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Review of ESA Listing Factor Threats for the Olympic Peninsula Steelhead DPS, 1996–Present: Appendix B to NOAA Technical Memorandum NMFS-NWFSC-198

October 2024

U.S. DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northwest Fisheries Science Center

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We appreciate the time and valuable information and data provided by members and staff of the Quinault Indian Nation, Quileute Tribe of the Quileute Reservation, Hoh Indian Tribe, Makah Indian Tribe of the Makah Indian Reservation, Lower Elwha Klallam Tribe, Jamestown S’Klallam Tribe, Northwest Indian Fisheries Commission (NWIFC), Washington Department of Fish and Wildlife (WDFW). We also thank reviewers of this document including James Dixon (NMFS WCR Sustainable Fisheries Division), Dave Price (NMFS WCR Washington Coast/Lower Columbia Branch), and Tim Beechie (NMFS Northwest Fisheries Science Center), as well as Mike Haggerty and Jon Moore for their review. We thank Lisa Clarke with the NOAA library for her work compiling updated literature on steelhead. We also acknowledge the extensive work that came before by NMFS staff to summarize information on threats to steelhead and information from the Olympic Peninsula region, including the NMFS (1996a) limiting factors report, the recent 5-year review for a salmonid population that overlaps geographically with OP steelhead (Lake Ozette sockeye, National Marine Fisheries Service (2022a)) and other ESA documents for other listed steelhead (e.g. critical habitat for Puget Sound steelhead National Marine Fisheries Service (2015)).

Errata

An earlier version of this appendix (and the accompanying technical memorandum) misreported the escapement goal for the Upper Quinault River, which led to additional miscalculations in the number of years escapement had been met. We thank the tribal comanagers for bringing this error to our attention.

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Analysis of ESA Section 4(a)(1) Factors

Section 4(a)(1) of the ESA directs NMFS to determine whether any species is threatened or endangered because of any of the following factors: (1) the present or threatened destruction, modification, or curtailment of its habitat or range; (2) overutilization for commercial, recreational, scientific, or educational purposes; (3) disease or predation; (4) the inadequacy of existing regulatory mechanisms; or (5) other natural or man-made factors affecting its continued existence. Section 4(b)(1)(A) requires us to make listing determinations after conducting a review of the status of the species and taking into account efforts to protect such species.

NMFS has reviewed the impacts of various factors contributing to the decline of Pacific salmon and *O. mykiss* in previous listing determinations (e.g., 63 FR 11482, March 9, 1998; 69 FR 33102 June 14, 2004) and supporting documentation (e.g. National Marine Fisheries Service 1996a; National Marine Fisheries Service 1998). These Federal Register notices and technical reports concluded that all of the factors identified in section 4(a)(1) of the ESA had played a role in the decline of West Coast salmonid stocks. Similarly, U.S. Fish and Wildlife Service found that most section 4(a)(1) factors threaten Bull Trout in the Olympic Peninsula and Puget Sound (not disease and predation, though it occurs), but mainly habitat destruction and modification and non-native fish introduction (Factor 5, “Other”) (see 64 FR 58910; November 1, 1999). More recently, many ESA 5-year status reviews have summarized new and existing information on these threats as part of the reviews, including for a salmonid population that overlaps geographically with OP steelhead (Lake Ozette sockeye, National Marine Fisheries Service (2022a)) and or other ESA documents for other listed steelhead (e.g. critical habitat for Puget Sound steelhead National Marine Fisheries Service (2015)). This review relies heavily on and draws from recent 5-year status reviews, as well as on other NMFS assessments for listed salmonids (such as (Ford 2022)), reports from Washington Department of Fish and Wildlife, reports from Northwest Indian Fisheries Commission and Northwest Treaty Tribes, conversations with managers of OP steelhead (Tribes and State referred to as “co-managers”), and peer-reviewed literature.

A condensed version of this review of ESA section 4(a)(1) factors is provided in OP Steelhead DPS Status Review Team (2024) and information in that document helped inform this review.

Summary - current status since last review

NMFS last reviewed the status and risk of OP steelhead in the 1996 report, Busby et al. (1996). At that time, the status review team (SRT) concluded that the “Olympic Peninsula steelhead ESU [DPS] is neither presently in danger of extinction nor likely to become endangered in the foreseeable future.” Despite this conclusion, the SRT had several concerns about the overall health of this DPS and the status of certain stocks within it related to downward trends in abundance, uncertainty around abundance (especially for summer-run steelhead), and potential impacts of hatchery production and introgression given the use of few parent stocks (see OP Steelhead DPS Status Review Team, 2024).

Since that time, actions have been taken to address certain threats. For instance, habitat restoration projects have occurred including the replacement of many culvert barriers (see

Northwest Indian Fisheries Commission (2020), and Coast Salmon Partnership 2022 Annual Report¹) in recent years and installation of large wood jams in selected rivers. Additionally, habitat connectivity continues to be maintained in the major river systems largely due to the absence of major blockages. More stringent State and Federal sport fishing regulations have gone into place including catch-and-release restrictions for recreational fishing and area and gear restrictions for natural-origin summer and winter steelhead. Also, more regulatory mechanisms have been established that protect salmonid habitat broadly, including Habitat Conservation Plans that address timber harvest (others include: Northwest Forest Plan and associated Aquatic Conservation Strategy and Land and Resource Management Plan for the Olympic National Forest, Washington Streamflow Restoration law and Fish Passage Barrier Removal Board, 2008 Statewide Steelhead Management Plan, Anadromous Salmon and Steelhead Hatchery Policy C-3624; see Listing Factor D below). Hatchery practices have been modified to reduce off-station releases, in order to increase the proportion of fish returning to the hatchery rack and decrease the number of hatchery-origin fish straying and spawning naturally².

Other threats continue to be an issue for this population. Legacy impacts of stream habitat modification have likely continued to impact this population since 1996 and continue now. Although efforts are underway to address habitat issues, it may take decades or even centuries for larger rivers to recover (Martens et al. 2019; Stout et al. 2018) especially related to woody debris (which may be most beneficial to steelhead, see Jorgensen et al. (2021)). Moreover, climate change will exacerbate conditions into the future (Wade et al. 2013). Climate change is currently impacting this DPS and will continue to negatively affect both the freshwater and marine habitat. In the foreseeable future, projected and modeled climate impacts that may affect steelhead include: prolonged summer low-flows, increased frequency and magnitude of peaks flows, elevated water temperatures, continued loss of glaciers (Wenger et al. (2010); Wade et al. (2013); and see below in Listing Factor E). Also, from a life history diversity perspective, kelt survival has continued to decline in the four major coastal rivers, possibly related to warmer sea surface temperature, pink salmon impacts, and Pacific Decadal Oscillations (but there is uncertainty about other potential contributing factors including predation).

Furthermore, though harvest management plans and hatchery operations have been modified, as described above, they continue to impact steelhead populations within the DPS. Prior to 2021, Olympic Peninsula steelhead populations experienced relatively high commercial and recreational fishing pressure (when compared to other DPSs) even while population run sizes declined. There are documented legacy and current impacts associated with harvest. Harvest four major OP rivers, which make up the majority of OP steelhead abundance was the highest in the state, 13.26%-59.19% depending on year and river between 2014-2020. Though catch and release regulations for natural-origin steelhead went into place in 2016, there is still has an assumed 10% mortality for released natural-origin steelhead, and some fish may be handled more than once. In the last 2 years (2021, 2022), harvest in the major four OP steelhead basins has declined to ~9-15%, depending on basin, but it is unclear if, and how long, these harvest reductions will continue. In those recent years, even with reduced harvest, escapement goals have not been met in some basins. At the same time, the proportion of harvest that is natural-

¹ <https://coastsalmonpartnership.egnyte.com/dl/VbBakQwmdS>

² For example, winter steelhead smolt release into Pysht was eliminated in 2009; Goodman Creek, Clallam River, and Lyre river in 2009, and in Sol Duc, summer smolt releases were terminated in 2011 and winter in 2013.

origin has increased so it is likely that proportionally more natural-origin steelhead are being caught in fisheries that target hatchery-origin steelhead (see section *SRT assessment of winter-run run timing changes* in OP Steelhead DPS Status Review Team, 2024). There is also evidence of compressed run timing with harvest disproportionately catching early winter returning natural-origin winter-run steelhead. Certain hatcheries have for decades continued to release large numbers of out-of-DPS stock smolts (in the hundreds of thousands), and returning hatchery-origin adults likely overlap to some degree with natural-origin adults (though to what extent is unknown). Although some hatchery practices have improved, the naturally-spawning population likely retain genetic legacy impacts of past hatchery practices. Finally, though there have been some positive management changes, there continues to be challenges associated with fisheries and hatchery management. Data limitations continue for assessing the current status and risk of summer-run OP steelhead, an issue identified in the 1996 review and more recently by Harbison et al. (2022). There continue to be undefined escapement goals for some rivers, differing escapement goals between co-managers for others, and uncertainty if the escapement goals can maintain or restore runs. Where escapement goals have been established, there is a need to validate the biological relationships used to develop the goals some 40 years ago. Certain hatchery fish are not marked in some major rivers on the coast. Many threats to Olympic Peninsula steelhead identified by Busby et al (1996) continue today, although some efforts have been made to diminish their effects. However, new threats, such as climate change are beginning to affect steelhead populations in the Olympic Peninsula DPS, and will likely increase in intensity in the future.

