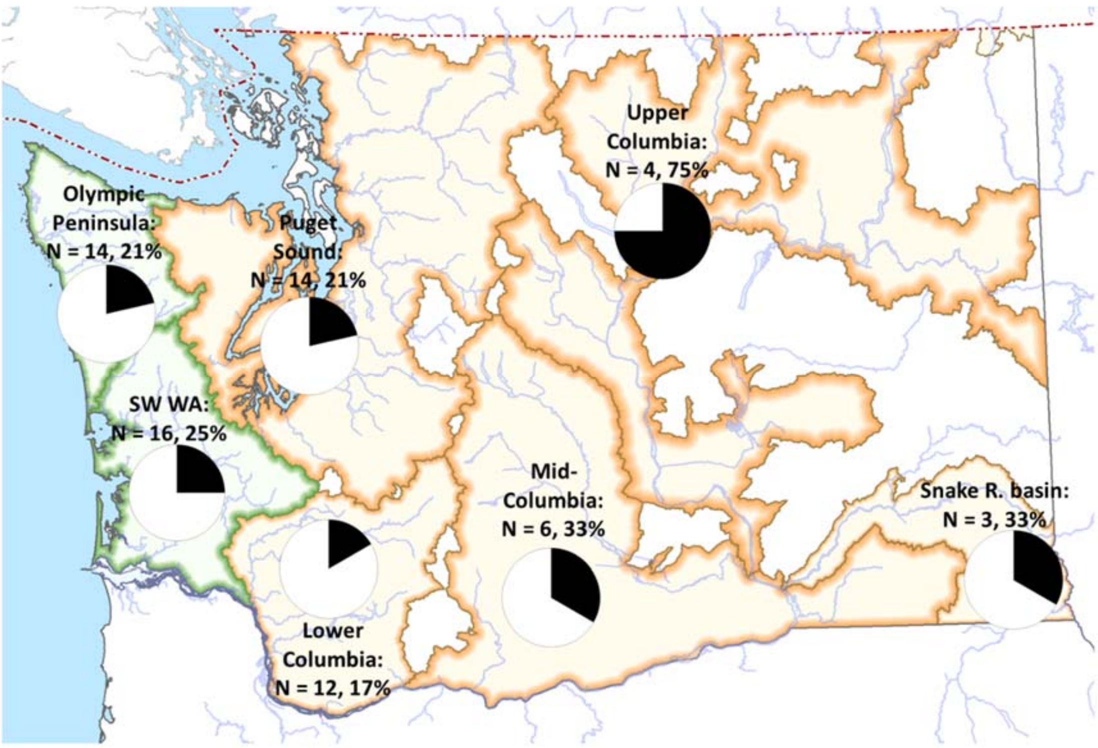

Figure 24. The number of Washington steelhead populations in each DPS (N) that can be assessed for extinction risk and the percent of populations with a greater than 20% probability of abundance falling below a QET at least once in the next 20 years. In the pie charts, the black portion shows the fraction of populations at risk for extinction under this criterion and white portion shows the fraction of populations that did not meet the criterion.

Of the 71 populations with defined escapement or recovery goals and appropriate abundance data, 20 (28%) had abundance above their escapement or recovery goal in seven or more of the recent 10 years. Thus, 51 populations (72%) met the high risk criterion of meeting their recovery or escapement goal (metric 4) in only six or fewer years of the last 10 (Table 5). None of the 17 Puget Sound DPS populations or the four UCR DPS populations had met their abundance goal in seven or more of the last 10 years and thus all met the high risk criterion. The majority of populations in the SRB DPS (67%) and the Olympic Peninsula DPS (54%) had met their goals (Figure 25). In all other DPSs, most populations met the high risk criterion. It is important to again note that comparison among DPSs of population abundance performance relative to escapement or recovery goals is limited by the differing methods used to establish these goals.

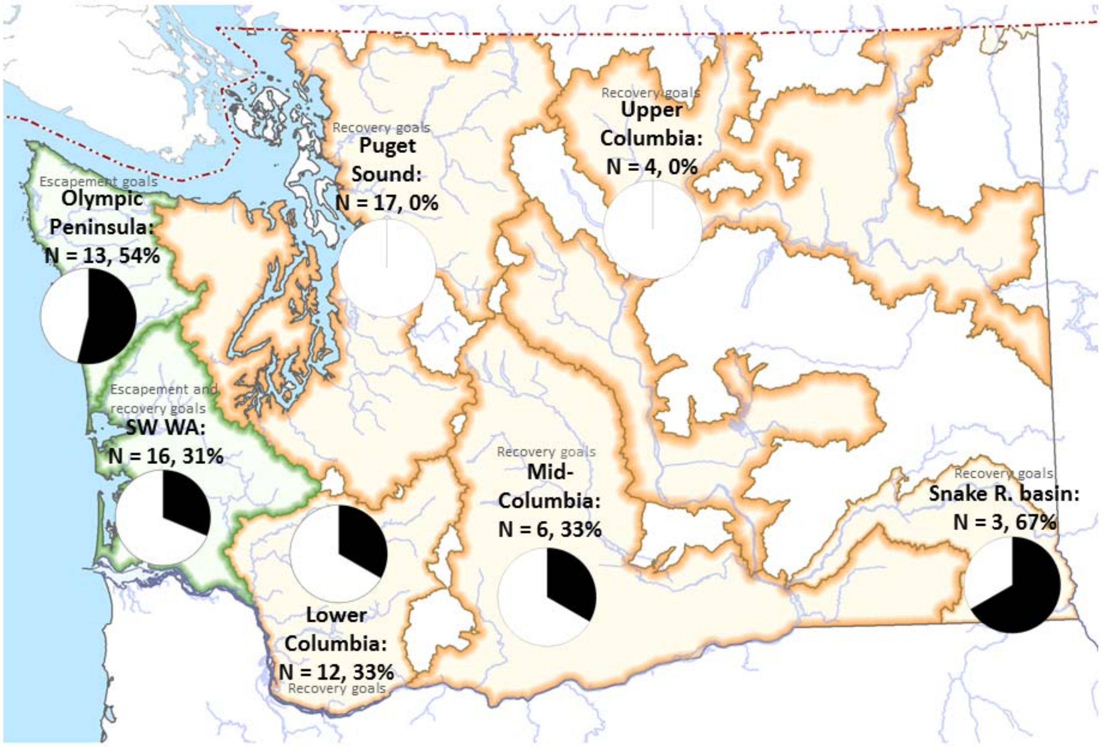

Figure 25. The number of Washington steelhead populations in each DPS (N) that can be assessed for meeting their recovery or escapement goal and the percent of populations whose annual escapement estimates in the most recent 10 years were above the population's escapement or recovery goal in 7 or more of those years. In the pie charts, the black portion shows the fraction of populations that met goals in seven or more years and white portion shows the fraction of populations that did not met goals in seven or more years of the 10-year period.

Statewide, we identified 21 populations (18%) at high risk, 49 (43%) at moderate risk, 16 (14%) at low risk, and 28 (25%) of undetermined risk (Table 5). Risk level was assigned to 15 populations based on a NOAA or TRT status review rating (fifth risk metric) because insufficient abundance data were available to assess risk using the other four metrics. The number of populations at high risk varied among DPSs, with the UCR having the highest fraction (75%; Figure 26) and Southwest Washington having no populations at high risk. Puget Sound, Olympia Peninsula, and Southwest Washington DPSs had a number of populations for which a total risk level could not be estimated.

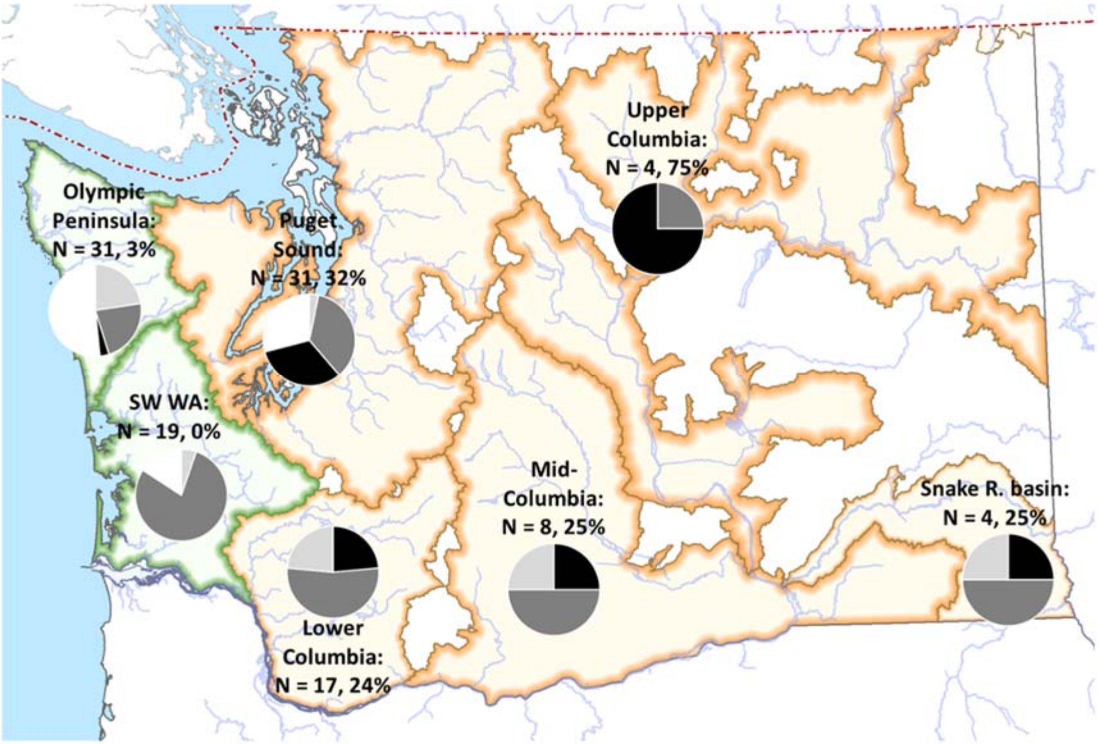

Figure 26. The number of Washington steelhead populations in each DPS (N) for which a total risk score can be estimated and the percent of populations with a high total risk score. In the pie charts, the black portion shows the fraction of populations with a total high risk score, the medium grey portion shows the fraction of populations with a moderate total risk score, the light grey portion shows the fraction of populations with a low total risk score, and the white is the fraction of populations for which a total risk score cannot be estimated due to insufficient data.

Table 5. Risk assessment results for five metrics for all Washington steelhead populations and focal population selections. Focal populations are identified above the red line and red text indicates values that exceeded specific criterion for each metric identified in section 4.1. Populations below the red line and above the yellow line were high risk but not focal populations because they are unlikely to qualify as an independent population (Goodman Creek), or they are a small population (remainder).

Population			SARR Risk Criteria					SARR Risk Score		
DPS	Population	Run	Long Term Abundance Trend	Short Term Decline	Extinction Risk	Status relative to abundance goal	NOAA 2010 or TRT Risk Score	SARR risk score	Population Risk Score	Focal Population
PS	Cedar	W	-100%	Yes	100%	0%	High	5.0	High	Yes
PS	Nisqually	W	-87%	No	2%	0%	High	3.0	High	Yes
PS	Puyallup/Carbon	W	-84%	No	8%	0%	High	3.0	High	Yes
PS	Stillaguamish	W	-80%	No	0%	0%	High	3.0	High	Yes
PS	Green	W	-59%	No	12%	0%	High	3.0	High	Yes
PS	South Hood Canal	W	-20%	No	insuf. data	0%	High	2.0	High	Yes
PS	Tolt	S	-19%	No	25%	0%	High	3.0	High	Yes
Snake	Tucannon	S	27%	No	54%	0%	High?	3.0	High	Yes
UC	Okanogan	S	50%	No	56%	0%	High	3.0	High	Yes
UC	Methow	S	89%	No	20%	10%	High	3.0	High	Yes
MC	Upper Yakima	S	264%	No	23%	0%	High	3.0	High	Yes
LC	Upper Cowlitz/Cispus	W	466%	No	27%	0%	High	3.0	High	Yes
PS	Dungeness	W	insuf. data	insuf. data	insuf. data	insuf. data	High	TRT only	High	Yes
PS	Elwha	W	insuf. data	insuf. data	insuf. data	insuf. data	High	TRT only	High	Yes
LC	North Fork Lewis	W	insuf. data	insuf. data	insuf. data	insuf. data	High	TRT only	High	Yes
PS	Sequim & Discovery Bays tribs.	W	-72%	No	79%	0%	High	4.0	High	No
OP	Goodman Creek	W	-54%	Yes	91%	60%	N/A	3.0	High	No
UC	Entiat	S	65%	No	58%	0%	High	3.0	High	No
LC	Lower Gorge	W	insuf. data	insuf. data	insuf. data	insuf. data	High	TRT only	High	No
MC	Rock	S	insuf. data	insuf. data	insuf. data	insuf. data	High	TRT only	High	No
LC	Salmon	W	insuf. data	insuf. data	insuf. data	insuf. data	High	TRT only	High	No
PS	Snohomish/Skykomish	W	-92%	No	11%	0%	Low	2.0	Moderate	No
OP	Lower Quinault	W	-69%	No	0%	goal undefined	N/A	1.0	Moderate	No
PS	Snoqualmie	W	-58%	No	1%	0%	Moderate	2.0	Moderate	No
LC	South Fork Toutle	W	-56%	No	16%	30%	Low	2.0	Moderate	No
SW WA	Hoquiam	W	-48%	No	0%	10%	N/A	1.0	Moderate	No
SW WA	Wishkah	W	-46%	No	30%	90%	N/A	1.0	Moderate	No
LC	Kalama	S	-45%	No	25%	50%	Moderate	2.0	Moderate	No
OP	Salt Creek/Independents	W	-43%	No	68%	20%	N/A	2.0	Moderate	No
PS	Skokomish	W	-39%	No	1%	0%	High	2.0	Moderate	No
PS	Strait of Juan de Fuca Ind. tribs.	W	-39%	No	insuf. data	30%	High	2.0	Moderate	No
LC	Upper Gorge	W	-32%	No	insuf. data	goal undefined	High	1.0	Moderate	No
SW WA	Bear	W	-29%	No	26%	100%	N/A	1.0	Moderate	No
OP	Queets	W	-29%	No	0%	50%	N/A	1.0	Moderate	No
SW WA	Chehalis	W	-28%	No	0%	30%	N/A	1.0	Moderate	No
OP	Clallam	W	-27%	No	60%	40%	N/A	2.0	Moderate	No
SW WA	Willapa	W	-26%	Yes	16%	10%	N/A	2.0	Moderate	No
PS	Skagit	S & W	-25%	No	0%	0%	Low	1.0	Moderate	No
SW WA	Nemah	W	-22%	No	26%	70%	N/A	1.0	Moderate	No
OP	Pysht/Independents	W	-21%	No	1%	30%	N/A	1.0	Moderate	No
SW WA	Naselle	W	-20%	No	3%	60%	N/A	1.0	Moderate	No
LC	Coweeman	W	-17%	No	1%	40%	Moderate	1.0	Moderate	No
OP	Hoh	W	-16%	No	0%	50%	N/A	1.0	Moderate	No
PS	Pilchuck	W	-12%	No	6%	0%	Low	1.0	Moderate	No
SW WA	Satsop	W	-11%	No	0%	30%	N/A	1.0	Moderate	No
SW WA	Wynoochee	W	-9%	Yes	0%	100%	N/A	1.0	Moderate	No
MC	Touchet	S	-4%	No	0%	0%	Maintained?	1.0	Moderate	No
SW WA	North/Smith	W	11%	No	8%	0%	N/A	1.0	Moderate	No
SW WA	Grays	W	12%	No	10%	20%	N/A	1.0	Moderate	No
PS	Nooksack	W	19%	insuf. data	insuf. data	0%	not rated	1.0	Moderate	No
MC	Walla Walla	S	21%	No	85%	40%	Maintained	2.0	Moderate	No
LC	Wind	S	21%	No	6%	10%	Low	1.0	Moderate	No
SW WA	Skamokawa/Elochoman	W	23%	No	0%	50%	N/A	1.0	Moderate	No
PS	White River (Puyallup)	W	26%	No	11%	0%	Moderate	1.0	Moderate	No
SW WA	Palix	W	34%	No	0%	30%	N/A	1.0	Moderate	No
SW WA	Mill/Abernathy/Germany	W	50%	No	37%	0%	N/A	2.0	Moderate	No
OP	Calawah	W	50%	Yes	0%	100%	N/A	1.0	Moderate	No
UC	Wenatchee	S	52%	No	7%	40%	High	2.0	Moderate	No

Population			SARR Risk Criteria					SARR Risk Score		
DPS	Population	Run	Long Term Abundance Trend	Short Term Decline	Extinction Risk	Status relative to abundance goal	NOAA 2010 or TRT Risk Score	SARR risk score	Population Risk Score	Focal Population
SW WA	Skookumchuck/Newaukum	W	57%	No	0%	40%	N/A	1.0	Moderate	No
Snake	Asotin	S	94%	No	4%	80%	Maintained-High?	1.0	Moderate	No
LC	Washougal	W	142%	No	11%	50%	Moderate	1.0	Moderate	No
LC	Tilton	W	195%	No	10%	60%	High	2.0	Moderate	No
LC	East Fork Lewis	W	200%	No	17%	20%	Moderate	1.0	Moderate	No
MC	Naches	S	332%	No	1%	50%	Maintained	1.0	Moderate	No
PS	Samish and Belligham Bay tribs.	W	440%	No	4%	0%	Low	1.0	Moderate	No
PS	East Hood Canal	W	insuf. data	insuf. data	insuf. data	insuf. data	Moderate	TRT only	Moderate	No
MC	Klickitat	S & W	insuf. data	insuf. data	insuf. data	insuf. data	Maintained?	TRT only	Moderate	No
LC	Lower Cowlitz	W	insuf. data	insuf. data	insuf. data	insuf. data	Moderate	TRT only	Moderate	No
Snake	Lower Grande Ronde	S	insuf. data	insuf. data	insuf. data	insuf. data	Maintained	TRT only	Moderate	No
PS	West Hood Canal	W	insuf. data	insuf. data	insuf. data	insuf. data	Moderate	TRT only	Moderate	No
OP	Hoko	W	-40%	No	0%	80%	N/A	0.0	Low	No
SW WA	Humptulips	W	-35%	No	0%	80%	N/A	0.0	Low	No
OP	Dickey	W	-22%	No	7%	100%	N/A	0.0	Low	No
Snake	Joseph	S	-19%	No	2%	100%	Low	0.0	Low	No
OP	Clearwater	W	-12%	No	0%	100%	N/A	0.0	Low	No
OP	Sol Duc	W	-9%	No	0%	80%	N/A	0.0	Low	No
OP	Quillayute/Bogachiel	W	-6%	No	0%	90%	N/A	0.0	Low	No
LC	Kalama	W	0%	No	11%	100%	Low	0.0	Low	No
OP	Upper Quinault	W	24%	No	0%	100%	N/A	0.0	Low	No
OP	Moclips	W	27%	insuf. data	insuf. data	goal undefined	N/A	insuf. data	Low	No
MC	Satus	S	166%	No	6%	100%	Maintained	0.0	Low	No
LC	Washougal	S	167%	No	9%	70%	Low	0.0	Low	No
LC	East Fork Lewis	S	299%	No	1%	80%	Moderate	0.0	Low	No
MC	Toppenish	S	471%	No	13%	80%	Maintained	0.0	Low	No
LC	North Fork Toutle	W	insuf. data	No	0%	70%	Moderate	0.0	Low	No
PS	Sauk	S & W	insuf. data	insuf. data	insuf. data	insuf. data	Low	TRT only	Low	No
OP	Calawah	S	insuf. data	insuf. data	insuf. data	insuf. data	N/A	insuf. data	insuf. data	No
PS	Canyon	S	insuf. data	insuf. data	insuf. data	insuf. data	not rated	insuf. data	insuf. data	No
SW WA	Chehalis	S	insuf. data	insuf. data	insuf. data	insuf. data	N/A	insuf. data	insuf. data	No
OP	Clearwater	S	insuf. data	insuf. data	insuf. data	insuf. data	N/A	insuf. data	insuf. data	No
OP	Copalis	W	insuf. data	insuf. data	insuf. data	insuf. data	N/A	insuf. data	insuf. data	No
PS	Deer	S	insuf. data	insuf. data	insuf. data	insuf. data	not rated	insuf. data	insuf. data	No
PS	Drayton Harbor tributaries	W	insuf. data	insuf. data	insuf. data	insuf. data	not rated	insuf. data	insuf. data	No
PS	East Kitsap	W	insuf. data	insuf. data	insuf. data	insuf. data	not rated	insuf. data	insuf. data	No
OP	Hoh	S	insuf. data	insuf. data	insuf. data	insuf. data	N/A	insuf. data	insuf. data	No
SW WA	Humptulips	S	insuf. data	insuf. data	insuf. data	insuf. data	N/A	insuf. data	insuf. data	No
OP	Kalaloch Creek	W	insuf. data	insuf. data	insuf. data	insuf. data	N/A	insuf. data	insuf. data	No
OP	Lyre	W	insuf. data	insuf. data	insuf. data	insuf. data	N/A	insuf. data	insuf. data	No
OP	Mosquito Creek	W	insuf. data	insuf. data	insuf. data	insuf. data	N/A	insuf. data	insuf. data	No
PS	Nookachamps	W	insuf. data	insuf. data	insuf. data	insuf. data	not rated	insuf. data	insuf. data	No
PS	North Fork Skykomish	S	insuf. data	insuf. data	insuf. data	insuf. data	not rated	insuf. data	insuf. data	No
PS	North Lake Washington Tribs.	W	insuf. data	insuf. data	insuf. data	insuf. data	not rated	insuf. data	insuf. data	No
OP	Ozette	W	insuf. data	insuf. data	insuf. data	insuf. data	N/A	insuf. data	insuf. data	No
OP	Queets	S	insuf. data	insuf. data	insuf. data	insuf. data	N/A	insuf. data	insuf. data	No
OP	Quillayute/Bogachiel	S	insuf. data	insuf. data	insuf. data	insuf. data	N/A	insuf. data	insuf. data	No
OP	Quinault	S	insuf. data	insuf. data	insuf. data	insuf. data	N/A	insuf. data	insuf. data	No
OP	Raft	W	insuf. data	insuf. data	insuf. data	insuf. data	N/A	insuf. data	insuf. data	No
OP	Sail	W	insuf. data	insuf. data	insuf. data	insuf. data	N/A	insuf. data	insuf. data	No
OP	Sekiu	W	insuf. data	insuf. data	insuf. data	insuf. data	N/A	insuf. data	insuf. data	No
OP	Sol Duc	S	insuf. data	insuf. data	insuf. data	insuf. data	N/A	insuf. data	insuf. data	No
OP	Sooes/Waatch	W	insuf. data	insuf. data	insuf. data	insuf. data	N/A	insuf. data	insuf. data	No
SW WA	South Bay	W	insuf. data	insuf. data	insuf. data	insuf. data	N/A	insuf. data	insuf. data	No
PS	South Fork Nooksack	S	insuf. data	insuf. data	insuf. data	insuf. data	not rated	insuf. data	insuf. data	No
PS	South Sound tributaries	W	insuf. data	insuf. data	insuf. data	insuf. data	not rated	insuf. data	insuf. data	No
PS	Baker	S & W	insuf. data	insuf. data	insuf. data	insuf. data	not rated	insuf. data	extirpated	No
LC	North Fork Lewis	S	insuf. data	insuf. data	insuf. data	insuf. data	High	TRT only	extirpated	No
MC	White Salmon	S & W	insuf. data	insuf. data	insuf. data	insuf. data	extirpated	TRT only	extirpated	No

4.2.1.1 Puget Sound DPS

Eight of 17 Puget Sound populations (47%) with sufficient data met the high risk criterion (> 55% decline) for long-term abundance trend (Table 5). Only three populations (Nooksack River, White River, Samish and Bellingham Bay tributaries) showed an increasing abundance trend. Fourteen extant populations could not be assessed for long-term trend risk due to insufficient data. Among the 16 populations with appropriate data, only one (Cedar River) met the high risk short-term decline criterion (growth rate significantly < 0). Among 14 populations with appropriate data, three populations met the high risk of extinction criterion (> 20% probability of reaching QET). All 17 populations with data met the high risk criterion for failure to meet interim abundance viability goals. For the fifth risk metric, 12 populations had a TRT high risk rating. Based on results for the five risk metrics we rated 10 populations at high total risk, 11 at moderate total risk, one at low total risk and nine at undetermined risk (Table 5; Figure 26). See also section 5.3.1, Table 6.

4.2.1.2 Olympic Peninsula DPS

Lower Quinault River was the only one of 15 Olympic Peninsula populations (7%) that met the high risk criterion for long-term abundance trend (Table 5). However, 11 others (73%) showed a decreasing (negative) abundance trend. Sixteen populations could not be assessed for long-term trend risk due to insufficient data. Among 14 populations with appropriate data, two (Goodman Creek, Calawah River) met the high risk short-term decline criterion. Three of 14 populations met the high risk of extinction criterion. Of the 13 populations with defined escapement goals, six met the high risk criterion for failure to meet escapement goals. Although many Olympia Peninsula populations showed declining abundance (Figure 23), 54% of populations had met escapement goals in at least 70% of last 10 years (Figure 25). The fifth risk metric was not applied to this DPS as it is not ESA listed. Based on results for the four risk metrics, we rated one population at high total risk, seven at moderate total risk, seven at low total risk and 16 at undetermined risk (Table 5; Figure 26). See also section 5.3.2, Table 7.

4.2.1.3 Southwest Washington DPS

None of 16 Southwest Washington populations met the high risk criterion for long-term abundance trend (Table 5). However, 10 populations (63%) showed a decreasing (negative) long-term trend. Three populations could not be assessed for long-term abundance trend risk due to insufficient data. Two of 16 populations (Willapa and Wynoochee rivers) met the high risk short-term decline criterion. Four of 16 populations met the high risk of extinction criterion. Eleven of 16 populations (69%) met the high risk criterion for failure to meet escapement goals. The fifth risk metric was not applied to this DPS as it is not ESA listed. Based on results for the four risk metrics, we rated 15 populations at moderate total risk, one at low total risk and three at undetermined risk (Table 5; Figure 26). See also section 5.3.3, Table 8.

4.2.1.4 Lower Columbia River DPS

South Fork Toutle River was the only one of 12 Lower Columbia populations (6%) that met the high risk criterion for long-term abundance trend (Table 5). Seven populations (58%) showed an increasing abundance trend. Five extant populations could not be assessed for abundance trend risk due to insufficient data. No populations met the high risk short-term decline criterion. Two populations (Upper Cowlitz/Cispus, Kalama summer-run) met the high risk of extinction criterion. Eight of 12 populations (67%) with appropriate data met the high risk criterion for failure to meet recovery goals. For the fifth risk metric, seven populations had a NOAA high risk rating. Based on results for the five risk metrics we rated four extant populations at high total risk, nine at moderate total risk, and four at low total risk (Table 5; Figure 26). See also section 5.3.4, Table 9.

4.2.1.5 Middle Columbia River DPS

None of six Middle Columbia populations with sufficient data met the high risk criterion for long-term abundance trend (Table 5). Five populations (83%) showed an increasing abundance trend. Three populations could not be assessed for long-term trend risk due to insufficient data. No populations with data met the high risk short-term decline criterion. Two of the six extant populations (Upper Yakima and Walla Walla rivers) met the high risk of extinction criterion. Four of six populations (67%) with appropriate data met the high risk criterion for failure to meet recovery goals. For the fifth risk metric, two populations had a NOAA high risk rating. Based on results for the five risk metrics we rated two populations at high total risk, four at moderate total risk, and two at low total risk (Table 5; Figure 26). See also section 5.3.5, Table 10.

4.2.1.6 Upper Columbia River DPS

None of four Upper Columbia populations met the high risk criterion for long-term abundance trend (Table 5). All four populations showed an increasing abundance trend, and none met the high risk short-term decline criterion. Three of the four populations met the high risk of extinction criterion. All four populations met the high risk criterion for failure to meet recovery goals. For the fifth risk metric, all four populations had a NOAA high risk rating (Table 5). Based on results for the five risk metrics we rated three populations at high total risk and one at moderate total risk (Table 5; Figure 26). See also section 5.3.6, Table 11.

4.2.1.7 Snake River Basin DPS

None of three Snake River Basin populations met the high risk criterion for long-term abundance trend, and none met the high risk short-term decline criterion (Table 5). One population could not be assessed for abundance trend risk due to insufficient data. One population (Tucannon River) met the high risk of extinction criterion and also met the high risk criterion for failure to meet recovery goals. For the fifth risk metric, two populations had a NOAA high risk rating. Based on results for the five risk metrics we rated one population at high total risk, two at moderate total risk, and one at low total risk (Table 5; Figure 26). See also section 5.3.7, Table 12.

4.3 Focal population selection

Out of the 21 high risk populations, we selected 15 as focal populations (Table 5; Figure 27). Of these populations, nine were from Puget Sound and six were from DPSs within the Columbia River Basin.

The criteria that most often led to a population being characterized as high risk were, in the order of the number of populations in each category: failure to meet escapement or recovery goal in more than three of 10 years (criterion 4); high NOAA or TRT risk score (criterion 5); > 20% probability of falling below QET in 20 years (criterion 3); and > 55% decline in long-term abundance (criterion 1). Only five populations had a growth rate significantly less than 0 in last 12 years (short-term decline; criterion 2), and two of these were characterized as high risk (Table 5).

Populations with high risk scores but not selected as focal populations due to small size and/or less critical to DPS-wide recovery as characterized by their respective TRTs were: Sequim and Discovery Bay tributaries (Puget Sound DPS), Lower Gorge, and Salmon Creek (LCR), Rock Creek (MCR), and Entiat River (UCR; Table 5). Goodman Creek (Olympic Peninsula) had a high risk score (Table 5) but was not selected as a focal population because we believed it would not qualify as a DIP under a formal population identification process given its small size. North Fork Lewis summer-run population had a high risk score (Table 5) but not selected as a focal population because it is considered extirpated.

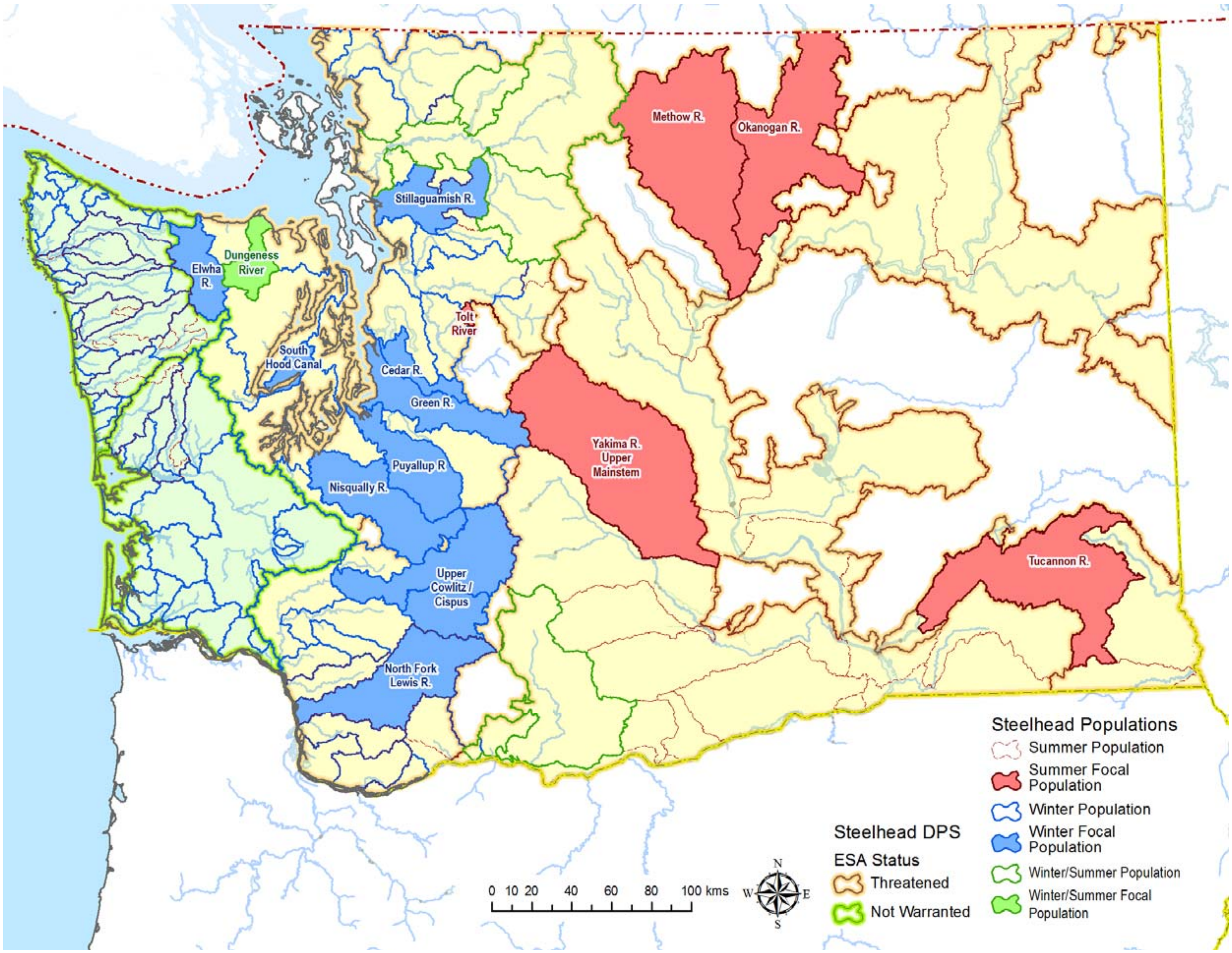
Methow R.
Okanogan R.
Stillaguamish R.
Dungeness River
Elwha R.
Tolt River
South Hood Canal
Cedar R.
Green R.
Yakima R. Upper Mainstem
Puyallup R
Nisqually R.
Upper Cowlitz / Cispus
Tucannon R.
North Fork Lewis R.
Steelhead Populations
Summer Population
Summer Focal Population
Winter Population
Winter Focal Population
Winter/Summer Population
Winter/Summer Focal Population
Steelhead DPS
ESA Status
Threatened
Not Warranted
0 10 20 40 60 80 100 kms
N
W
E
S

Figure 27. The fifteen steelhead focal populations selected in Washington.

Chapter 5 Threats and actions

In this chapter we:

- describe key threats and actions for steelhead at the statewide and DPS scales and
- identify threats and actions specific to focal populations.

We define a threat as anything reducing the viability of steelhead at the statewide, DPS, or population scale and actions are those that may eliminate or mitigate threats to increase steelhead viability. We expect the statewide- and DPS-scale actions we recommend to improve the viability of all populations. For focal populations, we recommend specific actions we think will help prevent their extinction in the long term.

5.1 Methods and approach

We reviewed and researched information on threats to steelhead viability and the types of actions known or expected to be effective at alleviating those threats. To fully identify applicable threats and actions, we used existing documents, particularly steelhead recovery plans, TRT reports, and NOAA 5-year status reviews. We also used results from our analysis of abundance, productivity, diversity and spatial structure (the VSP parameters) to identify threats. This approach provided the means to develop concise lists of threats and their associated actions that we thought most critical or addressed the most limiting factors. To help choose the most applicable threats and actions, we used a life-cycle framework to decide which ones may be most pressing or best dealt with the most common limiting factors. Whenever possible, we summarized threats at the broadest, most relevant scale. For example, threats that were common across DPSs were summarized as statewide issues. Threats shared among populations in a DPS were reported at that scale. At the population scale, we limited our attention to focal populations due to their high risk status. For these, we identified population-specific threats and recommended actions that could be implemented in the near term.

5.2 Statewide threats and actions

Historical changes in steelhead abundance have resulted from changes in habitat (freshwater and marine), dams and passage barriers, hatcheries, and harvest. However, the rate of abundance change and the extent of synchrony of that change associated with these causal factors differs greatly, suggesting that these causal factors may contribute unequally to recent fluctuations in steelhead abundance. For example, fishery impacts on most populations were reduced between the 1980s and early 2000s and harvest rates for most populations have remained relatively low and invariant over the most recent decade, suggesting harvest is unlikely to be responsible for recent synchronous changes in abundance at the larger, DPS spatial scale. Similarly, effects of changes in hatchery management along with spawning and rearing habitat conditions are unlikely to explain recent changes in abundance at large spatial scales because changes to these parameters have been slow and asynchronous. Specifically, changes in hatchery impacts have been neither synchronous nor large in most cases, and both improvement and degradation in spawning and rearing habitat has occurred at a relatively slow and inconsistent rate around the state. In contrast, variable marine survival has resulted in relatively synchronous changes in adult abundance at larger spatial scales in recent years (Kendall et al. 2017). Similarly, improved juvenile survival through Columbia Basin hydropower dams over the last decade has impacted adult abundance trends for UCR, MCR, and SRB DPSs in a positive and synchronous manner (Comparative Survival Study Oversight Committee and Fish Passage Center 2017). Continued assessment of long-term adult abundance trends provides the most comprehensive information for assessing threats.

We organized our description of statewide threats to steelhead viability in the following categories: hatcheries, harvest, habitat, dams, barriers and fish passage, and predation. These categories also were applied to threats description at the DPS scale. In this section, we summarize the nature of threats in each category that were common throughout Washington and describe expected impacts to viability. Fully addressing these threats will require WDFW and its resource management partners to maintain or implement a wide variety of management actions and strategies. WDFW has the ability to take direct action regarding hatchery and harvest threats, but has limited legal authority to directly control habitat threats. With this limited capacity, the agency continues its commitment to working with tribal, state, federal and local partners on habitat protection and restoration.

In choosing actions to recommend regarding statewide threats, we particularly focused on those WDFW could take directly and with existing partnerships. Some actions may be already underway, some likely could be implemented with minor additional funding, and some would require significant new funding. In choosing relevant actions, funding limitations did not constrain our choices. Instead, we hope our recommendations will be catalysts to secure funds to alleviate or eliminate threats to steelhead viability.

5.2.1 Hatcheries

It has been recognized for quite some time that the production, release, and return of hatchery fish present potential threats of harm to both the hatchery fish themselves and to the wild, native populations into which hatchery fish are released (e.g., Reisenbichler and McIntyre 1977; Reisenbichler 1983). There are a number of reviews and summaries of the possible harms associated with hatchery production of fish or salmonids (e.g., Araki et al. 2008; Araki and Schmid 2010; Naish et al. 2007). Statewide, WDFW currently operates 59 steelhead hatchery programs (Table 4). Hatcheries produce steelhead for purposes such as harvest augmentation and conservation and are generally successful at producing returning adults. As mentioned in section 2.5, WDFW has developed HGMPs that are intended to minimize hatchery-related threats to steelhead.

Hatchery threats or harms can be categorized broadly as ecological and genetic. Ecological harms include competition (hatchery fish competing with wild fish for limited resources) and predation (hatchery fish directly consuming wild fish). Genetic harms almost all require interbreeding of hatchery and wild fish and include domestication selection (increased frequency in the wild population of alleles favored in the hatchery environment), inbreeding (reduction in genetic diversity in wild fish due to inbreeding and reduction of genetic diversity in the hatchery population), and out-breeding depression (fitness reduction due to interbreeding between genetically different hatchery and wild fish).

In recognition of potential threats, the US Congress established the Hatchery Scientific Review Group (HSRG) in 2000. Its goals were to identify risks associated with hatcheries and provide recommendations and operational standards to reduce these risks. The HSRG proposed two models of managing hatchery programs to minimize genetic risks to wild populations associated with hatchery production. The key ingredient of these models is managing the interbreeding of hatchery and wild fish. Under the segregated model, only hatchery-produced fish are used as broodstock in the hatchery and interbreeding of hatchery and wild fish on the spawning grounds is kept very low as measured by a pHOS target of 5% or less. Under the integrated model, hatchery and wild fish can both be used as hatchery broodstock and hatchery fish are allowed to interbreed naturally with wild fish at a much higher rate. The Washington Fish and Wildlife Commission adopted the HSRG recommendations and developed a Hatchery and Fishery Reform Policy in 2009. WDFW now manages its steelhead hatchery programs using either the segregated or integrated model.

WDFW operates nearly all integrated steelhead programs for conservation purposes. Almost all segregated programs use one of two highly domesticated stocks, the Skamania summer-run steelhead stock (Washougal River (Lower Columbia) origin) or the Chambers winter-run steelhead stock (Chambers Creek (Puget Sound) origin). These stocks are also referred to as 'early summer' stock and 'early winter' stock, respectively, due to their artificially-selected early return and spawn timing compared to timing of contemporary wild summer- and winter-run populations. Hereafter, we use the terminology 'Chambers early winter' and 'Skamania early summer' when referring to these hatchery stocks.

The HSRG's integrated and segregated models minimize, but do not eliminate, the risk of genetic harms associated with hatchery production, and they do not address ecological harms at all. For example, it has been shown that using wild broodstock in an integrated program produces large numbers of residual steelhead, steelhead that fail to migrate to the sea (Hulett et al. 2004; McMichael et al. 1997; Reisenbichler et al. 2008; Sharpe et al. 2007; Snow et al. 2013). This outcome threatens reduction of life history diversity in the population, and loss of productivity if residualized fish have low relative fitness, as has been shown in other species (Chinook salmon, *O. tshawytsha*;) (Ford et al. 2012; Ford et al. 2015). Managing interbreeding of segregated hatchery and wild fish is difficult and, under some circumstances, (depending on logistics or similarity in return and spawn timing) it is not feasible or possible to limit hatchery fish on the spawning grounds (Seamons et al. 2012). Generations of interbreeding can lead to introgression of hatchery genes to the wild population and may, in theory, depress survival and productivity, leading to declines in abundance. Thus, even though WDFW manages steelhead hatchery programs using HSRG models, there are still risks of genetic harms to the wild populations.

