ESA Recovery Plan for the Puget Sound Steelhead Distinct Population Segment

(Oncorhynchus mykiss)

West Coast Regional Office

National Marine Fisheries Service

National Oceanic and Atmospheric Administration

ESA RECOVERY PLAN
FOR THE PUGET SOUND STEELHEAD
DISTINCT POPULATION SEGMENT
(Oncorhynchus mykiss)

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Cover photo: Adult steelhead. Credit: Morgan Bond.

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Acronyms and Abbreviations

AQI	Aquatic Inventories Project
BLM	Bureau of Land Management
BMP	Best Management Practice
BRT	Biological Review Team
CAO	Critical Area Ordinance
CIG	Climate Impact Group
CREP	Conservation Reserve Enhancement Program
CWA	Clean Water Act
DIP	Demographically Independent Population
DNR	Washington State Department of Natural Resources
DPS	Distinct Population Segment
DSS	Decision Support System
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
FBRB	Fish Barrier Removal Board
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FFFPP	Family Forest Fish Passage Program
FMEP	Fishery Management Evaluation Plan
FPDSI	Fish Passage and Diversion Screening Inventory
FRN	Federal Register Notice
GAO	U.S. Government Accountability Office
GSRO	Governor's Salmon Recovery Office
GMA	Washington State Growth Management Act
HCP	Habitat Conservation Plan
HGMP	Hatchery Genetic Management Plan
HPA	Hydraulic Project Approval
HUC	Hydrologic Unit Code
IP	Intrinsic Potential
IPCC	Intergovernmental Panel on Climate Change
LE	Lead Entity
LiDAR	Light Detection and Ranging remote sensing method
MMPA	Marine Mammal Protection Act
MPG	Major Population Group
N/A	Not Applicable
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration (NOAA Fisheries)
NRCS	National Resources Conservation Service
NWFP	Northwest Forest Plan
NWFSC	Northwest Fisheries Science Center

NWR	Northwest Region (of NOAA Fisheries) (Merged with Southwest Region to form West Coast Region on 10/1/13)
O&M	Operation and Maintenance
PBDE	Polybrominated diphenyl ethers
PCSRF	Pacific Coast Salmon Recovery Funds
PDO	Pacific Decadal Oscillation
PFMC	Pacific Fisheries Management Council
PSAR	Puget Sound Acquisition and Restoration
PSP	Puget Sound Partnership
PSSRC	Puget Sound Salmon Recovery Council
PSSTRT	Puget Sound Steelhead Technical Recovery Team
R/S	Recruits per Spawner
RCO	Recreation and Conservation Office
RMAP	Road Maintenance and Abandonment Plan
RM&E	Research, Management and Evaluation
SEPA	State Environmental Policy Act
SMA	Shoreline Management Act
SRFB	Salmon Recovery Funding Board
TMDL	Total Maximum Daily Load
TRT	Technical Recovery Team
UGA	Urban Growth Area
USACE	U.S. Army Corps of Engineers (or Corps')
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
USFWS	U.S. Fish and Wildlife Service
VSP	Viable Salmonid Population
WDFW	Washington Dept. Fish and Wildlife
WDOE	Washington Dept. of Ecology (or Ecology)
WSDOT	Washington Dept. of Transportation

Preface

This recovery plan (Plan) for Puget Sound steelhead has been developed pursuant to the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 et seq.). The Plan was produced through wide collaboration of the Puget Sound Steelhead Recovery Team and with helpful comments and suggestions from the state of Washington, tribes, other federal agencies, local governments, representatives of industry and environmental groups, and many others. This final ESA recovery plan also contains changes made in response to comments to the 2018 proposed recovery plan, which was released for public review in December 2018 (83 FR 64110, December 13, 2018).

Congress passed the Endangered Species Act to provide a means to conserve the ecosystems upon which endangered and threatened species depend, to provide a program for the conservation of such endangered and threatened species, and to take such steps as may be appropriate to achieve the purposes of the treaties and conventions that conserve such species. The National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) share responsibilities for the administration of the ESA. NMFS is responsible for recovering and conserving most ESA-listed marine and anadromous species, including the Puget Sound Steelhead (*Oncorhynchus mykiss*) Distinct Population Segment (DPS).

To help identify and guide recovery needs for listed species, section 4(f) of the ESA directs the Secretaries of Commerce and Interior to develop and implement recovery plans for listed species. A recovery plan must include, to the maximum extent practicable: (1) a description of site-specific management actions necessary to conserve the species; (2) objective, measurable criteria that, when met, will allow the species to be removed from the endangered and threatened species list; and (3) estimates of the time and funding required to achieve the plan's goals.

The goals and objectives of this recovery plan can be achieved only if a long-term commitment is made to support the actions recommended herein. Achievement of these goals and objectives will require the continued cooperation of the governments of the United States and other nations. Within the United States, the shared resources and cooperative involvement of federal, state, tribal, and local governments, industry, academia, nongovernmental organizations, and individuals will be required throughout the recovery period.

Executive Summary

Introduction

This recovery plan (Plan or recovery plan) provides guidance for the protection and recovery of Puget Sound steelhead, a listed threatened species under the federal Endangered Species Act (ESA). NOAA's National Marine Fisheries Service (NMFS) recognizes Puget Sound steelhead as a distinct population segment (DPS)[1] of steelhead *(Oncorhynchus mykiss).* The Puget Sound steelhead DPS (shown in Figure ES-1) includes all naturally spawned steelhead originating below natural and manmade impassable barriers in rivers flowing into Puget Sound from the Elwha River (inclusive) eastward, including rivers in Hood Canal, South Sound, North Sound, and the Strait of Georgia. The DPS includes steelhead from six artificial propagation programs.

At one time, rivers, streams, and estuaries along the shores of Puget Sound teemed each year with steelhead returning from the Pacific Ocean to their natal spawning grounds. The historical abundance of the fish is unknown, but commercial catch records and news articles indicate that 409,000 to 930,000 adult steelhead returned each year to Puget Sound at the end of the 19th Century. These runs played an integral role in the lives of Indian tribes that lived in the region, as well as for many of the people who settled in the area.

The once healthy and abundant runs of steelhead began to decline in the late 1800s and continued to decline through the 1900s. In recent years, significantly fewer steelhead have returned to Puget Sound; the current run is less than 5–10 percent of its historical size, and productivity continues to decline (Hard et al. 2015; NMFS 2016). NMFS listed Puget Sound steelhead as a threatened species under the ESA in 2007 (72 FR 26722, May 11, 2007). Since then, periodic NMFS reviews of the species' status have determined that the "threatened" classification remained appropriate.

This recovery plan provides guidance to recover the species to the point that it can be naturally self-sustaining over the long term. To achieve full recovery, steelhead populations in Puget Sound need to be robust enough to withstand natural environmental variation and some catastrophic events, and they should be resilient enough to support harvest and habitat loss due to human population growth. The Plan aims to improve steelhead viability by addressing the pressures that contribute to the current condition: habitat loss/ degradation, water withdrawals, declining water quality, fish passage barriers, dam operations, harvest, hatcheries, climate change effects, and reduced early marine survival. As directed by Section 4(f) of the ESA, the Plan describes: (1) site-specific management actions necessary to achieve the Plan's goals; (2) recovery goals and objective, measurable criteria which, when met, will result in a determination that the species be removed from the threatened and endangered species list; and (3) estimates of the time required and cost to carry out the Plan's goals. NMFS will use the recovery plan to organize and coordinate recovery of the species in partnership with state, local, tribal, and federal resource managers, and the many watershed restoration partners in the Puget Sound.

[1] A DPS is a group of steelhead that is discrete from other groups of the same species and that represents an important component of the evolutionary legacy of the species. Under the ESA, a DPS is treated as a species.

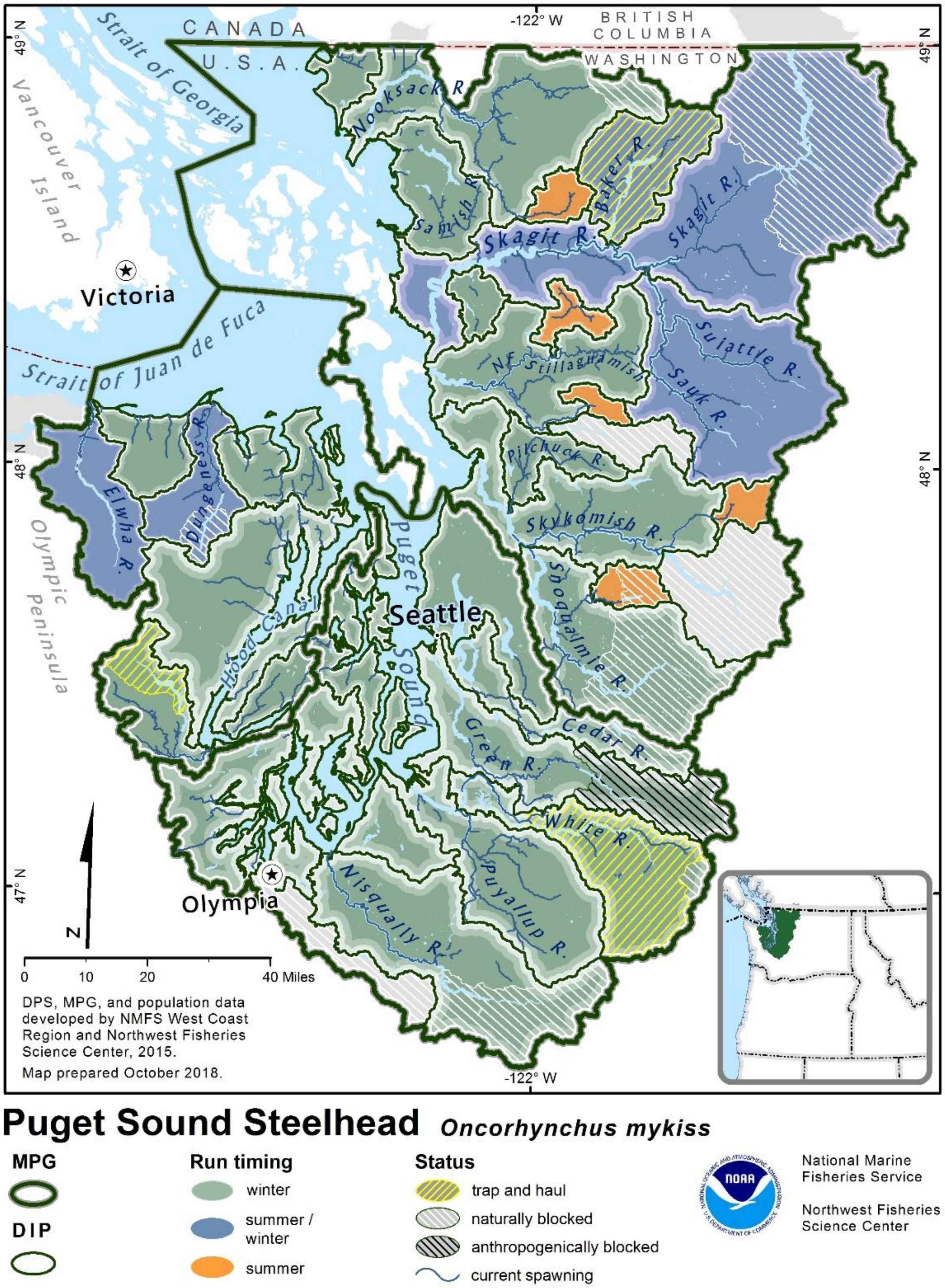

Figure ES-1. Puget Sound steelhead DPS and associated Major Population Groups (MPGs) and Demographically Independent Populations (DIPs).

Steelhead Life History and Habitat Requirements

Steelhead display a diverse range of life-history traits and use a wide variety of freshwater habitats throughout Puget Sound watersheds. Unlike salmon species, steelhead are iteroparous, capable of repeat spawning in successive years, and they have a resident life-history form (Rainbow trout) that is capable of producing anadromous offspring and interbreeding with anadromous life forms. Adult steelhead also have a leaping ability that exceeds salmon, which allows them to migrate far into the headwater reaches of watersheds.

Adult Puget Sound steelhead commonly return from the ocean after two to three years to spawning and rearing habitats in independent tributaries that flow into Puget Sound, Hood Canal, and the Strait of Juan de Fuca. Steelhead generally reside longer in freshwater than salmon species (commonly one to four years) and use diverse tributary habitats with cool, clean water. Channel features such as side channels, adjacent small tributaries and floodplains, and abundant large wood and coarse substrate (boulders and cobble) provide important habitat for juvenile steelhead, including as cover from predators and as refuge from fall and winter floods.

While steelhead show a high degree of diversity in their life-history traits, they exhibit two general types of life-history strategies: Winter-run steelhead return from the ocean in the fall and typically spawn in the spring; summer-run steelhead migrate into natal streams from the ocean during the late spring and summer, and hold for up to nine months in stream and river habitats with deep pools, diverse instream cover, and cool water before spawning in late-winter/early spring of the following year. Their early migration allows them upstream access through canyons and other confined channel areas that become flow barriers to winter-run steelhead later in the year. Most summer-run steelhead spawning areas in Puget Sound are located in headwater areas above narrow canyons. However, since the habitat features needed to sustain summer-run steelhead populations are uncommon in most Puget Sound watersheds, winter-run steelhead populations are the predominant life-history strategy.

Photo: Steelhead. Credit: Morgan Bond.

Factors Leading to ESA-Listing and Remaining Pressures

At the time of listing, NMFS identified several factors that led to the decline of Puget Sound steelhead and the determination that listing the species as threatened was warranted: widespread declines in abundance and productivity for most natural steelhead populations in the DPS — including the populations in the Skagit and Snohomish rivers, which previously were considered steelhead strongholds; the low abundance of several summer-run populations; and the sharply diminishing abundance of some steelhead populations, especially in south Puget Sound, Hood Canal, and the Strait of Juan de Fuca. Continued releases of out-of-DPS hatchery fish from Skamania-derived summer run were considered a major concern for diversity in the DPS (Hard et al. 2007).

The PSSTRT Viability Criteria document (Hard et al. 2015) found that while harvest and hatchery production of steelhead in Puget Sound were currently at low levels and not likely to increase substantially in the foreseeable future, some unfavorable environmental trends existed and were expected to continue. Habitat utilization by steelhead has been most affected by the degradation and fragmentation of freshwater habitats. Large dams in some watersheds have reduced abundance of steelhead populations and their limited their distribution within and among watersheds. In addition to eliminating access to habitat, dams affect habitat quality through changes in river hydrology, temperature profile, downstream gravel recruitment, and the movement of large wood. Many of the lower reaches of rivers and their tributaries in Puget Sound have been dramatically altered by urban development. Urbanization and suburbanization have resulted in the loss of historical forested landscapes in exchange for large areas of imperious surface (buildings, roads, parking lots, etc.). The human-related pressures have resulted in severe degradation of freshwater steelhead habitat and have reduced the species' abundance and productivity.

During the recovery plan development process, NMFS discussed steelhead habitat needs with many of the public and private parties whose future actions will help reduce the human-related pressures. NMFS also formed the Puget Sound Steelhead Recovery Team to assist in preparing the draft Plan. The recovery team included representatives from the Washington Department of Fish and Wildlife, Northwest Indian Fisheries Commission, Puget Sound Partnership, Seattle City Light, Long Live the Kings, Nooksack Indian Tribe, NMFS, and NMFS Northwest Fisheries Science Center.

The recovery team identified 10 primary pressures associated with the listing decision for Puget Sound steelhead and subsequent affirmations of the listing. These "pressures" are human activities and natural events that cause or contribute to the species' decline in viability. The 10 primary pressures are: fish passage barriers at road crossings; dams, including fish passage and flood control; floodplain impairments, including agriculture; residential, commercial, industrial development (including impervious runoff); timber management activities; water withdrawals and altered flows; ecological and genetic interactions between hatchery and natural-origin fish; harvest pressures (including selective harvest) on wild fish; juvenile mortality in estuary and marine waters of Puget Sound; and climate change. These pressures are described in Section 1.2.3 and addressed by the recovery strategies and actions for the species in Chapter 3 and Appendix 4.

Recovery Goals and Criteria

The recovery plan provides NMFS' recovery goals for the Puget Sound steelhead DPS in Chapter 2 and criteria for delisting in Chapter 4. The Plan reflects agreements made through a collaborative process initiated by NMFS and strengthened through wide regional and local participation.

ESA Recovery Goals

- The Puget Sound steelhead DPS achieves biological viability and the ecosystems upon which the DPS depends are conserved such that it is sustainable and persistent and no longer needs federal protection under the ESA, and
- The five listing factors from the ESA, section 4(a)(1), are addressed.

Recovery (Delisting) Criteria

NMFS uses two types of criteria to determine whether a species can be delisted:

Viability Criteria are the criteria NMFS will consider in determining whether the species has achieved a biological status consistent with recovery. The overarching viability criterion for Puget Sound steelhead is that the DPS "has a negligible risk of extinction due to threats from demographic variation, local environmental variation, and genetic diversity changes over a 100-year time frame" based on the status of major population groups (MPGs) and demographically independent populations (DIPs), and supporting ecosystems (McElhany et al. 2000). A self-sustaining viable population has a negligible risk of extinction due to reasonably foreseeable changes in circumstances affecting its abundance, productivity, spatial structure, and diversity characteristics and achieves these characteristics without dependence upon artificial propagation (see Section 4.2.2.1 for specific viability delisting criteria).

Listing Factor Criteria are the criteria that NMFS will evaluate to determine whether the underlying causes of steelhead decline have been addressed and mitigated and are not likely to re-emerge in the foreseeable future. The criteria address the five listing factors from the ESA section 4(a)(1): (A) the present or threatened destruction, modification, or curtailment of the species' habitat or range; (B) over-utilization for commercial, recreational, scientific, or educational purposes; (C) disease or predation; (D) inadequacy of existing regulatory mechanisms; and (E) other natural or human-made factors affecting the species' continued existence (see Section 4.3 for specific listing factor delisting criteria).

DPS Viability Criteria

The viability criteria for Puget Sound steelhead require that all three of the species MPGs (the Central and South Puget Sound MPG, Hood Canal and Strait of Juan de Fuca MPG, and North Cascades MPG) need to be viable for the DPS to be removed from the ESA's threatened and endangered species list. Currently, all three MPGs remain at low viability. Section 4.2.2 describes the DPS viability criteria and identify priority populations and watersheds in the three MPGs. Section 3.3 summaries the MPG-level strategies and actions to achieve recovery.

Recovery Strategies and Actions

The recovery strategy for Puget Sound steelhead has a single overriding focus: increasing productive habitats. Protecting existing high quality habitats and restoring impaired ecosystem functions and freshwater habitats will specifically benefit steelhead in the spawning and juvenile rearing life stages. Complementary strategies aim to improve early marine survival and ensure that fisheries management (harvest and hatcheries) is consistent with recovery. Collectively, these strategies address the 10 primary pressures (discussed earlier) that threaten Puget Sound steelhead recovery. They also describe research, monitoring, and evaluation needs. Chapter 3 and Appendix 4 describe the site-specific strategies and associated actions. Additional actions will be identified and prioritized by local recovery planners during watershed-level planning efforts to target specific pressures and stressors at the DIP level.

Recovery Strategies

Strategies to Improve Fish Passage

1. Maintain and increase support for the Fish Barrier Removal Board and related programs.
2. Highlight and remedy programmatic gaps in fish barrier removal programs.
3. Provide funding and resources for fish barrier removal.
4. Increase the use of education, social science, and social marketing programs that support fish passage barrier removal.
5. Align fish passage correction programs for consistency among federal, state, cities, counties, and private entities.
6. Prohibit new fish passage barriers.
7. Increase monitoring, data collection, information sharing, and reporting of fish passage correction progress.
8. Incorporate the benefits of beaver in barrier removal programs.

Strategies to Address Effects of Dams

1. Pursue current opportunities and identify future priorities for dam removal in watersheds where steelhead migration has been blocked.
2. Provide funding and resources for dam removal.
3. Remove high-priority dams that block or impair steelhead migration into historical spawning and rearing areas.
4. Construct or improve fish passage facilities at dams, locks, and water diversions where steelhead migration is blocked or impaired. Reduce passage injuries and mortalities at these facilities.
5. Increase education, social science, and social marketing about the effects of dams.
6. Dis-incentivize new dams, locks, and water diversion structures.
7. Improve instream flows downstream of hydroelectric dams and water storage reservoirs.
8. Using mitigation/restoration, improve habitat conditions downstream of hydroelectric dams and water storage reservoirs.
9. Improve temperature and water quality conditions downstream of hydroelectric dams and water storage reservoirs.

Strategies to Improve Floodplain Connectivity and Condition

1. Protect intact floodplains using effective land use regulations and enforcement.
2. Identify and protect floodplains and freshwater wetlands for steelhead by funding and implementing farm-fish-flood integrated planning programs at the local level.

3. Reduce levee impacts through setbacks and improved vegetation management.
4. Reduce bank armoring and other habitat stressors in steelhead river systems.
5. Educate the community to reduce bank armoring and other habitat stressors in steelhead river systems.

Strategies to Address Effects of Residential, Commercial, Industrial Development

1. Reduce impediments to infill and redevelopment in Urban Growth Areas.
2. Improve local implementation and enforcement of Growth Management Act existing regulations that protect streams and wetlands from residential/ commercial/ industrial development.
3. Incentivize protection of priority habitat areas beyond those covered via regulations.
4. Increase the use of, and compliance with, mitigation to offset impacts of development.
5. Improve federal and state highway maintenance and management to reduce impacts to steelhead.
6. Improve county and city road maintenance and new road development.
7. Align infrastructure improvements with steelhead recovery at the federal, state and local level.
8. Consider climate change impacts in planning and permitting.

Strategies to Address Effects of Timber Management

1. Support state and private landowner efforts to monitor forest practices rule compliance and effectiveness.
2. Collaborate on water temperature monitoring and modeling.
3. Explore potential funding and financial incentives for restoration discussions with timber companies on HCP lands.
4. Improve accuracy of water-type classifications to ensure steelhead habitats are protected (per WAC 222-16-010).
5. Improve fish passage at artificial barriers.
6. Implement best science practices on non-HCP forest lands.
7. Prioritize forest riparian restoration with Clean Water Act 303d listings on non-HCP lands.
8. Implement the Northwest Forest Plan (U.S. Forest Service for federally managed forestlands).

Strategies to Improve Instream Flows during Critical Periods

1. Identify, protect, and preserve instream flows for steelhead.
2. Maintain, restore, or improve instream flows by establishing and protecting tribal, state, and federal water rights; restricting permit-exempt wells that remove groundwater in areas that are hydraulically linked to waterways with low summer flows; enforcing regulations; and improving transparency, efficiency, and accountability.
3. Develop and implement incentive programs to protect and restore instream flows for steelhead.
4. Protect uplands to improve hydrological characteristics of watersheds; protect groundwater recharge areas to improve infiltration of precipitation and runoff into aquifers.
5. Improve instream flow protections and water rights for fish on federal lands.
6. Through the Habitat Conservation Plan process, provide long-term protections and conservation measures to meet steelhead instream flow needs.
7. Restore instream flows for steelhead in over-allocated watersheds.
8. Identify, develop, and fund habitat restoration projects that improved stream flows for steelhead spawning, rearing and migration.

Strategies to Reduce Negative Effects and Improve the Conservation Benefits of Hatchery Programs

1. Be intentional in the purpose of the hatchery program.
2. Be accountable for reducing risks of hatchery programs on natural-origin steelhead.

3. Adapt to new information and challenges in the operation and management of hatcheries.

Strategies to Reduce Harvest Pressures on Natural-Origin Fish

1. Coordinate harvest among all co-managers so that the collective impacts to each population are consistent with recovery goals, and associated management plans and biological opinions.

Strategies to Reduce Early Marine Mortality and Predation

1. Continue predation research and monitoring, with a focus on areas of greatest steelhead early marine mortality.
2. Assess and test the effectiveness of specific actions to alter harbor seal behavior at locations associated with high steelhead mortality. Thoroughly assess whether predator distribution will be adequately altered and evaluate unexpected consequences.
3. Implement regional actions to allow for testing the effectiveness of site-specific marine mammal management in support of steelhead recovery.
4. Support efforts to recover or enhance the abundance of forage fish as buffer prey.
5. Support efforts to recover or enhance the abundance of other prey historically important to harbor seals and other predators of concern (e.g., hake, cod, and rockfish).
6. Address high steelhead mortality at the Hood Canal Bridge through structural modifications or through management approaches to facilitate steelhead passage or alter predator behavior during the steelhead outmigration period.
7. Determine if hatchery fish act as a predator attractant and/or buffer prey, or both, in relation to steelhead early marine survival.
8. Implement actions to address *Nanophyetus salmincola* in watersheds where the parasite is prevalent and at high enough intensities to influence the health and survival of out-migrating juvenile steelhead.
9. Implement actions to identify and reduce/or eliminate contaminants suspected of affecting steelhead smolt condition.
10. Implement long-term monitoring protocol to continue to assess steelhead early marine mortality rates and distribution, and compare to freshwater and later ocean mortality.

Strategies to Reduce Impacts of Climate Change

1. By watershed, identify and prioritize climate change adaptation strategies and recovery actions that explicitly include climate change as a risk to steelhead.
2. Increase strategies or actions in other parts of the recovery plan that increase freshwater and fish connectivity, and thus increase life-history diversity, for populations and MPGs across Puget Sound.
3. Increase strategies and actions in other parts of the recovery plan that address stream temperatures and instream flows suitable for Puget Sound steelhead to maximize resiliency of aquatic systems to climate change.
4. Incorporate climate change adaptations into other steelhead recovery strategies and actions where appropriate.
5. At the MPG or population scale, use decision support tools available to prioritize and fund projects for both the 4-year work plans and annual funding rounds. All restoration projects submitted for funding should be required to demonstrate how they consider climate change and how they are designed to achieve, as much as possible, desired outcomes given future climate projections.
6. Monitor steelhead abundance, productivity, diversity, and spatial structure to detect specific impacts of climate change.

Strategies to Integrate Research, Monitoring, and Evaluations

1. Significantly improve status and trends monitoring to estimate steelhead freshwater productivity and marine survival.
2. Develop and maintain a long-term program to monitor the status and trends of steelhead habitat in Puget Sound.
3. Maintain and advance research programs intended to quantify the population viability benefits from recovery actions.
4. Identify linkages between steelhead life-history diversity and population viability.
5. Implement long-term monitoring protocol to continue to assess steelhead early marine mortality rates and distribution, and compare to freshwater and later ocean mortality.

Implementation

Ultimately, the recovery of Puget Sound steelhead depends on the commitment and dedicated actions of the many entities, tribes, agencies, and individuals who share responsibility for the species' future. Together, we face a common problem: We need to return the species to a level where we are confident that it is viable and naturally self-sustaining into the future.

During implementation of the recovery plan, NMFS anticipates the continued execution of ongoing programs, management actions and regulations, as well as the implementation of many new actions proposed in this Plan to address pressures on steelhead viability across the Puget Sound region. Importantly, the Plan includes an adaptive management process so we learn as we go, and adjust our efforts accordingly. Implementation of the adaptive management process will help us target actions based on best available science, monitor to improve the science, and update actions effectively based on new knowledge to achieve DPS recovery and delisting.

Implementing strategies and actions will require close coordination among restoration partners and co-managers (see Sections 1.3 and 1.4). NMFS will work with recovery partners to develop and integrate Plan implementation into existing recovery forums, such as the Puget Sound Salmon Recovery Council (PSSRC), Puget Sound Partnership Leadership Council, and the Washington State Salmon Recovery Funding Board (SRFB). NMFS intends to work closely with these and other entities in Puget Sound to coordinate decisions regarding the prioritization and implementation of recovery actions and to facilitate sharing of research and monitoring information. NMFS will make this information available on our web site.

Attaining ESA recovery for Puget Sound steelhead will not be an easy task. It will take all regional partners working together.

Time and Cost Estimates

The time needed to recover Puget Sound steelhead will likely depend on how much funding and resources are delivered to recovery efforts, and how early marine survival is ultimately addressed. Under any scenario, the time to recovery will take many decades and will depend on several variables: the continued implementation of ongoing actions, including actions that benefit Puget Sound Chinook and Chum salmon recovery; the implementation of regulatory mechanisms to protect habitat; the adequacy of funding for adaptive management to inform key uncertainties; the response of natural-origin steelhead to hatchery management improvements; the effectiveness of actions to improve early marine survival; and the effects of emerging large-scale ecological factors, such as changing ocean conditions and climate, on the species. Overall, since habitat protection and restoration efforts comprise the largest potential gains for steelhead viability — and needed improvements in habitat conditions can take decades to achieve — it may be 100 years before full protection and restoration efforts would lead to recovery.

NMFS believes that it is most appropriate to focus on the first 10 years of action implementation. We will rely on the adaptive management framework's structured process to conduct monitoring to improve the science, and on periodic plan reviews to evaluate the status of the species and add, eliminate, or modify actions based on new knowledge. Section 5.2 of the Plan provides 10-year cost estimates for Puget Sound steelhead recovery. In general, the cost estimates for Puget Sound steelhead build on the costs projected to recover Puget Sound Chinook and Hood Canal summer-run Chum salmon, both threatened species. According to 2016 cost estimates provided by the Washington Governor's Salmon Recovery Office (GSRO), the total estimated cost (capital and non-capital costs) to implement the Puget Sound Chinook and Chum salmon recovery plans is approximately $200 million per year, or $2 billion total over the next ten years (GSRO 2016). However, recovery efforts for those species have received an average of $52 million/year, a shortfall of $148 million/year.

NMFS' cost projections for steelhead recovery recognize the lack of full funding for salmon recovery efforts and that there are additional costs that apply more directly to steelhead recovery and less to Chinook and Chum salmon. These costs include (1) correcting shortfalls in funding for Chinook and summer-run Chum salmon where steelhead are also present; (2) additional funding for restoration of habitat occupied by steelhead but not Chinook and summer-run Chum salmon; (3) remedying fish passage barriers at road crossings and providing passage at (or removing) dams; (4) addressing early marine survival impediments; and (5) additional funds for gaps in monitoring and adaptive management.

Our estimated costs to recover Puget Sound steelhead address existing shortfalls and identify costs that apply directly to steelhead. We estimate that over the next 10 years (2020 to 2030) $1.48 billion will be needed for stream restoration and protection and $437 million will be needed to provide fish passage (at culverts and dams) to historic reaches of Puget Sound steelhead habitat that are not used by Chinook or Chum salmon. In addition, we estimate that $38 million will be needed to monitor and adaptively manage steelhead for the next 10 years. Additional funds will be needed to remedy early marine survival impacts to steelhead, but these costs are currently unknown. As adaptive management continues to improve our understanding of early marine migration impediments to recovery, costs will be developed and included with future iterations of this planning effort.

1. Introduction

This is an Endangered Species Act (ESA) recovery plan (Plan or recovery plan) for Puget Sound steelhead *(Oncorhynchus mykiss).* NOAA's National Marine Fisheries Service (NMFS) is required, pursuant to section 4(f) of the ESA, to develop and implement recovery plans for species listed under the ESA. The Plan focuses on steelhead that spawn and rear in tributaries of Puget Sound.

The Plan provides direction for the protection and conservation of the Puget Sound steelhead distinct population segment (DPS). A DPS is a group of salmon or steelhead that is discrete from other groups of the same species and that represents an important component of the evolutionary legacy of the species. Under the ESA, a DPS is treated as a species. The Puget Sound steelhead DPS is considered threatened under the ESA — signaling that it is likely to become endangered in the foreseeable future unless actions are taken to improve its viability. By extension, a viable DPS is one that is unlikely to be at risk of extinction in the foreseeable future (Hard et al. 2015).

The Puget Sound steelhead DPS consists of all naturally spawned anadromous *O. mykiss* originating below natural and manmade impassable barriers from rivers flowing into Puget Sound from the Elwha River (inclusive) eastward, including rivers in Hood Canal, South Sound, North Sound and the Strait of Georgia (Figure 1). Also, the DPS includes steelhead from six artificial propagation programs: the Green River Natural Program; White River Winter Steelhead Supplementation Program; Hood Canal Steelhead Supplementation Off-station Projects in the Dewatto, Skokomish, and Duckabush rivers; and Lower Elwha Fish Hatchery Wild Steelhead Recovery Program (72 FR 26722, May 11, 2007).

1.1 Purpose of the Plan

The recovery plan is intended to guide efforts to improve the viability of the Puget Sound steelhead DPS and address the factors that contributed to the current degraded condition. It aims to recover the species to the point that it is naturally self-sustaining in the wild over the long term and no longer requires protection under the ESA. To achieve full recovery, steelhead populations in Puget Sound need to be robust enough to withstand natural environmental variation and even some catastrophic events, and they should be resilient enough to support harvest and habitat loss due to human population growth (Hard et al. 2015).

1.1.1 Guidance for Action

This Plan provides guidance and specific planning targets to achieve recovery of Puget Sound steelhead at three hierarchical spatial scales (see Myers et al. 2015):

- **Distinct Population Segment (DPS).** A steelhead DPS is a distinctive group of steelhead that is uniquely adapted to a particular area or environment. Two criteria define a DPS of steelhead listed under the ESA: (1) discreteness of the population segment in relation to the remainder of the species to which it belongs, and (2) significance of the population segment to the species to which it belongs. DPSs may contain multiple populations that are connected by some degree of migration, and hence may have a broad geographic range across watersheds, river basins, and political jurisdictions.

- **Major Population Group (MPG).** Within a DPS, independent populations can be grouped into larger aggregates that share similar genetic, geographic, and/or habitat characteristics (McClure et al. 2003). MPGs are groupings of populations that are isolated from one another over a longer time scale than that defining the individual populations, but retain some degree of connectivity greater than that between different DPSs. An MPG is considered a "recovery unit" (see Interim Recovery Planning Guidance for Threatened and Endangered Species: https://www.fisheries.noaa.gov/national/endangered-species-conservation/endangered-species-act-guidance-policies-and-regulations) within a DPS and must be conserved to ensure the long-term viability of the species (Myers et al. 2015; Hard et al. 2015). In the context of Puget Sound steelhead recovery, all three MPGs must be viable for the DPS to be recovered (see Chapter 2).
- **Demographically Independent Populations (DIP).** McElhany et al. (2000) defined an independent population as: "…a group of fish of the same species that spawns in a particular lake or stream (or portion thereof) at a particular season and which, to a substantial degree, does not interbreed with fish from any other group spawning in a different place or in the same place at a different season." For purposes of this Plan, not interbreeding to a "substantial degree" means that two groups are considered to be independent populations if they are isolated to such an extent that exchanges of individuals among the populations do not substantially affect the population dynamics or extinction risk of the independent populations over a 100-year time frame.

DIPs exhibit different population attributes that influence their abundance, productivity, spatial structure, and diversity. They are the management units that will be combined by NMFS to form alternative recovery scenarios for MPG and DPS viability. Ultimately, except for the regional focus of Puget Sound marine waters, DIPs are the scale of recovery efforts (Myers et al. 2015). Each DIP, however, is not necessarily essential for the conservation of the species or necessarily included in the recovery scenarios (see Chapter 4). Figure 1 shows the Puget Sound steelhead DPS and associated MPGs and DIPs. Table 1 identifies the DIPs by numbers referenced in Figure 1.

Goal of this Recovery Plan

The primary recovery goal for Puget Sound steelhead is to ensure that the species is self-sustaining in the wild and no longer needs the protection of the ESA. A self-sustaining, viable DPS depends on the status of its component populations and major population groups and the ecosystems (e.g., habitats) that support them.

A self-sustaining viable population has a negligible risk of extinction due to reasonably foreseeable changes in circumstances affecting its abundance, productivity, spatial structure, and diversity characteristics over a 100-year time frame and achieves these characteristics without dependence upon artificial propagation. Artificial propagation may be used to benefit threatened and endangered species, and a self-sustaining population may include artificially propagated fish, but a self-sustaining population must not be dependent upon artificial propagation measures to achieve its viable characteristics.

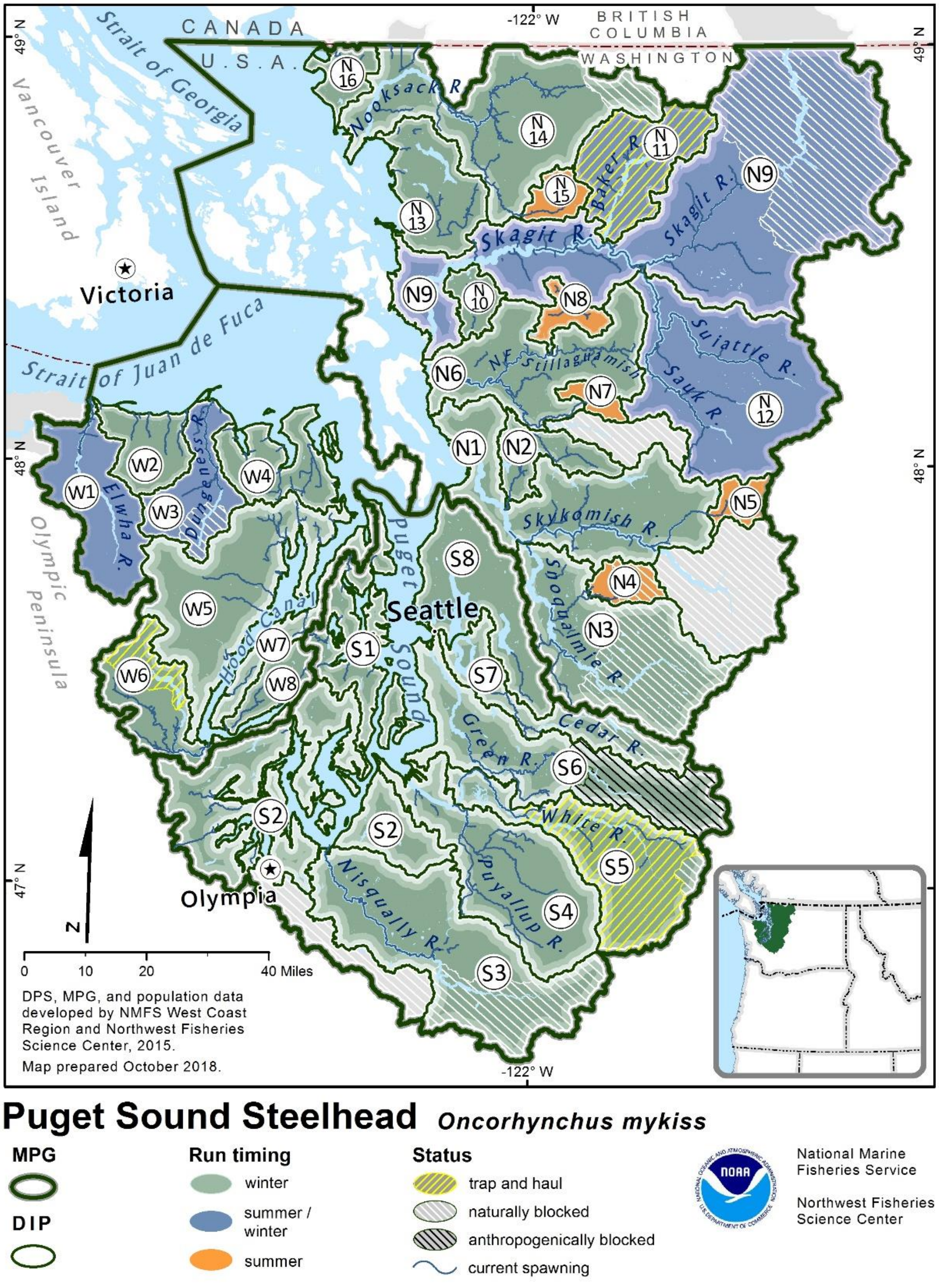

Figure 1. Puget Sound Steelhead DPS and associated major population groups (MPGs) and demographically independent populations (DIPs). Table 1 identifies the DIPs associated with the numbers referenced on the map.

Table 1. Puget Sound steelhead demographically independent populations (DIPs) by major population group (MPG). The numbers in the Figure 1 Reference column correspond to the DIP areas shown on Figure 1.

Figure 1 Reference	Demographically Independent Population by MPG
Northern Cascades (South Salish Sea) MPG	
N1	Snohomish/Skykomish rivers Winter Run
N2	Pilchuck River Winter Run
N3	Snoqualmie River Winter Run
N4	Tolt River Summer Run
N5	North Fork Skykomish River Summer Run
N6	Stillaguamish River Winter Run
N7	Canyon Creek Summer Run
N8	Deer Creek Summer Run
N9	Skagit River Summer Run and Winter Run
N10	Nookachamps Creek Winter Run
N11	Baker River Summer Run and Winter Run
N12	Sauk River Summer Run and Winter Run
N13	Samish River Winter Run
N14	Nooksack River Winter Run
N15	South Fork Nooksack River Summer Run
N16	Drayton Harbor Tributaries Winter Run
Central and South Puget Sound MPG	
S1	East Kitsap Peninsula Tributaries Winter Run
S2	South Puget Sound Tributaries Winter Run
S3	Nisqually River Winter Run
S4	Puyallup/Carbon rivers Winter Run
S5	White River Winter Run
S6	Green River Winter Run
S7	Cedar River Winter Run
S8	North Lake Washington and Lake Sammamish Winter Run
Hood Canal and Strait of Juan de Fuca MPG	
W1	Elwha River Winter Run (and possible Summer Run)
W2	Strait of Juan de Fuca Tributaries Winter Run
W3	Dungeness River Summer Run and Winter Run
W4	Sequim/Discovery Bays Tributaries Winter Run
W5	West Hood Canal Tributaries Winter Run
W6	Skokomish River Winter Run
W7	East Hood Canal Tributaries Winter Run
W8	South Hood Canal Tributaries Winter Run

1.1.2 Partners in Recovery

NMFS intends to use this recovery plan to organize and coordinate recovery of Puget Sound steelhead in partnership with local, state, and federal agencies, tribes, non-profit organizations, landowners, and other stakeholders. Accordingly, the recovery plan is intended to communicate recovery guidance to a variety of partners, including but not limited to:

- State and Tribal Co-managers — Treaty Tribes and Washington Department of Fish and Wildlife (WDFW)
- NMFS
- Puget Sound Partnership Leadership Council
- Puget Sound Partnership Ecosystem Coordination Board

- Puget Sound Partnership Science Panel
- State agencies
- Government land use planners, managers and decision makers (city, county, state, federal)
- Tribal communities
- Business communities
- Industrial landowners (agriculture, forestry, transportation)
- Port managers
- Water and storm water managers, flood control districts, and hydroelectric utilities
- Watershed groups and policy bodies for implementing salmonid recovery plans
- Grant managers and other funders
- Salmon Recovery Funding Board
- Puget Sound Salmon Recovery Council (PSSRC)
- Steelhead fishing community
- Project sponsors
- Conservation community
- Citizens and private landowners
- Scientists (steelhead, marine, habitat, and others)
- U.S. Fish and Wildlife Service (USFWS)
- Volunteer groups

Attaining ESA recovery for Puget Sound steelhead will not be an easy task; it will take all regional partners working together. Numerous organizations and individuals are currently implementing hundreds of recovery actions across Puget Sound, but more work is needed to ensure that the species survives into the future. This Plan defines goals and actions that build on past and current efforts, embracing the commitments of our many partners across the Puget Sound landscape whose continued involvement is needed to recover the species and restore the watershed conditions that will support future salmon and steelhead generations.

1.2 Why Puget Sound Steelhead are Listed as Threatened

At one time, the rivers, streams, and estuaries along the shores of Puget Sound teemed each year with steelhead returning from the Pacific Ocean to their natal spawning grounds. These runs played an integral role in the lives of Indian tribes that lived in the region, as well as for many of the people who later settled in the area.

The historical abundance of Puget Sound steelhead is impossible to estimate precisely. However, commercial catch records and news articles produced at the time indicate that an estimated 409,000 to 930,000 adult steelhead returned annually to Puget Sound streams at the end of the 19th Century (Myers et al. 2015; Hard et al. 2015).

Today, much smaller runs of steelhead return to Puget Sound. The current abundance of Puget Sound steelhead is less than 5–10 percent of the historical abundance, with productivity continuing to decline (Hard et al. 2015; NMFS 2016). The once mighty runs began to decline in the late 1800s, largely due to overfishing. The runs continued to drop through the 1900s with the expansion of human activities. Factors contributing to the decline of Puget Sound steelhead include habitat loss and degradation, water withdrawals and altered flows, declining water quality, blocked or restricted fish passage, reduced early marine survival, and effects from harvest, hatcheries, and climate change. This Plan addresses each of these factors while identifying paths toward steelhead recovery across Puget Sound.

To address the proximal factors contributing to the decline of Puget Sound steelhead, we describe the life-history characteristics of steelhead and the human-related pressures that limit their productivity and abundance in Puget Sound (Chapter 1). We then describe our goals and overarching strategy for recovery (Chapter 2) and identify strategies and actions to ameliorate the pressures (Chapter 3). Appendix 4 describes the specific strategies and actions in more detail. As watershed-specific planning activities are developed, NMFS will add those plans on our web page.

1.2.1 Ecosystem/Habitat Requirements of Steelhead

Steelhead display a wide range of life-history traits and use a wide variety of freshwater habitats throughout Puget Sound watersheds. Unlike the salmon species of the same genus *Oncorhynchus*, steelhead are iteroparous, capable of repeat spawning in successive years. Steelhead also have a resident life-history form (Rainbow trout), that is capable of producing anadromous offspring and interbreeding with anadromous life forms. Their run timing (return to freshwater from ocean residency) can span nine months or more. Steelhead are known to ascend small tributaries that are inaccessible to salmon. They use independent tributaries that flow directly into Puget Sound, Hood Canal, and the Strait of Juan de Fuca while Chinook salmon are largely isolated to major rivers. Adult steelhead also have a leaping ability that exceeds salmon (Reiser and Peacock 1985), which allows the distribution of steelhead to frequently extend far into the headwater reaches of watersheds. Lastly, juvenile steelhead commonly reside longer in freshwater than salmon species (1–4 years). The high degree of diversity and plasticity in the steelhead life history makes this species unique among salmonids in Puget Sound.

Steelhead use diverse habitats while rearing in freshwater streams. Like other salmonids, steelhead require cool, clean water to survive. Because steelhead are exothermic, they cannot regulate their body temperature in elevated stream temperature environments without a source of cool water (e.g., ground water, seeps, and hyporheic sources). Juvenile steelhead begin losing competitive interactions with non-salmonids and become increasingly susceptible to disease and parasites at 20°C (Reeves et al. 1987); they face lethal conditions when temperatures reach 24–26°C (Brett 1952; Bell 1986; McCullough 1999). Adult summer-run steelhead returning to spawn are even more susceptible to elevated temperatures. The physiological effects of elevated temperatures on summer-run adult steelhead is profound as they must endure up to nine months in streams (including summer months) while their gametes mature before spawning.

Because steelhead rear in rivers and streams for extended periods, their habitat requirements change as they grow and compete for resources. They need shallow stream margins, side channels, and other slow-moving channel features as emergent fry (Frissell 1992; Hines et al. 2017). Within the summer of their first year, they begin to move toward the center of the channel and, unlike salmon, juvenile steelhead develop territorial behaviors in diverse habitats that include pools, riffles, and cascades (Hartman 1965). Cover is an important component of juvenile habitat selection. Channel features such as side channels, adjacent small tributaries and floodplains, and abundant large wood and coarse substrate (boulders and cobble) provide important habitat for juvenile steelhead seeking cover from predators and refuge from fall and winter floods (Bustard and Narver 1975; Sedell et al. 1990; Fausch 1993; Ligon et al. 2016).