Listing Factor A: The Present or Threatened Destruction, Modification, or Curtailment of Steelhead Habitat or Range

Current habitat conditions within the OP DPS are summarized in multiple documents and reports including the State of Our Watersheds reports from Northwest Indian Fisheries Commission (2020) and reports on specific Water Resource Inventory Areas (WRIAs) (Washington Department of Ecology [WDOE] broke up the state of Washington into 62 WRIAs to delineate major watersheds within Washington and manage activities, where WRIAs 19-21 overlap with OP steelhead DPS range)³; see Smith (2000); Smith and Caldwell (2001). We also summarized watershed status within Appendix A (NMFS 2024) for the OP Steelhead DPS Status review (information on specific rivers and watersheds). Here we summarize habitat modifications that have occurred and likely continue to have legacy impacts on OP steelhead, but also touch on restoration efforts that are ongoing to address past destruction and modification. For more general discussion of habitat needs of steelhead and other salmonids, see the following documents: Hicks et al. (1991); National Marine Fisheries Service (1996a); National Marine Fisheries Service (2015). Because of the extensive summary of habitat modification impacts on steelhead presented in NMFS (1996a), we draw heavily from that document but with updates since that time. We also incorporate general steelhead ecology information from the critical habitat report and recovery plan for Puget Sound steelhead (NMFS 2015, NMFS 2019).

³ See also this website for current water quality information from WDOE
<https://apps.ecology.wa.gov/ApprovedWQA/ApprovedPages/ApprovedSearch.aspx>

Habitat Background

As summarized in NMFS (2015) (critical habitat report for Puget Sound steelhead), the overall health and likelihood of persistence of salmon and steelhead populations are affected by four main factors: abundance, productivity, connectivity/spatial structure, and diversity of the component populations (McElhany et al. 2000). With respect to the habitat requirements for a healthy salmonid DPS, a DPS composed of many diverse populations distributed across a variety of well-connected habitats can better respond to environmental perturbations including catastrophic events (Anderson et al. 2014; Brennan et al. 2019; Greene et al. 2010; Schindler, Armstrong and Reed 2015; Schindler et al. 2010). Additionally, well-connected habitats of different types are essential to the persistence of diverse, locally adapted salmonid populations capable of exploiting a wide array of environments, as well as capable of responding to and surviving both short- and long-term environmental change (e.g., (Groot and Margolis 1991; Wood 1995)). Differences in local flow regime, temperature regime, geological, and ecoregion characteristics correlate strongly with DPS population structure (Beechie et al. 2006; Ruckelshaus et al. 2006).

While there is some temporal overlap in spawn timing between winter-run and summer-run steelhead, in basins where they are both present, summer-run steelhead typically often spawn above at least partially impassable barriers, farther upstream (Myers et al. 2015). As noted in NMFS (2015), in many cases, it appears that the summer migration timing evolved to access areas above falls or cascades that present velocity barriers to migration during high winter flow months, but are passable during low summer flows (Myers et al. 2015; Narum et al. 2008—genetic indication of separation of habitat by anadromous vs. resident; Withler 1966). Most Olympic Peninsula rivers lack major in-stream velocity barriers, cascades, or falls, and it is unclear what mechanism has provided for the expression of the summer-run life history.

Within the Olympic Peninsula steelhead DPS, major river basins that drain into the Pacific Ocean originate within the Olympic National Park (ONP) where habitat is protected from most detrimental land-use practices such as logging (Figure 1). The lower portions of these watersheds extend outside of the park into Federal, State, and Private forest lands and other developed lands and are subjected to different levels of logging and other land-use practices. Table 1 presents the percent of each population's habitat that falls within the ONP as well as the number of years since last disturbance and overall percent forest cover (data from: Jin et al. (2023)). However, not all stream/river reaches are accessible to steelhead (see Table 1 below for percent of steelhead habitat used within the ONP). We note that even if steelhead can not utilize portions of a watershed within the ONP, protecting the integrity of the headwater areas provides benefits to the entire system (Table 2).

While populations were generally well described by WDFW, we generated our own polygonal geospatial layer representing both winter and summer groups⁴. This was done by dissolving

⁴ For all mapping presented: any summary calculations for the Olympic Peninsula Steelhead DPS climate, hydrological, and landscape data were performed utilizing ESRI's geospatial software. We used the National

catchment features by WDFW population name and run-type. The resulting shapefiles were used for both summarizing environmental data and generating figure maps. In addition, catchments were attributed with current steelhead use as defined by the Statewide Washington Integrated Fish Distribution (SWIFD) (SWIFD GIS Data 2014) and Streamnet (StreamNet GIS Data 2019). We employed current use for any life cycle stage as a screen for certain summaries within populations in order to more accurately account for steelhead distribution within sub-basins.

We also incorporated land manager status as a supplementary unit of analysis for various outputs. Values showing private or public ownership and manager type by agency name (local, state, tribal or federal) were obtained from the USGS's PAD database (U.S. Geological Survey (USGS) Gap Analysis Project (GAP) 2022). We then attributed catchments to land management type using geoprocessing tools. All catchment values were included in a single spreadsheet from which individual attributes were summarized by population name and/or land manager, with additional assessments done for steelhead life history use type.

Hydrography Dataset (NHDPlus) catchments (Moore and Dewald 2016) as the summary unit for all values, including raster products derived from the National Landcover Database (NLCD) (Jin et al. 2023; Yang et al. 2018), and streamflow (Wenger et al. 2010) and temperature (Isaak et al. 2016) metrics provided by the Rocky Mountain Research Station (for current, 2040, and 2080 climate predictions for listing factor E). Summaries were developed for individual catchments at the reach level and steelhead population sub-basins.

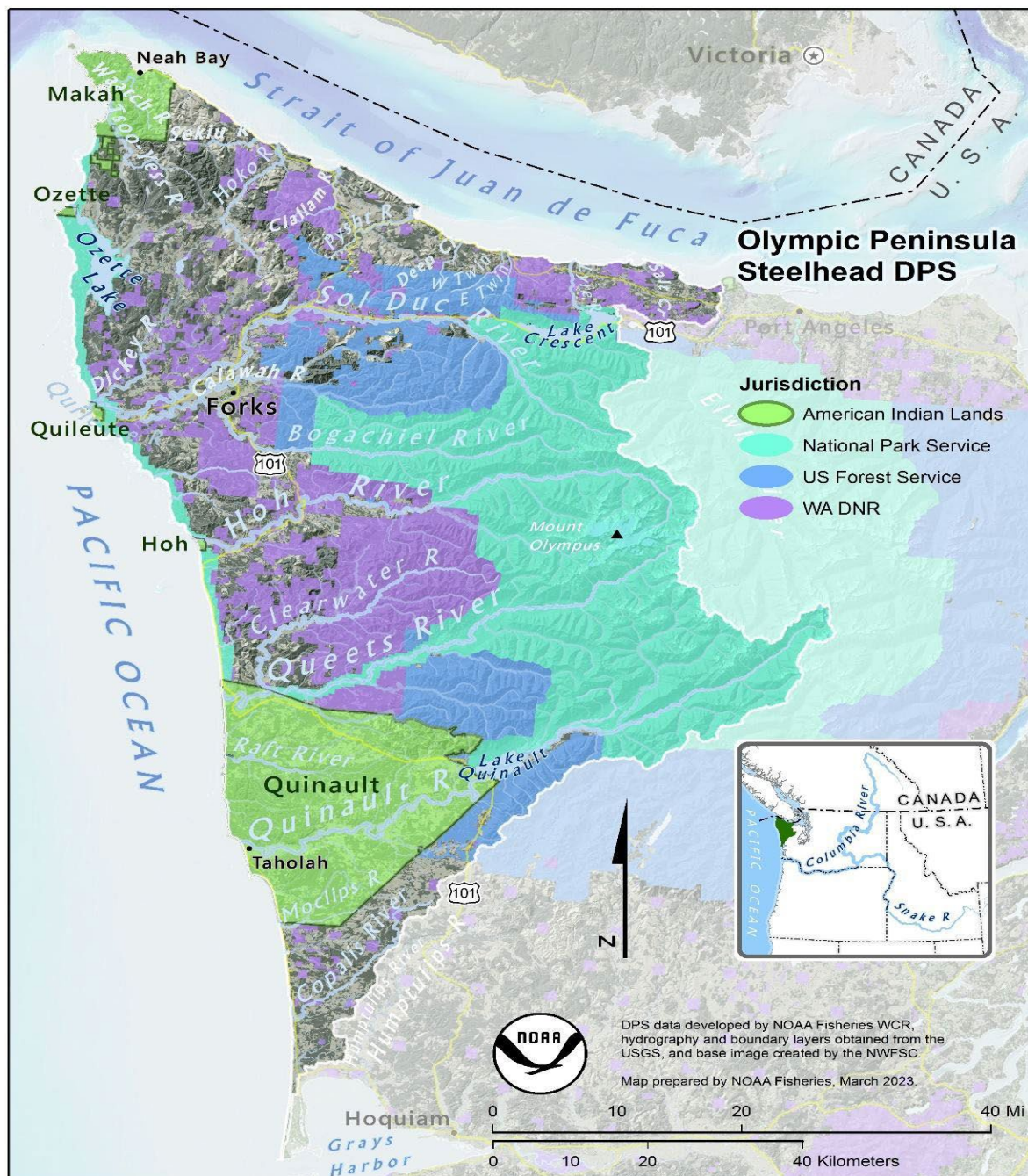


Figure 1. Map of OP steelhead freshwater habitat by jurisdiction.

Table 1. Olympic Peninsula steelhead DPS population/run timing and habitat for each in terms of percent that is forest covered, average years since last disturbed based on recent forest disturbance data between 1986-2019 (see Jin et al. 2023) and percent that is within the boundaries of Olympic National Park (ONP). Average across the whole DPS for each habitat metrics is also reported.