Ecological and behavioral interactions of hatchery- and wild-origin fish, including competition and disease transmission, may occur even if hatchery programs are operated under HSRG models. One such interaction includes that by the residualizing juveniles mentioned above. Steelhead in Washington typically spend about half of their life in freshwater. Freshwater resident fish compete for limited resources. Residualization of hatchery-origin juveniles creates opportunities for ecological interactions including competition and predation (Hausch and Melnychuk 2012). Segregated and integrated programs both produce residuals but at different rates, with integrated programs producing many more residuals than segregated programs (Sharpe et al. 2007). Thus, this type of ecological threat may be greater from integrated programs.

Hatchery steelhead may be predator or prey, feeding on wild-origin fishes or being eaten by predators. Evidence of ecological effects of steelhead hatchery releases has been revealed, for example, in decreased natural production of native, wild steelhead with releases of non-native hatchery steelhead (Kostow and Zhou 2006), but direct causes have not been thoroughly examined. Fish in hatcheries, because of their crowded conditions, are more susceptible to pathogenic diseases. Additionally, hatchery fish outplanting may introduce non-native pathogens to wild fish or amplify endemic pathogens in the wild, among other effects (Naish and Hard 2008). While these kinds of problems are possible for hatchery steelhead, evidence specifically for steelhead releases is absent from the literature.

Conservation hatchery programs, whose primary purpose is "to maintain or recover natural populations and their genetic resources" (Hatchery Scientific Review Group (HSRG) 2014), may be initiated if populations have a high extinction risk. In these situations, the demographic risk of extinction may outweigh any risks of genetic or ecological harms of hatchery programs. The HSRG compiled a framework intended to guide the management of conservation programs through recovery of populations in an ecological context while minimizing risks (Hatchery Scientific Review Group (HSRG) 2014). The framework identified four recovery stages of a target population: preservation, re-colonization, local adaptation, and full restoration. In the preservation stage, prevention of extinction and preservation of the genetic integrity and diversity of the population outweigh any risk of genetic and ecological harm. In the other three recovery stages, conservation hatchery programs are expected to minimize the risks of genetic harms associated with hatchery programs summarized above.

Statewide, as of 2014, there were 20 conservation-type hatchery programs, and they were present in all DPSs except Olympic Peninsula DPS (Appendix D). We included risks associated with conservation hatchery programs when assessing threats at the DPS level and for focal populations. Besides genetic risks mentioned above, conservation hatchery programs can pose ecological risks. For example, hatchery releases may have harmful ecological effects related to density dependence. If release goals are not scaled to a system's carrying capacity and relationship between density-dependence and productivity, natural production may be harmed, or at the least not benefited. Ecological threats from conservation programs can be assessed by evaluating relationship between natural smolt production and spawner abundance. If smolt production is demonstrated not to be spawner limited, a conservation program may not be effective. Several studies have documented deleterious effects of conservation hatchery programs on wild steelhead populations, and few have noted beneficial viability-related improvements associated with conservation programs (Araki and Schmid 2010; Byrne and Copeland 2012; Christie et al. 2014).

WDFW and its partners regularly conduct hatchery monitoring activities to evaluate production performance, assess benefits and impacts to wild populations, and meet regulatory requirements. WDFW has a goal of obtaining unbiased estimates of hatchery impacts consistent with hatchery goals and ESA permit conditions, as detailed in various HGMPs. This requires the monitoring of ecological and genetic interactions of hatchery fish with wild populations (Hulett et al. 2004). These monitoring activities were identified in HGMPs submitted to NOAA and are consistent with study designs to evaluate ecological and genetic risks of harm (Ham and Pearsons 2001; Hatchery Scientific Review Group (HSRG) 2014).

The effectiveness of hatchery programs is being evaluated around the state. For example, recent hatchery reform actions implemented in the Wenatchee Basin limit the number of hatchery fish allowed to spawn naturally upstream of Tumwater Dam. Of those hatchery fish, only progeny of wild broodstock are passed upstream. Progeny of wild broodstock have been shown to have reproductive success similar to that of natural fish in Hood River, Oregon studies (Araki 2007) and more recently in the upper Wenatchee Basin (WDFW, unpublished data). Another Upper Columbia River relative reproductive success and hatchery introgression study is ongoing in the Twisp River.

As part of the hatchery reform process, WDFW has already implemented many actions to reduce effects of hatcheries on wild steelhead, and will continue to move towards reducing and eliminating deleterious effects of hatcheries on wild fish. Driving WDFW's actions and priorities are: HSRG recommendations, SSMP, and the Fish and Wildlife Commission Fishery and Hatchery Reform Policy.

<u>Actions</u>

1. Operate all hatchery programs to minimize negative impacts on wild populations and meet HGMP requirements. Expand monitoring of presence of hatchery fish on spawning grounds for programs with largest potential impacts (e.g., off-site release programs, programs with largest releases relative to wild population size).
2. Improve our estimates of gene flow and pHOS for populations around the state for which high-quality data currently are not available.
3. To reduce the genetic risks associated with hatchery production, continue to follow the recommendations of the HSRG in implementing hatchery reform, including clearly identifying the goals of each program.

4. To provide mark-selective fisheries and to maximize efficiency of pHOS estimation and management, continue to externally mark all hatchery-produced steelhead, except when part of an active preservation hatchery program
5. To minimize harmful ecological effects related to density dependence, codify policy so that all existing and future conservation hatchery programs must scale smolt release goals to achieve desired spawning escapement by considering carrying capacity and density dependent relationships with productivity.
6. Transition to the use of volitional smolt releases, where juvenile steelhead swim out of the hatchery rather than being forced out, and to the release of non-migrants into land-locked waters for all hatchery programs.
7. Include population viability analysis as a regular component of monitoring, with outcomes that can be related to conservation hatchery performance measures and recovery stage.

5.2.2 Harvest

Declining population abundance, the initiation of universal adipose fin-clipping of hatchery steelhead, and ESA listings in most of the state have resulted in reduced fishery impacts on wild steelhead populations. Harvest impacts on wild steelhead are managed through mark-selective sport fisheries that require wild steelhead release, by legal prohibition of non-tribal commercial sale of steelhead, and through tribal treaty fisheries' operations designed to achieve conservation objectives. Although sport fishery impacts have been greatly reduced, non-treaty commercial fishery impacts have been minimal for many decades, and tribal treaty fishery impacts are managed within acceptable and/or agreed-to levels, harvest-related threats still remain. Besides direct and indirect wild steelhead mortality from fishery activities, estimates of harvest impacts may not be accurate or precise due to existing methods and fishery impacts could be higher than expected.

In general, established fishery mortality rates have been reduced and are proportional to population status, such that non-ESA-listed Olympic Peninsula and SW Washington populations are subjected to higher harvest rates than ESA-listed Puget Sound or Columbia Basin populations. However, there are risks associated with managing fisheries by allowable harvest rates. Harvest rates designed to achieve a conservation target (e.g., maximum sustainable yield, MSY) depend on population productivity, which is known to have varied considerably in space and time across the state. In addition to managing fisheries to achieve population-specific mortality rates, the quantification of fishery impacts provides another approach for managing risks to populations.

Wild steelhead mortality estimation methods could be improved in sport, non-treaty commercial, and tribal fisheries statewide. Managing fisheries with biased or very imprecise fishery mortality estimates poses risks because the true magnitude of fishery impacts is unknown, impacts may not be distinguished from other factors, and may thereby negate the ability of managers to address harvest-related declines in population status. Accuracy and precision of fishery mortality estimates should therefore be evaluated to ensure estimates are unbiased and precision is sufficiently high to be risk-averse.

To address indirect harvest threats, there are several opportunities to improve quantification of fishery impacts to wild steelhead. For example, sport fishery handle rate of wild fish (by which a mortality rate is multiplied to obtain total mortalities) is only estimated on an annual basis in a limited number of locations where creel surveys occur. Directed catch and release fisheries occur on most non-listed populations and some listed populations. Many listed and non-listed populations are encountered in either mark-selective steelhead fisheries targeting hatchery fish, or (presumably to a lesser extent) in fisheries targeting salmon or other trout species. Methods could be developed to estimate handle frequency for a greater proportion of sport fisheries, either by expanding creel programs or expanding the catch record card system to incorporate non-retention information. In addition to estimating handling rate, sport and non-treaty commercial fishery impact estimates would be improved by incorporating catch and release mortality rate information that is specific to fishery conditions such as water temperatures and gear types used in those fisheries. While this has occurred to some extent in the past, ongoing catch and release mortality studies should enable application of mortality rates that are appropriate for fishery-specific conditions.

In addition to improving quantification of fishery impacts resulting from known fishery mortality sources (legally retained or released steelhead), efforts should be made to quantify currently unaccounted-for fishery impacts. Unaccounted-for impacts include any source of fishery-related mortality not currently included in fishery impact estimates. Mortality sources may include gill net drop-out, which is currently only calculated for a subset of fisheries, and illegal and unreported harvest of wild steelhead that undoubtedly occurs throughout the state but is unquantified in mortality estimation models. Currently, estimates of released steelhead in sport and non-treaty commercial fisheries, and retained steelhead in tribal fisheries rely upon self-reporting (e.g., creel interviews, submission of commercial fish tickets). No systematic efforts have been made to estimate the rate of under-reporting and the extent to which current estimates of harvest are negatively biased.

No estimates are regularly made of illegal harvest that occurs outside of sanctioned fisheries. Efforts should be made to quantify illegal and under-reported harvest, particularly for populations with very low viability or especially vulnerable to illegal or unreported harvest, and for those with available information, such as tagging data, that suggests the magnitude of adult mortality may be considerably greater than reported harvest rates, thereby implying that harvest may be underestimated. Populations migrating through Columbia River mainstem upstream of Bonneville Dam particularly appear vulnerable to underestimated harvest threats.

Finally, for mixed stock fisheries (e.g., Columbia River mainstem; marine fisheries), little information is available to develop population-specific mortality rates. Although aggregate handle rates and impacts are calculated, if certain populations are handled disproportionately due to migration timing, migration routes, or body size (e.g., net selectivity), their true mortality rates may differ considerably from reported aggregate rates. Efforts should be made to identify stock-composition in mixed stock fisheries and to develop population-specific harvest rates.

Actions

1. Continue to construct sport and non-treaty commercial fishery regulations that protect wild steelhead through time, manner, and place
2. Continue to manage state fisheries to keep overall impacts at a low or acceptable rate.
3. Implement the practice of systematically and consistently estimating total harvest mortality on steelhead populations statewide, either by expanding creels or exploring alternative methods.
4. Determine whether catch record cards may be modified to accommodate the reporting of released wild steelhead in order to estimate handling in sport fisheries statewide without reliance on creel surveys.
5. Quantify risks by developing methods to estimate harvest mortality that include known precision and test for bias for all fisheries (e.g., sport, non-treaty commercial, tribal)
6. Initiate and continue studies to measure non-retention mortality and sub-lethal impacts to steelhead released from fisheries.

7. Undertake studies to quantify illegal harvest of wild steelhead and work to increase enforcement where necessary.
8. Conduct genetic or other analysis of mixed stock fisheries to better delineate population-specific impacts.

5.2.3 Riverine habitat

Freshwater habitat that steelhead depend on is degraded throughout the state due to a legacy of natural resource extraction, agricultural practices, increased surface flow diversion, and human development. Despite on-going restoration efforts, habitat continues to be negatively affected by human population growth and habitat conversion (Northwest Indian Fisheries Commission (NWIFC) 2012). Habitat loss is a key factor limiting steelhead productivity and recovery in all DPSs, especially those where steelhead are ESA-listed (Ford 2011). The quantity of available habitat for steelhead has been reduced by floodplain development, upstream passage barriers, and water extraction. Habitat quality has also been degraded throughout the state by development and natural resource extraction, which has resulted in reduced vegetative cover, disrupted groundwater connections to streams, river impoundment, and loss of natural channel form and floodplain structure that may lead to elevated water temperatures. Throughout the Pacific Northwest, Intensively Monitored Watersheds (IMW) are used to evaluate fish population response to different types of restoration. However, Bennett et al. (2016) remind us that degradation occurred over centuries and that restoration with an associated fish response should not be expected within the first decade of monitoring.

Threats from projected climate change impacts include increased freshwater temperatures and seasonal flow alterations, which would exacerbate existing poor habitat conditions. Modeled climate change projections of Wade et al. (2013) suggested that 1) exposure to high temperatures will be greatest in interior Columbia River Basin; 2) the most extreme reductions in low flow magnitudes would occur primarily in western Cascade Mountains, lower Snake River, and UCR drainages; and 3) exposure to extreme high flows would be greatest in the western Cascades region.

Loss of habitat and spatial structure due to dams and other major barriers was large for some populations (Table 3) and improving passage conditions would be beneficial to fish habitat capacity and population resilience. Of the 15 focal populations, 6 (40%) are affected by habitat lost (>5% loss) due to impassable dams. Numerous populations, especially in the UCR DPS, have been extirpated by impassable dams. If growth of populations is limited by available freshwater habitat, as was suggested by smolts per spawner productivity data (section 3.2.2), current freshwater habitat conditions would have to be improved, spatially and/or qualitatively, to yield increases in juvenile survival and smolt production. Thus, actions that increase freshwater habitat capacity may be highly effective for increasing abundance.

<u>Actions</u>

1. Direct research towards identifying stream reach type specific restoration practices to life stage specific survival bottlenecks.
2. Continue to support habitat restoration by expediting HPA permits, providing environmental engineering expertise, and providing planning and design expertise on priority restoration projects in steelhead watersheds.
3. Promote the use of climate change resilient culvert design into fish passage structures.
4. In HPA permit process, continue to promote mitigation actions that focus on the most limiting factors to steelhead production potential, if they are known, and continue to include monitoring requirements in water crossing structure permits to ensure performance standards are met.

5. Continue to use WDFW's Priority Habitat and Species Program to engage with local governments statewide to continue to protect and restore aquatic and riparian habitat, especially with riparian protection strategies under Critical Area Ordinances, and emphasize restoration efforts that address habitat restoration at a landscape/watershed scale. Continue to identify, protect, and enhance cold water refuges.
6. Continue to work with natural resource agencies, local governments, and forest owners to protect and restore functions of riparian areas, reduce impacts of forest roads, and address upland issues related to fresh water aquatic function.
7. Develop priority watersheds for recovery and share this population recovery strategy with Lead Entities and Salmon Recovery Regions.
8. Refine and train restoration practitioners in the use of Stream Restoration Guidelines developed by WDFW.
9. Continue to invest in instream flow enhancement projects where feasible including instream water transfers, irrigation or water-use efficiency projects, and fish screens at instream diversions to help achieve adequate streamflow levels, guard against critical temperature exceedance, and prevent fish entrainment that exchange colder tributary water for mainstem water to improve buffer against increasing temperatures.
10. Pursue land-use and fire management policy changes that would improve ecosystem integrity to fire and climate change related impacts.
11. Ask the Washington State Legislature to consider statutory changes to the HPA legislation to enable consideration of cumulative impacts of projects on fish life.
12. Direct research towards identifying locations where climate change will have particularly acute and negative impacts on steelhead in order to better prioritize habitat restoration and protection actions that may offset impacts.
13. Current and modeled future water temperature constraints should be incorporated in estimation of usable steelhead habitat to plan effective protection and restoration actions.

5.2.4 Dams, barriers and fish passage

Migration barriers occur throughout the state and limit or restrict passage or survival in a number of ways, and contribute to habitat loss and degradation. Although most large barriers, such as hydroelectric dams, are now passable, many barriers remain that exclude steelhead and other fish from historically productive habitat. Dams and culverts interrupt the transport of wood and sediment and thus hinder the maintenance and creation of critical aquatic habitat. WDFW estimates that there are at least 18,000-20,000 barriers to salmon and steelhead across Washington State. This estimate does not include barriers in resident-only waters (i.e., upstream of fully blocking natural barriers). As of 2017, over 48,000 instream features have been assessed by WDFW for fish passage. The Fish Barrier Removal Board, established in 2014 and chaired by WDFW, is actively prioritizing and has secured funding for passage improvements statewide. For steelhead, passage must be made effective and efficient for up- and down-stream migration by adults and juveniles. Throughout the state, vast improvements have been made in terms of providing connectivity to areas upstream of barriers, preventing the entrainment of fish into irrigation diversions, and improving survival through impoundments of all types. However, because they are so numerous and can have profound effects on steelhead populations, continued improvements to dams and other passage barriers likely represent some of the most beneficial actions across the state.

Given the paramount importance of the mainstem Columbia River migratory corridor to all Columbia Basin steelhead populations, it is essential to ensure the Columbia River hydropower system is managed in ways that promote the recovery and persistence of steelhead populations. Threats to juveniles and adults from passage through or past mainstem dams and reservoirs include longer and delayed migration times, greater exposure to predation, elevated water temperatures, and physical harm. Kelts especially experience poor survival when dam spill is low and they end up passing through turbines (NOAA Fisheries 2008). In the Snake River, spillway weirs installed at FCRPS dams appeared to be the primary passage route for kelts instead of turbine or juvenile bypass system routes, and provided the highest estimated survival at two of the dams in 2012 and 2013 (Colotelo et al. 2014). Continuing improvements to dam facilities and spill management are needed to minimize kelt and smolt outmigration mortality at all dams.

Actions

1. Continue to work with dam owners, including those with Federal Energy Regulatory Commission (FERC) licenses, and regulatory agencies to ensure adult and juvenile passage survival targets required by licenses, settlement agreements, and Habitat Conservation Plans (HCPs) are met at all dams.
2. To provide steelhead access to historical distribution, continue to pursue and advocate for strategies that improve or provide passage at water storage dams, diversion dams, hatcheries, and other non-energy producing dams statewide.
3. Work with Fish Barrier Removal Board members, salmon recovery boards, Lead Entities, and restoration partners to develop a quantitative prioritization strategy for removal of barrier culverts based on potential population benefits and recovery importance, and solicit legislative support.
4. To facilitate improving up- and downstream fish passage, complete mapped inventory and prioritization of culverts and irrigation diversions in Washington using WDFW expertise and salmon recovery partners, and strive to complete inventories in at least one high priority watershed in each salmon recovery region every two years.
5. Complete the statewide removal of all artificial fish passage barriers, including hatchery facility structures, on WDFW-owned lands by 2026.
6. To improve downstream passage of pre-spawn adult steelhead, kelts, and juveniles at all dams and irrigation diversions, continue active engagement on the Columbia River Technical Management Team, Fish Passage Advisory Committee, and Comparative Survival Study.
7. To improve outmigration survival for steelhead smolts and kelts at Columbia Basin hydropower dams, evaluate and test spill strategies against survival and condition benefits (Comparative Survival Study Oversight Committee and Fish Passage Center 2017).
8. Continue to systematically survey and modify irrigation diversions and screens to maximize fish passage and survival.
9. Work to refine Intrinsic Potential Models based on empirical data to provide predictions of population gains resulting from barrier removal and use results to prioritize restoration.

5.2.5 Predation

Predation is a natural source of mortality throughout fish life stages, but in many cases predation rates may be elevated as a result of anthropogenic modifications that either benefit predators or render steelhead more vulnerable. Elevated predation is associated with dams, irrigation diversions, man-made islands, and other habitat alterations that facilitate predation of juveniles or smolts by certain bird species and piscivorous fish (Antolos et al. 2005; Evans et al. 2012; Hostetter et al. 2015). Potential future predation by Northern Pike (*Esox lucius*) in the anadromous portion of the Columbia River basin is an emerging concern.

Returning adults may be predated on more heavily by marine mammals (Fryer 1998) that experience easier hunting as a result of habitat modifications, especially migration bottlenecks caused by dams or other passage barriers. Steelhead smolts appear to experience significant mortality while migrating through Puget Sound (Moore et al. 2015), and populations with a longer migration may experience higher mortality rates. Current research is examining the extent this mortality is due to predation by marine mammals, among other factors. The availability of alternative prey for steelhead predators may help reduce predation on juvenile steelhead, and thus efforts to protect and restore nearshore habitats to support forage fish are important. Predation risk factors at sea for all steelhead are not well known.

Actions

1. Compile a statewide review of available information on DPS- and population-specific predations rates, categorize by type (e.g., fish, bird, and marine mammal), identify factors associated with high predation rates, and identify data gaps for future research efforts.
2. Work to distinguish between natural predation rates and those inflated by anthropogenic impacts.
3. Work with dam operators and other resource management agencies to develop comprehensive plans to manage anthropogenically-inflated predation that may benefit multiple populations or DPSs.
4. Continue to protect and restore nearshore habitats to support forage fish.
5. Continue to support the Salish Sea Marine Survival project.

5.3 DPS-scale threats and actions

5.3.1 Puget Sound

Declining abundance was a major factor in NOAA's 2007 decision to list the DPS as threatened under the ESA. Continued abundance decline (Figure 10) and low abundance values were primary factors in overall high extinction risk estimated by the TRT for many populations (Hard et al. 2015). Lack of adult abundance data for 39% of populations (Figure 9), including all but one summer-run population, as well as a lack of SAR estimates for wild populations, contributes to relatively high uncertainty for DPS-wide abundance trends and extinction risk estimates. DPS-wide reliance on redd-count-based abundance estimates with unknown accuracy and precision also increase uncertainty in, and may bias, trend assessments. Nine Puget Sound populations qualified and were chosen as focal populations in our risk assessment (Tables 5 and 6).

In their ESA-listing determination, NOAA stated that a major threat to Puget Sound steelhead viability included natural spawning of out-of-DPS hatchery steelhead (Skamania early summer stock and Chambers early winter stock, which although Puget Sound-origin, is not included in DPS). Although NOAA concluded that overharvest due to previous management practices likely contributed to prior abundance declines, they believed that threats from overharvest had been largely addressed by elimination of directed wild steelhead sport harvest starting in the mid-1990s. Habitat loss and modification were identified in the listing determination as primary factors contributing to population declines, and habitat degradation continues to be a principal factor limiting viability of the DPS. A recovery plan is under development.

Table 6. Risk assessment results and ratings for Puget Sound DPS steelhead populations. Red text indicates values that exceeded specific criterion for each metric. Focal populations are indicated by bolded red text. Populations with a high risk rating that were not chosen as focal populations were either unlikely to qualify as independent populations or were small populations. TRT Risk Score is the Technical Recovery Team's PVA QET risk rating or AP/SSD viability rating, whichever was lower, for populations with full or partial adult abundance data series. Abbreviations: win. = winter-run; sum. = summer-run; tribs. = tributaries; insuf. = insufficient. See Table 5 for expanded presentation and additional details.

Population	Long Term Abundance Trend	Short Term Decline	Extinction Risk	Status relative to abundance goal	TRT Risk Score	SARR risk score	Population Risk Rating
Cedar win.	-100%	Yes	100%	0%	High	5.0	High
Sequim & Discovery Bays tribs. win.	-72%	No	79%	0%	High	4.0	High
Nisqually win.	-87%	No	2%	0%	High	3.0	High
Puyallup/Carbon win.	-84%	No	8%	0%	High	3.0	High
Stillaguamish win.	-80%	No	0%	0%	High	3.0	High
Green win.	-59%	No	12%	0%	High	3.0	High
Tolt sum.	-19%	No	25%	0%	High	3.0	High
South Hood Canal win.	-20%	No	insuf. data	0%	High	2.0	High
Dungeness win.	insuf. data	insuf. data	insuf. data	insuf. data	High	TRT only	High
Elwha win.	insuf. data	insuf. data	insuf. data	insuf. data	High	TRT only	High
Snohomish/Skykomish win.	-92%	No	11%	0%	Low	2.0	Moderate
Snoqualmie win.	-58%	No	1%	0%	Moderate	2.0	Moderate
Skokomish win.	-39%	No	1%	0%	High	2.0	Moderate
Strait of Juan de Fuca Ind. tribs. win.	-39%	No	insuf. data	30%	High	2.0	Moderate
Skagit sum.&win.	-25%	No	0%	0%	Low	1.0	Moderate
Pilchuck win.	-12%	No	6%	0%	Low	1.0	Moderate
Nooksack win.	19%	insuf. data	insuf. data	0%	not rated	1.0	Moderate
White River (Puyallup) win.	26%	No	11%	0%	Moderate	1.0	Moderate
Samish & Belligham Bay tribs. win.	440%	No	4%	0%	Low	1.0	Moderate
East Hood Canal win.	insuf. data	insuf. data	insuf. data	insuf. data	Moderate	TRT only	Moderate
West Hood Canal win.	insuf. data	insuf. data	insuf. data	insuf. data	Moderate	TRT only	Moderate
Sauk sum.&win.	insuf. data	insuf. data	insuf. data	insuf. data	Low	TRT only	Low
Canyon sum.	insuf. data	insuf. data	insuf. data	insuf. data	not rated	insuf. data	insuf. data
Deer sum.	insuf. data	insuf. data	insuf. data	insuf. data	not rated	insuf. data	insuf. data
Drayton Harbor tributaries win.	insuf. data	insuf. data	insuf. data	insuf. data	not rated	insuf. data	insuf. data
East Kitsap win.	insuf. data	insuf. data	insuf. data	insuf. data	not rated	insuf. data	insuf. data
Nookachamps win.	insuf. data	insuf. data	insuf. data	insuf. data	not rated	insuf. data	insuf. data
North Fork Skykomish sum.	insuf. data	insuf. data	insuf. data	insuf. data	not rated	insuf. data	insuf. data
North Lake Washington tribs. win.	insuf. data	insuf. data	insuf. data	insuf. data	not rated	insuf. data	insuf. data
South Fork Nooksack sum.	insuf. data	insuf. data	insuf. data	insuf. data	not rated	insuf. data	insuf. data
South Sound tributaries win.	insuf. data	insuf. data	insuf. data	insuf. data	not rated	insuf. data	insuf. data
Baker sum.&win.	insuf. data	insuf. data	insuf. data	insuf. data	not rated	insuf. data	extirpated

5.3.1.1 Hatcheries

Most steelhead hatcheries in Puget Sound have been operated as segregated programs for harvest augmentation using the early-winter and early-summer hatchery stocks. More recently, several integrated programs using wild fish for brood stock have been operated for supplementation or recovery purposes. As of 2014, Puget Sound had 16 hatchery programs, 14 operated by WDFW and two operated by tribes. Both tribal programs are integrated wild broodstock programs (Elwha River and White River; Appendix D), and WDFW operates four wild broodstock programs, one in Green River and three research programs in Hood Canal watersheds that are conducted with multiple partners, including NOAA-Manchester Lab and the nonprofit organization Long Live the Kings.

WDFW's ten segregated programs include three that produce Skamania early summer stock fish that are released in the Skykomish, Stillaguamish and Green rivers and seven that produce Chambers early winter stock. In April 2014, the settlement of a lawsuit prohibited releases of Chambers early winter steelhead from six of seven winter-run segregated programs (no effect on Skamania early summer stock releases and no effect on tribal hatchery programs) until the required permits from NOAA are obtained (Wild Fish Conservancy vs. WDFW 2014). Under the agreement, the Chambers early winter stock program at Wallace River Hatchery (Skykomish sub-basin) was allowed to release winter-run smolts without the required permit. In addition, the agreement terminated the Chambers early winter program at Marblemount Hatchery in Skagit River for 12 years. In 2015 and 2016, releases of Chambers early winter stock from six hatcheries also were prevented because NOAA permits were not obtained. Thus, currently, threats from segregated hatchery programs exist in Skykomish, Stillaguamish and Green rivers, and from integrated programs in White, Green, Skokomish, Duckabush, Dewatto, and Elwha rivers.

From 2000 to 2008, the average annual number of hatchery smolts released into Puget Sound rivers was 2,170,572 whereas from 2009 to 2013, the average annual release numbers dropped to 1,562,771 (Table 4). This reduction in releases was an action WDFW took in recognition of threats posed by hatchery steelhead interactions with wild populations. Many of the reductions came from elimination of off-site releases such that the average percent of off-site hatchery smolt releases was substantially lower for 2009-2013 (16.4%) than it was for 2000-2008 (40.4%; Table 4). Since 2009, WDFW has taken other steps, in addition to reducing off-site releases, to reduce hatchery steelhead interactions with wild fish, including promoting an increased harvest of hatchery fish, and changing program characteristics to reduce risks from genetic and ecological interactions.

WDFW has prepared HGMPs for Puget Sound hatchery programs that list goals for the maximum percent pHOS. However, the number of naturally spawning hatchery steelhead generally has not been quantified empirically in this DPS, and instead estimates rely on models or limited genetic data. Puget Sound wild-origin steelhead spawning censuses typically have used a March 15 threshold when counting redds; new redds appearing before March 15 are assumed to be made exclusively by Chambers early winter or Skamania early summer hatchery steelhead and new redds appearing on or after March 15^{th} are assumed to be exclusively made by wild-origin steelhead. This method assumes that spawning hatchery and wild fish do not overlap later than March 15 and ignores wild fish that may spawn earlier (e.g., McMillan et al. 2007). To our knowledge, censuses of presumed hatchery steelhead redds (pre-March 15) have been rare in Puget Sound rivers. Results from genetic analyses indicate natural reproduction by fish from both non-DPS hatchery stocks and their interbreeding with wild steelhead in some basins (Myers et al. 2015). However, without pHOS or other estimates of genetic interactions of hatchery and wild steelhead, WDFW cannot prove compliance with HGMP requirements or SSMP policies. To address this shortcoming, WDFW staff is implementing a monitoring plan to genetically estimate hatchery-wild introgressive hybridization in these five rivers: Nooksack, Stillaguamish, Skykomish, Snoqualmie, and Dungeness.

5.3.1.2 Harvest

Since 2003, annual harvest rates on wild steelhead have been low in Puget Sound (generally < 10%). However, historical harvest records document annual harvest rates of generally > 20% for the Green, Puyallup/Carbon, and Samish rivers prior to 1993, > 40% for the Nisqually River prior to 1994, > 10% for the Skagit River prior to 1998, > 12% for the Snohomish River system and Strait of Juan de Fuca independent tributaries prior to 1993, and > 20% for the Stillaguamish River prior to 2001, providing important context for their decline (Table 2). Although wild steelhead target fisheries are not allowed currently, wild fish mortalities may occur in ongoing fisheries.

To address threats to wild steelhead, WDFW and Puget Sound tribes have developed harvest management plans that regulate fisheries to limit impacts. Fisheries directed at hatchery winter-run steelhead may pose risks to early-returning wild steelhead through incidental harvest by gillnets and inadvertent mortality by angling. The 2010-2014 Puget Sound Chinook Harvest Resource Management Plan (Biological Opinion) and annual co-manager watershed-level harvest management plans specify allowable wild steelhead harvest rates at no more than 4.2% resulting from all fisheries over five major watersheds (Skagit, Snohomish, Green, Puyallup and Nisqually). Wild steelhead encounter rates have not been widely quantified for Puget Sound hatchery steelhead target fisheries or freshwater trout fisheries, but incidental impacts of the former have been estimated for a few populations using information from intensive winter-run steelhead creel surveys conducted during the mid-1970s to early 1990s. If creel surveys were not conducted on rivers during that time period, CRC estimates were utilized to estimate hatchery and wild harvest (and incidental mortality was not estimated).

5.3.1.3 Habitat

Freshwater habitat quantity and quality throughout Puget Sound has been degraded relative to historical conditions and habitat degradation is ongoing, though at a slower place (Bartz et al. 2015). Habitat loss threatens population viability through loss of spatial structure, productivity, and diversity. Expanding human development in many Puget Sound areas is a leading cause of habitat loss and degradation (Alberti et al. 2007; Bartz et al. 2015). For example, large dams have caused substantial habitat losses in watersheds with relatively high production potential (e.g., Baker River, Green River, and North Fork Skokomish rivers). Other types of barriers (e.g., culverts, road crossings, reduced flows) to adult and juvenile passage throughout their freshwater life-history result in additional habitat loss. WDFW and partners are currently quantifying the severity of these impassible structures.

Poor freshwater habitat quantity and quality likely has had profound effects on Puget Sound steelhead due to juvenile steelheads' long rearing period (typically 1-3 years), kelt out-migration, summer-run adults' holding period, and residency and freshwater maturation of some individuals. Watershed-specific conditions believed to affect population viability are described in detail by Blanton et al. (2011) for these habitat factors: loss of access to historical habitat, loss and degradation of side channels and floodplain, loss of large woody debris, loss of pool habitat, riparian habitat degradation and reduction, and loss of summer and winter rearing habitats. Our understanding of the relationships between changes in habitat quantity or quality and steelhead freshwater productivity is very poor because juvenile monitoring data are scarce. Within the Puget Sound DPS the only long-term (continuous data since the 1970s) wild smolt production datasets available are for Snow Creek and Big Beef Creek steelhead.

Habitat quality in Puget Sound marine waters is also a concern relative to smolt survival. Analysis of smolt to adult marine survival (Figure 19) showed a declining trend and usually had been less than 4% since 1997 (note that data were largely from the Snow Creek subpopulation). Data from acoustic telemetry studies (Goetz et al. 2015; Moore et al. 2010b) provided evidence for low smolt survival in Puget Sound and indicated that surviving smolts migrated from river mouths to the ocean relatively quickly. Low early marine survival is considered an emerging major threat to steelhead viability, particularly if SARs in Puget Sound approach or drop below 2% (values that have resulted in major threats to viability for Columbia Basin stocks). Research studies on potential causes of mortality within Puget Sound, such as toxic contaminants, disease, and predator-prey relationships, are ongoing.

Currently, hardened armor lines about 27% of the Sound's marine shoreline. Shoreline armor makes a dynamic shoreline static, disrupting many of the natural processes that replenish sand and gravel to beaches and spits of Puget Sound. As a result, sediment supply from bluffs that historically "fed" the beaches of Puget Sound is cut off, armor along sediment transport and accretionary landforms can limit accumulation of beach material, affecting nearshore habitat. Healthy beaches provide spawning habitat for forage fish, which are at the heart of the Puget Sound food web. Surf smelt (*Hypomesus pretiosus*) and Pacific sand lance (*Ammodytes hexapterus*) are forage fish species that depend on these habitats. Increasing abundance of these prey species can reduce pressure from predators who also feed on juvenile steelhead.

5.3.1.4 Dams, barriers and fish passage

Dams for hydropower, drinking water supplies, and flood control block access, impede passage, and/or alter hydrology in multiple watersheds, affecting at least nine Puget Sound steelhead populations. By blocking normal water and materials flows and through water withdrawals, dam operations degrade downstream habitat, affecting structural features (e.g., loss of instream woody debris), temperature, turbidity, sediment transport, and biological communities. Baker River dams appear to have extirpated the historical steelhead population. Specific impacts and threats from dam operations for five Puget Sound focal populations (Cedar, Tolt, Green, Puyallup/Carbon and Nisqually) are described later in Section 5.4. Additionally, dams block habitat in Skokomish (18% loss) and Nooksack (5% loss) basins. Dams in White River impede passage, requiring trapping and upstream trucking of adults, and affect survival of juvenile and kelt downstream migrants. The recent removal of Elwha River dams restored access to historical habitat and steelhead have been naturally colonizing the area. All but one fish passage barriers at road crossings on WDFW lands have been corrected in Puget Sound (and the remaining one is currently being worked on).

5.3.1.5 Actions

1. Continue and expand Puget Sound steelhead early marine survival research.
2. Continue to support forage fish recovery through armor reduction and prevention programs to protect forage fish spawning habitat. WDFW should provide regional leadership for local incentive programs that support landowner waterfront stewardship that prevents or removes armor. Enhance existing capital investments to remove armor through small and large-scale projects. Increased forage fish abundance will help to reduce pressure from predators who also feed on juvenile steelhead, so marine mammals will have food sources other than steelhead available to them.
3. Continue to manage fisheries to comply with harvest limitations in NOAA-approved harvest management plans. Work with NOAA to ensure harvest limitations are sufficiently protective to allow populations to recover while providing harvest opportunity where biologically allowable.
4. Prioritize agency actions directed at restoring access to the largest possible areas of historical steelhead habitat, and invest in habitat restoration projects that restore the largest amount of rearing area to productive conditions.
5. To reduce hatchery impacts and promote wild population recovery, work with steelhead interest groups and tribal co-managers to designate at least one population in the North Puget Sound MPG (per life history type, summer/winter where applicable) as a wild steelhead gene bank, preventing hatchery steelhead releases in those rivers.

6. Prioritize monitoring, solicit funding, and develop improved estimation methods and sample designs to collect or expand abundance data for un-monitored and partially-monitored populations.
7. Implement the Fish Barrier Removal Board's strategy to remove barriers in whole watersheds and demonstrate population responses.
8. To reduce the risk of harm from hatchery programs, determine whether smolt production is spawner-limited in populations currently augmented by conservation hatchery programs to determine whether the programs are needed.
9. Submit Fisheries Management and Evaluation Plans that provide for additional fishing opportunity while meeting recovery objectives.

5.3.2 Olympic Peninsula

Steelhead in the Olympic Peninsula DPS are not ESA-listed. Overall, declining abundance or lower productivity (see Chapter 3) did not appear to pose immediate or substantial threats to this DPS. However, 11 of 15 populations with data declined in abundance during the monitoring time period (Figure 11). No Olympic Peninsula DPS populations were chosen as focal populations in our risk assessment (Tables 5 and 7). As described in section 4.3, Goodman Creek is small population that was unlikely to qualify as a DIP. Habitat degradation, primarily from forestry activities, and potential hatchery or harvest impacts are the key threats affecting wild steelhead abundance. Very little is known about temporal and spatial patterns of freshwater population productivity (smolts per spawner) and smolt to adult return rates (SAR) for Olympic Peninsula DPS wild steelhead populations, and this is a substantial data gap.

Table 7. Risk assessment results and ratings for Olympic Peninsula DPS steelhead populations. Red text indicates values that exceeded specific criterion for each metric. Focal populations are indicated by bolded red text. Populations with a high risk rating that were not chosen as focal populations were either unlikely to qualify as independent populations or were small populations. Abbreviations: win. = winter-run; sum. = summer-run; insuf. = insufficient. See Table 5 for expanded presentation and additional details.

Population	Long Term Abundance Trend	Short Term Decline	Extinction Risk	Status relative to abundance goal	SARR risk score	Population Risk Rating
Goodman Creek win.	-54%	Yes	91%	60%	3.0	High
Salt Creek/Independents win.	-43%	No	68%	20%	2.0	Moderate
Clallam win.	-27%	No	60%	40%	2.0	Moderate
Lower Quinault win.	-69%	No	0%	no goal	1.0	Moderate
Queets win.	-29%	No	0%	50%	1.0	Moderate
Pysht/Independents win.	-21%	No	1%	30%	1.0	Moderate
Hoh win.	-16%	No	0%	50%	1.0	Moderate
Calawah win.	50%	Yes	0%	100%	1.0	Moderate
Hoko win.	-40%	No	0%	80%	0.0	Low
Dickey win.	-22%	No	7%	100%	0.0	Low
Clearwater win.	-12%	No	0%	100%	0.0	Low
Sol Duc win.	-9%	No	0%	80%	0.0	Low
Quillayute/Bogachiel win.	-6%	No	0%	90%	0.0	Low
Upper Quinault win.	24%	No	0%	100%	0.0	Low
Moclips win.	27%	insuf. data	insuf. data	no goal	insuf. data	Low
Calawah sum.	insuf. data	insuf. data	insuf. data	insuf. data	insuf. data	insuf. data
Clearwater sum.	insuf. data	insuf. data	insuf. data	insuf. data	insuf. data	insuf. data
Copalis win.	insuf. data	insuf. data	insuf. data	insuf. data	insuf. data	insuf. data
Hoh sum.	insuf. data	insuf. data	insuf. data	insuf. data	insuf. data	insuf. data
Kalaloch Creek win.	insuf. data	insuf. data	insuf. data	insuf. data	insuf. data	insuf. data
Lyre win.	insuf. data	insuf. data	insuf. data	insuf. data	insuf. data	insuf. data
Mosquito Creek win.	insuf. data	insuf. data	insuf. data	insuf. data	insuf. data	insuf. data
Ozette win.	insuf. data	insuf. data	insuf. data	insuf. data	insuf. data	insuf. data
Queets sum.	insuf. data	insuf. data	insuf. data	insuf. data	insuf. data	insuf. data
Quillayute/Bogachiel sum.	insuf. data	insuf. data	insuf. data	insuf. data	insuf. data	insuf. data
Quinault sum.	insuf. data	insuf. data	insuf. data	insuf. data	insuf. data	insuf. data
Raft win.	insuf. data	insuf. data	insuf. data	insuf. data	insuf. data	insuf. data
Sail win.	insuf. data	insuf. data	insuf. data	insuf. data	insuf. data	insuf. data
Sekiu win.	insuf. data	insuf. data	insuf. data	insuf. data	insuf. data	insuf. data
Sol Duc sum.	insuf. data	insuf. data	insuf. data	insuf. data	insuf. data	insuf. data
Sooes/Waatch win.	insuf. data	insuf. data	insuf. data	insuf. data	insuf. data	insuf. data

5.3.2.1 Hatcheries

Past and present hatchery operations have been a threat to genetic integrity of wild steelhead populations in this DPS. Hatchery fish releases occurred in most watersheds of the DPS (Appendix D) and adults, especially from off-site releases, have escaped fisheries and spawned naturally throughout the region (Phelps et al. 1997). Twenty years ago estimated pHOS ranged from 16% in Quillayute River to 44% in Quinault River (Busby et al. 1996). The presence of hatchery steelhead on spawning grounds within this DPS has not been quantified recently. As in other DPSs, wild-origin spawner surveys use March 15th as the spawn timing separation date for wild- and hatchery-origin steelhead.

Ten of eleven steelhead hatchery programs in this DPS are segregated programs for harvest augmentation, most using the Chambers early winter and Skamania early summer stocks, neither of which is native to this DPS. Of 11 hatchery programs in Olympic Peninsula watersheds as of 2014, three were operated by WDFW and eight were operated by either tribes or USFWS (Appendix D). These programs included five off-site release programs (two operated by WDFW) in which smolts were transferred from their natal hatchery and released in another watershed. If adults from these programs that return to release sites are not harvested, they are likely to spawn naturally, imposing genetic and ecological risks to wild populations.