Unlike most salmonids in Puget Sound, steelhead do not rear extensively in estuaries or nearshore habitats. Nevertheless, as steelhead migrate to sea as smolts, diverse riverine and estuarine channels with abundant wood and complex river deltas help protect them from predation, largely from marine mammals and birds (Simenstad et al. 1982; Gonor et al. 1988). Steelhead smolts typically migrate directly from natal freshwater streams and rivers to the ocean very rapidly, spending only a few days to a couple of weeks in Puget Sound. Despite their rapid migration into and through Puget Sound, however, research shows alarming mortality rates of steelhead during this life stage (Moore et al. 2010; Moore et al. 2015). Once the fish leave Puget Sound they commonly spend two to three years at sea before returning to Puget Sound as maturing steelhead and migrating to their native rivers and streams to spawn.

Photo: Adult steelhead. Credit: Morgan Bond.

Steelhead in the Puget Sound DPS exhibit two general life-history strategies, a winter run and a summer run, with the instream habitat requirements for adult summer-run steelhead being notably more stringent than those for winter-run steelhead.

- Winter-run steelhead are the predominant life-history type in Puget Sound. They generally return to Puget Sound watersheds in fall or winter and spawn in spring, as late as late June. The flows present at the time of this migration often restrict winter-run steelhead to spawning areas in lower and middle reaches of watersheds, below waterfalls and other physical stream features that can be passed earlier in the year when summer-run fish return. Figure 2 shows the winter-run steelhead life-history cycle.

- Summer-run steelhead are an early migratory life-history form that migrates into natal streams from the ocean during the late spring and summer. This early migration timing allows them to travel higher into watersheds through canyons and other confined channel areas that block access to winter-run steelhead later in the year (Busby et al. 1996). Summer-run steelhead hold for up to nine months in streams and rivers before spawning, and typically do not feed extensively during this time to conserve energy while their gametes mature. They commonly hold in habitats with deep pools, high quality instream cover, and cool water before spawning in late-winter/early spring of the following year (Hard et al. 2007). Most summer-run steelhead in Puget Sound spawn in headwater areas above narrow canyons, including those in the South Fork Nooksack River, Canyon Creek, Deer Creek, North Fork Skykomish River, and Tolt River DIPs (Hard et al. 2015). Many Puget Sound watersheds, however, lack the habitat features needed to sustain summer-run steelhead but do contain the geomorphic features needed to support winter-run steelhead.

Both summer- and winter-run adult steelhead require diverse channel features to support their spawning, rearing, and migration. Steelhead migrate upstream and spawn during the winter and spring when stream flows are relatively high, and therefore require velocity refuge provided by log jams, deep pools, and boulders. Multi-threaded channels, islands, large wood, streamside vegetation, and interconnected floodplains help ensure reproductive success by providing and maintaining clean gravels and protecting incubating eggs from floods. These diverse habitats are also critical to support the fish during their long period of juvenile rearing. The importance of diverse habitats and cool, clean water to steelhead cannot be overstated. Indeed, the loss and degradation of habitat is the principle cause of the decline and ultimate ESA-listing of Puget Sound steelhead (72 FR 26722, May 11, 2007).

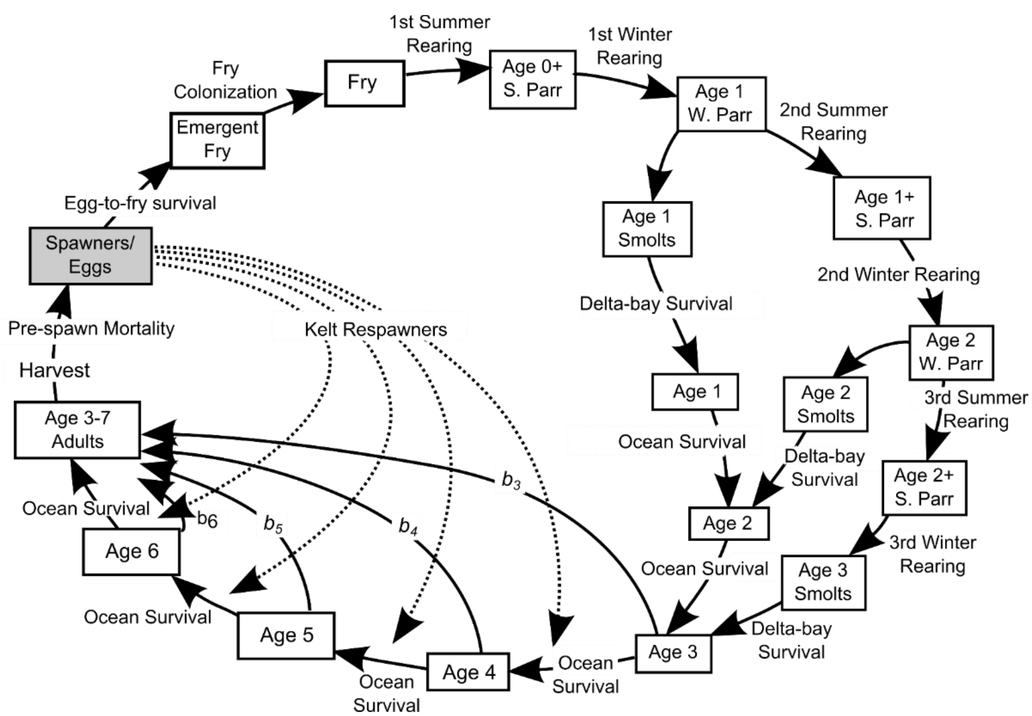

Figure 2. Steelhead life cycle pathways illustrating the diversity of the species (Beechie et al., in prep).

1.2.2 Population Status and Listing Decisions

NMFS initiated a review of the Puget Sound steelhead DPS by the Puget Sound Steelhead Biological Review Team in 2004 in response to a petition to list the species under the ESA. Findings from this biological review led NMFS to list Puget Sound steelhead as a threatened species under the ESA on May 11, 2007 (72 FR 26722). The following excerpts from the Biological Review Team report (Hard et al. 2007) summarize the factors that led to the decline of Puget Sound steelhead and the determination that listing as threatened was warranted (Ford 2011).

Factors Leading to ESA Listing for Puget Sound Steelhead

The Puget Sound Steelhead Biological Review Team (Hard et al. 2007) defined the major risk factors facing Puget Sound steelhead to be widespread declines in abundance and productivity for most natural steelhead populations in the DPS, including those in Skagit and Snohomish rivers, previously considered strongholds for steelhead in the DPS; the low abundance of several summer-run populations; and the sharply diminishing abundance of some steelhead populations, especially in south Puget Sound, Hood Canal, and the Strait of Juan de Fuca. Continued releases of out-of-DPS hatchery fish from Skamania-derived summer run were a major concern for diversity in the DPS.

The Biological Review Team observed that many populations in the DPS are small, especially those in Hood Canal and the Strait of Juan de Fuca. Declining trends in abundance have occurred despite widespread reductions in direct harvest of natural-origin steelhead in this DPS since the mid-1990s. Natural-origin run sizes (sum of incidental harvest and escapement) for most populations show even more marked declining trends than indicated by escapements, meaning the substantially reduced harvest rates for natural-origin fish since the early 1990s have not resulted in a rebound in steelhead production in Puget Sound.

In addition to abundance concerns, productivity, diversity, and catastrophic risk are high risk factors. For many of the Puget Sound steelhead populations, the decline in adult recruits-per-spawner has been precipitous. In addition, the Biological Review Team was concerned about the status of the summer-run populations of steelhead in the DPS. Populations of summer-run steelhead occur throughout the Puget Sound DPS but are concentrated in the northern Puget Sound area, are generally small populations in small watersheds, and are characterized as isolated populations adapted to streams with distinct attributes.

Habitat utilization by steelhead has been most affected by reductions in habitat quality and by fragmentation. A number of large dams in Puget Sound have affected steelhead populations and their distribution. Besides eliminating accessibility to habitat, dams affect habitat quality through changes in river hydrology, temperature profile, downstream gravel recruitment, and the movement of large woody debris. Many of the lower reaches of rivers and their tributaries in Puget Sound have been structurally simplified by urban development.

Subsequent status assessments of the DPS after the ESA-listing decision have found that the status of Puget Sound steelhead regarding risk of extinction has not changed substantially (Ford 2011; NMFS 2016; 81 FR 33468, May 26, 2016).[2] Scientists on the 2011 Biological Review Team identified degradation and fragmentation of freshwater habitat, with consequential effects on connectivity, as the primary limiting factors and threats facing the Puget Sound steelhead DPS. The Biological Review Team determined that most of the steelhead populations within the DPS continued to show downward trends in estimated abundance, with a few sharp declines (Ford 2011). Further, the NMFS' 2016 5-year review (NMFS 2016) concluded: "The biological risks faced by the Puget Sound steelhead DPS have not substantively changed since the listing in 2007, or since the 2011 status review. Furthermore, the Puget Sound Steelhead Technical Recovery Team (PSSTRT) recently concluded that the DPS was at very low viability, as were all three of its constituent MPGs, and many of its 32 DIPs (Hard et al. 2015)."

In 2016, NMFS designated critical habitat for the Puget Sound steelhead DPS (81 FR 9251, February 24, 2016) and this critical habitat designation remains in effect. Under section 3(5)(A), the ESA defines critical habitat as areas that contain physical or biological features that are essential for the conservation of the species and that may require special management or protection. The specific areas designated for Puget Sound steelhead include approximately 2,031 miles of freshwater habitat in Puget Sound. The designation applies only when federal funding, permits, or projects are involved. Under section 7 of the ESA, NMFS consults with other federal agencies to ensure that any action authorized, funded, or carried out by the agency is not likely to jeopardize the continued existence of a listed species, or destroy or adversely modify its designated critical habitat.

1.2.3 Pressures and Stressors Affecting the Decline of Steelhead

The loss of steelhead habitat in many areas of Puget Sound has been staggering, especially in those areas that have undergone extensive urban and residential development. Puget Sound riverscapes once featured extensive riparian forests, braided and unimpeded stream channels, unconstrained and spatially complex floodplains with abundant flows and cool water, fully functioning stream hydrology with large wood and intact wetlands, and productive estuaries with abundant prey (Sedell et al. 1988; Collins et al. 2002; Simenstad et al. 2011).

Today, many Puget Sound rivers and streams are simplified and degraded. Since the 1970s, Puget Sound has experienced rapid human population growth with as many as one million new inhabitants per decade influencing Puget Sound streams, rivers, and estuaries (Booth 1991; USCB 2010). The human-related pressures have resulted in severe consequences for steelhead habitat and their abundance and productivity (Hard et al. 2015).

During the recovery planning process, NMFS identified 10 primary pressures that were associated with the listing decision for Puget Sound steelhead and subsequent affirmations of the listing: fish passage barriers at road crossings; dams, including fish passage and flood control; floodplain impairments, including agriculture; residential, commercial, industrial development (including impervious runoff); timber harvest management; water withdrawals and altered flows; ecological

[2] Five-year reviews are available for listed Pacific salmon, steelhead, and eulachon as required by the ESA. These reviews evaluate whether the listing classifications of these species remains accurate or should be changed.

and genetic interactions between hatchery and natural-origin fish; harvest pressures (including selective harvest) on natural-origin fish; juvenile mortality in estuary and marine waters of Puget Sound; and climate change. These primary pressures are described briefly below. Chapter 3 provides more detail on the pressures and identifies different strategies and actions to address them so that Puget Sound steelhead may be self-sustaining in the wild over the long term.

Fish Passage Barriers at Road Crossings

Artificial stream barriers are pervasive in Puget Sound as a result of the conversion of forest lands to urbanizing environments. Roads account for the large majority of barriers in Puget Sound. As many as 8,000 culverts block access to steelhead habitats in Puget Sound (WDFW 2009; GAO 2001; WDFW 2018). Impassable culverts limit the upstream extent of spawning, which restricts the abundance of steelhead that can be produced in streams. Blocking culverts also reduce access to juvenile refuge habitat in tributaries and floodplain channels during floods, which reduces spatial structure and survival during catastrophic events, including floods. Culverts may limit genetic diversity in some stream systems. Impassable culverts have caused genetic variation among isolated fish populations within a single watershed (Wofford et al. 2005). Steelhead abundance and productivity is limited by access to suitable habitats above fish barrier culverts throughout Puget Sound. See Section 3.4.1 for additional information on fish passage.

Photo: Fish passage barrier culvert. Credit: Washington Department of Fish and Wildlife.

Dams, including Fish Passage and Flood Control

Like culverts, dams can block steelhead access to upstream habitats that were historically used for spawning and juvenile rearing. In addition, reservoirs created behind dams often cover historic spawning and rearing habitat. Some dams have fish ladders (i.e., fishways) or trap-and-haul facilities to accommodate passage, but the success and efficiency of these facilities is highly variable.

Providing upstream adult steelhead passage at dams is a formidable challenge, but often the greatest passage obstacle is in securing the downstream passage of juvenile and adult (kelts) steelhead (Wertheimer and Evans 2005). The continuously changing flows created by filling and draining the reservoirs disorients juvenile fish migrating downstream. Juvenile fish successfully finding a fishway may be subjected to supersaturated gas and predators at the outlet below the dam. Juveniles that exit through dam turbines encounter high mortality rates.

Dams also affect steelhead in their downstream habitats. Operations at some dams can create artificial floods that scour eggs and alevins from redds (Gendaszek et al. 2018). Dam operations can alter instream flows, which can reduce the quantity and quality of rearing habitat below the dam. Daily fluctuations in river flows to meet increasing power demands during the day and reduced power demands at night can dry out redds, and strand and kill fry and juvenile fish along the channel shoreline (Nagrodski et al. 2012). Altered flows from dam operations can limit access to mainstem side-channel and off-channel rearing habitats, thus reducing abundance and productivity of steelhead, as is currently the case below Howard Hansen Dam on the Green River (WRIA 9 2000). Dams limit sediment and wood transport to downstream reaches, which effectively limits the formation of rearing and spawning habitat below the dam (Kondolf 1997). Dams can also create elevated temperature regimes in streams by increasing exposure to solar radiation and delaying flow through the reservoir. Steelhead react to warmer temperatures by avoiding the area affected, or by delaying their migrations (Caudill et al. 2013). Finally, while dams often provide communities with flood relief and other benefits, this often leads to rapid increases in urban development below the dams in historic floodplains (Beck et al. 2012). See Section 3.4.2 for more information on dams.

Floodplain Impairments, including Agriculture

As previously described, diverse habitats and channel features are important for a variety of steelhead life-history stages. Dikes and levees adjacent to rivers and streams often restrict channels to single, featureless threads that are isolated from once productive floodplains. Approximately 254 miles of Puget Sound streams, rivers and delta channels have been narrowed and armored with dikes and levees (PSP 2012). Beamer et al. (2002) estimated that Skagit River delta habitats, including channels, sloughs, and intertidal habitats, have decreased by 72 percent from historic conditions. Dikes and levees greatly reduce or eliminate the opportunity for steelhead spawning in those reaches. Dikes and levees also isolate juveniles from historic floodplain rearing habitats, which may hasten the entry of pre-smolt juvenile steelhead to marine waters. See Section 3.4.3 for additional information on floodplain impairments.

Residential, Commercial, and Industrial Development (Urban Development)

Urbanization and residential development have led to dramatic changes on the landscape and, perhaps more than any other pressure, have reduced steelhead habitat and population abundance. This pressure continues to increase, with the Puget Sound region projected to grow to a population of 7 million people by 2040 (PSP 2018). Besides fostering other pressures, such as the building of fish passage barriers at road crossings and armoring of stream banks with dikes and levees, increased urban development has led to large areas of watersheds being covered by impervious surfaces (e.g., roads, parking lots, and roofs). The impervious surfaces restrict groundwater recharge and lessen groundwater contributions to instream flows during the summer and fall, thus reducing available habitat for juvenile steelhead during these months. Lower summer stream flows also indirectly elevate stream temperatures, which make the fish more susceptible to disease, predation, and a degraded aquatic invertebrate forage base. Urbanization and resulting increases in impervious surfaces also increase storm-water runoff during fall and winter months, which can scour steelhead redds, pollute water quality, and contaminate local aquatic systems. See Section 3.4.4 for additional information on residential, commercial, and industrial development.

Timber Management

Historically, timber management affected steelhead habitat by limiting the recruitment of instream features (especially large wood), reducing shade by harvesting riparian trees (which moderates stream temperature), increasing road construction (which resulted in fish passage barriers and fine sediment delivery to streams). Since 1999, timber management has improved steelhead habitat by increasing riparian forests, eliminating fish passage barriers on forest roads, and routing fine sediment away from streams. Forest management on private and state lands adhere to habitat conservation plans (HCPs), including the Forest Practices HCP (also known as the Forests and Fish HCP) and the State Trust Lands HCP. These HCPs also feature progressive monitoring and adaptive management programs. NMFS fully supports the implementation of the HCPs, including the monitoring and adaptive management programs within the HCPs as a means to continue protecting riparian habitats (including the delivery of cool, clean water), improving fish passage barrier corrections, and addressing sources of fine sediment delivery to streams. See Section 3.4.5 for additional information on timber management.

Photo: Large wood forming jams and important habitat features for steelhead. Credit: NMFS.

Water Withdrawals and Altered Flows

The construction of diversions and resulting water withdrawals from streams in the Puget Sound basin began in the mid-1800s (Palmisano et al. 1993). Water withdrawals and flow modifications occur through several activities. Water withdrawals occur through the exercise of an individual or municipal water right, either by diverting stream flows directly to drinking water facilities, or by pumping groundwater that has hydrologic connectivity to streams. Water is also diverted for agricultural use in many areas of Puget Sound. Together, these different withdrawals for human consumption (domestic and municipal water use, agricultural irrigation) have reduced summer flows in many steelhead-bearing rivers and streams in the Puget Sound basin. Altered flows can also affect steelhead. Altered flows occur when stream flows are stored in a stormwater system or reservoir on a seasonal basis and then released at a later time. Like water withdrawals, altered flows can reduce spawning and rearing habitat quality for steelhead. Reduced instream flows also have a number of secondary impacts to steelhead, including increased water temperatures and degraded water quality conditions, and reductions to the invertebrate food base of juvenile fish. See Section 3.4.6 for additional information on water withdrawals and altered flows.

Climate Change

Impacts from climate change will exacerbate the current ecosystem pressures facing steelhead (Battin et al. 2007). Hydrologically, many snowmelt-based streams in Puget Sound are expected to become rain dominated by the end of this century (Isaak et al. 2012). This change will leave steelhead especially vulnerable during summer low flows and elevated peak flows during winter (Wade et al. 2013). The period of peak snowmelt runoff will occur earlier in the year, which may impact spawning timing of adults and outmigration timing of smolts. A higher magnitude and frequency of peak winter flows caused by climate change will reduce overwinter survival rates of juvenile steelhead throughout the region (Wade et al. 2013). Because less water will be retained as snow over the winter, summer flows in areas affected by snowmelt runoff are expected to substantially drop below current base flows conditions. These reductions in base flows may limit the carrying capacity for juvenile steelhead during the summer and fall in many areas. Hydrologic factors could also decrease steelhead habitat capacity and population abundance by shifting available flows away from the times when the fish most need it. Climate change will also warm stream temperatures in the summer (Isaak et al. 2012). Because many steelhead streams are already nearing elevated temperature thresholds, riparian and floodplain habitat management efforts will need to meaningfully improve to ameliorate the effects of climate change. See Section 3.5 for additional information on climate change.

Ecological and Genetic Interactions between Hatchery and Natural-Origin Fish

Steelhead hatchery programs have been used to boost harvest opportunities for recreational and tribal fisheries. However, the adverse effects from the use of some hatchery operations and management have become well known over the last two decades. Reductions in the diversity and fitness of native steelhead populations have resulted from the use of out-of-basin stocks (i.e., Skamania Hatchery summer-run steelhead; see Hard et al. 2007 and Warheit 2014), which has precluded the stocks from being included in the DPS (73 FR 55451). Similarly, the wide-spread use of Chambers Creek Hatchery early winter-run stocks (a hatchery stock originating in South Puget Sound) have caused deleterious ecological effects to native steelhead populations throughout the region by increasing harvest pressures on natural-origin steelhead (Hard et al. 2015). Ecological interactions can negatively impact natural-origin steelhead when hatchery releases result in competition for food and habitat resources, or when hatchery fish attract predators that then forage on natural-origin steelhead. A growing body of scientific information indicates that interactions with hatchery-produced fish reduce the fitness of naturally produced fish. This new information has emerged through the use of improved tools that assess how parentage and other close genetic relationships affect the relative reproductive success of hatchery and natural-origin salmonids. The results suggest that strong and rapid declines in fitness of natural-origin fish have occurred due to their interactions with hatchery fish (Araki et al. 2008; Christie et al. 2014). Recently, integrated and conservation hatchery programs have sought to protect against the loss of diversity and bolster the productivity of native stocks. See Section 3.4.7 for additional information on hatcheries.

Harvest Pressures on Natural-Origin Fish

Harvest of steelhead was an early factor in the historic decline of abundance from Puget Sound rivers, and impacts of overfishing to steelhead were evident in the early 1900s (Gayeski et al. 2011). Directed commercial harvest has not occurred for many decades, however, and the current level of recreational and tribal harvest is not considered to be a prominent factor in the current decline of Puget Sound steelhead (Hard et al. 2015; NMFS 2016). Still, especially where population abundances have become precariously low, harvest can become a meaningful pressure, even in catch and release fisheries. See Section 3.4.8 for additional information on harvest.

Early Marine Survival

Recent work by the Salish Sea Marine Survival Project has revealed that the mortality of juvenile steelhead during the early marine life stage in Puget Sound has increased to the point where it is significantly impacting Puget Sound steelhead abundance and productivity. In recent years, survival has been measured from several river mouths through the Strait of Juan de Fuca. Survival of smolts ranged from 0.8 percent to over 39 percent over a few weeks. This means that a large percentage of steelhead smolts are not surviving the relatively short outmigration period through the marine waters of Puget Sound, and that this may be major bottleneck to the productivity of steelhead populations throughout the region. Human activities have fostered the increase of marine mammal populations, which have been observed preying on steelhead smolts and kelts (post-spawn adults). Early marine survival may also be affected by the increased risk of diseases, which may inhibit outmigration success, and increased infrastructure in the marine environment (e.g., Hood Canal Bridge) that likely alters the migration behavior and survival of juvenile steelhead. See Section 3.4.9 and Appendix 3 for more information on early marine survival.

Photo: Radio-tagged harbor seal. Credit: NMFS.

1.3 Planning Approach

The Plan is based on the best available scientific and commercial information and focuses on DPS-wide actions for Puget Sound steelhead, concentrating on addressing the ESA listing factors (discussed in Section 2.1) that continue to hinder the long-term sustainability and persistence of the species and its habitat. It also addresses other ESA requirements (described in Chapter 4).

The recovery strategy in this Plan aims to improve the viability of Puget Sound steelhead so that the species is self-sustaining in the wild. A viable DPS is one that is sufficiently abundant, productive, and diverse and likely to persist in the long term, defined as the next 100 years.

The overarching approach for recovery of Puget Sound steelhead is to focus primarily on protecting and restoring ecosystem functions and freshwater habitats, and improving juvenile survival in Puget Sound waters. Complementary strategies ensure that hatchery and harvest management do not impede recovery and, where possible, contribute to recovery.

Overarching Ecosystem-Based Approach

The overarching approach for recovery of Puget Sound steelhead focuses on protecting and restoring ecosystem functions and freshwater habitats, and improving juvenile survival in Puget Sound waters. Complementary strategies ensure that hatchery and harvest management do not impede recovery and instead, where possible, contribute to recovery.

This approach is consistent with NMFS' Ecosystem-based Management Policy and approach to recover species listed under the ESA (NOAA Fisheries Policy 01-120).

1.3.1 Plan Development – Collaboration with Recovery Planning Partners

This recovery plan is the product of a collaborative process initiated by NMFS and strengthened through regional and local participation. The goal was to produce a recovery plan that would meet ESA requirements for recovery plans, as well as recognizing broader needs. Throughout the recovery planning process, NMFS collaborated with the state of Washington, tribes, other federal agencies, local governments, representatives of industry and environmental groups, other stakeholders, and the public.

NMFS convened the Puget Sound Steelhead Recovery Team (recovery team or team) to assist the agency in preparing the recovery plan. Recovery team members will remain involved in recovery efforts during coming years through the development of watershed chapters to this regional recovery plan and through the adaptive management process, action implementation, and related research, monitoring, and evaluation (RM&E).

The collaborative process reflects NMFS' belief that ESA recovery plans for salmon and steelhead should be based on state, regional, tribal, local, and private conservation efforts already underway throughout the region. Local support of recovery plans by those whose activities directly affect the listed species, and whose actions will be most affected by recovery efforts, is essential to plan implementation.

The primary partners in recovery planning efforts for Puget Sound steelhead and their responsibilities are listed below. The Acknowledgments section and Section 1.1.2 also list a number of the stakeholders who joined NMFS in developing this recovery plan. These groups provided vital input during the planning process. Their continued involvement as we move forward to refine and focus efforts at the watershed level and then implement actions to improve steelhead productivity in freshwater, estuarine, and marine environments is critical to the success of our joint efforts to recover Puget Sound steelhead. While NMFS is responsible for recovery planning for salmon and steelhead, and for decisions to list and delist marine and anadromous species as endangered or threatened, it recognizes that continued local support of recovery plans — by those whose activities directly affect the listed species, and whose activities are most affected by recovery requirements — is essential to their successful implementation.

In the next stage of recovery planning, NMFS will assist state agencies, tribes, and Lead Entities (local, citizen-based groups) in the development of watershed chapters to this recovery plan that identify additional specific population- and reach-level actions. These watershed-scale chapters will be developed in two two-year phases, with the chapters for six watersheds completed in 2021 and the rest completed by 2023. NMFS will encourage the use of multidisciplinary teams (presumably led by the Lead Entities) from multiple jurisdictions to develop and implement the watershed chapters. Once a watershed chapter is completed, NMFS will review and approve the chapter and adopt it as a component of the recovery plan. The information will be made available on our web site and on the Puget Sound Partnership web site. As with other recovery planning efforts in Puget Sound, it will be important to organize, adaptively manage, and track progress of implemented steelhead recovery efforts through time. Additional funding for these efforts may be needed.

Photo: Pilchuck Dam blocking access to steelhead and Chinook and Coho salmon on the Pilchuck River. The dam is proposed for removal by the Tulalip Tribe with support from the City of Snohomish and funding by the Brian Abbott Fish Barrier Removal Board and the Recreation and Conservation Office. Credit: Tulalip Tribe.

Recovery Planning Partners and Responsibilities

Puget Sound Steelhead Technical Recovery Team (PSSTRT): This team of scientific experts from federal, state, tribal, and academic organizations was appointed by NMFS to provide a solid scientific foundation for recovery planning. The team developed a recommended scientific approach and DPS biological recovery criteria for the species. The team also provided scientific support to local and regional recovery efforts and scientific evaluations of proposed recovery plans (Hard et al. 2015; Myers et al. 2015).

Puget Sound Steelhead Recovery Team: NMFS convened the Puget Sound Steelhead Recovery Team to assist in preparing the draft recovery plan in 2014. The team includes participants from the Washington Department of Fish and Wildlife, Northwest Indian Fisheries Commission, Puget Sound Partnership, Seattle City Light, Long Live the Kings, Nooksack Indian Tribe, NMFS, and NMFS Northwest Fisheries Science Center.

State and Tribal Co-Managers: Puget Sound Treaty Tribes and the Washington Department of Fish and Wildlife have been actively involved in preparation of comprehensive harvest management plans and hatchery genetic management plans for listed species across the region. They work toward the integration of habitat, harvest and hatchery considerations in watershed and regional levels, monitor fish populations, and play an integral role in recovery planning efforts.

Puget Sound Partnership (PSP): The Puget Sound Partnership is the state agency leading the region's collective effort to restore and protect Puget Sound. The PSP works with its Leadership Council, Salmon Recovery Council, Ecosystem Coordination Board, Science Panel, local stakeholders and communities, Indian tribes, businesses, and state and federal agencies to identify, sequence, prioritize, and implement projects and programs to recover salmon.

Lead Entities: Lead Entities are local, citizen-based organizations established by Washington State law that develop watershed-scale recovery strategies and coordinate salmon recovery efforts in their watersheds. Per statute (RCW 77.85.050), Lead Entities are tasked with establishing a committee made up of habitat recovery interests in their area and developing a list of habitat restoration projects. A Lead Entity is commonly led by a coordinator (usually from a county, conservation district, or tribe) and includes a committee of technical experts, a committee of local citizens, and often a grant administrator. In Puget Sound, Lead Entities work with local and state agencies, tribes, citizens, and other community groups to adaptively manage their watershed recovery plans to recover salmon and steelhead and ensure that recovery actions are implemented on the ground. To date, only the Nisqually Lead Entity has a locally written steelhead recovery strategy/chapter. Others are underway for the Hood Canal, Skagit, and East Kitsap populations (West Sound).

Puget Sound Partnership Leadership Council: The Leadership Council, the governing body of the Puget Sound Partnership, provides region-wide direction and guidance on Puget Sound recovery. Its seven members are leading citizens appointed by the Governor. In 2008, Washington State designated the Council as the regional salmon recovery organization under the Puget Sound Partnership Act. The Act designated the Council as the lead for implementing the Puget Sound Salmon Recovery Plan, which was developed by the Shared Strategy, a non-profit organization, and approved by NOAA in 2007. The Leadership Council is supported by the Puget Sound Partnership, which administers the Council's direction, by the Ecosystem Coordination Board, which implements Council policy direction, and the Science Panel, which provides technical and scientific expertise.

Puget Sound Salmon Recovery Council (PSSRC): The Puget Sound Salmon Recovery Council (PSSRC) serves as an advisory body to the Leadership Council and the Puget Sound Partnership. This group consists of representatives from each of the 16 Puget Sound watersheds, environmental and business communities, Indian tribes, and state and federal agencies involved in salmon recovery. The PSSRC meets regularly to help set priorities for the types of recovery work to conduct, determine the issues to focus on, and provide recommendations for future projects and funding.

Puget Sound Partnership Science Panel: The Science Panel provides expertise and advice to the Leadership Council and informs the Puget Sound Partnership's efforts to develop a comprehensive, science-based plan to restore Puget Sound. Science Panel members are appointed by the Leadership Council and are chosen from among the top scientists in Washington.

Puget Sound Management Conference: The Management Conference is composed the Puget Sound Partnership and its statutory boards and advisory bodies, including the Leadership Council, Ecosystem Coordination Board (ECB), Science Panel, Puget Sound Salmon Recovery Council (PSSRC), and the Puget Sound Ecosystem Monitoring Program (PSEMP).

Puget Sound Task Force: The Puget Sound Federal Task Force is composed of nine federal agencies and cabinet departments who have agreed to enhance Puget Sound recovery by strengthening coordination among federal agencies, tribes, state and local governments, and private efforts, strengthening the integration of federal activities in the Puget Sound Action Agenda, contributing scientific and technical expertise, fulfilling federal trust responsibilities to Puget Sound federally recognized tribal governments, and creating and maintaining a standing federal venue through which to share information. The Puget Sound Federal Task Force developed an Action Plan that supports the Puget Sound Action Agenda.

1.3.2 Recovery at Multiple Scales – DPS to Watersheds

For this recovery plan to be effective, it requires a multi-faceted effort with coordination among federal, state, local agencies, and the private sector, and linked efforts at the watershed/ population, major population group, and DPS levels. Our long-term approach needs to be watershed process-oriented for freshwater strategies, and regionally oriented to increase smolt survival in the marine environment.

Since changes in land use associated with human development continue to apply pressures on stream and marine ecosystems throughout the DPS, an important element in our Plan is to identify watershed-level efforts that could, if implemented, address indirect pressures that are the root causes of ecosystem impairment. We intend to integrate these efforts, working with Lead Entities, landowners, businesses, and non-governmental and governmental organizations to find ways to accomplish multiple goals.

Concurrently, early marine survival has emerged as a serious pressure on steelhead survival. Our approach includes strategies and actions to understand and ameliorate factors that are causing the unsustainable decline of steelhead in the Puget Sound marine ecosystem, including freshwater factors that may inhibit the health and performance of young steelhead as they transition to the marine environment.

1.3.3 Relationship to Other Recovery Efforts

The Puget Sound steelhead DPS is one of 28 ESUs and DPSs of Pacific salmon and steelhead listed under the ESA as threatened or endangered throughout the NMFS West Coast Region (the states of Washington, Oregon, California, and Idaho). Three other ESA-listed salmonid species also spawn and rear within Puget Sound: Puget Sound Chinook and Hood Canal Summer-run Chum salmon, which are managed by NMFS, and bull trout, which are managed by USFWS. Recovery plans have already been completed for these other Puget Sound ESA-listed species.[3] This Plan only addresses steelhead recovery in the Puget Sound DPS, but complements the plans for the other listed species. Where possible and appropriate, actions should be taken to benefit the recovery of multiple species.

Similarly, the Puget Sound steelhead recovery plan is consistent and collaborative with state, tribal, and co-manager recovery plans. Scott and Gill (2008); WDFW (2008) outline recovery actions planned and undertaken by Washington State. A framework developed by WDFW and the Puget Sound Partnership (WDFW and PSP 2011) provides a structure for steelhead recovery planning at local (watershed) planning levels. NMFS encourages the use of this framework and other locally developed approaches in the recovery of Puget Sound steelhead, and will continue to work collaboratively with partners toward that end.

Relationship to Efforts by Technical Recovery Teams

NMFS organized the ESA-listed species by "recovery domains" based on geographic areas for the purpose of recovery planning. For each recovery domain, NMFS appointed a team of scientists who

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[3] https://www.westcoast.fisheries.noaa.gov/protected_species/salmon_steelhead/salmon_and_steelhead.html
https://www.fws.gov/pacific/bulltrout/

have geographic and species expertise to provide a solid scientific foundation for recovery plans. The agency appointed the Puget Sound Steelhead Technical Recovery Team (PSSTRT) for the Puget Sound steelhead DPS, which is part of the Puget Sound recovery domain. The PSSTRT included biologists from NMFS, state agencies, tribes, and academic institutions.

The PSSTRT and other NMFS technical recovery teams used a common set of biological principles in developing their recommendations for species and population viability criteria. The biological principles are described in NMFS' technical memorandum, "Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units" (McElhany et al. 2000). A viable salmonid population (VSP) is an independent population of Pacific salmonid (genus *Oncorhynchus*) that has a negligible risk of extinction due to threats from demographic variation (random or directional), local environmental variation, and genetic diversity changes (random or directional) over a 100-year time frame. Viable salmonid populations are defined in terms of four population parameters: abundance, population productivity or growth rate, population spatial structure, and diversity. Each technical recovery team made recommendations using the VSP parameters. The recommendations also reflected data availability, the unique biological characteristics of the species and habitats in the domain, and the members' collective experience and expertise. NMFS encouraged the technical recovery teams to develop species-specific approaches to evaluating viability, while using the common VSP scientific foundation (See Myers et al. 2015; Hard et al. 2015).

Relationship to Puget Sound Chinook Salmon, Hood Canal Summer-run Chum Salmon, and Bull Trout Recovery

NMFS and our recovery planning partners agree that Puget Sound steelhead recovery planning should be consistent with the regional and watershed strategies used for Puget Sound Chinook Salmon, Hood Canal summer-run Chum Salmon, and Coastal-Puget Sound bull trout (NMFS 2007). NMFS and the recovery planning partners identified recovery actions and developed this Puget Sound steelhead recovery plan concurrent with ongoing implementation of the Puget Sound Chinook and Hood Canal summer-run Chum salmon plans. NMFS recognizes that recovery planning for these species is ongoing at the watershed level and ultimately, there will be watershed-level plans for steelhead as well, or plans that integrate multiple listed species. As the regional organization for salmon recovery in Puget Sound, the Puget Sound Partnership Leadership Council oversees implementation of the Puget Sound Salmon Recovery Plan, with guidance from the Puget Sound Salmon Recovery Council and staff support from the Puget Sound Partnership. The Hood Canal Coordinating Council is the regional partner organization for summer-run Chum Salmon recovery and oversees implementation of the recovery plan. Several regional Chinook Salmon recovery plans have been, or are being, updated using a consistent recovery framework and language.

This steelhead plan is consistent with the recovery plans for these other Puget Sound salmon species, but tailored to the unique life histories and habitat use of steelhead. While steelhead occupy habitats and a geography that overlaps both Puget Sound Chinook and Hood Canal summer-run Chum salmon, they also use smaller tributaries further up in the watersheds and independent tributaries that drain directly into Puget Sound, which are not otherwise included in Chinook recovery planning. Also, unlike Chinook and summer-run Chum salmon, steelhead do not reside extensively in estuary/nearshore areas. Therefore, while this Plan provides consistent and compatible direction for overall recovery of Puget Sound salmon and steelhead, the Plan has unique elements that are specific to the geography, life histories, and current science of Puget Sound steelhead. For example, this Plan is the first in Puget Sound to identify strategies and actions necessary for survival in open marine waters, as neither Puget Sound Chinook nor summer-run Chum salmon recovery plans addressed pressures outside the estuary or nearshore environment.

The Plan is also compatible with the final Coastal-Puget Sound Bull Trout recovery plan, which was completed by the USFWS in 2015 and provides direction for recovery of Bull Trout in Puget Sound, the Olympic Peninsula, and portions of western Oregon. Bull Trout and steelhead share many of the same habitat requirements (clean and cold freshwater habitat conditions), and the distribution of both species extends into the headwater areas of Puget Sound watersheds. Thus, many of the primary threats identified for Bull trout in Puget Sound streams and rivers also apply for steelhead: degradation to upland and riparian lands, timber harvest, degraded water quality, impaired connectivity caused by fish passage barriers (culvert and dams), altered instream flows from dams and diversions, altered migration and declining survival in the marine waters of Puget Sound, and climate change (USFWS 2015). Accordingly, many of the recovery actions identified in this Plan will also benefit Bull trout populations in the region.

This Plan for Puget Sound steelhead builds on efforts implemented through the Shared Strategy, a collaborative initiative that began in 1999 concurrent with the ESA-listing of Puget Sound Chinook Salmon, Hood Canal summer-run Chum Salmon, and Coastal-Puget Sound Bull trout as threatened. Representatives of federal, state, tribal, and local governments, business, the agriculture and forestry industries, conservation and environmental groups, and local watershed planning groups met to shape “one strategy shared by many” for salmon recovery. A key objective defined in this process was to “(B)uild a scientifically robust, practical, cost-effective recovery plan by June 2005 that defines the strategies and actions necessary to recover naturally spawning Puget Sound Chinook Salmon, Bull Trout, and Hood Canal summer Chum Salmon to self-sustaining and harvestable levels within the context of a prosperous economy and sustainable growth (Volume I, Chapter 1)” (NMFS 2007).

Relationship to the Puget Sound Action Agenda

The Puget Sound Partnership Leadership Council provides policy direction and guidance in the recovery of Puget Sound, with responsibilities for reviewing and adopting the Puget Sound Action Agenda and serving as the Puget Sound salmon recovery regional organization.

The Puget Sound Partnership (PSP), a state agency, serves as the backbone organization for the Leadership Council and generally coordinates and guides Puget Sound recovery efforts under the direction of the Leadership Council. The PSP oversees development of updates to the Puget Sound Action Agenda, which charts the course to recovery of Puget Sound by identifying the goals and strategies for recovery, and by describing how the work of many partner organizations contributes to improving the health of the Puget Sound ecosystem. The 2018–2022 update to the Action Agenda articulates a vision for Puget Sound as a resilient ecosystem that can adapt to the impacts of climate change and the pressures of a growing human population, while meeting the needs of its native species.

The Puget Sound Steelhead Recovery Team consulted the Puget Sound Action Agenda and associated Implementation Plan during recovery plan development. Rather than reinventing the wheel, the recovery team used the PSP’s recent direction on land development, floodplains, and shoreline armoring to build out the recovery plan’s steelhead-specific strategies and actions.

Other regional and statewide processes were also used as a basis for strategy development, such as the Long Live the King's Salish Sea Marine Survival Project, WDFW's Fish Barrier Removal Board, and Washington Department of Ecology's 303(d) list and total maximum daily load. In addition, the Action Agenda and Puget Sound Federal Task Force specifically call out the need for supporting several long-term elements of the Salish Sea Marine Survival Project adopted in this Plan for recovery of steelhead, such as addressing increased predation, monitoring the marine food web, including zooplankton and forage fish efforts. The Action Agenda also calls out specific strategies to address pollution from stormwater runoff at local jurisdiction and regional scales.

1.4 Tribal Trust and Treaty Responsibilities

Northwest Indian treaty tribes have legally enforceable treaty rights reserving to them a share of the harvestable fish, taken at the Tribes' usual and accustomed grounds and stations. Achieving the basic purposes of the ESA such that the species no longer needs the protection of the Act may not by itself fully meet these rights and expectations, although it will lead to major improvements in the current situation. Ensuring a sufficient abundance of salmon to sustain harvest is an important element in fulfilling trust responsibilities and treaty rights and garnering public support for these plans. It is NMFS' policy that recovery of salmonid populations should achieve two goals: (1) the recovery and delisting of salmonids listed under the provisions of the ESA, and (2) the restoration of salmonid populations to a level sufficient to allow for the meaningful exercise of tribal fishing rights.

Thus, it is appropriate for recovery plans to take these considerations into account and plan for a recovery strategy that includes harvest. In some cases, the desired abundances for harvest may be achieved through increases in naturally spawning populations. In others, the recovery strategy may include appropriate use of hatcheries to support a portion of the harvest. Both of these strategies are used to achieve the recovery of the listed DPS under the ESA.

Pacific salmon and steelhead have been harvested both historically and in modern times, and there is a strong public interest in restoring them to harvestable levels. Because listed salmon and steelhead often migrate with non-listed fish, the listings not only constrain the harvest of listed fish but also have become factors limiting the harvest of other non-listed fish. Fisheries affecting both salmon and steelhead are co-managed by Washington State, Puget Sound Treaty Tribes, and federal agencies, under the principles of the Pacific Salmon Treaty (PST), the Magnuson-Stevens Act (MSA), the *U.S. v. Washington* court proceedings, and United States treaties with Puget Sound Treaty Tribes.

Historically, steelhead that returned to streams and rivers in Puget Sound played an integral role in the lives of Native Americans. At one time as many as 50 different tribes resided along the shores of Puget Sound and its rivers. Today, a smaller number of tribes live along Puget Sound but these tribes continue to retain strong spiritual and cultural ties to salmon and steelhead. These ties reflect thousands of years of use for tribal religious and cultural ceremonies, subsistence, and commerce.

A complex history of treaties, executive orders, legislation, and court decisions culminated in the recognition of tribes as co-managers who share management responsibilities and rights for fisheries in Puget Sound. Specific to the ESA, the Secretaries of the Interior and Commerce signed

Secretarial Order No. 3206, (*American Indian Tribal Rights, Federal-Tribal Trust Responsibilities and the Endangered Species Act,* June 5, 1997) in order to ensure that the ESA is administered in a manner that acknowledges the Federal trust responsibility to tribes, including engagement in government-to-government relationships. NMFS acknowledges and accepts its obligations to integrate its ESA responsibilities with its trust responsibilities for the Western Washington federally recognized tribes.

Western Washington Treaty Tribes include:

- Hoh Tribe
- Jamestown S'Klallam Tribe
- Lower Elwha Klallam Tribe
- Lummi Nation
- Makah Tribe
- Muckleshoot Tribe
- Nisqually Tribe
- Nooksack Tribe
- Port Gamble S'Klallam Tribe
- Puyallup Tribe of Indians
- Quileute Indian Tribe
- Quinault Indian Nation
- Sauk-Suiattle Tribe
- Skokomish Tribe
- Squaxin Island Tribe
- Stillaguamish Tribe
- Suquamish Tribe
- Swinomish Tribe
- Tulalip Tribes
- Upper Skagit Indian Tribe

ESA and tribal trust responsibilities complement one another. Both depend on a steady upward trend toward ESA recovery and delisting in the near term, while making aquatic habitat, harvest, and land management improvements for the long term.

Photo: First Salmon Ceremony. Credit: Lummi Nation.

Relationship to Treaty Rights at Risk Initiative

In 2011, the Western Washington Treaty Tribes launched the Treaty Rights at Risk Initiative to encourage the federal government to bring the suite of government agencies and programs affecting salmon and steelhead into a more coordinated, effective approach to recovery.

After years of constraining harvest and investing millions of dollars in salmon and steelhead recovery efforts in Puget Sound, salmon and steelhead continue to decline in abundance. The Treaty Rights at Risk Initiative focuses on the federal responsibility to help reverse this trend and protect the tribes' rights. The cornerstone strategy of the Treaty Rights at Risk Initiative[4] is to reverse the negative trend in suitable habitat for salmon and steelhead. Although some studies may indicate that protection strategies may be slowing the degradation of floodplains, estuaries, and mainstem rivers in Puget Sound (see Bartz et al. 2015), numerous scientific assessments show that despite many local efforts to recover habitat, concerns remain regarding habitat loss and conversion rates in areas that are important to steelhead and salmon throughout Puget Sound (http://treatyrightsatrisk.org).

1.5 How NMFS Intends to Use the Plan

NMFS intends to use this Plan to inform federal, state, and local agencies and interested stakeholders about what will be needed to recover Puget Sound steelhead to the point where they can be removed from the list of threatened and endangered species. While recovery plans are not regulatory, and their implementation is voluntary, they are important tools that help:

- Provide context for regulatory decisions;
- Guide decision making by federal, state, tribal, and local jurisdictions;
- Organize, prioritize, and sequence recovery actions;
- Guide research, monitoring, and evaluation efforts; and
- Provide a framework for the use of adaptive management.

NMFS is committed to implementing the actions in the Plan for which it has authority, and work cooperatively on implementation of other actions. NMFS encourages other federal agencies and non-federal jurisdictions to use the Plan as they make decisions and allocate resources including:

- Actions carried out to meet federal ESA section 7(a)(1) obligations to use their programs in furtherance of the purposes of the ESA and to carry out programs for the conservation of threatened and endangered species;
- Actions that are subject to ESA sections 4d, 7(a)(2), or 10;
- Hatchery and Genetic Management Plans and permit requests;
- Harvest plans and permits;
- Selection and prioritization of subbasin planning actions;
- Development of research, monitoring, and evaluation programs;
- Revision of land use and resource management plans, including critical Area Ordinance evaluation and modification; and
- Other natural resource decisions at the federal, state, tribal, and local levels.

[4] http://treatyrightsatrisk.org/

We will emphasize recovery plan information in ESA section 7(a)(2) consultations, section 10 permit development, and application of the section 4(d) rule by considering:

1. The nature and priority of the effects that will occur from an activity;
2. The level of effect to, and importance of, individuals and populations within the DPS;
3. The level of effect to, and importance of, the habitat for recovery of the species;
4. The cumulative effects of all actions to species and habitats at a population scale; and
5. The current status of the species and habitat.

In implementing these programs, recovery plans will be used as a reference for best available science and a source of context for evaluating the effects of actions on listed species, expectations, and goals. Recovery plans and recovery plan actions do not pre-determine the outcomes of any regulatory reviews or actions. We expect that agencies and others will use this recovery plan as a reference and a source of context, expectations, goals, and direction. We encourage federal agencies to describe in their biological assessments how their proposed actions will affect specific populations and limiting factors identified in the recovery plans, and to describe any mitigating measures and voluntary recovery activities in the action area for the proposed action.

Photo: First natural-origin steelhead tagged in the Elwha River after dam removal. Credit: John McMillan.

"Steelhead have survived in changing environments and move through an incredible diversity of habitats over their lifetimes. Their genetic and life history diversity is key to their survival and is a profound reflection of the complex land and water environment of the Salish Sea ecosystem. Their survival is an indicator of the health of our watersheds and is essential to the very lives and identity of Puget Sound Tribes. For steelhead and other Puget Sound salmon species to survive and thrive, we must accelerate habitat preservation and restoration so that our region's diverse ecosystems will once again survive and thrive." -- Dow Constantine, King County Executive

2. Recovery Goals and Overarching Strategic Approach

This chapter describes the ESA recovery goals and the overarching strategy for recovery of Puget Sound steelhead. Chapter 3 describes the recovery strategies and site-specific actions that NMFS recommends in order to implement the strategic approach and achieve the recovery goals. Chapter 4 describes specific criteria for delisting and how NMFS intends to consider the biological status along with the five listing factors when determining if delisting is warranted.