Population	Run	Percent Forest cover	Average Years Since Disturbed	Percent in ONP
Salt Creek-Independents	winter	81%	34.7	0
Lyre	winter	74%	35.0	0
Pysht-Independents (including the Twins)	winter	93%	32.6	0
Clallam	winter	87%	29.5	0
Hoko	winter	96%	25.8	0
Sekiu	winter	94%	23.0	0
Sail	winter	98%	25.5	0
Tsoo-Yess-Waatch	winter	85%	28.0	0
Ozette	winter	77%	27.8	12%
Quillayute-Bogachiel	winter	87%	35.6	37%
Dickey	winter	86%	25.4	0.1%
Sol Duc	winter	94%	35.0	17%
Calawah	winter	95%	33.0	16%
Hoh	winter	79%	36.7	52%
Goodman Creek	winter	91%	30.2	11%
Mosquito Creek	winter	95%	26.2	18%
Kalaloch Creek	winter	92%	32.7	28%
Queets	winter	79%	36.9	63%
Clearwater	winter	93%	32.7	0.1%
Raft	winter	88%	30.7	0

Population	Run	Percent Forest cover	Average Years Since Disturbed	Percent in ONP
Lower Quinault	winter	81%	31.6	0.5%
Upper Quinault	winter	71%	39.3	65%
Moclips	winter	83%	34.7	0
Copalis	winter	62%	28.3	0
Quillayute-Bogachiel	summer	82%	36.3	52%
Sol Duc	summer	94%	36.1	25%
Calawah	summer	95%	32.4	14%
Hoh	summer	76%	37.3	61%
Queets	summer	74%	37.0	77%
Clearwater	summer	90%	32.4	0.1%
Quinault	summer	63%	36.4	38%
Average		85%	32.2	19%

Table 2. The percentage of steelhead habitat utilized within the Olympic National Park (ONP) for various rivers and creeks or basins (for example, “Hoh river” contains subbasins) in coastal Washington that drain directly into saltwater, or in the case of Quillayute – the rivers that comprise the Quillayute system that had more than 0% in the ONP. Any basins/rivers not listed have 0% of steelhead habitat used in the park.⁵

Basin	Total Length of Steelhead Use (m)	Within Olympic National Park (m)	% Within	Outside Olympic National Park (m)	% Outside
Cedar Creek	17,103	2,833	17%	14,270	83%
Goodman Creek	44,652	5,443	12%	39,209	88%

⁵ We attributed the NHD catchments (Hill et al. 2016) with our proto populations (usually inheriting the largest river name) and steelhead distribution (WDFW 2022) by run and use type. These spatial features were then intersected with the land manager polygons from the PAD (USGS 2024) database. From these values we then summarized stream length by steelhead use and population name to determine the quantity and percent of occupied habitat within the Olympic National Park.

Basin	Total Length of Steelhead Use (m)	Within Olympic National Park (m)	% Within	Outside Olympic National Park (m)	% Outside
Kalaloch Creek	11,076	1,136	10%	9,940	90%
Ozette	149,053	14,113	9%	134,940	91%
Mosquito Creek	20,269	1,710	8%	18,558	92%
Upper Quinault	183,483	119,663	65%	63,821	35%
Queets	220,090	90,816	41%	129,274	59%
Hoh	276,356	103,266	37%	173,090	63%
Quillayute:					
Bogachiel	188,336	56,716	30%	131,620	70%
Calawah	139,831	24,264	17%	115,567	83%
Sol Duc	256,847	44,347	17%	212,500	83%

Hydropower development

There are no major dams or hydropower development in watersheds within the range of the OP steelhead DPS. The WDFW review of Washington steelhead stated that for the Olympic Peninsula population, that there's been no habitat loss due to large dams or barriers (Cram et al. 2018). But see section below on **Land-use Practices** for discussion of smaller barriers.

Land-use practices - Logging

Numerous studies have been conducted regarding the impacts of land use activities on salmonid habitat in the states of Washington, Oregon, Idaho, and California, many summarized in NMFS 1996a. Again, because of the extensive summary of impacts of these activities on steelhead in the previous steelhead threats assessment (NMFS 1996a), we incorporate extensively from that document. Land use activities associated with logging, road construction, urban development, mining, agriculture, and recreation have significantly altered fish habitat quantity and quality. Associated impacts of these activities include the following: alteration of streambank and channel morphology; alteration of ambient stream water temperatures; degradation of water quality; elimination of spawning and rearing habitat, fragmentation of available habitats; elimination of downstream recruitment of spawning gravels and large woody debris; removal of riparian vegetation resulting in increased stream bank erosion and higher water temperatures; and degradation of water quality (see references in Anderson 1993; Botkin et al. 1995; Bottom, Howell and Rogers 1985; Brown and Moyle 1991; Bryant 1994; California Advisory Committee on Salmon and Steelhead Trout 1988; California Department of Fish and Game 1965; California Department of Fish and Game 1991; California Department of Fish and Game 1994; California State Lands Commission 1993; Hicks et al. 1991 including: McEwan and Jackson 1996;

National Marine Fisheries Service 1996a; Nehlsen, Williams and Lichatowich 1991; Titus, Erman and Snider 2003). The loss of channel complexity, pool habitat, suitable gravel substrate, and large woody debris, and other development activities have caused increased fine sediment input into spawning and rearing areas (cited in NMFS 1996a: Bottom, Howell and Rogers 1985; Forest Ecosystem Management Assessment Team 1993; Higgins, Dobush and Fuller 1992; U.S. Forest Service and U.S. Bureau of Land Management 1994). Creation of splash dams and lumber transport via rivers associated with previous logging practices led to scouring of spawning gravel, clearing/loss of woody debris, degradation of stream beds and floodplain disconnection (summarized in Coast Salmon Partnership 2022 Annual Report⁶). Splash dam structures are mainly gone but their impacts remain. Due to anthropogenic activities such as timber harvest, Bisson et al. (1997) estimated that there was a 2 to 10 times increase in the frequency of major floods, that both debris flows and dam-break floods were 5 to 10 times more frequent, and also that slumps and earth flows were 2 to 10 times more frequent, compared to natural, background conditions.

Both logging and agriculture activities result in many similar impacts on salmonid habitat. Major impacts common to both activities include loss of large woody debris, sedimentation, loss of riparian (streamside) vegetation, increased water temperatures, and loss of habitat complexity, all of which affect water quality and the biotic communities. Nutrient loading impacts to stream productivity can be caused by mining, livestock, or forest management. Recent work by Naman et al. (2024) showed that across the range of Pacific salmonids, forestry activities led consistently to impacts to stream flow and stream temperature across the range but the magnitude of these impacts varied.

The vast majority of land-use practices in the range of OP steelhead that have been/are detrimental to OP steelhead habitat relate to logging and forestry practices, and only to a limited extent agriculture use, so we focus our discussion mainly to logging practices. The majority of land on the Strait of Juan de Fuca within river basins in the OP steelhead range is timberland (Table 3). For the Salt Creek, state and private forestlands are mostly located in the headwaters (~56%), while agricultural and rural residential lands (42%) are strongly clustered in low gradient stream channel areas in the middle and lower watershed (McHenry, McCoy and Haggerty 2004; North Olympic Peninsula Lead Entity for Salmon (NOPLS) 2015). The Lyre River watershed includes land in the Olympic National Park (~66%), as well as commercial timberlands (31%), and low-density rural residential (~3%) (McHenry, Lichatowich and Kowalski-Hagaman 1996; NOPLS 2015). For East Twin the majority is forest lands - Washington state Department of Natural Resources lands (WA DNR) and United States Forest Service lands (USFS) comprise over 90% of the ownership (NOPLS 2015). Similarly, for West Twin, Deep Creek, and Pysht the majority of the land is for forestry with the majority of the forestlands managed by USFS or WA DNR (~61% for West Twin, ~50% for Deep Creek, and 75% for Pysht) followed by 29%, ~43%, and ~24% owned as private timberlands for West Twin, Deep Creek, and Pysht respectively (NOPLS 2015). Washington state timberlands and industrial forest timberlands make up over 95% of the land ownership in the Clallam River basin (Haggerty 2008). The vast majority of land in the Hoko River is commercial timberlands, however portions of the Lower Hoko River and Little Hoko have been converted to open areas or hardwood-dominated areas and purchased by Washington state parks (NOPLS 2015, personal

⁶ <https://coastsalmonpartnership.egnyte.com/dl/VbBakQwmdS>

communication with Mike McHenry, Lower Elwha Tribe, December 5, 2023). The Sekiu is also predominately privately-owned and state-owned timberlands, with a portion on the Makah Tribal Reservation (NOPL 2015).

For the four major rivers on the West Coast, other than land within the ONP, Olympic National Forest (ONF) or Tribal, the remaining land is state or private- owned timberlands. Land ownership varies as a function of the area below and above Lake Quinault. Below Lake Quinault ownership is predominantly the Quinault Tribal reservation (~80%), followed by Olympic National Forest (~14%), and private timberlands (~7%). Above Lake Quinault ownership is dominated by Federal lands (~95%), followed by Quinault Tribal reservation (~4.5%), and private lands (<0.5%). See Appendix A to the Status Review (NMFS 2024) for further descriptions of each individual watershed/river.

Table 3. Percentage of each landownership type for watershed area by subbasin. Modified from NOBLE 2015. For acronyms: WDNR = Washington State Department of Natural Resources, ONP = Olympic National Park, USFS = United States Forest Service, and Ease./ROW = easements/right of ways.