From 2000 to 2008, average annual number of hatchery smolts released into Olympia Peninsula watersheds was 1,383,022 whereas from 2009 to 2013, average annual release number dropped to 1,072,781 (Table 4). This reduction in releases included reducing or ending off-site release programs. However, the average percent of smolts released off-site of hatcheries changed little between the two time periods (2000-2008: 65%; 2009-2013: 61%; Table 4). The lower Quinault hatchery program is the largest in region, releasing over 400,000 smolts annually (37% of all releases). The next largest program, Salmon River (Queets) segregated, released up to about 170,000 smolts per year from 2008 to 2012.

The Sol Duc River has one of the state's largest, non-ESA-listed populations of wild winter-run steelhead. For 25 years from 1986 to 2011 the Olympic Guide Association operated an integrated cooperative, harvest-augmentation hatchery program on the Sol Duc (Snider Creek program) using early-returning wild broodstock. The Snider Creek program and the Sol Duc segregated Skamania early summer program both ended recently, and, in accordance with the SSMP, the Sol Duc River has been designated as a Wild Steelhead Gene Bank (i.e., Wild Steelhead Management Zone). A new integrated harvest augmentation program using early returning wild broodstock was initiated on the Bogachiel River in 2013.

5.3.2.2 Harvest

The Quillayute, Hoh, Queets, and Quinault river systems were subject to annual sport and tribal wild winter-run steelhead harvest rates that generally ranged, since the 1980s, from 7% to > 40% annually (average over all years was 36.5%). These harvest rates are the highest in the state and are of concern given the limited availability of high quality population-level monitoring data and the recent declines in abundance. As of July 2016, sport fisheries are no longer allowed to harvest wild steelhead. Directed harvest by sport and tribal fishers on winter-run steelhead stocks occurs from November through April. Hatchery fish from several early-timed stocks normally begin arriving in November through January and February. Wild winter-run fish begin arriving in November with the bulk of the run returning from March through May.

Tribal fishers are allowed to harvest wild steelhead throughout their fishing seasons. There is risk of size-selective harvest impacts because analysis of scales from the tribal harvest fishery has indicated that older fish are taken in the fishery. Sport fishery scale sampling indicated that younger fish were being taken. There is also risk of fishery selection on run timing since the number of fishing days per week declines throughout the run period for treaty fisheries, presumably resulting in greater harvest on earlier returning adults. Similarly, historical sport fishery harvest was likely concentrated on early-returning wild adults, which were-comingled with early-timed hatchery stocks and had greater susceptibility to harvest through increased in-river residence time. The potential for increased fishing pressure and indirect effects on wild steelhead is an increasing concern as opportunities for steelhead fisheries declines in Western Washington and pressure potentially increases on the Washington Coast. Sport non-retention mortality and tribal net drop-out rates are quantified for only a few populations or systems, which is a major data gap.

5.3.2.3 Habitat

The legacy of habitat degradation from historic land-use practices within Olympia Peninsula DPS watersheds (outside of Olympic National Park boundaries) continues to threaten wild steelhead populations. Detrimental land-use practices include past clear-cut logging, road building, poorly designed and unmitigated bank protection projects, and other floodplain infrastructure impacts to channel migration zones. The effectiveness of currently implemented forest practices for minimizing impacts remains uncertain. For example, incorrectly applied or inadequately designed riparian management zones and incorrect stream typing classifications are known problems that impair habitat protection strategies (Hansen 2001). These practices result in loss of large woody material, fish passage impacts, altered hydrology, water quality impacts, mass wasting (landslides), and elevated stream temperatures (Naiman et al. 1998).

Clear-cut logging activities have been extensive throughout most Olympic Peninsula watersheds, with the exception of protected areas within Olympic National Park. Most of the DPS's major river systems originate within the Park, but drainage areas outside of the Park's boundaries are subject to intensive logging practices. Headwaters of the Clearwater River (Queets Basin) are not located within Olympic National Park and over time the Clearwater has been subject to extensive logging throughout much of its watershed. As a timber-managed tributary, the Clearwater River has experienced increased sediment inputs due to road building, road use, and tree harvesting. Logging operations have contributed to the loss of large woody debris recruitment to the river (Smith and Caldwell 2001). There are no major dams within this DPS that contribute to habitat loss or degradation.

Over the last century much of the Hoh River valley rainforest that was formerly managed for commercial timber harvest and it is now in various stages of regeneration because of land acquisitions by conservation organizations. With increases in forest restoration efforts, riparian and fish habitat are expected to improve dramatically over time. Forest recovery has a necessarily long time frame (hundreds of years) and may be enhanced by restoration intervention. Functional woody material in mainstem channels must be large enough to be stable (not easily mobilized), especially in large channels, while functional riparian ecosystems undergo long-term regeneration. Conservation organizations, such as the Hoh River Trust, have acquired approximately 6,800 acres of at-risk acres of land along the river from corporate owners. Approximately 90 percent of the Hoh River basin is currently owned by federal and state resource management agencies or conservation organizations, and majority of basin lands are within Olympic National Park.

In early 2014 US Senator Patty Murray and Representative Derek Kilmer introduced the Wild Olympics Wilderness and Wild and Scenic Rivers Act, which was reintroduced in March 2017. This legislation would designate 126,554 acres of existing federal land as wilderness in the Olympic National Forest and designate 464 river miles across 19 rivers and some major tributaries on the Olympic Peninsula as Wild and Scenic Rivers. Olympic Peninsula DPS headwater areas or river segments that would be additionally protected occur in Quinault, Queets, Hoh, Bogachiel, Calawah, and Sol Duc rivers if this legislation is enacted.

5.3.2.4 Actions

1. Expand monitoring programs to improve estimates of abundance as well as fishery mortality with estimable precision and testing for bias for all populations.
2. Improve monitoring of WDFW hatchery programs to ensure compliance with the SSMP and Hatchery and Fishery Reform Policy (HFRP).

3. Engage with co-managers to improve monitoring, including estimates of pHOS, PNI, and proportion hatchery effective contribution (pHEC) for large hatchery programs in the Queets, Quinault, and Quillayute basins; ensure programs are meeting HSRG standards.
4. Ensure that the new Bogachiel integrated hatchery program meets HSRG recommendations.
5. Continue to work with natural resource agencies, local governments, and forest owners to restore damaged forested riparian areas, reduce forestry road impacts, and protect intact riparian habitats and their uplands, and ensure adequate restoration funding is secured for monitoring and enforcement.
6. Continue to pursue Hoh River steelhead research program.

5.3.3 Southwest Washington

Declining abundance was common among populations in this DPS (Figure 12), and many populations did not frequently achieve abundance goals in a recent 10-year period (Table 8). However, no populations qualified as focal populations in our risk assessment. Primary ongoing threats to Southwest Washington wild steelhead include habitat degradation (land-use practices including clear-cut logging, development, levees, and bank armoring, especially in the lower reaches of these streams), hatchery programs for non-native winter- and summer-run stocks, a preponderance of negative abundance trends, moderate harvest rates, and biological data deficiency.

Existing dams on the Wynoochee and Skookumchuck rivers have caused habitat loss and degradation. A dam on the upper Chehalis River has been proposed as a flood control mechanism and a Programmatic Environmental Impact Statement (EIS) was finalized in 2017 (http://chehalisbasinstrategy.com/eis-library/). Steelhead spawn and rear in habitats upstream of proposed dam site. The populations in this DPS that occupy lower Columbia River drainages are affected by degraded habitat conditions in the Columbia River's mainstem and estuary during adult and juvenile migration periods. Relative to other DPSs, temporal and spatial patterns of freshwater population productivity (smolts per spawner) and smolt to adult return rates (SAR) are poorly understood for Southwest Washington populations. This is a substantial data gap that needs to be addressed.

Table 8. Risk assessment results and ratings for Southwest Washington DPS steelhead populations. Red text indicates values that exceeded specific criterion for each metric. Focal populations are indicated by bolded red text. Abbreviations: win. = winter-run; sum. = summer-run; insuf. = insufficient. See Table 5 for expanded presentation and additional details.

Population	Long Term Abundance Trend	Short Term Decline	Extinction Risk	Status relative to abundance goal	SARR risk score	Population Risk Rating
Willapa win.	-26%	Yes	16%	10%	2.0	Moderate
Mill/Abernathy/Germany win.	50%	No	37%	0%	2.0	Moderate
Hoquiam win.	-48%	No	0%	10%	1.0	Moderate
Wishkah win.	-46%	No	30%	90%	1.0	Moderate
Bear win.	-29%	No	26%	100%	1.0	Moderate
Chehalis win.	-28%	No	0%	30%	1.0	Moderate
Nemah win.	-22%	No	26%	70%	1.0	Moderate
Naselle win.	-20%	No	3%	60%	1.0	Moderate
Satsop win.	-11%	No	0%	30%	1.0	Moderate
Wynoochee win.	-9%	Yes	0%	100%	1.0	Moderate
North/Smith win.	11%	No	8%	0%	1.0	Moderate
Grays win.	12%	No	10%	20%	1.0	Moderate
Skamokawa/Elochoman win.	23%	No	0%	50%	1.0	Moderate
Palix win.	34%	No	0%	30%	1.0	Moderate
Skookumchuck/Newaukum win.	57%	No	0%	40%	1.0	Moderate
Humptulips win.	-35%	No	0%	80%	0.0	Low
Chehalis sum.	insuf. data	insuf. data	insuf. data	insuf. data	insuf. data	insuf. data
Humptulips sum.	insuf. data	insuf. data	insuf. data	insuf. data	insuf. data	insuf. data
South Bay win.	insuf. data	insuf. data	insuf. data	insuf. data	insuf. data	insuf. data

5.3.3.1 Hatcheries

As of 2014, there were 13 hatchery programs in Southwest Washington watersheds, 12 operated by WDFW and one operated by USFWS (Appendix D). These programs included two off-site release programs (North River and Wynoochee River), which, as described in Section 2.5, may pose greater risks of harm from hatchery fish spawning naturally than those of on-site release programs.

From 2000 to 2008, average annual number of hatchery smolts released into Southwest Washington watersheds was 909,644, and from 2009 to 2013 average annual release number was 941,664 (Table 4). The average percent of off-site hatchery smolt releases was lower in the later time period (2000-2008: 38%; 2009-2013: 29%; Table 4). The largest off-site release program was for Skamania early summer steelhead reared at Lake Aberdeen Hatchery and released in Wynoochee River (2009-2013 average annual release was 78,309 smolts; Appendix D). Two integrated programs, Skookumchuck and Wynoochee winter-run, had the largest average annual releases (>140,000 smolts) for 2009-2013 among all hatchery program releases in the DPS (Appendix D).

With the exception of the Willapa River population, the presence of hatchery steelhead on spawning grounds within this DPS generally has not been quantified. This is primarily due to spawning survey methods used in this DPS in which surveys start on March 15th, with the assumption that all redds counted are constructed by wild-origin steelhead. In the Willapa River, Dauer et al. (2009) used scale pattern analysis to estimate the ratio of hatchery fish to wild fish on the spawning grounds and found that under all reasonable scenarios the hatchery fish proportion exceeded HSRG recommended levels in all years of the study (1996-2003).

In Forks Creek, a major spawning tributary of the Willapa River, Seamons et al. (2012) found that up to 80% of naturally produced smolt steelhead in any given year of the study (1998-2009) were hatchery/wild hybrids. They concluded that divergent life history (e.g., return and spawn timing) failed to prevent interbreeding when physical isolation between hatchery and wild fish was ineffective, and that the extent of interbreeding was related to stream flow and the number of returning adult hatchery steelhead (Seamons et al. 2012). Other segregated hatchery programs in Southwest Washington likely pose similar risk. Ecological threats were not evaluated in Forks Creek studies.

5.3.3.2 Harvest

The annual combined Chehalis and Quinault tribal harvest rate plus the sport harvest rate on wild winter-run steelhead in the Chehalis River system and the Humptulips River has averaged 16% and 17%, respectively, since 1980. The wild steelhead management escapement objective for the Chehalis River and its tributaries was achieved only three times between 2004 and 2013. Wild winter-run steelhead entering the Humptulips River were harvested (sport plus tribal fisheries with sport fishery bycatch hooking mortality and commercial 2% net-drop-out added in) at an average rate of 12% between the 2004 and 2013 spawning years. The Humptulips River wild steelhead tribal harvest was 16% (with 2% net-drop-out added in) in the 2011/2012 and 2012/2013 seasons. The sport fishery harvest rate averaged 2.6% (with the hooking mortality estimate included) between 2004 and 2013, with the highest rate being 4.6% in the 2004/2005 season. However, wild steelhead harvest has not been allowed in the sport fishery by permanent rule since May 1998. WDFW and the Chehalis Tribe are working to improve harvest management communications to facilitate better information sharing and catch accounting.

Harvest-related threats to wild steelhead of Willapa Bay rivers should be, and are reported to be, very low because there are no directed tribal fisheries and sport harvest retention ended in 1998. Thus, the main harvest risk to wild steelhead is bycatch and hooking mortality in sport fisheries targeting hatchery fish. Although the wild steelhead-release fishing rule is in place, the spawning escapement goal for four of six populations in Willapa Bay rivers was not met in seven of 10 years (Table 5). Harvest threats to the three populations in lower Columbia River drainages within this DPS appeared relatively low, with average harvest rates of approximately 5% between 2001 and 2013 (Table 2a).

5.3.3.3 Habitat

Habitat degradation due to detrimental land-use practices within Southwest Washington DPS watersheds has been an ongoing threat to wild steelhead populations. In particular, clear-cut logging practices and associated road building have been extensive throughout the area. Recovery from impacts is expected to take a century or more to restore functional ecosystem processes. Logging activities continue to occur throughout Grays Harbor, Willapa Bay and lower Columbia River areas of this DPS. These practices have resulted in the loss of large woody material, fish passage blockages, altered hydrology, water quality impacts, mass wasting (landslides), and elevated stream temperatures. Degrees to which revisions of Washington's Forest Practices Rules (WAC 222) for state- and privately-owned forestlands are effective in abating these steelhead habitat impairments remain uncertain and require long-term evaluation.

The lower Columbia watersheds of this DPS (Grays and Elochoman rivers and Skamakowa, Mill, Abernathy and Germany creeks) were included in recovery planning for ESA-listed Lower Columbia DPS populations (Lower Columbia Fish Recovery Board (LCFRB) 2010). Habitat threats identified in the Lower Columbia recovery plan for these watersheds included degradation of freshwater and estuary habitat quality from agricultural and forestry practices. Tree harvesting has led to impacts in riparian areas and increased sediment delivery to rivers. Important aquatic habitats have been isolated or eliminated by channel modifications and by diking, filling, and draining floodplains and wetlands (Lower Columbia Fish Recovery Board (LCFRB) 2010, e.g., see sub-basin chapters in volume 2).

Only two large dams occur in this DPS. Wynoochee Dam at Wynoochee River km 80.6, a flood control, hydroelectric, and water storage project, blocks passage to a portion of the upper watershed, resulting in a 6.4% habitat loss, which is the inundated area upstream of the dam (Table 4). Fish are trapped below the dam and transported upstream for release. Skookumchuck Dam at Skookumchuck River km 35.2, which serves to supply water to the coal-fired Centralia Power Plant and has a small hydropower facility, blocks passage to the upper watershed and results in a 16.4% habitat loss for steelhead (Table 4). Potential impacts of a proposed flood-control dam in the Chehalis River mainstem upstream of Pe Ell have been evaluated in a Programmatic EIS, as mentioned above. Watershed-wide ecological effects and current status of aquatic habitats and fishes have been (http://chehalisbasinstrategy.com/publications/), and continue to be, investigated. WDFW research found that steelhead spawn in the mainstem and most of its tributaries upstream of proposed dam site.

5.3.3.4 Actions

1. Promote habitat restoration on agricultural lands, such as cattle exclusion fencing and floodplain re-connection.
2. Fulfill WDFW's role in the Chehalis Basin Strategy Project in ensuring that aquatic species impacts of proposed dam are accurately quantified and considered.
3. Fully implement the Aquatic Species Restoration Plan for the Chehalis Basin, which is being designed to improve population abundance of steelhead (among many other species) using strategic habitat restoration efforts. This should include engaging with Trans Alta on changes to the Skookumchuck Dam operations (e.g., increasing flows, temperature modifications, or dam removal) following the closure of Centralia Power Plant.
4. Implement the Fish Barrier Removal Board's priorities to restore fish passage in priority stream systems of the Chehalis Basin, and monitor these actions to assess their effectiveness in increasing steelhead spatial structure, abundance, and diversity.
5. Expand network of life-cycle monitoring sites to measure population-scale smolt abundance, smolts per spawner (freshwater productivity), and smolt to adult survival in wild populations.
6. Refine and improve adult abundance estimation methods to test for bias and measure precision.
7. Continue to develop improved communications with Chehalis Tribe to facilitate data sharing and catch accounting.

5.3.4 Lower Columbia River

The majority (58%) of LCR populations with abundance data showed increasing trends during monitoring time periods (Figure 23.) However, many populations did not frequently achieve recovery goals in a recent 10-year period (Table 9). Two populations, Upper Cowlitz/Cispus and North Fork Lewis River winter-run, qualified and were chosen as focal populations in our risk assessment (Tables 5 and 9). Current major threats to Washington's LCR steelhead populations include widespread reductions to the quality and quantity of habitat, juvenile and adult mortality caused by the migration through tributary dams (Cowlitz and North Fork Lewis basins), and hatchery impacts. Harvest is a less significant threat for most populations. The combined populations in the Upper Cowlitz Basin (Upper Cowlitz and Cispus) offer the greatest opportunity for recovery of LCR steelhead but their recovery depends upon the provision of adequate passage for juveniles and adults to and from the 3600 km^2 of habitat in the upper watershed located upstream of three dams (NMFS 2013). Much of the land in these watersheds is considered to be among the highest quality freshwater steelhead habitat in the LCR DPS.

Table 9. Risk assessment results and ratings for Lower Columbia DPS steelhead populations. Red text indicates values that exceeded specific criterion for each metric. Focal populations are indicated by bolded red text. Populations with a high risk rating that were not chosen as focal populations were either unlikely to qualify as independent populations or were small populations. NOAA/LCFRB Risk Score is the NOAA 2010 risk ranking we updated through 2013 using thresholds published in LCFRB 2010, Appendix E, Ch. 12, and is the lower of separate A/P (abundance/productivity) and SS/D (spatial structure/diversity) scores. Abbreviations: win. = winter-run; sum. = summer-run; insuf. = insufficient. See Table 5 for expanded presentation and additional details.

Population	Long Term Abundance Trend	Short Term Decline	Extinction Risk	Status relative to abundance goal	NOAA/LCFRB Risk Score	SARR risk score	Population Risk Rating
Upper Cowlitz/Cispus win.	466%	No	27%	0%	High	3.0	High
North Fork Lewis win.	insuf. data	insuf. data	insuf. data	insuf. data	High	NOAA only	High
Lower Gorge win.	insuf. data	insuf. data	insuf. data	insuf. data	High	NOAA only	High
Salmon win.	insuf. data	insuf. data	insuf. data	insuf. data	High	NOAA only	High
South Fork Toutle win.	-56%	No	16%	30%	Low	2.0	Moderate
Kalama sum.	-45%	No	25%	50%	Moderate	2.0	Moderate
Tilton win.	195%	No	10%	60%	High	2.0	Moderate
Upper Gorge win.	-32%	No	insuf. data	no goal	High	1.0	Moderate
Coweeman win.	-17%	No	1%	40%	Moderate	1.0	Moderate
Wind sum.	21%	No	6%	10%	Low	1.0	Moderate
Washougal win.	142%	No	11%	50%	Moderate	1.0	Moderate
East Fork Lewis win.	200%	No	17%	20%	Moderate	1.0	Moderate
Lower Cowlitz win.	insuf. data	insuf. data	insuf. data	insuf. data	Moderate	NOAA only	Moderate
Kalama win.	0%	No	11%	100%	Low	0.0	Low
Washougal sum.	167%	No	9%	70%	Low	0.0	Low
East Fork Lewis sum.	299%	No	1%	80%	Moderate	0.0	Low
North Fork Toutle win.	insuf. data	No	0%	70%	Moderate	0.0	Low
North Fork Lewis sum.	insuf. data	insuf. data	insuf. data	insuf. data	High	NOAA only	extirpated

5.3.4.1 Hatcheries

At the time of ESA listing (1998), more than two million winter-run and one million summer-run hatchery steelhead were released each year in the LCR DPS and were primarily from Chambers early winter and Skamania early summer stocks. These large scale hatchery releases were the principle factor documented in the status review which led to the listing this DPS (Busby et al. 1996). A reliance on models rather than empirical data to estimate rates of spawning interaction and introgression between hatchery and wild steelhead in the DPS was cited as a major data gap and risk factor in both the listing decision (Busby et al. 1996) as well as the Hatchery Scientific Review Group's review of LCR populations (Hatchery Scientific Review Group (HSRG) 2009).

Historically, segregated hatchery steelhead smolts were released both for harvest augmentation and as mitigation for Columbia River mainstem and tributary dams in all Washington LCR steelhead-bearing tributaries. Segregated steelhead hatchery programs in the region have undergone two major phases of revision to better meet conservation objectives. The first occurred in the late 1990s in conjunction with the ESA listing and resulted in reductions in the numbers of smolts planted, an increase in the use of acclimation to reduce straying, the adjustment of release locations downstream of primary wild spawning areas to increase spatial segregation between hatchery and wild spawners, and the termination of all hatchery steelhead releases in the Wind River.

The second phase is ongoing and involves the process of bringing Washington's LCR hatchery programs into alignment with the recommendations provided by HSRG, the SSMP (Hatchery Scientific Review Group (HSRG) 2009; Scott and Gill 2008; Washington Department of Fish and Wildlife (WDFW) 2008), and the Fish and Wildlife Commission's Hatchery and Fishery Reform Policy. Steps taken so far have included use of the All-H-Analyzer (AHA; Mobrand et al. 2005) to model pHOS, followed by subsequent adjustment of program sizes or implementation of other management actions to meet the pHOS and gene flow goals set forth by the HSRG and SSMP, respectively. WDFW recently designated four populations of LCR steelhead as wild steelhead gene banks under the SSMP: Upper Gorge summer-run (Wind River), East Fork Lewis summer-run, East Fork Lewis winter-run, and North Fork Toutle/Green winter-run. Additionally, WDFW is currently conducting a study of historic and ongoing genetic introgression resulting from hatchery programs throughout the DPS.

As of 2014, eighteen segregated and three integrated hatchery programs were operated in the LCR DPS; Appendix D). Integrated steelhead programs have augmented fisheries in the Kalama and Cowlitz rivers and have been used to provide a demographic boost to reintroduction programs in the upper Cowlitz and North Fork Lewis rivers where wild populations were extirpated by dams. In contrast to segregated programs, integrated programs have been noted throughout the LCR for producing larger numbers of residual steelhead relative to segregated programs at all locations where they are released, a phenomenon that has been particularly well documented in the Kalama River (Sharpe et al. 2007). From 2000 to 2008, average annual number of hatchery smolts released into Lower Columbia DPS watersheds was 2,309,976, and from 2009 to 2013 average annual release number was 2,160,426 (Table 4). The average percent of off-site hatchery smolt releases was higher in the later time period (2000-2008: 22.78%; 2009-2013: 31.6%; Table 4).

5.3.4.2 Harvest

Harvest impacts on LCR populations, although historically significant (particularly for summer-run populations), have been low since the mid-1980s when mass marking of hatchery steelhead began and wild steelhead release was first required in sport fisheries (Table 2). Commercial harvest of wild steelhead was prohibited beginning in 1977 (Interior Columbia Technical Recovery Team (ICTRT) 2007). Spatial and temporal closures were also implemented to limit catch and release fishery impacts—many upper watersheds where summer-run populations hold for extended periods prior to spawning were closed to angling and complete watershed seasonal closures were implemented in spring to limit wild winter-run steelhead encounters. Tributary sport fishery wild fish release mortality rates are not annually estimated but fisheries are managed through the LCR Fishery Management and Evaluation plan.

Modeling conducted in the development of this plan suggested that total wild population mortality resulting from release in sport fisheries should be well below the 10% cap for winter and summer-run steelhead below Bonneville Dam and 4% cap for summer-run steelhead above Bonneville Dam (Washington Department of Fish and Wildlife (WDFW) 2003). A series of ongoing creel surveys funded by the Columbia River Salmon and Steelhead Endorsement (CRSSE) was implemented in 2012 to estimate handling rates and mortality of wild steelhead and harvest of hatchery steelhead in sport fisheries in selected lower Columbia River tributaries. Results from the Washougal and South Fork Toutle rivers suggested the actual fishery mortality rates closely match modeled fishery mortality rates, and fisheries were therefore compliant with their permit conditions (Bentley et al. 2015).

Some mortality of LCR steelhead also occurs in non-tribal commercial fisheries in the mainstem Columbia River, though release of all steelhead is required in these commercial fisheries and DPS-level mortality rates have typically been < 1% for winter-run populations and < 2% for summer-run populations over the last decade (Robin Ehlke, WDFW, pers. comm.). Sport fisheries in the mainstem Columbia River also result in LCR wild steelhead release mortalities, however LCR steelhead transit these mainstem areas quickly and are comingled with more abundant upriver stocks, resulting in total population mortalities of typically < 2% of the run size on fish across the DPS (after applying release mortality rates to numbers of fish handled). Treaty tribal fisheries in the LCR DPS area only occur in the mainstem Columbia River from immediately below Bonneville Dam and upstream including tributary mouths. The principle LCR population impacted by these fisheries is the Wind River population, for which the *U.S. v Oregon* Technical Advisory Committee does not produce a population-specific harvest rate estimate. Lower than expected (e.g., ~63%) survival rates of tagged Wind River steelhead from Bonneville Dam to the Wind River (T. Buehrens, WDFW, unpublished data) suggested further study is needed of this population's mortality rate in sport and tribal fisheries and from other possible sources above Bonneville Dam.

5.3.4.3 Habitat

As in most other areas of Washington, freshwater habitat quantity and quality are the greatest long term limiting factors for steelhead abundance and productivity in the DPS (NOAA 2013). LCR watersheds reflect a legacy of past and ongoing habitat degradation. Most watersheds in the DPS were heavily logged and many were splash-dammed in the late 1800's and 1900's to transport logs downstream via log drives. These practices resulted in channel incision and simplification, loss of woody debris and gravels (which are not naturally abundant due to underlying geology in many watersheds), and changes in hydrology and water quality. Virtually all floodplain reaches of larger rivers in the DPS were developed for agriculture and many areas have been subsequently urbanized. Urbanization, including the use of dikes and levees to isolate stream channels from floodplain habitats, has greatly simplified and straightened floodplain channels and riparian zones, directly and indirectly reducing steelhead productivity by loss of habitat and through negative ecological impacts such as loss of aquatic insect prey species.

In addition to generalized loss and degradation of habitat, specific threats are posed to steelhead populations in the North Fork Toutle watershed as a result of the eruption of Mt. St. Helens, which greatly reduced habitat quality in the Toutle watershed, and particularly the North Fork. Although stream habitats have begun to stabilize and improve in their suitability for steelhead, fish passage to and from the upper North Fork Toutle watershed has been compromised as a result of the construction of a sediment retention structure (SRS; Figure 3;

https://docs.wixstatic.com/ugd/810197_f834b3cdcbed4bcda225a6d4ea48be96.pdf) by the Army Corps of Engineers. The structure requires the physical capture and transport of adults upstream, where they are only released in a few small tributaries, thereby leaving much of the productive habitat unused. Additionally, the structure has created a vast sediment plain which continually degrades mainstem habitat and prevents geomorphic and ecological recovery following the eruption. Current and proposed modifications of the SRS (e.g., raising its elevation) will likely only exacerbate these impacts.

Threats are also posed to Kalama River summer-run steelhead by the historic anthropogenic modification of Kalama Falls to allow greater passage of Kalama winter-run steelhead upstream. It is thought that historically Kalama native summer-run and winter-run steelhead populations were naturally largely isolated from each other in their spawning habitat, with summer-run steelhead spawning upstream of Kalama Falls (rkm 17) and winter-run steelhead spawning downstream. Construction of a fish ladder at the falls has permitted increased access for winter-run steelhead into habitat above Kalama

Falls that was formerly largely used by summer-run fish only. Although this action increased habitat availability and presumably productivity and capacity for the winter-run population, winter-run steelhead presence above the falls has likely resulted in increased intraspecific competition and potentially hybridization, with summer-runs, resulting in reduced productivity and capacity for the summer-run population.

Despite the continued work by habitat restoration groups, the majority of steelhead habitat in the LCR remains severely degraded, especially on private lands and in urbanizing areas. Further detail on the state of habitat in LCR watersheds, limiting factors, and recovery plans can be found on the Lower Columbia Recover Board SalmonPORT site (https://www.lcfrb.gen.wa.us/sport; look under Recovery Plan Actions).

Finally, all LCR steelhead populations are affected by upstream mainstem Columbia River dams and habitat modifications such as dredging in the lower mainstem and estuary, all of which affect physical habitat, flow, temperature, turbidity, sediment transport, and other abiotic and biotic features of the lower Columbia River. For example, recent studies based on PIT-tag detection have found 14 to 16% average annual predation rates on hatchery and wild steelhead smolts from SRB, UCR and MCR DPSs by Caspian terns and double-crested cormorants that breed on artificial islands constructed from dredge spoils in the Columbia River estuary (Evans et al. 2012). Predation rates on LCR steelhead smolts have not been estimated due to a lack of adequate PIT tag detection sites below Bonneville Dam but smolts are expected to be susceptible to the same avian predators in the estuary.

5.3.4.4 Dams, barriers and fish passage

Hydroelectric dams constructed from the 1930s-1950s on the Lewis and Cowlitz rivers, the largest watersheds in the DPS, were built without fish passage (which was in violation of Washington State law, but state law requiring fish passage was superseded by the Federal Power Act). They extirpated anadromous salmon and steelhead from approximately 80% and 50% of the most productive habitats in the Lewis and Cowlitz upper watersheds, respectively. The steelhead population size in the Cowlitz Basin alone was estimated at 22,000 adults in the 1950s despite the considerable habitat degradation that had already occurred and the existence of intensive fisheries (Serl and Morrill 2010). *Ceratomyxa shasta,* a myxosporean parasite, which is pervasive within the lower Cowlitz basin, results in reduced survival and rearing potential for steelhead. Its prevalence is likely exacerbated by the dam-modified hydrology and the presence of hatcheries near the top of the volitionally accessible anadromous reach (e.g., Alexander et al. 2014).

Hydroelectric dams on the Cowlitz blocked access to approximately 3,600 km^2 of drainage area and 386 km of current anadromous habitat on the mainstem as well as its major tributary, the Cispus River, while dams on the North Fork Lewis blocked 1,900 km^2 of drainage area and 275 km of current anadromous habitat until recent reintroduction efforts began in both basins. With the exception of inundated areas, the habitat above these dams remains in good condition as a result of protection from development under mostly USDA Forest Service ownership. Therefore, providing effective passage for juvenile and adult steelhead to and from areas above these dams is critical to realizing the productive potential of upstream habitat. Much has been done to mitigate for the loss of volitional passage around the dams since they were built, including truck and haul strategies. Cowlitz and Lewis both have new downstream collectors. Low collection efficiency for smolts, which is currently below FERC relicensing requirements, limits population viability for Upper Cowlitz and North Fork Lewis populations because a large proportion of juveniles never have an opportunity to go to sea. On the North Fork Toutle, poor adult collection facilities at the sediment retention structure and extremely limited release sites for adult steelhead limit the spatial distribution and viability of this population. It is important to note that System Survival (SS) and Collection Efficiency (CE) are improving so future SS and CE look promising.

Potential future predation by Northern Pike (*Esox lucius*) in the Columbia River basin is an emerging concern.

5.3.4.5 Actions

1. Continue to advocate for and work to improve juvenile and adult fish passage in the Upper Cowlitz, North Fork Lewis, and North Fork Toutle rivers.
2. Continue to work with and support recovery partners, such as Lower Columbia Fish Recovery Board, to develop prioritized long-term approaches to habitat protection and restoration, especially with regard to the high percentage of private land-ownership, and to assist implementation of priority habitat restoration projects.
3. Support actions to address and limit high predation rates by Caspian terns and cormorants on steelhead smolts in Columbia River estuary.
4. Consider limiting passage of wild winter-run steelhead above Kalama Falls in order to reduce competition with wild summer-run steelhead.
5. Investigate unaccounted-for loss, documented by PIT tags, of upstream migrating adult steelhead between Bonneville Dam and natal tributaries.
6. Work with *US. v. Oregon* Technical Advisory Committee to develop methods for estimating population-specific mortality rates with known precision.
7. Finish implementation of regional steelhead watershed management plans and hatchery reform actions called for in the Hatchery and Fishery Reform Policy and SSMP.
8. Continue studies initiated to measure genetic introgression and ecological impacts of segregated hatchery steelhead programs on LCR wild populations and use results to adaptively manage hatchery practices to meet policy goals.
9. Initiate analysis of life-cycle monitoring data to estimate population parameters (e.g., productivity and capacity) for LCR steelhead populations.
10. Refine and improve adult abundance estimation methods to test for bias and measure precision.
11. Continue to support efforts to restore floodplain connectivity and ecological function within the Columbia River estuary.
12. Continue implementation of the Intensively Monitored Watershed projects in Mill, Abernathy, and Germany creeks to assess effects on steelhead productivity (among other species) from intensive habitat restoration and nutrient enhancement efforts.
13. Implement the priority strategies of the Fish Barrier Removal Board to repair all fish passage barriers beginning in the lower Cowlitz watershed.
14. Document spatial and temporal extent of *C. shasta* related mortality and morbidity in Cowlitz Basin and determine whether mitigation of anthropogenically-altered flows could reduce incidence and severity.
15. Continue to work with hydropower licensees to develop and implement aquatic restoration and protection funding programs as established in settlement agreements and federal hydropower licenses. Identify priority habitat restoration and protection projects to be funded.

5.3.5 Middle Columbia River

Five of six MCR populations with abundance data showed increasing trends, but most populations did not frequently achieve recovery goals in a recent 10-year period (Table 10). The Upper Yakima River population qualified and was chosen as a focal population in our risk assessment (Tables 5 and 10). Current major threats to Washington's MCR steelhead populations include juvenile and adult mortality caused by migration through tributary irrigation diversion dams, reduced quality and quantity of habitat, avian predation, and loss of adults entrained upstream of Snake River dams (overshooting during return migration). The four populations in the Yakima River basin offer the greatest opportunity for recovery of MCR steelhead. Although Yakima populations' abundance has increased in recent years (Figure 14), their long-term viability depends upon the installation of adequate passage for juveniles to navigate the numerous instream diversion dams. Abundance data quality and consistency concerns for Walla Walla and Touchet populations may confound our interpretation of trends. Improved abundance monitoring methods are being developed and tested for these and other MCR populations.

Table 10. Risk assessment results and ratings for Middle Columbia DPS steelhead populations. Red text indicates values that exceeded specific criterion for each metric. Focal populations are indicated by bolded red text. Populations with a high risk rating that were not chosen as focal populations were either unlikely to qualify as independent populations or were small populations. NOAA Risk Score is the 2010 NOAA Status Review (Ford et al. 2011) risk ranking. Abbreviations: win. = winter-run; sum. = summer-run; insuf. = insufficient. See Table 5 for expanded presentation and additional details.

Population	Long Term Abundance Trend	Short Term Decline	Extinction Risk	Status relative to abundance goal	NOAA Risk Score	SARR risk score	Population Risk Rating
Upper Yakima sum.	264%	No	23%	0%	High	3.0	High
Rock sum.	insuf. data	insuf. data	insuf. data	insuf. data	High	NOAA only	High
Walla Walla sum.	21%	No	85%	40%	Maintained	2.0	Moderate
Touchet sum.	-4%	No	0%	0%	Maintained?	1.0	Moderate
Naches sum.	332%	No	1%	50%	Maintained	1.0	Moderate
Klickitat sum.&win.	insuf. data	insuf. data	insuf. data	insuf. data	Maintained?	NOAA only	Moderate
Satus sum.	166%	No	6%	100%	Maintained	0.0	Low
Toppenish sum.	471%	No	13%	80%	Maintained	0.0	Low
White Salmon sum.&win.	insuf. data	insuf. data	insuf. data	insuf. data	extirpated	NOAA only	extirpated

5.3.5.1 Hatcheries

While hatchery threats are particularly relevant for Oregon populations within the MCR DPS, Washington populations generally have a high proportion of natural-origin spawners and unknown or low stray rates of hatchery-origin fish into spawning areas (National Marine Fisheries Service (NMFS) 2009). The Yakima River basin, which includes four populations, has no hatchery steelhead releases and very low numbers of hatchery strays from programs located in other basins. Currently, hatchery programs exist in the Touchet, Walla Walla, and Klickitat rivers. Available data for Touchet population (https://fortress.wa.gov/dfw/score/score/species/population_details.jsp?stockId=6861) indicate that pHOS has averaged 17% since 1999. For Walla Walla and Klickitat, wild- and hatchery-origin steelhead counts are made at dams as fish return to these rivers, but there is little information about abundance or pHOS on spawning grounds or hatchery-wild interactions. From 2000 to 2008, average annual number of hatchery smolts released into Middle Columbia DPS watersheds was 392,211, and from 2009 to 2013 average annual release number was 361,455 (Table 4). The average percent of off-site hatchery smolt releases was the same (83.3%; Table 4) in both time periods. Three segregated hatchery programs release smolts off-site, and the one integrated program releases smolts on-site.

5.3.5.2 Harvest

Harvest impacts on MCR populations have been lower since the mid-1980s when mass marking of hatchery steelhead began and wild steelhead release was first required in sport fisheries. Although overharvest was a primary factor in the historical decline of steelhead in the MCR, contemporary reported harvest rates were relatively low (Table 2b). Targeted (tribal fisheries) and incidental reported harvest resulted in an average 10% harvest rate for MCR populations (Table 2b). Survival of MCR steelhead from Bonneville Dam to their natal river systems also may be affected by unreported harvest and/or loss due to fish passage at dams (e.g., steelhead overshoot). Average unaccounted-for loss for MCR populations during upriver migration was approximately 19%, and overall percent loss when combined with harvest rate averaged ~29% (Table 2b). Survival or conversion rate thus averaged ~71%. Losses estimated for Yakima River populations were relatively high, with 32.7% of returning adults detected at Bonneville Dam from 2001-2013 never arriving at Prosser Dam, 22.8% of this loss being unaccounted-for (Table 2b), and indicating that survival (conversion rate) was only 67.3%.

5.3.5.3 Habitat

Instream flows are depleted in mainstem and tributary habitats and this represents a key limiting factor for steelhead throughout the DPS. The same irrigation demand and water impoundment and delivery infrastructure result in some tributaries being disconnected due to structures or flow limitations, and the most prominent passage barriers are the large storage dams in the Yakima River basin that are currently impassable to upstream migrating fish. There is extensive infrastructure of fish screens on dams and irrigation water-delivery systems to protect fish from diversion-related mortality, but it needs to be reviewed to ensure that the screens are adequate and it needs continued long-term funding for operation and maintenance. These screening projects are critical to the persistence of steelhead and other species throughout irrigated watersheds, and securing a reliable funding source should be prioritized.

Historical and contemporary land use and development have resulted in channel incision and simplification, altered woody debris and sediment recruitment, and changes in hydrology and water quality among other problems. Virtually all floodplain reaches of larger rivers in the DPS were developed for agriculture and many areas have been subsequently urbanized. This greatly simplified, narrowed, and straightened floodplain channels, directly reducing their productivity for steelhead as well as indirectly through negative impacts on other species that steelhead depend on. Throughout the region, habitat restoration efforts are improving habitat quality and quantity, reconnecting tributaries, and improving water quality.

A number of fish habitat and fish passage projects have been completed or are currently underway in the Middle Columbia River. The Yakima River basin is undergoing a comprehensive planning process that will continue to benefit fish through improved instream flows, fish passage at major storage dams, and improved tributary habitat. If the plan is fully implemented, upstream and downstream passage would be created at Cle Elum, Bumping, Tieton, Keechelus, and Kachess dams (www.yakimabasinplan.org). Individually and cumulatively, these projects would represent huge gains in habitat quantity for steelhead and other fishes if passage is effective. There are also juvenile passage and reach survival issues for outmigrating steelhead smolts at Roza and Chandler diversion dams in the Yakima basin. The Yakima Basin Integrated Plan calls for reducing hydropower diversions to address this issue, but progress has been slow. In the Walla Walla drainage, Upper Mill Creek provides drinking water to the city of Walla Walla, but its lower reaches are highly degraded especially through Walla Walla where the channel is completely modified to reduce flood risks. Efforts are underway to create or improve passage through Walla Walla and into the protected upper watershed. Finally, significant gains in habitat quantity and fish passage were made when in 2011 Condit Dam was removed from the White Salmon River opening over 50 km of steelhead habitat.

5.3.5.4 Dams, barriers and fish passage

As mentioned above, large water storage dams in the Yakima River basin are currently not passable for upstream migrating fish. Most of the populations in the MCR are also affected by smaller instream diversion dams that may have profound negative effects on smolt emigration survival. Outside of the tributaries, the detrimental effects of the Federal Columbia River Power System (FCRPS) hydropower dams are well documented, including direct passage mortality, altered flow and habitat, increased predation, and numerous other problems (Hostetter et al. 2015; McClure et al. 2007; Zabel et al. 2008). Most MCR steelhead populations have to navigate two or three Columbia River mainstem dams during spawner and kelt migrations. All MCR steelhead populations are subject to threats posed by effects of Columbia and Snake rivers' mainstem dams on freshwater and estuarine habitats. Loss of suitable physical habitat and alterations to flow regimes, temperature, turbidity, sediment transport, and biotic systems pose threats to survival throughout the life cycle.