2.1 ESA Recovery Goals

Our primary goals are:

- The Puget Sound steelhead DPS achieves biological viability and the ecosystems upon which the DPS depends are conserved such that it is sustainable and persistent and no longer needs federal protection under the ESA, and
- The five listing factors from the ESA, section 4 (a)(1) are addressed.

Achieving Viability

Achieving DPS viability depends on the status of the DPS' component populations and major population groups and the habitats that support them. A self-sustaining viable population has a negligible risk of extinction due to reasonably foreseeable changes in circumstances affecting its abundance, productivity, spatial structure, and diversity characteristics over a 100-year time frame and achieves these characteristics without dependence upon artificial propagation.

Section 4.2 describes in detail the viability criteria for NMFS to consider in determining whether or not the species has achieved a biological status consistent with recovery. When evaluating whether the species has reached a recovered condition, we review the best available information, including that regarding steelhead viability. In order to make a determination that the DPS has achieved recovery, NMFS' review would need to support a finding that the DPS has abundance, population growth rate, population spatial structure, and diversity that meet the biological recovery goals described in this chapter.

The criteria for Puget Sound steelhead include the requirement that Puget Sound steelhead achieve viability at the DIP, MPG, and DPS scales, as described in detail in Chapter 4.

Addressing the Listing Factors

The same five listing factors identified in ESA section 4(a)(1) apply to all ESA-listed species; however, the relative importance of each factor varies from species to species. There is no set threshold for these five listing factors, so there are many different possible combinations of effort and results that could lead to a determination that Puget Sound steelhead have been recovered. NMFS uses the best available information to evaluate each factor. This is discussed in more detail in Section 4.3.

The five listing factors from the ESA, section 4(a)(1), include:

A. The present or threatened destruction, modification, or curtailment of the species' habitat or range;
B. Overutilization for commercial, recreational, scientific, or educational purposes;
C. Disease or predation;
D. Inadequacy of existing regulatory mechanisms; and
E. Other natural or human-made factors affecting the species' continued existence.

2.2 Overarching Strategic Approach

The ESA, under section 4(f), requires that recovery plans, "…to the maximum extent practicable…, incorporate … a description of such site-specific management actions as may be necessary to achieve the plan's goal for the conservation and survival of the species…" The overarching approach for recovery of Puget Sound steelhead focuses primarily on protecting and restoring ecosystem functions and freshwater habitat and improving juvenile survival in Puget Sound waters. Consistent with this approach is ensuring that fisheries management (harvest and hatcheries) is consistent with recovery, and to the extent practicable, improves viability of the DPS.

NMFS' approach to Puget Sound steelhead recovery applies NMFS' regulatory and non-regulatory tools in combination with those of tribes, federal, state and local governments and other stakeholders. It aims, to the extent practicable, to "protect the best and restore the rest." Species recovery in Puget Sound's biologically diverse geography — which includes the full spectrum of rural to urban human environments and terrestrial to marine ecosystems — requires the exercise of government regulatory measures as well as non-regulatory funding, restoration, and conservation actions. NMFS is committed to working with managers, agencies, recovery practitioners, citizens of Puget Sound and other stakeholders to expedite Puget Sound steelhead recovery through the use of all necessary and appropriate tools.

This recovery plan is a guidance and planning document. It provides a strategic roadmap to achieve steelhead recovery. It describes the various pressures that limit the species' viability and presents different strategies and actions that can be implemented at the DIP, MPG, and DPS levels to address them. Chapter 3 and Appendix 4 describe these strategies and actions. Importantly, however, the Plan does not restrict future recovery partners from identifying additional actions. Instead, it provides a flexible approach to recovery, recognizing that, as discussed in Chapter 4, a variety of combinations of strategies and actions could lead to recovery under the ESA, including some actions that are not identified in the Plan. Consequently, the Plan encourages agencies and local citizen groups to design their own creative, yet scientifically sound methods that will effectively address the pressures and evaluate uncertainties while also supporting their interests. Additional actions and 4-year work plans to address watershed-specific pressures will be identified through future planning efforts with recovery partners and presented on our web site as they are developed. Accordingly, NMFS will periodically update the Recovery Action Mapping Tool[5] to record project completion. NMFS will also continue to work closely with the tribal and state co-managers to implement hatchery and harvest management systems at the DPS, MPG, and DIP scales to improve or maintain consistency with recovery of Puget Sound steelhead and to improve viability of the DPS.

In conjunction with the focus on habitat, we employ an adaptive management approach that uses information gained through RM&E and life-cycle modeling to target actions that provide the best opportunities to improve viability, and then continues to refine the strategies and actions to improve their effectiveness. This approach recognizes that, because overall viability of Puget Sound steelhead is a function of survival in each life stage, significant improvement in survival in one life stage might expedite recovery more than improvements in other life stages. Through the adaptive management process, we will assess which life stage is limiting species recovery and identify where the greatest improvements can be achieved to move the species onto a trajectory toward recovery. In some cases, there may be trade-offs between investments and species responses. Thus, we will employ flexibility in selecting and implementing strategies and actions, depending on which issues and steelhead life-history stage(s) present the greatest recovery opportunity.

Finally, as discussed below in Section 2.3, to be successful in the overall effort and for all life stages, it will be important that NMFS, co-managers, and recovery partners implement a coordinated "All H" approach. Policy and technical staff working on the "four Hs" — habitat, hatcheries, harvest, and hydropower (dams) — will need to collaborate to maximize species benefits and recovery potential. Examples include aligning hatchery management with DIP-level targets and MPG-level priorities, harvest goals, and local habitat conditions, and integrating the best available science on habitat capacity and density dependence into habitat restoration, hatchery, and harvest actions, as described in Chapter 3 and Appendix 4.

2.3 Integrating Management

The major factors that affect the abundance, productivity, and diversity of steelhead occur in four different major management sectors: habitat, hydropower, harvest, and hatcheries (the "four Hs"). Each of these sectors has different economies, is subject to different authorities and regulations, and can make day-to-day decisions to achieve long-term goals without much interaction with other sectors. Although management within these sectors can occur independently, recovery of steelhead and other salmonids depends on making choices in all these management sectors that benefit populations.

[5] https://www.fisheries.noaa.gov/resource/data/recovery-action-database

"H-Integration" is the process of identifying, choosing, and implementing strategies and suites of actions that are coherent and logical in timing, sequences, locations, and outcomes so that they are predicted to achieve population and ESU/DPS viability based on the best scientific understanding of responses of fish populations to these actions. Characteristics of H-integration are:

- It includes all activities in habitat, harvest, hatchery, and hydropower management sectors that could affect the status and viability of fish habitat and populations.
- It addresses the interrelated effects of these actions on viability characteristics (such as diversity, abundance, productivity, and spatial structure).
- It is consistent with the causal hypotheses, protection and recovery strategies, and population goals.
- It produces no lasting (permanent) pathological effects on population viability.
- It is efficient (the allocation of resources, timing, sequence, and location of activities increases the expected rate of recovery towards achieving population and ESU goals.)
- It requires difficult trade-offs between competing economic and social objectives.
- It increases public support for salmon recovery.

To achieve H-integration, it is necessary to approach the problem as an adaptive challenge rather than a technical challenge. Adaptive challenges are defined by solutions that can only occur through changes in people's priorities, beliefs, habits, and loyalties. These solutions are often difficult to identify (and easy to deny), have unclear boundaries, have no quick fixes but require experimentation and learning, and arise from the people most affected by potential solutions (Heifetz et al. 2009). Management authority and expertise for many of these different "Hs", for example, rests with different federal, tribal, state, county, city agencies, and private landowners with often competing values and beliefs.

Over the last decade, considerable research has been focused on the role of leadership in adaptive challenges (BBCSS 2015). This work suggests that successful H-integration has five characteristics:

- Getting the right science.
- Getting the science right.
- Getting the right participation.
- Getting the participation right.
- Developing an accurate, balanced, and informative synthesis.

"Getting the right science" means that the technical analysis addresses the combined effects of all the Hs on salmon populations. "Getting the science right" means that the analysis meets rigorous scientific standards for data, analytical methods, and the treatment of uncertainty and the results are communicated accurately. Together these enhance credibility, relevance, and legitimacy of the effort. Getting the "right science right" poses several technical challenges. We must be able to understand (or predict) the effects of the individual "H" actions and their joint effects on population viability characteristics over the life of the actions, including:

- Comparing the short-term and long-term effects on VSP characteristics of the various "H" actions for directionality (+, -), magnitude, lag, and persistence. (This requires one or more "common denominators" for translating the effects of actions in the different management sectors on population viability characteristics);

- Timing (when do you do it) of the actions keeping in mind the status of population VSP attributes and desired VSP outcomes (the "first things first" principle);
- Sequencing (what order do you do it) and location of actions that minimizes the risk to the population while maximizing the cost-effectiveness and probability of achieving viability; and
- Communicating the effects of choosing different scenarios (suites of actions) and the uncertainty in language that is accessible to decision makers and the public.

"Getting the right participation" means that the process includes all those affected by the decisions and with authority to implement actions in each of the Hs and considers their different perspectives. "Getting the participation right" means that the process is responsive to the needs of the participants by recognizing their needs, rights, and viewpoints and it incorporates their abilities to implement change. Developing the opportunities, political values, processes and institutional support to manage this as an adaptive challenge is much more challenging than the technical issues listed earlier because the authorities involved in recovery planning have little experience with this kind problem solving.

Each of these steps is essential. The result should be a synthesis that identifies:

- A suite of actions that can be practically implemented and is consistent and predicted to move salmon populations towards short, moderate, and long-term recovery goals;
- The relative uncertainty of the suite of actions; and
- An approach to incorporate learning during the process to improve success.

To apply these principles within each watershed, agencies and governments that make decisions that affect habitat quantity and quality, hatchery operations, and fisheries must align the expected consequences and sequences of their actions so that taken in whole they represent the most efficient way to recover steelhead.

This recovery plan promotes H-integration through implementation of the adaptive management process, described in Section 3.1.1. The process incorporates life-cycle modeling and allows us to weigh the effects of different habitat, hatchery, and harvest strategies, individually and combined, at the watershed level and across watersheds and life-history strategies, and then update our efforts to increase their effectiveness. During recovery plan implementation, NMFS will also coordinate with various local, state, and regional managers and others to resolve conflicts and advance Puget Sound steelhead recovery through existing and new forums.

"It is essential that all state, local, and federal agencies increase coordination and contributions to this endeavor. This plan is like an engine that is designed to move an object forward; without the appropriate parts (agencies, stakeholders, and strategies) it will not run, and without fuel (funding) its progress will be limited."

– Kurt Nelson, Tulalip Tribes

3. Recovery Strategies and Actions

The ESA requires that recovery plans, "to the maximum extent practicable incorporate … site-specific management actions as may be necessary to achieve the plan's goal for the conservation and survival of the species…" This chapter describes the recovery strategies and site-specific management actions that NMFS recommends for the conservation and recovery of Puget Sound steelhead. These strategies and actions are based on the best scientific data available and are designed to help meet the recovery goals described in Chapter 2 and the delisting criteria in Chapter 4. The chapter also presents an adaptive management process framework and describes how knowledge gained through research, monitoring and evaluation, including life-cycle modeling, will be integrated into the process to help guide recovery plan implementation.

The biological status of Puget Sound steelhead has been impacted by numerous human activities over the last 150 years. The Puget Sound recovery team considered the "pressures" (human activities and natural events resulting in impairment to steelhead populations or their habitat) associated with each of the five ESA listing factors and developed the strategies and actions found in this chapter and further described in Appendix 4.

The recovery team followed an Open Standards for the Practice of Conservation approach[6] to identify the high-priority pressures that threaten steelhead, develop strategies to reduce or remove these pressures, and define strategies and actions to restore key habitat types that have been previously damaged. The high-priority pressures for steelhead were arrived at through analysis of several lines of evidence rather than a single pressure assessment. Initial work included the Puget Sound Pressure Assessment, a tool developed and used by the Puget Sound Partnership to assess (terrestrial and marine) threats to various species and habitats. Results of the assessment were organized by MPG, but the team found the results to be insufficient because steelhead were not one of the species included in the original analysis, and some steelhead-specific threats were not well understood or included when the tool was developed in 2014. In addition, both the cause and effect were often combined in the regional list. Thus, the team attempted a series of multivariate analyses to separate cause (e.g., timber harvest) from effect (e.g., sedimentation). These analyses found that many of the individual pressures identified in the assessment covaried strongly across the DPS, and that pressures and stressors (conditions that apply stress on the fish and limit viability) were sometimes confounded. The team also found that the potential impacts on steelhead from the

[6] Developed by the Conservation Measures Partnership, this is a publicly available approach to project design, management, and monitoring that aims to help practitioners improve the practice of conservation. The approach provides a general process for the successful development and implementation of conservation projects.

stressors differed appreciably among the three steelhead MPGs in Puget Sound. Defining specific strategies to reduce the impact of stressors through mitigation of pressures is challenging for steelhead and other migratory fish with complex life cycles because simple action pathways are often not possible to identify.

Beyond the Puget Sound Pressures Assessment, the team also looked to the original listing factors for steelhead in 2007, as well as the 2015 Northwest Fisheries Science Center status review for listed Pacific salmon and steelhead (Ford 2015) to round out a steelhead-specific list of high-priority pressures to address to reach recovery. Figure 3 shows how the team separated pressures from stressors, and the relationships between pressures and stressors in the two groups. In most cases, the recovery strategies were developed for each pressure. However, some pressures, such as roads and culverts, were split up and addressed as “fish passage barriers at road crossings” and as part of other pressures such as “residential, commercial, industrial development” (for paved roads) and “timber harvest” (for unpaved roads).

Photo: The Skagit River. Credit: ©Copi Vojta (Used by permission).

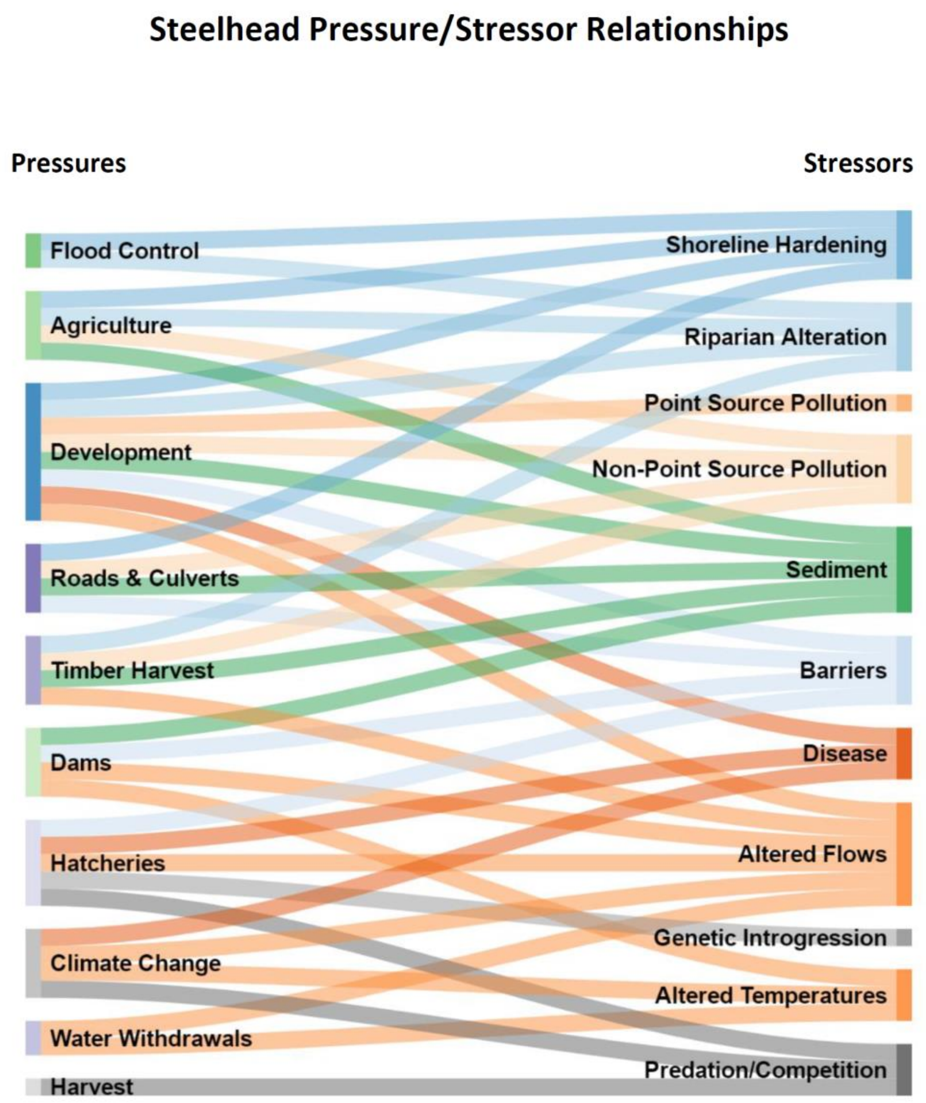

Figure 3. The complex relationship among pressures and stressors affecting steelhead abundance and productivity in Puget Sound ecosystems.

The sections below describe the adaptive management approach to Puget Sound steelhead recovery (Section 3.1) and define the various pressures on Puget Sound steelhead and the strategies and actions to reduce, alleviate, or mitigate them (Sections 3.2, 3.3, and 3.4). Sections 3.2 and 3.3 summarize strategies and actions at the DPS and MPG levels; Section 3.4 identifies specific strategies and actions to address the various pressures on the species. Additional sections in this chapter describe strategies to address current and future effects of climate change (Section 3.5) and to implement the necessary monitoring and research strategies and actions for adaptive management (Section 3.6), all of which crosscut multiple pressures and stressors. The strategies and actions are further described in Appendix 4. On-the-ground activities to implement the strategies and actions will be detailed in the separate watershed-level chapters that will be developed at the local level to reflect the needs of individual Puget Sound steelhead populations, habitats, and communities.

3.1 Recovery Strategy and Adaptive Management Framework

Our recovery strategy aims to improve the viability of natural-origin populations of Puget Sound steelhead so the species is self-sustaining in the natural environment and the populations are sufficiently abundant, productive, and diverse so that the species no longer needs ESA protection.

In this Plan we describe strategies and actions that span DPS to DIP scales. Many of the strategies and actions identified in the Plan are common among multiple watersheds in the DPS. To effectively recover Puget Sound steelhead, recovery strategies must span multiple spatial scales (DPS, MPG, and DIP), accommodate regional and watershed protection and restoration activities, include voluntary and regulatory elements, and directly address the listing factors.

A fundamental aspect of the recovery strategy for Puget Sound steelhead is to incorporate local, watershed-based strategies and actions (primarily DIP-level) into the Plan that address individual steelhead populations. Ultimately, these future watershed chapters and localized strategies will form a critical piece of our recovery strategy — particularly since the overarching approach for recovery of Puget Sound steelhead focuses primarily on protecting and restoring ecosystem functions and freshwater habitats. A key strength of this effort is that each future watershed chapter will be tailored to the particular conditions and needs of that basin, while appropriately scaled to adapt to changing conditions or knowledge. Another key strength of this approach is that the individual watershed chapters will integrate findings from life-cycle modeling to focus recovery efforts appropriately. Together, they will create a composite result that meets the criteria for MPG viability and DPS recovery provided by the Puget Sound Steelhead Technical Recovery Team. The individual work plans for these watersheds will remain dynamic; growing and changing over time as DPS, MPG, and watershed-level approaches to recovery evolve.

The strategies and actions described in Sections 3.4 address the following primary pressures contributing to the decline and listing of Puget Sound steelhead, as described in Section 1.2.3:

- Fish passage barriers at road crossings;
- Dams, including fish passage and flood control;
- Floodplain impairments, including agriculture;
- Residential, commercial, industrial development (including impervious runoff);
- Timber harvest management;
- Water withdrawals and altered flows;
- Ecological and genetic interactions between hatchery- and natural-origin fish;
- Harvest pressures (including selective harvest) on natural-origin fish; and
- Juvenile mortality in estuary and marine waters of Puget Sound.

Sections 3.5 and 3.6 provide strategies and actions to address climate change and to focus and integrate research, monitoring, and evaluation activities to improve our understanding of the factors that affect steelhead viability and the success of our efforts to address them.

We believe that the strategies and actions identified in this chapter and Appendix 4, if successfully implemented, will lead to the recovery of Puget Sound steelhead. Importantly, our approach to recovery is multifaceted. We need to conduct monitoring and research to gain critical information to assess and model life cycles and pressures that limit recovery, identify the actions most likely to improve steelhead population status, measure the effectiveness of those actions, adapt the actions accordingly to improve their effectiveness, and track progress towards recovery. We also need to identify additional activities and strategies within each MPG to adaptively manage DIP-specific pressures in individual watersheds. To that end, watershed-scale monitoring of natural-origin populations is necessary, and in a subset of watersheds, needs to be combined with habitat monitoring to validate recovery assumptions and progress.

3.1.1 Adaptive Management Process Framework to Guide Recovery Efforts

Our approach centers on the adaptive nature of the recovery plan. We recognize the importance of learning as we go, and adjusting our efforts accordingly. Thus, at the core of recovery plan implementation is an adaptive management process that targets actions based on best available science, monitors to improve the science, and updates actions based on new knowledge.

We need to:

- Continue to identify critical uncertainties and address them through monitoring and evaluation;
- Develop and integrate life-cycle modeling to weigh the effects of different factors, individually and combined, and among watersheds and life-history strategies;
- Monitor and evaluate the site-specific actions over time to determine progress and effectiveness in addressing the viability criteria; and
- Identify the next round of future actions, implement them, and then monitor their effects and influence on our progress toward recovery.

Figure 4 shows the different steps in the adaptive management process framework.

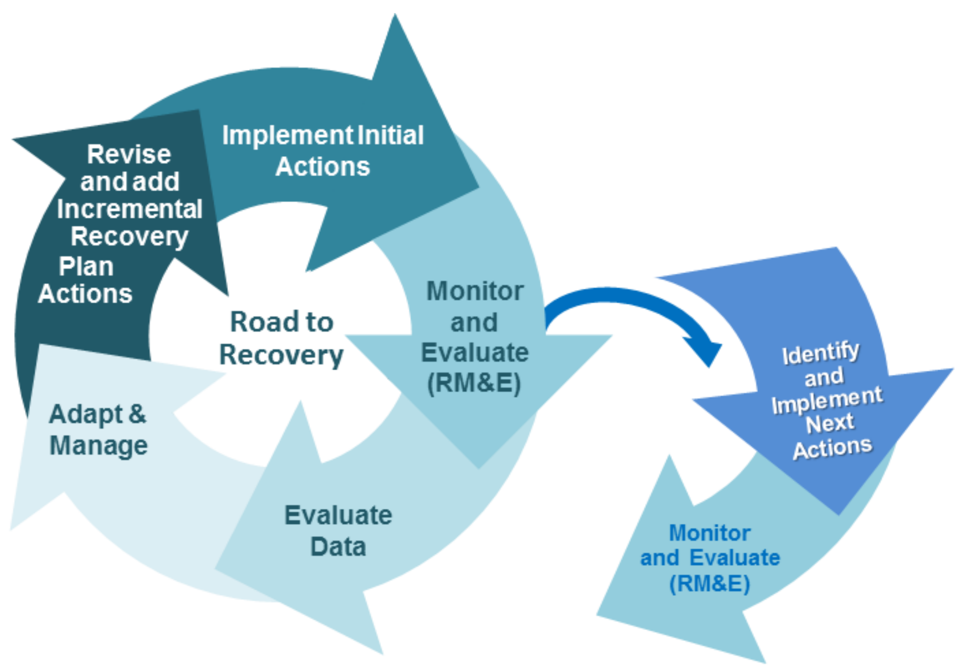

Figure 4. Adaptive management process framework.

Several key questions will guide the adaptive management process:

- Where and how can we focus our initial efforts most effectively?
- Are efforts working according to expectations? If not, what adjustments can be made to make our efforts more effective?
- For research, monitoring and evaluation implementation:
  - Are the actions being implemented?
  - Are our background assumptions still valid (e.g., climate)?
  - Are the actions having the expected effects (changes in habitat, response by fish populations)?
- What is the suite of potential future actions?
- What questions need to be answered to implement additional actions?

The adaptive management framework will provide structure for decision making so we can alter our course strategically as we gain new information;

1. Determine species current status (Chapter 1).
2. Establish recovery goals (Chapter 2) and viability and listing factor criteria for delisting (Chapter 4).
3. Assess the pressures and limiting factors that contribute to the gaps between current status and viability criteria (Chapter 3).
4. Identify and implement recovery strategies and actions that target the pressures and stressors (Chapter 3).
5. Identify and implement research, monitoring, and evaluation actions to evaluate the status of the species, the status and trends of pressures, and the effectiveness of ongoing and potential actions (Chapter 3).
6. Regularly review implementation progress, species response, monitoring and modeling results, and new available information (Chapter 4).
7. Adjust actions through an implementation structure that recognizes the interests of different stakeholders and the best opportunities to improve viability (Chapter 3).
8. Repeat the adaptive management cycle. Adaptive management should be a continuous loop of action including implementation, monitoring, and evaluation, assessment of new information, and updated actions.

3.1.2 Implementation Framework

The recovery of Puget Sound steelhead will ultimately depend on the commitment and dedicated actions of the many entities and individuals who share responsibility for the species' future. Together we face a common challenge. We need to return the species to a level where we are confident that it is viable and naturally self-sustaining. We also need to ensure that the pressures to the species across its life cycle have been adequately addressed, and that regulatory and other programs are in place to conserve the species over the long term.

During implementation of this recovery plan, NMFS will rely, to a great extent, on the continued implementation of ongoing programs, management actions and regulations, and on the implementation of the many new actions proposed in this Plan and in future watershed chapters to address threats to steelhead viability across the Puget Sound region. Our many partners have implemented hundreds of projects and made countless improvements to existing restoration program. The projects implemented by these different partners have protected, connected, and restored habitats throughout Puget Sound and improved fish management. Despite these efforts, however, most of the steelhead populations are not improving and the species' three major population groups remain at very low viability. Consequently, we will need to continue and in some cases dramatically increase our efforts if we are going to reach recovery. To this end, NMFS aims to improve collaboration with the various fish and habitat managers so that recovery actions are prioritized and targeted effectively, and to accelerate efforts by local watershed groups so that our collective efforts can bring the species to a point where we are confident that it can be self-sustaining in the natural environment for the long term. Section 1.3.1 identifies many of our current partners in steelhead recovery, and we encourage others to join our efforts.

In general, NMFS' vision for recovery plan implementation is that recovery plan actions are carried out in a cooperative and collaborative manner so that recovery and delisting occurs. NMFS' strategic goals to achieve this vision are as follows:

1. Sustain local and regional support and momentum for recovery plan implementation.
2. Implement recovery plan actions within the time periods identified in the Plan.
3. Encourage others to use their authorities to implement recovery plan actions.
4. Implement the adaptive management process to target and adjust efforts to verify that the implemented actions are contributing to recovery.
5. Provide accurate assessments of species status and trends, limiting factors, and threats.

3.1.2.1 NMFS' Role in Recovery Plan Implementation and Coordination

NMFS' role in implementation of this recovery plan is threefold: (1) to ensure that the agency's statutory responsibilities for recovery under the ESA are met; (2) to integrate recovery planning efforts with other related efforts in Puget Sound; and (3) to guide and support the various implementation groups so we can achieve steelhead recovery.

NMFS Recovery Planning Responsibilities

NMFS recovery planning responsibilities include the following tasks:

- Ensure that the recovery plan meets ESA statutory requirements, tribal trust and treaty obligations, and agency policy guidelines.
- Conduct ESA 5-year status reviews (see Section 4.4.2).
- Make determinations regarding listing, changes in ESA listing status, and delisting determinations.
- Coordinate with other federal agencies to ensure compliance under the ESA.
- Implement actions in this recovery plan for which NMFS has the authority and funding to do so.

- Report on the implementation of the management and RM&E actions in this Plan, and prepare updated findings during 5-year status reviews, or sooner if information warrants.

NMFS Coordination and Support Role

NMFS will work with regional and local implementation groups to make sure the recovery efforts are closely coordinated.

- Support existing management forums and local efforts, and provide needed coordination among those existing efforts, to accelerate recovery plan implementation.
- Use recovery plans to help guide state and local regulatory decision-making.
- Provide leadership in regional forums to develop RM&E processes that track effectiveness of recovery actions and status and trends of habitat and abundance indicators at the DIP, MPG, and DPS levels.
- Provide periodic reports on species status and trends, and progress in addressing listing factors and pressures.
- To the extent practicable, staff and support identified implementation groups for Puget Sound steelhead recovery.

During recovery plan implementation, NMFS will work with partners to integrate Plan strategies and actions into existing recovery forums, such as the Puget Sound Partnership Leadership Council and the Washington State Salmon Recovery Funding Board (SRFB). Integrating Plan implementation includes facilitating the sharing of RM&E information and coordinating decisions regarding the prioritization and implementation of recovery actions.

The components of the implementation framework, once integrated, will reinforce the need for (1) a science team to deliver rigorous, scientific reviews and ensure that the best available science informs implementation and is applied in all relevant research and monitoring activities; and (2) a Puget Sound Salmon Recovery Council (PSSRC) policy group made up of representatives from the tribes, state and federal agencies, local watershed teams, and other implementing entities to provide input about the best ways to coordinate efforts to advance Puget Sound steelhead recovery and maintain strong communication among recovery entities.

3.1.2.2 Watershed-Level Implementation and Coordination

Given the large number of economic, biological, and social uncertainties involved in implementation of this recovery plan, NMFS will work with state and tribal co-managers and the local watershed teams to integrate actions that benefit steelhead into the Chinook Salmon 4-year work plans that will focus implementation of recovery actions identified in this Plan and its individual watershed chapters. Specific actions, and costs as appropriate, will be identified based on the best information available at the time for these 4-year periods. The work plans developed for these periods will identify and prioritize site-specific actions and RM&E needs, determine costs and time frames, and identify responsible parties for action implementation, based on the strategies and actions in this recovery plan. Over the longer term, the recovery plan relies on ongoing monitoring and periodic Plan reviews to add, eliminate, modify, and prioritize actions through the adaptive management process as information becomes available, and until such time as the protection of the ESA is no longer required. Although NMFS considers the integration of steelhead actions into the Chinook

Salmon 4-year work plans to be an efficiency, additional resources may be necessary to fully accomplish this effort.

3.2 DPS-Level Strategies and Actions

Our overall recovery strategy aims to improve the viability of natural-origin populations of Puget Sound steelhead so that the species is self-sustaining in the wild and the populations are sufficiently abundant, productive, and diverse so that the species no longer needs ESA protection. Achieving species recovery will require coordinated and collaborative management and implementation of actions at local, watershed, and regional levels. This section describes recovery strategies and actions to address pressures and factors at the regional level (freshwater and marine environments, hatchery and fishery management, and climate change).

3.2.1 DPS-Level Strategies and Actions for Freshwater Habitat

Our recovery strategy has a single overriding focus: increasing productive habitats.

Protecting existing high quality habitats and restoring impaired habitats will specifically benefit steelhead in the spawning and juvenile rearing life stages. Habitat restoration actions will also improve habitat conditions and reduce mortalities for steelhead during their time in the marine environment. Improved freshwater and marine conditions means that more fish will reproduce, more juveniles will survive and migrate, and consequently more adults will return to the area. This pathway is consistent with NMFS' adopted ecosystem-based management approach to salmon and steelhead recovery.

Strategy to Improve Habitat at the DPS Level

Our habitat strategy recognizes that recovery demands the application of well-formulated, scientifically sound approaches. It is founded on the concepts presented in several salmonid habitat recovery planning documents and scientific studies (e.g., Beechie and Boulton 1999; Roni et al. 2002; Beechie et al. 2003; Roni et al. 2005; Stanley et al. 2005; Roni et al. 2008; Beechie et al. 2010; Beechie et al. 2013; Roni and Beechie 2013). These studies show that restoration planning that carefully integrates watershed ecosystem processes is more likely to succeed in restoring depleted salmonid populations (Beechie et al. 2003). Beechie et al. (2010) outlined four principles that would ensure that river restoration is guided toward sustainable actions:

1. Address the root cause of degradation.
2. Be consistent with the physical and biological potential of the site.
3. Scale actions to be commensurate with the environmental problems.
4. Clearly articulate the expected outcomes.

The habitat recovery strategies in this Plan apply these four principles. They also build on the many conservation efforts that are already helping to protect, conserve, and restore spawning and rearing habitats on public and private lands in Puget Sound. Recovery projects include: (1) protecting and conserving natural ecological processes and existing high quality habitat, (2) improving fish passage and stream flows to increase access to high quality habitat, (3) restoring floodplain connectivity and riparian vegetation, (4) improving water quality, and (5) restoring instream habitat complexity. Many of these projects are being accomplished through coordination between water and land managers, private landowners, public interest groups, and others using a variety of funding sources.

1. Protect and/or restore watershed processes and reconnect high quality historic habitats.
Many scientists have recognized that protecting and restoring ecosystems is essential to long-term success in salmonid recovery (Reeves et al. 1991; Nehlsen et al. 1991; and Beechie et al. 2003). Protecting high quality habitats, improving core juvenile rearing habitats, and increasing capacity by restoring access to high quality habitats are among the most commonly understood means to increase Puget Sound steelhead abundance, diversity, productivity and spatial structure (NWIFC 2016; Hard et al. 2015). High quality juvenile steelhead rearing habitat is a reflection of stream complexity, which is shaped by a combination of several key watershed processes that influence hydrologic, sediment, riparian, channel, biological, floodplain, and estuarine habitat functions. High quality over-wintering habitat for juvenile fish provides refuge from high flows. It usually contains one or more of the following features: large wood and debris, deep pools, connected side channels, off-channel alcoves, beaver ponds, and connected floodplains and wetlands. High quality summer-rearing habitat contains many of the same features as winter-rearing habitat, but also provides refuge from high summer stream temperatures.

2. Improve long-term ecosystem functions and high quality habitat by reducing habitat-related pressures.
Specific physical and biological features are essential to the conservation of the DPS. For example, connected and periodically inundated floodplains, channel complexity, spawning gravels, water quality and quantity, side channels, estuary habitat, and healthy food webs support Puget Sound steelhead spawning, rearing, migration, and foraging. Protecting and restoring these types of sites, and the features associated with them, constitutes a general high-priority recovery strategy applicable to all listed salmonid species, including Puget Sound steelhead.

3. Improve and recover the species through innovative partnerships.
Since multiple causes are responsible for impairing population viability, disrupting ecosystem functions and contributing to habitat loss and degradation, the habitat-related pressures and stressors that limit Puget Sound steelhead viability will need to be addressed in concert. Development and implementation of management actions that lead to recovery requires a sound understanding of conservation biology principles and ecosystem management as well as integration of planning, regulation, action implementation, funding, and monitoring such that each contributes to reaching our end goal. Consequently, our recovery strategy calls for increasingly effective voluntary actions, regulatory mechanisms, and enforcement of laws and regulations.

NMFS aims to strengthen partnerships with governmental and nongovernmental organizations and others to improve collaboration in Puget Sound steelhead recovery efforts. NMFS will rely on a combination of effective long-term participation in non-regulatory, voluntary conservation work plus focused regulatory programs to achieve DPS viability. In non-regulatory aspects, we will continue to work with our recovery planning partners to encourage and support conservation work by private landowners, local groups and others to improve ecological processes and habitats, particularly in areas with the greatest potential to create and/or support high quality steelhead rearing habitat. In regulatory aspects, it may be necessary to work with state and local agencies to strengthen laws and/or regulations to address some habitat-altering actions and/ or to boost enforcement of existing regulatory mechanisms to provide instream flows and habitat conditions that can support a sustainable DPS.

4. Track progress toward recovery, monitor changes to ecological conditions and population status, assess results, and refine strategies and actions accordingly.
Our DPS-level habitat strategy includes implementation of research and monitoring to gain needed information about the habitat factors and ecosystem functions that are currently limiting productivity. RM&E will also provide needed information to better focus our efforts, such as where cold-water refugia and overwintering habitats can be protected or improved to increase juvenile productivity and survival.

Status and trends monitoring will provide essential information on the status of the different steelhead populations, as well as trends in steelhead productivity and habitat in freshwater and marine environments. It will help us identify locations of habitat restoration opportunities, but importantly, it will help us comprehensively understand where habitat and populations may be declining.

Monitoring will also help us determine the effectiveness of habitat improvements in increasing tributary habitat function and carrying capacity, and track how fish respond to habitat restoration efforts, including the aggregate effects of multiple habitat actions at the watershed or population scale. In addition, by monitoring and evaluating common ecological conditions (e.g., flow and temperature) that define ecological concerns for steelhead across a diversity of ecological regions and habitat types, we will be able to assess and compare responses of the different populations to habitat restoration efforts.

3.2.2 DPS-Level Strategies and Actions for the Marine Environment

This strategy relies on the Puget Sound Steelhead Marine Survival Workgroup's hypothesis-driven adaptive management approach to test and evolve management actions that address hypothetical factors that influence survival while continuing to build understanding about the causes of low early marine survival. It also aims to work with local-level partners to increase efforts in individual watersheds to improve conditions, such as availability of buffer prey, to help boost survival of steelhead during their marine migration. Section 3.4.9 describes pressures to early marine survival and identifies strategies and actions to address them.

3.2.3 DPS-Level Strategies and Actions for Hatchery Management

The central challenge of recovery planning with respect to hatchery programs is finding a balance between the risks and benefits of hatchery production in working to achieve recovery goals. The path to determining the appropriate role of hatchery programs in recovery is complicated by the requirements of the ESA, legal agreements regarding production levels, agreements regarding mitigation levels, harvest agreements, tribal trust responsibilities, and scientific uncertainty. Section 3.4.7 describes the hatchery-related pressures and strategies and actions to address them.

3.2.4 DPS-Level Strategies and Actions for Harvest

The harvest strategy supports the recovery of Puget Sound steelhead by addressing direct and indirect fishery effects on the diversity, spatial structure, abundance, and productivity of steelhead populations. Section 3.4.8 describes the harvest-related factors that affect Puget Sound steelhead and strategies and actions to address them.

3.2.5 DPS-Level Strategies and Actions to Address Climate Change

The strategy for addressing impacts from climate change centers on protecting high quality habitats, increasing connectivity to blocked historical habitats and off-channel floodplain refuge, and restoring habitat conditions and habitat-forming ecosystem processes. In particular, as a hedge against climate change we need to implement strategies and action that will increase life-history diversity within MPGs and individual populations. At the watershed level, this includes increasing the complexity of habitat types in streams and estuaries and, thus, the number of successful pathways that steelhead have available. By providing the fish with ample diverse habitats, we will enhance their ability to adapt to climate-induced changes by moving between areas and/or adjusting their migration timing. The species' adaptive ability has provided resiliency to a wide variety of climatic conditions in the past and will likely be critical to their long-term persistence. Sections 3.4 and 3.5 identify strategies and actions to improve Puget Sound's freshwater and estuarine habitats and otherwise help guard the steelhead populations against the impacts from climate change. Increased monitoring efforts, as described in the strategies and actions of Section 3.6, will address uncertainties from climate change impacts.

At the DPS level, NMFS will coordinate and collaborate with WDFW, WDOE, tribes, cities, counties, other federal and state agencies, and other parties to protect critical habitat areas, improve and maintain instream flows, regain access to historical habitats now blocked by dams and other barriers, reduce risks from wildfire and other effects of climate change, and restore habitat-forming processes and water conditions in critical areas for steelhead production. NMFS will also work with managers to monitor hatchery programs and accordingly adapt to climate change impacts, and with harvest managers to adjust harvest strategies to protect natural-origin steelhead populations based on climate change forecasts and modeling.

Photo: Steelhead. Credit: John McMillan.

3.3 MPG-Level Strategies and Actions

Consistent with the biological viability criteria discussed in Chapter 4, all MPGs in the Puget Sound Steelhead DPS need to be viable for the DPS to be removed from the ESA's threatened and endangered species list. This section provides direction for recovery of the three Puget Sound steelhead MPGs to support DPS delisting.

3.3.1 Recovery Strategy for North Cascades MPG

North Cascades Steelhead MPG

Populations: Eight winter-run (Drayton Harbor Tributaries, Nooksack, Samish /Bellingham Bay, Nookachamps, Stillaguamish, Snohomish/Skykomish, Pilchuck, Snoqualmie); three winter/summer-run (Skagit, Baker, and Sauk); and five summer-run populations (SF Nooksack, Deer, Canyon, NF Skykomish, Tolt).

Desired Status: Achieve MPG-level viability (low risk) with at least 50 percent of DIPs (5 winter-run populations and 3 summer-run populations) at viable status and no more than one population of each life-history type considered not viable.

Current Status: Very low viability.

Recovery Strategy for the North Cascades Steelhead MPG

The basic recovery strategy for the North Cascades MPG aims to protect and increase access to high quality habitats, especially in upper watersheds, restore lower and middle watershed reaches with potential high quality habitat, and improve juvenile survival in Puget Sound waters.

- Restore access to historical habitats, especially to areas that retain historical processes, structural complexity, and well-functioning habitats.
- Reconnect stream reaches to side channels, wetlands, and other floodplain areas and restore channel migration opportunities by removing bank armoring and reducing confinement, including along the Skagit, South Fork, and mainstem Nooksack rivers.
- Restore riparian functions by replanting degraded riparian areas and reestablishing native vegetation appropriate for habitat formation and to increase shade.
- Protect instream flows and improve flows in the Nooksack, Skagit, Snohomish, Stillaguamish, and other identified rivers by enforcing regulations, restricting permit-exempt wells that remove groundwater in areas that are hydraulically linked to waterways with low summer flows, using incentive programs (such as water banking or water rights lease or purchase), protecting and restoring groundwater recharge areas, and improving other hydrological characteristics.
- Encourage use of low-impact development techniques for new construction and replace impervious surfaces with surfaces that allow water to soak into the ground.
- Remove Middle Fork Nooksack and Pilchuck Diversion Dams; provide passage at Baker Dam; remove other high-priority dams as identified and determined feasible.
- Protect intact floodplains and wetlands and restore habitat conditions by updating local plans consistent with recovery efforts, reducing allowance of variances and exceptions to plan restrictions, and enforcing Critical Area Ordinances, Shoreline Master Plans, growth management zoning, habitat conservation plans, and other existing land use regulations.
- Improve early marine survival by reducing predation, disease and toxic contaminants; removing bank armoring; enhancing tidal wetlands; and otherwise increasing fish survival.
- Manage hatchery programs and fisheries to promote and support steelhead recovery.

Priority Populations and Watersheds

Priority populations in this MPG include four winter or winter/summer-run populations from the Nooksack, Stillaguamish, Skagit or Sauk, and Snohomish River basins and three summer-run populations from the Nooksack, Stillaguamish, and Snohomish basins. The populations are targeted to achieve viable status to support MPG viability. Having viable populations in these basins assures geographic spread, provides habitat diversity, reduces catastrophic risk, and increases life-history diversity. Important reaches include the South Fork Nooksack River, Deer Creek or Canyon Creek, and Tolt River or North Fork Skykomish River. Section 4.2.2 provides more information on these priorities for MPG recovery.

3.3.2 Recovery Strategy for Central and South Puget Sound MPG

Central and South Puget Sound Steelhead MPG

Populations: Eight winter-run populations (Cedar River, North Lake Washington/Lake Sammamish, Green River, Puyallup/Carbon rivers, White River, Nisqually River, South Puget Sound Tribs., East Kitsap Peninsula).

Desired Status: Achieve MPG-level viability (low risk) with at least 50 percent of the DIPs at viable status (four populations) and no more than one population considered not viable.

Current Status: Very low viability.

Recovery Strategy for the Central and South Puget Sound Steelhead MPG

The basic recovery strategy for the MPG aims to protect and increase access to high quality habitats, especially in upper watersheds, restore lower and middle watershed reaches with potential high quality habitat, and improve juvenile survival in Puget Sound waters.

- Restore access to historical habitats, especially to areas that retain historical processes, structural complexity, and well-functioning habitats.
- Reconnect stream reaches to side channels, wetlands, and other floodplain areas and restore channel migration by removing bank armoring and reducing confinement, including along lower reaches of the Puyallup, White and Carbon rivers.
- Restore riparian functions by replanting degraded riparian areas and reestablishing native vegetation appropriate for habitat formation and to increase shade.
- Improve instream habitat complexity and juvenile rearing conditions by adding large wood and other natural habitat features.
- Protect and improve flows in the Puyallup, White, and other rivers by enforcing water use regulations, restricting permit-exempt wells that remove groundwater in areas that are hydraulically linked to waterways with low summer flows, using incentive programs (such as water banking or water rights lease or purchase), protecting and restoring groundwater recharge areas, and improving other hydrological characteristics.
- Encourage use of low-impact development techniques for new construction and replace impervious surfaces with surfaces that allow water to soak into the ground.
- Remove high-priority dams as identified and determined feasible; provide effective fish passage and monitor effectiveness of fish passage at Howard Hanson Dam, Hiram Chittenden Locks, Buckley Diversion Dam, Mud Mountain Dam, and Electron Dam.
- Protect intact floodplains and wetlands and restore habitat conditions by updating local plans consistent with recovery efforts, reducing allowance of variances and exceptions to restrictions, and enforcing Critical Area Ordinances, Shoreline Master Plans, growth management zoning, habitat conservation plans, and other existing land use regulations.
- Improve early marine survival by reducing predation, disease, and toxic contaminants (e.g., Puyallup River estuary and Sinclair Inlet); removing bank armoring; enhancing tidal wetlands; and otherwise increasing fish survival.
- Manage hatchery programs and fisheries to promote and support steelhead recovery.

Priority Populations and Watersheds

Priority winter-run populations in this MPG include the Green, Nisqually, and the Puyallup/Carbon or White populations. The populations are targeted to achieve viable status to support MPG viability. The Green, Puyallup, and Nisqually basins support the MPG's core extant winter-run steelhead populations and contain important, diverse stream habitats. Section 4.2.2 provides more information on these priorities for MPG recovery.

3.3.3 Recovery Strategy for Hood Canal /Strait of Juan de Fuca MPG

Hood Canal and Strait of Juan de Fuca Steelhead MPG

Populations: Seven winter-run (East Hood Canal Tribs., South Hood Canal Tribs., Skokomish River, West Hood Canal Tribs., Sequim/ Discovery Bay Tribs., Strait of Juan de Fuca Tribs., Elwha River) and one summer/ winter-run (Dungeness River) populations. Possible historical Elwha River summer-run population but now extirpated.

Desired Status: Achieve MPG-level viability with at least 50 percent of the DIPs attaining viable status (four populations) and no more than one independent population of each life history type considered not viable.

Current Status: Very low viability.

Recovery Strategy for the Hood Canal/ Strait of Juan de Fuca Steelhead MPG

The basic recovery strategy for the Hood Canal/Strait of Juan de Fuca MPG aims to protect and increase access to high quality habitats, especially in upper watersheds, restore lower and middle watershed reaches with potential high quality habitat, and increase juvenile survival in Puget Sound waters.