Sub-basin	Private	WDNR	ONP	USFS	Tribal Lands	County	Other state land	Other fed land	Ease./ROW	Other
Salt	50.2%	44.3%	0	0	0	1.1%	0	3.1%	1.34%	0
Lyre	10.4%	17.5%	65.5%	5.7%	0	0	0	0.6%	0.3%	0
East Twin	6.8%	46.1%	0.01%	46.2%	0	0.1%	0	0.5%	0.3%	0
West Twin	29.0%	9.9%	0	60.9%	0	0	0.01%	0	0.2%	0
Deep	43.2%	4.9%	0	50.4%	0	0.6%	0	0.8%	0.05%	0
Pysht	76.7%	5.9%	0	16.6%	0	0.03 %	0.2%	0	0.5%	0
Clallam	49.6%	47.6%	0	0.1%	0	0.1%	2.1%	0.02 %	0.6%	0.01%
Hoko	72.5%	24.6%	0	0.9%	0	0.2%	1.7%	0	0.1%	0.02%
Sekiu	75.7%	17.3%	0	0	7.1%	0	0.01%	0	0.01%	0
WSI	57.1%	57.1%	0	0	16.8 %	0.6%	0.4%	1.2%	1.0%	0.1%
Total WRIA 19	51.4%	22.3%	11.6%	9.1%	3.9%	0.3%	0.6%	0.5%	0.4%	0.02%

In the OP, past timber harvest practices have resulted in a loss of stream buffers, the removal of instream wood, high-density road construction and frequent use, and harvesting large proportions of watersheds (Martens et al. 2019). These practices resulted in deleterious changes to sediment supply, wood supply, the amount and condition of streamflow, and stream channel morphology (Abbe and Montgomery 2003; Cederholm, Reid and Salo 1981; Logan, Kaler and Bigelow 1991; McHenry et al. 1998; Northwest Indian Fisheries Commission 2020). Forest harvest without stream buffers or minimal streamside buffers, coupled with the removal of instream wood results in stream channels widening due to accelerated erosion, the loss of current and future instream wood important to juvenile steelhead, and overall habitat simplification that results in more variable low and peak flow stream conditions due to the lack of attenuation from instream wood, streambank trees, or more stable streambanks (Abbe and Montgomery 2003; Cederholm, Reid and Salo 1981; Logan, Kaler and Bigelow 1991; McHenry et al. 1998; Northwest Indian Fisheries Commission 2020).

National Marine Fisheries Service (1996a) summarizes impacts of logging (and similar impacts of agriculture) on steelhead habitat by important habitat features - woody debris, sedimentation, riparian vegetation, and habitat complexity/connectivity. Here, we draw from and incorporate extensively from that document for information on impacts to these habitat features.

Riparian vegetation

The loss of riparian vegetation can also negatively affect steelhead. Reduction in shade canopy from tree loss in the riparian zone can lead to increased water temperatures (see discussion in Hicks et al. (1991)). Riparian vegetation also protects stream banks from exacerbated erosion rates and provides depositional areas for gravel and finer materials, all which create and maintain salmon and steelhead habitat (Bottom, Howell and Rogers 1985; California Department of Fish and Game 1994; Forest Ecosystem Management Assessment Team 1993). The reduction in shade canopy due to logging stands adjacent to rivers has resulted in increased water temperatures, in some instances (Bisson et al. 1987; California Department of Fish and Game 1994; Forest Ecosystem Management Assessment Team 1993), and can increase temperatures by 11.7 to 18°F (7.8 to 11.3 °C) (Reynolds et al. 1993). Riparian vegetation provides important substrates for aquatic invertebrates, cover for predator avoidance, and resting habitat for many fish species. Dead organic matter from the riparian vegetation is an important source of nutrients and contributes to the detrital food web (Bisson and Bilby 1998). Removal of riparian vegetation can change autotrophic production, emergence time of fry, growth rate and age at smolting, survival of juveniles, and increased susceptibility to disease (Hicks et al. 1991). Removal may also result in more needles, bark, and branches in the stream in the short-term, increasing dissolved oxygen demand, increasing organic matter, but also increasing in-river cover - these changes may reduce spawning success but also create short-term increases in food production and juvenile survival (Hicks et al. 1991). Any activities that result in direct riparian or streambank modification or streamflow modification that alters riparian composition can contribute to vegetation loss (Reynolds et al. 1993).

Woody debris

Downed trees are important to the functionality of streams and estuaries (Naiman et al. 1992; Sedell and Luchessa 1982; Sedell and Maser 1994; Swanson, Lienkaemper and Sedell 1976) and large woody debris impacts cover, storage of gravel, channel morphology/hydraulic complexity, geometry, pattern, and position, as well as pool formation (Bisson et al. 1987; Hicks et al. 1991). Downstream transport rates of sediment and organic matter are controlled in part by storage of this material behind large wood (Beschta 1979). Woody debris is important to salmonid habitat because it impacts formation of habitat units, provides shelter (cover and complexity) and protection from peak flows, and acts as substrate (Bisson et al. 1987; Hicks et al. 1991; Sedell et al. 1982; Swanson, Lienkaemper and Sedell 1976). Loss of woody debris may also reduce carrying capacity of habitat, increase predation vulnerability for salmonids, lower winter survival, reduce food production, and may result in lower species diversity (Hicks et al. 1991). Reduction of large wood from the harvest of streamside timber has resulted in the reduction of cover and shelter from turbulent high flows (Cederholm et al. 1997). Logging practices before the 1970s led to clogged waterways due too much woody debris that blocked fish migration. Afterwards, actions to remove woody debris led to excessive removal and resulted in loss of salmonid habitat (Botkin et al. 1995; Bottom, Howell and Rogers 1985; California Department of Fish and Game 1994) that could be expected to persist for 50-100 years. Furthermore, past logging has resulted in the elimination of large trees on streamside areas, so consequently there are very few significant trees available for recruitment into streams. Recent research has shown that there are temporal dynamics of wood and that the status is not necessarily static (see Gregory et al. 2024).

Sediment effects

In general, effects of sedimentation on salmonids are well documented and include: clogging and abrasion of gills and other respiratory surfaces; adhering to the chorion of eggs; providing conditions conducive to entry and persistence of disease-related organisms; inducing behavioral modifications; entombing different life stages; altering water chemistry by the absorption of chemicals; affecting useable habitat by scouring and filling of pools and riffles and changing bedload composition; reducing photosynthetic growth and primary production (and thus prey); and affecting intergravel permeability and dissolved oxygen levels (Hicks et al. 1991; Jensen et al. 2009; Koski and Walter 1978; Suttle et al. 2004). Most forest land-use practices accelerated rates of erosion and supply of both coarse and fine sediment, and road networks from logging are a major source of fine sediment (Forest Ecosystem Management Assessment Team 1993; Gibbons and Salo 1973). Accelerated rates and magnitudes of erosion can result in instream sediment levels being 2.5 times the magnitude of unlogged streams, thus reducing egg survival (Cederholm and Reid 1987; Cederholm and Salo 1979; McHenry et al. 1998; Tagart 1984). Sediment effects on steelhead can be grouped into effects of suspended sediment (turbidity), fine sediment that settles into the bed, and coarse sediment.

Suspended sediment can have negative physical and biological impacts. Turbidity from continued sediment suspension can decrease photosynthesis of aquatic plants (through light scattering) and clog respiratory and feeding systems of animals (Bash, Berman and Bolton 2001). Loss of aquatic plants reduces the abundance of snails and invertebrate prey for young salmonids. Turbid water may also impact fry emergence and/or reproduction and social behaviors (Berg and Northcote 1985; Phillips et al. 1975).

Fine sediment that settles into the stream bed affect both survival of eggs in the gravel and production of benthic invertebrate prey (discussed in Hicks et al. (1991), including Cederholm, Reid and Salo (1981); Cordone and Kelley (1961); Lloyd (1987)). From a more recent study, egg-to-fry survival asymptotes at only 10% when fine sediment (<0.85 mm) is greater than 25% (Jensen et al. 2009). Survival of eyed eggs was >90% until fine percentages increased above 20-25% and then survival decreased (Jensen et al. 2009). Embedded sediment and particles deposited as bedload sediment and unstable spawning gravels may also negatively affect steelhead. Increased sedimentation of gravels and pools can also increase stream temperatures (Hagans, Weaver and Madej 1986).

Coarse sediment (generally small gravels and larger) can fill pools fill in with sediment and aggrade (raise the grade or level of) the streambed (Beechie 1998; Beechie et al. 2005), resulting in reduced flood flow capacity as well as wider and shallower streams with less structure and undercut banks. Such changes cause decreased stream stability and increased bank erosion, which exacerbates existing sedimentation problems. Stream widening and reduced depth can increase predation vulnerability for salmonids, and can increase carrying capacity for young fish (age 0) but reduce for age-1 and older fish (Hicks et al. 1991). This can lead to starvation, predation, or reproductive failure of the species. Erosion can also result in increased debris torrents which may decrease cover in some places but increase debris elsewhere; blocking migration and reducing survival or improving habitat where debris is increased (Hicks et al. 1991).

Habitat complexity

A diverse habitat mosaic is essential for healthy and sustainable salmon and steelhead populations (Brennan et al. 2019; Hilborn et al. 2003). In Pacific Northwest and California streams, habitat simplification is a common consequence of land use and has led to a decrease in the diversity of anadromous salmonid habitat, life histories, and overall species complexity (Bisson and Sedell 1984; Hicks 1990; Li et al. 1987; Munsch et al. 2022; Reeves, Everest and Sedell 1993). Habitat simplification may result from various land-use activities, including but not limited to timber harvest, grazing, urbanization (California State Lands Commission 1993; Forest Ecosystem Management Assessment Team 1993; Frissell 1992) and agriculture (Forest Ecosystem Management Assessment Team 1993). Timber harvest and range management activities can result in a decrease in the number and quality of pool habitats (Sullivan et al. 1987). Reduction of wood in stream channels, either from past or present activities, generally reduces pool quantity and quality (Wohl 2017), alters stream shading which can affect water temperature regimes and nutrient input (Bowler et al. 2012), and can eliminate critical stream habitat needed for both vertebrate and invertebrate populations (Richardson and Danehy 2007).