Mainstem dams impose an additional threat relative to adult downstream passage. Mid-Columbia steelhead returning in the summer and fall often swim past their natal systems into the Upper Columbia and Snake rivers (overshooting), passing one or several dams to do so. It is possible these steelhead are seeking thermal refuges. Later, many, but not all, return to their natal streams for spawning, and those that do not return contribute to artificially high stray rates and gene flow into Snake River populations, reduced abundance for MCR populations, and incorrect estimates of productivity. The dams are thought to prevent or hinder the return of these overshooting steelhead to their natal streams. This phenomenon has DPS- and population-specific implications. Some MCR populations lose individuals to this phenomenon (e.g., Walla Walla) and others are relatively unaffected (e.g., Yakima River populations). There are emerging research efforts to understand and address this problem.

Potential future predation by Northern Pike (*Esox lucius*) in the Columbia River basin is an emerging concern.

5.3.5.5 Actions

1. Evaluate impacts and advocate for improved downstream fish passage of adult steelhead that overshoot into Snake River.
2. Advocate for and support efforts to improve smolt survival at diversion dams within the Yakima River basin to benefit all Yakima populations.
3. Advocate for and support efforts to create fish passage at barriers, including passage into all the upper Yakima basin storage reservoirs (priorities established by the Fish Barrier Removal Board), multiple smaller tributaries of the upper Yakima River, and upper Mill Creek in the Walla Walla River basin.
4. Implement process for determining Wild Steelhead Gene Bank populations.
5. Investigate unaccounted-for loss, documented by PIT tags, of upstream migrating adult steelhead between Bonneville Dam and natal tributaries.
6. Secure funding for operation and maintenance of irrigation screens throughout the region.
7. Increase engagement with Comparative Survival Study and Fish Passage Center to better understand juvenile survival in hydropower system and potential actions (e.g., spill, bypass, breach, etc.).

5.3.6 Upper Columbia River

Long-term abundance showed increasing trends for all four extant Upper Columbia populations (Table 11). This recent population growth may be attributed to improvements in ocean and Columbia River hydropower system survival, habitat quality and connectivity, and screening of irrigation diversions (Maier 2014). However, abundance was consistently below recovery targets for three of the populations (Figure 15). Methow River and Okanogan populations qualified and were chosen as focal populations in our risk assessment (Tables 5 and 11).

Current major threats to Washington's UCR steelhead populations include hatchery-related interactions, mortality associated with juvenile and adult migration, reduced habitat quality, and avian predation. We anticipate improvements in abundance data quality due to transitioning to a PIT-tag based escapement estimation methodology, which has been in place for several years now and is under evaluation. The methodology is expected to decouple trends among populations by better allowing for population-specific inter-annual variability. It also would provide critical information about the distribution of steelhead within populations, which was not available from dam counts and is difficult to discern with redd surveys.

Table 11. Risk assessment results and ratings for Upper Columbia DPS steelhead populations. Red text indicates values that exceeded specific criterion for each metric. Focal populations are indicated by bolded red text. Populations with a high risk rating that were not chosen as focal populations were either unlikely to qualify as independent populations or were small populations. NOAA Risk Score is the 2010 NOAA Status Review (Ford et al. 2011) risk ranking. Abbreviations: sum. = summer-run. See Table 5 for expanded presentation and additional details.

Population	Long Term Abundance Trend	Short Term Decline	Extinction Risk	Status relative to abundance goal	NOAA Risk Score	SARR risk score	Population Risk Rating
Okanogan sum.	50%	No	56%	0%	High	3.0	High
Methow sum.	89%	No	20%	10%	High	3.0	High
Entiat sum.	65%	No	58%	0%	High	3.0	High
Wenatchee sum.	52%	No	7%	40%	High	2.0	Moderate

5.3.6.1 Hatcheries

The Upper Columbia River DPS has seven steelhead hatchery programs, of which five are operated by WDFW (Appendix D). The programs are all related to mitigation for blocked habitat upstream from Chief Joseph Dam or survival impacts from Douglas, Chelan, and Grant PUD dams. Production levels for the PUD-mitigation programs are dictated by survival estimates for outmigrating smolts. Smolt survival is estimated yearly and program sizes are recalculated every 10 years according to changes in Columbia River mainstem survival. The most recent recalculation occurred in 2014 and the resulting changes to hatchery operations and production obligations should benefit wild steelhead populations in the Methow, Entiat, and Wenatchee rivers.

The number of smolts released into the Wenatchee River basin has declined by about 40% to a goal of 247,300 smolts, of which 50% are progeny of wild-origin steelhead and 50% are spawned from first generation hatchery-origin broodstock. Hatchery smolt production also has been reduced in the Methow River basin by up to 100,000 (up to 29%) smolts per year (maximum production of 350,000). Okanogan River hatchery steelhead annual production goal remains at 100,000, but may increase in the near future as new programs are being considered. The Entiat River does not have a hatchery program for steelhead, although numerous hatchery-origin adults stray into the Entiat for spawning in some years (range 10 – 32% pHOS over past five years; WDFW unpublished).

The location for Wenatchee hatchery steelhead overwinter acclimation has been shifted from sites on the Columbia River (Turtle Rock and Chelan hatcheries) to the Chiwawa River Acclimation Ponds, where fish are reared on Wenatchee and Chiwawa River water. This action is expected to reduce straying of Wenatchee hatchery steelhead into the Entiat River and Wenatchee River tributaries downstream of Tumwater Dam.

Hatchery-origin adult management opportunities have expanded as well. The proportion of hatchery-origin steelhead on the spawning grounds in the Wenatchee River is managed at Tumwater Dam and through recreational fisheries in the lower river. These fisheries, known as "conservation fisheries", also occur in the Entiat, Methow, and Okanogan in order to remove hatchery-origin adults (i.e., reduce pHOS). Identifying infrastructure that may be used to extract hatchery steelhead from UCR populations' spawning grounds will be critical as these programs transition from the HSRG re-colonization phase into the local adaptation phase.

Deleterious hatchery interactions could be reduced in the Wenatchee River with changes in how releases are conducted. Juvenile hatchery steelhead releases are volitional and historically non-migrants were forced out or transported to the lower river and released. These juvenile non-migrants frequently residualized and, thus, avoided adult management opportunities while competing and spawning with natural-origin fish (Snow et al. 2013). A proposal to cease the forced release of non-migrants in order to reduce the negative outcomes described above is currently being considered, but remains controversial due to the wild broodstock that led to non-migrant juveniles. Rather than a forcible release, non-migrants would be released into lakes without access to the sea and made available for recreational harvest.

Despite these improvements to hatchery steelhead management in the Upper Columbia DPS, hatchery-related risks remain high in the Methow, Okanogan, and Wenatchee populations. Changes to the smolt acclimation process may reduce that risk for the Entiat population, but other populations continue to have high proportions of hatchery fish on the spawning grounds and continue to have broodstock needs that reduce the abundance of wild-origin natural spawners.

5.3.6.2 Harvest

Although overharvest was a primary factor in the historical decline of steelhead throughout the Columbia River basin, contemporary reported harvest is relatively low (Table 2b). Harvest impacts on UCR populations have been lower since the mid-1980's when mass marking of hatchery steelhead began and wild steelhead release was implemented in sport fisheries. Reported targeted (by tribal fisheries) and incidental harvest was ~10% for UCR populations (Table 2b). Population-specific total harvest rates (excluding tribal fishery net drop-out, which has not been estimated) have never been estimated for these populations.

5.3.6.3 Habitat

Most of the relevant anthropogenic barriers in UCR watersheds are being, or have been, removed or modified to allow for fish passage. However, there are still numerous tributaries that are partially or completely blocked that would offer additional productive steelhead habitat. Historical habitat degradation is slowly being addressed through instream remediation, but vast portions of UCR watersheds are chronically degraded by historical development, logging, and floodplain encroachment. Most areas are still deficient in wood for cover and channel forming processes. Habitat restoration is generally prioritized by habitat limiting factors. However, a transition to a prioritization process driven by empirical estimates of life-stage-specific survival and capacity by tributary would be a major improvement.

Another key area of concern throughout the DPS is water quality and quantity, especially with growing demands for water and a rapidly changing climate. Agricultural diversions take substantial amounts of water from many steelhead streams in the Upper Columbia, which affects stream temperatures, habitat quantity, and habitat quality. Substantial efforts are under consideration or underway to move points of diversion from tributaries (e.g., Chewuch and Twisp rivers, Icicle and Peshastin creeks) into mainstems of their river systems (e.g., Methow and Wenatchee rivers) to improve the efficiency of irrigation water delivery systems. These projects are expected to increase the quality and quantity of critical habitats.

The extensive fish screening infrastructure that protects fish from water diversion-related mortality is currently operational, but lacks long-term funding for operation and maintenance. These screening projects are critical to the persistence of steelhead and other species throughout irrigated watersheds, and securing a reliable funding source should be prioritized.

5.3.6.4 Dams, barriers and fish passage

The most prominent dams in the UCR DPS are Chief Joseph and Grand Coulee, which eliminated access to about half of the spawning and rearing habitat in the upper Columbia River and extirpated the Upper Columbia (four individual populations) and Spokane River (two individual populations) MPGs. Phased analysis is exploring the feasibility of steelhead reintroduction above these dams. Migrating juveniles and adults from extant UCR populations must navigate past seven to nine dams when traveling to or from the ocean. Substantial mortality occurs in upstream and downstream migrations (Comparative Survival Study Oversight Committee and Fish Passage Center 2017). However, some of the recent increases in UCR steelhead abundance are likely associated with survival improvements throughout the mainstem Columbia River hydropower system over the past few decades including turbine improvements, juvenile bypasses, and measures to decrease avian predation. Removal of Enloe Dam on the Similkameen River would provide access to approximately 483 km of mainstem and tributary habitat.

All UCR steelhead populations are affected by mainstem dams and habitat modifications that affect physical habitat, flow, temperature, turbidity, sediment transport, and other abiotic and biotic features throughout the river and estuary. Upper Columbia River steelhead are particularly affected by dam-related threats because of their long migration distance and multiple dams in their path. Conversion (survival) rates of UCR steelhead from Bonneville Dam to the mainstem dam closest to their natal streams ranged from 68 to 76% since 2000. Interestingly, the lowest conversion rates within the DPS were measured for Wenatchee steelhead, despite a shorter migration and one to two fewer mainstem dams to pass; this may be due to low PIT tag detection efficiency at Rock Island Dam.

Potential future predation by Northern Pike (*Esox lucius*) in the Columbia River basin is an emerging concern.

5.3.6.5 Actions

1. Continue to participate in regional evaluations of providing passage at the Icicle Creek Boulder Field, Chief Joseph, Grand Coulee, and Enloe Dams, each of which could potentially restore access to large areas of critical steelhead habitat.
2. Implement process for determining Wild Steelhead Gene Bank populations in this DPS.
3. Continue to exclude hatchery steelhead from the Wenatchee River basin downstream from Tumwater Dam and from the Chewuch River (Methow Basin).

4. Secure funding for operation and maintenance of irrigation screens throughout the region.
5. Investigate unaccounted-for loss, documented by PIT tags, of upstream migrating adult steelhead between Bonneville Dam and natal tributaries.
6. Advocate for instream flow projects that increase water instream by reduce reducing water consumption and/or changing points of diversion, especially in cold tributaries.

5.3.7 Snake River Basin

Long-term abundance showed increasing trends for two of three Snake River Basin populations with data (Table 12). Despite its positive abundance trend, the Tucannon River population met high risk criteria for the extinction and goal achievement metrics and qualified as a focal population in our risk assessment (Tables 5 and 12). Snake River Basin populations are threatened by habitat-, survival-, and migration-related problems associated with Columbia and Snake rivers' mainstem dams, by land and water use, and hatchery-related impacts. Joseph Creek and the lower Grande Ronde populations occur primarily in Oregon, and most actions in those systems are subject to the Northeast Oregon Recovery Plan. Although hatchery-related threats are common in most DPSs, only one of the Washington populations in the Snake River Basin DPS (Tucannon) faces enough hatchery program threats to reduce its viability.

Table 12. Risk assessment results and ratings for Snake River Basin DPS steelhead populations. Red text indicates values that exceeded specific criterion for each metric. Focal populations are indicated by bolded red text. NOAA Risk Score is the 2010 NOAA Status Review (Ford et al. 2011) risk ranking. Abbreviations: sum. = summer-run. See Table 5 for expanded presentation and additional details.

Population	Long Term Abundance Trend	Short Term Decline	Extinction Risk	Status relative to abundance goal	NOAA Risk Score	SARR risk score	Population Risk Rating
Tucannon sum.	27%	No	54%	0%	High?	3.0	High
Asotin sum.	94%	No	4%	80%	Maintained-High?	1.0	Moderate
Lower Grande Ronde sum.	insuf. data	insuf. data	insuf. data	insuf. data	Maintained	NOAA only	Moderate
Joseph sum.	-19%	No	2%	100%	Low	0.0	Low

5.3.7.1 Hatcheries

While hatchery threats are relevant for Idaho and Oregon populations within the Snake River Basin DPS, Washington populations generally have a minimal hatchery influence due to a high proportion of natural-origin spawners and low proportion of hatchery spawners. Currently, segregated hatchery programs exist in the Grande Ronde and mainstem Snake rivers, The Tucannon River has one segregated and one integrated program (Appendix D). Joseph Creek, Asotin Creek, and the Wenaha River have no hatchery programs. From 2000 to 2008, average annual number of hatchery smolts released into Snake River DPS Washington watersheds was 411,025, and from 2009 to 2013 average annual release number was 389,981 (Table 4). The average percent of off-site hatchery smolt releases was the same (75%; Table 4) in both time periods. The average annual percent of hatchery-origin steelhead in Tucannon River spawning areas from 2007 to 2015 was very high (approximately 72%), based on existing information, and these hatchery steelhead included fish from facilities on other rivers. Hatchery fish that enter Asotin Creek are actively removed at a weir so pHOS is maintained near 0% in most years.

5.3.7.2 Harvest

Harvest impacts on Snake River populations have been relatively minor since the mid-1980s when mass marking of hatchery steelhead began and wild steelhead release was implemented in sport fisheries. Contemporary reported harvest is low (Table 2b). Annual targeted and incidental average harvest rates ranged from ~ 10 to 14% for three Snake River populations (average = 11.5%; Table 2b). Conversion (survival) rates of these same Snake River steelhead from Bonneville Dam to the mainstem dam nearest their natal river systems was approximately 68% for 2000-2013.

5.3.7.3 Habitat

There are substantial watershed restoration efforts underway in Tucannon River and Asotin Creek. Both watersheds were developed for grazing, crop production, and residential purposes. These factors resulted in increased channel confinement, erosion, sedimentation, temperatures, and reduced riparian cover, pools, and wood recruitment. Asotin Creek is currently an Intensively Monitored Watershed (IMW), one of several watersheds in Washington under intense study to monitor population response to improved riparian condition, wood placement, and increased pool habitat. The Tucannon River is also being targeted with numerous habitat restoration projects aimed at improving fish abundance and productivity.

Chronically low returns of wild-origin steelhead to Asotin Creek from 1990 to 2009 improved markedly in 2010, likely due to many factors, including improved ocean conditions, habitat restoration, and the removal of hatchery-origin steelhead with a weir located near the mouth of the creek. There is one remaining passage barrier to be addressed in Asotin Creek, Headgate Dam, and efforts are underway to improve passage at that site. The Joseph Creek population has been stable for years and is likely near carrying capacity, although extensive habitat work is occurring in the upper watershed.

Irrigation diversion structures affect water quality and quantity for all Snake River DPS populations, where temperatures and flow are already problematic seasonally in parts of each watershed. Diversions could be upgraded to reduce water extraction and facilitate fish passage and survival. As with other interior Columbia Basin DPSs, an ongoing source of fish screen maintenance funding is needed.

5.3.7.4 Dams, barriers, and fish passage

The detrimental effects of the FCRPS hydropower dams are well-documented, including direct passage mortality, altered flow and habitat, increased predation, and numerous other problems. A developing concern is the phenomenon of steelhead overshooting their respective natal watersheds, and the potential implications for “donor” and “recipient” populations. Adult steelhead commonly migrate upstream of their natal or release location, perhaps seeking thermal refugia or natural stream conditions, but the causal mechanisms are not well understood. Emerging PIT tag evidence suggests that this behavior, combined with impaired downstream passage of adults at dams in the Snake River relative to the upper Columbia River dams can have a substantial influence on the spawning assemblages of affected populations (WDFW unpublished). This situation is likely artificially elevating the wild-origin abundance estimates for “sink” streams and inhibiting the recovery of “source” populations.

The Tucannon River is located in a unique situation where it receives strays from Middle Columbia populations, and loses Tucannon-produced wild-origin fish to systems upstream of Lower Granite Dam. In 2009-2012 there were an estimated total of 679 wild, Tucannon-origin spawners compared to 548 stray wild-origin spawners in the Tucannon River. Over the same time period there were 3,231 endemic and segregated, hatchery-origin Tucannon spawners and 2,859 hatchery-origin spawners from other basins. The recent positive trend in wild-origin spawners in Asotin Creek may be confounded by this phenomenon given its proximity to Lower Granite Dam. There are demographic, ecological, and genetic consequences to this complicated problem, and they are likely variable for each population. Improving our understanding of the magnitude and extent of the effects on affected populations will be critical for recovery and for monitoring the effects of hatchery and habitat actions.

Potential future predation by Northern Pike (*Esox lucius*) in the Columbia River basin is an emerging concern.

5.3.7.5 Actions

1. Continue to advocate for evaluation and improvement of downstream fish passage over Snake River dams of adult steelhead that overshoot into and within the Snake River.
2. Implement process for determining Wild Steelhead Gene Bank populations in this DPS and continue to manage the Wenaha River without hatchery influences.
3. Advocate for and seek secure funding for operation and maintenance of irrigation screens throughout the region.
4. Investigate unaccounted-for loss, documented by PIT tags, of upstream migrating adult steelhead between Bonneville Dam and natal tributaries.
5. Implement fish passage projects prioritized and funded by the Fish Barrier Removal Board

5.4 Focal Populations – threats and actions

For focal populations (Section 4.3; Table 5) we identified population-specific threats and actions (Table 13) that would likely reduce some of the identified risks to population viability. All focal populations are ESA-listed and thus there were numerous documents intended to guide recovery-related activities for ESA-listed DPSs. We relied on formal recovery plans (when available), HGMPs, harvest management plans, and NOAA TRT documents to select key population-level threats. We classified threats for summarization purposes as follows: barriers, climate change, dams, data deficiency, disease/parasites, habitat degradation, hatcheries, and marine survival. We selected action recommendations emphasizing WDFW's role in implementation, and created descriptions of an action's threat reduction goal when a goal was not explicitly stated in documents (Table 13).

For the 15 focal populations, we identified a total of 36 threats and associated actions that could reduce extinction risks (Table 13). Of these, 36% of threats were posed by dams and other barriers that affect passage, survival or water quantity/quality, 19% of threats were due to habitat degradation, and 25% of threats were from hatchery operations. Remaining threats were due to data deficiency (6%), disease/parasites (6%), marine survival (6%), and climate change (3%). Considering that dams and other barriers are forms of habitat degradation, most threats to focal populations (56%) were habitat-related.

5.4.1 Elwha River winter-run steelhead

Since the early 1900s, two dams restricted the Elwha River steelhead population to 14% of its historical basin. Resulting habitat was limited to the mainstem and tributaries downstream of river kilometer (rkm) 7.9. With the removal of Elwha Dam in March 2012 and Glines Canyon Dam in August 2014 about 113 km of river habitat is now accessible and the biggest threat to the population (86% loss of habitat), has been eliminated. Resident *O. mykiss* occurred above the former dams, but it was unknown if resident populations contained an anadromous legacy and could potentially contribute to steelhead recovery (Myers et al. 2015). The Elwha monitoring and adaptive management plan for steelhead and Chinook salmon (Peters et al. 2014) is intended to guide recovery actions as we learn how fish populations respond to this exceptional restoration of access to pristine habitat.

We did not conduct a PVA for Elwha population because adequate spawner abundance estimates for the lower river prior to dam removal were unavailable. It is likely that population abundance has been very low compared to pre-dam historical abundance. Low abundance is a threat to population rebuilding in newly restored habitat. Historical population intrinsic potential high capacity estimates were approximately 7000 to 14,000 adult steelhead (Myers et al. 2015). In 2014, 135 steelhead redds were counted within 62.7 km of tributary habitat surveyed below rkm 21.6, the Glines Canyon dam site (McMillan et al. 2014).

The Lower Elwha Klallam Tribe operates an integrated hatchery program (Appendix D) using native steelhead stock and will manage production according to four recovery phases (preservation, recolonization, local adaptation, and self-sustaining). Goals for the recolonization phase are an increasing trend of natural-origin adults (500-700), and total return exceeding 2,000 for 4 successive years, according to the 2012 HGMP. Prior to 2013, Chambers early winter steelhead were released annually into lower Elwha River (Appendix D). These releases were discontinued to reduce risks to recovering native population following dam removal.

Key threats and actions

Adult spawner and juvenile production data were not adequate for status monitoring prior to dam removal, and these data deficiencies were considered a threat to population management (Table 13). Although a formal Puget Sound steelhead recovery plan is not yet in place, the Elwha management plan (Peters et al. 2014) is intended to aid restoration of population abundance during the re-colonization phase, through actions such as the hatchery supplementation program mentioned above and systematic monitoring. Adult and juvenile annual data collection is needed for accurate status assessment and to adaptively manage relevant recovery actions. We recommend that WDFW continue to participate in this data collection through collaboration with federal and tribal partners to obtain and evaluate smolt and adult monitoring data. To summarize:

Key threat:	**Action:**
The lack of adult and juvenile abundance data has prevented status and trend assessment, reducing the ability to implement effective conservation actions.	Continue WDFW's collaboration with federal and tribal partners in obtaining and evaluating smolt and adult abundance data.

5.4.2 Dungeness River summer- and winter-run steelhead

The Dungeness population includes steelhead that spawn in the mainstem Dungeness River and in its main upper basin tributary the Greywolf River (Figure 2). River headwaters are in high elevation areas of the Olympic Mountains, which results in glacial influence and a snowmelt dominated flow regime. The lower basin is in the mountains' rain-shadow and experiences relatively low total annual rainfall for western Washington. Long-term total spawner abundance data were not available for this population. A partial (index; non-total) escapement estimate in 2001 was 183 adults, and partial escapement estimates from 1988 to 1994 ranged from 292 to 438 spawners. Estimating escapement through redd observation has been problematic because river conditions during spawning (snowmelt runoff) often obscure redd visibility.

Most Dungeness steelhead are winter-run. In the past, anglers that caught a wild steelhead in Dungeness River on or after May 1, recorded the fish as a summer-run on catch record cards. However, information on gonadal ripeness or spawn timing for such fish has not been available. Summer-run-labeled steelhead have been encountered in headwater areas, which are also used by winter-run fish, and it is unknown whether a distinct summer-run population existed historically. Owing to a lack of information, a separate summer-run population was not designated by NOAA (Myers et al. 2015).

Intrinsic potential high capacity historical population estimates were approximately 2,500 to 4,900 adult steelhead (Myers et al. 2015). Based on smolt trap captures between 2005 and 2013, the estimated average annual juvenile outmigration abundance was 10,900 (range 5,500-19,600; WDFW unpublished data). WDFW operates a segregated hatchery program (Chambers early winter stock) in the Dungeness. Between 2009 and 2013 the average annual number of hatchery smolts released was 8,525 (Appendix D). Hatchery releases did not occur in 2015 and 2016.

Habitat threats include mass wasting from road building in the upper watershed, although road impacts are being addressed through project actions primarily on federal lands. Habitat has been lost and degraded by the constriction, diking and alteration of the floodplain channel migration zone in the lower 16 kilometers of the river. Alterations in the lower river have greatly reduced the amount and complexity of side channel and tributary habitat. Floodplain constriction and the loss or removal of large woody material has increased streambed aggradation, scour and channel shifting, which affect redd persistence and fish productivity. Formation of functional complex habitat is impaired by alteration of riparian plant communities (such as by agricultural practices) and continued cutting and removal of large woody material. Water quantity and quality may be negatively affected by irrigation water diversion management. The Department of Ecology is implementing a recently adopted Dungeness water management rule that requires mitigation of any new groundwater withdrawals. Habitat conditions that pose threats to steelhead viability in Dungeness River are described in detail by Blanton et al. (2011).

Key threats and actions

We identified two key threats for this population (Table 13), one from hatchery operations, and one data deficiency. Following the recent issue of a federal (NOAA) permit, the number of hatchery steelhead smolts released has been sized to minimize the potential negative effects on wild steelhead. However, future management and monitoring of pHOS will be required to manage risks of genetic and ecological harm from hatchery practices. We recommend that WDFW develop methods to assess pHOS that are effective in the Dungeness River. The lack of adult abundance data prevented adequate status and trend assessment, and reduces our ability to design effective conservation actions. We recommend that WDFW develop and implement annual spawner survey methodology that is effective under normal conditions in the Dungeness River. To summarize:

Key threat:	**Action:**
Current methods for estimating pHOS are ineffective in the Dungeness River under normal conditions.	Develop methods to assess proportion of hatchery fish on spawning grounds that are effective in Dungeness River conditions.
The lack of adult abundance data prevented status and trend assessment, reducing our ability to implement effective conservation actions.	Implement annual survey methodology that is effective in the Dungeness River under normal conditions.

5.4.3 South Hood Canal winter-run steelhead

This population includes steelhead that spawn in rivers and streams on the southwest side of the Kitsap Peninsula, primarily the Tahuya and Union rivers, which drain into the "hook" of southern Hood Canal (Figure 2). All the watersheds occur in lowland habitats and have rain-dominated flow patterns. Currently, many streams have critically low summer flows, which are partially due to the hydrology of the watersheds, but are likely exacerbated by land-use practices over the last century. Abundance-based PVA analyses for the population were based only on data from Tahuya River (Union River data were available only from 1998 forward), which thus are an index of total population abundance. Results from these index data showed a declining long-term abundance trend, especially since 1998 (Figure 28), and extinction risk was estimated as very high (Table 5), which is likely due to very low spawner abundance. Historical population intrinsic potential high capacity estimates were approximately 3,000 to 6,000 adult steelhead (Myers et al. 2015). Chambers early winter hatchery steelhead were released into the Tahuya and Union rivers in most years from 1966 up to 1994 (Myers et al. 2015). No hatchery steelhead releases into this population's watersheds occurred during our evaluation period of 2000 to 2013 (Appendix D).

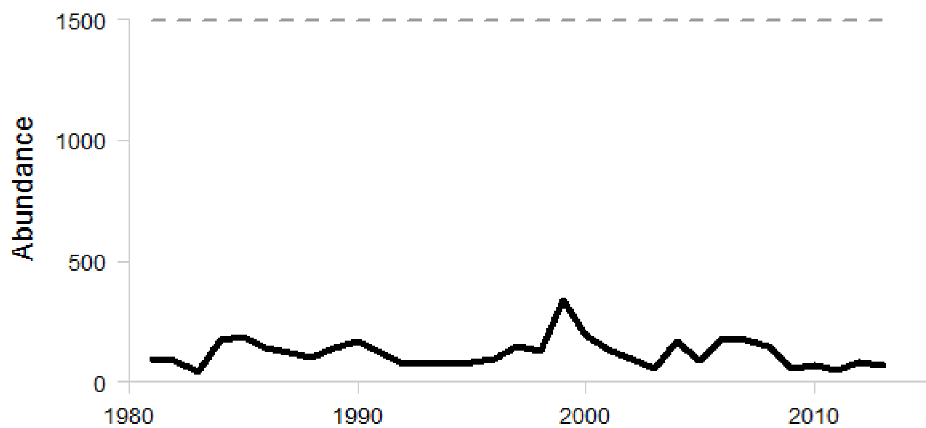

Figure 28. Index escapement data for South Hood Canal winter-run steelhead from 1981 to 2013, representing Tahuya River, the largest subpopulation of the South Hood Canal DIP. A PSSTRT historical viability goal is not available for only the Tahuya River. This subpopulation has declined 20% over the time period with data.

Key threats and actions

We identified three key threats related to marine survival, climate change and habitat degradation for this population (Table 13). Detailed information about various other threats to this population are described in a recent recovery planning report (Long Live the Kings 2014). Marine survival studies on juvenile steelhead migrating through Hood Canal have estimated high mortality around Hood Canal Bridge (Moore et al. 2010a), contributing to relatively low overall early marine survival, which is a threat to abundance and productivity. Current low summer stream flows are a threat to juvenile freshwater survival and productivity that may be worsened by lower summer flows and increased water temperature predicted by climate change projections. Given the uncertainty of projections, it would be advantageous to determine effective approach for tracking high and low flow hydrologic regimes in population's watersheds and implement flow and temperature monitoring. Based on data from recent trapping in the Tahuya River, smolt production relative to watershed potential appeared low (WDFW unpublished), suggesting degraded habitat conditions. Action is needed to improve knowledge of freshwater conditions, their relationship to juvenile survival, and habitat-related threats. To summarize:

Key threat:	**Action:**
Smolt mortality appears to be relatively high around Hood Canal Bridge, and contributes to low overall early marine survival.	Continue collaborating on research to identify causes of low marine survival, including higher mortality around Hood Canal Bridge.

Summer flows are critically low, which likely limit juvenile survival and productivity. Climate change projections predict lower flows and increasing water temperatures.	Determine best approach for tracking high and low flow hydrologic regime, implement flow and temperature monitoring, and pursue instream flow conservation actions.
Smolt production relative to watershed potential appears low, but data and inference are limited.	Investigate parr production and survival to smolt stage relative to instream habitat conditions over several years to document status, variation, and habitat correlations.

5.4.4 Cedar River winter-run steelhead

This population includes the Cedar River and tributaries to the southern end of Lake Washington, primarily Kelsey, May, and Coal creeks (Figure 2). The Cedar River historically was a tributary of the Green River. In the early 1900s Cedar River was artificially rerouted from its Green River/Black River confluence into Lake Washington, and the concurrent construction of the Lake Washington ship canal established its new outflow to Puget Sound. Upstream, Landsburg Dam at rkm 34 blocked fish passage to about 28 km of mainstem and tributary habitat from 1900 to 2003. Fish passage was added in 2004, and Chinook, coho, and steelhead are now passed upstream. The dam still serves to divert Cedar River water for Seattle and King County municipal uses. Steelhead abundance declined to less than 50 fish by 2000 (Figure 29), and with extinction risk calculated at 100% (Table 5), the population could be considered functionally extirpated. However, a substantial resident *O. mykiss* population exists throughout Cedar River, and genetically these fish are similar to steelhead from the Cedar and Green rivers (Marshall et al. 2006).

Although the resident fish produce smolts, there has been no rebuilding of steelhead numbers since the Landsburg Dam fish ladder became operational. Since 2009, few steelhead smolts (<15) have been encountered annually in WDFW's lower Cedar River smolt trap (e.g., Kiyohara 2015). Monitoring for spawners in the upper watershed is conducted by Seattle Public Utilities (SPU). In its current watershed configuration, this population's intrinsic potential high capacity estimates were approximately 6000 to 12,000 adult steelhead (Myers et al. 2015). Chambers early winter steelhead were released in the Cedar River from 1965 to 1991 (tabulated as "Lake Washington System;" Myers et al. 2015). No hatchery steelhead releases into this population's watersheds occurred during our evaluation period of 2000 to 2013 (Appendix D).

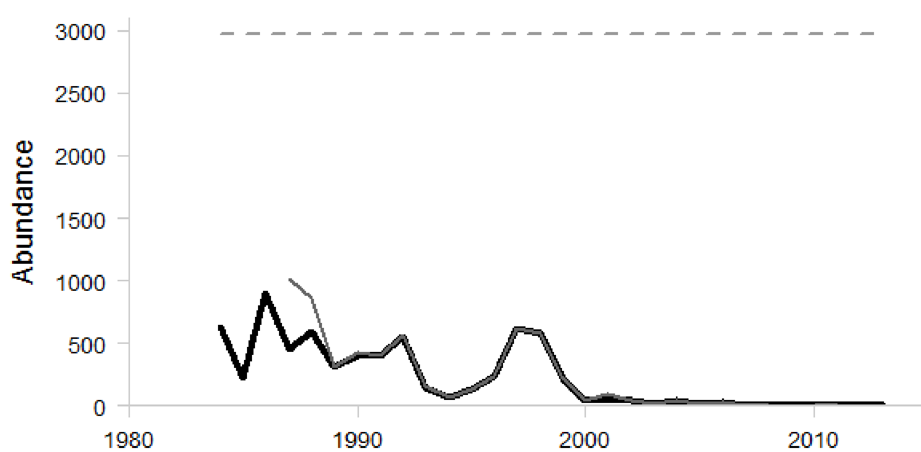

Figure 29. Abundance data for Cedar River winter-run steelhead from 1984 to 2013. The thick black line represents the total escapement, the thin grey line represents the total run size (escapement plus reported sport and tribal harvest plus estimated sport bycatch mortality), and the dashed grey line is PSSTRT historical viability goal. The population has declined 100% over the time period with data.

Key threats and actions

Habitat degradation is a key threat to this population's recovery (Table 13). Various forms of habitat degradation, such as river water withdrawals, urbanization, changes in river and lake fish communities, and fish passage conditions at the ship canal locks, affect all life stages. Major physical changes to Cedar River and Lake Washington Basin and its fish communities appear to have nearly extirpated the anadromous life-history of Cedar River *O. mykiss* because smolt to adult survival was so low.

While smolt survival in Puget Sound is currently thought to be low (Moore et al. 2015), Cedar River steelhead also may be experiencing low survival in their freshwater migration corridor. Research on Puget Sound survival is ongoing. To learn where and when smolt mortality is highest in the freshwater migration corridor, we suggest developing a research project to identify sources and rates of smolt mortality from Landsburg Dam to Shilshole Bay using Green River wild-origin broodstock hatchery smolts. This information would inform any recovery actions.

To summarize:

Key threat:	Action:
Very poor smolt survival in the freshwater migration corridor appears to be related to physical changes and environmental conditions in Cedar River and Lake Washington, and prevents recovery of anadromous population.	Develop research project to identify sources and rates of smolt mortality from Landsburg Dam to Shilshole Bay using tagged Green River wild-origin broodstock hatchery smolts.

5.4.5 Stillaguamish River winter-run steelhead

This population includes winter steelhead that spawn in the mainstem, north, and south forks of the Stillaguamish River and in numerous tributaries (Figure 2). The basin includes lowland and high elevation habitats, and annual flows are characterized as rain-and-snow transitional. Our adult abundance-based analyses for the population were based solely on data from consistently surveyable reaches of the North Fork Stillaguamish, including the mainstem upstream of the Deer Creek confluence, and selected mainstem tributaries. As such, these data are an index of total population abundance and the PSSTRT historical viability goal was scaled to the indexed area. Normal river conditions elsewhere in the basin, including mainstem South Fork Stillaguamish, obscure visibility of redds during the spawning and survey period. The index data showed a large decline in abundance (Figure 30), but we did not compute extinction risk due to lack of population-level abundance estimates.

Historical population intrinsic potential high capacity estimates were ~ 19,000-38,000 adult steelhead (Myers et al. 2015). WDFW has operated two segregated hatchery programs (Chambers early winter and Skamania early summer stocks) on the North Fork Stillaguamish, with annual releases dating back to at least 1965 (Myers et al. 2015). Between 2009 and 2013 the average annual number of winter-run hatchery smolts and summer-run hatchery smolts released was 113,832 and 75,338, respectively, and in this period all hatchery smolts were released on-site (Appendix D). Habitat impacts from human development have been considerably greater in upland areas of the Stillaguamish watershed than in lowland areas. By the end of the 1940s, the entire anadromous channel network, with the exception of a few areas, had been logged (Washington State Conservation Commission 1999). Forestry activities in the upper watershed likely alter the recruitment of fine sediment and wood, which reduce steelhead habitat quality and quantity and thus freshwater productivity of steelhead. Understanding recovery of the upper watershed from logging impacts is important.

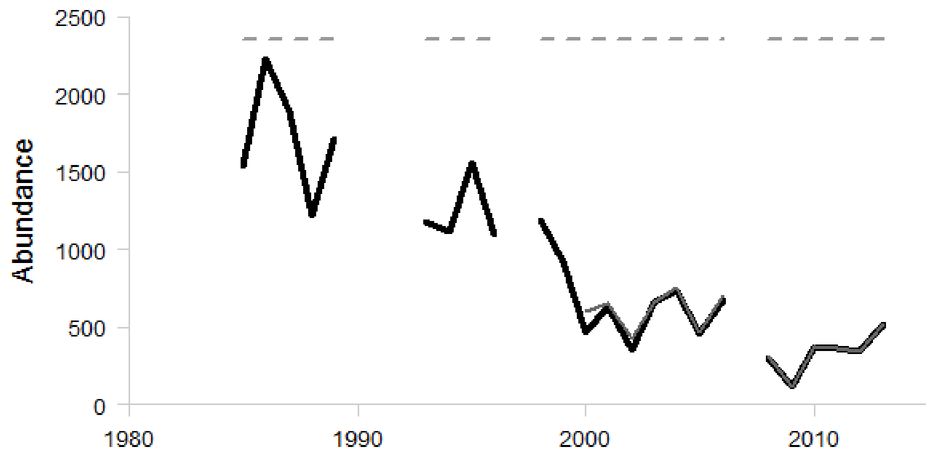

Figure 30. Index abundance data for Stillaguamish River winter-run steelhead from 1985 to 2013. The thick black line represents an index of total escapement, the thin grey line represents the total run size (escapement plus reported sport and tribal harvest plus estimated sport bycatch mortality), and the dashed grey line is PSSTRT historical viability goal. The population has declined 80% over the time period with data.

Key threats and actions

A key threat for Stillaguamish winter-run steelhead is from hatchery operations (Table 13) due to the risk of ecological and genetic harms. The pHOS from both segregated programs spawning naturally has not been estimated, and thus compliance with HGMP goals is unknown. Chambers early winter hatchery smolts were not released in 2015 and 2016. Skamania early summer hatchery smolts continue to be released. In order to inform current and future management and monitoring of hatchery fish natural spawner abundance, we recommend that WDFW develop and implement methods to assess pHOS from both stocks that are effective under normal Stillaguamish River conditions. To summarize:

Key threat:	**Action:**
pHOS is not estimated, and thus risks of genetic and ecological harm from both segregated hatchery programs are unknown.	Implement methods to monitor pHOS from each program and estimate and manage genetic and ecological interactions between hatchery and wild steelhead.

5.4.6 Tolt River summer-run steelhead

The Tolt River is a small (255 km^2) watershed (Figure 2) in the Snoqualmie sub-basin, within the Snohomish Basin. Summer-run steelhead occur in areas upstream of falls that historically were temporal migratory barriers to winter-run fish in North Fork and South Fork Tolt rivers. In the North Fork Tolt, summer-run steelhead are known to spawn in a small area between falls at rkm 4 and a complete migratory barrier at about rkm 5.8 (Pfeifer 1990). The falls at rkm 4 has been thought to be difficult for winter-run steelhead to pass, potentially leaving summer-run steelhead with some exclusive habitat upstream. However, based on WDFW staff observations, winter-run steelhead also ascend and spawn upstream of rkm 4. In the South Fork Tolt, a series of low falls found between approximately rkm 4.5 and 5.6 appear to act as temporal migratory barriers, facilitating passage by summer-run but not winter-run steelhead, and a complete barrier falls occurs at rkm 12.6 (Pfeifer 1990).

The South Fork Tolt Dam, which is located about 0.8 km upstream of the natural anadromous barrier, serves to supply 30% of Seattle-area drinking water, and it regulates seasonal flows. Dam operations have altered South Fork Tolt hydrology resulting in lower winter peak flows and higher summer flows, with unknown consequences on steelhead populations downstream. It is likely that some Tolt summer-run steelhead hold in non-natal areas such as the upper Snoqualmie River upstream of the Tolt River confluence, prior to migrating to natal spawning grounds. These habitats, in addition those in the Tolt watershed, would be important for adult pre-spawning survival.

Our adult abundance-based analyses for the population were based solely on data from the South Fork Tolt spawner area and are thus an index of abundance. Based on these data, there has been a relatively small (22%) decline in abundance that is particularly evident since the late 1990's (Figure 31), but we estimated a relatively high extinction risk (25%; Table 5). This population is chronically below historical population intrinsic potential high capacity estimates, which were 321-641 adult steelhead (Myers et al. 2015). There is a long history of direct and nearby releases of Skamania early summer and Chambers early winter hatchery fish in Tolt River and other Snohomish sub-basins such as Snoqualmie River; however, no hatchery steelhead were released into Tolt River during our evaluation period of 2000 to 2013 (Appendix D). Skamania early summer smolts, reared at several hatcheries, were released directly into Tolt between at least 1965 and 1993 (Myers et al. 2015). Wild-born steelhead with Skamania early summer stock genetic characteristics were found in several South Fork Tolt sampling events (Myers et al. 2015; WDFW unpublished data)). Observations of two spawning peaks (February and mid-April) by WDFW staff has been hypothesized as evidence of a naturalized population of Skamania early summer steelhead in the South Fork Tolt River (Campbell et al. 2008).