- Restore access to historical habitats above culverts, small dams and other artificial barriers, especially to areas that retain historical processes, structural complexity, and well-functioning habitats.
- Reconnect stream reaches to side channels, wetlands, and other floodplain areas along the Dungeness, Skokomish, and other identified rivers and restore channel migration opportunities by removing bank armoring and reducing confinement.
- Restore riparian functions by replanting degraded riparian areas and reestablishing native vegetation appropriate for habitat formation and to increase shade.
- Protect instream flows and improve flows in the Dungeness and other rivers by enforcing regulations, restricting permit-exempt wells that remove groundwater in areas that are hydraulically linked to waterways with low summer flows, using incentive programs (such as water banking or water rights lease or purchase), protecting and restoring groundwater recharge areas, and improving hydrological characteristics.
- Continue cleanup and restoration to improve water quality in Port Angeles Harbor.
- Remove high-priority dams as identified and determined feasible.
- Protect intact floodplains and wetlands and restore habitat conditions by updating local plans consistent with recovery efforts; reducing allowance of variances and exceptions to plan restrictions; and enforcing Critical Area Ordinances, Shoreline Master Plans, growth management zoning, habitat conservation plans, and other existing land use regulations.
- Improve early marine survival by reducing predation, disease, and toxic contaminants; removing bank armoring; enhancing tidal wetlands; and otherwise improving fish survival.
- Manage hatchery programs and fisheries to promote and support steelhead recovery.

Priority Populations and Watersheds

Priority populations in this MPG include the Elwha River winter/summer-run and the Skokomish River winter-run. Both are targeted to support MPG viability. Two other populations (one from the Hood Canal area and one from the Strait of Juan de Fuca area) also need to achieve viability to maximize geographic spread and habitat diversity. The Elwha and Skokomish rivers are the MPG's two largest single watersheds and bracket the geographic extent of the MPG. Both the Elwha and Skokomish populations have recently exhibited summer-run life histories. Section 4.2.2 provides more information on these priorities for MPG recovery.

3.4 Strategies and Actions to Address Pressures

The strategies and actions described in Sections 3.4.1–3.4.9 address the following high-priority pressures contributing to the decline and listing of Puget Sound steelhead, as described in Section 1.2.3.

- Fish passage barriers at road crossings;
- Dams, including fish passage and flood control;
- Floodplain impairments, including agriculture;
- Residential, commercial, industrial development (including impervious runoff);
- Timber harvest management;
- Water withdrawals and altered flows;
- Ecological and genetic interactions between hatchery and natural-origin fish;
- Harvest pressures (including selective harvest) on natural-origin fish; and
- Juvenile mortality in estuary and marine waters of Puget Sound.

Many of the strategies and actions identified here address tributary habitat-related pressures. These strategies and actions will be further defined and prioritized by local recovery planners during watershed-level planning efforts for Puget Sound steelhead to target specific pressures and stressors at the DIP level. Adaptive management, RM&E, and life-cycle modeling are important parts of the habitat implementation strategy. Employing these tools is in keeping with our precautionary approach to recovery, and will help us define our steps effectively to best meet DIP, MPG, and DPS viability goals. The tools will also provide valuable insight as we strive to be proactive in addressing potential impacts from climate change.

3.4.1 Pressure: Fish Passage Barriers at Road Crossings

Fish passage barriers at road crossings are prevalent in Puget Sound streams. The WDFW estimates that as many as 8,000 culverts block access to steelhead habitats in Puget Sound (WDFW 2009; GAO 2001; WDFW 2018). Impassable culverts reduce habitat carrying capacity, limiting abundance and spatial structure. Wofford et al. (2005) found that blocking culverts have caused genetic variation among isolated fish populations. Blocking culverts also reduces access to juvenile steelhead refugia habitat in tributaries during floods. Because steelhead occupy both higher elevation, smaller tributaries to major river systems, as well as independent smaller river systems that flow directly into Puget Sound, fish passage barriers are a more prominent concern for this species than for listed Puget Sound Chinook salmon.

Culverts can form fish passage barriers in a number of ways. Roads and culverts are a fixed feature in a dynamic stream environment where shifting channels move both vertically and laterally. Culverts need to be designed and installed to withstand these movements as well as flood pulses, sediment movement, and drifting large wood. Culverts that meet these criteria are most commonly among “stream simulation” designs. Culverts designed without these criteria often form barriers through time (Price et al. 2010). Barriers to steelhead occur when culverts become perched above the substrate, are designed or installed too steeply, or when they are undersized relative to the channel resulting in swimming velocity barriers. Changing stream flow patterns due to climate change also continue to impact passage conditions and need to be considered in culvert design.

A number of existing programs in Washington have improved fish passage over the last 20 years, but there are still many barriers remaining to be repaired, especially on non-forest private lands and local government roads. Under the Forests and Fish Agreement (WDNR 2005), state and private industrial forest landowners committed to repairing fish passage barriers on their roads under the Road Maintenance and Abandonment Program's Road Maintenance and Abandonment Planning (RMAP) process. Twenty years later, nearly all of those barriers (7,300 statewide) have been fixed. Unfortunately, successful programs in non-forest landscapes are still developing or are under-funded. Among the programs showing the most promise for successfully prioritizing and removing barriers to steelhead are the Fish Barrier Removal Board (FBRB) and the Family Forest Fish Passage Program (FFFPP). Programs within local governments (cities and counties) are among the most in need of development and progress.

Photo: Culvert replacement for fish passage restoration. Credit: Nooksack Salmon Enhancement Association.

The U.S. Supreme Court recently affirmed the rights of Western Washington Treaty Tribes to have unobstructed salmon and steelhead passage at Washington State road crossings in Puget Sound and coastal streams (*Washington v. United States*, 138 S. Ct. 1543, 200 L. Ed. 2d 736 (2018)). The case affirmed the tribes' rights to harvestable fish against fish-blocking culverts on state-owned roadways. Although Washington State has been correcting fish passage barriers for more than 20 years, approximately 415 salmon/steelhead barriers remain to be repaired on state-owned roads by 2030 at an estimated cost of $3.8 billion (WSDOT 2019). Both voluntary and regulatory tools are needed to repair barrier culverts and recover Puget Sound steelhead. One such tool, recently developed by WDFW, allows engineers, managers, regulators and others to explore possible impacts of climate change on fish passage and to design culverts that accommodate anticipated changes in stream flow.

Strategies and Actions to Improve Fish Passage

Strategy 1. Maintain and increase support for the Fish Barrier Removal Board and related programs.

- **Action 1.a.** Seek continued funding for the Fish Barrier Removal Board.
- **Action 1.b.** Complete RMAP program and increase funding for the FFFPP.
- **Action 1.c.** Support Snohomish County's barrier repair pilot program and expand to other areas.
- **Action 1.d.** Develop and implement a robust RMAP monitoring/adaptive management program.
- **Action 1.e.** Repair RMAP barriers within six years if they become renewed barriers.

Strategy 2. Highlight and remedy programmatic gaps in fish barrier removal programs.

- **Action 2.a.** Ensure that Lead Entities include fish passage projects in their priorities, especially to restore/ improve access to high quality habitats for priority populations and to provide valuable cold-water refugia from the effects of climate change.
- **Action 2.b.** Consult the Burlington Northern railroad for barrier repair partnerships/opportunities.
- **Action 2.c.** Provide training for contractors / engineers to prevent new barriers.
- **Action 2.d.** Provide training for cities and counties to provide passage at existing barriers and prevent new barriers.
- **Action 2.e.** Leverage other programs to increase repairs (Floodplains by Design, Federal Emergency Management Agency [FEMA], Farm-Fish-Flood).
- **Action 2.f.** Synchronize the FBRB and Federal Action Plan priorities.
- **Action 2.g.** Develop partnerships with cities and counties to use taxing authority to repair barriers.
- **Action 2.h.** Implement abundance monitoring in coordination with watershed barrier repairs.
- **Action 2.i.** Review military base natural resource management plans and suggest improvements pertaining to culvert passage and riparian vegetation management.

Strategy 3. Provide funding and resources for fish barrier removal.

- **Action 3.a.** Increase and diversify funding/resources for barrier removal.
- **Action 3.b.** Maintain existing funding/resources.

Strategy 4. Increase the use of education, social science, and social marketing programs that support fish passage barrier removal.

- **Action 4.a.** Create enthusiasm in landowners with barrier repair opportunities.
- **Action 4.b.** Educate about the need for culvert repair to adapt/be resilient to climate change.
- **Action 4.c.** Educate the general public on steelhead and the need to remove fish passage barriers.
- **Action 4.d.** Develop partnership opportunities with private corporations to remove barriers.

Strategy 5. Align fish passage correction programs for consistency among federal, state, cities, counties, and private entities.

- **Action 5.a.** Share expertise, improvements in technology among local government agencies.
- **Action 5.b.** Create and distribute a roster of experts.
- **Action 5.c.** Develop a mechanism to share barrier correction data among agencies, including information from ongoing assessment programs to verify fish passage.

Strategy 6. Prohibit new fish passage barriers.

- **Action 6.a.** Enforce and support regulation to prevent new fish passage barriers.

Action 6.b. Evaluate effectiveness of newly installed culverts.

Action 6.c. Improve federal permit process to expedite stream simulation designs in repairs.

Strategy 7. Increase monitoring, data collection, information sharing, and reporting of fish passage correction progress.

Action 7.a. Integrate steelhead life-cycle data with the FBRB's work.

Action 7.b. Align mapped DIPs to hydraulic unit code (HUC)-10s.

Action 7.c. When inventorying culverts, focus on already prioritized fish passage recovery areas identified by the Lead Entities and the FBRB.

Action 7.d. Build fish passage to accommodate future climate change impacts (e.g., storm events, higher/lower flows, other downstream effects)

Action 7.e. Examine current climate change tools in the design of culverts, including WDFW's tool for designing culverts that accommodate anticipated changes in stream flow due to climate change.

Action 7.f. Lead Entities and governments annually report corrected barriers to WDFW.

Action 7.g. Lead Entities and local governments annually plan DIP-level culvert repair priorities.

Action 7.h. Align the Habitat Work Schedule (HWS) with the WDFW fish passage database.

Action 7.i. Align permitting databases (e.g., Hydraulic Project Approval [HPA] database with Fish Passage and Diversion Screening Inventory [FPDSI]).

Strategy 8. Incorporate the benefits of beaver in barrier removal programs.

Action 8.a. Incorporate beaver needs into barrier removal programs and guidelines.

Action 8.b. Provide information to landowners on the role of beaver in healthy landscapes

Action 8.c. Provide information to landowners on different ways to manage beaver activity, including tree protection, flow devices to lower pond levels, beaver deterrents, translocation, and other non-lethal alternatives.

3.4.2 Pressure: Dams, including Fish Passage and Flood Control

Dams are found throughout Puget Sound, and include hydroelectric generation facilities, flood control projects, large municipal water supply and diversion projects, and smaller water storage reservoirs. Figure 5 shows the major dams that block steelhead access or modify their habitat in Puget Sound. Figure 6 shows the smaller dams that affect steelhead distribution.

Dams and their associated reservoirs have a wide range of complex impacts on steelhead and their habitats in Puget Sound. The key impacts to steelhead associated with dams include blocked or impaired upstream and downstream migration, loss of historic habitat in areas inundated by reservoirs, alterations to hydrology and water temperature regimes, alterations to sediment recruitment and transport, impaired large wood recruitment and altered woody debris transport, and alterations to nutrient and organic carbon inputs and cycling to downstream riverine ecosystems. Since the alterations in these natural ecosystem processes can extend substantial distances downstream of dams, they impact steelhead and their habitat over large areas in Puget Sound.

Several dams in Puget Sound have blocked the upstream passage of adults into historical steelhead spawning and juvenile rearing areas. These dams can also impair the downstream passage of juveniles of anadromous or resident *O. mykiss* that are present in the watershed upstream of the dam. The dams reduce the natural production of steelhead by reducing available spawning and rearing habitat. They also impair life-history and genetic diversity by restricting spawning and rearing to the lowland habitat areas within a river basin.

Key strategies for restoring access to watershed areas above dams that historically supported steelhead populations include dam removal and the construction and improvement of fish passage facilities at dams. The removal of the two Elwha River dams provides an excellent example of a dam removal project that has restored steelhead migration into a large headwater basin that historically supported a distinct steelhead population. The removal of these dams also restored the river’s natural hydrological and thermal regimes, sediment and wood transport, and aquatic and riparian ecosystem functions. Construction of fish passage facilities at existing dams can also restore or improve the upstream migration of adults and the upstream and downstream migration of juveniles. NMFS has authority to prescribe mandatory fish passage conditions for steelhead and salmon for inclusion in a license issued by the Federal Energy Regulatory Commission (FERC) for new hydroelectric dams, or during the relicensing process for existing hydroelectric dams.

Photo: Elwha River flowing through the former site of the Glines Canyon Dam. Credit: ©John Gussman (used by agreement).

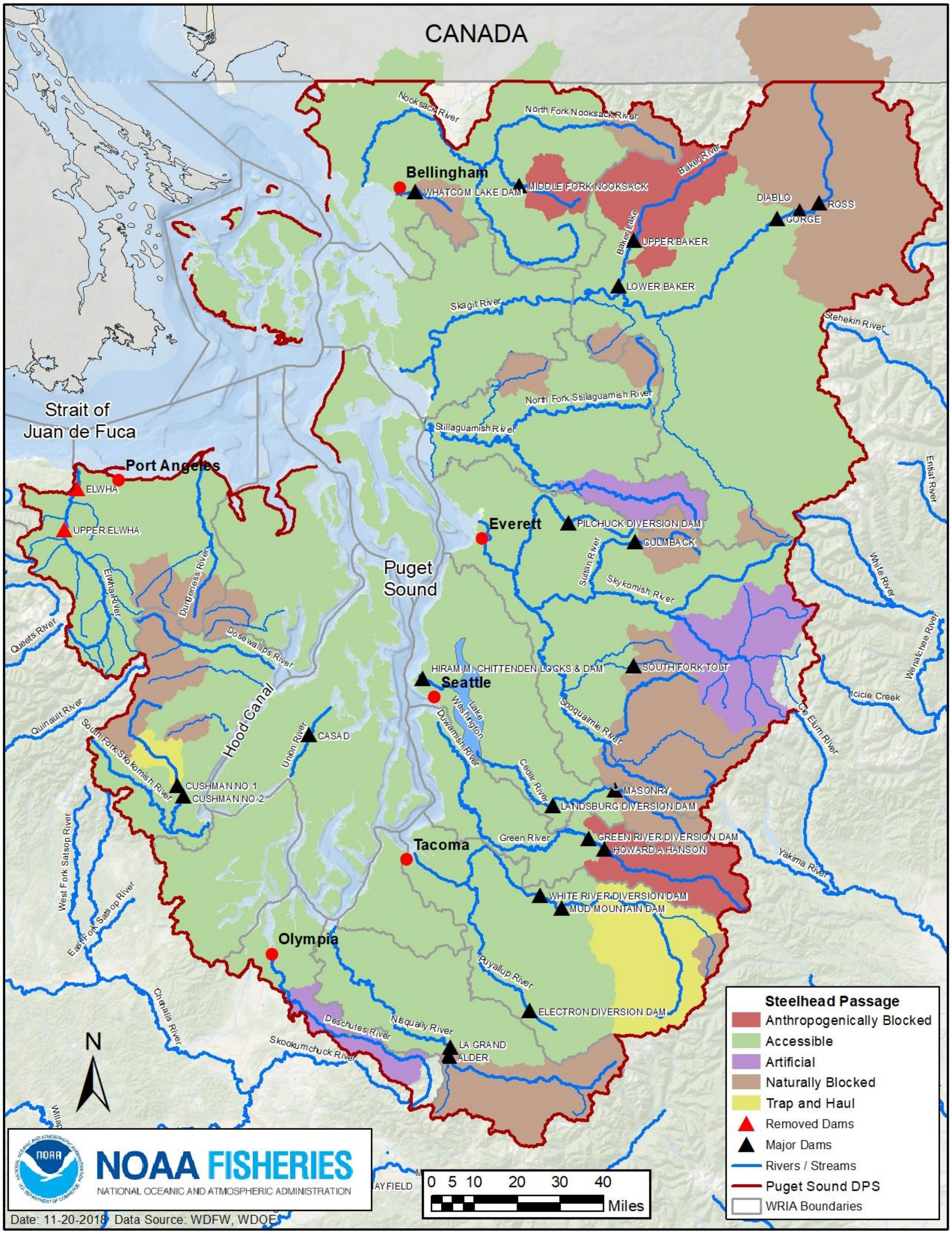

Figure 5. Major dams blocking steelhead or modifying their habitat in Puget Sound. The term "Artificial" refers to areas that are naturally and historically inaccessible to steelhead, but where facilities have been installed to facilitate their passage.

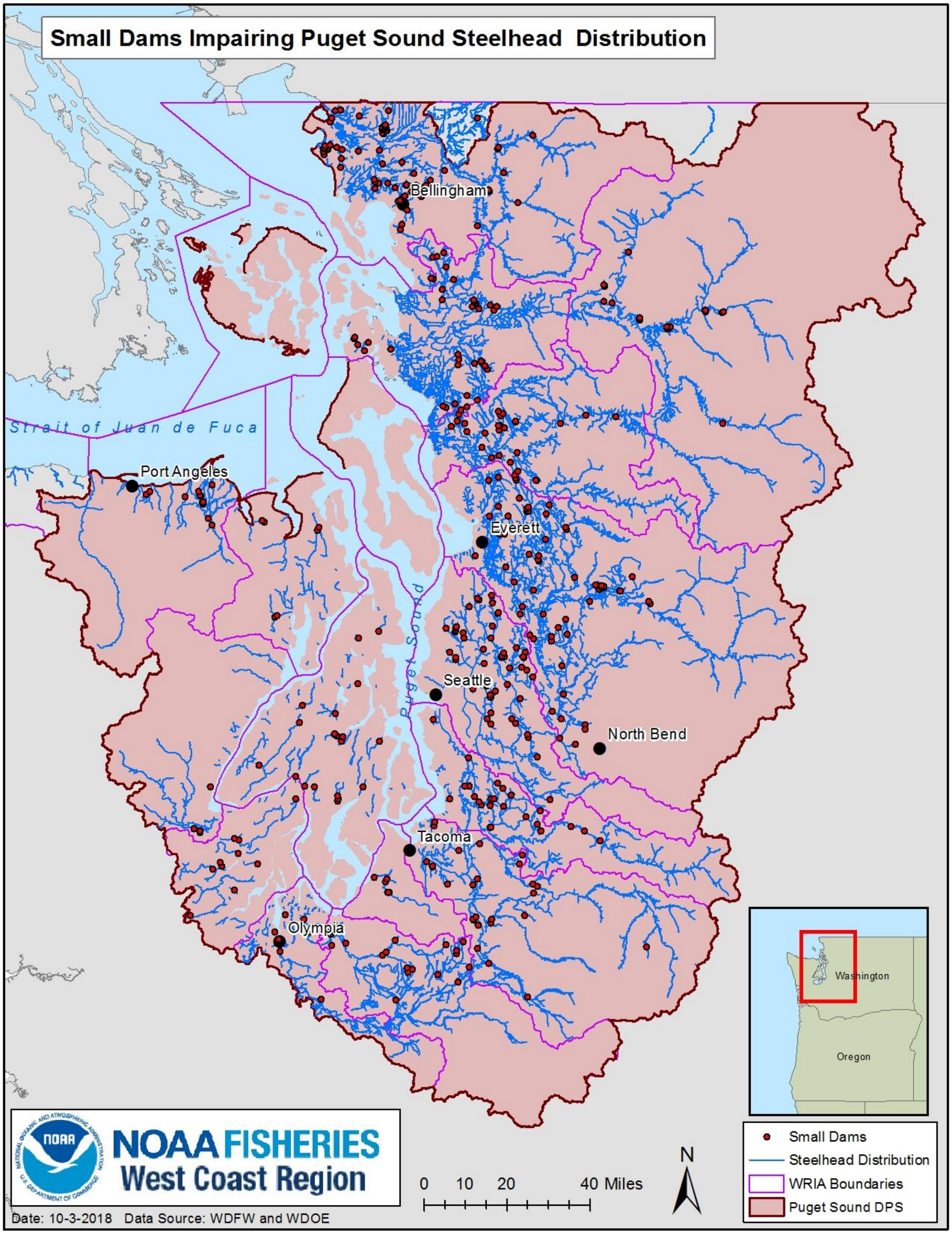

Figure 6. Small dams in the Puget Sound DPS that impair steelhead distribution**.**

Table 2 identifies the major dams in the Puget Sound steelhead DPS and describes their location, purpose, and status. It also identifies whether a dam affects summer-run or winter-run steelhead, whether it allows steelhead passage, and whether it meets NMFS' fish passage standards.

Table 2. Major dams in the Puget Sound steelhead DPS.

Dam	River	Dam purpose	Status	Run affected (Summer-run; Winter-run)	Steelhead Passage	Meets NMFS fish passage standards (Yes/No)
Elwha Dam (1910)	Elwha	Hydroelectric /Water supply	Removed (2012)	Winter & Summer	Not blocking	Yes
Glines Canyon Dam (1926)	Elwha	Hydroelectric /Water supply	Removed (2014)	Winter & Summer	Not blocking	Yes
LaGrande (Alder) Dam (1945)	Nisqually	Hydroelectric	Presumed Historical natural barrier	N/A	Not blocking	N/A
Pilchuck Dam	Pilchuck	Water supply[4]	fishway	Winter	Partial blockage	No
Mud Mountain (1948) and Buckley diversion dam (1911)	White	Flood control Recreation/ Hydroelectric	Trap and haul	Winter	Blocking	No, but fish passage being improved
Electron Dam (1904)	Puyallup	Hydroelectric	Fishway	Winter	Partial blockage	No
Howard Hanson Dam (1961)	Green	Flood control	Trap and haul	Winter	Blocking	No
Cushman 1 (1926) and Cushman 2 Dams (1930)	Skokomish	Hydroelectric	Trap and haul	Winter	Blocking	No, but early fish passage is being improved
CASAD (1957)	Union	Water supply	Historical natural barrier	Winter	Not blocking	N/A
MF Nooksack Dam (1962)	Nooksack	Water supply	Barrier	Winter	Blocking	No, but dam removal planned
Hiram Chittenden Locks (HCL) (1916)	Cedar/ N. Lk. Wash.	Transportation	Current partial barrier	Winter	Blocking	No
Everett Diversion Dam (1965)	Sultan River	Water supply	Volitional passage created (2017)	Winter	Not blocking	Yes
Lo. Baker Dam (1925)	Skagit	Hydroelectric	Trap and haul	Summer & Winter	Blocking	No
Up. Baker Dam (1959)	Skagit	Hydroelectric	Trap and haul	Summer & Winter	Blocking	No
Gorge Dam (1924, 1961)	Skagit	Hydroelectric	Historical natural barrier?	Summer & Winter	Uncertain	N/A
Diablo Dam (1930)	Skagit	Hydroelectric	Historical natural barrier	Summer & Winter	N/A	N/A
Ross Dam (1949)	Skagit	Hydroelectric	Historical natural barrier	Summer & Winter	N/A	N/A
Whatcom Lake Dam	Nooksack	Water supply	Historical natural barrier	Winter	N/A	N/A
Landsburg diversion	Cedar	Water supply	Fishway	Winter	Passable	Yes
Green R diversion	Green	Water supply	Trap and haul	Winter	Blocking	No
Tolt Dam (1964)	SF Tolt	Water supply	Above natural barrier	Summer	N/A	N/A
Masony Dam (1915)	Cedar River	Water supply / Hydroelectric	Historical natural barrier	Winter	Not blocking	N/A

In addition to impairing fish passage, dams can significantly alter the hydrology of a stream or river downstream of a project, especially when large volumes of water are stored in the reservoir for hydroelectric generation and water supply purposes. The altered flows released by dams can impact all freshwater life stages of steelhead, including upstream and downstream migration, spawning, incubation, and juvenile rearing.

Water storage dams in Puget Sound store water during high flow periods of the year (winter storm flow and spring snowmelt periods), and release this water during seasonal low-flow periods (late summer and fall; winter snow accumulation). Without flow management measures to protect fish, the alterations in seasonal runoff can impair access by adult steelhead to spawning areas, reduce spawning success, and cause redd dewatering and reduced egg survival (Gendaszek et al. 2018). Seasonal alterations in flow also impact the rearing habitat of juvenile steelhead downstream of a dam, and can provide too much or too little flow depending upon channel characteristics and the habitat requirements of the fish (Nagrodski et al. 2012). Hydroelectric dams can also alter daily flow patterns in downstream streams and rivers through peaking and load-following generating practices, which involve the release of larger volumes of water during periods of high electricity demand. The alteration of daily flow patterns can dewater steelhead redds during the late spring and summer incubation periods, and dewater juvenile steelhead which become stranded along the banks of the river during periods of down-ramping (i.e., water releases from dams are reduced due to lowered electricity demand).

The impacts of hydrological alterations to steelhead below dams can be substantially reduced through instream flow prescriptions and through fish flow protection agreements with the utilities that are produced in consultation with NMFS, WDFW, the Washington Department of Ecology (WDOE or Ecology), tribes, and non-governmental organizations. Dams can also be operated to reduce impacts to steelhead from natural flood events, including to reduce peak flows that can scour spawning redds and injure and kill juvenile fish. The lead state agency for setting instream flow regimes for fish downstream of dams is typically WDOE under the authority of state water rights regulations and instream flow rules.[7] Instream flows set by rule are intended to protect beneficial uses, including fish and wildlife. WDOE can also prescribe instream flow requirements below dams to protect water quality, fish habitat conditions, and ecological processes important for steelhead growth and survival under the authority of the Clean Water Act.

Dams also impact the quantity and quality of habitat for steelhead in a stream or river by cutting off the natural supply of sediment (especially gravels required for spawning) and wood from the upper watershed. Cutting off the natural supply of large wood from the upper watershed can reduce the quality of holding, spawning, and juvenile rearing habitat. Dam operations that alter peak flows can also impact the transport of sediments and large wood in the channel downstream, subsequently altering the geomorphology of river (and thus fish habitat conditions) below the dam. In some cases, the capture of sediments from the upper watershed by a dam results in gravel “starvation” to a river, which can reduce available spawning habitat and juvenile foraging habitat for steelhead. Mitigation measures, including gravel seeding, can be prescribed during the licensing or relicensing process of hydroelectric dams to reduce the impacts to steelhead caused by sediment starvation. In other cases, fine sediment can accumulate in the river channel downstream of a dam resulting in

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[7] RCW 43.21A.064.

reduced egg survival in redds, and degraded habitat for juvenile rearing. In these cases, flushing flows can be prescribed as part of the instream flow regime developed during the FERC licensing and relicensing process for a hydroelectric dam. In non-FERC situations, flow regimes and downstream habitat improvements can also be prescribed by NMFS as part of the ESA Section 7 consultation process for federal dams that do not produce electricity. Habitat mitigation measures, including improvements to instream habitats (e.g., large wood habitat projects), can also be used to reduce the impacts of dams to steelhead.

Dams with large storage reservoirs can substantially alter the natural temperature regime of the river or stream downstream of the dam. The resulting shifts in temperature can alter the migration and spawning timing of adult steelhead, the outmigration timing of smolts, the incubation timing and survival rates of eggs and embryos, and the growth and survival rates of rearing juveniles. Dams can release water that is too warm, too cold, or nearly optimal for egg incubation and juvenile rearing depending upon where the water is withdrawn from the reservoir. Withdrawal of surface waters typically result in releases of water that are warmer than the natural flow, while the withdrawal of deep waters results in the release of water that is colder than natural flow. Depending on dam operation or configuration, temperature regimes below dams can be improved for steelhead by modifying dam operations and instream flow releases. These actions can be prescribed by WDOE under the authority of the Section 401 Certification process required under the Clean Water Act that occurs as part of the FERC licensing process, during Clean Water Act Section 401 certifications of water storage reservoirs, and under WDOE's Total Maximum Daily Load (TMDL) process for water quality impaired waters.

Small dams in Puget Sound also affect steelhead viability. These dams often provide water storage, and include private dams and reservoirs on small streams that provide for stock watering, aesthetics, or recreation uses. WDOE monitors the safety of these smaller dams that are not tracked by FERC and other entities (RCW 43.21A.064; RCW 43.21A.080; RCW 86.16.061; RCW 90.03.350). Although these individual dams may not block large amounts of habitat, they cumulatively limit the abundance, production, and spatial structure of Puget Sound steelhead (see Figure 6).

Strategies and Actions to Address Effects of Dams

Strategy 1. Pursue current opportunities and identify future priorities for dam removal in watersheds where steelhead migration has been blocked.

- **Action 1.a.** Educate and assist cities / counties on ways to improve steelhead passage at federal and non-federal dams.
- **Action 1.b.** Follow and participate in work of the ongoing dam removal prioritization team to include projects that will benefit steelhead.

Strategy 2. Provide funding and resources for dam removal.

- **Action 2.a.** Seek federal authorization and funding for the removal of high-priority dams.
- **Action 2.b.** Seek funding for state and local governments for the removal of local and private dams and to conduct feasibility studies to remove dams.
- **Action 2.c.** Support federal and state salmon restoration funds to remove high-priority dams.
- **Action 2.d.** For small dam removal opportunities, fund and support the Fish Barrier Removal Board's prioritization process.

Strategy 3. Remove high-priority dams that block or impair steelhead migration into historical spawning and rearing areas.

- **Action 3.a.** Remove Middle Fork Nooksack Diversion Dam.
- **Action 3.b.** Remove the Pilchuck Diversion Dam.
- **Action 3.c.** Remove other high-priority dams as identified and determined feasible.

Strategy 4. Construct or improve fish passage facilities at dams, locks, and water diversions where steelhead migration is blocked or impaired. Reduce passage injuries and mortalities at these facilities.

- **Action 4.a.** Require that fish passage be restored into historic spawning and rearing areas as a condition of FERC licensing and relicensing of dams.
- **Action 4.b.** Use regulatory tools to remove or provide fish passage at federal and non-hydropower dams.
- **Action 4.c.** Improve upstream and downstream fish passage at Hiram Chittenden Locks.
- **Action 4.d.** Provide effective fish passage facility at Howard Hanson Dam.
- **Action 4.e.** Provide effective fish passage at Buckley Diversion Dam and Mud Mountain Dam.
- **Action 4.f.** Monitor compliance and effectiveness of steelhead passage above and below Electron Dam with NMFS' performance standards.
- **Action 4.g.** Pass steelhead above Baker Dam. Improve and monitor effectiveness of steelhead passage (up and downstream) at Baker Dam and improve effectiveness through time.

Strategy 5. Increase education, social science, and social marketing about the effects of dams.

- **Action 5.a.** Educate and engage in FERC licensing or relicensing processes.
- **Action 5.b.** Educate and engage in NEPA review process for dams and diversion structures.
- **Action 5.c.** Educate the public on the effects of dams on steelhead (e.g., water temperatures and other water quality conditions, large wood and sediment distribution, fish passage barriers).

Strategy 6. Dis-incentivize new dams, locks, and water diversion structures.

- **Action 6.a.** Enforce regulations to prevent new steelhead passage barriers, including dams.
- **Action 6.b.** Use Federal Power Act to require fish passage at FERC dam licensing or relicensing.
- **Action 6.c.** Use the Wild and Scenic Rivers Act and Wilderness Act to prevent new dams that would affect steelhead migration and use of historical habitats.

Strategy 7. Improve instream flows downstream of hydroelectric dams and water storage reservoirs.

- **Action 7.a.** Revise instream flow requirements at dams to meet steelhead recovery goals.
- **Action 7.b.** Increase steelhead life stage survival through improved dam flow operations and maintenance (O&M).
- **Action 7.c.** Develop and use flow ramping criteria to increase life stage productivity at dams.

Strategy 8. Using mitigation and restoration, improve habitat conditions downstream of hydroelectric dams and water storage reservoirs.

- **Action 8.a.** Synchronize habitat restoration, life stage needs, and improved dam flow O&M.
- **Action 8.b.** Mitigate and restore geomorphological conditions downstream of dams.
- **Action 8.c.** Reintroduce gravels and large wood where starved due to dam O&M.
- **Action 8.d.** Restore large wood jams downstream of dams.

Action 8.e. Where FERC relicensing efforts are anticipated (e.g., Skagit River), reinforce the opportunities to restore floodplain function, such as large wood loading and transport, sediment supply and transport, and the formation and maintenance of in- and off- channel habitat features.

Strategy 9. Improve temperature and water quality conditions downstream of hydroelectric dams and water storage reservoirs.

Action 9.a. Ensure that dam O&M meets state water quality standards for steelhead recovery, including temperature, turbidity, and dissolved gases.

3.4.3 Pressure: Floodplain Impairments, including Agriculture

Diverse stream features and associated habitats support a variety of steelhead life-history stages. Access to streams with multi-threaded channels and well-connected side channels, riparian areas, and floodplains provides important habitat diversity that contributes to the productive habitat conditions fish need during their freshwater life cycle.

Many of the dikes and levees along rivers and streams in Puget Sound were constructed in the past when early farmers settled the area. The structures protected crops and farm animals from floods and increased agricultural production, but they often isolated river channels to single threads that were largely absent of the diverse habitat features available in the previously braided and meandering channels. The isolation of rivers from their floodplains led to increases in river velocities and river height during storm events, forcing farmers on the opposing side and downstream of the levees to also construct new levees. It also restricted the transfer of large wood, rich nutrients, and other materials from floodplains to river channels where they had once created complex instream habitats. As Puget Sound became increasingly populated, many farms were converted to sprawling urban and suburban communities with increasing needs for public safety and associated infrastructure. As a result, flood control dams, dikes, and levees have become more prominent and damaging to steelhead populations over time.

Photo: Skagit River levee isolating the river from the floodplain. Credit: NMFS.

Today, approximately 254 miles of Puget Sound's 17 major streams and rivers are narrowed and armored with dikes and levees. Figure 7 shows the dikes and levees in Puget Sound. As one consequence of this construction, Beamer et al. (2002) estimated that Skagit River delta habitats — including channels, sloughs, and intertidal habitats — had decreased by 72 percent from historical conditions. Dikes and levees greatly reduce or eliminate opportunities to restore steelhead spawning or rearing habitats in those reaches and hasten the entry of juvenile steelhead to marine waters.

Figure 7. Dike and levees in Puget Sound rivers and streams.

Riparian vegetation has also been reduced through agricultural activity and other land development. Agriculture is commonly an exempted land use activity in the implementation of Washington State's Shoreline Management Act of 1971 (RCW 90.58) and Growth Management Act of 1990 (RCW 36.70A). As a result, riparian areas have not received adequate protection to support steelhead habitats in floodplains, especially where farmers maintain cleared riparian areas to support agriculture activities. Healthy riparian habitats are necessary to maintain suitable stream temperature, provide a long-term supply of large wood to form complex habitats and diverse channel structure, and support water supply and water quality.

Strategies and Actions to Improve Floodplain Connectivity and Condition

Strategy 1. Protect intact floodplains using effective land use regulations and enforcement.

Action 1.a. Integrate NMFS riparian buffer tables into land use planning and regulations.

Action 1.b. Increase coordination between local governments and recovery groups to protect habitat.

Action 1.c. Assess the effectiveness of existing land use regulations (GMA/SMA) in protecting and maintaining floodplain health and connectivity.

Action 1.d. Incentivize agriculture programs to retain floodplain and riparian conditions that provide compatible steelhead habitat.

Action 1.e. Identify and prioritize stream recharge areas to restore low flows and moderate high flows.

Action 1.f. Increase public education and awareness of land use regulations that protect and maintain floodplain conditions that support steelhead.

Action 1.g. Fund and enforce floodplain, riparian, and instream habitat regulations.

Action 1.h. Limit the exemptions and variances to anadromous habitat Critical Area Ordinances (CAOs) and the SMA.

Action 1.i. Develop and implement standardized mitigation where floodplain development is unavoidable to create a net habitat benefit for steelhead.

Action 1.j. Use land swaps, transferable development rights, mitigation banking programs, and in-lieu fee mitigation to increase habitat or mitigate impacts.

Action 1.k. Require a qualified geotechnical professional to assess safety needs to avoid land use encroachments before minimizing and mitigating impacts.

Action 1.l. Coordinate with regional transportation councils and agencies to incorporate steelhead and salmon protection and recovery into long-range planning efforts.

Strategy 2. Identify and protect floodplains and freshwater wetlands for steelhead by funding and implementing farm-fish-flood integrated planning programs at the local level.

Action 2.a. Increase funding and use of Floodplains by Design to protect and restore floodplains.

Action 2.b. Support engagement in locally developed plans such as the Snoqualmie Farm, Fish, and Flood, Snohomish County Sustainable Lands Strategy, Puyallup Floodplains for the Future Project.

Action 2.c. Use WDFW's High Resolution Change Detection tool and analyses to determine where land change is happening, define the type of conversion, and identify hotspots where change is rapid.

Action 2.d. Use NMFS riparian buffer tables to standardize protocols and priorities for permanent riparian buffer easements and fund these priorities.

Action 2.e. Develop a tax benefit program for landowners willing to retain adequate existing riparian buffers (e.g., Public Benefit Rating System).

Action 2.f. In rural areas, use conservation easements, current use taxation (e.g., Public Benefit Rating System and other programs) to protect floodplains and wetlands.

Action 2.g. Increase technical assistance to help small forest and agricultural landowners develop plans and assess benefits afforded to restoration of steelhead habitat.

Action 2.h. Develop funding mechanisms to pay farmers to "grow salmon" by planting streamside trees and reopening historic side channels for rearing juvenile salmonids.

Action 2.i. Support the Washington Conservation Commissions Voluntary Stewardship Program where benefits to steelhead may be gained.

Action 2.j. Use down-scaled climate change projection models to anticipate where flooding will impair agriculture activities in the future, and develop cooperative agreements to acquire or create landscape changes to benefit steelhead in these areas.

Action 2.k. Recreate habitat conditions that allow for natural processes that support expansion, colonization of beaver.

Strategy 3. Reduce levee impacts through setbacks and improved vegetation management.

Action 3.a Integrate floodplain planning guidance described in the National Flood Insurance Program, Clean Water Act, levee standards, SMA, and GMA.

Action 3.b. Analyze floodplain data for projected population growth, flood risk, and hydrological and geomorphological benefits to steelhead.

Action 3.c. Update climate change projections to strengthen knowledge of high-risk flooding areas.

Action 3.d. Educate policymakers on flood and flood risk-tolerance projections.

Action 3.e. Develop and showcase examples of mutual benefit projects that help alleviate flooding and benefit steelhead.

Action 3.f. Develop and implement regional variance models to existing U.S. Army Corps of Engineers vegetation requirements on levees.

Action 3.g. Incorporate Reasonable and Prudent Alternatives from the Federal Emergency Management Agency Biological Opinion into local government planning and Critical Area Ordinances.

Action 3.h. Prioritize and fund opportunities to setback levees and increase floodplain access.

Strategy 4. Reduce bank armoring and other habitat stressors in steelhead river systems.

Action 4.a. Increase the use of “demonstration of need” for new hard armor permits.

Action 4.b. Incentivize the use of soft bank protection permitting to enhance habitat diversity.

Action 4.c. Fully mitigate the installation of unavoidable bank armoring in steelhead streams to off-set the loss of steelhead habitat by removing at least an equivalent amount of armoring elsewhere in the basin.

Action 4.d. Develop civil penalties and enforce them to reduce unpermitted bank armoring and the removal of large wood from streams and riparian areas.

Action 4.e. Incentivize the removal of invasive vegetation and plant native and beneficial species in riparian and floodplain areas.

Action 4.f. Assist property owners in riparian and floodplain restoration (e.g., templates for designing riparian planting, identifying and removing invasive species, designing habitat restoration, and identifying potential grant funding).

Action 4.g. Implement actions to remove hard bank protection from streams and replace with soft approaches that improve stream functions, floodplain function, and habitat diversity.

Action 4.h. Implement site-specific actions, such as removing bulkheads/shoreline hardening at key forage fish sites, adding wrack to beaches, protecting and restoring submerged vegetation including eelgrass and kelp, and removing pilings. Explore beach nourishment options where infrastructure disconnects drift cells.

Action 4.i. Recreate floodplain conditions in critical areas that restore natural processes and support the expansion and colonization of beaver.

Strategy 5. Educate the community to reduce bank armoring and other habitat stressors in steelhead river systems.

Action 5.a. Educate and engage the public in local government planning, development and public works processes.

Action 5.b. Educate and engage the public in the Washington State Environmental Policy Act (SEPA), RCW 43.21c, review process for bank armoring.

Action 5.c. Educate the public on the effects of riprap on steelhead that include all consequences.

Action 5.d. Educate the public on benefits of down trees in streams and rivers for stream health and fish, including steelhead.

3.4.4 Pressure: Residential, Commercial, Industrial Development

Residential, commercial, and industrial development have dramatically altered stream ecosystems, reducing steelhead habitat and population abundance. In addition to fostering other pressures, such as increasing fish passage barriers at road crossings and the armoring of stream banks with dikes and levees, urban development has reduced groundwater levels and instream flows (especially during summer). The reduction in summer flows reduces available habitat directly for juvenile steelhead but also indirectly elevates stream temperatures, which leads to increased susceptibility of steelhead to disease and predation. Urbanization also increases stormwater runoff during fall and winter months (Booth 1991), which can scour steelhead redds and pollute water quality. Although historically abundant throughout Puget Sound, many riparian forests are now confined to upper headwater reaches of Puget Sound streams.

Puget Sound has experienced rapid human population growth. In 1985, approximately three million people lived in the basin; today, the population has increased to nearly five million people. As the number of people on the landscape has increased, so too have their demands on natural resources, including space for residential, commercial, and industrial development. Figure 8 shows the different land uses that occur within the area occupied by the Puget Sound steelhead DPS.

Land use management in Puget Sound is regulated through a complex system of federal, state and local governments, each with unique responsibilities and jurisdictions. While NMFS has responsibility for administration of the ESA, the authority to regulate habitat activities that affect ESA-listed species is limited to activities that are funded, authorized, or carried out by other federal agencies. Typically, NMFS does not have a regulatory role in activities that occur on state or local lands. Similarly, state and local natural resource management agencies have defined management responsibilities. Successful habitat management for Puget Sound steelhead will require effective collaboration across all levels of government.

In 2017, Puget Sound federal natural resource management agencies signed a Memorandum of Understanding creating the Puget Sound Federal Task Force (Task Force) and clarifying agency commitments to align their programs, activities, and funding priorities to expedite recovery of the Puget Sound ecosystem, including ESA-listed salmon and steelhead. The Task Force released an Interim Puget Sound Federal Action Plan that laid out a shared vision and priority actions for Puget Sound Recovery. NMFS co-chairs the Regional Leadership and Implementation teams for the Task Force and is actively engaged with other federal agencies on common science, management, and funding activities. For additional information, see: https://www.fisheries.noaa.gov/west-coast/habitat-conservation/habitat-conservation-west-coast-puget-sound-action-plan

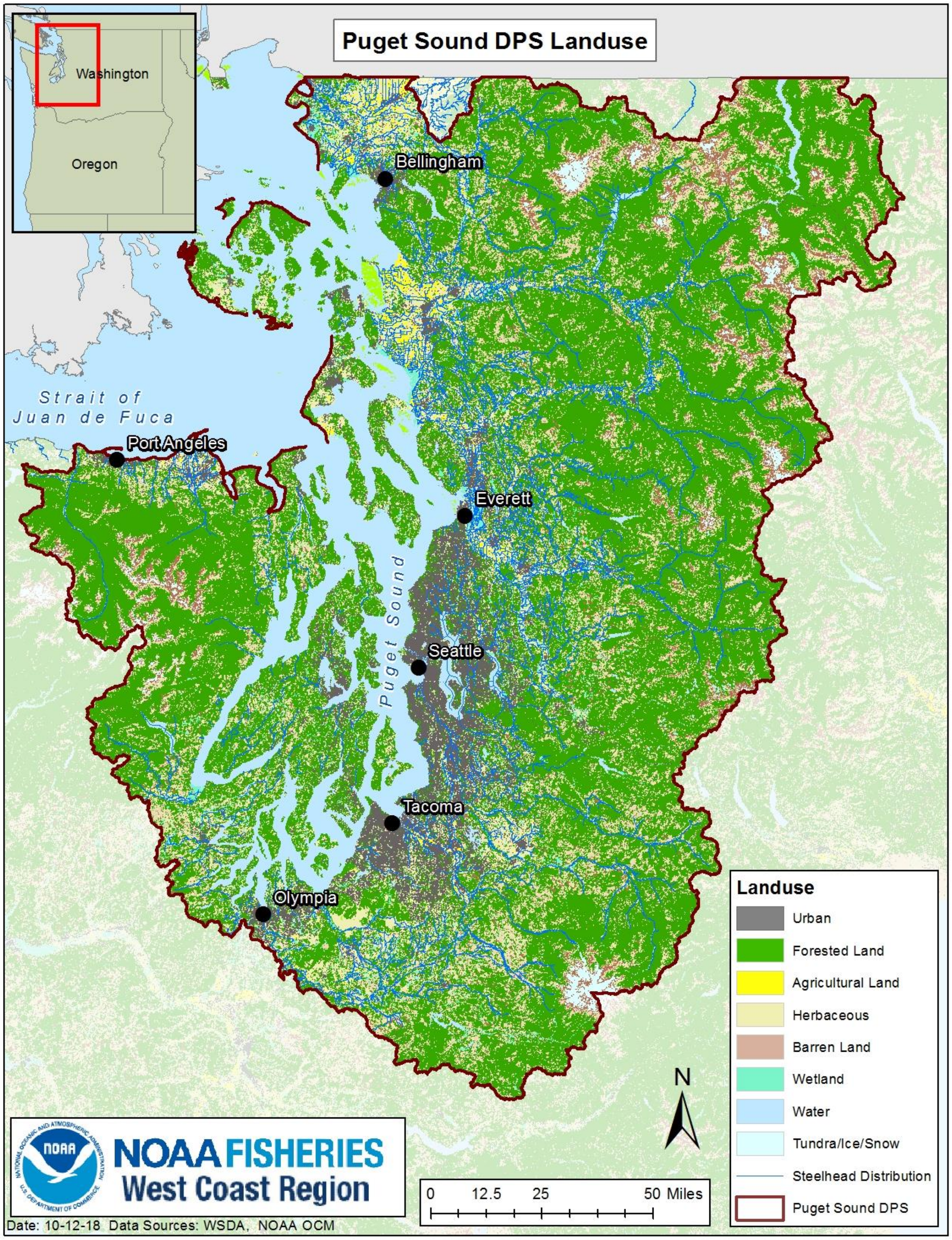

Figure 8. Different land uses in the Puget Sound steelhead DPS.

The Washington State Growth Management Act, which was implemented in 1990, requires state and local governments to manage human population growth by identifying and protecting critical areas and natural resource lands, including habitat for anadromous fishes such as steelhead. To

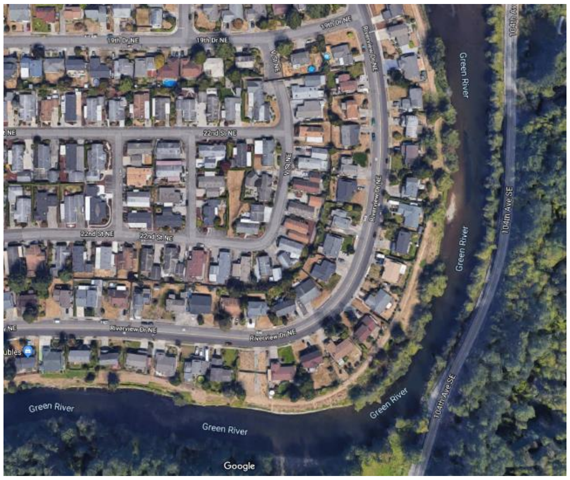

Photo: Residential development along the Green River. Credit: Google Maps.

adequately protect critical habitat, the GMA requires counties and some cities to designate urban growth areas, prepare comprehensive plans, and implement the plans through capital investments and development regulations. Impairments to steelhead habitat occur when these rules are not fully implemented or where exemptions and variances are allowed. Steelhead habitat is similarly degraded when transportation planning fails to account for adequate fish passage and effective stormwater control for water quantity and quality factors.

Strategies and Actions to Address Effects of Residential, Commercial, Industrial Development

Strategy 1. Reduce impediments to infill and redevelopment in Urban Growth Areas.