Olympic Peninsula- Watershed Specific Legacy Impacts and Restoration

Above we summarized the impacts of logging land-use practices and here we provide more details on specifics within the OP steelhead DPS range for specific rivers/watersheds, and we provide even more detail in Appendix A (NMFS 2024; a comprehensive watershed assessment provide by the Status Review Team). In addition to the effects of logging, culverts have blocked access to various spawning grounds and rearing habitat and impacted downstream recruitment processes related to sediment and wood (Kemp 2015; Sullivan et al. 1987). Although efforts are underway to address these issues, it may take decades for habitat to recover (Martens et al. 2019) and climate change may exacerbate conditions (Wade et al. 2013). For example, Figure 2 shows currently where barriers exist on the OP due to anthropogenic influence but note below discussion of ongoing barrier removal in the section on *Recent Research on Restoration Potential*. Even with ~25 years of more protective timber harvest regulations related to riparian zones important salmonid habitat components such as instream wood and pools have not recovered through the natural recruitment of wood (Martens and Devine 2023). The estimated timeline for recovery of these remaining degradations could range between 100 and 225 years (Martens and Devine 2023; Stout et al. 2018).

WDFW concluded that the legacy impacts of historical land-use resulting in habitat degradation that continues to be a threat to naturally-produced steelhead, and identified practices including: past clear-cut logging, road building, bank protection mitigations that were poorly designed or unmitigated, as well as floodplain infrastructure impacts (Cram et al. 2018). However, as noted above, most of headwaters for the major river basins occupied by OP steelhead originate within the Olympic National Park (ONP) where these effects should be minimal. WDFW (Cram et al. 2018) identified particular impacts to the Clearwater River, which has headwaters outside of the ONP (unlike other OP steelhead rivers). Specifically, WDFW noted that this river tributary has been extensively logged and this has resulted in increased sediment inputs (from road building and use and tree harvest). Smith and Caldwell (2001) showed that logging in the Clearwater Basin has led to the loss of large woody debris recruitment (see Appendix A, NMFS 2024; for watersheds on the Strait of Juan de Fuca). On the other hand, improvements have been made in

the Hoh River basin, where recent land acquisitions (approximately 90 percent of the basin is now owned by state and Federal government or conservation organizations) and subsequent efforts to restore and protect habitat has led to various stages of regeneration across the Hoh River valley rainforest (Cram et al. 2018). Still, between 2016 and 2020 some 51.6 sq. km of timberland were harvested in the Hoh River basin (Northwest Indian Fisheries Commission 2020). According to Cram et al. (2018), “The effectiveness of currently implemented forest practices for minimizing impacts remains uncertain. For example, incorrectly applied or inadequately designed riparian management zones and incorrect stream typing classifications are known problems that impair habitat protection strategies (Hansen 2001). These practices result in loss of large woody material, fish passage impacts, altered hydrology, water quality impacts, mass wasting (landslides), and elevated stream temperatures (Naiman et al. 1998).”

Smith (2005) summarized habitat quality by multiple limiting factors for each WRIA in Washington. Here, we replicate the findings by habitat factor for WRIs 19-21 (Table 4) within the range of OP steelhead, where DG = data gap. Note that across Washington state, most ratings for limiting factors were DG (43%) or poor (38%) and only 20% of ratings were good or fair. See Smith 2005 for more information on each.

Table 4. Summarized habitat quality by multiple limiting factors for each WRIA within the range of OP steelhead (19-21), where DG = data gap. Findings replicated from Smith (2005).

WRIA	Access (culvert, dams)	Side channel Flood-plain	Sediment quantity	Sediment quality	Road density	Bank/Stream-bed/Channel stability	Instream large woody debris	Pool habitat	Riparian	Water temp.	Water dissolved O ₂	Water other nutrient, toxins, pH	Hydro maturity high flows	Impervious surfaces	Low flows
19	Fair-poor	Poor	Poor	Poor	Fair	Poor	Poor	DG	Poor	Poor-Good	DG	DG	Poor	DG	DG
20	DG	Poor	Poor	Poor	Fair	Poor	Poor	Good	Poor	Poor	DG	DG	Fair	DG	DG
21	DG	Poor	DG	DG	Good	DG	Fair	Fair	Fair	Poor	Good	DG	Good	DG	Good

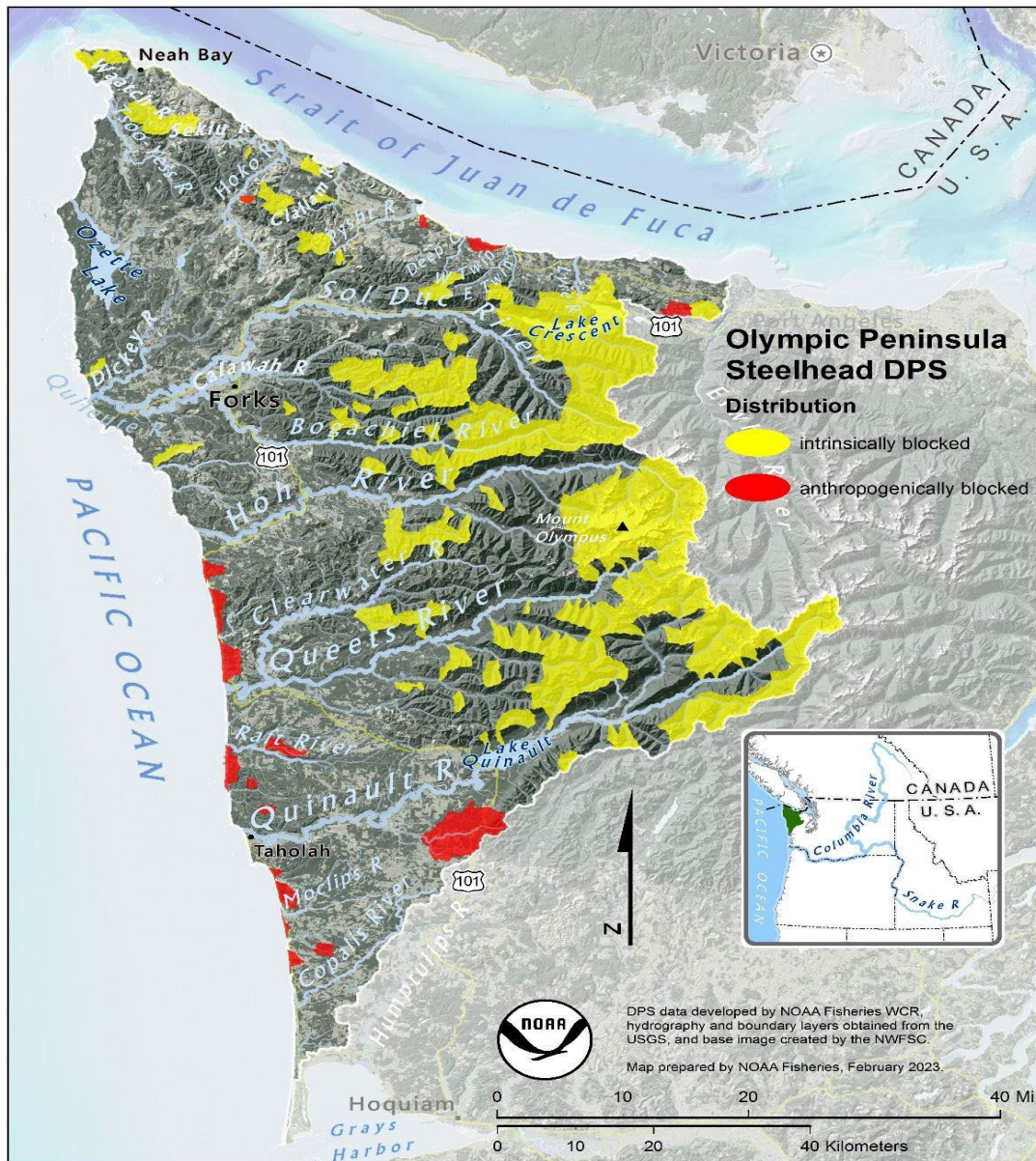


Figure 2. Natural and man-made barriers in the range of the OP steelhead DPS.

We summarized land-use practices, as well as some specific restoration work, by watershed and river (see Appendix A to the Status Review). Here we summarize major themes that were informed by that review about impacts of past and ongoing land-use practices in the OP. For streams within the Strait of Juan de Fuca watershed, the loss of wood due to systematic removal during the 1950s was widespread, occurring in the Lyre, Salt, East Twin, West Twin, Pysht, Clallam, Hoko, and Sekiu basins. Similarly, the loss of riparian recruitment potential due to previous timber harvest and road development was widespread, and not all streams have had or have ongoing restoration actions (wood treatments) (for example West Twin but see description of treatment in East Twin and Deep Creek). Wood treatment to help restore woody debris can also be impacted by natural disturbances such as flooding events. Relatedly, there has been stream channel incision due to the loss of obstructions like woody debris but also due to

decreased floodplain activity. The frequency of landslides has also increased in the Strait watersheds specifically west of Lyre River in East Twin, West Twin, Pysht, Hoko, and Sekiu basins. As we cover extensively in listing Factor E related to climate change, increases in winter flow events, decreases in summer flows and increases in stream temperatures have already been observed. Finally, estuarine area has been reduced by almost 50% for the Pysht River due to land-use and estuarine mouth of the Clallam River has been blocked due to anthropogenic impacts from channel modifications, log rafting, milling, etc. Efforts have been made in Clallam River to allow for connection between the river and marine water and in the Pysht River there are plans to restore the estuarine habitat. Thus, for many basins draining to the Strait of Juan de Fuca the legacy of past land use practices continues to influence habitat stream and riparian habitat quality.