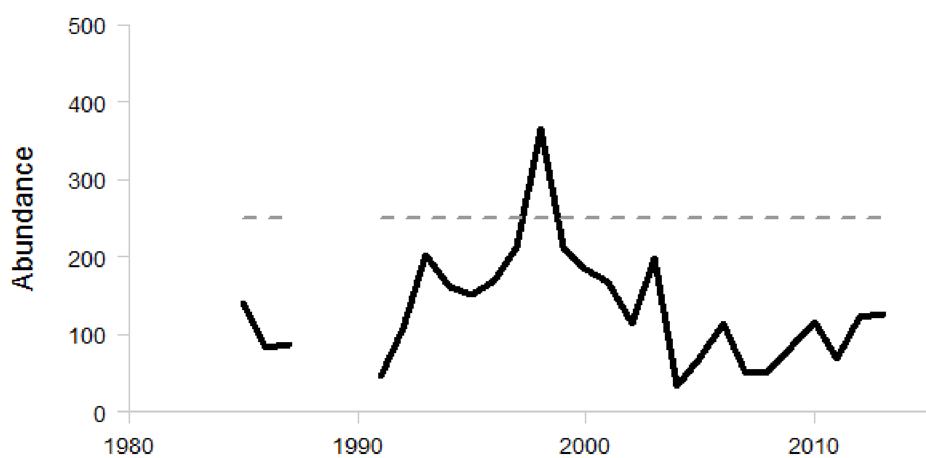

Figure 31. Index abundance data for Tolt River summer-run steelhead from 1985 to 2013. The dashed grey line is PSSTRT historical viability goal. The population has declined 19% over this time period.

<u>Key threats and actions</u>

We identified two key threats due to hatcheries and barriers for this population (Table 13). Although the risk of harm from Snoqualmie and Skykomish sub-basin hatchery programs has been reduced (e.g., off-station releases into Snoqualmie ended in 2008; Appendix D), impacts from previous hatchery releases may persist. Deleterious effects from segregated program releases elsewhere in the Snohomish Basin may occur and warrant further investigation. Genetic and other evidence has suggested naturalization by Skamania early summer hatchery steelhead in South Fork Tolt River. We recommend continuing the work in North Fork and South Fork Tolt sub-basins to genetically analyze samples of putative summer-run steelhead (wild-born) and any winter-run steelhead to verify identity and then assess abundance by stock origin in both areas.

Flow modification and reduction by the South Fork Tolt Dam may be a threat to this population (Table 13), but specific impacts are not well-documented. Previously, WDFW staff speculated that the altered hydrograph affected steelhead passage at the temporal barrier falls (Pfeifer 1990). There is a possibility, especially in drought conditions, that the altered summer flows are beneficial to steelhead by providing higher flows and cooler temperatures than would normally occur. The dam impacts other instream processes such as gravel and wood recruitment, however some of these impacts were addressed in the 1988 FERC re-licensing Settlement Agreement. Seattle City Light has conducted a Chinook salmon and steelhead redd scour study on South Fork Tolt River to help identify limiting factors, including the installation of accelerometers at four sites. The results of this study will provide more information about the scour threshold and may address operations and flow maximum when spill can be controlled. To summarize:

Key threat:	**Action:**
Releases for previous and nearby Snohomish Basin hatchery programs may still cause genetic and ecological harms, as current evidence suggests naturalization by Skamania early summer steelhead.	Continue genetic studies in North Fork and South Fork Tolt sub-basins on summer-run and winter-run steelhead to verify identity and assess abundance by stock origin.
South Fork Tolt Dam operation has altered flow volume and annual hydrograph. Potential impacts on summer steelhead need to be better understood and mitigated.	Work with City of Seattle through the 2024 FERC relicensing process and subsequent settlement agreement negotiations to mitigate any dam operation impacts.

5.4.7 Green River winter-run steelhead

This population includes winter-run steelhead that spawn throughout the Green River Basin (Figure 2). This basin is smaller than its historical size because the Cedar and White rivers are no longer tributaries to this watershed. Steelhead were blocked at rkm 98 from approximately 598 km^2 of former habitat by City of Tacoma's Headworks Diversion dam. The U.S. Army Corp of Engineer's (USACE) Howard Hanson Dam occurs upstream of the diversion dam at rkm 104. Upstream passage was recently established at the Diversion Dam, and facilities for a trap and haul passage program to upper Green River were constructed for Howard Hanson Dam. However, downstream passage facilities are not available. Soos and Newaukum creeks are the main tributaries in the lower basin utilized by steelhead. Analysis of spawner abundance data showed a large (65%) decline for the long term trend (Figure 32), but estimated extinction risk was relatively low (12%; Table 5). Historical population intrinsic potential high capacity estimates were approximately 19,800 to 39,000 adult steelhead (Myers et al. 2015).

Annual smolt production has been difficult to estimate accurately, but 2009 and 2010 estimates were 26,174 (±16,023) and 71,710 (±22,393), respectively (Topping and Zimmerman 2013).

Three hatchery programs have been in operation in the basin: two segregated hatchery programs (Chambers early winter and Skamania early summer stocks), and an integrated native winter steelhead program. From 2000 to 2008 and from 2009 to 2013, the average annual number of Skamania early summer hatchery smolts released was 89,634 and 72,017, respectively, and the percentage of hatchery smolts released off-station was 70.3% and 24.3%, respectively (Appendix D). From 2000 to 2008 and from 2009 to 2013, the average annual number of Chambers early winter hatchery smolts released was 174,494 and 107,977, respectively, and the percentage of hatchery smolts released off-station was 84% and 43%, respectively (Appendix D). Chambers early winter hatchery smolts were released in 2014, but not since then and no releases are planned for future years. The native broodstock program started in 2001 to enhance harvest opportunities, but it was reclassified as a conservation program in 2009. From 2000 to 2008 and from 2009 to 2013, the average annual number of native winter hatchery smolts released was 24,121 and 21,556, respectively, and the percentage of hatchery smolts released off-station was 15.3% and 10.2%, respectively (Appendix D).

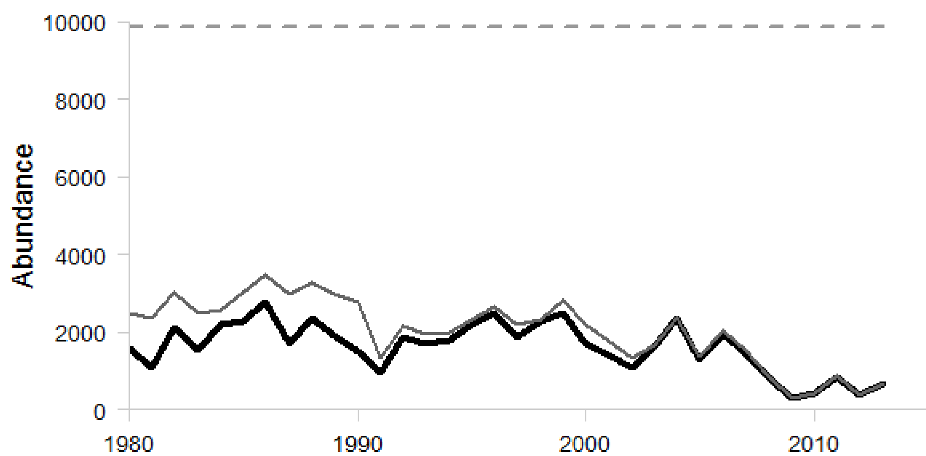

Figure 32. Abundance data for Green River winter-run steelhead from 1980 to 2013. The thick black line represents the total escapement, the thin grey line represents the total run size (escapement plus reported sport and tribal harvest plus estimated sport bycatch mortality), and the dashed grey line is PSSTRT historical viability goal. The population has declined 59% over the time period with data.

<u>Key threats and actions</u>

We identified four key threats from dams, other passage barriers, hatcheries, and disease/parasites for this population (Table 13). An approximately 41% loss of historical habitat upstream of Howard Hanson Dam and its lack of fish passage impede this population's ability to recover to high viability levels. We recommend that WDFW continue to prioritize work with NOAA, Tacoma Public Utilities and USACE to ensure development and construction of effective downstream fish passage at upper watershed dams. Other barriers such as culverts, road crossings, and channel dikes or levees occur throughout lower basin, reducing spawning and rearing habitat. We recommend that WDFW work with other agencies and local jurisdictions to prioritize culvert blockage removals in Soos and Newaukum creeks and restore fish passage.

Risk of harm from hatchery operations exists from the two remaining programs. The pHOS from each program has not been estimated, and thus risk levels and compliance with HGMP goals are unknown.

Skamania early summer and native winter-run hatchery smolt releases continue to present a substantial risk of genetic and ecological harm. We recommend that WDFW develop and implement methods to assess pHOS throughout the basin. In addition, WDFW must evaluate the need for the native conservation program by determining whether smolt production is currently spawner-limited.

Green River steelhead, especially those from the Soos Creek watershed, are known to be infected by the parasite *Nanophyetus salmincola*, which may impact their marine survival. We recommend that WDFW and partners investigate whether intensity of infection is a causal component of poor marine survival. To summarize:

Key threat:	**Action:**
The 41% loss of historical habitat due to Howard Hanson Dam and its lack of fish passage reduce abundance and productivity, impairing population recovery.	Continue to prioritize work with Muckleshoot Tribe, Tacoma Public Utilities, NOAA, USACE, USFWS, WDFW, Ecology and King County to ensure development and construction of effective downstream fish passage at upper watershed dams in the Additional Water Storage Agreement (AWSA). Also continue coordination in order to properly allocate water for steelhead and Chinook to keep redds watered and provide additional instream flow.
Culverts, road crossings, and channel dikes or levees occur throughout lower basin and reduce habitat available for spawning and juvenile rearing.	Prioritize and implement culvert blockage removals for passage restoration in Soos and Newaukum creeks
pHOS is not estimated, and thus risks of genetic and ecological harm from hatchery programs are unknown, and the need for a conservation hatchery program is unknown.	Develop and implement method to estimate and manage pHOS, and determine whether native stock smolt production is spawner-limited.
Green River steelhead, especially those from Soos Creek, have high infection rates from the parasite *Nanophyetus salmincola*, and infection levels have been hypothesized to impact marine survival.	Investigate whether intensity of *N. salmincola* infection is a causal component of poor marine survival.

5.4.8 Puyallup/Carbon River winter-run steelhead

This population includes winter-run steelhead in the Puyallup River and one of its major tributaries, the Carbon River (Figure 2). Steelhead in Puyallup River's other major tributary, the White River, are a separate population. The Puyallup and Carbon rivers drain from glaciers and slopes of Mt. Rainier. The entire watershed includes lowland habitats, and annual flows are characterized as rain-and-snow transitional. Spawners utilize Puyallup and Carbon mainstem channels, but the majority of spawning occurs in many of their tributaries. South Prairie Creek, a Carbon River tributary, is non-glacial, with less sediment and moderate temperatures and appears to support much greater levels of steelhead spawning than other areas. South Prairie Creek is 24.8 rkm in length, suggesting that current steelhead abundance may be heavily dependent on a relatively small area.

The diversion dam for Electron Dam on Puyallup River at rkm 67 blocked passage to about 42 km of river habitat from 1904 to 2000. A fish ladder now allows upstream passage around the diversion dam, but there is not effective downstream passage (Mudd and Leigh 2008). Electron Dam is not on the river itself but on a hill above the river. A wooden flume transports water 10 miles along the ridge of the river valley to the reservoir. The diversion is not compliant for fish screening, so fish that pass into the diversion are not likely to survive. The water in the flume passes through several settlement ponds where fish are trapped and exposed to high temperatures. Those fish that do make it to the reservoir are collected and returned to the river. WDFW is part of the process to make recommendations on a new fish screen design that will minimize the number of juvenile fish entering the diversion and accommodate the high sediment loads (P. Miller, WDFW, pers. comm.). About 42 km of lower Puyallup River historical floodplain is highly modified with revetments and levees, and lower-most and estuarine areas are almost entirely urbanized or industrialized (Puyallup River Basin Chapter; Northwest Indian Fisheries Commission (NWIFC) 2012).

Analysis of spawner abundance data showed a large (88%) decline for the long term trend (Figure 33), but estimated extinction risk was relatively low (8%; Table 5). Historical population intrinsic potential high capacity estimates were approximately 14,700 to 29,000 adult steelhead (Myers et al. 2015). Estimates of annual smolt abundance are not available because trapping rates have been too low. WDFW's Voights Creek Hatchery releases of Chambers early winter stock ended in 2009. The hatchery lacked adult collection facilities, suggesting un-harvested returning adults likely would have spawned naturally, posing genetic and ecological risks. Average annual number of hatchery smolts released from 2000 to 2008 was 189,159 (Appendix D).

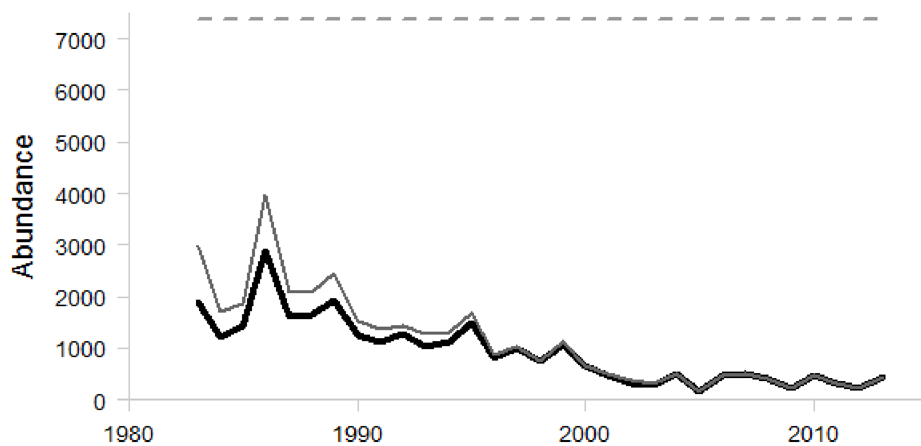

Figure 33. Abundance data for Puyallup/Carbon River winter-run steelhead from 1983 to 2013. The thick black line represents the total escapement, the thin grey line represents the total run size (escapement plus reported sport and tribal harvest plus estimated sport bycatch mortality), and the dashed grey line is PSSTRT historical viability goal. The population has declined 84% over the time period with data.

<u>Key threats and actions</u>

We identified habitat degradation and dam operations as key threats to this population's recovery (Table 13). The high percentage of habitat degradation from urbanization and development in lower Puyallup River likely reduces abundance and productivity. We recommend that WDFW and its conservation partners promote habitat protection and restoration in South Prairie Creek and other tributary or mainstem areas where spawners currently are concentrated. Upstream passage has been established at the diversion dam for Electron Dam, but downstream passage is compromised by the diversion system that channels water to the reservoir behind Electron Dam and through the penstocks to the power house adjacent to the river. Some fish make it to the reservoir but likely most die in route. Those that make it to the reservoir but not all are trapped and hauled back to the river. Various problems with entrainment at the diversion are described in Mudd and Leigh (2008). Downstream migration needs to be evaluated. WDFW is working with Electron Hydro LLC and the Puyallup Tribe to ensure effective fish passage and downstream survival at Electron Dam through the Habitat HPA process. To summarize:

Key threat:	**Action:**
High percentage of habitat degradation in lower river reduces abundance and productivity.	Promote habitat protection and restoration in South Prairie Creek and other tributary or mainstem areas.
Passage has been established at the diversion dam for Electron Dam, but current downstream migration problems remain unresolved.	Continue to prioritize work with Electron Hydro LLC and Puyallup Tribe to ensure effective fish passage and downstream survival at Electron Dam and diversion dam.

5.4.9 Nisqually River winter-run steelhead

This population includes steelhead that spawn throughout Nisqually River mainstem (Figure 2) and its tributaries including the Mashel River. LaGrande Dam blocks upstream access in the Nisqually River at rkm 68.4 and Alder Dam occurs just upstream at rkm 71.1. Historically, a series of cascades near these dams' locations may have been a complete barrier to fish passage, though conclusive information is not available. Yelm Diversion Dam on the mainstem at rkm 42.2 has a fish ladder. This dam diverts water to a canal for hydropower generation (the Yelm Hydroelectric Project) and has screening to prevent juvenile fish from entering the canal. Much of the accessible river habitat occurs in lowlands areas, and the river currently exhibits a rain-dominated flow pattern, which is most likely heavily influenced by dam operation that controls and moderates snowmelt and rain run-off from Mt. Rainier.

Analysis of spawner abundance data showed a large (90%) decline (Figure 34), but estimated extinction risk was relatively low (2%; Table 5). Historical population intrinsic potential high capacity estimates were approximately 15,000 to 31,000 adult steelhead (Myers et al. 2015). Based on smolt trap captures between 2009 and 2013, the estimated average annual juvenile outmigration abundance was about 65,000 (range about 20,000-94,700; WDFW unpublished data). Chambers early winter stock were released into Nisqually River from 1966 up to 1982, and Skamania early summer stock were released in most years from 1977 up to 1994 (Myers et al. 2015), No hatchery releases into Nisqually occurred during our evaluation period of 2000 to 2013 (Appendix D).

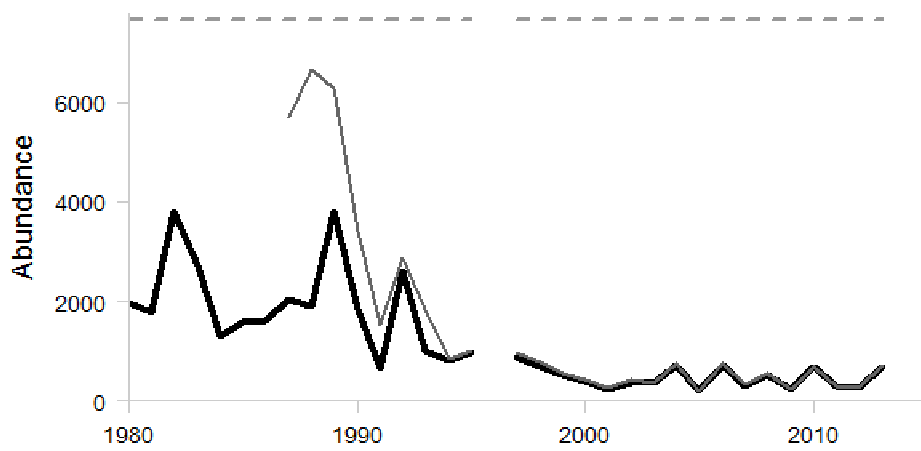

Figure 34. Abundance data for mainstem Nisqually River winter-run steelhead from 1980 to 2013. The thick black line represents the total escapement, the thin grey line represents the total run size (escapement plus reported sport and tribal harvest plus estimated sport bycatch mortality), and the dashed grey line is PSSTRT historical viability goal. The population has declined 87% over the time period with data.

Key threats and actions

We identified seven key threats related to habitat degradation, dams, disease/parasites, and marine survival for this population (Table 13). Degraded riparian areas exist watershed-wide due to land uses such as agriculture, military activities, residential development, and timber harvest, likely reducing survival and production of adults and juveniles. The draft Nisqually steelhead recovery plan recommends restoration of riparian native plant communities to improve wood recruitment, provide for stream shading, and reduce sediment transport (Nisqually River Steelhead Recovery Team 2014). Nisqually-Mashel State Park development on Mashel River as planned would degrade riparian and in-stream habitat, reducing steelhead survival. WDFW and its conservation partners should work to ensure a management plan for Nisqually-Mashel State Park provides adequate river and riparian protection and restoration. Timber harvesting can impair riparian and river conditions, reducing spawning habitat and juvenile survival. The recovery plan recommends development of a Nisqually/Mashel Community Forestry initiative to address riparian buffers, road networks, and upland timber harvest.

Until relicensing of the LaGrande and Alder dams, moderating flow during steelhead spawning is optional for Tacoma Power, who operate these dams. Currently, they generate based on market demand for electricity during steelhead spawning, so Tacoma Power can change flow significantly as long as they follow ramping rates and maintain minimum flow. During or right after a storm event, increasing the amount of flow released from the dams is likely for dam safety, not to follow the market demand. Stage change cannot be moderated during those events. Though not documented yet, WDFW biologists have indicated that high flow is pushing steelhead to side channels to spawn and then, when flows drop, redds are dewatered. After documentation and discussions, WDFW is hoping to find a solution that is acceptable to Tacoma Power. Additionally, Yelm Diversion Dam may reduce survival due to impingement of juveniles on fish screens or entrainment into diversion canal. The screens were designed to meet NMFS and WDFW screen criteria, but due to wear and tear they may no longer be compliant. The recovery plan recommends evaluation of effectiveness of the Dam's fish screens during summer, and survival level of fish encountering the screen bypass system.

A long migration through Puget Sound to the ocean for Nisqually steelhead smolts may increase their exposure to mortality risks, and marine survival appears to be low compared to that of other Puget Sound populations. We recommend that WDFW continue collaborating on the Nisqually steelhead smolt marine survival acoustic study as part of the Puget Sound-wide study. Finally, Nisqually steelhead smolts have high prevalence and high infection rates of the parasite *Nanophyetus salmincola*, which may impact marine survival. We recommend that WDFW and partners continue to investigate whether intensity of infection is a causal component of poor marine survival. To summarize:

Key threat:	**Action:**
Degraded riparian areas exist watershed-wide due to a wide variety of land-uses, likely reducing survival of adults and juveniles.	Support efforts to restore riparian native plant communities, improve wood recruitment, provide for stream shading, and reduce sediment transport.
Nisqually-Mashel State Park development on Mashel River may degrade riparian and in-stream habitat, potentially reducing survival of adults and juveniles.	Ensure management plan for the Nisqually-Mashel State Park will provide protection and opportunities for restoration of riparian, in-stream, and floodplain conditions.
Timber harvesting may result in mass wasting, excessive sediment delivery, and reduced riparian functioning, all of which can reduce spawning habitat and juvenile survival.	Support efforts to develop Nisqually/Mashel Community Forestry initiative to address riparian buffers, road networks, and upland timber harvest.
Potential redd dewatering below Tacoma Power dam due to flow regulations during steelhead spawning season.	Gather data to inform redd dewatering and if it is documented, and determined necessary, work with Tacoma Power to provide consistent flow during steelhead spawning.
Centralia Diversion Dam may reduce juvenile survival due to impingement on fish screens or entrainment into diversion canal.	Support efforts to evaluate effectiveness of Yelm Diversion Dam fish screens to determine if juveniles experience impingement or entrainment during summer, and survival level of fish encountering screen bypass system.
Long Puget Sound migration distance appears to expose smolts to high mortality risks, resulting in relatively low early marine survival.	Continue work on Nisqually steelhead smolt marine survival studies.
Nisqually steelhead smolts have high infection rates from the parasite *N. salmincola*. High infection levels have been hypothesized to impact marine survival.	Investigate whether intensity of *N. salmincola* infection is a causal component of poor marine survival.

5.4.10 Upper Cowlitz/Cispus rivers winter-run steelhead

The three populations in the upper Cowlitz watershed (Figure 3; Upper Cowlitz, Cispus, and Tilton; Myers et al. 2006) together historically comprised the most abundant steelhead run in any LCR watershed, yet all have high levels of viability risk and have been extirpated or greatly reduced in adult abundance due to the construction of dams on the Cowlitz River (Figure 35). Mayfield Dam, completed in 1963 on the Cowlitz River mainstem at rkm 84, provided upstream and downstream passage but operation of the upstream facility was terminated in 1968 due to the lack of fish entering the facility. Mossyrock Dam, completed in 1968 more than 40 rkm below the confluence of the Cispus River and upper Cowlitz River, was built without adult or juvenile fish passage facilities. Instead the Barrier Dam was built in 1969 to collect fish for the hatchery and for upstream transport. Returning adults were collected at the Barrier Dam's facilities (rkm 79.7, just downstream of Mayfield Dam). Adult steelhead not used for broodstock were transported into the upper Cowlitz basin at Mayfield Lake and above Mossyrock Dam for a number of years, but efforts to transport fish into Riffe Lake ended in 1972 because juvenile fish trapping in Riffe Lake, the reservoir backed up by Mossyrock Dam, was unsuccessful. Steelhead continued to be transported and release into the Tilton River via truck and haul. As a result, Upper Cowlitz and Cispus populations were extirpated. Resident *O. mykiss* are found in the area and may include a genetic remnant of anadromous populations.

A reintroduction program was initiated in the 1990s to reestablish upper Cowlitz/Cispus and Tilton steelhead populations. The construction of outmigrant fish collection facilities at Cowlitz Falls Dam was expected to make reestablishment possible. Late-returning wild steelhead trapped at Barrier Dam were spawned and large numbers of their unmarked fry were released in Upper Cowlitz and Cispus rivers between the late 1990's and 2001. A similar program for Tilton River steelhead occurred concurrently.

Starting in 1995 juvenile outmigrants were collected at Cowlitz Falls Dam and transported to lower Cowlitz River. In 1997, wild-born adults trapped at Barrier Dam were transported to upper Cowlitz above Cowlitz Falls Dam and to the Tilton River. Afterwards, differential marking was used on trapped and transported juveniles from the two populations. However, an unknown proportion of Tilton River outmigrants were not captured and tagged at Mayfield Dam (because they passed through turbines rather than the juvenile fish facility), which likely resulted in some Tilton-origin unmarked returning adults being transported to upper Cowlitz (since they would not have been wire-tagged). Starting in 2010, marking strategies for Tilton and upper Cowlitz outmigrants transitioned to allow accurate identification and transportation of returning adults. Upper Cowlitz/Cispus population outmigrants are 100% blank wire-tagged, and only these that return as adults to Barrier Dam are transported to upper Cowlitz. The new operational license for Mossyrock and Mayfield dams granted by FERC in 2002 required restoration of passage for juvenile and adult salmonids to and from above-dam areas at sufficiently high rates to promote self-sustaining and harvestable natural populations.

Genetic analysis of wild-born adults returning to Barrier Dam in 2005 that were tagged as juveniles while emigrating from the upper watershed suggested they were genetically distinct from Chambers early winter and Skamania early summer stocks propagated at Cowlitz Hatchery, and not differentiated from the native, late-winter Cowlitz hatchery stock. Thus, at that time, the restoration project appeared to be using the stock native to the basin, as intended, and it also appeared that transported late-winter Cowlitz stock hatchery parents had been producing returning offspring (Small et al. 2010). An integrated hatchery program has been initiated for upper Cowlitz/Cispus population. Smolts are differentially marked relative to smolts produced by a Tilton steelhead hatchery program to enable transport of returning adults to their rivers of origin.

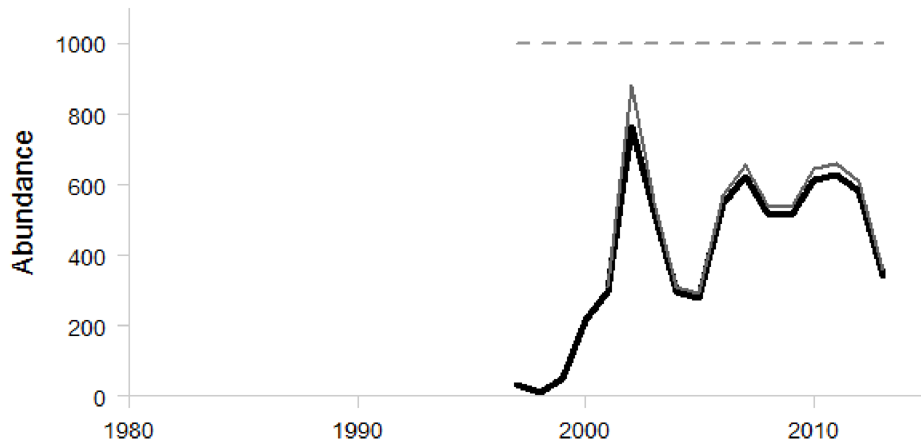

Figure 35. Abundance data for Upper Cowlitz/Cispus rivers winter-run steelhead from 1997 to 2013. The thick black line represents the total escapement, the thin grey line represents the total run size (escapement plus reported sport and tribal harvest plus estimated sport bycatch mortality), and the dashed grey line is the recovery goal. The population has increased 466% over the time period with data.

Key threats and actions

Inundated historical spawning and rearing habitat, forest practices and other land use, and channelization and diking of the lower river collectively degrade habitat in the basin resulting in reduced fish populations. Here, we have focused on threats for which there are more immediate, actionable solutions.

We identified two key threats related to hydropower dams and hatcheries for this population (Table 13). The biggest risk factor for this population is low smolt to adult return rates (SARs), due to inadequate juvenile collection efficiency by transport systems at Cowlitz Falls Dam, and resulting poor survival of smolts attempting to emigrate from upper basin. The new Tacoma Power Cowlitz FERC license requires the installation of "…proposed facilities and measures most likely to achieve the goal of 95% fish passage survival…" for downstream migrating juveniles from the upper Cowlitz and Cispus rivers to the lower watershed (National Marine Fisheries Service (NMFS) 2004), and stipulates a minimum of 75% survival (deemed the minimum for viable populations) be achieved. Collection efficiencies for steelhead juveniles from the upper Cowlitz and Cispus rivers since reintroduction efforts began have ranged from < 5% to 68% with most years below 50%. Collection efficiencies at this level are generally not sufficient to support self-sustaining populations (Serl and Heimbigner 2013).

WDFW's primary management action is to work with Cowlitz dam owners and operators to improve fish collection efficiency to greater than 75% and preferably >95%. Tacoma Power acquired the fish collection facilities at Cowlitz Falls Dam from Bonneville Power in 2014 and continued to contract with WDFW to operate this facility through 2016. Tacoma Power has completed construction of an additional, larger fish collection facility which incorporates the original facility. The new collection complex began operation during the 2017 smolt outmigration season.

The relatively new integrated native hatchery program provides a demographic boost to the wild population by increasing spawner abundance in Upper Cowlitz and Cispus rivers, which will be necessary until collection efficiency for juveniles is high enough to permit self-sustaining natural production, but also presents significant risk of genetic and ecological harm if managed improperly. The Tilton population integrated hatchery program operates in shared Cowlitz Hatchery facilities and returning adults from all hatchery programs are handled at Barrier Dam. This type of operation poses risks of population mixing if juvenile marking and adult fish management are inadequate. Mixing could result in reduced fitness due to outbreeding depression and reduced productivity from ecological interactions. Significant changes in Cowlitz hatchery programs have occurred and continue through an adaptive hatchery management plan to meet the dual purpose of steelhead recovery while supporting sport harvest. To summarize:

Key threat:	Action:
Ineffective juvenile collection facilities associated with dam infrastructure result in low survival of emigrants.	Continue to support efforts of NOAA and dam operators to improve juvenile collection efficiencies at Cowlitz Falls Dam from current rates (usually <50%) to between 75% and 95%.
Upper Cowlitz/Cispus and Tilton integrated programs require adequate monitoring to reduce risks of genetic and ecological harms, and differential juvenile marking and adult transportation to prevent mixing of the populations.	Manage hatchery programs according to HSRG recommendations and maintain stock-specific marking for outmigrating and trapped juveniles and correctly identify and transport wild-born returning adults to their natal rivers.

5.4.11 North Fork Lewis River winter-run steelhead

The North Fork Lewis River historically contained the second largest winter-run steelhead population in the LCR DPS, with historical abundance estimated at 8,300 adults (Lower Columbia Fish Recovery Board (LCFRB) 2010). Estimated natural spawner abundance data are not available for this population. Three dams constructed between 1931 and 1958 on the North Fork Lewis blocked 1900 km^2 of drainage area and 275 km of currently available riverine habitat and resulted in the extirpation of wild steelhead until recent reintroduction efforts began (Figure 3). The reintroduction program was initiated in 2012 using wild winter steelhead from the lower North Fork Lewis River to reestablish a winter-run steelhead population in the North Fork Lewis watershed. New operational licenses recently granted by FERC in 2008 required that dam operators restore passage for juvenile and adult salmonids to and from areas upstream of Swift Dam at sufficiently high rates to promote self-sustaining and harvestable natural populations. An integrated winter-run steelhead hatchery program (Appendix D) is being used to jumpstart recolonization of the upper watershed. Collection and passage downstream of juveniles reared upstream of the reservoirs, and collection and passage upstream of returning adults will need to be efficient enough and result in high enough survival to result in a viable population. Currently, juvenile passage collection efficiency is < 10%, which is greatly below levels necessary to sustain a population (e.g., > 75%). In addition, downstream passage for steelhead kelts has thus far been ineffective with hundreds of adults being passed upstream and most kelts ending up stranded in the Swift Reservoir. Operators are also required to provide effective passage to and from areas above Yale and Merwin Dams or to provide “in lieu” funding for habitat restoration if it is determined by action agencies that restoration of habitat above Swift Reservoir will result in greater improvements to populations than provision of passage into Yale and Merwin reservoirs. A decision is likely in 2018.

<u>Key threats and actions</u>

We identified two key threats related to hydropower dams and hatcheries for this population (Table 13). North Fork Lewis hydropower dams have no volitional fish passage facilities. Currently the steelhead reintroduction program requires adult fish collection at Merwin Dam facilities and their transportation upstream of Swift Dam for release into upper river spawning areas. Outmigrating juveniles must be captured at Swift Dam by a floating surface collector and transported by truck downstream to a lower river release facility. In the future there may be passage through Merwin and Yale reservoirs. If passage is not provided, mitigation funds will be provided for habitat restoration in lieu of passage. Regardless, success of this program depends on adequate trapping and transportation of juveniles and adults. The greatest threat is that required capture rates of juvenile migrants will not be obtained for population rebuilding. Collection efficiency at Swift Dam juvenile capture facility must be improved to meet capture rate goal of >75%. If built, collection efficiencies at the other dams would have to be similarly high to be effective.

The integrated hatchery program requires adequate trapping of native wild-origin winter-run fish in the lower river where steelhead of other origins may occur. During initial years, capture of about 65 adults is needed in order to achieve broodstock goal of up to 50 spawners of correct genetic stock for the hatchery program. To avoid threat of stock mixing, genetic identification testing is necessary to select adults of correct origin for broodstock. To summarize:

Key threat:	Action:
Ineffective juvenile and kelt collection facilities at Swift Dam result in low survival of emigrants.	Continue to work with PacifiCorp and regulatory agencies to refine collection and passage systems to ensure passage targets are met for smolts and kelts.
Population mixing is a threat posed by misidentification of wild winter-run steelhead trapped at Merwin Dam for North Fork Lewis reintroduction hatchery program broodstock.	Adequately capture, manage, and correctly identify broodstock adults to meet integrated hatchery program goals and achieve HSRG standards.

5.4.12 Upper Yakima River summer-run steelhead

The Upper Yakima River summer-run steelhead population was rated at high viability risk because it had an unacceptably high likelihood of extinction (23%), had yet to meet its minimum delisting goal (500 spawners, Figure 36) in any recent return year, and it was characterized as high risk in the 2010 Status Review (Ford 2011). It is the only focal population in the Middle Columbia DPS. The Yakima River basin drains a 15,928 km^2 watershed and joins the Columbia River near Richland, WA. The Upper Yakima steelhead population's area includes the Yakima River mainstem and tributaries upstream of Naches River confluence (Figure 4). This upper basin is heavily managed for agricultural needs and the Cle Elum, Keechelus, and Kachess water storage dams inundate and block passage to upstream habitat. Water management at these dams produces an annual maximum flow in summer when stored water is released to agricultural lands downstream, and flows are reduced in other seasons while snow-melt water is being stored. Historically, maximum flows occurred during snow-melt in spring.

The consequences of this altered annual hydrograph are not well known, especially for steelhead, though recent evidence suggests that smolt survival is negatively impacted by low flows during spring outmigration (Courter et al. 2015). Instream flow has declined in many Upper Yakima tributaries due to significant diversion of surface flows for irrigation. This may be a primary limiting factor for steelhead productivity as several major steelhead-producing tributaries, including the Umtanum, Swauk, and Teanaway rivers, which are subject to water extraction and low summer flows. Taneum Creek is one of the few key steelhead streams where significant habitat, passage, and instream flow restoration efforts have been recently completed. Similar restoration efforts are underway in several other tributaries.

At its peak, the Yakima River is thought to have supported between 20,800 (Kreeger and McNeil 1993) and 100,000 steelhead (Smoker 1956), with most of them being members of the Upper Yakima population. Roza Dam, which is located near the downstream extent of the Upper Yakima population, was impassable during steelhead migration season (October-March) from 1941-1959 (Hatchery Scientific Review Group (HSRG) 2009). There was also substantial smolt mortality associated with four diversion dams downstream of Roza Dam. By the 1980s and 1990s steelhead were nearly extirpated and in many years zero adults passed Roza Dam. Today, the Upper Yakima population represents less than 10% of the total steelhead production in the Yakima River basin, but production is trending upward (Figure 36).

The Yakima Basin Integrated Water Resource Management Plan (YBIP) includes numerous important fish-related components along with water conservation and irrigation system upgrades. Most notably for Upper Yakima steelhead, the YBIP includes provision of fish passage at Cle Elum, Keechelus, and Kachess Dams, as well as at other fish passage barriers at smaller irrigation diversion structures. Historically, many small tributaries to the upper Yakima River were blocked for irrigation purposes, roads, and other infrastructure. Restoring connectivity is a major priority.

WDFW played a key role in development of the Yakima Tributary Access and Habitat Program (YTAHP) that was developed in 2001 to provide technical assistance to landowners in restoring critical salmonid habitat by implementing projects that protect, restore, and enhance riparian and floodplain habitat currently or historically used by upper Yakima River salmonid populations. Program objectives are to screen irrigation diversions, remove manmade barriers (dams, culverts, etc.), restore fish passage to areas blocked by instream irrigation diversions, and enhance stream habitat. Many fish passage barriers have been removed and habitat and instream flows restored through this program. Work continues on tributaries with inadequate passage and screening.

Upper Yakima River steelhead are currently minimally affected by hatchery programs, although that has not always been the case. From the 1950's to 1987 various hatchery programs were initiated and terminated, including use of Skamania early summer steelhead and California-lineage domesticated rainbow trout. Introgression from the domesticated hatchery trout has been identified in some tributaries, including Umtanum Creek (Campton 1985). Since 1987 there have been no local or out-of-basin hatchery steelhead released in the Yakima River (Hatchery Scientific Review Group (HSRG) 2009). However, hatchery strays do occur and are passed upstream of Roza Dam; pHOS for the Upper Yakima population has been 0-7.7% from 1985-2009 (Conley et al. 2009). A robust population of resident rainbow trout, supported by high summer flows, moderated temperatures and productive food web, is sympatric with Upper Yakima steelhead, and resident females have produced steelhead offspring (Courter et al. 2013). Resident and anadromous interaction may be important for Upper Yakima steelhead persistence.

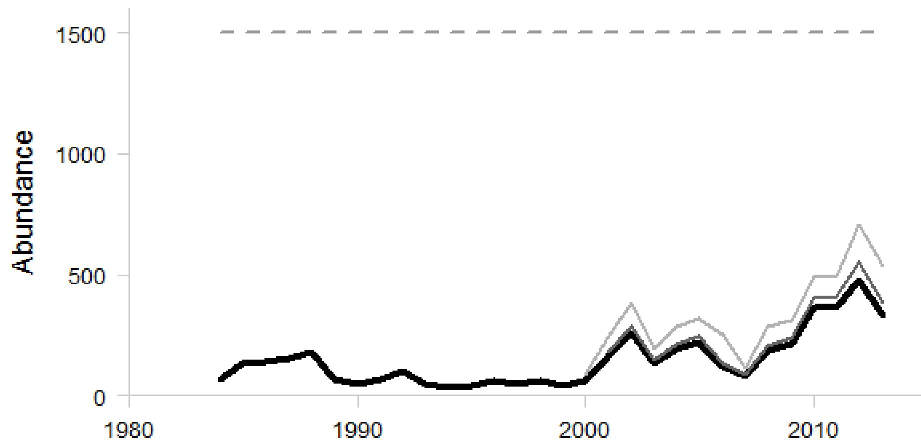

Figure 36. Abundance data for Upper Yakima River summer-run steelhead from 1985 to 2013. The thick black line represents the total escapement, the thin dark grey line represents the total run size reconstructed using escapement and reported sport and tribal harvest plus sport and commercial harvest bycatch mortality, the thin light grey line represents estimated total run size calculated as escapement plus harvest plus unaccounted-for loss, and the dashed grey line is the recovery goal. The population has increased 264% over the time period with data.

Key threats and actions

We identified two key threats related to dams and other barriers for this population (Table 13). The most substantial threats are attributed to water storage and diversion dams, and unscreened irrigation diversions diverting all or most flow from tributary streams used for spawning and rearing. Flow manipulation, such as water extraction and irrigation water delivery, is associated with low smolt survival (Conley et al. 2009). During spring when smolts are outmigrating, the Yakima River downstream of the storage dams suffers from a lack of instream flow and elevated water temperatures. Courter et al. (2012) observed higher rates of avian predation on smolts during periods of low flows. Additionally, hydropower diversions at Roza and Chandler dams should be reduced. These dams serve mostly as irrigation diversions; their minor power generation abilities could be reduced further with no harm to irrigation districts if BPA provides them with power from elsewhere at a good rate. We recommend that WDFW continue to work with regulatory agencies to support restoration of historically natural flow conditions throughout Upper Yakima basin and the lower mainstem.

Loss of connectivity due to large dams and irrigation infrastructure threatens persistence by reducing spatial structure, abundance, and productivity (Yakima Basin Fish and Wildlife Recovery Board 2009). Unscreened irrigation diversions result in loss of rearing juveniles and migrant fish. Although much progress has been made in the upper Yakima River with regard to fish passage and instream flow restoration, numerous potentially valuable steelhead tributaries are still inaccessible and none of the large water storage dams are passable. We recommend that WDFW work with steelhead recovery partners to ensure that effective adult and juvenile passage is restored to as much historical habitat as possible, and to maximize survival of migrating fish. To summarize:

Key threat:	**Action:**

Flow manipulation, due to water storage and irrigation diversion dams and their seasonal pattern of water extraction and delivery, is associated with low smolt survival.	Continue to work with regulatory agencies to support restoration of historically natural flow conditions throughout Upper Yakima basin and the lower mainstem.
Water storage dams, irrigation diversions and other barriers block passage and limit population recovery; direct mortality is associated with diversions and their screening. Specifically, need to reduce hydropower diversions at Roza and Chandler dams.	Work with recovery partners to ensure that effective adult and juvenile passage is restored to historical habitat, and that all diversions are screened.