- **Action 1.a.** Increase incentives for developers during redevelopment of infilled property to upgrade stormwater systems or substantially increase shoreline riparian function through planting or removal of armoring.
- **Action 1.b.** Increase resources for the WDOE voluntary cleanup program.
- **Action 1.c**. Coordinate with Regional Transportation Councils and agencies to incorporate steelhead and salmon protection and recovery into long-range planning efforts.
- **Action 1.d.** Provide resources for the federal Brownfields program and expand program to assist landowners in having properties tested and prepared for habitat restoration.

Strategy 2. Improve local implementation and enforcement of Growth Management Act existing regulations that protect streams and wetlands from residential/ commercial/ industrial development.

- **Action 2.a.** Minimize expansions of current Urban Growth Areas.
- **Action 2.c** Improve compliance with CAO protections for aquatic buffers and wetlands.
- **Action 2.d.** Require assessments by a qualified geotechnical professional to avoid clearing, grading, or development on steep stream slopes.
- **Action 2.e.** Align Urban Growth Areas with steelhead habitat data to prioritize protection applications.
- **Action 2.f.** Assess accuracy of historic buildout scenarios (Alternative Futures) to determine where habitat protection efforts are most crucial.
- **Action 2.g.** Advance other, systemic ways of improving local implementation of GMA such as restoring state funding that supports county-level GMA planning, or assisting local jurisdictions with enforcement and implementation of the GMA and CAO, including water typing.
- **Action 2.h.** Use WDFW's High Resolution Change Detection tool and analyses to determine where land change is happening, the type of conversion, and identify hotspots where change is rapid.
- **Action 2.i.** Assess the degree to which exemptions and variances are occurring and the resulting extent of degradation to riparian and wetland habitats.

Strategy 3. Incentivize protection of priority habitat areas beyond those covered via regulations.

Action 3.a. Assist small forest and rural landowners in land-use and conservation plans.

Action 3.b. Assist property owners in steelhead restoration (e.g., templates for riparian planting plan, assistance with designing habitat restoration, and grant funding).

Action 3.c. Implement transferable development rights, environmental mitigation banking/reserve programs, and in-lieu fee mitigation for steelhead restoration.

Action 3.d. Develop a tax benefit program for landowners willing to retain adequate existing riparian buffers (e.g., Public Benefit Rating System) and share information with local governments Puget Sound-wide to maximize this program.

Action 3.e. Align steelhead priorities with open space priorities mapped and highlighted as "conservation needs" in the Puget Sound Regional Council's Regional Open Space Conservation Plan.

Strategy 4. Increase the use of, and compliance with, mitigation to offset impacts of development.

Action 4.a. Support on-site, in-kind mitigation when it is ecologically feasible and likely to succeed long-term.

Action 4.b. Consider off-site mitigation options, such as a mitigation bank or in-lieu fee mitigation, for restoring ecological function of habitat that supports steelhead.

Action 4.c. Integrate steelhead recovery strategies into mitigation needs for all non-restoration permitting proposals and in all responding permits to improve recovery trajectories of Puget Sound steelhead populations.

Strategy 5. Improve federal and state highway maintenance and management to reduce impacts to steelhead.

Action 5.a. Treat or mitigate runoff from major bridges.

Action 5.b. Identify and implement solutions to steelhead mortality at Hood Canal Bridge and other locations where steelhead may be concentrated.

Action 5.c. Coordinate with Regional Transportation Councils and agencies to incorporate steelhead and salmon protection and recovery into long-range planning efforts.

Action 5.d. Determine feasibility of I–5 and Hwy 101 improvements, such as bridges at confined estuaries.

Action 5.e. Reduce construction of new road crossings of steelhead tributaries and improve passage at existing crossings, including railway crossings, which restrict steelhead passage and riverine processes.

Action 5.f. Follow best management practices for road maintenance and management (e.g., Aquatic Habitat Guidelines by state and federal agencies).

Strategy 6. Improve county and city road maintenance and new road development.

Action 6.a. Work with counties to develop long-term plans to accelerate fish passage barrier removal or improvements on county roads.

Action 6.b. Align county and city Public Works Capital Improvement Program priorities with steelhead recovery activities.

Action 6.c. Track highway expansions and new roads in steelhead habitat. Consultation should pay particular attention to steelhead cumulative impacts.

Action 6.d. Reduce construction of new road crossings of steelhead tributaries and improve passage at existing crossings.

Action 6.e. Follow best management practices for road maintenance and management (e.g., Aquatic Habitat Guidelines by state and federal agencies).

Strategy 7. Align infrastructure improvements with steelhead recovery at the federal, state, and local level.

Action 7.a. Restore Public Works Trust Fund and include salmon habitat benefits when reforming the program.

Action 7.b. Use pollution load heat maps to identify areas with the greatest opportunity to address water quality.

Strategy 8. Consider climate change impacts in planning and permitting.

Action 8.a. Develop and implement plans to address an increased number of emergency permit requests for shoreline and property protection as sea-level rise, saltwater intrusion, storm surge, and high flows become more common.

Action 8.b. Develop climate change considerations in comprehensive planning by local governments to acquire at-risk parcels where they may benefit steelhead.

Action 8.c. Require developers to implement best management practices to address impacts from climate change.

Action 8.d. Consider climate change when designing new stream crossings and stormwater infrastructure; design should use future predicted rainfall rather than historic.

3.4.5 Pressure: Timber Management

Riparian forests are largely isolated to headwater reaches of Puget Sound watersheds and currently serve as an anchor of habitat protection for steelhead in a rapidly developing Puget Sound landscape. Since at least 1999, timber management practices have improved steelhead habitat by returning the recruitment of instream features (especially large wood), increasing shade by reserving riparian trees, and by repairing fish passage barriers. As described in Section 3.4.1, Fish Passage Barriers at Road Crossings, fish blocking culverts have dramatically declined on forested landscapes due to the implementation of the state's Road Maintenance and Abandonment program. From 2001 through 2017, forest landowners removed over 7,900 barriers to fish passage, opening up more than 5,200 miles of historic fish habitat in addition to maintaining forested buffers on fish bearing streams that provide cool, clean water, spawning habitat and large woody debris.

State and private forest management activities are largely governed by state regulations and federal habitat conservation plans, including the Washington State Trust Lands HCP (WDNR 1997) and the Washington State Forest Practices HCPs (WDNR 2005). These HCPs also feature progressive monitoring and adaptive management programs. NMFS fully supports the implementation of the HCPs, including monitoring and adaptive management programs within the HCPs, as a means to continue protecting riparian habitats (including the delivery of cool, clean water), improving fish passage barrier corrections, and addressing sources of fine sediment delivery to streams. NMFS regards these rules and plans as supportive of steelhead habitat and recovery.

Some private forest lands and management activities are managed under alternative forest practices rules and are not included in federal HCPs (i.e., non-HCP lands). Non-HCP lands include two primary types: 20-acre exemptions (parcels 20-acres or less and when the property owner owns less than 80 acres of forest land statewide); and parcels that are, or may be, subject to a land-use conversion after the harvest (i.e., Class IV, as described in the Washington State Forest Practices Rules, WAC 222-16-050, 051, and 060). Non-HCP forest management activities present the largest challenge to maintain adequate protection for Puget Sound steelhead. Non-HCP activities are commonly located near the urban growth boundary where functional forest habitat can undergo human development expansion. The rules and authorities under Class IV forest activities can become confusing as authority of the activity shifts from the Washington State Department of Natural Resources (DNR), which manages forest practices, to local governments, which manage development and have different rules and interests. There is currently no federal oversight of Non-HCP forest lands or activities.

On federal lands within Puget Sound, policy and management activities are governed by the Northwest Forest Plan. Within the area where Puget Sound steelhead DPS is found, federal agencies that implement forest activities are primarily limited to the U.S. Forest Service, National Park Service, National Wildlife Refuges, and military installations. Agency policies and activities are generally protective of steelhead and their habitat, which are also reviewed by NMFS for consistency with Section 7 of the ESA. Still, adequate funding to support restoration activities is needed, including for the repair of fish barriers and installation of instream restoration activities.

Strategies and Actions to Address Effects of Timber Management

Strategy 1. Support state and private landowner efforts to monitor forest practices rule compliance and effectiveness.

- **Action 1.a.** Support the Department of Natural Resources (DNR) and the Cooperative Monitoring, Evaluation, and Research (CMER) programs for compliance and effectiveness monitoring of the Washington State Forest Practices HCP (WDNR 2005) and associated Forests and Fish rules (WAC 222) for riparian buffers, sediment management, and fish passage.
- **Action 1.b.** Support the implementation of monitoring and adaptive management schedules (Schedule L1 and L2) to fully implement the adaptive management program.
- **Action 1.c.** Consistent with the goals of the Forest Practices HCP, implement strategic outcomes of the adaptive management program.

Strategy 2. Collaborate on water temperature monitoring and modeling.

- **Action 2.a.** Improve the understanding of water temperature dynamics in forest headwater riverscapes by identifying novel water monitoring and modeling efforts.
- **Action 2.b.** Coordinate, integrate, and expand existing water temperature monitoring efforts to understand how cool stream temperatures can remain cool in non-forested reaches.
- **Action 2.c.** Coordinate with WDOE to test assumptions about riparian shade to meet Clean Water Act temperature criteria, especially to maintain cool temperatures in reaches downstream of forested reaches.

Strategy 3. Explore potential funding and financial incentives for restoration discussions with timber companies on HCP lands.

- **Action 3.a.** Explore successes and failures of Pacific Northwest Community Forest Coalition ventures and their ability to maintain or increase functional stream habitats.

Action 3.b. Support volunteer incentives where benefits to steelhead may be realized more effectively and quickly with the use of alternate plans (such as actively recruiting large wood to streams where appropriate).

Strategy 4. Improve accuracy of water-type classifications to ensure steelhead habitats are protected (per WAC 222-16-010).

Action 4.a. Develop methodologies for accurately delineating steelhead habitat that are less harmful to steelhead than electrofishing.

Action 4.b. Use LiDAR to improve watercourse delineation to better define habitat breaks.

Action 4.c. Support training and certification requirements of water-type surveyors and reviewers, especially where electrofishing is used.

Action 4.d. Improve participation in water-type modification process to increase partnership review.

Strategy 5. Improve fish passage at artificial barriers.

Action 5.a. Assist landowners to meet the 2021 time extension deadline for Road Maintenance and Abandonment Plans (RMAP).

Action 5.b. Consistent with the Forest Practices HCP, repair remaining barriers that may have remained uncorrected due to incorrect determinations of steelhead habitat.

Action 5.c. Consistent with the HCPs, support compliance and repair programs so that new roads do not impose new barriers or that non-barriers do not become barriers.

Action 5.d. Increase funding to support the Family Forest Fish Passage Program.

Strategy 6. Implement best science practices on non-HCP forest lands.

Action 6.a. Review forest practice regulations for “20-acre exempt” protections (WAC 222-30-023) for steelhead. Develop recommendations for Forest Practices Board as necessary.

Action 6.b. Support the DNR in using best available science to protect steelhead habitats when processing and approving Class IV special actions permits.

Action 6.c. Provide local jurisdictions with best available science for managing Class IV general permits.

Action 6.d. Fund compliance and effectiveness studies to determine the extent to which Class IV permits comply with the rules and conditions as determined by DNR and local governments.

Action 6.e. Lengthen stand rotation times and incentivize/encourage locally owned community forests to use selective harvest rather than clearcutting to preserve summer flows and limit localized temperature increases.

Strategy 7. Prioritize forest riparian restoration with Clean Water Act Section 303(d) listings on non-HCP lands.

Action 7.a. Where riparian habitats are not protected by HCPs, identify and compare 303d listings with steelhead streams and the Type N streams above them, and make these data available.

Action 7.b. Use WDFW’s High Resolution Change Detection tool and analyses to prioritize revegetation efforts using existing temperature models.

Action 7.c. Identify a list of the most impaired streams in the area where each DIP is found and seek restoration opportunities with landowners.

Strategy 8. Manage the Northwest Forest Plan (U.S. Forest Service [USFS] for federally managed forestlands).

Action 8.a. Fund ongoing USFS forest management planning and activities to manage forests for hydrologic and habitat forming benefits to steelhead.

Action 8.b. Increase funding for acquisitions within the USFS district boundaries to secure inholdings and ecologically sensitive areas.

Action 8.c. Increase funding for fish passage projects and align priorities with state programs to maximize watershed benefits to steelhead.

3.4.6 Pressure: Water Withdrawals and Altered Flows

Steelhead require adequate stream flow to meet their life-history requirements. The high demands for water to accommodate residential, commercial, industrial, and agricultural needs have decreased stream flows through time. Water withdrawals can occur through the exercise of a municipal, agricultural, industrial, commercial, or residential water right, or by exempt use, either by diverting stream flows directly to drinking water facilities or by pumping groundwater in areas that have hydrologic connectivity to streams. Some Puget Sound streams experience seasonal periods of extremely low flow due to water withdrawals for human consumption (domestic and municipal water use), causing summer rearing habitat to become limited. Altered flows also occur when stream flows are held back or accelerated artificially (usually with a dam), or are diverted and returned to the river at a downstream location. Both channeling of stormwater runoff in urban areas and ditching in rural and agricultural areas route rainwater into water courses, preventing or decreasing infiltration into groundwater and aquifers. As a result, cool groundwater is less available during summer. Climate change is also affecting flow regimes, with some streams displaying lower summer flows and higher peak winter flows than in previous years.

Most water withdrawals from streams require a water right issued by the WDOE. However, the state of Washington provides a water right permit exemption to property owners not served by a community water system, allowing users to pump up to 5,000 gallons of groundwater per day — more, in some instances, such as for stock watering. When many exempted wells occur within a hydrologically connected aquifer they can extract more water from an aquifer than is being recharged, causing the aquifer volume to drop and the natural outflow to a stream system from the aquifer to decrease. This diminishes the amount of stream flow available to streams, lakes, and wetlands. A new state law (Engrossed Substitute Senate Bill 6091, RCW 90.94) was recently passed to minimize and mitigate for the situation where wells reduce stream flows. However, it remains unclear how stream restoration mitigation that does not involve stream flow could be effective in mitigating for lost flow in those streams where flow limits steelhead production and abundance.

Strategies and Actions to Improve Instream Flows during Critical Periods

Strategy 1. Identify, protect, and preserve instream flows for steelhead.

Action 1.a. Determine instream flows required for steelhead recovery in Puget Sound streams and rivers.

Action 1.b. WDOE will continue to annually publish actual instream flows relative to recommended flows for steelhead.

Action 1.c. Develop tools to locate areas where water diversions and withdrawals are impairing steelhead and catalog them, such as an Instream Atlas for Puget Sound Steelhead.

Action 1.d. Establish or revise instream flow rules in Puget Sound Water Resource Inventory Areas (WRIAs) to better protect steelhead.

Action 1.e. Identify and protect instream flows required to meet state water quality standards established under authority of Clean Water Act.

Action 1.f. Address instream flows requirements for steelhead under the Watershed Planning and Management process established under RCW 90.82.

Action 1.g. Improve habitat-flow models (e.g., 2D flow modeling, bioenergetic models) for determining instream flows for steelhead.

Strategy 2. Maintain, restore, or improve instream flows by establishing and protecting tribal, state, and federal water rights; restricting permit-exempt wells that remove groundwater in areas that are hydraulically linked to waterways with low summer flows; enforcing regulations; and improving transparency, efficiency, and accountability.

Action 2.a. Establish, implement, and enforce instream flows for steelhead.

Action 2.b. Eliminate illegal water use and withdrawals by enforcing regulations.

Action 2.c. Extinguish water rights if they are not used for five years.

Action 2.d. Protect existing wetlands in aquifer recharge areas.

Action 2.e. Set a lower limit for domestic water use, stock watering, commercial lawn or garden, and industrial use from permit exempt wells in over-allocated basins.

Action 2.f. Enforce or implement monitoring requirements for surface and groundwater diversions.

Action 2.g. Evaluate the effects of the 'Hirst decision' (*Whatcom County, Hirst (Eric) v: W Wash. Growth Mgmt. Hr'gs Bd*., No. 91475-3, 2016) and the Washington State remedy (RCW 90.94) and pursue necessary remedies where steelhead are negatively impacted.

Action 2.h. Restrict allowance of permit-exempt wells in areas where groundwater is hydraulically linked to streams with low summer flows,

Strategy 3. Develop and implement incentive programs to protect and restore instream flows for steelhead.

Action 3.a. Develop collaborative funding mechanisms to support willing irrigation districts and landowners in applying more efficient irrigation systems.

Action 3.b. Support and encourage irrigation districts to upgrade their efficiency and bank the saved rights into the Trust for Water Rights Program or other conservation programs.

Action 3.c. Apply new funding under stream flow restoration law (ESSB 6091) toward restoring instream flows for steelhead, including acquiring senior water rights.

Strategy 4. Protect uplands to improve hydrological characteristics of watersheds; protect groundwater recharge areas to improve infiltration of precipitation and runoff into aquifers.

Action 4.a. Where CAOs have not adequately protected recharge areas, acquire transfer of development rights of key hydrologic importance.

Action 4.b. Determine the adequacy of timber harvest methods and their protection of natural hydrologic regimes.

Action 4.c. Add steelhead-specific recovery goals in the checklist of CAOs to include the protection of hyporheic areas from development pressures.

Action 4.d. Implement best management practices for stormwater management and enforce these actions in development strategies, especially to reduce peak flows and enhance base flows.

Action 4.e. Retrofit stormwater ditch systems and take other steps to increase infiltration and reduce storm runoff.

Action 4.f. Use Low Impact Development design and practices for future development, and inside cities and Urban Growth Areas, to conserve natural processes whenever possible, reduce runoff and pollution, and protect flows.

Action 4.g. Protect natural hydrologic processes and/or acquire land in floodplains for future levee setbacks.

Action 4.h. Pursue opportunities to protect forest and agriculture lands from conversion (minimize sale of agricultural land and tree farms to residential developers).

Action 4.i. Evaluate DNR public trust lands for hydrologic contributions for steelhead.

Action 4.j. Reintroduce beavers into areas where historic wetlands have been lost or diminished in function.

Strategy 5. Improve instream flow protections and water rights for fish on federal lands.

Action 5.a. Utilize steelhead and instream flow experts as part of project evaluation alternatives in SEPA/NEPA processes.

Action 5.b. Participate in EIS review of major water resources developments, including storage reservoirs and water diversions, on federal lands.

Action 5.c. Exercise federal reserve water rights on federal lands and tribal reservations for protecting and restoring instream flows.

Action 5.d. Establish instream flows to protect critical habitat for steelhead on federal lands.

Strategy 6. Through the Habitat Conservation Plan process, provide long-term protections and conservation measures to meet steelhead instream flow needs.

Action 6.a. Evaluate instream flows for steelhead benefits or impairments in the development, review, and implementation of new HCPs.

Action 6.b. Review and engage in adaptive management plans for existing HCPs, particularly if any instream flow committees.

Strategy 7. Restore instream flows for steelhead in over-allocated watersheds.

Action 7.a. Acquire senior water rights in basins where instream flows are insufficient for steelhead.

Action 7.b. Facilitate water right transfers that result in increased channel flow.

Action 7.c. Incentivize local governments and water districts to develop and implement water reuse and recovery strategies.

Action 7.d. Reclaim water at wastewater facilities to replace water diversions for golf courses, irrigation, and other appropriate uses.

Action 7.e. Reuse irrigation water, and use agricultural drainage water, to improve instream flows.

Action 7.f. Allocate or purchase reservoir storage to meet instream flow requirements for steelhead.

Action 7.g. Develop and market conservation programs that reduce water demand.

Strategy 8. Identify, develop, and fund habitat restoration projects that improve stream flows for steelhead spawning, rearing and migration.

Action 8.a. Develop and fund habitat restoration projects that result in improved instream flows to streams and rivers.

Action 8.b. Improve access to beaver management information and WDFW and local county beaver management tools, including pond levelers, beaver deterrents, relocation programs, and lethal removal

Action 8.c. Streamline Hydraulic Project Approval permits for pond levelers and beaver deceivers.

Action 8.d. Determine criteria for fish passage through beaver deceivers and other beaver dams with pond levelers.

Action 8.e. Create habitat conditions that favor beaver activity.

3.4.7 Pressure: Hatcheries ─ Ecological and Genetic Interactions between Hatchery and Natural-Origin Fish

Hatchery production of steelhead can be an effective tool to increase fish abundance for conservation and harvest. However, use of hatcheries can also pose demographic, genetic, and ecological risks to natural steelhead. Hatcheries intended to aid steelhead conservation strategies are successful when they provide benefits that outweigh risks to recovery.

Successful hatcheries have three common characteristics that form the basis for the steelhead hatchery strategies and actions outlined below:

1. They are intentional. Successful programs will have clearly stated descriptions of the hatchery's purpose (conservation or harvest); the intended relationship with natural production (integrated or segregated); the population viability objectives (abundance, productivity, diversity, and spatial structure) they are intended to promote; and the trade-offs associated with these objectives given the stage of recovery of the ecosystem.
2. They are accountable. They use the best available scientific information to minimize genetic and ecological stressors and demographic risks on potentially affected populations while maximizing benefits.
3. They adapt to new information and challenges.

Risks and benefits of hatchery steelhead production are best evaluated in the context of the purpose of the hatchery program. A common purpose related to steelhead recovery is conservation. The primary goal of steelhead conservation in Puget Sound is sustainable natural production of locally adapted fish throughout the accessible watersheds in the DPS (Hard et al. 2015). Thus, to effectively achieve its goals, a conservation hatchery program must increase the abundance, productivity, spatial structure, and/or diversity of a natural-origin steelhead population. In an applied context, a conservation hatchery goal might be reintroducing fish to unoccupied habitat (Anderson et al. 2014), preventing the extinction of a unique genetic lineage until habitat restoration can support a self-sustaining natural population (Peters et al. 2014), providing a demographic abundance boost to cross a demographic threshold needed for population growth (Berejikian et al. 2008; Venditti et al. 2018; Berejikian and Van Doornik 2018), or amplifying a unique or underrepresented life-history trait. Where necessary to preserve or recover the DIP, these conservation programs would utilize local founding stocks, where available, and be operated in an integrated fashion because these local stocks are likely to be more effective in supplementing natural reproduction than non-local stocks that are genetically distinct from local populations, and integration should limit divergence from the natural genetic profile. In contrast, some hatchery programs have a different goal: to provide harvest opportunities. These hatchery programs may be either integrated or segregated. Traditionally, steelhead hatchery programs in Puget Sound have segregated operations using hatchery stocks (Chambers Creek winters and Skamania summers) which have been selectively bred to have low levels of interbreeding with the natural populations with the added goal of not appreciably reducing the likelihood of survival and recovery of ESA-listed Puget Sound steelhead.

Interactions of hatchery- and natural-origin steelhead pose different risks to abundance, productivity, genetic diversity, and fitness of fish spawning in the natural environment depending on how hatcheries are operated. A growing body of scientific literature, stemming from improved tools to assess parentage and other close genetic relationships on relative reproductive success (RRS) of hatchery and natural-origin salmonids, suggests that strong and rapid declines in fitness of natural-produced fish due to interactions with hatchery-produced fish are possible (Araki et al. 2008; Christie et al. 2014). These studies have focused primarily on steelhead, Chinook salmon, Coho salmon, and Atlantic salmon. Limited but growing evidence suggests that steelhead may be more susceptible to genetic risk (i.e., domestication) posed by hatchery propagation than other species (Ford et al. 2016). Further, because selective regimes and mortality differ dramatically between natural and cultured populations, some genetic change cannot be avoided (Waples 1999). These changes are difficult to predict quantitatively because there may be considerable variation in RRS among species, populations, and habitats, as well as temporal variability owing to environmental change. Where uncertainty makes precise predictions difficult, precautionary strategies are appropriate for reducing unexpected risks and impacts.

Some of the genetic risk associated with hatchery programs can be reduced by choosing an appropriate broodstock strategy. As described above, two different choices are integrated and segregated broodstock management (Ford 2002; Currens and Busack 2004; Mobrand et al. 2005). The integrated strategy incorporates natural-origin steelhead into hatchery broodstock, genetically linking the hatchery and natural components, with the intent of promoting greater local adaptation to the natural environment for the hatchery-origin component of the population. The intent of integrated hatcheries is for hatchery broodstock and hatchery-origin fish produced by the hatchery to be as biologically similar to the native population as possible (e.g., Baskett and Waples 2013). Consequently, most conservation hatcheries employ integrated broodstock management. By contrast, ideally, the segregated hatchery strategy is designed to minimize genetic interaction between hatchery-origin and natural-origin fish. In segregated hatcheries, mostly hatchery-origin fish are spawned in the hatchery, and hatchery and harvest management aims to minimize the number of hatchery-origin fish that spawn in the natural environment. Harvest-oriented hatchery programs commonly employ segregated broodstock management.

Examples of the segregated strategy are the programs that have used early winter-run steelhead (Chambers Creek stock) and Skamania Hatchery summer-run steelhead to provide harvest opportunities. In Puget Sound, early returning winter-run hatchery steelhead broodstocks are derived from a Chambers Creek population from southern Puget Sound, which was developed in the mid-20th century and has been highly domesticated for many generations to produce fast-growing, yearling smolts (Crawford 1979). Likewise, “Skamania” summer-run hatchery steelhead currently produced in Puget Sound were originally derived from the Washougal and Klickitat rivers in the Columbia River basin, out-of-DPS populations (Crawford 1979). The Chambers Creek early returning winter-run steelhead were specifically excluded from the Puget Sound steelhead DPS because the long-term genetic effects of artificial selection and domestication have led to considerable divergence in life history (Myers et al. 2015). Similarly, Skamania summer-run hatchery steelhead were excluded from the DPS at listing because they did not originate from Puget Sound. Because naturally produced, indigenous stocks of fish are the definitive unit in measuring population viability of the DPS, neither Chambers Creek early winter-run nor Skamania River summer-run hatchery programs can directly contribute to conservation and recovery of Puget Sound steelhead.

Chamber Creek early winter-run and Skamania River summer-run hatchery stocks show variable but generally low levels of interbreeding success with natural-origin steelhead populations in Puget Sound, demonstrating high levels of program segregation. An exception is where Skamania-origin steelhead appear to have interbred extensively with natural populations in the Snohomish basin. Currently, the genetic profiles of summer steelhead populations in the South Fork Skykomish River (above Sunset Falls), the North Fork Skykomish River, and the South Fork Tolt River all indicate high levels of Skamania lineage.

This colonization of parts of the Snohomish basin by self-reproducing Skamania stock-origin steelhead has likely put an indelible Columbia-basin signature on the genetic profile of the Snohomish River steelhead and more broadly, the genetic diversity patterns within the Puget Sound steelhead DPS. Measureable Columbia-basin influence on genetic diversity may decrease over time due to natural selection and genetic drift, but cannot be fully eliminated from the Snohomish populations without further risking the persistence of the extant natural-origin summer steelhead populations — an important and limited life history in the DPS. Thus, some natural-origin summer steelhead populations with substantial levels of Skamania lineage will be among the populations contributing to overall DPS viability, and to future hatchery programs. The long-term fitness consequences of the introduction of genetic material from the Columbia basin into the Puget Sound steelhead DPS are unknown, but the successful self-reproduction of Skamania-lineage fish in the Snohomish basin may indicate that their fitness is unlikely to be suppressed through interbreeding with the native populations. Expansion of this colonization to other basins in Puget Sound should be discouraged, as these fish do not represent the original genetic lineage of Puget Sound steelhead and may threaten productivity of native summer-run fish in these basins. Where substantial measures may be necessary to recover an individual DIP or the DPS, the use of any hatchery stock founded from the extant Snohomish summer steelhead populations, outside of the Snohomish basin, will need to consider the risks associated with the stock's mixed lineage on the genetic diversity profile of the DIP and overall Puget Sound steelhead DPS as well as on their proven success at establishing natural production in summer steelhead habitat. Propagation using broodstock with known genetic influence from Skamania stocks should be avoided elsewhere in the Puget Sound Basin.

Ecological interactions with natural-origin steelhead that reduce abundance or productivity because of the abundance, fish size, and release strategies of hatchery fish (including salmon and trout hatcheries) are a risk common to both segregated and integrated hatchery programs (e.g., Einum and Flemming 2001; Kostow 2009; Tatara and Berejikian 2012). Once released from the hatchery, for example, juvenile steelhead might compete with natural-origin steelhead if they consume resources such as food and rearing territories, thereby reducing the resources available to natural-origin fish. Hatchery-produced steelhead might prey on natural-origin steelhead, or other ESA-listed salmonids such as Chinook salmon, although recent studies have not revealed a strong predation risk (e.g., Sharpe et al. 2008). The time frame of competition and predation could be extended, and the effects magnified, if hatchery juveniles do not migrate rapidly downstream but rather rear in freshwater, extending the period they could interact with natural-origin fish. Finally, hatcheries may release large pulses of juveniles that can potentially attract avian, mammalian, and piscine predators that have learned to anticipate the releases. Thus, appropriate sizing, rearing, and release strategy of hatchery steelhead are key risk reduction measures.

Hatchery actions typically involve trade-offs between different population viability characteristics that change as the ecosystem changes or is restored. Acceptable trade-offs may also depend on the biological importance of the population in the recovery of the DPS. For example, for populations facing imminent threat of extinction, using hatcheries to maintain and increase abundance may come at the cost of reducing genetic diversity and short-term fitness. However, in watersheds where populations are more stable, the objective of integrated programs to release hatchery fish that are as ecologically and genetically similar as possible to natural-origin fish to promote better survival may also increase the potential for ecological interactions.

Table 3 describes the current hatchery programs where steelhead are produced in Puget Sound. For each program, it identifies the watershed it is located in, the hatchery program name and date for its Hatchery Genetic Management Plan (HGMP), steelhead population origin, species run or race, program purpose, hatchery operator, the HGMP release number, and the primary hatchery facility.

Pressure from Net Pen Operations

Net pen aquaculture operations in Puget Sound pose a potential risk to the viability of the DPS. Net pen operations using non-native Atlantic salmon in Puget Sound are allowed until the beginning of 2022 when they will no longer be able to raise non-native fish in Washington State waters. Until then, net pen facility operators may obtain a permit from the WDOE to produce Atlantic salmon or other fish for harvest and sale. The operations present a risk to steelhead for several reasons. Uneaten fish food and fish feces from the operations pollute waters adjacent to rearing areas for salmon and steelhead. The accidental release of Atlantic salmon from the facilities also poses a risk. In 2017, the near complete collapse of a net pen near Cypress Island caused the release of 160,000 Atlantic salmon into Puget Sound. Most of these fish were never recovered. Although there is no direct evidence that these fish have successfully colonized streams in the DPS, there is evidence that successful colonization of Atlantic salmon in steelhead habitat has occurred in the past (Volpe et al. 2000). Disease and pathogen outbreaks caused by net pen operations also pose a risk to the DPS. In 2012, a massive outbreak of infectious hematopoietic necrosis (IHN) in net pens near Bainbridge Island resulted in the loss of more than one million Atlantic salmon. IHN is readily transmittable to steelhead. Recently updated permits from the WDOE will require that Atlantic salmon farms and other net pen operations in Puget Sound increase their monitoring, inspections and reporting, and have emergency response plans. A recent proposal has emerged to rear steelhead in Puget Sound net pens as a replacement of Atlantic salmon. NMFS will review these proposals as they become available.

Table 3. Hatchery programs producing steelhead in Puget Sound. Programs shown in **BOLD** type are listed or proposed for listing as part of the DPS.

Steelhead major population group	Watershed	Program name, HGMP[1] date (in parentheses), and listing status [listed or proposed for listing are shown in bold]	Steelhead population origin	Species run or race	Program type	Program purpose	Hatchery operator	HGMP release number	Primary facility
Northern Cascades	Nooksack	Kendall Creek Hatchery (July 2014)	Chambers Creek	Winter	Segregated	Harvest	WDFW	150,000	Kendall Creek Hatchery
Northern Cascades	Stillaguamish	Whitehorse Pond Program (draft 2014)	Skamania Hatchery	Summer	Segregated	Harvest	WDFW	70,000	Whitehorse Pond
Northern Cascades	Stillaguamish	Whitehorse Pond Program (July 2014)	Chambers Creek	Winter	Segregated	Harvest	WDFW	130,000	Whitehorse Pond
North Cascades	Snohomish/ Skykomish	Reiter Pond Program (draft 2013)	Skamania Hatchery	Summer	Segregated	Harvest	WDFW	130,000	Reiter Ponds
Northern Cascades	Snohomish/ Skykomish	Skykomish River Program (February 2016)	Chambers Creek	Winter	Segregated	Harvest	WDFW	140,000 27,600	Reiter Ponds Wallace Hatchery
Northern Cascades	Snohomish/ Snoqualmie	Tokul Creek Program (July 2014)	Chambers Creek	Winter	Segregated	Harvest	WDFW	74,000	Tokul Creek Hatchery
Northern Cascades	Green	Soos Creek Program (October 2015)	Skamania Hatchery	Summer	Segregated	Harvest	WDFW	50,000 50,000	Soos Creek Hatchery Icy Creek Pond
Northern Cascades	Green	**Green River Program (October 2017)**	Green River	Winter	Integrated recovery	Conservation	WDFW	23,000 15,000 17,000	Soos & Icy Creek Pond Soos & Flaming Geyser (Pond) Soos & Palmer Pond
Central and South Puget Sound	Green	**Fish Restoration Facility (FRF) (July 2014)**	Green River	Winter	Integrated recovery	Conservation/ Harvest Augmentation	Muckleshoot Indian Tribe	350,000	FRF
Central and South Puget Sound	White	**White River Program (June 2018)**	White River	Winter	Integrated recovery	Conservation	Puyallup Tribe of Indians	60,000	Diru Creek Hatchery and upper river acclimation sites
Hood Canal and Strait of Juan de Fuca	Skokomish, Dewatto, Duckabush	**Hood Canal Supplementation Project (April 2014)**	Skokomish River & Hood Canal tributaries	Winter	Integrated recovery	Conservation	Long Live the Kings	42,000	McKernan Hatchery & Lilliwaup
Hood Canal and Strait of Juan de Fuca	North Fork Skokomish River	**North Fork Skokomish River Program (draft April 2016)**	Skokomish River	Winter	Integrated recovery	Conservation	Tacoma Power	15,000 (225 adults)	NF Skokomish Salmon Hatchery
Hood Canal and Strait of Juan de Fuca	Dungeness	Dungeness Program (July 2014)	Chambers Creek	Winter	Segregated	Harvest	WDFW	10,000	Dungeness Hatchery
Hood Canal and Strait of Juan de Fuca	Elwha	**Lower Elwha Fish Hatchery (August 2012)**	Elwha River	Winter	Integrated recovery	Conservation	Lower Elwha Klallam Tribe	175,000	Lower Elwha Hatchery

[1] Hatchery Genetic and Management Plan.

Strategies and Actions to Reduce Negative Effects and Improve the Conservation Benefits of Hatchery Programs

To ensure that benefits of hatchery programs outweigh potential risks and at least do not impede recovery, hatchery steelhead programs in Puget Sound should follow these basic strategies:

Strategy 1. Be intentional in the purpose of the hatchery program.

Action 1.a. Each hatchery program has a clearly identified purpose and actions for the program are consistent with that purpose.

Action 1.b. Each hatchery program has clearly stated population viability objectives for abundance, productivity, diversity, and spatial structure and the objectives are consistent with the role of the population in recovery of the DPS.

Action 1.c. Where harvest is the purpose, harvest objectives reflect the contribution to specific fisheries and expected impacts on abundance, productivity, spatial structure and diversity of the natural population.

Action 1.d. Each hatchery population has implemented a broodstock strategy that minimizes risk to natural-origin populations.

- For all programs, selection of the appropriate broodstock source, for both the program objective and for the management of the associated risks, is paramount. Broodstock sources that cannot achieve the program objective for both benefits and risks should be phased out of use.
- For integrated strategies, the primary purpose is to reestablish or rebuild indigenous populations, although use of an integrated strategy for harvest may be possible when a segregated strategy is not workable and risks of the integrated strategy are understood and can be controlled.
- For integrated strategies, broodstock should be limited to local, indigenous populations.
- For segregated strategies, broodstock should be limited to populations originating from the Puget Sound steelhead DPS.
- For both integrated and segregated hatchery strategies, monitor gene flow and potential ecological interactions to maintain conservation objectives for the natural population.

Action 1.e. Ensure all hatchery programs have self-sustaining broodstocks and minimize impacts on natural-source populations while maximizing survival of hatchery fish consistent with conservation goals. To this end, natural-origin steelhead should be purposefully taken for broodstock only when:

- The donor population is currently at or above the viable threshold and the collection would not impair its viability; or
- If the donor population is not currently viable but the sole objective of the current collection program is to enhance the viability or survival of the listed DPS; or
- If the donor population is shown with a high degree of confidence to be above critical threshold although not yet functioning at viable levels, and the collection will not appreciably slow the attainment of viable status for that population.

Action 1.f. Ensure that trade-offs among benefits and risks are appropriate for the population's stage of ecosystem recovery as ecosystem conditions change based on understanding of how the ecosystem is functioning from:

- Monitoring habitat, including the quality and quantity of spawning areas, rearing areas, migratory corridors, and changing selection pressures on natural-origin populations, including other species;
- Monitoring population status and response to hatchery actions, such as gene flow, proportions of hatchery fish spawning in the natural environment, relative reproductive success, and

phenotypic and life characteristics (size, age structure, fecundity, breeding sex ratios, phenology, and repeat spawning);
- Developing metrics, models, and thresholds for assessing trade-offs and transitioning between recovery stages.

Strategy 2. Be accountable for reducing risk of hatchery programs on natural-origin steelhead.

Action 2.a. Ensure that management actions for integrated programs reduce the loss of natural-origin characteristics in hatchery-origin fish that can arise from broodstock collection, rearing, and release by:
- Scaling hatchery programs based on habitat carrying capacities to keep the relative size of natural production as high as feasible to increase adaptation to the natural environment and increase abundance and productivity without degrading genetic diversity; and
- Reducing impacts of returning adult hatchery-origin fish on natural-origin fish by controlling the proportions of hatchery fish spawning in the natural environment consistent with the natural population's biological significance and stage of recovery.

Action 2.b. Ensure that hatchery facilities are constructed and operated to use appropriate ecological, genetic, and demographic risk containment measures for handling adults, withdrawal of water for hatchery use, discharging effluents, and promoting floodplain function.

Action 2.c. Ensure that each hatchery program implements fish culture practices that avoid disease and parasite risks, including low rearing densities, adequate water supply, and appropriate food and feeding management.

Action 2.d. Ensure that fish cultural practices at each hatchery implement rearing strategies to induce smoltification and reduce residualism and precocious male maturation. These should consider:
- Growth regimes that consider growth opportunity (temperature units from emergence to the spring smolt window) based on spawn timing and water temperatures; and
- Releasing smolts at age-1 for earlier spawning and warmer rearing temperatures, and age-2 smolts for later spawning and colder rearing temperatures, or a combined approach. Manipulating incubation temperatures and size sorting may be useful tools in this approach.

Action 2.e. Ensure that release strategies, such as volitional release, minimize ecological interactions and promote survival while achieving other objectives.

Action 2.f. As feasible in conservation hatchery programs, use live-spawning methods for natural-origin fish to promote iteroparity.

Strategy 3. Adapt to new information and challenges in the operation and management of hatcheries.

Action 3.a. Ensure that every hatchery program has a process for regularly reviewing its objectives and performance as new information becomes available

Action 3.b. Ensure that monitoring and evaluation processes are in place to assess the status of the population, the health of the watershed, and hatchery effectiveness.

Action 3.c. Prioritize state, tribal, and federal agency research to improve understanding of factors affecting fitness and ecological interactions to minimize hatchery influenced impacts to natural-origin populations.

Action 3.d. Monitor and manage hatchery program adaptation for climate change impacts on stage-specific survival, growth, and reproduction.

Action 3.e. Evaluate the effects of hatchery releases, including species and timing, to identify interactions with predators and determine impacts on predator abundance, forage fish, and the food web that supports orcas.

Action 3.f. Discontinue or modify programs if risks outweigh benefits.

Additional details and explanations on these strategies may be found in Appendix 4 of this Plan.

3.4.8 Pressure: Harvest Pressures (including Selective Harvest) on Natural-Origin Fish

Ensuring fisheries are consistent with the survival and recovery of Puget Sound steelhead requires addressing direct and indirect fishery effects on the diversity, spatial structure, abundance, and productivity of steelhead populations. Steelhead fishery management traditionally focused on controlling the harvest of returning adults to meet spawner abundance objectives. While this remains essential, managers now recognize that fishery mortality during other life stages can affect population viability, and that fishery effects on other VSP parameters must also be carefully assessed and addressed. Harvest management, for example, can reduce age at maturation in anadromous salmonids, with concomitant effects on size at age, fecundity, and potentially timing of adult return. For steelhead, which are iteroparous, harvest levels that are too high may also reduce population productivity by constraining the proportion of repeat spawners. Sustainable harvest of steelhead should be managed to: allow adequate numbers of large, older-age adults to spawn; to not disproportionally impact segments of return timing; and conserve current levels of and not preclude increased levels of repeat spawning. In particular, given the importance of life-history diversity to the viability of steelhead populations, it is important that fisheries (consistent with habitat protection strategies) are conducted in a manner that maintains local adaptation and does not limit a population's ability to respond to natural selection.

NMFS' proposal to list Puget Sound steelhead[8] as threatened under the ESA concluded that "Although overutilization for recreational purposes was a factor that contributed to the present decline of Puget Sound steelhead populations, we do not believe that overutilization is a factor limiting the viability of the Puget Sound steelhead DPS into the foreseeable future." The associated status review expressed concern, however, that "High harvest rates before the mid-1990s may have removed a substantial proportion of natural-origin summer-run and early returning/spawning natural-origin winter-run fish from many of these systems" (Good et al. 2005). Fisheries during November, December, and January, although directed at early returning hatchery-origin steelhead, may have had the unintended consequence of reducing the diversity of steelhead populations by placing an unsustainable harvest rate on the early returning or early spawning natural-origin steelhead.

The PSSTRT identified two additional diversity characteristics, iteroparity and the abundance of sympatric resident fish, which can be important contributors to the viability of Puget Sound

[8] 71 Federal Register 15666, 03/26/2006. Listing Endangered and Threatened Species and Designating Critical Habitat: 12–Month Finding on Petition to List Puget Sound Steelhead as an Endangered or Threatened Species under the Endangered Species Act.

steelhead populations (Hard et al. 2015). Modeling of the influence of repeat spawning on steelhead demography (Hard et al. 2015) and a recent analysis of reproductive success in Hood River (Oregon) steelhead (Christie et al. 2018 PNAS) indicate that the frequency of repeat spawning in steelhead can have a substantial effect on individual fitness and population productivity. While the frequency of repeat spawners is affected by many factors, fisheries directed at returning adult spring-run Chinook or Sockeye salmon, or other fisheries conducted when outmigrating kelts are present, can reduce the potential for repeat spawners by reducing the number of steelhead that successfully return to marine waters. While the incidental impact to kelts from these fisheries may be relatively low (3 – 5% in the Skagit), the contribution of repeat spawners to the reproductive success of steelhead may be meaningful (Hard et al. 2015). Freshwater fisheries directed at trout can also inadvertently affect the viability of steelhead populations. Studies conducted by the Washington Department of Fisheries determined that the opening of trout fisheries before June 1st in the Green River resulted in the incomplete emigration of steelhead smolts (WDG 1941). Fishing pressure can affect the abundance of juvenile steelhead and the resident life-history form of *O. mykiss* which, under some conditions, can be a valuable genetic and demographic contributor to the anadromous population.

Limit 4 of NMFS' ESA Section 4(d) rule recognizes the breadth of direct and indirect effects of fisheries on threatened species and describes the fundamental considerations for assessing proposed fishery management plans for consistency with the survival and recovery of listed species. The limit is structured around the importance of maintaining the biological diversity provided by populations within the DPS, and addresses the significant risk that fisheries could pose when natural-origin populations are below a critical threshold. A population not achieving the critical threshold is at a high risk of extinction over a short time period.

Limit 4 of NMFS' 4(d) rule (CFR § 223.203(b)(4)) establishes three tiers with associated fishery management actions:

1. Population below Critical Threshold. Fisheries impacting populations that are functioning at or below the critical threshold should be managed to avoid or have negligible impact to the genetic and demographic risks facing the population and must be designed to permit the population's achievement of viable function, unless the plan demonstrates that the likelihood of survival and recovery of the entire ESU in the natural environment would not be appreciably reduced by greater risks to that individual population.
2. Population between Critical and Viable Threshold. For a population shown with a high degree of confidence to be above a critical level but not yet at a viable level, fishery management must not appreciably slow the population's achievement of viable function.
3. Populations at or above Viable Threshold. Fisheries impacting populations at or above the viable level must be designed to maintain the population or management unit at or above that level.

The framework for Limit 4 of NMFS' 4(d) rule is encapsulated below in the harvest strategy for the recovery plan.

Strategies and Actions to Reduce Harvest Pressures on Natural-Origin Fish

The overall harvest strategy for Puget Sound steelhead is to manage steelhead fisheries to allow harvest without jeopardizing or appreciably slowing the population's achievement of viable function. Actions to implement this strategy include addressing the criteria of Limit 4 or Limit 6 of NMFS' 4(d) rule (50 CFR § 223.203(b)(4) and § 223.203(b)(6)) and ensuring the development of integrated "Four-Hs" management. Consistent with the discussion above, the actions also identify three specific considerations important for Puget Sound steelhead: contributing to an increase in repeat spawners, restoring the diversity of run- and spawn-timing, and providing sufficient protection for juvenile migrant and resident *O. mykiss*.

Strategy 1. Coordinate harvest among all co-managers so that the collective impacts to each population are consistent with recovery goals, and associated management plans and biological opinions.

Action 1.a. Continue to conduct harvest management in a manner consistent with Limits 4 and 6 of the 4(d) rule.

Action 1.b. Consistent with Section 2.3, integrate the best available science and policy regarding habitat and harvest management, including the use of current climate change forecasts.

Action 1.c. Co-managers will work to identify and implement ways that harvest can reduce impacts on the abundance and survival of repeat spawners (kelts), including managing stream fishing during steelhead, Chinook, Coho, Pink, and Sockeye salmon harvest.

Action 1.d. Consistent with habitat protection strategies, and modeled climate change effects, develop and manage harvest plans to ensure adequate escapement and abundance of breeding adults and execute plans and actions in such a way that key aspects of phenotypic and genetic diversity are maintained or enhanced in the population throughout a watershed (i.e., minimizing the selective pressures of fisheries). Examples of key diversity elements include the extent of run and spawn timing; spatial distribution; variability in size, age, and sex ratio of spawners; and the abundance and condition of repeat spawners.

Action 1.e. Consistent with DIP goals, manage recreational stream fisheries to avoid or minimize negative effects to juvenile steelhead (i.e., timing recreational stream fisheries to limit incidental impacts to juvenile steelhead where the DIP is at a critical or non-viable status).

Photo: Fly fishing on the Skagit River. Credit: ©Copi Vojta (Used by permission).

3.4.9 Pressure: Early Marine Mortality

High mortality of juvenile Puget Sound steelhead during their migration through the marine environment of Puget Sound remains a primary factor limiting the species' survival and recovery. Puget Sound steelhead early marine mortality is generally defined as mortality that occurs as steelhead smolts (juveniles) enter the marine environment and die during a short outmigration window though the Sound before entering the Pacific Ocean. Steelhead spend a few days to a few weeks migrating through Puget Sound, and the mortality rates during this short period of their life cycle are critically high. Puget Sound steelhead marine survival rates are lower than for populations from other nearby regions, including for coastal Washington and Columbia River populations.

The high mortality rates currently observed in steelhead smolts migrating through Puget Sound towards the ocean represent a major bottleneck to the productivity and abundance of steelhead on a regional basis. These high mortality rates are unsustainable over the long term, since they are seriously impairing the VSP components of steelhead (especially productivity), and thus the recovery of the Puget Sound steelhead DPS.