Along the West (Pacific Ocean) side of the Peninsula there have been similar impacts of previous land-use and logging. Historical land-use practices included forest harvest without stream buffers, the removal of instream wood, high-density road construction and frequent road use, and harvesting large proportions of watersheds (Martens et al. 2019). This past timber harvest has resulted in changes to sediment supply, wood supply, streamflow, stream temperature, and stream channel morphology. Timber harvest intensity does vary by river; for example, the Calawah River Basin had intensive logging and road building after a fire in 1951, while the Bogachiel River is partially within ONP boundary and has had less timber harvest and road building (Jaeger, Anderson and Dunn 2023). In general, the reduction in wood loadings and instream wood removal have led to the loss of pools, and decreases in stabilizing wood jams which led to the loss of channel complexity (particularly in the Queets) (Abbe and Montgomery 2003; Martens et al. 2019). Wood loadings continue to decrease and the density of large wood in the OP in forests managed by USFS has decreased by ~50% from 2002-2018 (Dunham et al. 2023). Historic logging in the Queets River basin, even though a large portion of the watershed is in ONP and has a protected floodplain corridor, was intensive and extensive (McHenry et al. 1998).

Road construction in the Queets during this time included techniques that are now known to be sub-standard and resulted in road failures, increased landslide rates (which were 168 times those of a natural reference area), reduced stream habitat conditions particularly in some of the tributaries such as the Clearwater River basin, and 2.5 times the instream sediment levels of unclogged OP streams resulting in reduced salmon egg survival and fry emergence from the density of roads (Cederholm and Reid 1987; Cederholm and Salo 1979; McHenry et al. 1998; Tagart 1984). Additionally, the loss of large trees along riparian zones have resulted in greater streambank erosion (Abbe and Montgomery 2003; Martens 2018). Changes to stream channel morphology have resulted from stream channel incision, stream channel widening, and increased bedload movement. Stream width reduction has occurred in the Calawah River basin since the 1990s, but not in the Bogachiel River (Jaeger, Anderson and Dunn 2023).

In the Hoh River, increases in sediment supply (from timber harvest and glacial retreat) has led to an increase in channel width and braiding, and due to the high alpine terrain of the Hoh Basin, its hypothesized that the Hoh could be particularly vulnerable to sediment increases from high-altitude warming and glacial melting (East et al. 2017). There are anthropogenically blocked areas due to culverts (Figure 2). Similar to the Strait, there has been an increase in the magnitude

and frequency of flooding events on the west side of the Peninsula. From climate change, glacial extent declines have already occurred (up to 1/3 of summer critical water from ice) as well as increases in the frequency and magnitude of summer low flows and summer water temperatures (Dunham et al. 2023; and see Listing Factor E).

Northwest Indian Fisheries Commission (2020)⁷ State of Our Watersheds report summarizes current habitat status (and thus impacts of past and current land use) for the major watersheds within the region. These reports by the Tribes for various watersheds also include useful maps of habitat quality and use and tables with summaries of habitat quality by Tribal indicators. Here, we briefly summarize those descriptions (note more on Climate Change from this report is found in Factor E). Note that most reports provide road density per square mile and densities of greater than 3 miles of road per square mile may impede habitat function (including due to sediment input). Also, there is overlap in area between some of these reports but we summarize conclusions for all that overlap with the OP steelhead DPS.

Quillayute river basin (NWIFC 2020): The Quileute Tribe highlights that the area of interest for Quileute has 75% forest cover and forest cover conditions being good to healthy (NWIFC 2020). Similar to the Hoh watershed, there has been a decline in forest harvest activity with 24.5 square miles per year harvested from 2011-2015 and 17.1 square miles per year from 2016-2019. 56% of land in this region has road density that exceeds 3 miles per square mile. Many culverts that were barriers to fish passage were fixed, but 15% remain that were identified by Road Maintenance and Abandonment Plan (RMAP), while 57% of 371 barriers that were not part of RMAP still remain impassable. Similar to Hoh, peak flows in the region have increased while low flows have decreased. Invasive plant species like scotch broom, reed canary grass, and herb Robert are problematic and could impact salmon, though knotweed presence has declined as a result of eradication work by the Tribe.

Hoh river basin (NWIFC 2020): The Hob Tribe highlights that 80% of the area outside of the ONP has high road density (>3 miles per square mile). Many culverts that were barriers to fish passage were fixed but 20% remain that were identified by the RAMP, while on non-forestland 50% remain and are impassable. Between 2011-2015, forestlands were harvested at a rate of 12.5 square miles per year but this has dropped to 6.1 square miles per year since 2016. Invasive plant species like scotch broom, reed canary grass, herb Robert, tansy ragwort, and Canada thistle are prevalent and could impact salmon, though knotweed has been controlled. As discussed under Factor E (Climate Change), there has been an increase in peak flows and decrease in low flows. High water temperatures impair many streams in this system with 14 bodies of water on the water temperature pollution list (303(d) list for water pollution), and for streams monitored by the Hoh Tribe, 8 of 9 have “widespread maximum temperature exceedances”. Though water temperature is a problem there has been improvement in pH and bacteria pollution.

Queets, Quinault, Chehalis river basins (NWIFC 2020): The Quinault Indian Nation highlights that the area of interest for Quinault has 65% forest cover and 51% of the area has forest cover conditions of good to healthy. Areas in the region that are mainly private forestland have

⁷ <https://nwifc.org/publications/state-of-our-watersheds/#:~:text=The%20State%20of%20Our%20Watersheds,to%20the%20region's%20environmental%20health.>

moderate to poor forest cover conditions and there was a 10% decline in forest cover from 1992-2016. At the same time, most of the area is not impacted by impervious surface (“good” for impervious surface indicator). Many culverts that were barriers to fish passage were fixed but 14% remain that were identified by RMAP while 23% of 728 barriers that were not part of RMAP still remain impassable. 87% of land in this region has road density that exceeds 3 miles per square mile, however, higher road density areas are disproportionately outside of OP steelhead DPS near Chehalis and Centralia. Similar to other watersheds already discussed, winter peak flows continue to increase and summer low flows are decreasing (except in Chehalis where low flow has increased but this is a rain dominated river and outside of OP steelhead DPS range). Water temperature pollution⁸ and dissolved oxygen continue to be water quality problems but again with the majority of these streams being outside OP DPS range (Chehalis river). The addition of water wells continues in the general area and may negatively affect groundwater supply. Work by the Quinault Indian Nation has continued to control invasive species: knotweed, Scotch broom, tansy ragwort, and herb Robert (in the floodplains of Quinault and Queets rivers).

While cumulatively these habitat changes have been large over space and time, the Hoh River Basin, as well as the Queets, Quinault, and Quillayute still exhibit fundamental natural watershed processes and associated habitat characteristics. These include a large forested floodplain that is still intact and functioning. Further a large proportion of these watersheds lie within the ONP (Ericsson et al. 2022). Thus, efforts to protect, restore, and increase the overall resiliency of these larger rivers have been implemented to secure core natural assets (Ericsson et al. 2022).

Pacific Coast region (NWFIC 2020): For the Pacific region as a whole, 5% of forest cover was removed from 2011-2016, with “properly functioning” riparian forest cover decreasing 34.2% between 2011-2016. Further, road densities that equate to “not properly functioning” accounted for 90% of the area in 2019 (an increase from 86% in 2014). Alternatively, at this time, 85% of RMAP culverts have been fixed; however, 226 blocking culverts (non-RMAP) still need correction. In most watersheds winter peak flows have increased (average increase of 12%) and summer low flows decreased (average -27%). Increases in the number of wells threatens groundwater availability, but with greatest amounts of new and existing wells occurring outside the OP DPS range (in Chehalis basin). Only 3% of this region's stream miles were assessed for water quality in 2014 with 86% of those impaired for one or more parameters identified by Washington Ecology. An intensive eradication effort focused on Knotweed has been successful and efforts have expanded to other invasive plants. Another invasive, the European green crab may spread if action is not taken to abate its expansion.

Northwest Olympic Peninsula (NWFIC 2020): Habitat assessment by the Makah Tribe for this area (along the Strait and around the tip of the Olympic Peninsula), indicates that 81.2% of land has healthy or good forest cover, an improvement from 2011, but an overall decline since 1992. Around 81% of RMAP-identified culverts are not barriers to fish migration, but still more than half of non-RMAP fish culverts on private, federal, and county land remain and are impassable to fish. 83% of the land area has road densities of >3 miles per square mile. Water temperature

⁸ Note that a public comment on the 90 day finding noted that the Washington Department of Ecology’s 2022 Water Quality Assessment shows half of Queets and Clearwater river watershed miles don’t meet water quality standards for temperature (as well as total maximum daily loads) - <https://apps.ecology.wa.gov/ApprovedWQA/ApprovedPages/ApprovedSearch.aspx> (last retrieved Apr. 10, 2023)

and dissolved oxygen are the main water pollution problems with 79% of monitored stream length impaired due to temperature and 17% impaired due to dissolved oxygen. Big River is the most degraded with 16.1 miles of impaired stream from temperature, dissolved oxygen, and pH. Similar to the other regions, winter peak flows have increased and summer low flows have decreased (specifically shown for the Hoko River). Additionally, the Makah Tribe continues to work to address the invasive European green crab issue.

Morse Creek to Neah Bay (NWIFC 2020): Lower Elwha Klallam Tribe summarized habitat conditions for portions of WRIAs 18 and 19, which includes a portion of the OP steelhead DPS range. They report a net reduction of 1,966 feet of shoreline due to shoreline armoring (903 feet of new shoreline armoring, 475 feet of replacement, and 4,802 feet of removal of armoring). 91.5% of the area has little to no impact from impervious surfaces. Additions of water wells continue in the general area and may affect groundwater supply, but the rate of increase in the number of new water wells has slowed. 71% of the area has good - healthy forest cover with the most damaged conditions are near the town of Sequim (outside the DPS range). However, there were significant negative forest cover changes near the Pysht River. Invasive plants and animals (European Green crab especially) may be impacting species in the area. This report summarizes more specifics for rivers/streams outside of OP DPS range.