5.4.13 Methow River summer-run steelhead

The Methow River occupies a 4,662 km^2 basin and joins the Columbia River at Pateros. Spawning areas for this population include Methow, Twisp, Chewuch, and Lost rivers and Gold, Wolf, and Early Winters creeks. The Methow River population was characterized as high risk due to an unacceptably high risk of extinction over the next 20 years (20%), only reaching its minimum recovery abundance goal twice in past ten years (Figure 37), and being rated as high risk in the 2010 NOAA Status Review (Ford 2011). Smolt recruits per spawner values were very low (Figure 19), which may be attributed to numerous factors including habitat-related density dependence and hatchery domestication effects for hatchery-origin spawners.

Methow River steelhead were severely affected by Washington Water Power Company's (WWPC) dam, which existed from the approximately 1911 until its removal in 1929 (Mullen et al. 1992). At the time of dam removal, *O. mykiss* had persisted as resident rainbow trout. The genetic integrity of Methow steelhead and other UCR populations was compromised with the inception of the Grand Coulee Fish Maintenance Project in 1939, in which fish from multiple populations were collected at Rock Island Dam and released into spawning tributaries or propagated in hatcheries (Mullen et al. 1992) for release throughout the UCR.

Methow River steelhead must pass nine Columbia River dams (Figure 5). Adult and juvenile mortality incurred over the long freshwater migration distance has slowed recovery, although recent returns of wild steelhead occasionally have exceeded recovery goals (Figure 37). In order to continue the progress seen in recent years, adult-to-adult productivity must improve. Smolt-to-adult return rates are low in part due to juvenile out-migrant mortality through the hydropower dams. Despite vast improvements in juvenile survival at Columbia mainstem dams in recent decades, even if most are meeting their survival objectives (approximately 95% survival), only 66% of steelhead smolts survive the downstream migration to below Bonneville Dam. Also, conversion (survival) rates, based on PIT-tagged fish, of adults migrating from Bonneville Dam to Wells Dam have averaged approximately 76% since 2001, which further reduced adult-to-adult productivity and SARs.

Three hatchery programs currently operate in the Methow basin (Appendix D). There are two integrated conservation programs, including one 48,000 smolt release program in the Twisp River using localized wild broodstock collected at the Twisp Weir and one up to 200,000 smolt release at Winthrop National Fish Hatchery using an upper Methow composite wild broodstock. The third program is the Methow integrated safety net program (100,000 smolt release goal) that uses adult returns from the two conservation programs (Appendix D). Efforts to minimize negative domestication and ecological effects of hatchery fish spawning in the natural environment and juvenile competition on the Methow population include reduced program sizes, retaining juveniles that do not volitionally migrate, and promulgation of conservation fisheries with mandatory retention of externally marked hatchery-origin fish. Additionally, recent efforts have included operation of outfall traps at Methow Fish Hatchery and Winthrop National Fish Hatchery, as well as the Twisp Weir and the Volunteer Channel trap at Wells Fish Hatchery. These adult management techniques are intended to reduce pHOS and facilitate wild steelhead recovery, but they have yet to reduce pHOS to the interim 25% pHOS goal identified in the Douglas PUD Wells Complex HGMP addendum. Additional measures may need to be taken to boost wild adult production and reduce the abundance of hatchery-origin spawners.

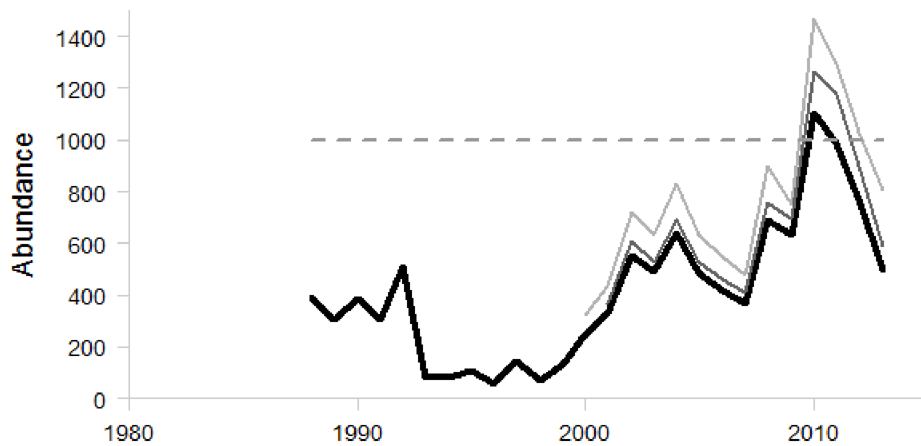

Figure 37. Abundance data for Methow River summer-run steelhead from 1988 to 2013. The thick black line represents the total escapement, the thin dark grey line represents the total run size reconstructed using escapement and reported sport and tribal harvest plus sport and commercial harvest bycatch mortality, the thin light grey line represents estimated total run size calculated as escapement plus harvest plus unaccounted-for loss, and the dashed grey line is the recovery goal. The population has increased 89% over the time period with data.

Key threats and actions

We identified two key threats related to hatcheries and hydropower dams for this population (Table 13). Mortality at numerous dams still limits overall juvenile survival and impedes recovery. Juvenile PIT tagging of Methow steelhead occurs and provides a mechanism for analyzing survival past dams. We recommend that WDFW and research partners develop PIT-tag based survival models and work towards survival standards at all Columbia River mainstem dams that lead to population viability. The primary hatchery threat is pHOS that exceeds HGMP goals, with resultant threats of domestication and competition. Primary recommended management actions are centered on the reduction of pHOS. Removal of hatchery adults through fisheries or at hatchery facilities is inadequate so hatchery releases may need to be further reduced. Differential marking of conservation versus safety-net fish could be used to prevent unintended harvest of conservation program adults. As wild spawner abundance improves, hatchery programs will need adaptive management as the need for conservation and safety net programs should decrease, threats associated with unclipped hatchery fish may increase, and there is higher risk for these programs to undermine recovery. To summarize:

Key threat:	**Action:**
High pHOS from several hatchery programs may decrease population fitness and adaptation to natural environment.	Work with co-managers to implement recommended hatchery reform and fishery management actions to reduce pHOS, including complete adipose fin-clipping of

	all hatchery steelhead and reducing wild broodstock program sizes.
Cumulative mortality at nine Columbia River dams limits overall juvenile survival and impedes recovery.	Maintain juvenile PIT tagging and develop PIT-tag based survival models, and continue to advocate for and support efforts to achieve population viability survival standards at all mainstem dams.

5.4.14 Okanogan River summer-run steelhead

The Okanogan River watershed covers 23,160 km^2 in the USA (Figure 5) and Canada, and joins the Columbia River at Brewster, WA. Despite the large watershed size, the minimum delisting abundance goal for the portion of the population in the United States is 750 fish due to limited suitable habitat. The Okanogan River steelhead population was identified as high risk because it has a 56% chance of extinction over the next 20 years, it has not yet reached its minimum recovery goal of 750 fish (Figure 38), and it was rated as high risk in the 2010 NOAA Status Review (Ford 2011). Most of the potential steelhead habitat in the US portion of the Okanogan River has been reopened through habitat improvement projects, although instream flows can be severely depleted in tributaries due to water extraction. In Salmon Creek, a major spawning tributary, a diversion dam and Conconully Dam decrease water quantity and alter flow timing reducing or preventing spawner use and limiting juvenile rearing.

Okanogan River steelhead, like Methow River steelhead, must navigate nine Columbia River dams. Adult and juvenile mortality incurred over the long migration distance has slowed recovery. In order to continue the increased abundance seen in recent years, adult-to-adult productivity must improve. Smolt-to-adult return rates are low due to juvenile out-migrant mortality through the hydropower dams. Even if most dams meet their survival objectives (approximately 95% survival), only 66% of steelhead smolts survive the downstream migration to downstream of Bonneville Dam. Zosel Dam on the mainstem Okanogan River may further reduce survival of juveniles, and a lack of passage facilities at Okanogan Lake Dam in Canada blocks access to multiple tributaries.

Adult mortality occurs during upstream dam passage as evidenced by conversion (survival) rates of adults from Bonneville Dam to Wells Dam that have averaged approximately 76% since 2001 which further reduced adult-to-adult productivity and SARs. Enloe Dam at approximately rkm 14 of the Similkameen River, the Okanogan River's largest tributary, may block access to the majority of historical habitat in this watershed, although there is uncertainty regarding historic passage of steelhead and other anadromous fishes above a natural waterfall immediately below the dam (Mitchell 1980).

The best opportunities for steelhead recovery actions are primarily focused on restoring connectivity to Okanogan Lake and the Similkameen River above Enloe Dam. The Okanogan Lake Dam has sufficient fish passage facilities, but political concern about sockeye-kokanee interactions has prevented Canada from supporting restoring anadromous fish passage into Okanogan Lake where approximately 25 tributaries to the lake could provide important habitat for steelhead. Similarly, there is increasing scrutiny of Enloe Dam and the potential benefits for anadromous fish if the dam were removed. The history of fish passage at Similkameen Falls, which is immediately downstream from Enloe Dam, is unclear, with historical accounts and incidental evidence pointing towards either a natural barrier or historical fish passage. No one has yet captured a fish in the bypass reach that has been irrefutably identified as an anadromous fish (Upper Columbia Salmon Recovery Board (UCSRB) 2007).

However, organizations like the Columbia River Inter-Tribal Fish Commission (CRITFC), Confederated Colville Tribes, Lower Similkameen Indian Band, WDFW, federal agencies, and private authors have documented anecdotal accounts of historical fish passage. This is a complicated issue socially, politically, biologically, and economically, but the potential anadromous fish benefits are profound with up to 550 km of accessible mainstem and tributary habitat upstream of the dam (approximately five times larger than area of Elwha River opened through dam removal) that would likely benefit steelhead as well as Chinook salmon, sockeye salmon, and lamprey if passage at the falls occurs.

There are two integrated hatchery programs associated with Okanogan steelhead (Appendix D). The average annual number of smolts released from 2009 to 2013 for WDFW's Wells-Okanogan Safety-net hatchery program was 100,756 and from the Colville Tribes' Wells-Okanogan locally-adapted integrated program was 33,666 (Appendix D). Ongoing high pHOS (62% to 90% range during 2005-2014; Okanogan Basin Monitoring and Evaluation Program (OBMEP) 2015) may be a threat to recovery of Okanogan population. Adaptive management of hatchery program releases is needed as well as expanded opportunities for removing adults from spawning grounds, which will be critical as these programs transition from the re-colonization phase into the local adaptation phase.

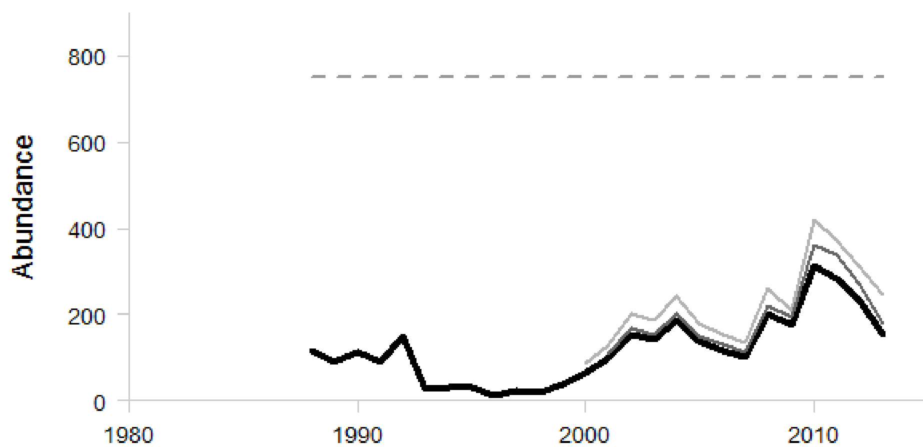

Figure 38. Abundance data for Okanogan River summer-run steelhead from 1988 to 2013. The thick black line represents the total escapement, the thin dark grey line represents the total run size reconstructed using escapement and reported sport and tribal harvest plus sport and commercial harvest bycatch mortality, the thin light grey line represents estimated total run size calculated as escapement plus harvest plus unaccounted-for loss, and the dashed grey line is the recovery goal. The population has increased 50% over the time period with data.

Key threats and actions

We identified four key threats related to habitat degradation, dams, and hatcheries for this population (Table 13). Reduction and alteration of stream flows and timing in Salmon Creek impact spawner use and threaten juvenile rearing capacity and survival (Upper Columbia Regional Technical Team (UCRTT) 2014). We recommend that WDFW work with irrigators and Conconully Dam operators to develop better water management that adequately supports fish needs, such as year-round flow improvements that would increase over-winter survival and production in the lower three miles of Salmon Creek.

Habitat loss or lack of access due to impassable dams on the Similkameen River and the Okanogan River in Canada at Okanogan Lake limit steelhead production and population recovery (Upper

Columbia Regional Technical Team (UCRTT) 2014). Regarding the Similkameen River, we recommend WDFW continue to engage in discussions with regional organizations, co-managers, and other agencies about the benefits and appropriateness of Enloe Dam removal or providing fish passage should the dam be renovated to produce electricity. Regarding disconnected habitat in upper Okanogan watershed in Canada, we recommend that WDFW engages with Canadian Department of Fisheries and Oceans, British Columbia Ministry of Fisheries, and the Okanogan Nation Alliance to pursue permanent passage into Okanogan Lake and its tributaries.

Threats to natural production from domestication and competition exist due to a high pHOS. WDFW can continue to work with co-managers to develop local broodstocks of appropriate size, and to assist in minimizing hatchery adults on spawning grounds. To summarize:

Key threat:	**Action:**
Decreased water quantity and altered flow timing in Salmon Creek due to irrigation diversions and Conconully Dam reduce or prevent spawner use and limit juvenile rearing.	Support efforts to develop better water management to adequately support fish needs, such as year-round flow improvements to increase over-winter survival and production in lower three miles of Salmon Creek.
Lack of access upstream of Enloe Dam into a very large area of potential historical habitat limits steelhead production.	Continue to engage in ongoing Enloe Dam removal discussions, advocate for removal, and provide technical assistance as needed.
Okanogan Lake Dam eliminates access to over 15 tributaries that would support steelhead spawning and rearing.	Work with B.C. Ministry of Fisheries and Canadian Dept. of Fisheries and Oceans to develop passage at dam.
High pHOS may decrease population fitness and adaptation to natural environment.	Continue to work with co-managers to optimize conservation hatchery programs for recovery.

5.4.15 Tucannon River summer-run steelhead

The Tucannon River basin occupies 1,300 km^2 in southeast Washington, and is a tributary to the lower Snake River downstream of Little Goose Dam (Figure 6). It is a relatively linear system with few large tributaries, and most steelhead spawn in the mainstem. The Tucannon River steelhead population was identified as high risk because it has a 54% chance of extinction over the next 20 years, it has not yet reached its minimum recovery goal of 1,000 fish in any recent year (Figure 39), and it was rated as high risk in the 2010 NOAA Status Review (Ford 2011), although reliable spawner abundance data were, and still are, lacking. A legacy of development, recreation, roads, beaver trapping, logging, and grazing/agriculture has resulted in the lack of channel complexity (e.g., off channel habitat and sinuosity) that exists today. Early 20th century dams on the lower river likely accelerated the steelhead decline as upstream passage was inadequate and outmigrating juveniles may have been impinged or entrained (Bryant and Parkhurst 1950; Snake River Salmon Recovery Board (SRSRB) 2011). The uppermost of these dams (De Ruwe Dam) was destroyed in a 1964 flood and the remaining dam (Starbuck Dam) was retrofitted with an updated fish ladder in 1992. Recent habitat restoration activities have reduced temperatures and fine sediment flux through riparian planting, grazing reform, and minimum-till agriculture (Snake River Salmon Recovery Board (SRSRB) 2011). Aggressive instream restoration is taking place to improve physical habitat complexity and floodplain interaction.

The Snake River hydropower dams (four in lower mainstem) have numerous known threats for steelhead and other salmonid populations, but until the recent proliferation of juvenile steelhead PIT tagging, their effect on the ability of adult steelhead to return to their natal stream was unknown. Evidence suggests that adult steelhead often swim past their natal streams during their return migration and then fail to descend back downstream through dams to their natal rivers for spawning ("overshooting"). This overshooting phenomenon affects numerous populations in the MCR and SRB DPSs, and in the SRB, the Tucannon River population appears to be particularly vulnerable (Bumgarner and Dedloff 2011). For 2009 – 2013, 60% of Tucannon wild-origin steelhead that reached Ice Harbor Dam initially overshot the Tucannon River and passed upstream of Lower Granite Dam. About 22% of those that overshot eventually returned to the Tucannon, but overall only 46% of the Tucannon River steelhead that passed Ice Harbor Dam actually made it back to the Tucannon River. Overshoot and return rates for hatchery-origin fish released into Tucannon River (Lyons Ferry stock or Tucannon Endemic stock) were similar to Tucannon wild-origin fish.

Wild Tucannon steelhead abundance has been consistently low and well below recovery goals since before 2000 with no indication of improvement, despite positive trends seen in recent years for many MCR, UCR, and SRB populations. A detailed examination of the origins of steelhead utilizing the Tucannon suggests that wild-origin escapement is often comprised of 30-40% out-of-basin fish (WDFW unpublished). Recent efforts to document this phenomenon need follow up with further investigations into mechanisms and potential solutions. The Tucannon River has had a very high estimated pHOS (annual average 0.72 from 2007-2015, including all hatchery-origin spawners regardless of basin-of-origin; Bumgarner and Dedloff 2011 and WDFW unpublished data) that exceeds HGMP goals. Annual estimated pHOS has dropped slightly since ending the release of Lyons Ferry stock steelhead in the basin (last adult return was in 2012).

For the periods 2000-2008 and 2009-2013, the average annual number of Lyons Ferry segregated stock smolts released dropped from 111,593 to 42,128 (Appendix D). Although these smolt releases no longer occur in the Tucannon River, this stock still commonly strays from the Lyons Ferry Hatchery or from the Walla Walla and Touchet rivers into the Tucannon River for spawning. Tucannon integrated endemic stock hatchery production was increased when Lyons Ferry stock releases ended. The existing endemic hatchery program should be adaptively managed to ensure that it is contributing to the recovery of Tucannon steelhead. To achieve pHOS goals, adult management techniques including removing hatchery-origin fish at traps and through conservation fisheries targeting hatchery adults could be expanded to remove excess hatchery adults.

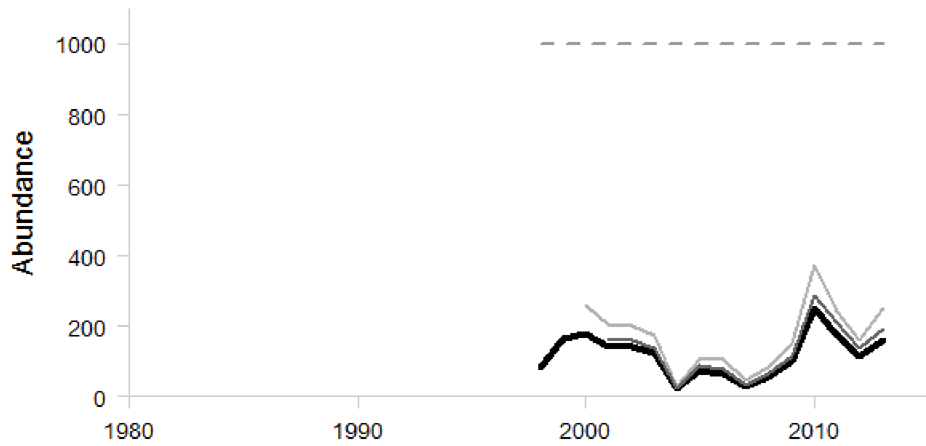

Figure 39. Abundance data for Tucannon River summer-run steelhead from 1998 to 2013. The thick black line represents the total escapement, the thin dark grey line represents the total run size reconstructed using escapement and reported sport and tribal harvest plus sport and commercial harvest bycatch mortality, the thin light grey line represents estimated total run size calculated as escapement plus harvest plus unaccounted-for loss, and the dashed grey line is the recovery goal. The population has increased 27% over the time period with data.

Key threats and actions

We identified two key threats due to hydropower dams and hatcheries for this population (Table 13). Viability of Tucannon steelhead is threatened by complex demographic consequences of adult overshoot behavior within Snake River hydropower system, especially including high stray rates to and from Tucannon River. Inability of Tucannon steelhead to return to natal spawning grounds, and straying onto those spawning grounds by non-Tucannon steelhead unable to return to natal streams threatens abundance, productivity and diversity of Tucannon population. Downstream adult passage at Snake River dams must be improved to provide successful downstream migration of pre-spawning adults after overshooting natal streams. Threats of domestication and loss of productivity result from genetic and ecological interactions between hatchery-origin steelhead (of local and non-local origins) and Tucannon wild-origin steelhead, which are exacerbated by adult overshoot phenomenon. Documented pHOS in Tucannon River exceeds HGMP goals for in-basin and out-of-basin hatchery programs. We recommend that WDFW work with co-managers to implement recommended hatchery reform and fishery management actions that will reduce pHOS, including complete adipose fin-clipping of all hatchery-reared steelhead, and utilize monitoring and adaptive management to reduce risks that become apparent. To summarize:

Key threat:	**Action:**
Snake River dams prevent adequate downstream passage of adults that overshoot natal rivers during initial return migration, resulting in a high proportion of Tucannon steelhead spawning elsewhere, and in non-local steelhead straying into and spawning in Tucannon River, which threaten abundance, productivity and diversity.	Support efforts to improve downstream passage at Snake River dams to allow successful homing after pre-spawning migrations through dams into upstream non-natal areas.

High pHOS in Tucannon River exceeds HGMP goals for in-basin and out-of-basin hatchery programs, and may decrease population fitness and adaptation to natural environment.	Work with co-managers to implement recommended hatchery reform and fishery management actions that will reduce pHOS.

Table 13. Focal population threats and actions.

DPS	Focal Population	Threat Category	Key Threats	Action	Threat reduction goal	Source documents
PS	Elwha	Data deficiency	The lack of adult and juvenile abundance data has prevented status and trend assessment, reducing the ability to implement effective conservation actions.	Continue WDFW's collaboration with federal and tribal partners in obtaining and evaluating smolt and adult abundance data.	Annual adult surveys and juvenile production estimates provide adequate data for managing habitat and hatchery recovery actions	Peters et al. 2014. Guidelines for Monitoring and Adaptively Managing Restoration of Chinook Salmon (*Oncorhynchus tshawytscha*) and Steelhead (*O. mykiss*) on the Elwha River; McMillan et al. 2014. Winter Steelhead (*Oncorhynchus mykiss*) Redd Survey and Steelhead Relocation Summary for Middle Elwha River 2013/2014.
PS	Dungeness	Hatcheries	Current methods for estimating pHOS are ineffective in the Dungeness River under normal conditions.	Develop methods to assess proportion of hatchery fish on spawning grounds that are effective in Dungeness River conditions.	Annual proportions of hatchery-origin natural spawners are estimated	WDFW. 2014. Dungeness River Early Winter Steelhead Hatchery Program HGMP
		Data deficiency	The lack of adult abundance data prevented status and trend assessment, reducing ability to implement effective conservation actions.	Implement annual survey methodology that is effective in the Dungeness River under normal conditions.	Annual surveys produce adequate data for estimating spawner abundance	WFDW's SaSI database; e.g., https://fortress.wa.gov/dfw/score/score/species/population_details.jsp?stockId=6301
PS	South Hood Canal	Marine Survival	Smolt mortality appears to be relatively high around Hood Canal Bridge, and contributes to low overall early marine survival.	Continue collaborating on research to identify causes of low marine survival, including higher mortality around Hood Canal Bridge.	Reduce marine mortality around Hood Canal Bridge so that early marine survival is adequate	Moore et al. 2010. Early marine survival and behavior of steelhead smolts through Hood Canal and the Strait of Juan de Fuca. Work group reports of work group on steelhead mortality around Hood Canal Bridge
		Climate Change	Summer flows are critically low, which likely limit juvenile survival and productivity. Climate change projections predict lower flows and increasing water temperatures.	Determine best approach for tracking high and low flow hydrologic regime, implement flow and temperature monitoring, and pursue instream flow conservation actions.	Baseline flow regime data are established and status can be assessed through time	Long Live The Kings. 2014. Hood Canal Steelhead Recovery Planning Pilot Project Final Report to Puget Sound Partnership.
		Habitat Degradation	Smolt production relative to watershed potential appears low, but data and inference are limited.	Investigate parr production and survival to smolt stage relative to instream habitat conditions over several years to document status, variation, and habitat correlations.	Primary variables that control parr productivity and survival during the research period will be identified	NOAA unpublished smolt abundance estimates; Puget Sound Steelhead Technical Recovery Team. 2015. Viability Criteria report.
PS	Cedar	Habitat Degradation	Very poor smolt survival in the freshwater migration corridor appears to be related to physical changes and environmental conditions in Cedar River and Lake Washington, and prevents recovery of anadromous population.	Develop research project to identify sources and rates of smolt mortality from Landsburg Dam to Shilshole Bay using tagged Green River wild-origin broodstock hatchery smolts	Knowledge of sources of smolt mortality throughout freshwater migration corridor that will inform future recovery actions.	Supporting information in: Marshall et al. 2006. Genetic relationships among anadromous and non-anadromous *Oncorhynchus mykiss* in Cedar River and Lake Washington - implications for steelhead recovery planning.
PS	Stillaguamish	Hatcheries	pHOS is not estimated, and thus risks of genetic and ecological harm from both segregated hatchery programs are unknown.	Implement methods to monitor pHOS from each program and estimate and manage genetic and ecological interactions between hatchery and wild steelhead.	Annual proportions of hatchery-origin natural spawners are estimated	WDFW. 2014. Whitehorse Summer steelhead HGMP; Whitehorse early winter steelhead HGMP
PS	Tolt	Hatcheries	Releases for previous and nearby hatchery programs may still cause genetic and ecological harms, as current evidence suggests naturalization by Skamania early summer steelhead.	Continue genetic studies in North Fork and South Fork Tolt sub-basins on summer-run and winter-run steelhead to verify identity and assess abundance by stock origin.	Knowledge of winter steelhead and hatchery summer steelhead impacts in N.F. and S.F. Tolt, and identity of wild spawners and relative abundance	Campbell et al. 2008. Snohomish Basin Steelhead trout (*Oncorhynchus mykiss*) "State of Knowledge." Report prepared for Snohomish Basin Recovery Technical Team. Pfeifer. 1990. Tolt River summer-run steelhead stock assessment. WDFW unpublished report. WDFW unpublished data.
		Barriers	South Fork Tolt Dam operation has altered flow volume and annual hydrograph. Potential impacts on summer steelhead need to be better understood and mitigated.	Work with City of Seattle through the 2024 FERC relicensing process and subsequent settlement agreement negotiations to mitigate any dam operation impacts.	Seasonal flow conditions are modified as needed to mitigate impacts on summer steelhead and promote population recovery	Campbell et al. 2008. Snohomish Basin Steelhead trout (*Oncorhynchus mykiss*) "State of Knowledge." Report prepared for Snohomish Basin Recovery Technical Team. Pfeifer. 1990. Tolt River summer-run steelhead stock assessment. WDFW unpublished report.

DPS	Focal Population	Threat Category	Key Threats	Action	Threat reduction goal	Source documents
PS	Green	Dams	The 41% loss of historical habitat due to Howard Hanson Dam and its lack of fish passage reduce abundance and productivity, impairing population recovery.	Continue to prioritize work with NOAA, Tacoma Public Utilities and USACE to ensure development and construction of effective downstream fish passage at upper watershed dams.	Ensure adequate survival of downstream migrants past upper watershed dams	Puget Sound Steelhead Technical Recovery Team. 2015. Viability Criteria report.
		Barriers	Culverts, road crossings, and channel dikes or levees occur throughout lower basin and reduce habitat available for spawning and juvenile rearing.	Prioritize and implement culvert blockage removals for passage restoration in Soos and Newaukum creeks.	A prioritized culvert removal list is developed and salmon recovery partners implement removal projects in both Soos & Newaukum creeks by 2020	WDFW culvert removal prioritization planning process
		Hatcheries	pHOS is not estimated, and thus risks of genetic and ecological harm from hatchery programs are unknown, and the need for a conservation hatchery program is unknown.	Develop and implement method to estimate and manage pHOS, and determine whether native stock smolt production is spawner-limited.	Annual proportions of hatchery-origin natural spawners are estimated	WDFW. 2014. Soos Summer steelhead HGMP; Soos early winter steelhead HGMP; Green River native winter steelhead HGMP
		Disease/parasites	Green River steelhead, especially those from Soos Creek, have high infection rates from the parasite Nanophyetus salmincola, and infection levels have been hypothesized to impact marine survival.	Investigate whether intensity of *N. salmincola* infection is a causal component of poor marine survival.	Understand effects of *N. salmincola* and mitigate for them if necessary	NWIFC unpublished data and report by Martin Chen, WDFW
PS	Puyallup/Carbon	Habitat Degradation	High percentage of habitat degradation in lower river reduces abundance and productivity.	Promote habitat protection & restoration in South Prairie Creek and other tributary or mainstem areas.	Habitat features that promote spawner use and success, and that control juvenile productivity and survival in the lower river will be protected or restored.	Supporting information in: Northwest Indian Fisheries Commission. 2012. State of Our Watersheds Report, Puyallup Tribe of Indians Chapter-Puyallup River Basin.
		Dams	Passage has been established at the diversion dam for Electron Dam, but current downstream migration problems remain unresolved.	Continue to prioritize work with Electron Hydro LLC and Puyallup Tribe to ensure effective fish passage and downstream survival at Electron Dam and diversion dam.	Sufficient passage at the dam is demonstrated	Mudd, D.R., and C.S. Leigh. 2008. Electron Project Downstream Fish Passage. WDFW Final Report to Washington State Legislature.
PS	Nisqually	Marine Survival	Long Puget Sound migration distance appears to expose smolts to high mortality risks, resulting in relatively low early marine survival.	Continue work on Nisqually steelhead smolt marine survival studies.	Determine primary sources of Puget Sound smolt mortality and mitigate for them as much as possible	Nisqually River Steelhead Recovery Plan- Draft 2014. Nisqually Steelhead Recovery Team. Prepared for the Nisqually Indian Tribe, Olympia, WA. Puget Sound steelhead early marine survival working group reports.
		Disease/parasites	Nisqually steelhead smolts have high infection rates from the parasite *N. salmincola*. High infection levels have been hypothesized to impact marine survival.	Investigate whether intensity of *N. salmincola* infection is a causal component of poor marine survival.	Understand effects of *N. salmincola* and mitigate for them if necessary	NWIFC unpublished data and report by Martin Chen, WDFW
		Habitat Degradation	Degraded riparian areas exist watershed-wide due to a wide variety of land uses, likely reducing survival of adults and juveniles.	Support efforts to restore riparian native plant communities, improve wood recruitment, provide for stream shading, and reduce sediment transport.	Former Mock City site on JBLM-Whitewater reach is revegetated and watershed-wide riparian invasive plant control program is implemented	Nisqually River Steelhead Recovery Plan- Draft 2014. Nisqually Steelhead Recovery Team. Prepared for the Nisqually Indian Tribe, Olympia, WA.
		Habitat Degradation	Nisqually-Mashel State Park development on Mashel River may degrade riparian and in-stream habitat, potentially reducing survival of adults and juveniles.	Ensure management plan for the Nisqually-Mashel State Park will provide protection and opportunities for restoration of riparian, in-stream, and floodplain conditions.	Reduce threats by this development	Nisqually River Steelhead Recovery Plan- Draft 2014. Nisqually Steelhead Recovery Team. Prepared for the Nisqually Indian Tribe, Olympia, WA.
		Habitat Degradation	Potential redd dewatering below Tacoma Power dam due to flow regulations during steelhead spawning season.	Gather data to inform redd dewatering and if it is documented, and determined necessary, work with Tacoma Power to provide consistent flow during steelhead spawning.	Increase egg-to-fry survival in area below Tacoma Power dam	Peggy Miller, WDFW, pers. comm.
		Habitat Degradation	Timber harvesting may result in mass wasting, excessive sediment delivery, and reduced riparian functioning, all of which can reduce habitat and juvenile survival.	Support efforts to develop Nisqually/ Mashel Community Forestry initiative to address riparian buffers, road networks, and upland timber harvest.	Sediment delivery from forestry roads and harvested areas is minimized, and riparian buffers are protected or expanded.	Nisqually River Steelhead Recovery Plan- Draft 2014. Nisqually Steelhead Recovery Team. Prepared for the Nisqually Indian Tribe, Olympia, WA.
		Dams	Centralia Diversion Dam may reduce juvenile survival due to impingement on fish screens or entrainment into diversion canal.	Support efforts to evaluate effectiveness of Centralia Diversion Dam fish screens to determine if juveniles experience impingement or entrainment during summer, and survival level of fish encountering screen bypass system.	Knowledge of fish screen effectiveness that enables any improvements to be implemented.	Nisqually River Steelhead Recovery Plan- Draft 2014. Nisqually Steelhead Recovery Team. Prepared for the Nisqually Indian Tribe, Olympia, WA.

Table 13 continued.

DPS	Focal Population	Threat Category	Key Threats	Action	Threat reduction goal	Source documents
LC	Upper Cowlitz/Cispus	Dams (hydropower)	Ineffective juvenile collection facilities associated with dam infrastructure result in low survival of emigrants.	Continue to support efforts of NOAA and dam operators to improve juvenile collection efficiencies at Cowlitz Falls Dam from current rates (usually <50%) to between 75% and 95%.	Dam operational licenses require 75% minimum juvenile downstream passage survival with a target of 95%	Cowlitz River Projects FERC License (no. 2016) Amended (July 2004)
		Hatcheries	Upper Cowlitz/Cispus and Tilton integrated programs require adequate monitoring to reduce risks of genetic and ecological harms, and differential juvenile marking and adult transportation to prevent mixing of the populations.	Manage hatchery programs according to HSRG recommendations and maintain stock-specific marking for outmigrating and trapped juveniles and correctly identify and transport wild-born returning adults to their natal rivers.	Mixing of Tilton- and Upper Cowlitz/Cispus-origin steelhead will be highly unlikely.	WDFW. 2015. Hatchery and Genetic Management Plan for the Cowlitz River Winter-late Steelhead Program.
LC	NF Lewis winter-run	Dams (hydropower)	Ineffective juvenile collection facilities at Swift Dam result in low survival of emigrants.	Continue to work with PacifiCorp and regulatory agencies to refine collection and passage systems to ensure passage targets are met for smolts.	Collection efficiency at Swift Dam juvenile capture facility is improved so that capture rate goal of >75% is met.	Lewis River Projects FERC Licenses June 2008; 2004 multi-party Settlement Agreement
		Hatcheries	Population mixing is a threat posed by misidentification of wild winter-run steelhead trapped at Merwin Dam for North Fork Lewis reintroduction hatchery program broodstock.	Adequately capture, manage, and correctly identify broodstock adults to meet integrated hatchery program goals and achieve HSRG standards.	Wild broodstock collection numbers will remain below the 30% of natural population threshold, and genetic analysis will achieve required accuracy and precision.	WDFW. 2015. Hatchery and Genetic Management Plan for the Lewis River Winter-late (endemic) Steelhead Program.
MC	Upper Yakima	Dams	Flow manipulation, due to water storage and irrigation diversion dams and their seasonal pattern of water extraction and delivery, is associated with low smolt survival.	Continue to work with regulatory agencies to support restoration of historically natural flow conditions throughout Upper Yakima basin and the lower mainstem.	Smolt survival meets recovery goals; survival standard should meet or exceed goals for FCRPS projects.	Courter et al. 2015. Evaluation of stream flow effects on smolt survival in Yakima River Basin, WA. Yakima Basin Fish and Wildlife Recovery Board. 2009. Yakima Steelhead Recovery Plan
		Barriers	Water storage dams, irrigation diversions and other barriers block passage and limit population recovery; direct mortality is associated with diversions and their screening. Specifically, need to reduce hydropower diversions at Roza and Chandler dams.	Work with recovery partners to ensure that effective adult and juvenile passage is restored to historical habitat, and that all diversions are screened.	Provide access to all potential steelhead tributaries and eliminate diversion-related mortality.	Yakima Basin Fish and Wildlife Recovery Board. 2009. Yakima Steelhead Recovery Plan
UC	Methow	Hatcheries	High pHOS from several hatchery programs may decrease population fitness and adaptation to natural environment.	Work with co-managers to implement recommended hatchery reform and fishery management actions to reduce pHOS, including complete adipose fin-clipping of all hatchery steelhead and reducing wild broodstock program sizes.	Achieve pPHOS levels in Methow sub-basins as specified in HGMP	WDFW. 2011. Wells Hatchery Complex summer steelhead program HGMP.
		Dams (hydropower)	Cumulative mortality at nine Columbia River dams limits overall juvenile survival and impedes recovery.	Maintain juvenile PIT tagging and develop PIT-tag based survival models, and continue to advocate for and support efforts to achieve population viability survival standards at all mainstem dams.	Achieve a total juvenile survival rate to downstream of Bonneville Dam that ensures long-term population viability.	Upper Columbia Salmon Recovery Board. 2007. Upper Columbia Salmon and Steelhead Recovery Plan.

Table 13 continued.

DPS	Focal Population	Threat Category	Key Threats	Action	Threat reduction goal	Source documents
UC	Okanogan	Habitat Degradation	Decreased water quantity and altered flow timing in Salmon Creek due to irrigation diversions and Conconully Dam reduce or prevent spawner use and limit juvenile rearing.	Support efforts to develop better water management to adequately support fish needs, such as year-round flow improvements to increase over-winter survival and production in lower three miles of Salmon Creek.	Water quantity and quality are improved such that successful spawning and rearing occur in affected areas.	Upper Columbia Regional Technical Team. 2014. A biological Strategy to protect and restore salmonid habitat in the Upper Columbia Region. Draft report to Upper Columbia Salmon Recovery Board
		Dams	Lack of access upstream of Enloe Dam into a very large area of potential historical habitat limits steelhead production.	Continue to engage in ongoing Enloe Dam removal discussions, advocate for removal, and provide technical assistance as needed.	Decision on Enloe Dam removal benefited from WDFW's participation	Upper Columbia Regional Technical Team. 2014. A biological Strategy to protect and restore salmonid habitat in the Upper Columbia Region. Peven, C. 1993. unpublished report
		Dams (hydropower)	Okanogan Lake Dam eliminates access to over 15 tributaries that would support steelhead spawning and rearing.	Work with B.C. Ministry of Fisheries and Canadian Dept. of Fisheries and Oceans to develop passage at dam.	Lack of passage at Okanogan Lake Dam is resolved.	
		Hatcheries	High pHOS may decrease population fitness and adaptation to natural environment.	Continue to work with co-managers to optimize conservation hatchery programs for recovery.	Achieve pPHOS levels in Okanogan as specified in HGMPs.	
SRB	Tucannon	Dams (hydropower)	Snake River dams prevent adequate downstream passage of adults that overshoot natal rivers during initial return migration, resulting in a high proportion of Tucannon steelhead spawning elsewhere, and in non-local steelhead straying into and spawning in Tucannon River, which threaten abundance, productivity and diversity.	Support efforts to improve downstream passage at Snake River dams to allow successful homing after pre-spawning migrations through dams into upstream non-natal areas.	Tucannon-origin steelhead successfully return from upper Snake River areas to Tucannon spawning grounds	Bumgarner and Dedloff. 2011. Lyons Ferry complex hatchery evaluation: summer steelhead annual report 2008 and 2009 run year. WDFW unpublished report, Olympia, WA.; Keefer et al. 2014. Tucannon River steelhead radio-tagged adult at Lower Granite Dam. Letter Report to Walla Walla District USACE.
		Hatcheries	High pHOS in Tucannon River exceeds HGMP goals for in-basin and out-of-basin hatchery programs, and may decrease population fitness and adaptation to natural environment.	Work with co-managers to implement recommended hatchery reform and fishery management actions that will reduce pHOS.	pHOS and diversity goals are achieved.	Bumgarner and Dedloff. 2011. Lyons Ferry complex hatchery evaluation: summer steelhead annual report 2008 and 2009 run year. WDFW unpublished report, Olympia, WA.; WDFW. 2011. Tucannon River Endemic Steelhead Stock HGMP.

Chapter 6 Management progress, data gaps, and monitoring needs

In this chapter we:

- describe progress in implementing management recommendations since 2008,
- identify monitoring needs to address current data gaps, and
- recommend specific monitoring improvements

In their 2008 assessment, Scott and Gill provided a variety of recommendations aimed at improving steelhead status and management practices in Washington. We evaluated progress towards implementing these recommendations (Appendix F). In this document we have described steelhead data availability, viability status, and threats statewide based on information from monitoring programs or activities. Without such monitoring, it is impossible to know if recovery objectives are being met, if status is improving or worsening, or if risks are being effectively managed. In prior chapters we pointed out where abundance, productivity, spatial structure and diversity data were missing and where monitoring improvements are needed.

Steelhead populations that are ESA-listed or subjected to direct harvest should be monitored for all VSP parameters. At the very least they should be monitored for abundance. Even if monitoring is occurring, incomplete or inaccurate data can hinder effective management, thus population monitoring programs may need improvements. We recommend strategies for data collection that can meet challenges posed by the species' biological and life-history characteristics, and encourage managers to implement them, pursuing adequate funding as needed.

6.1 Progress on recommendations since 2008

This report serves as a partial update to the assessment of steelhead populations and programs completed by Scott and Gill (eds.) in 2008 (http://wdfw.wa.gov/publications/00150), which served as a scientific foundation for the SSMP. Based on their review and assessment of similar risk factors, they made a number of recommendations related to habitat, hatcheries, fishery management and VSP parameters that WDFW could take to improve long-term viability and productivity of Washington steelhead. We compiled those recommendations and identified relevant actions taken since 2008 to address them (Appendix F). Substantial progress has been made on many of the recommendations but not all are complete (Appendix F). Many of the recommendations made in this report can serve as updates to those made in 2008.