The Salish Sea Marine Survival Project set out to answer where and why high mortality exists in Puget Sound. Specific funding was provided by Washington State to examine steelhead mortality during the smolt outmigration and develop management actions to address the early marine mortality of Puget Sound steelhead. This research is part of a larger effort looking at high early marine morality in Puget Sound, the Strait of Georgia, and the Strait of Juan de Fuca that also includes Coho and Chinook salmon outmigrants. This multi-year, cross-boundary research effort provides some clear results pointing toward management solutions to test.

Results of research to date indicate that predation by harbor seals and other pinnipeds is the most likely direct source of mortality for juvenile steelhead in the Puget Sound marine environment. It also shows that, in years when early marine mortality was highest (2006–2009 and again in 2014, compared to 2015–2017), steelhead smolts that traveled farther through Puget Sound (i.e., those from south Puget Sound or south Hood Canal) suffered higher mortality rates than steelhead in other monitored migration segments (Moore et al. 2015, Moore and Berejikian 2017).

Appendix 3 of this Plan discusses the Puget Sound Steelhead Marine Survival Workgroup's hypothesis-driven adaptive management approach to test and evolve management actions that address hypothetical factors that influence survival while continuing to build understanding about the causes of low early marine survival. The appendix includes an overview of the research methods and findings, and justifications for the proposed strategies. It provides a summary of the evidence for each hypothesis for high early marine mortality. The two primary hypotheses are evaluating impacts from (1) increased predator presence, abundance, or targeting of juvenile steelhead in the Puget Sound marine environment (especially by harbor seals) during the steelhead outmigration period; and (2) decreased abundance of buffer or alternative prey for predators during the steelhead outmigration window. Other hypotheses examine additional potential causes of mortality, including the effects of increased human infrastructure, reduced fish condition due to disease or toxic contaminants, and whether smolts in some populations may be predisposed to higher early marine mortality and higher disease loads.

Appendix 3 describes how, why, and where the hypotheses and related management strategies and actions should be implemented and tested. It is also important to note that, as of the drafting of the Plan, the Salish Sea Marine Survival Project and assessment of the Hood Canal Bridge were still underway; the recommendations here reflect specific actions based on those findings, as well as best available science.

The strategies and actions described below summarize the elements of the early-marine program adaptive management approach, and monitoring discussed in Appendix 3. The research, however, is ongoing and priorities are continuously being reviewed and revised through the adaptive management program. Elements are repeated in other sections of the Plan, such as nearshore habitat restoration, hatchery management, research, and monitoring. Including the research and monitoring elements in this part of the Plan is important for implementation of the Plan and integration of adaptive management at the regional and local level. The order below does not imply a sequence for implementation of actions to be taken. Several strategies need further research before being implemented while others are specific to certain DIPs or MPGs.

Strategies and Actions to Reduce Early Marine Mortality and Predation

Strategy 1. Continue predation research and monitoring, with a focus on areas of greatest steelhead early marine mortality.

Action 1.a. Monitor steelhead early marine mortality rates, predation (e.g., diets, behavior), and other response variables for reactions to environmental change and before and after testing management strategies to assess effectiveness. Monitor later marine mortality for the same steelhead populations to test whether early marine, predation-based mortality is additive vs compensatory.[9] Use information to help determine whether, when, what, and where management actions should be fully implemented.

Action 1.b. Monitor the abundance of harbor seals and their distribution during the juvenile steelhead outmigration period. Continue to assess the trajectory of harbor seal population abundance and consider impacts such as the increasing presence of transient killer whales as a potential natural moderator of harbor seal population size.

Action 1.c. Continue to improve assessments of harbor seal predation rates on juvenile steelhead. Conduct studies on specific steelhead DIPs to estimate the impact of harbor seal predation on steelhead smolts in estuaries and in specific segments in Puget Sound during the smolt migration window. Acoustic telemetry and harbor seal scat analyses should be conducted in carefully coordinated studies to estimate predation rates from populations with estimated smolt abundance(s).

Action 1.d. Continue research into whether steelhead smolts with certain genetic fingerprints are predisposed to higher early marine mortality and parasite loads.

Strategy 2. Assess and test the effectiveness of specific actions to alter harbor seal behavior at locations associated with high steelhead mortality. Thoroughly assess whether predator distribution will be adequately altered and evaluate unexpected consequences.

Action 2.a. Identify and remove artificial haul-out sites in key areas while animals are not present.

Action 2.b. Consistent with the Marine Mammal Protection Act (MMPA), test acoustic deterrents or hazing of animals in mortality hotspots during the short steelhead outmigration window

[9] Additive predation decreases survival in a prey population. Compensatory predation does not affect overall survival of a prey population and merely replaces or compensates for existing sources of mortality.

Strategy 3. Implement regional actions to allow for testing the effectiveness of site-specific marine mammal management in support of steelhead recovery.

- **Action 3.a.** Continue monitoring to determine whether marine mammal populations of concern are at optimum sustainable population sizes.
- **Action 3.b.** Consistent with MMPA, identify "problem areas or animals" and experiment with non-lethal action (see Strategy 2).
- **Action 3.c.** If warranted, work with Washington's congressional delegation to change requirements in the MMPA to allow for proactive and flexible management actions by the state.
- **Action 3.d.** Specify the regulatory options in the MMPA for controlling specific marine mammals.
- **Action 3.e** Track progress in the Columbia River pinniped management program and learn from results.
- **Action 3.f.** Determine the feasibility and effectiveness of actions that reduce predator numbers, including wildlife contraception, relocation, and culling.

Strategies and Actions Related to Factors that may Lead to, Exacerbate, or Ameliorate Predation-based Mortality in Puget Sound

It may be feasible and effective to address factors that may exacerbate or ameliorate predation-based mortality in certain populations and MPGs, as summarized below and further described in Appendix 3. We need to determine which of these factors to address based upon the specific predator, location of high out-migrating juvenile steelhead mortality, and specific steelhead populations affected. Factors include but may not be limited to buffer prey, human infrastructure, disease, contaminants, hatchery fish distribution, and genetic fitness, as described in Appendix 3.

Strategy 4. Support efforts to recover or enhance the abundance of forage fish as buffer prey.

- **Action 4.a.** Advocate for, fund and track progress to develop and test herring management strategies, such as increasing egg survival rates, reducing noise at spawning sites at key times, identifying herring predation hotspots, and improving habitat quality (see Bargmann 1998 and the Salish Sea Pacific Herring Assessment and Management Strategy Team 2018).
- **Action 4.b.** Evaluate the benefits to steelhead of reducing commercial harvest of herring in Puget Sound.
- **Action 4.c.** Fund and expedite acquisition, restoration, and protection of high-priority nearshore habitat for forage fish population spawning and rearing sites in Puget Sound.
- **Action 4.d.** Implement site-specific actions, such as removing bulkheads/shoreline hardening at key forage fish sites, adding wrack to beaches, protecting and restoring submerged vegetation including eelgrass and kelp, and removing pilings. Explore beach nourishment options where infrastructure disconnects drift cells.
- **Action 4.e.** Continue monitoring efforts on plankton abundance, composition, and distribution as it relates to providing food for forage fish and species that buffer predation on steelhead, and refine actions to support productive plankton communities.

Strategy 5. Support efforts to recover or enhance the abundance of other prey historically important to harbor seals and other predators of concern (e.g., hake, cod, and rockfish).

- **Action 5.a.** Implement NMFS' rockfish recovery plans for Puget Sound/Georgia Basin.
- **Action 5.b.** For other species not covered by recovery plans, work with NMFS, WDFW, and advocacy groups to identify and protect key habitats and populations.

Strategy 6. Address high steelhead mortality at the Hood Canal Bridge through structural modifications or through management approaches to facilitate steelhead passage or alter predator behavior during the steelhead outmigration period.

- **Action 6.a.** Fund and complete the Hood Canal Bridge Assessment to isolate how bridge is leading to high steelhead mortality.
- **Action 6.b.** Develop, test, and implement specific actions based on the results of the assessment.
- **Action 6.c**. Continue research to further assess the extent of impact by human infrastructure on Puget Sound steelhead mortality.

Strategy 7. Determine if hatchery fish act as a predator attractant or buffer prey, or both, in relation to steelhead early marine survival.

- **Action 7.a.** Determine the effectiveness of distributing the marine-entry timing of hatchery Chinook salmon (and possibly other species, such as Coho salmon), particularly in areas where hatchery Chinook and Coho salmon are of a size that attracts predators, in places that overlap with high steelhead early marine mortality. Assess the hatchery management, harvest, and natural-origin fish recovery implications to Chinook and Coho salmon of any action considered.
- **Action 7.b.** Test and, if successful, implement different release strategies that attempt to increase distribution of marine entry timing.
- **Action 7.c.** Test and, if successful, implement other manipulations to hatchery fish (photoperiod, water temperatures, feeding) that improve ability to increase distribution of marine entry timing.
- **Action 7.d.** Assess whether increasing the abundance of similar-sized natural-origin or hatchery out-migrating juvenile Chinook and Coho salmon buffers predation and lowers steelhead smolt mortality. Consider that hatchery-based efforts may have a negative ramification in the context of potential pulse-abundance impacts (see above). Assess the hatchery management, harvest, and recovery implications to Chinook and Coho salmon of any action considered.
- **Action 7e**. Continue research to further assess the pulse abundance and buffer prey hypotheses for hatchery fish impacts on steelhead early marine mortality and survival.
- **Action 7f**. Determine whether pulse abundances of hatchery fish are affecting predator behavior and increasing predation on Puget Sound steelhead.
- **Action 7g**. Consider mesocosm experiments that test the pulse abundance hypothesis in areas of high steelhead early marine mortality.

Strategy 8. Implement actions to address *Nanophyetus salmincola* in watersheds where the parasite is prevalent and at high enough intensities to influence the health and survival of out-migrating juvenile steelhead.

- **Action 8.a.** Test the effectiveness of removing hatchery carcasses burdened with *N. salmincola* from nutrient enhancement efforts in problem watersheds.
- **Action 8.b.** Filter or treat hatchery water supplies in rivers where *N. salmincola* is present.
- **Action 8.c.** If water supplies cannot be treated, consider reducing or eliminating upstream passage of hatchery fish.
- **Action 8.d.** Test the effectiveness of isolating *N. salmincola* hotspots and associated *juga* snail (intermediate host) colonies and employing actions to reduce the abundance of *Juga plicifera* snails.
- **Action 8.e.** Determine the effectiveness of reducing juga snail abundance through habitat restoration, including variables such as water temperature, altered flow regimes, increased riparian vegetation to increase shade, and re-establishing historic gravel/cobble substrates that minimize bedrock and silt.

Strategy 9. Implement actions to identify and reduce/or eliminate contaminants suspected of affecting steelhead smolt condition.

- **Action 9.a.** Reduce polybrominated diphenyl ethers (PBDEs) and other toxic chemicals in river basins with levels and sources known to impact steelhead.
- **Action 9.b.** Assess other watersheds where contaminants may be of concern (e.g., Snohomish and Puyallup).
- **Action 9.c.** Identify and implement actions to reduce contaminant loads in steelhead.

Strategy 10. Implement long-term monitoring protocol to continue to assess steelhead early marine mortality rates and distribution, and compare to freshwater and later ocean mortality.

- **Action 10.a.** Select index streams for each major population group, taking into consideration where monitoring has or continues to occur.
- **Action 10.b.** Fund maintenance of Puget Sound acoustic telemetry array to track migration patterns, survival rates, and locations of mortality.
- **Action 10.c.** Continue to assess later marine mortality for the same steelhead populations to test whether early marine mortality is additive vs compensatory. Perform this monitoring in the context of tracking responses to environmental change and in the context of the other research considerations for specific factors affecting the early marine mortality of steelhead.
- **Action 10.d.** Support efforts to improve monitoring and understanding of forage fish and other prey of historic importance (e.g., Pacific Hake and rockfish) to predators of concern.

3.4.10 Relationship between the Pressures and Ecological Concerns

The pressures discussed in the previous sections generally can apply stress on the fish and limit their viability by directly or indirectly impacting abundance, productivity, spatial structure or diversity. NMFS' Northwest Fisheries Science Center has identified ten ecological concerns that encompass the different conditions that directly impact salmonids and can be addressed by management actions (e.g., habitat restoration, hatchery reform) (Barnas et al. 2019; Hamm 2012). These ecological concerns are the ecological conditions essential for maintaining the long-term viability of a given population of salmonids. The concerns can cause mortality, injury, reduced health, or reduced reproduction.

The ten ecological concerns that directly impact salmonids are:

1. Habitat quantity (anthropogenic barriers, natural barriers, competition);
2. Injury and mortality (predation, pathogens, mechanical injury, contaminated food);
3. Food (altered primary productivity, food-competition, altered prey species composition and diversity);
4. Riparian condition (riparian condition, large wood recruitment);
5. Peripheral and transitional habitats (side channel and wetland condition, estuary conditions, nearshore conditions);
6. Channel structure and form (bed and channel form, instream structural complexity);
7. Sediment conditions (decreased sediment quantity, increased sediment quantity);

8. Water quality (temperature, oxygen, gas saturation, turbidity, pH, salinity, toxic contaminants);
9. Water quantity (increased water quality, decreased water quality, altered flow timing); and
10. Population-level effects (reduced genetic adaptiveness, small population effects, demographic changes, life history changes).

The NWFSC identified these ten concerns to provide a consistent language for capturing the different problems that have been identified for various salmonid ESUs and DPSs in the Pacific Northwest using various terms (e.g., limiting factors, stressors, concerns, factors, threats) (Barnas et al. 2019). Use of this consistent language improves our ability to evaluate whether the ecological conditions on which the fish depend are improving, becoming more degraded, or remaining the same. It also allows us to more fully capture the impacts of pressures and stressors across different species, populations, and life stages. Table 4 provides a crosswalk that links the ten main ecological concerns for salmon and steelhead to the pressures and stressors identified in this Plan. Table 5 identifies the main ecological concerns for the different Puget Sound steelhead populations.

Table 4. Crosswalk between Ecological Concerns and Related Pressures and Stressors.

Ecological Concern	Definition	Related Pressures	Related Stressors
Habitat Quantity	Insufficient quantity of total habitat or habitat diversity due to elimination of access.	Dams, culverts, tidal gates and other obstacles that reduce access; reduced carrying capacity due to hatchery fish, predation, competition	Loss of full or partial access to habitat due to barriers
Injury and Mortality	Lethal or sublethal effects due to other organisms, including human activities. Includes predation, pathogens, mechanical injury, contaminated food	Invasive/exotic fish or predators, pinnipeds, fishing, disease, inadequate screening, bioaccumulation of toxics	Increased mortality due to predation, infection, disease, injury, toxic substances
Food	Insufficient or inadequate food for salmonids	Altered food web, increased competition from hatchery fish, prey species abundance, ocean condition, invasive species	Insufficient food due to altered ecological dynamics, addition of competition, altered prey species
Riparian Condition	Degradation of habitat adjacent to streams, rivers, lakes and nearshore areas. Impairment of near-bank areas to support plants, including large trees that stabilize stream, provide shade and LWD.	Activities and development that result in bank degradation, insufficient buffers, loss of mature trees and riparian vegetation, inability to supply organic matter and filter sediments	Impaired riparian function/condition, reduced LWD recruitment, lack of shade
Peripheral & Transitional Habitats	Loss and/or degradation of peripheral habitat of streams and rivers, including standing water, connected channels and areas that are periodically inundated during high flows.	Activities/ development, including diking and levees, that result in loss of side channels, wetlands, and other peripheral habitat; reduce estuarine habitats, tidal flats.	Loss of access to peripheral freshwater habitat, including side channels; Degradation, elimination, or loss of access to floodplain, shallow water areas.
Channel Form & Structure	Changes to river, stream, lake, estuarine tributary/ distributary channel form, including instream structural complexity, width-to-depth ratios, sinuosity, and bedload movement.	Channelization, bank armoring, bank hardening, bridge crossings, confinement, nearshore sediment loss, beach erosion.	Decline in instream habitat quantity, quality and complexity, including reduced sinuosity, bank hardening, channel incision, poor gravel/sediment sorting, reduced refugia.
Sediment Conditions	Reduction of quantity and quality of spawning habitat due to changes in background quantity, size of sediment input	Bank erosion or aggradation, embeddedness, disruption of sediment processes that increase sediment load, excess fines.	Excessive sedimentation, fines; lack of spawning gravel.
Water Quality	Degraded chemical, physical, and biological characteristics of water with respect to the suitability for salmonids, excluding toxins and pathogens.	Development that leads to increased stormwater runoff, release of toxic contaminants, increased temperature,	Oxygen depletion, excess nutrients, gas saturation, suspended sediment, pH, stormwater pollutants, toxic contaminants, ocean acidification, salinity
Water Quantity	Detrimental effects of deviations to natural amount and timing of water quantity instream, including lowered water quality and barriers to access.	Water withdrawals, diversions, altered flows, upland activities that reduce groundwater recharge, surface impoundments, loss of beaver, climate change.	Altered flow timing, increased or decreased water quantity during critical periods.
Population-level Effects	Changes to make up, genetic adaptiveness, of population	Interactions between hatchery and natural-origin fish, harvest or domestication selection.	Loss of life history diversity, changes to migration timing, reduced resiliency

Table 5. Main Ecological Concerns for Puget Sound Steelhead Demographically Independent Populations (DIPs). A check mark (√) indicates a concern for a steelhead population and a dash (-) indicates that it is not a problem for a population.

Steelhead MPGs and DIPs	Habitat Quantity	Injury & Mortality	Food	Riparian Condition	Peripheral & Transitional	Channel Form/Structure	Sediment Conditions	Water Quality	Water Quantity	Population-level Effects
North Cascades MPG										
Snohomish/Skykomish River	√	-	-	-	√	√	√	-	√	-
Pilchuck River	√	-	-	-	√	√	-	-	-	-
Snoqualmie River	√	-	-	-	-	√	√	-	√	-
North Fork Skykomish River	-	-	-	√	-	-	-	-	-	-
Stillaguamish River	-	-	-	√	√	√	√	√	√	-
Canyon Creek	-	-	-	√	√	√	√	-	-	√
Deer Creek	-	-	-	-	√	√	√	-	-	√
Skagit River	√	-	-	√	√	√	√	√	√	-
Nookachamps Creek	-	-	-	√	√	√	-	√	-	-
Baker River	√	-	-	-	-	-	-		-	√
Sauk River	-	-	-	√	√	√	√	√	√	-
Samish River	√	-	-	√	√	√	√	√	-	-
Nooksack River	√	-	-	√	√	√	√		√	-
South Fork Nooksack River	√	-	-	√	√	√	√	√	-	√
Drayton Harbor Tributaries	-	-	-	-	√	-	-	√	-	√
Central and South Puget Sound MPG										
East Kitsap Peninsula Tributaries	√	-	-	√	√	√	-	√	√	-
South Puget Sound Tributaries	√	-	-	-	√	√	-	√	√	-
Nisqually River	√	-	-	√	√	√	√	-	-	√
Puyallup/Carbon Rivers	√	-	-	√	√	√	√	√	√	-
White River	√	-	-	√	√	√	√	√	√	√
Green River	√	-	√	√	√	√	√	√	√	-
Cedar River	√	-	-	√	√	√	√	√	√	√
N. Lake Washington / Lake Sammamish	-	-	-	-	√	-	√	√	√	√
Hood Canal and Strait of Juan de Fuca MPG										
Elwha River	√	-	-	-	√	√	√	-	√	-
Strait of Juan de Fuca Tributaries	-	-	-	-	-	-		-	-	√
Dungeness River	-	-	-	√	√	√	√	-	-	-
Sequim/Discovery Bays Tributaries	-	-	-	√	√	√		-	-	√
West Hood Canal Tributaries	√	-	-	√	√	√	√	√	-	-
Skokomish River	√	-	-	√	√	√	√	√	-	-
East Hood Canal Tributaries	√	-	-	√	√	√	-	-	-	√
South Hood Canal Tributaries	-	-	-	-	-	-	-	-	-	√

3.5 Addressing Climate Change

Likely changes in temperature, precipitation, wind patterns, ocean acidification, and sea level height have profound implications for survival of Puget Sound steelhead in their freshwater, estuarine, and marine habitats. At various stages of their life cycle (Beechie et al. 2013), steelhead are predicted to be impacted by five climate change conditions:

- Warmer water temperatures,
- Higher peak flows,
- Lower base flows,
- Increased sediment, and
- Altered marine environment.

Recent climate models for Washington State and Puget Sound have consistently predicted wetter, warmer winters and hotter, drier summers. These changes are likely to affect water temperature, the magnitude and timing of low and peak flows, and other hydrologic variables including receding glaciers, shifts from basins being snow dominant to rain dominant, and increased sedimentation (Harvey et al. 2006; Isaak et al. 2012; Mauger et al. 2015; Montgomery et al. 1996; Wenger et al. 2011; Wu et al. 2012). Wade et al. (2013) predicted changes in stream flows, with low summer flows decreasing up to 30 percent between 2030 and 2059 and high winter flows increasing up to 30 percent during the time period under future climate change conditions. Water temperatures are expected to increase 1–2˚C during this time period. Even greater changes are expected by the end of the 21st century (Beechie et al. 2013).

The effects from climate change pose direct and indirect risks to steelhead abundance, productivity, spatial structure, and diversity; however, our ability to predict how the species and its specific populations and life histories will respond to these changes remains difficult. Over generations, the species' has developed an adaptive ability that has provided resiliency to a wide variety of climatic conditions in the past, and that could help them survive future changes in climate conditions in the absence of other anthropogenic stressors (Ford 2015). Currently, the adaptive ability of Puget Sound steelhead is depressed due to reductions in population size, habitat quantity and diversity, and loss of behavioral and genetic variation. Without these natural sources of resilience, systematic changes in local and regional climatic conditions due to anthropogenic global climate change will likely reduce long-term viability and sustainability of populations in Puget Sound. Species response to climate change is complex and will vary by population, and is context dependent (Crozier and Hutchings 2014; Munoz 2015; Mantua et al. 2010). Changes in phenology — the timing of migration out of or into a river — and reproduction, age at maturity, age at juvenile migration, growth, survival, and fecundity are associated primarily with changes in temperature (Crozier and Hutchings 2014).

Puget Sound steelhead are more susceptible to changes from climate than some other species because of their extended freshwater residency period (often a year or more). Thus, the predicted changes in flow, water temperature, and other hydrologic characteristics are likely to impact adult steelhead river entry, pre-spawn mortality, spawning, and egg incubation, and juvenile steelhead rearing. Adult summer-run steelhead are especially vulnerable to climate change because they hold in streams and rivers during the summer and fall, and can be exposed to the warmest temperatures and lowest flows of the year.

Anticipated temperature increases in Puget Sound due to climate change are likely to move ambient stream temperatures closer to or above upper levels of tolerance thresholds for steelhead (Isaak et al. 2012; Wade et al. 2013; Wu et al. 2012). However, the elevation zone that provides optimal temperatures will shift upward with climate change, causing areas in the lower watershed to become less suitable, and areas in the upper watershed to become more suitable. Temperature increases will also impact the freshwater ecological community in which steelhead are a part, including their food web and potential predators (Kuehne et al. 2017; Lawrence et al. 2014; Rahel and Olden 2008; Sorte et al. 2013; Wade et al. 2013). Changes in stream flows, which are often harder to mitigate for than temperature changes (Wade et al. 2013), are likely to impact steelhead habitat availability, predation, food resources, and other conditions (Mantua et al. 2010; Tonkin et al. 2018) — except in river and stream reaches below storage reservoirs where dam operators can adjust flow releases to create conditions that are more suitable for the fish.

Wade et al. (2013) assessed whether steelhead across the Pacific Northwest were expected to be exposed to elevated temperatures and changes in flow at different life stages under future A1B carbon emissions scenario (IPCC 2007) climate conditions scenario for the years 2030–59. They modeled steelhead in nine Puget Sound rivers (Nooksack, Skagit, Sauk, Stillaguamish, Snohomish, Skykomish, Green, Puyallup, and Nisqually rivers) and predicted that fish from two to five of the rivers were likely to be exposed to very high temperatures during adult migration, spawning, and egg incubation, especially in lower-river areas. They predicted that fish in only one river (Snohomish River) were likely to be exposed to very high temperatures during the rearing stage. They also found that steelhead in eight of the assessed rivers (all except the Puyallup River) were expected to be exposed to greatly reduced flows during the summer (during rearing and migration) and, in all or parts of every system, high flows during migration and incubation.

Results from a study of climate change impacts in the South Fork Nooksack River also show effects on steelhead habitat conditions. The 2016 assessment by the Environmental Protection Agency evaluated the effects of climate change impacts on steelhead and salmon in the South Fork Nooksack, where water temperatures in multiple reaches already exceed the temperature criteria established for protection of cold-water salmonid populations and are expected to continue to rise with climate change (USEPA 2016a). The assessment, which used an adaptation of the “Beechie method” (Beechie et al. 2013), evaluated climatic change impacts in the South Fork Nooksack by three risk factors: changes in water temperature, hydrologic, and sediment regimes. It also evaluated the effectiveness of restoration actions to address legacy, ongoing, and future climate change impacts within different reaches of the South Fork Nooksack watershed. The assessment found that actions that restore riparian and wetland conditions, increase shading, and reconnect floodplains will be most effective in ameliorating the impacts of climate change in the South Fork watershed. It also identified protection and restoration of local cold-water refuges as an important strategy to mitigate the effects on the fish during high-temperature events (USEPA 2016b).

Additionally, increasing ocean temperatures and shifting ocean conditions (including currents and offshore nutrient upwelling) due to climate change will likely impact the food web and ultimately the marine survival of steelhead. In recent years higher ocean temperatures in the northeast Pacific Ocean and a strong El Niño resulted in dramatic shifts in marine ecosystem conditions and species that influence Puget Sound steelhead. While the water off the Washington /Oregon coast normally remains cool and favors important food sources for steelhead (anchovies and northern copepods), which have high lipid levels and promote high salmonid growth and survival, the warmer ocean waters favored southern copepods, which have lower lipid levels, and thus led to reduced juvenile growth and survival in the ocean. Consequently, recent early marine survival rates of several Puget Sound steelhead populations have been quite low (Moore et al. 2015; Moore and Berejikian 2017), and may be limiting the populations' productivity. A warming ocean is likely to further reduce marine survival of steelhead migrating from Puget Sound. These fish make extensive seasonal migrations across broad areas of the North Pacific Ocean. A recent study on tagged California steelhead suggests that the fish closely track preferred sea surface temperatures (and likely other conditions) during their marine migrations (Hayes et al. 2016). However, in certain cases steelhead have been documented remaining off the coast from their natal river and returning to the natal river just a few months after ocean entry. An increased and more wide-ranging prevalence of this life-history strategy may indicate thermally blocked marine migratory corridors or changing ocean conditions.

Rising atmospheric carbon dioxide concentrations will further affect the steelhead. Increases in these carbon dioxide concentrations drive changes in seawater chemistry, increasing the acidification of seawater and thus reducing the availability of carbonate for shell-forming invertebrates, including some that are prey items for juvenile salmonids. This process of acidification is under way, has been well documented along the U.S. Pacific Coast, and is predicted to accelerate with increasing greenhouse gas emissions (Crozier and Siegel 2018).

It is also possible that — as has been seen in recent years — responses of other species, such as whales and harbor seals, to changes in ocean temperatures and food supplies could affect survival. Such possibilities reinforce the importance of implementing research, monitoring, and evaluation to track indicators and adapt actions to respond to climate change (Beechie et al. 2013; Crozier and McClure 2015). It also reinforces the importance of maintaining habitat diversity and achieving survival improvements throughout the entire life cycle, and across different populations since neighboring populations with differences in habitat may show different responses to climate changes (Crozier et al. 2008; Justice et al. 2017; Morelli et al. 2016).

In summary, all other pressures and conditions remaining equal, future alteration of water quality, water quantity, and/or physical habitat due to climate change can be expected to cause a reduction in the number of naturally produced adult steelhead returning to populations across the DPS. Still, how the steelhead response to climate change depends on genetic adaptation and plasticity in both migration timing and thermal tolerance. Their ability to adapt and to move between different habitats is valuable to the fish and their long-term persistence. Thus, much uncertainty remains regarding the effects that climate change will have on species abundance, productivity, spatial structure, and diversity. This uncertainty reinforces the importance of monitoring, and the ability to adjust actions accordingly through adaptive management. Monitoring of steelhead abundance, spatial distributions in freshwater and the ocean, and life histories over time will help us to understand the impacts of climate change in both environments, and if and how the fish adapt to the environment.

A number of the recovery strategies and actions, identified previously in this chapter, to address pressures from passage barriers, floodplain impairment, residential, commercial and industrial development, timber management, transportation, water withdrawals, and other activities will help address impacts from climate change. Strategies to improve access to historic habitats, restore riparian areas and wetlands, reconnect floodplains, protect cold-water refugia, and improve instream structure will be particularly important in reducing the impacts of climate change. In addition, we identify several climate adaptation strategies to be implemented by local watershed groups, planning groups, the Puget Sound Partnership, WDFW, NMFS, and others, as appropriate, to identify and address the impacts of climate change on steelhead largely through the lens of freshwater habitat protection and restoration. Climate adaptations for steelhead would seek to reduce the vulnerability of steelhead DIPs, and the ecosystems that they depend upon, to climate change impacts. As mentioned above, climate impacts will also affect the food web for steelhead in Puget Sound (including prey and predators). The issue of early marine survival of steelhead in Puget Sound in described in more detail in Section 3.4.9 and Appendix 3.

The strategies and actions identified below, while specific to climate change, complement those measures identified in Section 3.4 to remedy the habitat-related pressures. Thus, the strategies in Sections 3.4 and here in Section 3.5 should be implemented together as needed to reduce the various pressures on Puget Sound steelhead.

Continued research is critical to understanding the impacts of climate change on steelhead during various life stages and how they respond to those impacts. Addressing climate change and studying its impacts on steelhead are particularly important in a setting such as Puget Sound where the climate effects on hydrology will be compounded through anthropogenic effects, such as land use conversions, increased impervious surfaces, and storm water pollution due to urbanization.

Strategies and Actions to Reduce Impacts of Climate Change

Strategy 1. By watershed, identify and prioritize climate change adaptation strategies and recovery actions that explicitly include climate change as a risk to steelhead.

- **Action 1.a.** Evaluate climate risk factors (stream temperature, hydrologic and sediment regimes).
- **Action 1.b.** Evaluate restoration actions under legacy, ongoing, and future climate change impacts by reach and sub-watershed to increase habitat diversity and resilience.
- **Action 1.c.** Identify and prioritize protection and acquisition strategies to reduce the risk to steelhead from climate change impacts (e.g., cool-water refugia).

Strategy 2. Increase strategies or actions in other parts of the recovery plan that increase freshwater and fish connectivity, and thus increase life-history diversity, for populations and MPGs across Puget Sound.

- **Action 2.a**. Increase the number and scale of fish passage projects, particularly at key dams and culvert programs that open up habitat. Prioritize passage to higher elevation areas. At the watershed level, deprioritize passage to areas that may be too hot or have scour events not conducive for steelhead to survive.
- **Action 2.b**. Increase number and scale of floodplain connectivity projects, especially those associated with cold-water refuges, to provide refuge for steelhead during low flow and high flow events and provide hydrologic connections for flow and temperatures.
- **Action 2.c**. Develop habitat restoration projects that provide increased connectivity to groundwater and floodplain hyporheic zones. These projects will improve “vertical connectivity” (Beechie et al. 2013) that will help sustain base flows during dry periods. Prioritize these projects in basins especially vulnerable to low flows.

Strategy 3. Increase strategies and actions in other parts of the recovery plan that address stream temperatures and instream flows suitable for Puget Sound steelhead to maximize resiliency of aquatic systems to climate change.

Action 3.a. Identify and then prioritize high-resiliency sites for restoration in light of projected future climate changes. Identify and delineate cold-water refuge areas from regional water temperature monitoring and climate change modeling efforts. Protection and restoration of these habitats will provide additional levels of resiliency to climate change for steelhead in the future. Incorporate protection and restoration of these areas as part of state and federal habitat recovery funding (e.g., Pacific Coast Salmon Recovery Fund (PCSRF), Puget Sound Acquisition and Restoration (PSAR), and Salmon Recovery Funding Board (SRFB) grants). Focus local restoration efforts on groundwater contributions to stream flow and the creation of thermal refugia via hyporheic exchange.

Action 3.b. Seek input on estimating, developing, and maintaining appropriate instream flows (e.g., Donley et al. 2012) in streams from WDFW Water Science Team and WDOE Water Resources Program (for more details, see Water Withdrawals and Altered Flow section of the plan: Section 3.4.6).

Action 3.c. Consider water temperatures when addressing riparian buffer retention, mitigation, and restoration programs. Use models, such as NetMap, when selecting sites for riparian restoration to take into account solar input, aspect, and topography. Aggressively restore riparian vegetation especially along streams that are susceptible to warming under climate change (e.g., as in Justice et al. 2017). Note that it may take several decades for riparian vegetation to mature to provide climate change resiliency benefits.

Action 3.d. Re-aggrading incised stream channels, using beaver dams and beaver dam analogs, can increase base flows. Additionally, water stored by beaver dams at stream's headwaters can increase flows during low-flow periods.

Action 3.e. To increase instream flows, work to increase irrigation efficiency (through programs like the Washington State Conservation Commission's Irrigation Efficiencies Grants Program) and promote the acquisition or change of water rights to keep more water instream during low flow periods (through programs such as the WDOE Trust Water Rights Program, Washington Water Trust, and the Trout Unlimited Washington Water Project).

Action 3.f. To reduce high peak stream flows, restore floodplain connectivity to push the water out onto higher ground, prevent storm water from draining directly into streams in urban areas, and prevent runoff from forest roads draining directly into streams.

Strategy 4. Incorporate climate change adaptations into other steelhead recovery strategies and actions where appropriate. Some examples include:

Action 4.a. Identify opportunities for using hydroelectric dams and major storage reservoirs to buffer increased hydrological and water temperature variability in downstream streams and rivers. Existing dams and storage reservoirs can be used to reduce peak flows during major flood events, and supplement base flows during dry periods. Cold water stored in major reservoirs can be used to reduce water temperatures in downstream mainstem areas when they exceed critical thresholds for steelhead.

Action 4.b. Develop habitat restoration projects that provide increased resilience to climate change by providing "refuge habitats" during peak flow and low flow events. For example, side channel habitats will become increasingly important for protecting juvenile steelhead during peak flow events. Habitat projects that result in deep pools will help protect adult summer-run steelhead and juvenile steelhead during dry and warm periods.

Action 4.c. Incorporate predicted climate change effects in the culvert passage projects as recommended by Climate Impact Group (CIG), WDFW (https://wdfw.wa.gov/publications/01867/), and tribal culvert climate changes studies. Culverts should be appropriately sized to convey flows and sediment under future climate change conditions to provide long-term benefits to steelhead.

Action 4.d. Identify forest management practices, especially road and culvert best management practices, to address their increased sediment inputs, landslide risks, and impacts to flow expected under climate change.

Action 4.e. Identify forest management practices, including silvicultural and pest management, which reduce risks of wildfires in private, state, and federal forests. Increased forest fires resulting from climate change represent a major threat to steelhead populations in the forested headwater areas of the Puget Sound.

Strategy 5. At the MPG or population scale, use decision support tools (e.g., life-cycle modeling) available to prioritize and fund projects for both the 4-year work plans and annual funding rounds. All restoration projects submitted for funding should be required to demonstrate how they consider climate change and how they are designed to achieve, as much as possible, desired outcomes given future climate projections.

Action 5.a. Modify the Climate Adaptation Decision Framework developed by EcoAdapt and others to quantify a population's or watershed's climate vulnerabilities, including habitat suitability, connectivity, and food web shifts, of greatest risk to steelhead. With this information, develop strategies and actions to prioritize limited funding at the MPG or DIP scale.

Action 5.b. Address future impacts of climate change on freshwater habitat and steelhead using qualitative (e.g., Klein et al. 2017 - South Fork Nooksack River is an excellent example) and quantitative (e.g., WDOE's temperature TMDL) assessments. Klein et al.'s (2017) qualitative assessment started by evaluating climate risk from temperature, hydrologic, and sediment regimes and then modeling the impacts of restoration strategies on future conditions.

Action 5.c. Use the Puget Sound Partnership tool: Planning for the Effects of Climate Change on Protection and Restoration Projects, which has been used for Chinook recovery, in designing restoration projects to accommodate future climate scenarios.

Strategy 6. Monitor steelhead abundance, productivity, diversity, and spatial scale to detect specific impacts of climate change.

Action 6.a. Work with partners, such as U.S. Geological Survey (USGS), to improve water temperature and flow monitoring in Puget Sound streams and rivers. Develop water temperature metrics that describe key life-stage specific sensitivities of steelhead to warming water temperatures that are predicted under climate change.

Action 6.b. Monitor age-class composition, growth, densities, and survival of juvenile steelhead in Puget Sound streams. Compare these juvenile abundance, age class structure, growth, and survival metrics in cold and warm streams to identify systems that are most vulnerable to climate change impacts, including those that support summer- as well as winter-run populations.

Action 6.c. Steelhead ocean age should be monitored so that if more steelhead are detected spending only a few months at sea and forgoing their ocean migration, scientists and managers can evaluate whether and how this is related to changing ocean conditions and connectivity to North Pacific waters.

3.6 Integrating Research, Monitoring, and Evaluations (RM&E) and Life-Cycle Modeling

Monitoring and research provide the fundamental information necessary to identify actions likely to improve steelhead population status, to measure the effectiveness of those actions, and to track progress towards recovery. In particular, long-term, annual estimates of adult abundance, adult age structure, and smolt abundance gained through status and trends monitoring can provide the data needed to monitor freshwater productivity and marine survival; the essential information to understand trends in abundance and predict the response to recovery actions. Unfortunately, such information is very limited in Puget Sound relative to other species in this region (e.g., Chinook salmon) or steelhead in other regions (e.g., Interior Columbia River basin). For example, in a recent analysis of steelhead marine survival, data were available from only three native populations in Puget Sound (Kendall et al. 2017); one population from a large river (Nisqually River) and two (Snow Creek and Big Beef Creek) from small creeks that are subsets of two different DIPs identified by Myers et al. (2015). Further, adult and juvenile abundance data for Puget Sound summer-run steelhead are nearly non-existent (WDFW 2018). Given the importance of large rivers to Puget Sound steelhead recovery, these are critical locations for improving our knowledge of the factors affecting population abundance and productivity.

Research and monitoring also provide needed information regarding the factors affecting steelhead viability. The continued destruction of freshwater habitat is a primary cause for declining steelhead trends. Despite recent efforts to quantify habitat quality and landscape-scale human impacts on habitat (Beechie et al. 2017; NWIFC 2016), Puget Sound lacks a comprehensive long-term program to monitor the quality of salmon and steelhead habitat. Such a program is a high research priority. Focused research on topics such as the benefits afforded by habitat restoration, marine survival, hatchery and native-origin fish interactions, and climate change will help identify specific actions that have a high likelihood of benefitting steelhead viability and allow for adaptive management of the species. To that end, the Puget Sound Science Panel, Northwest Fisheries Science Center, Salmon Science Advisory Group, and the Puget Sound Ecosystem Monitoring Program will play vitally important roles. Fundamentally, it is important to enhance the resolution of information on these topics from broad generalizations (e.g., habitat restoration is good for steelhead) to specific actions (identifying restoration methods and locations that maximize the return on restoration investment).

To increase the benefits from RM&E efforts, we have adopted use of a data dictionary developed by NMFS' NWFSC (Barnas et al. 2019; Hamm 2012) that describes impacts on salmonids in consistent terms of ecological concerns and habitat conditions. Table 4 in Section 3.4.10 provides a crosswalk that links the ten main ecological concerns for salmon and steelhead to the pressures and stressors identified in this Plan. Using this consistent language, we can effectively evaluate whether the ecological conditions on which the fish depend are improving, becoming more degraded, or remaining the same. We can also better capture the impacts of pressures and stressors across species, populations, watersheds, and life stages. Further, it eases our ability to effectively share information, compare results from different actions, and identify changes to make actions more effective.

Finally, life-history diversity is a hallmark of steelhead biology, and there is a growing awareness that population and trait diversity are linked to population viability (e.g., Moore et al. 2014).

Improving the quality of information on life-history traits such as run timing, spawn timing, size at age, repeat spawning, and interactions with resident trout will help clarify linkages to population persistence, resilience, abundance and productivity. Knowledge gained through this research will help us focus our actions more effectively to reach recovery.

Strategies and Actions to Integrate Research, Monitoring, and Evaluations

Implementation of the following strategies and actions will help focus and integrate research, monitoring, and evaluation activities to improve our understanding of the factors that affect steelhead viability and the success of our efforts to address them.

Strategy 1. Significantly improve status and trends monitoring for estimation of steelhead freshwater productivity and marine survival (i.e., Fish In/Fish Out).

Action 1.a. Establish and maintain long-term, annual monitoring of steelhead adult and kelt abundance, adult age structure, and smolt abundance and age in at least eight sites within Puget Sound: two in the Strait of Juan de Fuca and Hood Canal MPG, two in the Central and South Sound MPG, and four in the North Cascades MPG. At least one site per MPG should be at the watershed scale of a large Puget Sound river. At least one of the eight sites should monitor a summer-run steelhead population where current monitoring efforts are sparse. Life table/Integral Projection Model analyses is valuable where these traits are feasible to monitor. All monitoring sites should meet or exceed Crawford and Rumsey's (2011) data quality guidelines.

Action 1.b. Explore and expand alternative technologies for increasing accuracy and precision of adult abundance and life-stage-specific survival estimates, including SONAR and PIT tagging.

Strategy 2. Develop and maintain a long-term program to monitor the status and trends of steelhead habitat in Puget Sound.

Action 2.a. Identify and track trends in habitat metrics associated with steelhead abundance, productivity, spatial distribution, and life-history diversity.

Strategy 3. Maintain and advance research programs intended to quantify the population viability benefits afforded by recovery actions.

Action 3.a. Support, maintain, and advance research designed to evaluate the effectiveness and population viability benefits afforded by habitat restoration and protection. Expand the use of Intensively Monitored Watersheds to include steelhead streams in each MPG to assess the effectiveness of recovery actions.

Action 3.b. Support, maintain, and advance research designed to understand and address factors affecting steelhead marine survival.

Action 3.c. Support, maintain, and advance research designed to understand interactions between hatchery and native-origin steelhead, and assess the effectiveness of conservation hatchery programs.

Action 3.d. Predict climate change impacts to steelhead population viability and habitat suitability.

Strategy 4. Identify linkages between steelhead life-history diversity and population viability.

Action 4.a. Implement research and monitoring programs designed to improve our understanding of migration timing, spawn timing, repeat spawning, and interactions with resident *O mykiss*. These efforts will likely be linked to the monitoring activities of Action 1.a.

Action 4.b. Evaluate the degree to which life-history traits diversity enhances population productivity and confers resilience to uncertain environmental conditions.

Action 4.c. Evaluate the effects of Rainbow trout fisheries in streams for their impact to juvenile steelhead and implement management actions where population abundance, productivity, and diversity can be improved for steelhead.

Strategy 5. Implement long-term monitoring protocol to continue to assess steelhead early marine mortality rates and distribution, and compare to freshwater and later ocean mortality.

Action 5.a. Select index streams for each MPG, taking into consideration where monitoring has occurred or continues to occur.

Action 5.b. Fund maintenance of Puget Sound acoustic telemetry array to track migration patterns, survival rates, and locations of mortality.

Action 5.c. Continue to assess later marine mortality for the same steelhead populations to test whether early marine mortality is additive versus compensatory. Perform this monitoring in the context of tracking responses to environmental change, and in the context of the other research considerations for specific factors affecting the early marine mortality of steelhead.

Action 5.d. Support efforts to improve monitoring and understanding of forage fish and other prey of historic importance (e.g., Pacific Hake and rockfish) and predators of concern.

Photo: Steelhead research. Credit: John McMillian.

4. Criteria for Delisting

This chapter describes how NMFS will determine whether recovery has been achieved and the species can be removed from the list of threatened and endangered species. Section 4.1 describes the ESA requirements for making a delisting determination and removing a species from the list. Sections 4.2 and 4.3 discuss the two types of criteria (viability criteria and listing factors criteria) that NMFS will evaluate in making such a determination.

4.1 ESA Requirements

The ESA defines a "threatened species" as "any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." When a "listed" species no longer meets this definition, NMFS can determine (based on relevant criteria) that ESA recovery has been achieved and remove the species from the list of threatened and endangered species — in other words "delist."

The ESA, under section 4(f), requires that recovery plans, "to the maximum extent practicable…incorporate...objective, measurable criteria which, when met, would result in a determination, in accordance with the provisions of [the ESA], that the species be removed from the [Federal List of Endangered and Threatened Wildlife and Plants (50 CFR 17.11 and 17.12)]." NMFS uses these criteria to determine if a species has achieved recovery (i.e., met recovery goals) and can then be removed from the list of threatened and endangered species.

In order to make a listing or delisting determination, NMFS applies two kinds of criteria:

- **Viability Criteria** (see Section 4.2) relate to the biological risk to the species. The viability criteria reflect the likelihood of persistence (probability of avoiding extinction over a specified time frame, typically 100 years) and the prospects for sustainability of the species (maintenance of its defining characteristics). The criteria assess a species' viability in terms of its abundance, productivity, population spatial structure, and diversity (genetic, phenotypic, and demographic) (McElhany et al. 2000).
- **Listing Factors Criteria** (see Section 4.3) are based on the five listing factors found in the ESA, section 4(a)(1) that affect the species. The listing factors criteria address the human activities (pressures or threats) that contributed to the decline in the status of the species and those that continue to impede recovery. The criteria constitute a major part of the ESA listing decision framework for evaluating the status of the threats to the species. The listing factor criteria define the conditions under which the listing factors, or pressures, can be considered addressed or mitigated.

Together, the viability criteria and listing factor criteria make up the "objective, measurable criteria" [hereinafter referred to as *delisting criteria*] required under section 4(f)(1)(B)(ii) for the delisting decision.

Criteria for Delisting

NMFS will remove the Puget Sound steelhead DPS from federal protection under the ESA when it determines that:

(1) The species has achieved a biological status consistent with recovery, meaning the best available information indicates it has sufficient abundance, population growth rate, population spatial structure, and diversity to indicate it has met the biological recovery goals (see Section 4.2.2.1 for specific delisting metrics); and

(2) Factors that led to ESA listing have been reduced or eliminated to the point where federal protection under the ESA is no longer needed, and there is reasonable certainty that the relevant regulatory mechanisms are adequate to protect Puget Sound steelhead viability (see Section 4.3 for specific delisting metrics).

Figure 9 shows how the recovery actions and research, monitoring, and evaluation (on the left side of the figure) inform the analyses and assessments that NMFS considers when making species listing or delisting decisions. The analysis of the five listing factors is shown across the top of the figure. The viability assessments of the populations are shown to be aggregated to the left to the major population group level, which are aggregated at the species level. The role of adaptive management in the process is shown at the bottom of the figure. The scroll on the right side of the figure shows that we will consider both the listing factor analysis and species viability assessment when we make a decision to list or delist a species.