In general, urbanization has led to degraded steelhead habitat through stream channelization, floodplain drainage, and riparian damage (Botkin et al. 1995) (see summary in National Marine Fisheries Service 1996a). Point source and nonpoint source pollution occur due to urbanization, impervious surfaces reduce filtration and increase run-off into the future (and creates flood risk; Leopold (1968)), and flood control and land drainage schemes may also increase flood risk. As the human population increases, additional urbanization and habitat modification are likely to occur. Recently, county populations on the Olympic Peninsula have increased by ~5-12% (see <https://usafacts.org/data/topics/people-society/population-and-demographics/>, Figure 3) which may continue into the future and would likely lead to continued habitat modification in the region.

Along with fish passage correction mentioned above, various projects funded through the Washington State Recreation and Conservation Office since 2000 have led to the protection and restoration of riparian habitat for almost 33,000 acres on the Washington coast (Coast Salmon Partnership 2022 Annual Report - <https://coastsalmonpartnership.egnyte.com/dl/VbBakQwmdS>). This annual report summarizes various restoration efforts for WRIAs within the OP steelhead DPS boundaries (WRIA 20, 21) including many efforts by Tribes. In WRIA 20 (Pacific Coast from Cape Flattery to the Quillayute and Hoh rivers), there have been corrections to 36 fish passage barriers, improvement of sediment transport due to ~450 acres of upland area restoration, 1,353 acres riparian restoration, 11 acres of floodplain reconnection, and 30 miles of restoration instream. In WRIA 21 (predominantly Queets and Quinault rivers), corrections to 33 fish passage barriers have occurred, improvement of sediment transport due to ~480 acres of upland area restoration, 5,939 acres riparian restoration, 14 acres of floodplain reconnection, and 6 miles of restoration instream. For the Pacific Coast Region, that includes watersheds south of the OP, the State of Washington had repaired or replaced 99 fish blocking culverts in the first six years of the program; this however, apparently leaves 226 culverts yet to be replaced by 2034 (Northwest Indian Fisheries Commission 2020).

Ocean Habitat

Myers (2018) describes in depth what is known of the ocean ecology of steelhead. Across the North Pacific steelhead are sparsely distributed throughout their ocean range and distribution varies by age and maturity group. Although steelhead (*O. mykiss*) is an iconic species found throughout the North Pacific rim, little is known about its ocean ecology. To provide insights into migratory routes and habitats occupied by steelhead in the North Pacific Ocean, Courtney et al. (2022) attached pop-up satellite archival tags (PSATs) to steelhead kelts in 2018 (n = 16), 2019 (n = 12), and 2020 (n = 35) from the Situk River, a robust Alaskan population. PSATs recorded extensive post-spawning migrations extending to the western North Pacific Ocean, and as far north as the central Bering Sea. While at sea, tagged steelhead spent the majority of their time in surface waters (< 5 m) and occasionally dived to 15–20 m, but displayed no observable diel depth-based behaviors. Tagged steelhead kelts experienced a thermal environment of 4–16 °C from June to January, after exiting the Situk River. Results from this project corroborate the limited past research suggesting that steelhead predominantly occupy surface waters and that their distribution is largely influenced by sea-surface temperatures of ~5–15 °C. Additionally, results from this study suggest that the waters near the Aleutian Islands are important feeding grounds for steelhead kelts from the Situk River, and thus may play a critical role in the successful reconditioning of repeat spawners in this population. These results provide the first detailed insights into the ocean ecology of steelhead and may be used for a variety of applications (e.g., niche construction, and forecasting future range dynamics under climate scenarios).

Marine habitat factors influencing steelhead include predation, access to prey (primarily forage fish), contaminants (toxics), disease and parasites, and migration obstructions, that can be exacerbated by degraded habitat conditions. Information on steelhead marine habitat was recently summarized in the Puget Sound steelhead DPS recovery plan (NMFS 2019). Studies on tagged steelhead suggest that the fish closely track preferred sea surface temperatures (and likely other conditions) during their marine migrations (Courtney et al. 2022; Hayes et al. 2016). Work

summarized in Myers (2018) also points to sea surface temperature as the primary physical factor impacting marine distribution; salinity and currents may also influence distribution. At sea, steelhead tend to travel at depths less than 5 meters (Courtney et al. 2022), and so are more likely to respond to changes in sea surface temperatures than if they traveled at deeper depths with more constant temperatures. 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. The increased expression of this, more localized, ocean migration life-history strategy may indicate thermally blocked marine migratory corridors or changing ocean conditions. Myers (2018) speculates that prey availability may be the primary biological factor impacting steelhead distribution (see that work for a complete discussion of diet at various life stages).

Work from Myers et al. (2013) summarizes that salmon and steelhead can consume a variety of plastic on the high-seas such as pellets, foams, sheets and that the presence of plastic in the stomach varied by species, age, maturity group, area, and time. They note that potential mechanisms for mortality could be direct through mechanical injury or toxicity, or indirect through impacts to gene expression in offspring and subsequent effects to offspring survival.

A likely threat to marine habitat of steelhead is climate change and this is discussed in the section on listing Factor E.

Listing Factor B: Overutilization for commercial, recreational, scientific, or educational purposes

The discussion under this heading focuses on the patterns of utilization for commercial, recreational, and Tribal purposes. Current management and regulatory schemes for these activities are discussed more in depth under the heading Listing Factor D: Inadequacy of Existing Regulatory Mechanisms and are only discussed here to give context to the harvest data. Harvest of OP steelhead has declined within in the last decade (particularly the last few years) and varies greatly by region (Strait of Juan de Fuca populations vs. the “four major basins” on the coast – Queets, Quinault, Quillayute, and Hoh). We summarize primarily what has occurred since the last NOAA status review (Busby et al. (1996) report), though also provide some information for earlier. Most information presented here is for winter-run natural-origin steelhead in the major four basins (Queets, Quinault, Quillayute, and Hoh – which we refer to as the major four basins) and there are limited data for rivers draining into the Strait of Juan de Fuca (where harvest is mainly terminated) and for summer-run natural-origin steelhead.

As summarized in the previous status review (NMFS 1996a), historically, abundant steelhead populations in western coastal and interior streams supported numerous coastal and inland indigenous tribal fisheries precontact, and Tribal, commercial and recreational fisheries thereafter (Nickelson et al. 1992). In 1932 the newly formed Washington State Game Commission prohibited the commercial catch, possession, or sale of steelhead (Crawford 1979). See the summary of historical fisheries management of steelhead on the Olympic Peninsula and

Washington coast in the WDFW Coastal Steelhead Proviso Implementation Plan (CSPIP) (Harbison et al. 2022) available here: <https://wdfw.wa.gov/publications/02360>.

We do note that Indigenous groups have managed fisheries and the landscape since time immemorial (for example see explanation in Martin 2023), during a time when steelhead thrived. A document by Martin (2023) from Makah notes that sustainable harvest management is a core principle of traditional resource management and embedded into Tribe societal roles, salmon and steelhead have been managed since time immemorial (including their habitat), and this management included both traditional hatchery and harvest practices (see further information from that document presented in Factor D).

The river systems throughout the Olympic Peninsula DPS support sport fishing and commercial, ceremonial, and subsistence gill-net fisheries, with Pacific salmon and steelhead populations subjected to fishing pressure and harvest during most weeks of the year. The highly popular sport fisheries that include guided and non-guided sport fishing are economically important to local communities. Commercial catches of Pacific salmonids are integral to the Treaty Tribes and fish are sold to local, regional, and national markets. Subsistence catch is for personal consumption and ceremonial catch is taken for cultural events by Treaty Tribes. There is no directed ocean harvest of steelhead.

OP steelhead have in the recent past sustained the highest harvest rate among Washington state steelhead populations with an annual harvest rate of 25.6 percent for natural-origin steelhead averaged across rivers where there was data (Cram et al. 2018) and was also highest in the four major basins (Queets, Quinault, Quillayute, and Hoh) – 36.5% from 1980s to 2013. Specifically, until 2013, winter-run OP natural-origin steelhead in the Hoh, Queets, Quinault, and Quillayute systems have had harvest rates ranging from 7% to greater than 48% annually since the 1980s (Table 5). Although fishing mortality has been relatively high, it is likely that this factor alone is not the cause of run size declines, and there are other factors in combination with harvest that underlie observed declines.

Estimates of harvest rates since the 1980s for winter-run natural-origin steelhead for the four major systems (Hoh, Queets/Clearwater, Quillayute, and Quinault [upper + lower]) were provided by the co-managers (COPSWG 2023) along with estimated run size. This information can be used to estimate percent harvest mortality (see *Total Run Size and Estimated Harvest Mortality* in OP Steelhead DPS Status Review Team, 2024; Table 5). More recently (2014-2022) harvest rates in the major four basins have ranged from 13.26%-59.19% depending on year and basin up through 2020, with Queets and Quinault continuing to have average harvest rates in the last decade (2013-2022) of 27% and 36%. During this period harvest rates in the Quillayute and Hoh rivers averaged closer to 20%. In the last 2 years for which we have records, 2021-2022, there have been substantial declines in harvest rates, with harvest rates of 8.66% to 15.44% (across basins) (Table 6). Notably, outside of the major coastal basins, harvest in most rivers along the Strait of Juan de Fuca was terminated in the late 2000s/2010s (see Figure 32 in OP Steelhead DPS Status Review Team, 2024; but see Hoko) and we present harvest information for populations along the Strait of Juan de Fuca in the section *Population Growth and Harvest in Strait Populations* in OP Steelhead DPS Status Review Team, 2024, and further in this section.