6.2 Data gaps and monitoring needs

Assessments of population status and viability often were challenged by a lack of data on historical and contemporary population characteristics. Although we performed an extensive search for data to use in this report, additional data may exist but were not included because they were not compiled or available in a centralized location. The lack of robust monitoring data was one of the most ubiquitous impediments to conducting the wild steelhead status assessments statewide, and therefore poses a risk of harm to populations because of the high uncertainty of management action effectiveness.

Inadequate population monitoring and a resulting dearth of abundance, productivity and diversity data were pervasive problems for populations in western Washington. Monitoring of Columbia Basin summer-run populations has improved in the past decade, but in other areas little or no monitoring exists for many summer-run populations. In western Washington, smolt monitoring is much less common than adult monitoring, resulting in few data on freshwater productivity or marine survival, particularly for large populations. Most winter-run steelhead adult abundance data available were based on redd survey methods that were not well-documented, did not test assumptions required to ensure statistical validity, and did not include estimation of accuracy and precision. We need to gain knowledge of the uncertainty of these redd-based estimates by improving our adult monitoring methods.

Quantitative analyses are also needed to measure freshwater carrying capacity and population productivity, and the role of density dependence in population dynamics under current habitat conditions. It is important to note that in many areas of the interior Columbia River basin, in particular, there have recently been significant improvements in access to tributaries, instream flow, and habitat. There may be a lag time for spawners and juveniles to find and utilize improved habitat.

Data gaps in harvest monitoring include few or no current wild steelhead release mortality estimates for sport fisheries and net drop-out mortality estimates for tribal fisheries, and a lack of uncertainty estimates for wild steelhead mortality in other fisheries. The catch record card system used to estimate harvest of hatchery steelhead currently does not provide any information on harvest or release mortality of wild steelhead. As a result, sport fishery impacts on wild steelhead populations are estimated through creel surveys involving statistical expansion of angling effort counts and catch-per-unit-effort obtained from angler interviews. However, creel surveys are not conducted annually, or in all areas, and may be cost-prohibitive to expand in coverage. Therefore sport fishery impacts must be estimated through modeled encounter rates (e.g., number of steelhead handled) and release mortality rates established as part of management agreements. However, such modeling is not available for most populations and we are unable to estimate mortality from most sport fisheries.

Efforts to modify the catch record card system to accommodate unbiased estimates of release mortality for wild steelhead would greatly reduce survey costs and increase spatial and temporal coverage of wild steelhead sport fishery impacts. Methods used to estimate treaty harvest and non-retention mortality are not well-documented and do not currently contain estimates of uncertainty. This is a problem particularly in areas where harvest rates are relatively high (e.g., Olympic Peninsula, Grays Harbor, upstream of Bonneville Dam on the Columbia River). Work with tribal co-managers is needed to document methods used to estimate treaty harvest, to test assumptions related to estimations, and to report estimates of uncertainty.

A major data gap is the current poor ability to estimate gene flow or pHOS resulting from hatchery steelhead spawning in the wild. Redd surveys, which are currently used to monitor most winter-run steelhead populations, cannot provide identification of hatchery- and natural-origin spawners. Therefore, assessments of gene flow resulting from segregated hatchery steelhead spawning in the wild environment must rely on genetic analysis of juveniles or limited adult tissue collections (e.g., genetic stock identification; Warheit 2014). Gene flow assessment problems are substantially exacerbated for integrated programs where hatchery and wild fish are essentially genetically identical. Relative proportions of integrated hatchery and wild steelhead can only be assessed through visual identification of mass marked and unmarked adults on the spawning grounds, which is often difficult due to survey conditions during spawning, or through genetic parentage data collection, which typically requires dams or other sampling locations that enable capture of large proportions of adults. Thus, for most western Washington populations no methods currently exist with which to obtain the hatchery monitoring data required to ensure that integrated programs are being managed consistent with the Fishery and Hatchery Reform Policy (Hatchery Scientific Review Group (HSRG) 2009) and program-specific HGMPs.

Generally, all hatchery programs, whether they are intended to facilitate recovery or provide harvest, need to be monitored such that measureable goals can be assessed with sufficient accuracy and precision. Ideally, requisite monitoring and funding plans are built into hatchery operations, and hatchery programs without sufficient monitoring would not be operated. At a minimum, all programs should be monitored to ensure they are meeting HSRG targets for pHOS and SSMP targets for gene flow. Because integrated programs are unable to provide conservation benefits, even theoretically, to populations that are not spawner-limited (e.g., wild spawner abundance routinely is able to fully seed freshwater habitat), we must determine whether freshwater production (smolt abundance) is currently spawner-limited in wild populations for which conservation hatchery programs exist.

6.2.1 Habitat restoration effectiveness monitoring

To recover ESA-listed steelhead populations, many millions of dollars are spent each year on freshwater habitat restoration. These actions can be assessed for their effectiveness through estimating freshwater productivity (i.e., the number of smolt recruits per spawner) and capacity for juvenile steelhead at all WDFW "Fish in/Fish out" monitoring locations (cite Example Reports) and, in more detail, in intensively monitored watersheds (Bennett et al. 2016), and through project-scale action effectiveness monitoring (Roni et al. 2013). Studies that link fish response to habitat alteration are essential, especially if they allow for further investigation of the synergistic interactions of habitat manipulation and hatchery programs. These recovery tools are often considered in isolation, but should be evaluated together.

6.2.2 Key findings

Steelhead populations in western Washington are generally less rigorously monitored than those in the central and eastern part of the state. This is due to many factors, but a combination of improved monitoring technology and the declining status of many populations have resulted in expanded monitoring in the Columbia River basin. It is critically important that ESA-listed populations statewide be monitored sufficiently to detect progress towards delisting.

In Puget Sound, Southwest Washington, and Olympic Peninsula DPSs, population-scale monitoring is mostly limited to redd count methods with unknown accuracy and no estimates of precision. Other VSP parameters often are not measured and virtually no data collection on an annual basis occurs for summer-run populations. Given recent declines in abundance in all of these DPSs and the ESA-threatened status of Puget Sound steelhead, robust monitoring programs are needed for successful conservation and management.

Based on information in Crawford and Rumsey (2011), Rawding and Rodgers (2013), and this report, the current statewide steelhead monitoring program in Washington needs to be updated. There are opportunities to improve current WDFW monitoring activities to meet management needs, especially in the areas of VSP parameters, hatchery impacts monitoring, and some effectiveness monitoring. This can be done through clarifications of management priorities, improvement of study designs, and increased financial resources. Standardization of data collections methods will ultimately lead to more cost effective, accurate, and precise estimates and allow for efficient large-scale analyses, as presented in this report. The opportunity to improve the statewide steelhead monitoring will require agency priority and additional resources.

Throughout this document we have highlighted general and specific monitoring needs that are relevant at statewide, DPS, or population spatial scales. Establishing and implementing monitoring methods that will improve accuracy and precision of monitoring data and future evaluation of population status should be prioritized. Specific monitoring needs that relate to threats or VSP parameters should be prioritized regionally depending on the availability of funding, shifting priorities, and logistical concerns.

6.2.3 Specific monitoring recommendations

1) Initiate monitoring of wild summer-run steelhead and additional populations in the Puget Sound and Olympic Peninsula DPSs.
2) Initiate robust (demonstrable accuracy and quantifiable precision) population-scale monitoring, including adult and juvenile abundance and age composition, for one or more moderate- to large-sized populations in Puget Sound, Olympic Peninsula, and SW Washington DPSs.
3) Develop and initiate genetic methods to monitor gene flow between hatchery and wild populations as required by HGMPs for segregated steelhead programs. For integrated steelhead programs, for which genetic stock identification of hatchery and wild individuals is not possible, develop parentage-based or field methods for quantifying reproductive interactions between wild and hatchery steelhead.
4) Develop robust redd monitoring designs including representative sampling, estimates of females per redd, observer efficiency and redd life, and methods to account for uncertainty in redd-based estimates.
5) Develop methods to estimate wild steelhead released by sport fisheries and incorporate uncertainty in CRC-based harvest estimates.
6) Evaluate the effectiveness of recently-created steelhead gene bank populations in achieving their goals.
7) Continue to monitor the ecological impacts of hatchery steelhead on wild population abundance and productivity. For example, in basins where WDFW operates smolt traps downstream of hatchery releases, provide an estimate of the number of hatchery fish that residualize.
8) Evaluate multi-species juvenile migrant trap sites to determine methods to increase steelhead smolt catch.
9) Expand network of life-cycle monitoring sites to measure population-scale smolt abundance, adult to smolt ratio, and smolt to adult (marine survival) in Olympic Peninsula DPS.

6.2.4 General monitoring recommendations

1) Use previous reviews of monitoring data quality (e.g., Crawford and Rumsey 2011; Rawding and Rodgers 2013), and conduct new data quality assessments where none

exist, to develop 1) agency priorities for wild steelhead monitoring to address key management questions and uncertainties, and 2) a scientific review process to ensure monitoring programs will meet goals for accuracy and precision within a specified timeline.

2) Align wild steelhead monitoring with agency priorities across VSP parameters, hatchery and harvest impacts, and habitat restoration effectiveness monitoring.
3) Explicitly integrate ongoing hatchery effectiveness, genetic impact, and relative reproductive success studies into recovery and habitat restoration planning and evaluation.
4) Assess and modify statewide steelhead monitoring programs to ensure standardized production of unbiased estimates with an acceptable level of precision for VSP parameters, hatchery and harvest impacts, and effectiveness monitoring.
5) Expand investigations into monitoring effectiveness, including evaluating the bias, accuracy, and precision of standard protocols, such as winter-run steelhead redd surveys.
6) Develop open, transparent, and publically-available standardized steelhead monitoring designs for each population (e.g., MonitoringMethods.org).
7) Develop standardized statewide databases for storing raw and summarized data to facilitate analysis, management decisions, and reporting.
8) Improve public sharing of steelhead information and reports on WDFW website.

6.3 Data management and reporting

Monitoring of steelhead VSP parameters, fishery and hatchery impacts, and habitat restoration effectiveness indicators provides little value unless the data collected can be efficiently stored, managed, queried, analyzed, reported, and made available to managers and others. WDFW databases that manage statewide monitoring data (e.g., JMX, the juvenile migrant exchange database for juvenile salmonid counts) and report such data (e.g., SCoRE) are undergoing further improvements. The juvenile monitoring database (JMX) accommodates a wide range of data types and its use should greatly improve the standardized collection and reporting of juvenile steelhead data. However, this database does not include an efficient data entry platform and data entry is particularly problematic for projects involving PIT tagging that are common in Columbia River Basin. Additionally, JMX does not accommodate analysis and querying from statistical packages such as R.

WDFW has developed an adult salmonid database (“Traps, Weirs and Surveys”, TWS) that can accommodate a wide variety of adult data, including spawning ground survey data as well as data from weirs, dams and fish traps. It is cross-compatible with existing WDFW data archives (e.g., Age and Scales, SGS databases), however statewide use of TWS database has not occurred and incorporation of PIT tag data is still lacking. No statewide database exists to store and report harvest information for steelhead populations. Harvest data for this report were collected from disparate sources that were inconsistent in format, and often poorly documented. Spatial distribution data for adult and juvenile steelhead currently are stored in inconsistent and poorly documented formats on SalmonScape, which limits their usefulness and reliability.

Rawding et al. (2012) stated that steelhead data management has not been able to keep up with the increase in monitoring and reporting requirements. They recommended standardization of data definitions, study designs, data quality assurance, data entry, and corporate databases along with improved mechanisms to report indicator data to managers and others. Although there has been progress since this 2012 report, there are more opportunities to improve standardization and reporting.

7.3.1 Specific data management recommendations

1) Expand and develop data entry and data analysis capabilities of JMX (juvenile monitoring database).
2) Work towards statewide adoption of the use of the TWS database for entry and storage of adult data and develop PIT tag compatibility.
3) Develop a standardized harvest reporting database where steelhead exploitation rates and supporting metadata would be entered and stored.
4) Initiate efforts to standardize statewide steelhead spatial distribution information.

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Appendix A

Adult abundance data used for analyses. Nearly all data were available in and accessed from SaSI in 2015. Abbreviations for population names in the data table are as follows:

DPS	Population Name	Abbreviation
Puget Sound	Cedar River winter-run	Cedar
	East Hood Canal winter-run	EHoodCn
	Green River winter-run	Green
	Nisqually winter-run	Nisqually
	Nooksack winter-run	Nooksack
	Pilchuck winter-run	Pilchuck
	Puyallup/Carbon winter-run	Puy/Carb
	Samish & Bellingham Bay tributaries winter-run	Samish
	Sequim & Discovery Bays Tributaries winter-run	Seq/Disc
	Skagit River Summer and winter-run	Skagit SW
	Skokomish winter-run	Skokom
	Snohomish/Skykomish winter-run	Snoh/Sky
	Snoqualmie winter-run	Snoqual
	South Hood Canal winter-run	SHoodCn
	Stillaguamish winter-run	Stillagua
	Strait of Juan de Fuca Independent Tributaries winter-run	Strait JdF
	Tolt summer-run	Tolt S
	West Hood Canal winter-run	WHoodCn
	White River (Puyallup) winter-run	White
Olympic Peninsula	Calawah winter-run	Calawah
	Clallam winter-run	Clallam
	Clearwater winter-run	Clearwtr
	Dickey winter-run	Dickey
	Goodman Creek winter-run	Goodmn
	Hoh winter-run	Hoh
	Hoko winter-run	Hoko
	Lower Quinault winter-run	Lo. Quin
	Moclips winter-run	Moclips
	Pysht/Independents winter-run	Pysht
	Queets winter-run	Queets
	Quillayute/Bogachiel winter-run	Quill/Bog
	Salt Creek/Independents winter-run	Salt/Inde
	Sol Duc winter-run	Sol Duc
	Upper Quinault winter-run	Up. Quin
South-west WA	Bear River winter-run	Bear
	Chehalis winter-run	Chehalis
	Grays winter-run	Grays
	Hoquiam winter-run	Hoquiam
	Humptulips winter-run	Humptul

DPS	Population Name	Abbreviation
South-west WA	Mill/Abernathy/Germany Creeks winter-run	M/Ab/Gr
	Naselle winter-run	Naselle
	Nemah winter-run	Nemah
	North River/Smith Creek winter-run	North/Sm
	Palix winter-run	Palix
	Satsop winter-run	Satsop
	Elochoman/Skamokawa winter-run	Elo/Skam
	Skookumchuck/Newaukum winter-run	Sko/New
	Willapa winter-run	Willapa
	Wishkah winter-run	Wishkah
	Wynoochee winter-run	Wynooch
Lower Columbia	Coweeman winter-run	Coweem
	East Fork Lewis summer-run	EFLewis S
	East Fork Lewis winter-run	EF Lewis
	Kalama summer-run	Kalama S
	Kalama winter-run	Kalama
	North Fork Toutle winter-run--Series 1	NFToutle1
	North Fork Toutle winter-run--Series 2	NFToutle2
	South Fork Toutle winter-run	SF Toutle
	Tilton winter-run	Tilton
	Upper Cowlitz and Cispus winter-run	UCow/Cis
	Upper Gorge winter-run	UpGorge
	Washougal summer-run	Washou S
	Washougal winter-run	Washou
	Wind River summer-run	Wind S
Middle Columbia	Naches summer-run	Naches S
	Satus Creek summer-run	Satus S
	Toppenish Creek summer-run	Toppen S
	Touchet summer-run	Touche S
	Upper Yakima summer-run	Up Yak S
	Walla Walla summer-run	Walla S
Upper Columbia	Entiat summer-run	Entiat S
	Methow summer-run	Metho S
	Okanogan summer-run	Okanog S
	Wenatchee summer-run	Wenatc S
Snake River Basin	Asotin Creek summer-run	Asotin S
	Joseph Creek summer-run	Joseph S
	Tucannon summer-run	Tucann S

Appendix A continued.

	Puget Sound DPS													
Year	**Cedar**	**EHoodCn**	**Green**	**Nisqually**	**Nooksack**	**Pilchuck**	**Puy/Carb**	**Samish**	**Seq/Disc**	**Skagit SW**	**Skokom**	**Snoh/Sky**	**Snoqual**	**SHoodCn**
1980			1566	1972				80	120	5288				
1981		12	1083	1782		490		142	128	4308		1297	1167	94
1982		34	2121	3807		657			109	9609	822	2242	1261	86
1983		22	1526	2705		779	1892		52	7732	659	1843	2536	44
1984	636	86	2188	1304		930	1219		131	8963	777	3197	2305	172
1985	224	102	2286	1599		1706	1432	1052	154	8603	968	3082	1748	185
1986	900	32	2778	1620		1644	2880		61	11098	866	4076	2070	142
1987	456	3	1685	2022		1416	1603	836	72	8305	546	3628	2420	119
1988	588	23	2378	1916		1424	1634	606	71	13194	742	4710	1610	102
1989	306	22	1916	3817		1650	1930	244	29	11854	1444	3618	1810	142
1990	406		1484	1853		1124	1242	106	12	10017	370	2896	1478	164
1991	394		944	642		968	1130		34	5818	729	3136	1832	122
1992	554		1868	2618		1582	1280		51	7514	172	4760	2246	73
1993	144	40	1702	993			1022		30	6900				75
1994	64	18	1782	804		1308	1124	941	41	6412	473	4014	1848	77
1995	126	22	2198	987		1588	1509	918	45	7656	398	4130	2004	78
1996	232	39	2500				828	797	139					92
1997	616	11	1882	882			992		73					144
1998	576	28	2284	700		1558	763	586	64	7448	373	4132	2004	126
1999	216	15	2480	530		1270	1076	617	55	7870	311	2937	2164	340
2000	48	23	1694	411		590	651	676	166	3780	261	1558	674	191
2001	42	19	1402	240		462	477	908	58	4584	286	1265	1395	133
2002	38	30	1068	353		279	326	859	28	5394	156	1166	789	97
2003	20	18	1615	350		696	287	915	90	6818	132	1915	988	53
2004	44	39	2359	730	1582	1522	501	930	40	7332	233	3404	1506	168
2005	22	23	1298	190		604	162	597	15	6382		2850	1060	91
2006	32	53	1955	722		580	462	791	22	6757	231	3038	1856	183
2007	8	28	1452	303		976	509	494	34	4242	359			175
2008	4	49	833	515		646	401	432	8	4887	285			144
2009	0	15	304	232		344	241	434	16	2502	502			53
2010	2	13	423	691	1897	294	472	697	10	3981	322	732	662	68
2011	4	92	855	297	1774	552	329	1028	34	5462	423	1150	664	47
2012	0	55	392	265	1747	848	233	524	21	6185	500	876	792	78
2013	8	203	656	699	1901	1036	447	916	50	8727	1028	1008	614	68

Appendix A continued.

	Puget Sound DPS					Olympic Peninsula DPS								
Year	**Stillagua**	**Strait JdF**	**Tolt S**	**WHoodCn**	**White**	**Calawah**	**Clallam**	**Clearwtr**	**Dickey**	**Goodmn**	**Hoh**	**Hoko**	**Lo. Quin**	**Moclips**
1980					263	989			312		2660		3646	
1981					234	2384			429		2224		3592	
1982					263	2913		2508	1607		3984		2972	
1983					349	2521		1758	568		4593		1716	
1984		139			1019	3220		1638	430		3670		3052	
1985	1542	145	140		1039	2191		2262	405		3228	802	2162	
1986	2226	105	84		887	3480		1816	719		3000	726	2354	
1987	1892	118	88		727	2994		2203	332		2908	792	1764	
1988	1222	138			1762	4526		2363	179		2906	913	3002	130
1989	1718	60	60		1424	3556		2178	606		2808	699	2910	250
1990		78			708	2573		1735	554		2390	770	2682	244
1991	950	91	45		768	2046		1807	419		2783	861	1745	200
1992		100	108		1033	1957		2662	310		2061	394	2192	492
1993	1178		202		574	1945		2299	285		2053	425	1557	328
1994	1118		161		507	1458		1405	143		2239	453	1755	388
1995	1556	128	151		637	3375		1414	377	221	2204	792	1352	268
1996	1094	89	170		540	5558		847	580	188	2304	667	1282	250
1997		183	213	54	396	3607		1070	591	203	3008	397	1903	560
1998	1185	102	366	24	440	5124		1699	871	316	3689	756	1091	136
1999	917	81	214	50	626	5210	199	1018	854	328	3095	990	734	298
2000	463	162	185	55	598	5411	284	1582	624	330	3162	770	1136	352
2001	630	99	167	16	570	4413	224	1368	483	209	2767	365	956	
2002	354	71	115	246	614	3990	230	1385	742	272	2811	787	684	
2003	660	84	198	142	309	2850	175	1261	347	264	1616	497	462	
2004	740	121	34	243	338	3773	178	2966	418	374	2268	747	859	
2005	462		68	133	238	2602	162	2327	405	142	1480	499	867	
2006	676	124	114	91	299	3371	177	1665	385		3547	408	1036	
2007		118	50	185	300	3144	110	1762	214	45	3026	390	1050	
2008	306		52	191	230	2911	79	2270	443	164	2419	321	1487	
2009	120	24	86	83	186	1875	45	2054	172	83	2256	193	932	
2010	372	52	116	63	609	2618	105	1879	490		2234	634	1347	
2011	362		68	164	593	3705	213	2273	587		3499	583	1320	
2012	340		122	124	593	2875	159	1500	380		3221	452	1167	
2013	514		126	93	610	2199	155	1733	251		2302	559	922	

Appendix A continued.

	Olympic Peninsula DPS						Southwest Washington DPS							
Year	**Pysht**	**Queets**	**Quill/Bog**	**Salt/Inde**	**Sol Duc**	**Up. Quin**	**Bear**	**Chehalis**	**Grays**	**Hoquiam**	**Humptul**	**M/Ab/Gr**	**Naselle**	**Nemah**
1980		4771	1228		3477	1294					2854			
1981		4170	1587		4170	1192					1967			
1982		3824	2428		4712	1070					4400			
1983		2864	2163		3509	772					2248			
1984		2248	2892		4127	2722		3084		766	4074			
1985	565	2978	1576		2504	1218		2818		730	4048			
1986		3186	2501		4046	2644		3322		862	4470			
1987		3323	2569		4105	1227		3682		814	3666			
1988		2981	3381		4099	1264		2264		525	3410			
1989		3142	4553		5333	1430		2392	441	675	2754			
1990		2973	1680		3289	1832		2596	525	583	3100			
1991		3387	1642		3551	1719		1694	716	822	2604			
1992		4421	973		2295	1192		1896	1224	531	2524			
1993		4578	1329		2711	1156		1762	1086	580	2048	304	974	572
1994		4678	1491		4191	1299		1970	704	469	1390	166		712
1995	536	1990	2050	123	5124	1208		1730	256	422	2053	76	1026	488
1996	654	1424	2208	181	6845	1177	255	1564	329	802	1454	56	892	291
1997	585	2260	1596	125	4764	1745	89	1821	158	477	1012	110	996	303
1998	908	1930	3320	206	7634	1307	236	998	775	275	1344	236	837	346
1999	761	2080	3465	237	6973	1133	266	2620	441	284	1970	188	878	231
2000	936	2680	3214	178	5416	1470	1276	3620	1064	363	1315	380	2554	1711
2001	588	3574	3112	137	4575	1612	477	2794	1130	270	1322	458	1456	1454
2002	530	3571	1964	122	4546	1514	283	2350	724	426	2522	354	1856	962
2003	659	1910	1854	73	3673	1572	278	1991	1200	258	2658	342	1324	436
2004	681	4875	2163	170	5110	1269	461	3654	1132	950	3884	446	1856	908
2005	322	3737	2224	97	3602	2877	117	2710	396	224	2250	248	894	482
2006	409	4758	2583	107	4718	2343	257	2869	718	320	2392	338	996	462
2007	227	2650	1293	105	2819	1652	176	1465	724	364	2096	332	617	350
2008	312	2496	1526	60	3448	1449	116	1263	764	332	1484	490	484	228
2009		1102	895	62	1791	1319	150	1765	568	418	1159	370	547	360
2010	406	2872	1491	84	2949	1485	358	1358	422	423	1168	376	1082	588
2011	493	3023	3208	142	3763	1488	130	1177	318	446	2401	254	1061	258
2012	439	2698	2240	92	3430	1637	160	1945	488	426	2097	162	831	436
2013	597	2281	1853	90	3173	1712	258	2395	834	448	2819	346	853	452

Appendix A continued.

	Southwest Washington DPS								Lower Columbia DPS					
Year	**North/Sm**	**Palix**	**Satsop**	**Elo/Skam**	**Sko/New**	**Willapa**	**Wishkah**	**Wynooch**	**Coweem**	**EFLewis S**	**EF Lewis**	**Kalama S**	**Kalama**	**NFToutle1**
1980												718	1139	
1981												2926	2388	
1982												1385	966	
1983												869	591	
1984			3126				1016	998				247	1048	
1985			3504				1182	2168				461	702	
1986			4602		752		1534	3190			282	473	1021	
1987			4242		1128		998	2878	889		192	748	1091	
1988			1466		694		860	988	1088		258	950	1199	
1989			1890		894		472	1384	392		140	684	556	18
1990			2244		692		652	2406	522		102	745	396	36
1991			2203		562		624	2572			72	704	1065	108
1992			2136	582	644		846	1882			88	1075	2193	322
1993			1765	636		1184	882	1151	438		90	2283	937	165
1994			3220	438			444	2153	362		78	1041	806	90
1995			3038			875	624	2427			53	1302	1144	175
1996	248	87	2421		771	460	368	1659		215		614	806	251
1997	401	10	1864	192	1006	355	134	1402	108	197	238	602	507	183
1998	633	114	2287	344	807	414	264	1333	486	141	376	182	472	149
1999	946	102	3116	316	1932	721	556	2212	198	139	442	220	544	133
2000	2613	334	2825	650	2136	3059	684	2051	530	229		140	921	238
2001	756	152	2513	656	1667	1228	596	1962	384	271	377	286	1042	185
2002	1204	18	3506	370	1262	1338	850	2046	298	440	292	454	1495	328
2003	514	94	2676	668	1384	738	590	1525	460	910	532	817	1815	410
2004	898	226	4519	768	2438	1560	1102	3162	722	425	1298	549	2400	249
2005	346	70	2508	376	1450	822	594	1573	370	673	246	435	1982	
2006	616	44	2855	632	1686	1114	454	2234	372	560	458	387	1733	
2007	442	38	2499	490	1205	668	440	1629	384	412	448	361	1011	
2008	432	60	1990	666	787	557	320	1823	722	365	548	237	742	
2009	348	62	1751		1120	368	336	1565	602	800	688	308	1044	
2010	820	178	1775	534	960	942	524	1725	528	602	336	370	961	
2011	858	42	1912	442	510	594	577	1468	408	1036	308	534	622	
2012	492	196	2329	378	581	364	768	1543	256	1084	272	646	1061	
2013	598	120	3382	784	1716	750	426	1409	622	1059	488	738	811	

Appendix A continued.

	Lower Columbia DPS								Middle Columbia DPS					
Year	**NFToutle2**	**SF Toutle**	**Tilton**	**UCow/Ci**	**UpGorge**	**Washou S**	**Washou**	**Wind S**	**Naches S**	**Satus S**	**Toppen S**	**Touche S**	**Up Yak S**	**Walla S**
1980														
1981														
1982														
1983														
1984		836							285	351	91		70	
1985		1807							621	765	199		137	
1986		1595				154			634	779	203		140	
1987		1650				419			625	768	200	491	153	
1988		2222				447			778	957	249	890	177	
1989		1371				260		1016	321	395	103	256	71	
1990		752				306		561	256	256	41	374	48	
1991		904				333	114	596	252	234	82	276	70	
1992		1290				196	142	535	452	940	260	606	98	
1993		1242				170	118	677	347	415	151	294	45	1079
1994		632				152	158	468	174	191	82	508	32	634
1995						154	206	543	270	307	129	377	39	513
1996						103		466	143	138	56	340	60	389
1997		388		34		148	92	734	310	268	233	228	47	347
1998		374		11		120	195	320	304	348	131	445	61	452
1999		562	93	52		135	294	323	329	335	201	369	41	337
2000		490	141	215	20	140		218	507	397	434	295	59	615
2001		348	191	295	53	184	216	486	983	645	909	296	161	894
2002		640	314	766	51	404	286	690	1454	1155	1129	502	260	1744
2003		1510	318	523	27	607	764	1113	709	646	460	482	133	789
2004		1212	343	296	28		1114	893	886	567	790	267	195	551
2005	388	520	389	280	22	608	320	600	1092	890	801	459	223	854
2006	892	656	97	544	23	636	524	658	646	746	260	290	123	825
2007	565	548	111	622	13	681	632	766	492	521	263	381	79	464
2008	650	412	72	517	7	755	732	638	976	946	585	314	190	676
2009	699	498	140	513	20	433	418	605	1114	1044	693	279	216	863
2010	508	274	179	614	30	787	232	766	2138	2751	621	827	367	1616
2011	416	210	209	627	17	842	204	1497	1963	2274	799	468	364	1628
2012	473	378	284	580	21		306	815	2203	1812	667	294	475	1211
2013	553	972	445	343	18	479	678	760	1683	928	510	501	334	741

Appendix A continued.

	Upper Columbia DPS				Snake River Basin DPS		
Year	**Entiat S**	**Metho S**	**Okanog S**	**Wenatc S**	**Asotin S**	**Joseph S**	**Tucann S**
1980							
1981							
1982							
1983							
1984							
1985							
1986					1030		
1987	104			776	607	4374	
1988	182	393	117	1415	275	6354	
1989	113	304	89	905	247	5292	
1990	109	385	113	847	255	3394	
1991	56	302	89	435	336	659	
1992	104	509	150	801	69	1172	
1993	62	80	26	495	715	3228	
1994	36	80	29	272	227	1820	
1995	36	109	29	259	390	574	
1996	48	59	11	343	398	1084	
1997	31	147	22	242	207	1251	
1998	37	68	20	252	270	3171	83
1999	38	131	38	239	465	2133	165
2000	51	247	65	356	383	2020	180
2001	98	332	98	704	760	2596	142
2002	266	554	155	1968	666	4752	140
2003	117	488	142	853	690	2381	122
2004	94	637	185	656	636	1756	22
2005	116	484	138	813	730	1832	74
2006	128	419	118	906	638	1428	67
2007	59	366	102	387	306	1212	30
2008	123	688	201	714	308	2322	56
2009	102	634	177	709	363	3598	100
2010	297	1102	314	2237	1411	1831	250
2011	293	987	285	2189	1128	5647	176
2012	190	770	235	1420	915	1305	115
2013	129	494	152	936	539	2148	159

Appendix B

Data available for mapping Washington steelhead DPS and population boundaries, occupied habitat distributions, and dam locations including their sources and website links for each dataset.

Data	Source	Link
DPS boundaries	NOAA NMFS: West Coast Regional Office 2013	• http://www.westcoast.fisheries.noaa.gov/maps_data/species_population_boundaries.html
Steelhead population boundaries (PS)	NOAA/NMFS 2006	• http://www.nwfsc.noaa.gov/trt/puget_docs/popidtm78final.pdf • Damon Holzer, NOAA, provided the spatial data
Steelhead population boundaries (LCR, MCR, UCR, Snake R.)	NOAA/NMFS NW regional office 2006	• http://www.nwfsc.noaa.gov/trt/mapsanddata.cfm
Steelhead population boundaries (OP, SW)	WDFW SASI database 2005	• https://fortress.wa.gov/dfw/score/score/species/steelhead.jsp?species=Steelhead
Steelhead stream distributions	WDFW SWIFD database 2014	• http://apps.wdfw.wa.gov/salmonscape/ • http://apps.wdfw.wa.gov/salmonscape/SS2_WIFD_Documentation.pdf
Major dams	USGS NHD point events; WA Dept. of Ecology dams; National Inventory of Dams	• http://www.ecy.wa.gov/services/gis/data/inlandWaters/nhd/NHDdownload.htm • http://www.ecy.wa.gov/services/gis/data/data.htm • http://www.agc.army.mil/Media/FactSheets/FactSheetArticleView/tabid/11913/Article/480923/national-inventory-of-dams.aspx

Appendix C

Spatial structure and diversity indicator results, including percent of historical habitat lost due to the presence of large impassable dams or barriers, adult and smolt age data availability, and availability of baseline genetic data for each steelhead population.

DPS	Population	Run	Percent of habitat lost to large dams and major irrigation diversions	Adult age data availability	Smolt age data availability	Baseline genetic data availability
Puget Sound	Baker	S & W	98.7%	no	no	no
Puget Sound	Canyon Cr.	S	0.0%	no	no	no
Puget Sound	Cedar	W	0.0%	no	no	yes
Puget Sound	Deer Cr.	S	0.0%	yes	no	yes
Puget Sound	Drayton Harbor tributaries	W	0.0%	no	no	no
Puget Sound	Dungeness	S & W	0.1%	no	yes	yes
Puget Sound	East Hood Canal	W	2.1%	yes	yes	yes
Puget Sound	East Kitsap	W	0.0%	no	no	no
Puget Sound	Elwha	W	0.0%	yes	no	yes
Puget Sound	Green	W	33.2%	yes	yes	yes
Puget Sound	North Lake Washington tribs.	W	0.0%	no	no	no
Puget Sound	North Fork Skykomish	S	0.0%	yes	no	yes
Puget Sound	Nisqually	W	0.0%	yes	yes	yes
Puget Sound	Nookachamps	W	0.0%	no	no	no
Puget Sound	Nooksack	W	4.9%	no	no	yes
Puget Sound	Pilchuck	W	0.0%	yes	no	yes
Puget Sound	Puyallup/Carbon	W	1.5%	yes	yes	yes
Puget Sound	Samish & Belligham Bay tribs.	W	0.0%	no	no	yes
Puget Sound	Sauk	S & W	0.6%	no	no	yes
Puget Sound	Sequim & Discovery Bays tribs.	W	6.4%	yes	yes	yes
Puget Sound	Skagit	S & W	0.1%	yes (S & W)	yes	yes
Puget Sound	Skokomish	W	17.8%	no	no	yes
Puget Sound	Snohomish/Skykomish	W	2.2%	yes	no	no
Puget Sound	Snoqualmie	W	0.5%	yes	no	no
Puget Sound	South Fork Nooksack	S	0.0%	no	no	yes
Puget Sound	South Hood Canal	W	0.0%	no	no	yes
Puget Sound	South Sound tributaries	W	0.0%	no	no	no
Puget Sound	Stillaguamish	W	0.0%	yes	no	yes
Puget Sound	Strait of Juan de Fuca Ind. Tribs.	W	0.0%	no	no	yes
Puget Sound	Tolt	S	0.0%	no	no	yes
Puget Sound	West Hood Canal	W	5.3%	no	no	yes
Puget Sound	White River (Puyallup)	W	0.0%	no	no	yes
Olympic Peninsula	Calawah	S	0.0%	no	no	no
Olympic Peninsula	Calawah	W	0.0%	no	no	yes
Olympic Peninsula	Clallam	W	0.0%	no	no	no
Olympic Peninsula	Clearwater	S	0.0%	no	no	no
Olympic Peninsula	Clearwater	W	0.0%	no	no	no
Olympic Peninsula	Copalis	W	0.0%	no	no	no
Olympic Peninsula	Dickey	W	0.0%	no	no	no
Olympic Peninsula	Goodman Creek	W	0.0%	no	no	no
Olympic Peninsula	Hoh	S	0.0%	no	no	no
Olympic Peninsula	Hoh	W	0.0%	yes	no	yes
Olympic Peninsula	Hoko	W	0.0%	no	no	no
Olympic Peninsula	Kalaloch Creek	W	0.0%	no	no	no
Olympic Peninsula	Lower Quinault	W	0.0%	no	no	no
Olympic Peninsula	Lyre	W	0.0%	no	no	no

Appendix C continued

DPS	Population	Run	Percent of habitat lost to large dams and major irrigation diversions	Adult age data availability	Smolt age data availability	Baseline genetic data availability
Olympic Peninsula	Moclips	W	0.0%	no	no	no
Olympic Peninsula	Mosquito Creek	W	0.0%	no	no	no
Olympic Peninsula	Ozette	W	0.0%	no	no	no
Olympic Peninsula	Pysht/Independents	W	0.0%	no	no	no
Olympic Peninsula	Queets	S	0.0%	no	no	no
Olympic Peninsula	Queets	W	0.0%	yes	no	yes
Olympic Peninsula	Quillayute/Bogachiel	S	0.0%	no	no	no
Olympic Peninsula	Quillayute/Bogachiel	W	0.0%	no	no	yes
Olympic Peninsula	Quinault	S	0.0%	no	no	no
Olympic Peninsula	Raft	W	0.0%	no	no	no
Olympic Peninsula	Sail	W	0.0%	no	no	no
Olympic Peninsula	Salt Creek/Independents	W	0.0%	no	no	no
Olympic Peninsula	Sekiu	W	0.0%	no	no	no
Olympic Peninsula	Sol Duc	S	0.0%	no	no	no
Olympic Peninsula	Sol Duc	W	0.0%	no	no	yes
Olympic Peninsula	Tsoo-Yess/Waatch	W	0.0%	no	no	no
Olympic Peninsula	Upper Quinault	W	0.0%	no	no	no
SW Washington	Bear	W	0.0%	no	no	no
SW Washington	Chehalis	S	0.0%	no	no	no
SW Washington	Chehalis	W	0.0%	yes	no	no
SW Washington	Grays	W	0.0%	no	no	yes
SW Washington	Hoquiam	W	0.0%	no	no	no
SW Washington	Humptulips	S	0.0%	no	no	no
SW Washington	Humptulips	W	0.0%	no	no	no
SW Washington	Mill/Abernathy/Germany	W	0.0%	no	yes	yes
SW Washington	Naselle	W	0.0%	no	no	no
SW Washington	Nemah	W	0.0%	no	no	no
SW Washington	North/Smith	W	0.0%	no	no	no
SW Washington	Palix	W	0.0%	no	no	no
SW Washington	Satsop	W	0.0%	yes	yes	no
SW Washington	Skamokawa/Elochoman	W	0.0%	no	no	yes
SW Washington	Skookumchuck/Newaukum	W	16.4%	yes	no	no
SW Washington	South Bay	W	0.0%	no	no	no
SW Washington	Willapa	W	0.0%	no	no	yes
SW Washington	Wishkah	W	0.0%	yes	no	no
SW Washington	Wynoochee	W	6.4%	yes	no	no
Lower Columbia	Coweeman	W	0.0%	no	yes	yes
Lower Columbia	East Fork Lewis	S	0.0%	yes	no	yes
Lower Columbia	East Fork Lewis	W	0.0%	no	no	yes
Lower Columbia	Kalama	S	0.0%	yes	yes	yes
Lower Columbia	Kalama	W	0.0%	yes	no	yes
Lower Columbia	Lower Cowlitz	W	4.7%	no	no	yes
Lower Columbia	Lower Gorge	W	0.0%	no	no	no
Lower Columbia	North Fork Lewis	S	78.2%	no	no	yes
Lower Columbia	North Fork Lewis	W	30.7%	yes	no	yes
Lower Columbia	North Fork Toutle	W	0.0%	yes	no	yes
Lower Columbia	Salmon	W	0.0%	no	no	no
Lower Columbia	South Fork Toutle	W	0.0%	no	no	yes
Lower Columbia	Tilton	W	0.0%	no	no	no
Lower Columbia	Upper Cowlitz & Cispus	W	19.4%	no	no	no
Lower Columbia	Upper Gorge	W	0.0%	yes	no	yes
Lower Columbia	Washougal	S	0.0%	yes	no	no
Lower Columbia	Washougal	W	0.0%	no	no	yes
Lower Columbia	Wind	S	0.1%	yes	yes	no

Appendix C continued

DPS	Population	Run	Percent of habitat lost to large dams and major irrigation diversions	Adult age data availability	Smolt age data availability	Baseline genetic data availability
Middle Columbia R.	Klickitat	S & W	0.0%	no	no	yes
Middle Columbia R.	Naches	S	15.1%	no	no	yes
Middle Columbia R.	Rock	S	0.0%	no	no	no
Middle Columbia R.	Satus	S	3.0%	no	no	yes
Middle Columbia R.	Toppenish	S	11.0%	no	no	yes
Middle Columbia R.	Touchet	S	4.5%	yes	yes	yes
Middle Columbia R.	Upper Yakima	S	45.2%	no	no	yes
Middle Columbia R.	Walla Walla	S	0.0%	no	no	yes
Middle Columbia R.	White Salmon	S & W	0.0%	no	no	yes
Snake River Basin	Asotin	S	3.0%	yes	yes	yes
Snake River Basin	Joseph	S	0.0%	yes	no	no
Snake River Basin	Lower Grande Ronde	S	0.0%	no	no	yes
Snake River Basin	Tucannon	S	6.0%	yes	yes	yes
Upper Columbia R.	Entiat	S	10.0%	yes	no	yes
Upper Columbia R.	Methow	S	0.0%	yes	yes	yes
Upper Columbia R.	Okanogan	S	18.3%	yes	no	yes
Upper Columbia R.	Wenatchee	S	10.9%	yes	yes	yes

Appendix D

Description of statewide steelhead hatchery programs relative to populations they are associated with, including: names and types of programs operated by WDFW or other entity; programs existing as of 2014; average annual number of smolts released and average percent of smolts released off-site of hatcheries for 2000-2008 and 2009-2013; and weir/trap presence.