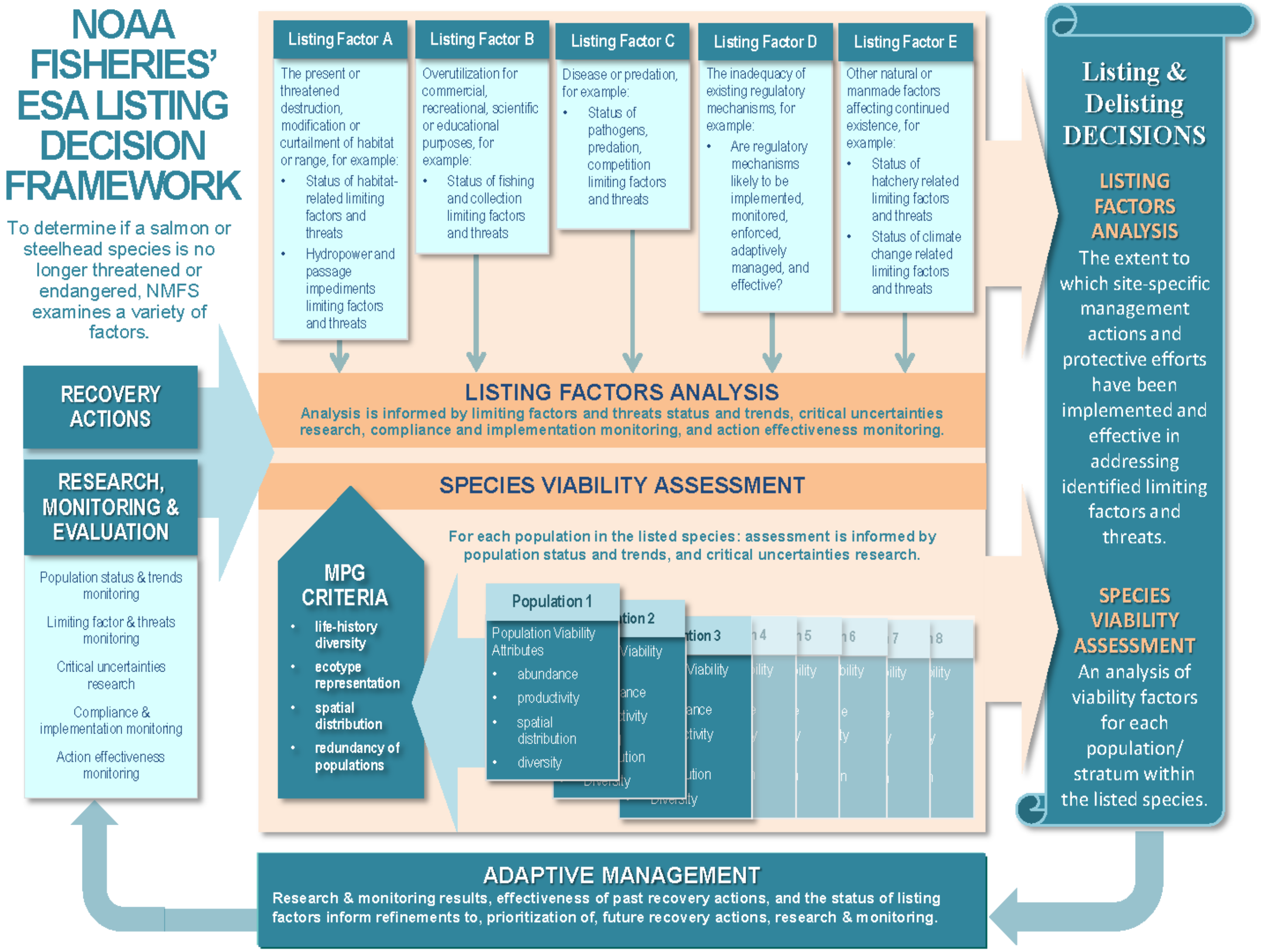

Figure 9. Flow diagram outlining the ESA listing decision framework used by NMFS to assess the status of viability criteria and listing factor criteria.

4.2 Delisting Criteria for Puget Sound Steelhead Viability

The biological goals and delisting criteria in this Plan apply to steelhead, and do not apply to resident Rainbow trout. The technical foundation for these criteria is the PSSTRT's viability criteria (Hard et al. 2015), and work done by the Puget Sound Steelhead Recovery Team and other sources that constitutes the best scientific and commercial information available. These criteria are established at the DPS level, but are based on consideration of criteria at the MPG and DIP scales.

The overarching viability criterion for Puget Sound steelhead is that the DPS "has a negligible risk of extinction due to threats from demographic variation, local environmental variation, and genetic diversity changes over a 100-year time frame" based on the status of the MPGs and DIPs, and supporting ecosystems (McElhany et al. 2000). A self-sustaining viable population has a negligible risk of extinction due to reasonably foreseeable changes in circumstances affecting its abundance, productivity, spatial structure, and diversity characteristics and achieves these characteristics without dependence upon artificial propagation. In future listing decisions, NMFS will consider the specific criteria presented in this section and other available information to determine if this criterion has been met.

As described in detail in Section 3.4.7, under appropriate circumstances, hatcheries can support salmonid recovery. Under the ESA, artificial propagation (hatchery programs) can be used to assist the recovery of Puget Sound steelhead, and a self-sustaining population may include artificially propagated fish. However, hatchery programs can pose risks to long-term recovery and a self-sustaining population must not be dependent upon propagation measures to achieve or maintain its viable characteristics. Artificial propagation may contribute to recovery, but is not a substitute for addressing the underlying factors (threats) causing or contributing to a species' decline.

4.2.1 Viable Salmonid Populations

Viability is a key concept within the context of the Endangered Species Act. NMFS' technical memorandum, *Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units,* (McElhany et al. 2000) provides guidance for assessing viability. Consistent with NMFS' precautionary approach, it describes a Viable Salmonid Population as an independent population of any

CRITERIA TO DEFINE A VIABLE SALMONID POPULATION

NMFS must determine that a species is viable before delisting.

A Viable Salmonid Population is an independent population of any Pacific salmon or steelhead that has a negligible risk of extinction due to threats from demographic variation, local environmental variation, and genetic changes over a 100-year time frame.

NMFS scientists measure salmon recovery in terms of four viable salmonid population (VSP) parameters, which influence the biological viability and long-term resilience of a salmonid population: abundance, productivity, spatial structure, and diversity. These parameters are closely associated, such that improvements in one parameter typically cause, or are related to, improvements in another parameter.

Pacific salmon or steelhead that has a negligible risk of extinction due to threats from demographic variation, local environmental variation, and genetic changes over a 100-year time frame (McElhany et al. 2000). NMFS scientists measure salmon recovery in terms of four parameters, called viable salmonid population (VSP) parameters, which influence the biological viability and long-term resilience of a salmonid population: abundance, productivity, spatial structure, and diversity. These parameters are closely associated, such that improvements in one parameter typically cause, or are related to, improvements in another parameter. For example, improvements in productivity might depend on increased diversity or habitat quality, and be accompanied by increased abundance and spatial structure.

Abundance and Productivity

Abundance and productivity are linked. Populations with low productivity can still persist if they are sufficiently large, and small populations can persist if they are sufficiently productive. A viable population needs sufficient abundance to maintain genetic health and to respond to normal environmental variation, and sufficient productivity to enable the population to quickly rebound from periods of poor ocean conditions or freshwater perturbations.

Abundance is often expressed in terms of natural-origin spawners (adults on the spawning ground), measured over a time series, i.e., some number of years. The PSSTRT defined the measure of current abundance of all life stages of the species.

Productivity is a measure of the population growth rate over the entire life cycle. It is often measured as the average number of surviving offspring (recruits) per parent (spawner), or as the long-term population growth rate (λ). Productivity is an indicator of the population’s ability to sustain itself. Population-specific estimates of abundance and productivity are derived from time series of annual estimates, which are typically subject to a high degree of annual variability and sampling-induced uncertainties.

Spatial Structure and Diversity

A population’s spatial structure is made up of both the geographic distribution of individuals in the population and the processes that generate that distribution (McElhany et al. 2000). Spatial structure refers to the amount of habitat available, the organization and connectivity of habitat patches, and the relatedness and exchange rates of adjacent populations. Diversity refers to the distribution of life-history, behavioral, and physiological traits within and among populations. Some of these traits are completely genetically based, while others, including nearly all morphological, behavioral, and life-history traits, vary as a result of a combination of genetic and environmental factors (McElhany et al. 2000). Spatial structure and diversity considerations are combined in the evaluation of a salmonid population’s status because they are so interrelated.

Spatial structure influences the viability of steelhead because populations with restricted distribution and few spawning areas are at a higher risk of extinction as a result of catastrophic environmental events, such as a landslide, fires, floods, or droughts than are populations with more widespread and complex spatial structures. A population with a complex spatial structure, including multiple spawning areas, experiences more natural exchange of gene flow and life-history characteristics.

Steelhead exhibit considerable diversity within and among populations, and this variation can have important effects on population viability (Boughton et al. 2007). There are three general reasons why biological diversity is important for population (and DPS) viability. First, it allows a population to use a wider array of habitats under changing environmental conditions than they could without it. Second, diversity protects against short-term spatial and temporal changes in the environment. Third, genetic diversity provides the raw material for adapting to long-term environmental change.

The precise role that diversity plays in salmonid population viability and the relationship of spatial processes to viability is incompletely known (Myers et al. 2015; Hard et al. 2015). Accordingly, the PSSTRT adopted the principle from McElhany et al. (2000) that historical spatial structure and diversity should be preserved on the assumption that historical, natural populations did survive many environmental changes and therefore must have had adequate spatial structure and diversity.

Figure 10 identifies the PSSTRT viability criteria developed in Hard et al. (2015), and shows how these characteristics can be applied hierarchically to viability criteria from the DIP level, to the MPG level, to the Puget Sound steelhead DPS. At the DIP level, the criteria are partitioned between persistence and sustainability factors related to VSP components. For example, for both winter- and summer-run life histories, the criteria consider spawner abundance, productivity, occupancy, and fish density in suitable habitat by adults and juveniles; frequency of repeat spawning; and sources of human-induced mortality as factors that primarily influence demography and, therefore, DIP persistence. The criteria also examine effective population size, influence of hatchery fish (both genetic and ecological impacts), age variation in spawners, and variation in spawn timing as factors that primarily influence diversity and, therefore, population sustainability.

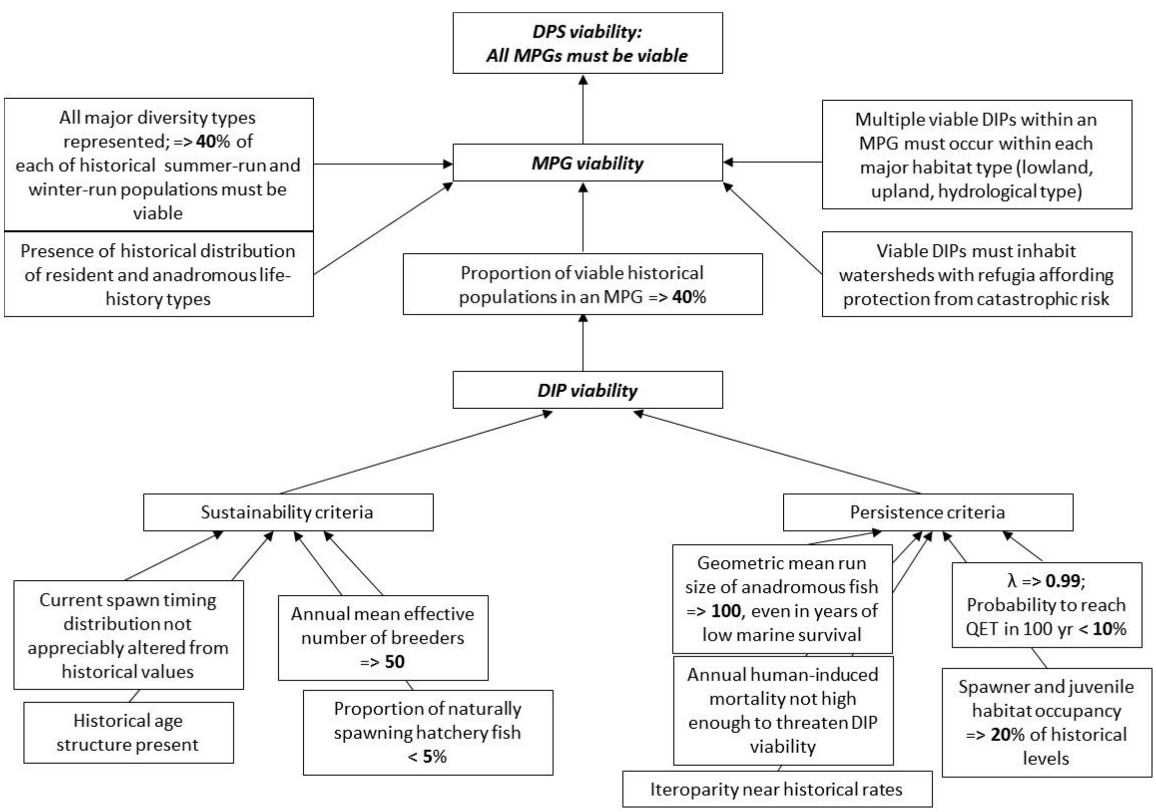

Figure 10. The Puget Sound Steelhead Technical Recovery Team's recommended viability criteria for the steelhead DPS. The chart shows how DIPs are aggregated to MPGs, and then to the larger DPS. See also Hard et al. 2015, Figure 56.

4.2.2 DPS Viability Criteria

NMFS staff and the Puget Sound Steelhead Recovery Team (including the PSSTRT chair and members) modified the PSSTRT viability criteria to produce the viability criteria for Puget Sound steelhead, as described below.

4.2.2.1 DPS-Level Viability Criteria

- All three MPGs must be viable.

  This criterion is based on a PSSTRT Viability Criterion (see Hard et al. 2015). The three MPGs differ substantially in key biological and habitat characteristics that contribute in distinct ways to the overall viability, diversity, and spatial structure of the DPS.

- There must be sufficient data available for NMFS to determine that each MPG is viable.

4.2.2.2 MPG-Level Viability Criteria

This sub-section presents (1) specific criteria required for MPG viability, (2) specific DIPs needed for viability in each of the three MPGs, and (3) additional attributes that contribute to steelhead viability at the MPG level.

1. **Specific criteria are required for MPG viability.**
   - At least 50 percent of steelhead populations in the MPG achieve viability.
   - Natural production of steelhead from tributaries to Puget Sound that are not identified in any of the 32 identified populations provides sufficient ecological diversity and productivity to support DPS-wide recovery.
   - In addition to the minimum number of viable DIPs (50%) required above, all DIPs in the MPG must achieve an average MPG-level viability that is equivalent to or greater than the geometric mean (averaged over all the DIPs in the MPG) viability score of at least 2.2 using the 1–3 scale for individual DIPs described under the DIP viability discussion in the PSSTRT Viability Criteria document (Hard et al. 2015). This criterion is intended to ensure that MPG viability is not measured (and achieved) solely by the strongest DIPs, but also by other populations that are sufficiently healthy to achieve MPG-wide resilience. An alternative evaluation method to that in Hard et al. (2015) may be developed and used to assess MPG viability.
2. **Specific DIPs in each of the three MPGs must be viable.**
3. **Additional Attributes — characteristics associated with a viable MPG.**
   - All major diversity and spatial structure conditions are represented, based on the following considerations:
     - Populations are distributed geographically throughout each MPG to reduce risk of catastrophic extirpation; and
     - Diverse habitat types are present within each MPG (one example is lower elevation/gradient watersheds characterized by a rain-dominated hydrograph and higher elevation/gradient watersheds characterized by a snow-influenced hydrograph).

The following MPG-level recovery scenarios would meet these criteria and support DPS viability.

Central and South Puget Sound MPG

Four of the eight DIPs in the Central and South Puget Sound MPG must be viable. The four DIPs described below must be viable to meet this criterion:

- Green River Winter-Run;
- Nisqually River Winter-Run;
- Puyallup/Carbon rivers Winter-Run, or the White River Winter-Run; and
- At least one additional DIP from this MPG: Cedar River, North Lake Washington/Sammamish Tributaries, South Puget Sound Tributaries, or East Kitsap Peninsula Tributaries.

Rationale: Steelhead inhabiting the Green, Puyallup and Nisqually River watersheds currently represent the core extant steelhead populations and these watersheds contain important diversity of stream habitats in the MPG.

Figure 11 shows the Central and South Puget Sound MPG and the DIPs that must be viable to support DPS delisting.

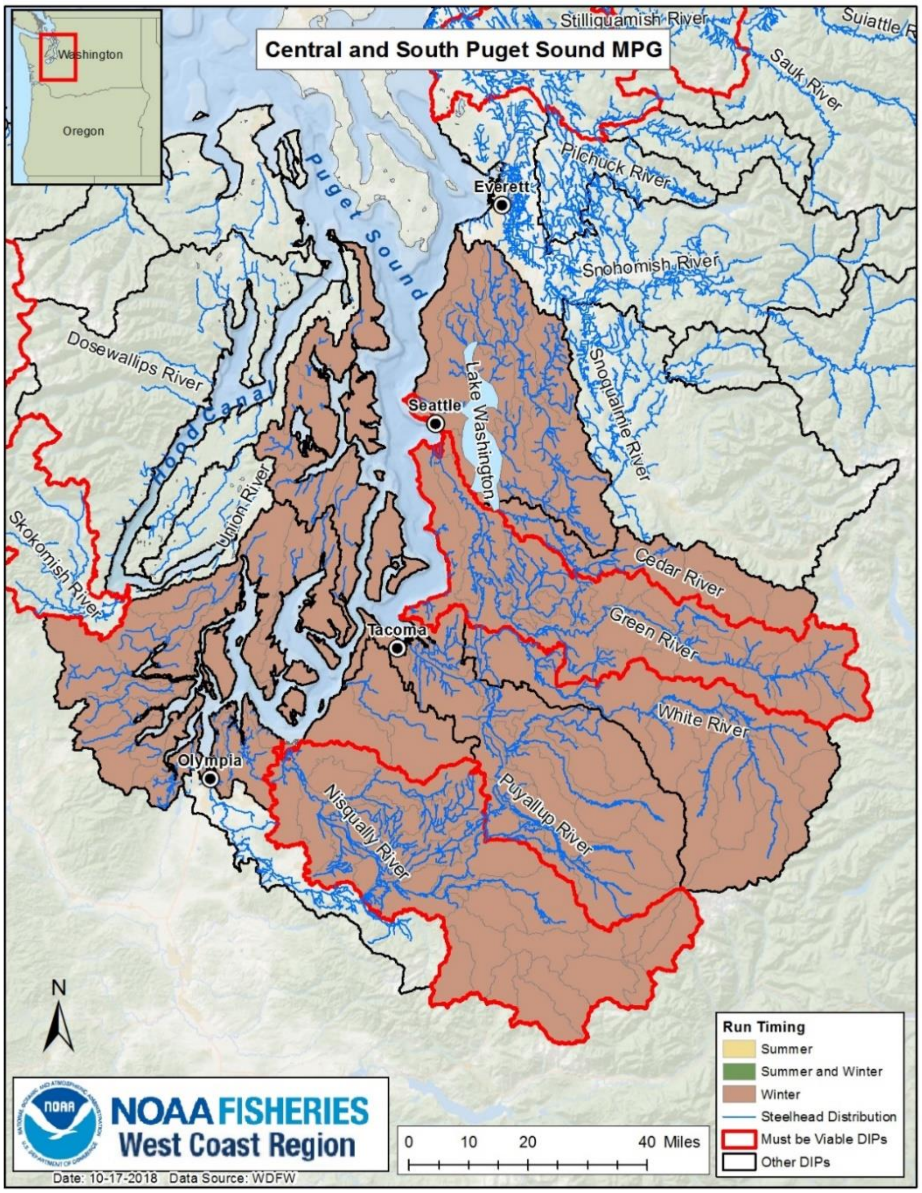

Figure 11. Central and South Puget Sound MPG and DIPs that must be viable to support DPS delisting.

Hood Canal and Strait of Juan de Fuca MPG

Four of the eight DIPs in the Hood Canal and Strait of Juan de Fuca MPG must be viable. The four DIPs described below must be viable to meet this criterion:

- Elwha River Winter/Summer-Run (see rationale below);
- Skokomish River Winter-Run;
- One from the remaining Hood Canal populations: West Hood Canal Tributaries Winter-Run, East Hood Canal Tributaries Winter-Run, or South Hood Canal Tributaries Winter-Run; and
- One from the remaining Strait of Juan de Fuca populations: Dungeness Winter-Run, Strait of Juan de Fuca Tributaries Winter-Run, or Sequim/Discovery Bay Tributaries Winter-Run.

Rationale: The Elwha and Skokomish rivers are the two largest single watersheds in the MPG and bracket the geographic extent of the MPG. Furthermore, both Elwha and Skokomish populations have recently exhibited summer-run life histories, although the Dungeness River population was the only summer/winter run in this MPG recognized by the PSTRT in Hard et al. (2015). Two additional populations — one population from the Strait of Juan de Fuca area and one population from the Hood Canal area — are needed for a viable MPG to maximize geographic spread and habitat diversity.

Figure 12 shows the Hood Canal and Strait of Juan de Fuca MPG and the DIPs that must be viable to support DPS delisting.

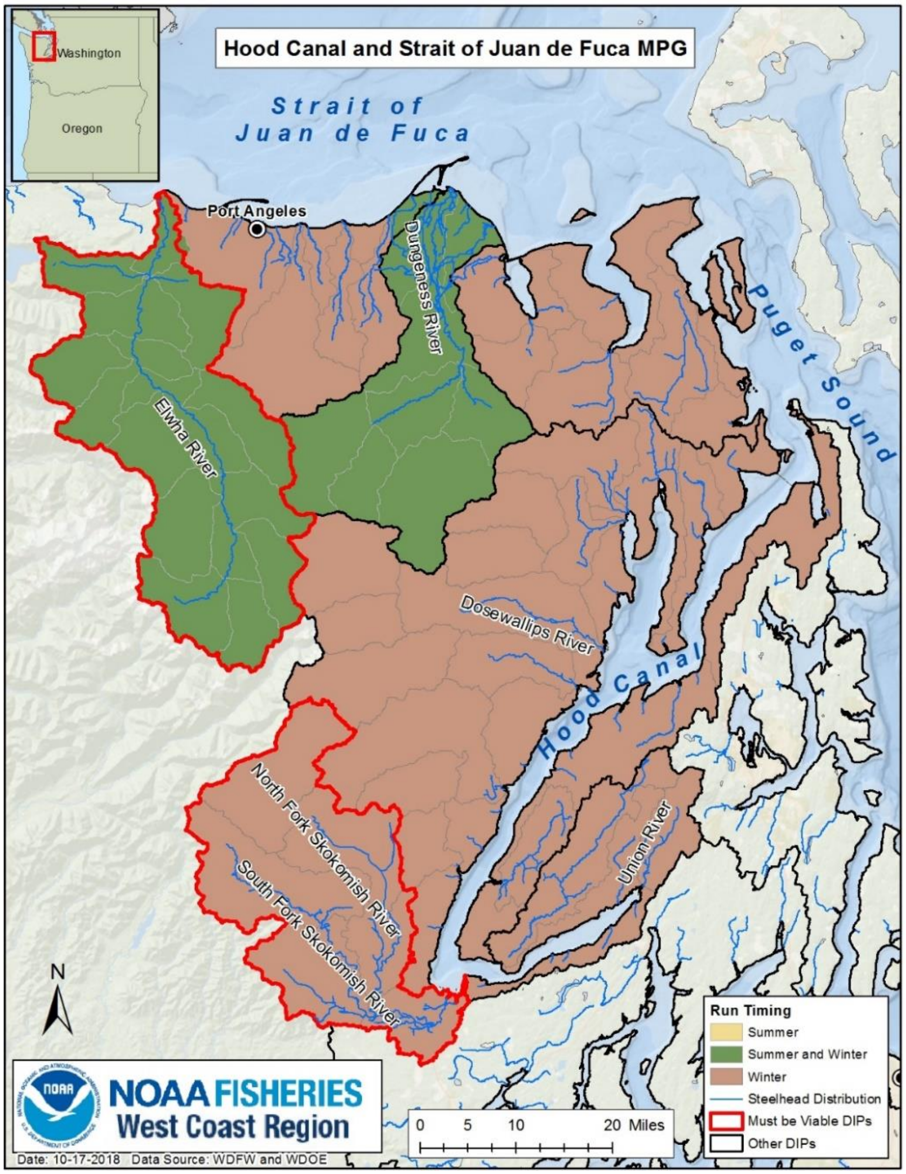

Figure 12. Hood Canal and Strait of Juan de Fuca MPG and DIPs that must be viable to support DPS delisting.

North Cascades MPG

Eight of the sixteen DIPs in the North Cascades MPG must be viable. The eight (five winter-run and three summer-run) DIPs described below must be viable to meet this criterion:

- Of the eleven DIPs with winter or winter/summer runs, five must be viable:
  - Nooksack River Winter-Run;
  - Stillaguamish River Winter-Run;
  - One from the Skagit River (either the Skagit River Summer-Run and Winter-Run or the Sauk River Summer-Run and Winter-Run);
  - One from the Snohomish River watershed (Pilchuck, Snoqualmie, or Snohomish/Skykomish River Winter-Run); and
  - One other winter or summer/winter run from the MPG at large.

Rationale: There are four major watersheds in this MPG; one viable population from each helps attain geographic spread and habitat diversity within core extant steelhead habitat.

- Of the five summer-run DIPs in this MPG, three must be viable representing in each of the three major watersheds containing summer-run populations (Nooksack, Stillaguamish, Snohomish rivers).
  - South Fork Nooksack River Summer-Run;
  - One DIP from the Stillaguamish River (Deer Creek Summer-Run or Canyon Creek Summer-Run); and
  - One DIP from the Snohomish River (Tolt River Summer-Run or North Fork Skykomish River Summer-Run).

Rationale: Ensuring that the viable summer-run populations do not all come from the same watershed reduces catastrophic risk and increases habitat/life-history diversity.

Figure 13 shows the North Cascades MPG and the DIPs that must be viable to support DPS delisting.

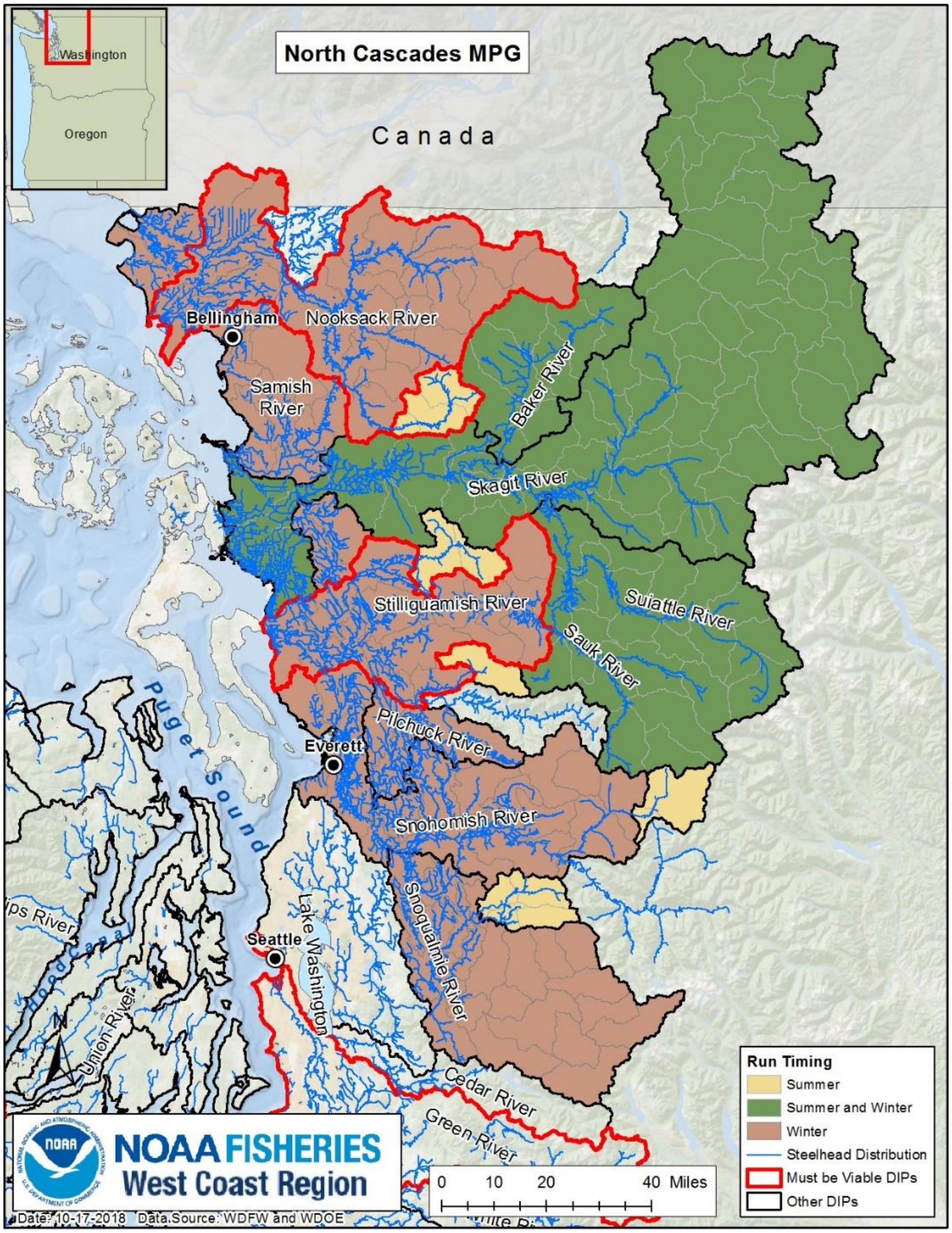

Figure 13. North Cascades MPG and DIPs that must be viable to support DPS delisting.

4.2.2.3 DIP-Level Viability Criteria

The goal of ESA section 4(f) recovery plans is to achieve the conservation and survival of the listed species. To facilitate progress toward that goal, population-level goals may be included in a recovery plan. However, NMFS recognizes the challenges associated with describing exact thresholds for each DIP (i.e., single population goals), given the fact that recovery goals could be achieved by multiple scenarios, and abundance and productivity thresholds are interrelated. Therefore, we employ planning targets which include measurable criteria for abundance and productivity. In other words, by describing ranges of targets for objective and measurable criteria, we are allowing for recovery scenarios that include trade-offs between criteria. For example, abundance thresholds for recovery can be lower when productivity is consistently higher, and abundance thresholds can be relatively high when productivity is consistently low. This sub-section presents criteria (requirements) for DIP viability.

Approach to Abundance and Productivity Planning Targets and Ranges

Following the policy precedent established with Puget Sound Chinook salmon (NMFS 2006), we have established a range of abundance and productivity planning targets for Puget Sound steelhead populations. These planning targets are a range of paired abundance and productivity (recruits per spawner) values in which the upper end of the abundance range, paired with a low (replacement) productivity, is anchored to an estimate of 70 percent of historical abundance. Conversely, lower abundances consistent with recovery are paired with higher productivity values. The recovery target of 70 percent of historical abundance is based on an evaluation of stock-recruit productivity and capacity under properly functioning conditions, expressed as a proportion of historical conditions, derived from Ecosystem Diagnosis Treatment modeling in the Puget Sound Chinook salmon recovery plan (NMFS 2006 and NMFS 2007). For Puget Sound steelhead, the estimated ratio of properly functioning to historical conditions typically ranges from 60–75 percent. The ratio of properly functioning to historical conditions for Puget Sound Chinook salmon, when applied to the estimates of historical steelhead abundance, provides abundance goals for recovery that combine available steelhead information with an established policy precedent (see Anderson et al. 2017 in Appendix 2 for details).

Historical Abundance Estimates

We used historical commercial fisheries catch data circa 1895 (Wilcox 1898), previously analyzed by Hard et al. (2007), to estimate historic abundance of each of the 32 demographically independent populations of Puget Sound steelhead (Myers et al. 2015). Hard et al. (2007) estimated a total annual abundance of adult steelhead of 327,592 – 545,987, assuming a 30 – 50 percent harvest rate and approximately 12 lbs. per fish. We used the midpoint of this range (N = 436,970 adult steelhead), and allocated total abundance to the 32 constituent populations based on proportional estimates of historical habitat availability in linear stream kilometers. The historical habitat estimates, shown in Table 6, were initially generated from an intrinsic potential model of steelhead habitat (see Hard et al. 2015), and subsequently modified based on feedback from steelhead biologists in a series of meetings with recovery team members throughout Puget Sound. Appendix 2 includes additional information about aggregating DIPs and local recovery efforts.

Although Gayeski et al. (2011) also estimated historical abundance of Puget Sound steelhead based on this same 1895 catch data, we used the Hard et al. (2007) estimates for three reasons. First, Hard et al. (2007) employed a relatively simple analysis using arithmetic, which in our appraisal, matched the resolution and precision of the historical fishery data. Second, Gayeski et al. (2011)

likely underestimated populations outside the Nooksack, Stillaguamish, Skagit, and Snohomish rivers, particularly in central and southern Puget Sound. Finally, when presented with our initial recovery goals, recovery team members supported using the estimates from Hard et al. (2007), which were more conservative than the estimates from Gayeski et al. (2011).

We suspect that our methods overestimated the historical steelhead abundance of populations composed of many small independent streams relative to those in larger rivers. Our estimates of historical habitat availability weighted all streams equally, irrespective of habitat attributes such as stream size or gradient. Populations that are composed of many independent streams covering a large geographic area yielded big estimates of total linear stream kilometer, but these streams may not have been sufficiently large in size to support highly abundant steelhead populations. Notable examples include the North Lake Washington, East Kitsap Peninsula, South Puget Sound, Strait of Juan de Fuca, Discovery Bay, East Hood Canal, West Hood Canal, and South Hood Canal DIPs.

Recovery Goals as Productivity Curves

In order to establish the abundance and productivity curves, the 70 percent historical abundance estimates were set as the equilibrium point (S_0) on the stock-recruit curve where the population is neither increasing nor decreasing. Figure 14 shows this stock-recruit curve. We used the following form of the Beverton-Holt (1957) equation:

$$R = \frac{aS}{1+\frac{a}{b}S} \qquad \text{Equation 1}$$

Where S is the number of adult spawners, R is the number of adult recruits, a is the intrinsic productivity, and b is capacity. To estimate a, we used Buehrens' (2017) hierarchical analysis of spawner-to-smolt data from 15 populations of steelhead in western Washington, estimating an a value of 110. Assuming a 5 percent smolt-to-adult return rate, which is likely higher than current values (Kendall et al. 2017) but plausibly attainable given investment in recovery actions, we used an adult to adult a value of 5.5 (110 * 0.05 = 5.5). At the equilibrium point, S = R, one can solve for b given S_0 and a.

The high abundance / low productivity end of the recovery planning target range was set at S_0, the point where the stock-recruit curve crosses the replacement line, as illustrated in Figure 14. The low abundance / high productivity end of the recovery target range was set at the point of maximum productivity, also known as the point of maximum sustainable yield (S_{MSY}). S_{MSY} was calculated based on the approach of Hilborn and Walters (1992), where

$$b = \frac{aS_0}{a-1} \qquad \text{Equation 2}$$

We rounded the recovery goal abundance targets to the nearest 100 fish.

$$S_{MSY} = b\sqrt{\frac{1}{a}} - \frac{b}{a} \qquad \text{Equation 3}$$

For example, given a 70 percent historic abundance estimate for the Stillaguamish River winter-run population of 23,400 (Table 7), this yields a Beverton-Holt *b* value of 28,600 adult steelhead. The low productivity (R/S = 1.0) / high abundance recovery goal is 23,400 adult steelhead, and the high productivity (R/S = 2.35) / low abundance recovery goal is 7,000. In Figure 14, these productivity estimates are shown below the curve. Similar calculations were made for each DIP in the Puget Sound steelhead DPS and are identified in Tables 7 and 8.

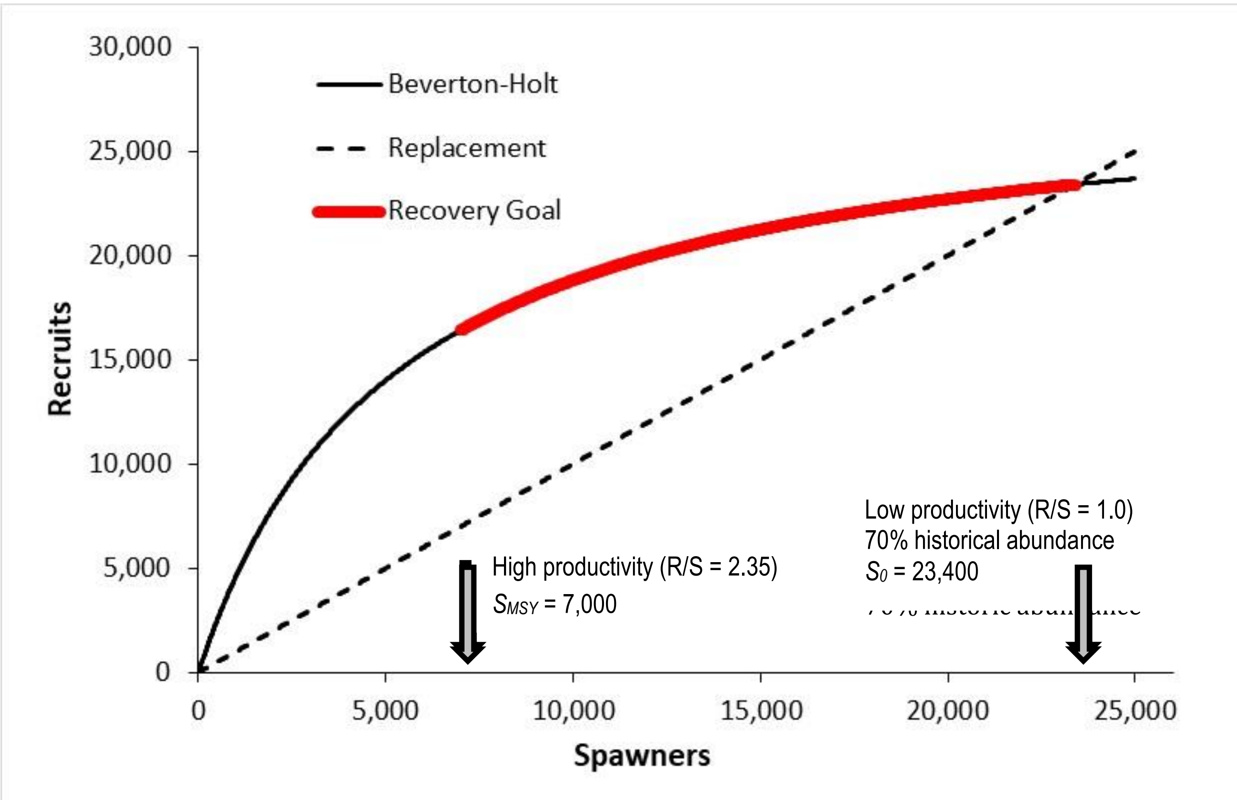

Figure 14. Recovery goal curve incorporating information on both abundance and productivity for the Stillaguamish River winter-run steelhead population. Productivity estimates reflect recruits/spawner (R/S).

Table 6. Historical abundance estimates for Puget Sound steelhead DIPs in each major population group (MPG), based on estimates in Hard et al. (2007, 2015).

MPG	Demographically Independent Population	Habitat (km)	Habitat Proportion	Historical Abundance	70% Historical Abundance
North Cascades MPG	Drayton Harbor Tributaries	79	1.2%	5,231	3,661
	Nooksack River	468	7.1%	30,986	21,690
	South Fork Nooksack River (summer-run)	29	0.4%	1,920	1,344
	Samish River + independent tributaries	131	2.0%	8,674	6,071
	Skagit River	477	7.2%	31,582	22,108
	Sauk River	213	3.2%	14,103	9,872
	Nookachamps Creek	91	1.4%	6,025	4,218
	Baker River	83	1.3%	5,495	3,847
	Stillaguamish River	504	7.6%	33,370	23,359
	Canyon Creek (summer-run)	8	0.1%	530	371
	Deer Creek (summer-run)	50	0.8%	3,311	2,317
	Snohomish/Skykomish River	444	6.7%	29,380	20,566
	Pilchuck River	178	2.7%	11,785	8,250
	Snoqualmie River	247	3.7%	16,354	11,448
	Tolt River (summer-run)	25	0.4%	1,655	1,159
	North Fork Skykomish River (summer-run)	11	0.2%	728	510
Central/South Puget Sound MPG	Cedar River	86	1.3%	5,694	3,986
	North Lake WA Tributaries	346	5.2%	22,909	16,036
	Green River	403	6.1%	26,683	18,678
	Puyallup/Carbon River	326	4.9%	21,585	15,109
	White River	259	3.9%	17,148	12,004
	Nisqually River	443	6.7%	29,331	20,532
	East Kitsap	188	2.8%	12,448	8,713
	South Sound Tributaries	458	6.9%	30,324	21,227

MPG	Demographically Independent Population	Habitat (km)	Habitat Proportion	Historical Abundance	70% Historical Abundance
Strait of Juan de Fuca/ Hood Canal MPG	Elwha River	122	1.8%	8,078	5,654
	Dungeness River	89	1.3%	5,893	4,125
	Strait of Juan de Fuca Independent Tributaries	108	1.6%	4,683	3,278
	Discovery Bay Tributaries	110	1.7%	2,395	1,677
	Skokomish River	157	2.4%	10,395	7,276
	West Hood Canal	181	2.7%	11,984	8,389
	East Hood Canal	133	2.0%	8,806	6,164
	South Hood Canal	153	2.3%	10,130	7,091
	Total	6,600	100.0%	436,970	305,879

Table 7. Current abundance and recovery goals for Puget Sound steelhead in the North Cascades Major Population Group (MPG) based on recruits/spawner (R/S) in years of high productivity and low productivity. Current abundance is the five-year average terminal run size (escapement + harvest) for return years 2012 – 2016, unless otherwise noted or not available (n/a). We suspect that our methods overestimated the historical steelhead abundance of populations composed of many small independent streams relative to those in larger rivers.

North Cascades MPG Populations		Recovery Goals	
		Abundance under Beverton-Holt	
Population	Current Abundance	High productivity (R/S = 2.3)	Low productivity (R/S = 1.0)
Drayton Harbor Tributaries	35[A]	1,100	3,700
Nooksack River	1,850	6,500	21,700
South Fork Nooksack River (summer-run)	n/a	400	1,300
Samish River + independent tributaries	1,090	1,800	6,100
Skagit River	8,278[B]	15,000[D]	
Sauk River			
Nookachamps Creek			
Baker River	n/a	1,100	3,800
Stillaguamish River	493[C]	7,000	23,400
Canyon Creek (summer-run)	n/a	100	400
Deer Creek (summer-run)	n/a	700	2,300
Snohomish/Skykomish River	1,066	6,100	20,600
Pilchuck River	878	2,500	8,200
Snoqualmie River	836	3,400	11,400
Tolt River (summer-run)	89	300	1,200
North Fork Skykomish River (summer-run)	n/a	200	500

[A] Restricted to Dakota Creek, return years 2014 – 2016.

[B] Combined abundance estimate for Skagit River, Sauk River, and Nookachamps Creek populations.

[C] Index of escapement for North Fork Stillaguamish River and tributaries upstream of Deer Creek, does not include entire watershed or population.

[D] Interim target for the Skagit River of an average total run abundance of 15,000 and with an intrinsic productivity at least equal to what was observed from 1978 through 2017.

Table 8. Current abundance and recovery goals for Puget Sound steelhead in the Central and South Sound and Hood Canal and Strait of Juan de Fuca Major Population Groups (MPGs) based on recruits/spawner (R/S) in years of high productivity and low productivity. Current abundance is the five-year average terminal run size (escapement + harvest) for return years 2012 – 2016, unless otherwise noted or not available (n/a). We suspect that our methods overestimated the historical steelhead abundance of populations composed of many small independent streams relative to those in larger rivers.

Population	Current Abundance	Recovery Goals	
		Abundance under Beverton-Holt	
		High productivity (R/S = 2.3)	Low productivity (R/S = 1.0)
Central and South Sound MPG Populations			
Cedar River	5	1,200	4,000
North Lake WA Tributaries	n/a	4,800	16,000
Green River	1,166	5,600	18,700
Puyallup/Carbon	740	4,500	15,100
White River	635	3,600	12,000
Nisqually River	951	6,100	20,500
East Kitsap tributaries	n/a	2,600	8,700
South Sound Tributaries	n/a	6,300	21,200
Strait of Juan de Fuca MPG Populations			
Elwha River	1168[A]	2,619[B]	
Dungeness River	626[C]	1,200	4,100
Strait Juan de Fuca Independent Tributaries	216[D]	1,000	3,300
Sequim and Discovery Bay Tributaries	27	500	1,700
Skokomish River	921	2,200	7,300
West Hood Canal tributaries	109	2,500	8,400
East Hood Canal tributaries	89	1,800	6,200
South Hood Canal tributaries	61	2,100	7,100

[A] Restricted to return years 2014 – 2017 and includes both natural-origin and hatchery-origin fish.
[B] Peters et al. (2014) identified 2,619 adult steelhead as the goal to reach the Viable Population Phase, the last four sequential recovery phases following removal of two dams on the Elwha River. In contrast to other recovery goals presented here, the Elwha River goal is not in the context of a stock-recruit productivity curve.
[C] Restricted to return years 2013 – 2015 and 2017.
[D] Estimate restricted to return years 2015 and 2016 within Morse Creek plus McDonald Creek, two of several streams in this population.

Relationship to Other Puget Sound Steelhead Recovery Goals

The goal of ESA section 4(f) recovery plans is to achieve the conservation and survival of the listed species. To facilitate progress toward that goal, population-level goals may be included in a recovery plan. The recovery planning targets presented in Tables 5 and 6 apply a standard, uniform approach to all steelhead populations in Puget Sound. They are intended to aid recovery planning at its outset by providing an initial statement on the degree of population status improvement desired for Puget Sound steelhead. They are not intended to replace or obviate the need for local watershed efforts to establish recovery goals. Indeed, local groups in the Nisqually, Elwha, Skagit, Stillaguamish, Dungeness, Strait of Juan de Fuca Tributaries, Discovery Bay, and East Kitsap watersheds have undertaken efforts to develop recovery goals specific to individual populations.

Watershed level recovery goals will likely use a variety of approaches and information, and these efforts are in varying stages of completion. For example, the Nisqually River Steelhead Recovery Plan (2014) stated a recovery goal of an annual treaty harvest of 2,500 adult steelhead, a value consistent with the productivity curve. While ensuring some consistency in the long-term goals across Puget Sound despite different methodologies, we anticipate locally based recovery goals may replace estimates from the curves presented here when they become available and after they have been reviewed by NMFS. Appendix 2 includes additional information about aggregating DIPS and local recovery efforts.

Importance of Marine Survival

In order to demonstrate the importance of marine survival to achieving recovery goal curves (see Appendix 3), we assumed density independent marine survival *m*, and used the Beverton-Holt stock-recruit curve to describe freshwater productivity (i.e., smolts per spawner). We replaced R with S_0/m in the Beverton-Holt equation:

$$\frac{S_0}{m} = \frac{aS_0}{1+\frac{a}{b}S_0} \qquad \text{Equation 4}$$

And rearranged Equation 4 to calculated smolt capacity *b* as

$$b = \frac{S_0 a}{am-1} \qquad \text{Equation 5}$$

In this exercise, we chose *a* values to represent the median (*a* = 110) and 80 percent credible interval (*a* = 56 – 245) described by Buehrens (2017).

Furthermore, one can rearrange equation 5 to solve for *m*.

$$m = \frac{1+S_0\frac{a}{b}}{a} \qquad \text{Equation 6}$$

Thus, for a given S_0 and intrinsic productivity (*a*), one can calculate the relationship between marine survival (*m*) and smolt capacity (*b*). This allows us to express a recovery goal curve as a function of both *m* and *b.* Figure 15 shows the recovery goal curves for Puget Sound steelhead.