DPS	Population	Run-time	Total number of hatchery programs as of 2014	Number of WDFW hatchery programs as of 2014	Number of other hatchery programs as of 2014	WDFW or other hatchery program name and type (fish primarily return and spawn there)	Average % of smolts from off-site hatchery (2000-2008)	Average % of smolts from off-site hatchery (2009-2013)	Average annual number of smolts released (2000-2008)	Average annual number of smolts released (2009-2013)	Is weir/trap available for removal of adult hatchery fish from spawning ground?
Puget Sound	Baker	S & W	0						0	0	
Puget Sound	Canyon Cr.	S	0								
	Canyon Cr.	S		0		off-site hatchery segregated summer-run	100%	100%	2,463	1,020	N
	Canyon Cr.	S		0		off-site hatchery segregated winter-run	100%		5,066	0	N
Puget Sound	Cedar	W	0	0					0	0	
Puget Sound	Deer Cr.	S	0	0					0	0	
Puget Sound	Drayton Harbor tributaries	W	0	0					0	0	
Puget Sound	Dungeness	W	1	1		Dungeness segregated-winter	0%	0%	10,973	8,525	Y
Puget Sound	East Hood Canal	W	1								
	East Hood Canal	W		1		Lilliwaup Hatchery - Long Live the Kings experimental wild brood		0%	0	6,242	N
Puget Sound	East Kitsap	W	0						0	0	
Puget Sound	Elwha	W	1								
	Elwha	W		0	0	Elwha Hatchery & Lower Elwha hatchery segregated-winter	0%	0%	117,472	67,233	Y
	Elwha	W		0	0	off-site hatchery segregated summer-run	100%		1,111	0	
	Elwha	W		0	1	Elwha Hatchery integrated-wild winter		0%	0	91,755	Y
Puget Sound	Green	W	3								
	Green	W		1		Soos Creek (& Palmer Ponds, Icy Cr Ponds & Flaming Geyser Coop) segregated-winter	84%	43%	174,494	107,977	Y?
	Green	W		1		Soos Creek (& Palmer Ponds, Icy Cr Ponds & Flaming Geyser Coop) segregated-summer	70.3%	24.3%	89,634	72,017	Y?
	Green	W		1		Soos Creek integrated-wild winter	15.3%	10.2%	24,121	21,556	Y & N
Puget Sound	North Lake Washington tribs.	W	0								
	North Lake Washington tribs.	W		0		Experimental wild brood stock project	0%		1,676	0	
Puget Sound	North Fork Skykomish	S	0						0	0	
Puget Sound	Nisqually	W	0						0	0	
Puget Sound	Nookachamps	W	0						0	0	
Puget Sound	Nooksack	W	1								
	Nooksack	W		1		Kendall Creek segregated-winter	0%	0%	118,500	117,573	Y
Puget Sound	Pilchuck	W	0								
	Pilchuck	W		0		off-site hatchery segregated winter-run	100%	100%	27,260	6,240	N
Puget Sound	Puyallup/Carbon	W	0								
	Puyallup/Carbon	W		0		Voights Creek segregated-winter	0%	0%	189,159	10,310	Y
Puget Sound	Samish & Belligham Bay tribs.	W	0								
	Samish & Belligham Bay tribs.	W		0		Whatcom Creek Hatchery segregated-winter	0%	0%	26,043	35,506	Y
Puget Sound	Sauk	S & W	0								
	Sauk	S & W		0		off-site hatchery segregated winter-run	100%		20,487	0	N
Puget Sound	Sequim & Discovery Bays tribs.	W	0						0	0	
Puget Sound	Skagit	S & W	1								
	Skagit	S & W		1		Marblemount Hatchery segregated-winter	0%	0%	436,887	221,310	Y
Puget Sound	Skokomish	W	1								
	Skokomish	W		0		Eells Springs segregated-winter	0%		33,262	0	Y
	Skokomish	W		1		McKernan experimental wild brood program	0%	0%	455	23,565	Y & N?

Appendix D continued

DPS	Population	Run	Total number of hatchery programs as of 2014	Number of WDFW hatchery programs as of 2014	Number of other hatchery programs as of 2014	WDFW or other hatchery program name and type (fish primarily return and spawn there)	Average % of smolts from off-site hatchery (2000-2008)	Average % of smolts from off-site hatchery (2009-2013)	Average annual number of smolts released (2000-2008)	Average annual number of smolts released (2009-2013)	Is weir/trap available for removal of adult hatchery fish from spawning ground?
Puget Sound	Snohomish/Skykomish	W	2								
	Snohomish/Skykomish	W		1		Reiter Ponds & Wallace R. segregated-summer	0%	0%	176,800	189,177	Y
	Snohomish/Skykomish	W		1		Reiter Ponds & Wallace R. segregated-winter	0%	0%	206,849	169,806	Y
Puget Sound	Snoqualmie	W	1								
	Snoqualmie	W		0		off-site hatchery segregated summer-run	100%		49,125	0	N
	Snoqualmie	W		1		Tokul Creek Hatchery segregated-winter	0%	0%	192,851	160,245	Y
Puget Sound	South Fork Nooksack	S	0						0	0	
Puget Sound	South Hood Canal	W	0						0	0	
Puget Sound	South Sound tributaries	W	0								
	South Sound tributaries	W		0		Tumwater Falls Hatchery segregated-winter	89%	0%	13,385	0	Y
Puget Sound	Stillaguamish	W	2								
	Stillaguamish	W		1		Whitehorse segregated-winter	0%	0%	140,249	113,832	Y
	Stillaguamish	W		1		Whitehorse segregated-summer	11.4%	0%	82,648	75,338	Y
Puget Sound	Strait of Juan de Fuca Ind. Tribs.	W	0								
	Strait of Juan de Fuca Ind. Tribs.	W		0		off-site hatchery segregated winter-run	100%		2,778	0	N
Puget Sound	Tolt	S	0						0	0	
Puget Sound	West Hood Canal	W	1								
	West Hood Canal	W		0		off-site hatchery segregated winter-run	100%		10,041	0	N
	West Hood Canal	W		1		Lilliwaup Hatchery - Long Live the Kings experimental wild brood program	0%	0%	893	2,664	N
Puget Sound	White River (Puyallup)	W	1								
	White River (Puyallup)	W			1	White River integrated- wild winter	0%	0%	9,112	23,369	Y
	White River (Puyallup)	W		0		off-site hatchery segregated winter-run	100%	100%	6,778	37,510	N
Olympic Peninsula	Calawah	S	1								
	Calawah	S		1		off-site hatchery segregated summer-run	100%	100%	29,773	35,432	N
Olympic Peninsula	Calawah	W	1								
	Calawah	W		1		off-site hatchery segregated winter-run	100%	100%	64,500	40,668	N
Olympic Peninsula	Clallam	W	0								
	Clallam	W		0		off-site hatchery segregated winter-run	100%	100%	7,337	2,007	N
Olympic Peninsula	Clearwater	S	0						0	0	
Olympic Peninsula	Clearwater	W	0						0	0	
Olympic Peninsula	Copalis	W	0						0	0	
Olympic Peninsula	Dickey	W	0						0	0	
Olympic Peninsula	Goodman Creek	W	0								
	Goodman Creek	W		0		off-site hatchery segregated winter-run	100%	100%	20,000	4,000	N
Olympic Peninsula	Hoh	S	0						0	0	
Olympic Peninsula	Hoh	W	1								
	Hoh	W			1	off-site hatchery segregated winter-run	100%	100%	91,317	68,295	N
Olympic Peninsula	Hoko	W	1								
	Hoko	W			1	Hoko River segregated-winter	0%	0%	24,431	24,558	Y
Olympic Peninsula	Kalaloch Creek	W	0						0	0	
Olympic Peninsula	Lower Quinault	W	1								
	Lower Quinault	W			1	Quinault NFH & Quinault Lake segregated winter	0%	0%	434,450	414,426	Y & N?
Olympic Peninsula	Lyre	W	0								
	Lyre	W		0		off-site hatchery segregated summer-run	100%	100%	8,111	2,000	N
	Lyre	W		0		off-site hatchery segregated winter-run	100%	100%	26,724	5,387	N
Olympic Peninsula	Moclips	W	0								
	Moclips	W			0	off-site hatchery segregated winter-run	100%		7,000	0	N
Olympic Peninsula	Mosquito Creek	W	0						0	0	
Olympic Peninsula	Ozette	W	0						0	0	
Olympic Peninsula	Pysht/Independents	W	0								
	Pysht/Independents	W		0		off-site hatchery segregated winter-run	100%	100%	11,140	2,003	N
Olympic Peninsula	Queets	S	0						0	0	
Olympic Peninsula	Queets	W	1								
	Queets	W			1	Salmon River (Queets) segregated-winter	0%	0%	139,166	157,219	Y

Appendix D continued

DPS	Population	Run	Total number of hatchery programs as of 2014	Number of WDFW hatchery programs as of 2014	Number of other hatchery programs as of 2014	WDFW or other hatchery program name and type (fish primarily return and spawn there)	Average % of smolts from off-site hatchery (2000-2008)	Average % of smolts from off-site hatchery (2009-2013)	Average annual number of smolts released (2000-2008)	Average annual number of smolts released (2009-2013)	Is weir/trap available for removal of adult hatchery fish from spawning ground?
Olympic Peninsula	Quillayute/Bogachiel	S	0	0					0	0	
Olympic Peninsula	Quillayute/Bogachiel	W	1								
	Quillayute/Bogachiel	W		1		Bogachiel Hatchery segregated-winter	0%	0%	83,778	101,587	Y
Olympic Peninsula	Quinault	S	0						0	0	
Olympic Peninsula	Raft	W	0								
	Raft	W			0	off-site hatchery segregated winter-run	100%		13,913	0	N
Olympic Peninsula	Sail	W	1								
	Sail	W			1	off-site hatchery segregated winter-run	100%	100%	5,662	10,305	N
Olympic Peninsula	Salt Creek/Independents	W	0						0	0	
Olympic Peninsula	Sekiu	W	1								
	Sekiu	W			1	off-site hatchery segregated winter-run	100%	100%	10,085	11,949	N
Olympic Peninsula	Sol Duc	S	0								
	Sol Duc	S		0		off-site hatchery segregated summer-run	100%	100%	17,046	13,000	N
Olympic Peninsula	Sol Duc	W	0								
	Sol Duc	W		0		Snider Creek Rearing Ponds integrated winter	0%	0%	64,089	10,800	Y?
Olympic Peninsula	Sooes/Waatch	W	1								
	Sooes/Waatch	W			1	Makah NFH segregated-winter	0%	0%	171,155	96,238	Y
Olympic Peninsula	Upper Quinault	W	1								
	Upper Quinault	W			1	Quinault Lake segregated or integrated?	0%	0%	153,347	72,907	Y?
SW Washington	Bear	W	0						0	0	
SW Washington	Chehalis	S	0								
	Chehalis	S		0		Lake Aberdeen Hatchery segregated-summer	100%	100%	13,050	3,400	Y
SW Washington	Chehalis	W	0								
	Chehalis	W		0		Lake Aberdeen Hatchery segregated-winter	0%		2,439	0	Y
SW Washington	Grays	W	1								
	Grays	W		1		Grays River segregated-winter	0%	0%	32,150	41,490	Y
SW Washington	Hoquiam	W	0								
	Hoquiam	W		0		off-site hatchery segregated winter-run	100%		14,421	0	N
SW Washington	Humptulips	S	1								
	Humptulips	S		1		Humptulips Hatchery segregated-summer	0%	0%	14,326	31,304	Y
SW Washington	Humptulips	W	1								
	Humptulips	W		1		Humptulips non-native but 'integrated'-winter	0%	0%	104,459	116,799	Y
SW Washington	Mill/Abernathy/Germany	W	1								
	Mill/Abernathy/Germany	W			1	USFWS Abernathy FTC Hatchery integrated-winter	0%	0%	14,477	19,252	Y
SW Washington	Naselle	W	1								
	Naselle	W		1		Naselle segregated-winter	0%	0%	39,089	59,714	Y
SW Washington	Nemah	W	0								
	Nemah	W		0		Nemah segregated-winter	0%	0%	11,822	5,020	Y
SW Washington	North/Smith	W	1								
	North/Smith	W		1		off-site & March Spawning Channel segregated-winter	100%	100%	18,856	17,040	N
SW Washington	Palix	W	0						0	0	
SW Washington	Satsop	W	1								
	Satsop	W		1		Bingham Creek integrated-winter	0%	0%	69,744	69,800	Y
SW Washington	Skamokawa/Elochoman	W	2								
	Skamokawa/Elochoman	W		1		Beaver Creek & Elochoman segregated-summer	0%	0%	29,981	29,800	Y
	Skamokawa/Elochoman	W		1		Beaver Creek & Elochoman segregated-winter	0%	0%	104,199	97,800	Y
SW Washington	Skookumchuck/Newaukum	W	1								
	Skookumchuck/Newaukum	W		1		Skookumchuck integrated-winter	0%	0%	112,606	144,100	Y
	Skookumchuck/Newaukum	W		0		off-site hatchery segregated summer-run	100%		16,433	0	N
SW Washington	South Bay	W	0								
	South Bay	W		0		off-site hatchery segregated winter-run	100%		20,293	0	N
SW Washington	Willapa	W	1								
	Willapa	W		1		Forks Creek segregated-winter	0%	0%	59,478	62,360	Y
SW Washington	Wishkah	W	0						0	0	

Appendix D continued

DPS	Population	Run	Total number of hatchery programs as of 2014	Number of WDFW hatchery programs as of 2014	Number of other hatchery programs as of 2014	WDFW or other hatchery program name and type (fish primarily return and spawn there)	Average % of smolts from off-site hatchery (2000-2008)	Average % of smolts from off-site hatchery (2009-2013)	Average annual number of smolts released (2000-2008)	Average annual number of smolts released (2009-2013)	Is weir/trap available for removal of adult hatchery fish from spawning ground?
SW Washington	Wynoochee	W	2								
	Wynoochee	W		1		off-site hatchery segregated summer-run	100%	100%	54,443	78,309	N
	Wynoochee	W		1		Lake Aberdeen integrated-winter	100%	100%	177,380	165,476	Y?
Lower Columbia	Coweeman	W	0								
	Coweeman	W		0		off-site hatchery segregated winter-run	100%	100%	14,341	8,472	N
Lower Columbia	East Fork Lewis	S	1								
	East Fork Lewis	S		1		off-site hatchery segregated summer-run	100%	100%	34,702	15,545	N
Lower Columbia	East Fork Lewis	W	1								
	East Fork Lewis	W		1		off-site hatchery segregated winter-run	100%	100%	81,314	61,563	N
Lower Columbia	Kalama	S	2								
	Kalama	S		1		Fallert Creek segregated-summer	0%	0%	32,079	32,577	Y
	Kalama	S		1		Kalama Falls integrated-wild summer	0%	0%	44,188	48,175	Y
Lower Columbia	Kalama	W	2								
	Kalama	W		1		Kalama Falls segregated-winter	0%	0%	50,402	56,076	Y
	Kalama	W		1		Kalama Falls & Fallert Cr. integrated winter	0%	0%	34,131	56,252	Y
Lower Columbia	Lower Cowlitz	W	3								
	Lower Cowlitz	W		1		Cowlitz Trout Hatchery, Friends of Cowlitz facilities segregated-summer	0%	0%	496,142	590,140	Y
	Lower Cowlitz	W		1		Cowlitz Trout and Cowlitz Salmon hatcheries segregated-winter	0%	0%	326,663	254,638	Y
	Lower Cowlitz	W		1		Cowlitz Trout segregated-late winter	0%	0%	350,989	454,716	Y
Lower Columbia	Lower Gorge	W	0						0	0	
Lower Columbia	North Fork Lewis	S	1								
	North Fork Lewis	S		1		Merwin segregated-summer	pending	pending	266,999	254,488	
Lower Columbia	North Fork Lewis	W	2								
	North Fork Lewis	W		1		Merwin segregated-winter	0%	0%	112,424	97,586	Y
	North Fork Lewis	W		1		Merwin integrated-native late winter		0%	0	34,377	Y
Lower Columbia	North Fork Toutle	W	0								
	North Fork Toutle	W		0		North Fork Toutle segregated-summer	0%	0%	22,150	25,078	Y
Lower Columbia	Salmon	W	1								
	Salmon	W		1		Klineline Ponds segregated-winter	100%	100%	18,148	19,945	N
Lower Columbia	South Fork Toutle	W	1								
	South Fork Toutle	W		1		off-site hatchery segregated summer-run	100%	100%	22,283	16,384	N
Lower Columbia	Tilton	W	0								
	Tilton	W		0		Cowlitz Trout segregated-winter	0%		6,781	0	Y
	Tilton	W		0		Cowlitz Trout segregated late winter	0%		26,511	0	Y
Lower Columbia	Upper Cowlitz	W	1								
	Upper Cowlitz	W		0		Cowlitz Trout segregated-winter	0%		30,242	0	Y
	Upper Cowlitz	W		1		Cowlitz Trout segregated-late winter	0%		56,392	0	Y
Lower Columbia	Cispus	W	1								
	Cispus	W		0		Cowlitz Trout segregated-winter	0%		36,498	0	
	Cispus	W		1		Cowlitz Trout segregated-late winter	0%	0%	115,643	3,320	Y
Lower Columbia	Upper Gorge	W	0								
	Upper Gorge	W				off-site hatchery segregated winter-run		100%	0	4,000	N
Lower Columbia	Washougal	S	1								
	Washougal	S		1		Skamania segregated summer	0%	0%	68,320	64,159	Y
Lower Columbia	Washougal	W	1								
	Washougal	W		1		Skamania segregated winter	0%	0%	62,635	62,936	Y
Lower Columbia	Wind	S	0						0	0	
Middle Columbia River	Klickitat	S & W	1								
	Klickitat	S & W		1		off-site hatchery segregated summer-run	100%	100%	101,647	92,758	N?
Middle Columbia River	Naches	S	0						0	0	
Middle Columbia River	Rock	S	0						0	0	
Middle Columbia River	Satus	S	0						0	0	
Middle Columbia River	Toppenish	S	0						0	0	

Appendix D continued

DPS	Population	Run	Total number of hatchery programs as of 2014	Number of WDFW hatchery programs as of 2014	Number of other hatchery programs as of 2014	WDFW or other hatchery program name and type (fish primarily return and spawn there)	Average % of smolts from off-site hatchery (2000-2008)	Average % of smolts from off-site hatchery (2009-2013)	Average annual number of smolts released (2000-2008)	Average annual number of smolts released (2009-2013)	Is weir/trap available for removal of adult hatchery fish from spawning ground?
Middle Columbia River	Touchet	S	2								
	Touchet	S		1		Lyons Ferry/Wallowa segregated summer run - Dayton Acclimation Pond	100%	100%	98,474	86,353	Y
	Touchet	S		1		Touchet River endemic integrated summer-run; N.F. Touchet R.	100%	100%	43,070	54,584	Y
Middle Columbia River	Upper Yakima	S	0						0	0	
Middle Columbia River	Walla Walla	S	1								
	Walla Walla	S		1		Lyons Ferry/Wallowa segregated summer-run - Walla Walla River	100%	100%	106,252	104,313	N
Middle Columbia River	White Salmon	S & W	0								
	White Salmon	S & W		0		off-site hatchery segregated summer-run	100%	100%	18,895	14,399	N
	White Salmon	S & W		0		off-site hatchery segregated winter-run	100%	100%	19,617	8,000	N
Snake River Basin	Asotin	S	0						0	0	
Snake River Basin	Joseph	S	0						0	0	
Snake River Basin	Lower Grande Ronde	S	1								
	Lower Grande Ronde	S		1		Cottonwood Creek Pond-Wallowa stock segregated summer-run	100%	100%	189,114	182,817	Y
Snake River Basin	Tucannon	S	1								
	Tucannon	S		0		Lyons Ferry Hatchery segregated summer-run	100%	100%	111,593	42,128	Y
	Tucannon	S		1		Tucannon integrated summer-run	100%	100%	50,216	48,945	Y
Snake River Basin	*Snake R. mainstem releases*	S	1								
	Snake R. mainstem releases	S		1		Lyons Ferry/Wallowa segregated summer-run - Snake River mainstem	0%	0%	60,101	116,091	N
Upper Columbia River	Entiat	S	0						0	0	
Upper Columbia River	Methow	S	3								
	Methow	S		1		Wells-Lower Methow safety-net segregated summer (formerly integrated)	0%	0%	315,019	247,535	
	Methow	S		1		Twisp integrated summer-run		0%	0	18,529	
	Methow	S			1	USFWS Winthrop Hatchery	0%	0%	115,576	107,774	Y?
Upper Columbia River	Okanogan	S	2								
	Okanogan	S		1		Wells-Okanogan Safety-net integrated summer-run	0%	0%	134,822	100,756	?
	Okanogan	S			1	Wells-Okanogan locally-adapted integrated summer-run	0%	0%	12,730	33,666	?
Upper Columbia River	Wenatchee	S	1								
	Wenatchee	S		1		Wenatchee integrated-Chiwawa summer-run	0%	0%	302,903	315,677	Y?
Upper Columbia River	*Columbia R. mainstem releases*	S	1								
	Columbia R. mainstem releases	S		1		Wells Hatchery segregated summer-run stock mainstem releases, including Ringold Springs facility	0%	0%	192,780	172,896	Y

Appendix E

Summary of viability risk scoring metrics and criteria used to evaluate all Washington State steelhead populations, including their purpose, scoring scheme, and general comments.

Risk Metric	Purpose	Criterion for Score of 1 risk point	Comments
1. Long-term adult abundance trend	Tracks the long-term change in abundance, beginning and end point of fitted regression trend line.	Ending population size is less than 55% of starting population size	• 10% of populations met this criteria (i.e., more than 55% decline since 1980
2.Short-term growth trend (PVA)	Identify populations with recent significant decline	Population abundance (spawning escapement) in significant decline (growth rate < 0)	• A decline is measured as if the slope of a fitted regression line is significantly less than 0 for the natural logarithm of abundance (less than 1 on original scale • Consistent with Scott and Gill (2008)
3. Extinction risk (PVA)	Identify populations most at risk of extinction	Population has a >20% probability of reaching its QET at least once in 20 years.	• This same scoring system was used in Allendorf et al. (1997) to identify salmonid populations with a high extinction risk
4. Recent abundance relative to escapement or recovery goals	Evaluate risk associated with current abundance (previous metrics target trend and extinction risk)	Population has a < 70% probability of meeting its escapement or recovery goal in recent 10 year period	• More accurately describes the risk facing populations where dramatic decline occurred prior to 1980 (e.g., Interior Columbia populations) because in that case they would not trigger criteria 1 and 2 above. • Large populations are inherently less likely to hit QETs (when set near 50), so many large populations may be at high risk but by their inherent size do not trigger and extinction risk criterion • This measure provides a measure of "early warning" for populations that repeatedly miss their escapement goals but are not considered "high risk." Helps identify populations that have declined to below their escapement goals but are not necessarily at critically low abundance. • 70% threshold is considered conservative because these are minimum escapement or recovery goals. The intention is that these goals would be met or exceeded every year.

Risk Metric	Purpose	Criterion for Score of 1 risk point	Comments
5. NOAA/TRT risk score for ESA-listed populations	Independent evaluation including multiple stakeholders and all VSP criteria.	NOAA/TRT designation is High Risk	• Elevates potential score for ESA-listed DPSs which should be the most at risk i. ICTRT populations - raw AP/SSD risk scores from 2010 Status Review ii. LC - updated AP/SSD scores through 2013 using LCFRB 2010, Appendix E, Chap. 12 abundance thresholds & the lower of AP and SSD scores iii. PS – used TRT's PVA QET risk rating or AP/SSD viability rating, whichever was lower, for populations with adequate adult abundance data iv. Not applicable to non-listed DPSs

Appendix F

Review of progress made on recommendations for Washington steelhead from Scott and Gill (2008).

BIOLOGY

Recommendation 2-1. Evaluate and modify management actions to promote local adaptation, increase and maintain the diversity within and among populations, and sustain and maximize the long-term productivity of populations.

> **Update**: Since 2008, several populations have been declared Wild Steelhead Management Zones, meaning they will be managed for the protection of wild steelhead and hatchery programs will be excluded from the watershed. The SSMP called for one wild steelhead management zone per MPG throughout the state, including one each for winter and summer steelhead, where they co-occur within an MPG. As of 2015, progress has been made, but many more WSMZs are needed particularly in Puget Sound, Southwest Washington, and the Interior Columbia. The only official WSMZs currently are the Wind River summer run, East Fork Lewis River summer and winter runs, and the NF Toutle/Green winter run in the Lower Columbia River DPS, and the Sol Duc River summer/winter runs in the Olympic Peninsula DPS. There are numerous other populations in each DPS that currently operate as de-facto WSMZs, but the official designation is still needed.

Recommendation 2-2. Develop improved tools that relate environmental factors (e.g., climate, water temperature, stream flow) and the physiological status (e.g., length, growth rate) of juvenile *O. mykiss* to the diversity, spatial structure, abundance, and productivity of steelhead populations.

> **Update**: There are numerous projects around the state that are addressing this broad recommendation. Life-cycle models are being developed in Puget Sound, the Wind River, the Tucannon River, and elsewhere to explicitly track survival and movement across steelhead generations and relate metrics for VSP parameters to environmental conditions and other factors. Intensively Monitored Watershed (IMWs) are also intended to relate fish population response to habitat restoration through paired restoration and fish monitoring activities. IMWs are ongoing in most DPSs. Fish-in fish-out monitoring provides the critical baseline information needed to evaluate the effects of environmental conditions on SARs or smolt recruits per spawner. There is a focused study ongoing that is specifically evaluating early marine survival of steelhead in Puget Sound. Finally, work is ongoing to update estimates of demographic (e.g., productivity, capacity) and management (spawners at MSY) conditions for populations based on existing Fish-In-Fish-Out data and habitat attributes.

Recommendation 2-3. Build on studies in the Cedar River, Yakima River, and other locations to develop a better understanding of the relationship of resident and anadromous *O. mykiss*. Conduct reconnaissance level surveys to estimate the proportion of juveniles originating from anadromous and non-anadromous parents. From these studies, develop improved tools to assess the potential effects of management actions and enhanced management strategies that effectively address resident and anadromous life history forms.

Update: These studies are ongoing and providing valuable insights into population dynamics. Work in the upper Yakima River will address this but it is a managed river with robust rainbow trout abundance so the transferability of results in unclear. Similar work is ongoing in Hood Canal rivers. More work is needed.

Recommendation 2-4. Design and initiate a program to monitor the genotypic and phenotypic characteristics of steelhead populations and a management structure for analysis and reporting. Phenotypic characteristics include migration or spawn timing, age structure, and size at age. Expanding the scope of the Salmonid Stock Inventory (SaSI) to include data pertaining to diversity and spatial structure as well as spawner abundance data would promote concurrent reporting of all four of the viable salmonid population (VSP) characteristics.

Update: Throughout the state some progress has been made towards formalizing genetic and phenotypic monitoring, however it is only completed in the Yakima River MPG and Upper Columbia DPS. Genetic baseline data collection has been expanded to include more Puget Sound, Lower Columbia, and Southwest Washington populations, with emphasis on getting genetic samples from adults along with their phenotypic data. Analysis of these data will at the least be documented in an agency report(s). SaSI has not been expanded to include phenotypic (e.g. age data), diversity, or spatial structure data.

HABITAT

Recommendation 3-1. Ensure that the technical expertise of WDFW is available to local planning groups, fish recovery groups, and governments to assist in the identification of the habitat factors reducing the viability of steelhead populations and actions to achieve desired protection and restoration actions.

Update: WDFW is engaged with these processes throughout the state, but the need far exceeds existing personnel capacity. WDFW staff work on projects that identify limiting factors for fish populations and habitat conditions, disseminate critical fish population data to recovery planners and restoration practitioners, and in some cases work directly with project sponsors to maximize the benefits of individual projects for steelhead. More engagement is needed at planning and implementation levels, but capacity is lacking.

Recommendation 3-2. Promote effective habitat actions by providing web access to a cohesive set of tabular and map-based habitat information, including watershed use by steelhead and priorities for habitat protection and restoration.

Update: The 2016 update to the Columbia River Instream Atlas (CRIA; sponsored by WA Department of Ecology) provides this type of information for 13 interior Columbia watersheds (https://fortress.wa.gov/ecy/publications/documents/1612006.pdf). The interactive GIS-based web map with CRIA data, while available to WDFW staff, is not yet available to the public. WDFW's fish passage barrier database needs to be updated and verified with extensive metadata regarding passage limitations to steelhead and other fish of all life stages.

Recommendation 3-3. Work with local governments, sister state agencies, the federal government, and within WDFW to improve the protection of steelhead habitat through the consistent implementation of existing regulatory authorities. Using the best available science, enhance the protective elements of regulatory authorities where current measures do not provide sufficient protection of steelhead habitat.

Update: Not reviewed

Recommendation 3-4. Work with stakeholders and staff to evaluate and enhance the effectiveness of the HPA program. Advance the protection of steelhead habitat through the implementation of the Department's Habitat Conservation Plan development process. Maximize the current use of existing HPA authorities. Continue to streamline HPA's for habitat restoration projects, and implement an effective analysis for HPA projects.

Update: Not reviewed

Recommendation 3-5. Develop and implement a consistent method for using remote sensing data to monitor trends in the status of habitat. Many planning forums require or would benefit from information about the status and trends of habitat across Washington State. This coarse-scale information, in various forms, is widely available through remote sensing but little effort has been given to standardizing products to meet multiple stakeholder needs simultaneously or in providing a template upon which future updates can made.

Update: WDFW's Habitat Program has developed a vegetation change detection method that utilizes1-meter aerial imagery data from 2006 to 2015. This process, called High Resolution Change Detection (HRCD), has been used to track major vegetation changes in Puget Sound watersheds and to other areas statewide. See: http://wdfw.wa.gov/conservation/research/projects/aerial_imagery/

Recommendation 3-6. Develop a plan that describes the projected impacts of climate change on steelhead habitat, provides hypotheses on effects on steelhead populations, and identifies actions to promote perpetuation of steelhead.

Update: Extensive evaluations of climate change impacts on salmonids, including steelhead, have been done in the Pacific Northwest region. WDFW evaluated climate change vulnerability of selected species, including all ESA-listed steelhead, in its 2015 State Wildlife Action Plan (see Chapter 5 in the Plan at: http://wdfw.wa.gov/conservation/cwcs/). In some areas of the state we have expanded critical baseline monitoring that will be needed to evaluate future changes in population viability or other metrics.

ARTIFICIAL PRODUCTION

Recommendation 4-1. Evaluate the potential range of gene flow from returning adults to natural populations in all watersheds where Chambers Winter, Skamania Summer, or other nonlocal steelhead are released. Where risks are inconsistent with policy objectives for the natural population, implement one or more of the following actions: 1) release steelhead juveniles from isolated [segregated] programs only at locations where returning adults can be captured; 2) adjust the size of the program, release location, fishery harvest rate, or other factor to achieve an acceptable rate of gene flow; or 3) replace the isolated [segregated] program with an integrated program developed from local broodstock.

Update: Evaluations of gene flow are currently being conducted in Puget Sound and the Lower Columbia River DPSs. Once completed, the project will be expanded to the Olympic Peninsula. Recent hatchery management and production measures should also greatly reduce unwanted gene flow. Most hatchery steelhead juvenile releases have been terminated where there are no adult traps to facilitate effective adult management. Also, wherever possible broodstock sources have been transitioned to more local origins.

Recommendation 4-2. Design and initiate a program to monitor the genetic characteristics of steelhead populations. Prioritize the collection of samples from watersheds with both a hatchery program and a significant natural population to assess the potential loss of diversity associated with hatchery programs.

Update: Fully implemented in Upper Columbia River DPS, and partially implemented in Puget Sound, Southwest Washington, Middle Columbia (Yakima River Basin) and Snake River Basin DPSs. Ongoing project in Lower Columbia River is focused on quantifying hatchery steelhead introgression.

Recommendation 4-3. Support and expand research to link changes in genetic markers to the abundance and productivity of the population. Current genetic monitoring typically assesses changes in the frequency of neutral alleles, or alleles that are not believed to have a functional effect on fitness. If we could identify genetic markers that were related to fitness, we could provide an improved assessment of what changes in the frequency of these markers mean to population productivity and other characteristics.

Update: We currently have the technology to survey genomes, including neutral and non-neutral genetic loci. We have a collaborative project in Region 5 to develop markers for better distinguishing hatchery and wild fish in the lower Columbia. It's possible that some of those markers will be linked to non-neutral fitness-related genes. We are in a very early stage in the process of connecting specific loci or genes to productivity or other characteristics.

Recommendation 4-4. Submit for publication in a peer-reviewed journal a paper describing the methods developed to compare the potential fitness loss associated with integrated and isolated [segregated] artificial production programs. These methods may be of broad interest in the evaluation and management of artificial production programs.

Update: Although WDFW staff were not involved, work on this topic was published by other scientists: Baskett, M.L., and R.S. Waples. 2013. Evaluating alternative strategies for minimizing unintended fitness consequences of cultured individuals on wild populations. Conservation Biology, Vol. 27(1): 83–94.

Recommendation 4-5. Evaluate the potential effects of competition when considering the relative risks and benefits of isolated [segregated] programs, particularly if conservation concerns exist. Where risks are inconsistent with policy objectives for the natural population, implement one or more of the actions described in Recommendation 4-1.

Update: Need PCD Risk software to be recoded in R.

Recommendation 4-6. Evaluate the potential effects of integrated programs on the diversity, spatial structure, abundance, and productivity of the indigenous natural population. Carefully consider the size of the program and characteristics of the release strategy (location, time, size of fish) to assure that potential genetic and ecological risks are consistent with policy objectives.

> **Update**: Fully implemented in Upper Columbia River DPS and partially implemented in Snake River Basin DPS.

Recommendation 4-7. Develop a "population rescue" reference document that discusses the conditions under which a hatchery conservation program may be warranted and the key questions that should be addressed during the development of the program.

> **Update**: Not yet implemented.

Recommendation 4-8. Evaluate the fishery and economic benefits of isolated [segregated] hatchery programs in Puget Sound relative to those of hatchery programs for other salmonid species and the potential benefits of conservation programs for natural steelhead populations. If necessary, adjust programs to provide enhanced economic and conservation benefits.

> **Update:** Not yet implemented.

MANAGEMENT

Recommendation 5-1. Develop and implement improved methods and forums to inform constituents about steelhead management trade-offs, generate and discuss new strategies, and solicit review and comment on alternative strategies. In addition to the existing Fish and Wildlife Commission process and the Steelhead and Cutthroat Policy Advisory Group, these methods could include informal workshops and focus groups.

> **Update**: Not reviewed.

Recommendation 5-2. Building on the concepts developed in this paper, develop and apply on a population specific basis analytical tools to evaluate trade-offs between competing management objectives.

> **Update**: Not reviewed.

Recommendation 5-3. In conjunction with the fishery co-managers, continue to annually assess the predicted abundance of steelhead populations, identify allowable fishing rates, and monitor the impacts of fisheries.

> **Update**: This process is ongoing statewide.

POPULATION STRUCTURE

Recommendation 6-1. Evaluate and modify management actions to promote local adaptation, increase and maintain the diversity within and among populations, and sustain and maximize the long-term productivity of populations.

> **Update**: See Recommendation 2-1

Recommendation 6-2. Design and initiate a program to monitor the genotypic and phenotypic characteristics of steelhead populations and a management structure for analysis and reporting. Phenotypic characteristics include migration or spawn timing, age structure, and size at age. Expanding the scope of the Salmonid Stock Inventory (SaSI) to include data pertaining to diversity and spatial structure as well as spawner abundance data would promote concurrent reporting of all four of the viable salmonid population (VSP) characteristics.

> **Update**: See Recommendation 2-4

Recommendation 6-3. Evaluate the population structure of steelhead in the Puget Sound, Olympic Peninsula, and Southwest Washington regions. Evaluate assumptions of the 1992 co-manager analysis and, building on the tools developed by the Puget Sound, Willamette/Lower Columbia, and Interior Columbia technical recovery teams, define and implement a consistent procedure for evaluating population structure.

> **Update**: Population structure for Puget Sound steelhead was evaluated in TRT analysis of historical, demographically independent populations (Myers et al. 2015). Recent Puget Sound sampling and genotyping has been done to update and improve representation of populations. We need further sampling of some populations (e.g., Stillaguamish) and to gain temporal replicates for almost all populations. Some genetic analyses of Olympic Peninsula and SW WA steelhead have been done, but spatial coverage in these DPSs has been limited and far from systematic. Steelhead from Willapa Bay tributaries are mostly absent from collections. For Olympic Peninsula DPS, we have collections from most major rivers (but sample sizes may be small and temporal replicates scarce), and few from most of the smaller rivers. We are not yet able to fully evaluate genetic population structure to aid the process of verifying 1992 population definitions for Olympia Peninsula and SW Washington DPSs.

Recommendation 6-4. Focus future collection of genetic samples in areas with significant uncertainty in population structure. Collect genetic samples for microsatellite or SNP analysis with methods that assure run timing and life history type are known. Conduct analyses using high-resolution DNA markers appropriate to research objectives and supplement with life history data.

> **Update**: While no official funded project to collect and analyze steelhead collections from areas with uncertainty in population structure has been created, the WDFW Molecular Genetics Laboratory (MGL) has leveraged existing research projects to fill in holes in the dataset where possible. Ongoing research in the Chehalis River basin includes sampling spawning steelhead in tributaries for genetic analysis. No efforts have yet been taken to obtain representative collections from steelhead spawning in Willapa Bay tributaries. The WDFW MGL conducts all genetic analyses of *O. mykiss* with 192 high-resolution single nucleotide polymorphism (SNP) markers, which are appropriate for most research objectives. Additional SNP markers are identified and added when necessary to meet research objectives.

DIVERSITY AND SPATIAL STRUCTURE

Recommendation 7-1. Evaluate and modify management actions to promote local adaptation, increase and maintain the diversity within and among populations, and sustain and maximize the long-term productivity of populations.

> **Update**: See Recommendation 2-1

Recommendation 7-2. Design and initiate a program to monitor the genotypic and phenotypic characteristics of steelhead populations and a management structure for analysis and reporting. Phenotypic characteristics include migration or spawn timing, age structure, and size at age. Expanding the scope of the Salmonid Stock Inventory (SaSI) to include data pertaining to diversity and spatial structure as well as spawner abundance data would promote concurrent reporting of all four of the viable salmonid population (VSP) characteristics.

> **Update**: See Recommendation 2-4

Recommendation 7-3. Enhance GIS capabilities by creating spatial data layers that identify barriers to fish passage, by incorporating additional variables into the model developed in this paper for predicting fish distribution, and by annually mapping the distribution of redds.

> **Update**: See Recommendation 3-5. The statewide extent of annual mapping of redd distribution was not reviewed.

ABUNDANCE AND PRODUCTIVITY

Recommendation 8-1. Prioritize monitoring, solicit funding, develop alternative estimation methods and sample designs, and enlist the assistance of other organizations to increase the percentage of populations assessed on a regular basis.

> **Update:** Numerous improvements to monitoring have occurred throughout the state. We now utilize PIT tag detection arrays and AUC redd surveys in the UCR, PIT tag detection arrays and dam counts in the Yakima Basin (MCR DPS), and are working towards PIT tag-based abundance estimation in the Snake River. Improvements in the LCR: a steelhead distribution model based on presence/absence surveys to improve redd-based abundance estimates; analytical method development and optimal sampling design (Liermann et al. 2014) to improve redd study designs; mark-recapture in Cowlitz tributaries to estimate redds/female to reduce reliance on Snow Creek demographics; and mark-resight snorkeling for all summer-run populations to obtain all VSP parameters.

Recommendation 8-2. Ensure that the technical expertise of WDFW is available to local planning groups and governments to assist in the identification of the habitat factors reducing the viability of steelhead populations. Provide web access to map-based information on the stream reaches of high value for protection and restoration actions.

> **Update**: See Recommendation 3-1

Recommendation 8-3. Enhance the ability of local planning groups to effectively pursue new funding opportunities and efficiently use existing fund sources by developing a web application that identifies a schedule of priority habitat protection areas and restoration projects.

> **Update**: See Recommendation 3-2

Recommendation 8-4. Through a recently initiated project to evaluate the feasibility of developing habitat conservation plans for the Hydraulic Project Approval (HPA) program, and for WDFW owned and managed wildlife areas: a) assess the potential impacts of WDFW land management activities on steelhead; b) assess the potential impacts of HPA-permitted activities on steelhead; c) evaluate potential conservation measures to fully mitigate for adverse impacts resulting from HPA permitted activities; d) identify HPA activities that will require new research or monitoring efforts to assess impacts and potential mitigation measures; and e) develop tools and strategies to facilitate the monitoring, tracking, and adaptive management of HPA activities.

> **Update**: Not reviewed

Recommendation 8-5. Develop and implement a consistent method for using remote sensing data to monitor trends in the status of habitat. Many planning forums require or would benefit from information about the status and trends of habitat across Washington State. This coarse-scale information, in various forms, is widely available through remote sensing but little effort has been given to standardizing products to meet multiple stakeholder needs simultaneously or in providing a template upon which future updates can be made.

> **Update**: See Recommendation 3-5

Recommendation 8-6. Reassess the status of all populations in Washington on a 4 to 8 year cycle to assure that opportunities for early action are not missed. Use PVA to filter spawner abundance data and, for populations identified to have a potential conservation concern, broaden the analysis to evaluate the contribution of rainbow trout to population viability, the previous performance of the population, and factors affecting population status.

> **Update**: Status reassessment is included in this report, however further improvements to viability modeling are needed. Specifically, models that incorporate density dependence are needed. We have not fully evaluated the contribution of rainbow trout to population viability.

Recommendation 8-7. Annually monitor and review the status of populations at risk, identify limiting factors, and assess the effectiveness of management actions. If necessary, implement new programs to address limiting factors, and potentially initiate "rescue programs" like kelt reconditioning or hatchery supplementation to conserve natural populations until limiting factors are addressed.

> **Update**: This report identifies and reviews status of populations at risk, identifies limiting factors, and provides some assessment of management action effectiveness.