This exercise demonstrates that marine survival values > 5 percent are generally required to achieve recovery goal curves for populations with $S_0 \geq 5{,}000$ adult steelhead. The curves in Figure 15 demonstrate strong inflection points; as marine survival decreases, the incremental increase in smolt capacity required to offset a 1 percent decrease in marine survival gets larger and larger. For example, a smolt capacity > 300,000 is needed to achieve $S_0 = 5{,}000$ if marine survival is < 5 percent (Figure 15). Interestingly, the curves in Figure 15 appear more sensitive to marine survival than *a* (alpha). This important outcome is reinforced repeatedly in the life cycle model analyses: early marine survival poses a demographic bottleneck for Puget Sound steelhead. Actions to address the early marine survival limiting factor are listed in Section 3.4.9.

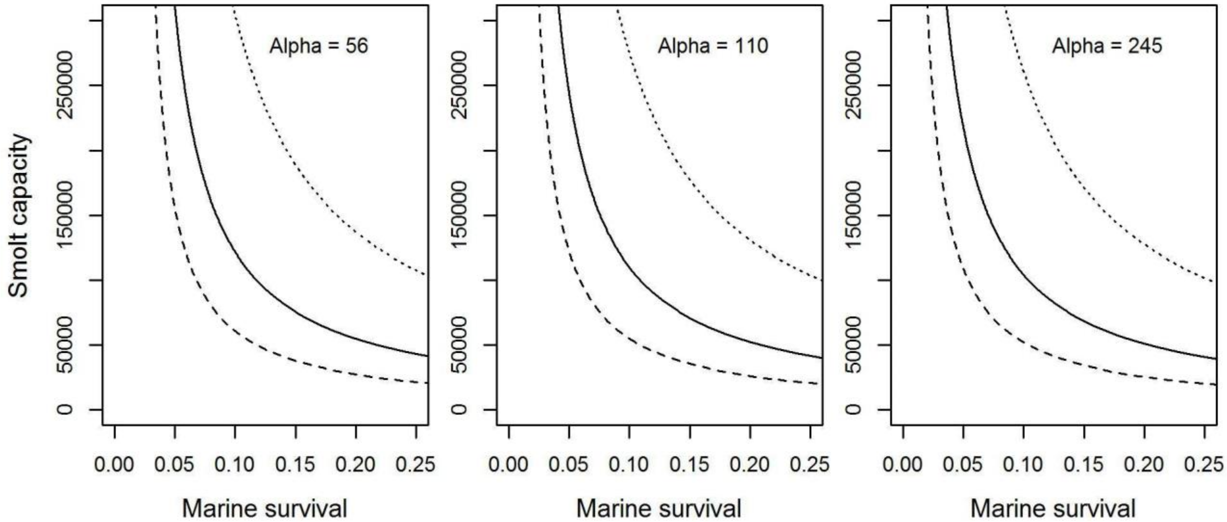

Figure 15. Recovery goal curves for Puget Sound steelhead reflecting different combinations of smolt capacity and marine survival across a range of alpha values. In each plot, dashed line (S_0=5,000), solid line (S_0=10,000), and dotted line (S_0=25,000).

Photo: NMFS research scientist, Megan Moore tagging steelhead for marine survival studies. Credit: NMFS.

4.3 Delisting Criteria for the Five Listing Factors

4.3.1 Introduction to Listing Factor Criteria

As part of a future delisting determination, NMFS will evaluate, based on the best available scientific and commercial information, implementation of the proposed actions described in the Plan and the extent to which each of the section 4(a)(1) listing factors has been addressed. To assist in this examination, NMFS will use criteria described below, in addition to the evaluation of biological criteria and other relevant data, to determine whether the underlying causes of steelhead decline have been addressed and mitigated and are not likely to re-emerge in the foreseeable future. There are multiple combinations of strategies and actions that could meet the biological criteria and listing factors, and protective efforts, and there is no single, pre-established, approach to progress from threatened to recovered status for Puget Sound steelhead. Section 4.4 describes NMFS' approach in using these factors to make delisting decisions for Puget Sound steelhead.

NMFS recognizes that our understanding of pressures, and their significance, can change over time due to changes in the natural environment or changes in the way human activities affect the entire life cycle of steelhead. In our recent 5-year review (NMFS 2016), NMFS determined that freshwater habitat is a dominant pressure on Puget Sound steelhead. We also recognized that newly identified threats, such as those posed by reduced early marine survival and climate change are limiting productivity of steelhead. Considering potential climate change scenarios and expected continued urban development, NMFS is concerned that the cumulative effect of all threats will have a continuing detrimental impact on the status of the Puget Sound steelhead DPS and the habitat upon which steelhead depend.

The criteria below describe the improvements in condition that, if realized, would provide evidence that the listing factors have been addressed.

4.3.2 Listing Factor A: The Present or Threatened Destruction, Modification, or Curtailment of a Species' Habitat or Range

Goal for Listing Factor A

The physical or biological features that are essential for the conservation of the species are protected or have been restored to support recovery. This is in addition to the regulatory mechanisms related to habitat described in Listing Factor D below.

Acknowledgment of Past and Ongoing Efforts

While this Plan describes substantial loss of steelhead habitat as a major challenge to recovery, NMFS acknowledges that there has been, and continues to be, an enormous amount of work done to protect and restore salmon and steelhead habitat in Puget Sound. To be sure, despite heroic efforts to restore steelhead habitat, recent and ongoing efforts have not resulted in meaningful improvement of VSP parameters. DPS-wide protection and strategic restoration efforts must increase to recover Puget Sound steelhead because habitat remains the primary factor influencing their recovery. NMFS intends to continue to support and collaborate with many partners in Puget Sound to protect and restore habitat for steelhead and salmon.

4.3.2.1 Introduction to Habitat Criteria

Puget Sound steelhead have suffered from widespread loss and degradation of freshwater habitat and degradation of nearshore marine habitat (NMFS 2016). The reduced quantity and quality of freshwater habitat that limits the viability of steelhead in Puget Sound streams is the primary factor that led to the listing of Puget Sound steelhead. Unless habitat is more effectively protected and restored, Puget Sound steelhead are very unlikely to recover.

NMFS will need to determine that steelhead habitat condition is, and will likely continue to be, adequate to support a viable DPS before it can remove Puget Sound steelhead from the list of threatened species. Healthy freshwater and nearshore marine habitat conditions will be particularly important given the recent evidence of very low marine survival in the Salish Sea, which has led to recent periods of unprecedented low overall survival and productivity.

NMFS suggests that an overarching strategy that emphasizes certain, effective voluntary approaches to habitat protection and a strong regulatory framework to increase protection of Puget Sound steelhead habitat will be required to achieve recovery. Restoration activities must be sustained, and in some cases, dramatically increased for Puget Sound steelhead to achieve recovery. To be effective, protection and restoration activities must be consistent with the best available scientific information relating to high quality steelhead habitat and nearshore marine conditions. For purposes of ESA delisting (in particular, compatibility with Listing Factor D), NMFS will assess the adequacy of the combination of voluntary measures and "regulatory backstops" that are in place so that the desired outcomes will be achieved, as described below.

4.3.2.2 Delisting Criteria for Steelhead Habitat Condition

The criteria below describe the improvements in condition that, if realized, would provide evidence that Listing Factor A has been addressed and no longer precludes recovery.

1. Passage obstructions are removed or modified to improve distribution (spatial structure and diversity) and survival (abundance and productivity) and restore access to historically accessible habitat where necessary to support recovery goals. This includes steelhead passage conditions through hydropower and flood control systems (including dams and reservoirs) which should consistently meet or exceed NMFS performance standards[10], and (a) accurately account for total mortality (i.e., juvenile passage and adult passage mortalities) and (b) are implemented in such a way as to avoid deleterious effects on populations or negative effects on the abundance or distribution of populations. Consistent, accurate monitoring of the numbers of fish moving through, or whose migration is hindered by, passage obstructions is critical to assessing these criteria.

2. Flow conditions that support adequate rearing, spawning, and migration are achieved through management of mainstem and tributary municipal withdrawals, irrigation, and hydropower operations. All diversions should be screened and maintained in accordance to NMFS performance standards to avoid entrainment of juvenile steelhead. Increased

[10] https://www.fisheries.noaa.gov/insight/barriers-fish-migration

efficiency and conservation in consumptive water uses should be improved to secure and maintain adequate quantities of water in streams.

3. Water quality (including temperature, dissolved oxygen, total dissolved gas, and turbidity and chemical parameters) has been improved to meet or exceed Clean Water Act standards. In the nearshore marine environment, measurable improvements to water quality from contaminants in Puget Sound should be documented.
4. Nearshore habitat in Puget Sound has been improved (protected and restored) to provide adequate spawning habitat for important forage fish and for refuge from predators during their early marine migration through Puget Sound to the ocean. Consistent with the Puget Sound Partnership target on shoreline armoring, increase the rate of armoring removal so that it exceeds new armoring. Where replacement armoring is necessary, increase “soft” approaches to maintain shoreline ecosystem processes.
5. Consistent with the Forests and Fish HCP, forest management practices have been implemented on HCP lands to protect watershed and stream functions. The number of temperature-impaired Clean Water Act Section 303(d) - listed water bodies originating from non-HCP forest lands has been reduced. Increased instream flow, stream complexity, channel diversity, and large wood recruitment of substrate and large wood has been observed as a result of continued implementation of the Washington State Forest Practices HCP (WDNR 2005) and Washington State Trust Lands HCP (WDNR 1997).
6. Agricultural practices, including farming and grazing, are managed in a manner that improves (protects and restores) riparian areas, floodplains, and stream channels, and protects water quality from fine sediment, pesticide, herbicide, and fertilizer runoff. Agriculture practices should contribute to exceeding Clean Water Act standards. Riparian areas should reveal improvement in meeting NMFS’ buffer guidelines.
7. Urban and rural development (including land use conversion from agriculture and forestland to residential uses) does not reduce water quality or quantity, or impair natural stream conditions required to achieve recovery goals. Increased stormwater runoff treatment from new and existing developments and transportation corridors should be demonstrated.
8. Channel function (including vegetated riparian areas, canopy cover, stream-bank stability, off-channel and side-channel habitats, natural substrate and sediment processes, and channel complexity) are protected or restored to provide adequate rearing and spawning habitat (*see also Listing Factor D*).
9. Floodplain function and the availability of floodplain habitats for steelhead are restored to support a viable DPS. This restoration should include connectedness between river and floodplain and the restoration of natural sediment delivery mechanisms and processes. Floodplain development should be curtailed to show a net increase in floodplain habitats for steelhead.
10. Local government, municipal, federal, tribal, and state rules and regulations are effectively enforced and reported, including compliance with growth management and critical area ordinances.

4.3.3 Listing Factor B: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

Goal for Listing Factor B

Fishing activities do not impede the recovery of Puget Sound steelhead.

Discussion

NMFS' proposal to list Puget Sound steelhead[11] concluded that "Although overutilization for recreational purposes was a factor that contributed to the present decline of Puget Sound steelhead populations, we do not believe that overutilization is a factor limiting the viability of the Puget Sound steelhead DPS into the foreseeable future."

To ensure that overutilization does not preclude delisting, fisheries as well as scientific or educational activities should be conducted in a manner consistent with the appropriate limits of the 4(d) rule to avoid jeopardizing the DPS, and go beyond that to achieve long-term viability and recovery. Several criteria of Limit 4 of the 4(d) rule are discussed below with particular attention to factors constraining the conservation and survival of Puget Sound steelhead.

4.3.3.1 Delisting Criteria for Harvest Regulation

In addition to the criteria relating to harvest regulatory mechanisms in Listing Factor D, ongoing utilization for tribal, commercial, recreational, scientific, or educational purposes should be managed as outlined below to address Listing Factor B:

Harvest management plans are designed and implemented using the best available information on habitat capacity, density dependence, and other relevant factors so that they support DIP viability goals in all MPGs to achieve Puget Sound steelhead DPS viability, including:

- Contributing to the maintenance or restoration of the historical frequency of repeat spawning.
- Contributing to the protection of resident life histories forms where they are present and important for the recovery of DIPs.
- Contributing to restoring or maintaining genetic and demographic diversity within and among DIPs, in conjunction with habitat and hatchery efforts.
- Contributing to restoring or maintaining run and spawn timing to historic ranges.

[11] 71 Federal Register 15666, 03/26/2006. Listing Endangered and Threatened Species and Designating Critical Habitat: 12–Month Finding on Petition to List Puget Sound Steelhead as an Endangered or Threatened Species under the Endangered Species Act.

4.3.4 Listing Factor C: Disease or Predation

Goal for Listing Factor C

Diseases and predation and their effects on reproduction and survival are not a threat to the sustainability of the Puget Sound steelhead DPS.

Discussion

Based on the most recent status review for Puget Sound steelhead (NMFS 2016) and supplemental information, NMFS is concerned about the following:

- Pinniped predation continues to increase and remains a concern for listed species in Oregon and Washington due to a general increase in pinniped populations along the West Coast.
- Since 2011, there has been a significant increase in the number of pinnipeds, especially harbor seals, Steller sea lions, and California sea lions in Puget Sound waters (Chasco et al. 2017; Wiles 2015).
- Research suggests that unprecedented steelhead smolt emigration mortality, likely from predation by seals, occurs in the Salish Sea (Moore et al. 2015). Berejikian et al. (2016) suggest that harbor seals contribute to predation of steelhead in Puget Sound and in major river deltas (See Appendix 3).
- The findings of the Salish Sea Marine Survival project indicate that parasitic and disease infections of steelhead, including *Nanophyetus salmincola* infection of smolts impact fish condition, and may increase mortality and impede recovery (See Appendix 3).
- Net pen operations in Puget Sound have produced large outbreaks of infectious diseases, notably IHN, which is readily transmittable to native-origin steelhead.

4.3.4.1 Delisting Criteria for Disease and Predation Influences

NMFS will consider the goal for Listing Factor C to be met if there is evidence that predation effects are abated (reduced so that marine survival is sufficiently improved to support recovery) and disease and parasite influences do not impair recovery. To determine that the DPS is recovered, any disease or predation that threatens its continued existence should be addressed as outlined below (based in part on Crawford and Rumsey 2011):

1. Studies on the effectiveness of actions to reduce predation by marine mammals, are undertaken in a way that improves our understanding of their impact on the Puget Sound steelhead DPS. NMFS recognizes the challenges associated with managing the predation of one federally protected species (Puget Sound steelhead) by other federally protected species (marine mammals).
2. State, tribal, and federal fish health experts monitor the risks to steelhead from disease and pathogens so that disease outbreaks are determined early and do not impede recovery of the Puget Sound steelhead DPS.
3. Net pen operations have strong monitoring programs to detect diseased fish early. Detections are reported and protective actions are taken immediately to prevent outbreaks in and outside of the net pens.
4. Early marine survival of steelhead smolts in Puget Sound is sufficiently understood and management efforts have been implemented to address them.

4.3.5 Listing Factor D: The Inadequacy of Existing Regulatory Mechanisms

Goal for Listing Factor D

Regulatory mechanisms are in place, reinforced, maintained, and implemented to support the recovery of the Puget Sound steelhead DPS. Listing Factor D pertains to multiple categories of regulatory mechanisms including habitat, predation, disease, and hatcheries. Regulatory mechanisms related to harvest are addressed in Listing Factor B (Section 4.3.3). New regulatory mechanisms need to be added as necessary and ineffective regulatory mechanisms that impede recovery should be reduced or eliminated.

NMFS' general approach recognizes that the state of Washington and many stakeholders find that including voluntary approaches to achieving ESA recovery is more cost-effective than relying exclusively on a regulatory approach. A combination of voluntary and regulatory approaches is key to achieving recovery goals. However, in order to address ESA Listing Factor D, NMFS needs assurance that voluntary programs are backed up by regulatory mechanisms that ensure that the Puget Sound steelhead DPS is not threatened or endangered, nor will it become so, because of the present or threatened destruction, modification, or curtailment of its habitat or range. NMFS therefore accepts the concept of and need for a "regulatory backstop." This means we support the goal of achieving recovery with a strong voluntary effort, but we will look for evidence that regulatory mechanisms are in place to protect Puget Sound steelhead now and in the future.

4.3.5.1 Delisting Criteria for Inadequacy of Regulatory Mechanisms Related to Habitat

NMFS can recommend, but does not have the legal authority to require, changes in local and state regulatory mechanisms in order to protect steelhead habitat. The criteria below describe regulatory mechanisms that will, if implemented, provide important contributions to recovery, and NMFS will look for evidence that these have been developed and implemented. To determine if the DPS is recovered there should be sufficient evidence that regulatory mechanisms are in place, are being implemented, and are effective to protect against further destruction, modification, or curtailment of the species' habitat or range. This needs to include a combination of the following:

1. Federal agency actions under section 7(a)(1) and section 7(a)(2) of the ESA consider cumulative effects of actions in order to minimize the risks from hundreds or thousands of separate actions that degrade steelhead habitat.
2. Regulatory mechanisms are in place that effectively reduce the development and conversion of areas that are ecologically important for steelhead recovery. This includes increased effort to: increase floodplain habitats, improve shoreline habitat and functioning marine feeder bluffs for forage fish, eelgrass, and wetlands; provide adequate riparian area protection; improve water quality, including control of toxic chemicals; maintain and improve connectivity between larger rivers, tributaries and wetlands; reduce stormwater runoff; and minimize impacts to natural channel processes from channel changes, pipeline crossings, and other projects.
3. Steelhead recovery needs are communicated and integrated into land use planning and construction project design. This includes linking planning, policies and regulatory actions through decision-making processes by different agencies and departments. For example,

shoreline designations and associated uses should be consistent with specific watershed areas identified as protection or restoration priorities for steelhead.

4. Steelhead habitat areas are protected with riparian corridors consisting of mature, native trees and shrubs which maintain self-sustaining stream processes and riparian ecosystems (e.g., WDFW riparian management recommendations).[12]
5. Plans for residential, municipal, and commercial water withdrawals that may contribute to low-flow stream conditions during summer months are reviewed for consistency with Clean Water Act criteria and instream flows are in place to protect water quantity and quality to support steelhead recovery.
6. Increased regulatory, incentive, and policy actions are installed or implemented to reduce stormwater runoff impacts to steelhead. This includes increased use of temporary erosion and sediment controls, designation of easements, and the use of low-impact development approaches and techniques that manage stormwater.
7. Federal policies are aligned to improve shoreline habitat protection in marine and estuarine areas, such as applying the highest astronomical tide (HAT) as the landward jurisdictional extent of Clean Water Act section 404 and section 10 of the Rivers and Harbors Act permitting.
8. Interagency coordination is strengthened and streamlined to improve the implementation and enforcement of land use laws and permitting processes among state, federal, and local government authorities.
9. Federal and state agency scientists are funded and available to local governments to increase efforts to assist local governments in integrating recovery strategies into local land use planning. For example, development is often located in low-gradient areas within a watershed that provide important habitat for steelhead. Urban growth in these environments can alter land surface, soil, vegetation and hydrology by increasing the area of impervious surface. Local governments need support to identify key steelhead habitats, and to define and implement plans, regulations and policies that protect the habitats and the ecosystem processes that maintain them.
10. Restoration practitioners and habitat scientists educate communities about ways that they can develop and implement regulatory mechanisms to support steelhead recovery protection and restoration. For example, work with the real estate industry to provide information on buffers and wetlands that are constraints on developing properties.
11. Existing regulatory mechanisms are enforced and additional funding is provided for federal, state, and especially local governments to provide for sufficient habitat protection and restoration.
12. FEMA and local government agencies improve protections for floodplain rearing habitats by implementing Reasonable and Prudent Alternatives in the NMFS Biological Opinion on the National Floodplain Insurance Program, to limit future loss of floodplain habitat in jurisdictions enrolled in that program.

[12] https://wdfw.wa.gov/publications/01987/

13. Protection mechanisms are strengthened in state regulations to protect habitat conditions and watershed function where resource extraction such as gravel mining and gold mining impair spawning and rearing habitat and limit steelhead production.
14. Implementation and enforcement of existing regulatory laws and policies is increased to prevent additional exotic plant and animal species invasions to occur where they pose threats to steelhead.
15. Where instream water rights for fish habitat exist, they are protected and enforced. Where instream flows to protect steelhead are not in place, they are being prioritized for protection.

4.3.5.2 Delisting Criteria for Inadequacy of Regulatory Mechanisms Related to Disease and Predation

1. Predation by federally protected marine mammals and birds is managed in a way that allows for recovery of the Puget Sound steelhead DPS. NMFS recognizes the challenges associated with managing the predation of one federally protected species (Puget Sound steelhead) by other federally protected species (migratory birds and marine mammals).
2. State, tribal, and federal fish health experts implement protective regulatory mechanisms to reduce the risks to steelhead from disease and pathogens so that diseases do not threaten the recovery of the Puget Sound steelhead DPS.
3. Hatchery operations do not subject targeted populations to deleterious diseases and parasites which could result in increased predation rates of natural-origin fish.

4.3.5.3 Delisting Criteria for Inadequacy of Regulatory Mechanisms Related to Other Factors (Climate and Hatcheries)

Listing Factor D, Inadequacy of Regulatory Mechanisms Related to Climate Change

Goal for Listing Factor D for Climate Change

Regulatory mechanisms are developed, adapted, and implemented to consider and adapt to the impacts from climate change on Puget Sound steelhead and their habitat.

Delisting Criteria

1. Regulatory mechanisms related to climate change are developed and implemented to the maximum extent practicable so that steelhead have adequate ecosystem conditions, including water temperature, water quantity, and instream habitat features; and can adapt to changes in sea-level rise and ocean acidification.

Listing Factor D, Inadequacy of Regulatory Mechanisms Related to Hatcheries

Goal for Listing Factor D for Hatcheries

Regulatory mechanisms relating to hatchery programs are adequate, meaning they are effective in ensuring that hatchery programs do not impede the recovery of Puget Sound steelhead.

Delisting Criteria

1. To determine that the regulatory mechanisms related to hatchery production of steelhead in Puget Sound are adequate to support recovery, NMFS will need to ensure that ESA sections 7 and 10 and 4(d) (limits 5 and 6)[13] are implemented using the best available scientific information specifically related to the effects of steelhead hatchery programs on short- and long-term viability of the DPS.

4.3.6 Listing Factor E: Other Natural or Human-made Factors Affecting the Species' Continued Existence

4.3.6.1 Delisting Criteria for Climate Change Effects

Goal for Listing Factor E, Related to Climate Change

NMFS intends to evaluate natural and human-made factors affecting the continued existence of Puget Sound steelhead for effects that impede recovery, as well as actions taken to remove or reduce those effects. In particular, the effects from climate change are adequately addressed so they do not limit the productivity of steelhead or impede recovery.

Discussion: Climate Change Effects on Steelhead

The potential effects of global climate change have emerged as a critical concern for steelhead. A review by the NMFS' NWFSC shows moderate certainty that the 30-year average temperature in the Northern Hemisphere is now higher than it has been over the past 1,400 years. High certainty exists that ocean acidity has increased with a drop in pH of 0.1 (Ford 2015). The trends in warming and ocean acidification are highly likely to continue during the next century, although uncertainty remains whether the northeast Pacific Ocean will track global trends (IPCC 2013; Crozier and Siegel 2018).

The effects from climate change pose risks to steelhead abundance, productivity, spatial structure and diversity. In their freshwater habitats, anticipated temperature increases in Puget Sound due to climate change are likely to move ambient stream temperatures near or above upper levels of tolerance thresholds for steelhead in some areas. Changes in water temperature will also impact freshwater ecological communities, including food webs and potential predations. Changes in stream flow will likely restrict habitat availability and increase the demand for cool-water refuge. In the marine environment, increasing ocean temperatures and shifting ocean conditions due to climate change will likely impact the food web and ultimately the marine survival of steelhead. For example, from 2014 until 2016 higher ocean temperatures in the northeast Pacific Ocean and a strong El Niño resulted in dramatic shifts in the marine ecosystem conditions and food availability

[13] Limits 5 and 6 from 50 CFR 223.203(b)(5)(6)

that influence Puget Sound steelhead (NWFSC 2015 and NMFS 2016). Nevertheless, our ability to predict how the species and its specific populations will respond to such changes remains difficult and uncertain. Within limits, the species has developed an ability to adapt and displays plasticity in both migration timing and thermal tolerances. This ability to adapt is valuable to the fish and their long-term persistence; however, the rapid pace of climate effects increases the uncertainty of steelhead abundance. The uncertainty regarding steelhead response reinforces the importance of monitoring, and the ability to adjust actions accordingly through adaptive management.

Delisting Criteria

A monitoring system is in place to evaluate the effects of climate change on Puget Sound steelhead so they can, to the extent practicable, be minimized or adaptively managed to adjust to changing conditions and support DPS recovery.

1. The potential effects of climate change are evaluated and incorporated into management programs for hydropower, flood control, instream flows, water quality, fishery management, and hatchery management.
2. Watershed-specific recovery plans incorporate down-scaled model results of precipitation changes into protection and restoration strategies.
3. Early indicators of ocean conditions are considered in harvest management plans.
4. Habitat restoration projects consider the effects of down-scaled model results in their designs to facilitate resilience to altered flow and precipitation patterns.

4.3.6.2 Delisting Criteria for Hatchery Effects

Goal for Listing Factor E, Related to Hatcheries

Hatchery programs and operations are effectively managed and do not impede the recovery of Puget Sound steelhead.

Delisting Criteria

To determine if the DPS is recovered, regulatory mechanisms that protect steelhead from potential detrimental effects of hatcheries must include the following recovery actions:

1. The use of non-Puget Sound-derived hatchery broodstock has been fully phased out.
2. Puget Sound steelhead hatchery programs are operated in a manner consistent with maintaining viability of the DPS, including control of demographic, genetic and ecological risks of hatchery operations, impacts of water withdrawal and discharge, and fish health. For control of genetic risk, particular attention is paid to choice of appropriate Puget Sound broodstock and management of exposure to risk of domestication.
3. Monitoring and evaluation plans are implemented to measure population status, hatchery effectiveness, and compliance with ecological, genetic, and demographic risk containment measures.
4. The resource co-managers adaptively manage, using the most current scientific research, hatchery production levels, hatchery practices, and monitoring measures to insure the levels of risk are appropriate for viability and recovery of the DPS and its constituent populations and major population groups.

4.4 Making a Delisting Determination

At the time of a delisting decision for the Puget Sound steelhead DPS, NMFS will examine the extent to which each of the section 4(a)(1) listing factors has been addressed. To assist in this examination, NMFS will use the ESA listing decision framework described below and shown in Figure 9, in addition to evaluating the biological status relative to the recovery criteria and other relevant data and policy considerations. The threats need to have been addressed to the point that delisting is not likely to result in their re-emergence.

4.4.1 Biological Status and Pressure/Threats Review

NMFS recognizes that perceived threats, and their significance, can change over time due to changes in the natural environment or changes in the way threats affect the entire life cycle of salmonids. Indeed, this has already happened. As discussed earlier, some threats to Puget Sound steelhead at the time of listing, such as harvest mortality and hatchery influence, have since been reduced through management adjustments and now pose less danger to species viability. Other threats, such as the condition of freshwater and nearshore marine habitats, continue to limit recovery progress, although conditions in some areas are improving through the work of volunteers and stakeholders. At the same time, new threats, such as those posed by climate change, may be emerging. During the next five-year status review of Puget Sound steelhead, NMFS will review its biological status and the listing factor criteria.

As described in this chapter and portrayed in Figure 9, the listing decision framework for Puget Sound steelhead combines our assessment of biological status, the five listing factors, recovery actions, and research, monitoring and evaluation. The combined results from these assessments provide NMFS with the information needed to fully assess the overall risk to the species in future listing determinations.

4.4.2 ESA 5-Year Status Reviews

Under section 4(c)(2) of the ESA, NMFS is required to review the status of listed species at least every five years. The 5-year status review is used to determine whether an ESA-listed species should (1) be removed from the list, (2) be changed in status from an endangered species to a threatened species, or (3) be changed in status from a threatened species to an endangered species.

Accordingly, at 5-year intervals, NMFS will conduct status reviews of Puget Sound steelhead. These reviews will consider information that has become available through RM&E since the most recent status review and that informs assessment of the biological status of the DPS and/or of the pressures and stressors that affect the DPS. The reviews will make recommendations regarding whether there is substantial evidence to suggest that a change in listing status may be warranted. If a change in status may be warranted, NMFS will conduct a more in-depth review consistent with section 4(a) of the ESA. Any status review will be based on NMFS' ESA listing decision framework (see Figure 9) and will be informed by the information obtained through implementation of the monitoring, research, and evaluation programs.

Similarly, new information considered during 5-year status reviews may also compel more in-depth assessments of implementation and effectiveness monitoring and associated research to inform adaptive management decisions to guide Puget Sound steelhead recovery efforts.

4.4.3 Applying the Listing Decision Framework for Puget Sound Steelhead

NMFS plans to consider all the factors portrayed in Figure 9 in future status reviews and when making future decisions regarding the overall risk of extinction of Puget Sound steelhead. As described earlier and based on the available information at the time this Plan was drafted, NMFS expects to give greater weight to freshwater habitat and early marine survival than the other factors. Status reviews will be based on the best scientific information available at that time and take into account the following:

- The viability criteria and listing factor criteria described above.
- The management programs in place to address the threats.
- Principles presented in the Viable Salmonid Populations paper (McElhany et al. 2000).
- Best available information on population and DPS status and new advances in risk evaluation methodologies.
- Other considerations, including: the number and status of extant spawning groups, the status of the major spawning groups, linkages and connectivity among groups, the diversity of life history and phenotypes expressed, and considerations regarding catastrophic risk.
- The concept of trade-offs[14] between the various objectives and criteria and efforts.
- The fact that the Puget Sound steelhead DPS is a complex structure with important processes operating at scales ranging from individual spawning grounds to the entire Puget Sound steelhead DPS.
- The threatened (future) destruction, modification, or curtailment of its habitat.
- The uncertainties described in our listing determinations and multiple scientific reports.
- The reality that there are multiple combinations of strategies and actions that could meet the biological criteria and listing factors, and protective efforts, and there is no single, pre-established, approach to progress from threatened to recovered status for Puget Sound steelhead.

The following tables show the factors that we will consider to determine the status of the biological health of the DPS and the status of the five listing factors, and assess the certainty that the goals and criteria have been met. These tables do not suggest a specific outcome or answer, instead they are intended to show alternative future scenarios under which NMFS could reach a decision to delist the DPS.

- Table 9 presents the components of the listing decision framework in a manner that allows us to indicate the certainty we have that the viability and listing factor criteria have been met.
- Table 10 shows how the factors, particularly reduced habitat conditions and related habitat regulatory mechanisms, contributed to our threatened status determination in 2007.

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[14] NMFS Recovery Guidance 2007.

- Table 11 describes the strongest case for delisting — if we have "complete certainty" that the biological viability and all the listing factors meet their respective objectives and criteria.
- Table 12 shows a hypothetical characterization of how we might delist if we have certainty that a number of the criteria have been met, even if one criterion was not met. The ESA and NMFS guidance do not require the highest level of certainty that all criteria have been met, nor do they specify exactly what the status of the species and the listing factors must be in order to delist.
- Table 13 illustrates the concept of trade-offs — how we could delist with different combinations of certainty that viability and listing factor criteria have been met.

Table 9. Components of the ESA listing decision framework that NMFS will consider in evaluating the status of Puget Sound steelhead.

Degree of certainty that criterion for each column has been met	Biological Status (Is the DPS sustainable?)	Listing Factor (LF) A Is the habitat adequate for recovery?	LF B (Harvest)	LF C (Disease & Predation)	Listing Factor D The regulatory mechanisms for each listing factor (A,B,C, and E) are adequate to achieve and sustain recovery				LF E Other factors
					A	B	C	E	
High certainty the criterion has been met	-	-	-	-	-	-	-	-	-
Moderate certainty the criterion has been met	-	-	-	-	-	-	-	-	-
Low certainty it is met	-	-	-	-	-	-	-	-	-
Uncertain	-	-	-	-	-	-	-	-	-
Low certainty the criterion has not been met	-	-	-	-	-	-	-	-	-
Moderate certainty the criterion has not been met	-	-	-	-	-	-	-	-	-
High certainty criterion has not been met	-	-	-	-	-	-	-	-	-

Table 10. Characterization of the determination to list Puget Sound steelhead in 2007.

Degree of certainty that criterion for each column has been met	Biological Status (Is the DPS sustainable?)	Listing Factor (LF) A Is the habitat adequate for recovery?	LF B (Harvest)	LF C (Disease & Predation)	Listing Factor D The regulatory mechanisms for each listing factor (A,B,C, and E) are adequate to achieve and sustain recovery					LF E Other factors(Climate and Hatcheries)	
					A	B	C	E			
								Hatchery	Climate	Hatchery	Climate
High certainty the criterion has been met	-	-	-	-	-	-	-	-	-	-	-
Moderate certainty the criterion has been met	-	-	-	-	-	-	-	-	-	-	-
Low certainty the criterion has been met	-	-	-	-	-	-	-	-	-	-	-
Uncertain	-	-	-	-	-	-	-	-	-	-	-
Low certainty the criterion has not been met	-	-	-	(Predation)	-	-	Predation	-	-	-	-
Moderate certainty the criterion has not been met	-	-	-	-	Regulatory mechanisms for habitat	-	-	-	-	-	-
High certainty criterion has not been met	-	-	-	-	-	-	-	-	-	-	-

Table 11. The strongest case for delisting: "Complete certainty" that the biological status and all the listing factors meet their respective goals and that protective efforts are effective.

Degree of certainty that criterion for each column has been met	Biological Status (Is the DPS sustainable?)	Listing Factor (LF) A Is the habitat adequate for recovery?	LF B (Harvest)	LF C (Disease & Predation)	Listing Factor D The regulatory mechanisms for each listing factor (A,B,C, and E) are adequate to achieve and sustain recovery				LF E Other factors (Climate and Hatcheries)	
					A	B	C	E		
High certainty the criterion has been met	-	-	-	-	-	-	-	-	-	-
Moderate certainty the criterion has been met	-	-	-	-	-	-	-	-	-	-
Low certainty the criterion has been met	-	-	-	-	-	-	-	-	-	-
Uncertain	-	-	-	-	-	-	-	-	-	-
Low certainty criterion has not been met	-	-	-	-	-	-	-	-	-	-
Moderate certainty criterion has not been met	-	-	-	-	-	-	-	-	-	-
High certainty criterion has not been met	-	-	-	-	-	-	-	-	-	-

Table 12. Hypothetical characterization of how NMFS might delist: Despite remaining uncertain that the habitat is adequate for recovery, the biological status is strong and newly strengthened regulatory mechanisms are deemed sufficient to improve the habitat enough to warrant delisting.

Degree of certainty that criterion for each column has been met	Biological Status (Is the DPS sustainable?)	Listing Factor (LF) A Is the habitat adequate for recovery?	LF B (Harvest)	LF C (Disease & Predation)	Listing Factor D The regulatory mechanisms for each listing factor (A,B,C, and E) are adequate to achieve and sustain recovery				LF E Other factors (Climate and Hatcheries	
High certainty the criterion has been met	-	-	-	-	-	-	-	-	-	-
Moderate certainty the criterion has been met	-	-	-	-	-	-	-	-	-	-
Uncertain	-	-	-	-	-	-	-	-	-	-
Low certainty criterion has not been met	-	-	-	-	-	-	-	-	-	-
Moderate certainty criterion has not been met	-	-	-	-	-	-	-	-	-	-
High certainty criterion has not been met	-	-	-	-	-	-	-	-	-	-
High certainty criterion has not been met	-	-	-	-	-	-	-	-	-	-

Table 13. Hypothetical characterization of trade-offs (combinations of how NMFS could delist): If there was a high certainty that the habitat and regulatory mechanisms were adequate to sustain recovery, NMFS could consider delisting with a lower score for biological sustainability.

Degree of certainty that criterion for each column has been met	Biological Status We might not need high certainty the DPS is sustainable if listing factors are in good shape.	Listing Factor (LF) A Certain the habitat is adequate for recovery	Certain B criteria are met	Certain C criteria are met	Listing Factor D The regulatory mechanisms for each listing factor (A,B,C, and E) are adequate to achieve and sustain recovery				LF E Other factors are consistent with recovery	
High certainty the criterion is met			-	-	-		-	-	-	-
Moderate certainty the criterion is met			-	-	-		-	-	-	-
Low Certainty it is met	-	-	-	-	-	-	-	-	-	-
Uncertain	-	-	-	-	-	-	-	-	-	-
Low Certainty criterion is not met	-	-	-	-	-	-	-	-	-	-
Moderate certainty criterion is not met	-	-	-	-	-	-	-	-	-	-
High certainty criterion is not met	-	-	-	-	-	-	-	-	-	-

"The Plan provides a solid, science-based framework from which recovery partners can begin implementing the highest priority actions in support of steelhead recovery across Puget Sound."

– Puget Sound Partnership

5. Time and Cost Estimates

ESA section 4(f)(1) requires that recovery plans, to the maximum extent practicable, include "estimates of the time required and the cost to carry out those measures needed to achieve the plan's goal and to achieve intermediate steps toward that goal" (16 U.S.C. 1531-1544, as amended). This chapter is intended to meet this ESA requirement.

5.1 Time Estimates

The time to recover Puget Sound steelhead will likely depend on how much funding and resources are delivered to recovery efforts, and how the strong influence of early marine survival is ultimately addressed. Under any scenario, the time to recovery will take many decades and will depend on several variables, including the following:

- Whether ongoing habitat protection and restoration actions continue to be effectively implemented and adapted;
- How Puget Sound steelhead respond to protection and restoration actions;
- Whether regulatory mechanisms to protect habitat are implemented;
- Whether resources that benefit Puget Sound Chinook and Hood Canal summer-run Chum salmon can be sustained while additional resources are implemented in a timely manner to benefit steelhead;
- Whether an adequately funded adaptive management program can be sustained to inform key uncertainties;
- Whether natural-origin steelhead respond to new and ongoing hatchery management improvements;
- Whether effective actions to improve early marine survival of Puget Sound steelhead can be successfully implemented; and
- How ecological factors, such as changing ocean conditions and climate, impact the species.

Factors inhibiting the recovery of Puget Sound steelhead are disproportionately influential and likely require different levels of effort and time to remedy. For example, the early marine survival of steelhead in Puget Sound has been very low in recent years leading to unsustainable productivity. If remedies to reduce predation by harbor seals and other pinnipeds in Puget Sound can be successfully implemented within a decade, steelhead trends in abundance and productivity may slowly rebound thereafter.

In freshwater, fish passage projects at major dams and blockages such as Baker River (Skagit River), Howard Hansen (Green River), the Nooksack diversion (Middle Fork Nooksack River), Mud Mountain, Buckley Diversion Dam (White River), and the Hiram Chittenden Locks (Lake Washington/ Cedar) provide the greatest and timeliest opportunity to increase VSP criteria for steelhead in Puget Sound. Fish passage around major structural features like dams can take a decade or more to plan and implement, but measurable increases in steelhead abundance to newly available, high quality habitat can occur within several generations (12–20 years).

Hatchery improvements in recent years, including through the implementation of hatchery genetic management plans (HGMPs) and the use of conservation hatcheries, have steadily improved the outlook for diversity of steelhead. These improvement efforts continue as more HGMPs and other hatchery practice modifications are anticipated over time. How quickly steelhead respond from hatchery practice improvements is largely unknown.

Habitat protection and restoration efforts comprise the largest potential gains for steelhead VSP criteria. However, despite gradual improvement through time with increased funding, 100 years may be needed before full protection and restoration efforts would lead to recovery.

In freshwater, fish passage projects at major dams and blockages provide some of the greatest and timeliest opportunities to increase VSP criteria for steelhead in Puget Sound. The projects can take time to plan and implement, but measureable increases in steelhead abundance to newly available, high quality habitat can occur within several generations (12-20 years.)

5.2 Cost Estimates

Consistent with ESA recovery planning guidelines, this section provides estimates of cost, to the maximum extent practicable, to achieve the Plan's goal to delist the Puget Sound steelhead DPS (NMFS and USFWS 2010). Staff from NMFS' West Coast Region worked with the recovery team to identify ongoing and potential additional actions to recover ESA-listed Puget Sound steelhead. They developed these recovery strategies and actions using the most up-to-date assessment information for the species without consideration of cost or potential funding.

While continued programmatic actions in the management of habitat, hatcheries, hydropower, and harvest will warrant additional expenditures beyond the first 10 years, NMFS believes it is impracticable to estimate all projected actions and costs over 50 to 100 years given the large number of economic, biological, and social variables involved. Instead, NMFS believes it is most appropriate to focus on the first 10 years of action implementation and rely on the adaptive management framework's structured process to conduct monitoring to improve the science and on periodic plan reviews to evaluate the status of the species and add, eliminate, or modify actions based on new knowledge. The adaptive management process will continue to frame decision making to gain needed information and use it to alter our course of action strategically until such time as the protection under the ESA is no longer required.

All yearly costs are provided in present-year dollars (that is, without adjusting for inflation). Costs are estimates for the Fiscal Year (FY) in millions of dollars ($M). The total costs are the sum of the yearly costs without applying a discount rate. Unless otherwise noted, the costs are direct, incremental costs, meaning that they are (1) out-of-pocket costs that a public or private interest would pay to initiate and complete a management action, and (2) costs that are in addition to the baseline costs for existing programs and activities. This approach is consistent with NMFS West Coast Region guidance on cost estimates for ESA recovery plans.

Protection and restoration efforts to recover Puget Sound Chinook and Hood Canal summer-run Chum salmon have been underway since before 1999. In our 2006 Supplement to the Puget Sound Salmon Recovery Plan, NMFS concurred that $120 million per year would be needed over 10 years to place Puget Sound Chinook salmon on a trajectory toward recovery within a 50– to 100-year recovery timeframe (NMFS 2006). The Puget Sound region received approximately $516 million in state and federal funding ($52 million per year on average) during the ensuing 10 years (2006–2016) (GSRO 2016). Despite a historic boost in restoration efforts during the period, steelhead and Chinook salmon abundance has not appreciably improved (NMFS 2016).

Updated cost estimates to recover Puget Sound Chinook and Hood Canal summer-run Chum salmon were developed by the Washington Governor's Salmon Recovery Office. The total estimated cost to implement the Puget Sound Chinook and Chum salmon recovery plans (capital and non-capital costs) is approximately $200 million per year, or $2 billion total over the next 10 years (GSRO 2016).

To develop cost estimates for Puget Sound steelhead recovery, we considered five primary areas where additional funding was necessary to recover the species:

- Shortfalls in funding for Chinook and summer-run Chum salmon for areas where steelhead are also present;
- Extended habitat range occupied by steelhead, but where Chinook or summer-run Chum salmon are absent;
- Fish passage at road/stream crossings and dams;
- Early marine survival; and
- Large gaps in monitoring and adaptive management.

The current funding for Puget Sound Chinook salmon and Hood Canal summer-run Chum salmon recovery also benefits steelhead recovery; however, the shortfall in funding necessary to recover Chinook and Chum salmon is also a shortfall for steelhead. Therefore, we added the funding shortfalls necessary to achieve a trajectory for recovery of those species to the costs needed to recover steelhead. The Washington Governor's Salmon Recovery Office estimates that $200 million/year is necessary for Chinook and Chum salmon to achieve a recovery trajectory over the next 10 years (GSRO 2016). However, recovery efforts for those species has received an average of $52 million/year, a shortfall of $148 million/year.

Steelhead ascend rivers and streams further inland than Chinook and Chum salmon, and commonly occupy headwater streams that are not used by these species. Although most stream reaches occupied by Chinook and Chum salmon are also occupied by steelhead, competition among the species may be a driver for the added use of small streams and headwater reaches by steelhead (Meehan and Bjornn 1991), where the swimming capabilities of steelhead enable them to navigate steep and fast headwater channels (Busby et al. 1996). Conservatively, the historic habitat used by steelhead is more than twice the length of habitat known to have supported Chinook salmon (WDFW 2018).

Many headwater reaches are managed under habitat conservation plans, which include adaptive management processes. Similarly, federal lands (largely U.S. Forest Service lands) operate under the Northwest Forest Plan and include habitat protection strategies and an adaptive management program. So long as these programs remain adequately funded and implemented (including adaptive management), NMFS believes they are protective of steelhead habitat. Small streams and headwater reaches not protected by HCPs or other federally recognized strategies require increased habitat protection and restoration, including fish barrier repairs (discussed below), riparian habitat improvement, and in-channel restoration efforts. We do not have estimates of the amount of habitat in small streams and headwater reaches in need of restoration. However, costs will be developed and included with future iterations of this planning effort as new information becomes available.

Fish passage barriers at road crossings are a pervasive impediment to Puget Sound steelhead recovery. The WDFW estimates that between 6,700 and 8,000 anadromous barriers exist in Puget Sound streams that would otherwise provide accessible habitat for steelhead and Coho salmon (WDFW 2018). We assume that 70 percent of these barriers need to be corrected to meet our recovery goals. Concurrent with the estimated number of barriers reported, WDFW also estimated approximate costs to repair the barriers. Table 14 shows the estimated costs, by entity, to repair the fish passage barriers.

Table 14. Estimated costs to remedy fish passage barriers in anadromous streams of Washington by entity. Costs do not include inflation.

Entity	Est. Cost to remedy	Data source used
Private	$114,000	Average FFFPP[1] project cost
County	$582,018	Average County project cost on FBRB[2] 17-19BN[3] List
State - non-WSDOT	$348,009	Average State - non-WSDOT project cost on FBRB 17-19BN List
City	$686,145	Average City project cost (FBRB 17-19BN)
Special Districts	$582,018	Average County project cost (FBRB 17-19BN)
Other/Unknown	$582,018	Average County project cost (FBRB 17-19BN)
Ports	$582,018	Average County project cost (FBRB 17-19BN)
Tribal	Not provided	Not included
Federal	Not provided	Not included
State - WSDOT	$5,052,000	WSDOT 2018

[1] FFFPP (Family Forest Fish Passage Program) is a family forest grant program.
[2] FBRB (Fish Barrier Removal Board) is a Washington State program to remove anadromous barriers.
[3] 17-19BN (Biennial budget for fiscal years 2017–2019).

To estimate the cost of repairing fish passage barriers in Puget Sound, we took the mean of the WDFW estimate number of barriers (7,350) and assumed that 70 percent of those barriers were associated with steelhead habitat and were necessary to recover the species. We then applied the mean cost to repair private, city, and county road crossings (about $460,000) to the resulting estimated number of barriers (5,145). If costs are amortized over the next 100 years, the estimated costs to repair steelhead barriers at road crossings in Puget Sound over the next 10 years is $237M. We assume that fish passage over a minimum of two Puget Sound dams would be necessary over the next 10 years (Howard Hanson and one additional dam) at a cost of $100M each. The total cost of providing fish passage (dams and culverts) to historic reaches of Puget Sound steelhead, as shown in Table 15, is estimated at $437M over the next 10 years.

The costs to remedy early marine survival impacts to steelhead are currently unknown. As adaptive management continues to improve our understanding of early marine migration impediments to recovery, costs will be developed and included with future iterations of this planning effort.

The costs associated with additional monitoring and adaptive management for steelhead recovery are assumed to be two percent of the additional Puget Sound steelhead recovery costs. Currently, many steelhead populations are not monitored for fundamental adult spawners or smolt outmigrants, and this information is needed to properly manage the recovery of steelhead populations. Although we assume that monitoring efforts for Chinook and Chum salmon will contribute to some of the necessary steelhead monitoring needs, we estimate that an additional $3.8 million/year is needed to monitor and adaptively manage steelhead for the next 10 years.

Table 15. Summary of recovery costs for Puget Sound steelhead.

Activity	Annual cost	10-Year cost (2020–2030)
Stream restoration and protection[1]	$148 Million	$1.48 Billion
Fish passage at road crossings[2]	$23.7 Million	$237 Million
Fish passage at dams	$20 Million	$200 Million
Monitoring and adaptive management	$3.8 Million	$38 Million

[1] Governor's Salmon Recovery Office (GSRO) 2016.
[2] Washington's Fish Barrier Removal Board (FBRB) 2018.

Photo: Juvenile steelhead and Coho salmon. Credit. John McMillian.

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