Sport and Tribal catch of winter-run population has typically occurred from November- April. In 2004, Olympic National Park implemented catch-and-release regulations for wild steelhead throughout coastal rivers of the DPS within the park. In 2016, WDFW changed the recreational fishing regulations (not including streams in tribal reservations and the ONP) to prohibit retention of natural-origin winter-run steelhead in OP steelhead river basins. Tribal harvest targets early returning winter steelhead, which includes both hatchery- and natural-origin steelhead. Most estimates of harvest rates we present here do not include catch and release mortality (hooking mortality), but there is a management assumed 10% hooking mortality (see below in this section for further information on where included, including for the Hoh River). However, information from Bentley (2017) led to a sport angler encounter rate calculation of 1.14 for wild steelhead, implying some steelhead are caught and released more than once (Harbison et al. 2022), and hooking mortality is not known for fish handled more than once and this may be contributing additional mortality. For the Queets and Quinault rivers, regulations allow for retention of steelhead with a dorsal fin of less than 2 1/8 inches, the height of a credit card (so named the “credit card rule”), because hatchery-origin steelhead are assumed to have eroded dorsal fins and majority hatchery fish in these systems are not marked. Other regulations related to prohibiting bait, limits on hooks, size limits etc. are listed in Appendix 12.4 of Harbison et al. (2022). Recreational fisheries on tribal lands do not prohibit the retention of natural-origin steelhead.

On January 26, 2024, the co-managers clarified for the SRT in a written response what data are included in estimates of run size and harvest (email correspondence with Jim Scott, on behalf of the co-managers, January 26, 2024). For the Hoh River, run size and total catch of natural-origin steelhead included hooking mortality in the sport fishery dating back to 2003/2004 season. The estimated mortality was based on total estimated encounters from sport creel surveys multiplied by 10%, the presumed hooking mortality rate. For the Quillayute, Queets, and Quinault Rivers, annual run reconstruction and total catch of wild steelhead does not account for hooking mortality in the sport fishery. Therefore, the total number of natural-origin winter steelhead mortalities was underestimated for those rivers in all years. For the Hoh River and Quillayute River Basins, ceremonial and subsistence fisheries were included in the estimates of total run size. For the Queets and Quinault systems, on reservation hook and line harvest was included, although the sport on-reservation harvest component for the Queets River was not included in the harvest estimates or associated run reconstruction until the 2020/21 season. Furthermore, there are key differences in estimates of natural-origin steelhead escapement in surveys in Quillayute/Hoh versus Queets systems. The Quillayute/Hoh estimates are based on number of redds x 0.81 female/redd x 2 fish. In the Queets, the estimator is total number of redds x 1 female/redd x 2 fish. Assuming 1,000 redds in a given river, these escapement estimates of natural-origin fish vary by 19%. Harvest rates for winter-run steelhead include any and all steelhead landed in the weeks between week 45 (approximately November 1st) and week 18 in the following year (approximately April), regardless of what fishery / what species was being targeted (Scott, J.B. OP steelhead follow-up questions. Email to Laura Koehn. 17 July 2024); however, any steelhead caught in other salmonid fisheries outside this time period were not included.

Table 5. Annual harvest rates for specific winter-run populations (natural-origin and hatchery combined) for the years specified (from Cram et al. 2018)⁹.

Population (winter-run)	Harvest Rate	Years
Clallam	0.7%	1999-2013
Goodman	6.8%	1995-2009
Hoh	36.7%	1980-2013
Pysht/Independents	14.0%	1995-2013
Queets system	35.5%	1981-2011
Quillayute system	29.6%	1978-2013
Quinault system	48.2%	1991-2013
Salt/Independents	3.9%	1995-2013

Table 6. Calculated harvest rate for the four largest basins (Queets, Hoh, Quinault, Quillayute) for years in the late 1970s/early 1980s to 2022, from run size and escapement data provided by the co-managers (Tribes and WDFW; COPSWG 2023), where harvest is equal to run size – escapement and percent mortality is equal to harvest / run size.

Year	Hoh	Queets Clearwater System	Quillayute System	Quinault (Upper + Lower)
1978			17.23%	
1979			32.67%	
1980	0.00%		30.73%	
1981	0.00%	47.27%	22.40%	
1982	0.00%	38.43%	23.01%	
1983	0.00%	45.78%	18.68%	
1984	0.00%	45.76%	19.45%	
1985	0.00%	49.50%	40.71%	49.17%
1986	0.00%	45.32%	25.28%	34.38%
1987	35.76%	48.71%	33.31%	66.33%
1988	49.07%	48.50%	38.29%	50.77%
1989	36.40%	41.83%	28.45%	48.24%

⁹ Post-spawn steelhead (kelts) may be harvested while returning to the ocean. The redds created by these steelhead (females) would be used to estimate escapement. Thus, there may be double counting of some fish in estimating harvest rates. Given that there is relatively limited harvest in the March-May harvest time, when kelts are emigrating, the bias may not be large.

Year	Hoh	Queets Clearwater System	Quillayute System	Quinault (Upper + Lower)
1990	47.18%	42.84%	38.24%	42.83%
1991	33.83%	37.26%	38.00%	46.01%
1992	54.35%	41.27%	54.38%	57.40%
1993	50.46%	38.97%	53.10%	60.41%
1994	43.86%	28.16%	33.69%	40.11%
1995	38.28%	39.20%	34.89%	42.85%
1996	42.89%	54.80%	29.72%	52.18%
1997	27.55%	41.55%	35.96%	41.15%
1998	7.24%	28.87%	10.30%	51.93%
1999	24.93%	42.77%	21.50%	46.20%
2000	29.23%	30.25%	28.39%	45.96%
2001	48.29%	31.48%	36.48%	59.85%
2002	45.15%	10.40%	28.23%	61.40%
2003	54.90%	35.06%	28.04%	54.90%
2004	44.04%	17.22%	25.74%	62.01%
2005	41.71%	16.37%	24.25%	43.93%
2006	10.97%	14.61%	18.25%	41.03%
2007	22.69%	28.43%	36.14%	38.63%
2008	30.91%	19.22%	25.78%	31.77%
2009	28.18%	23.95%	30.25%	45.91%
2010	26.56%	29.56%	27.32%	37.54%
2011	20.37%	35.07%	19.48%	29.52%
2012	28.50%	42.64%	29.41%	56.30%
2013	36.76%	38.28%	29.16%	49.12%
2014	43.19%	31.31%	26.65%	47.46%
2015	26.58%	30.67%	29.19%	44.43%
2016	19.31%	29.16%	30.34%	59.19%
2017	16.63%	39.78%	16.53%	33.41%
2018	13.79%	20.86%	15.63%	28.14%
2019	13.26%	29.90%	13.90%	36.51%
2020	19.31%	29.91%	13.94%	37.39%
2021	12.29%	9.76%	10.93%	15.44%
2022	9.96%	8.66%	8.93%	11.31%

Typically, summer-run and winter-run steelhead fisheries in ONP are catch and release for wild fish and anglers can retain up to 2 hatchery steelhead per day during the open season, typically from June 1-March 31. The ONP has required catch-and-release of wild summer steelhead since 1992 and for wild winter steelhead starting in 2005. Additionally, the park has implemented numerous conservation measures including: in-season emergency actions to protect wild steelhead in major coastal watersheds (e.g. closures, reduced seasons, gear restrictions), selective

gear regulations and eliminating the use of bait in most sport fisheries directed at wild steelhead; dedication of fly fishing only water (e.g. Hoh River); several major habitat restoration efforts including culvert replacements, permitting of steelhead fishing guides with requirements of reporting of daily catch, effort, and CPUE at the end of each season. See the section on Listing Factor D for further regulations within the ONP and current regulations brochure¹⁰.

The number of natural-origin OP steelhead that are encountered in the sport fishery is calculated by WDFW via creel surveys, with a 10 percent catch-and-release mortality rate and is included in the harvest estimates for the Hoh River basin data. WDFW recently reported recreational fishing pressure for two coastal rivers¹¹. In the Hoh River, a total of 666 interviews were conducted with an estimated 57,273 angler hours in 2022-23 fishing season from December 16-March 31. WDFW estimated that 3,575 wild steelhead were caught and released or ~86% of the run. In the Sol Duc River, WDFW conducted 264 interviews with an estimated 28,329 angler hours. Anglers reported catching 2,204 wild steelhead or ~55% of fish that entered the Sol Duc. Work by Bentley (2017) from WDFW presented evidence that coastal creel catch since 2002-2003 has likely underestimated true total catch (specifically in Hoh and Quillayute watersheds), possibly due to a false assumption that all fishing pressure occurs in index effort count reaches (specific regions used to estimate effort). This work highlights multiple needs for improvements to creel surveys and information storage (including the surveys should extend past April since steelhead continue to spawn¹²). Finally, Bentley (2017) estimated total harvest and release mortality for lower and upper Hoh River and estimated a total of 2,977 released wild in the lower, and 1,603 released wild in the upper from Dec 2014- April 2015 (total escapement goal is 2,400 for the Hoh). Information from Bentley (2017) led to a sport angler encounter rate calculation of 1.14 for wild steelhead, implying some steelhead are caught and released more than once (Harbison et al. 2022). These are no mortality rate estimates for steelhead caught multiple times, but it is likely that this rate would be higher than the first-time encounter rate. Overall, given that the SRT did not have a complete estimate of hooking mortality for most populations, it was presumed that available estimates were a minimum at best, and hooking mortality could even be larger than landed catch in certain systems especially in the last few years when landed catch has been low (in the low hundreds of steelhead).

Many public comments on the 90-day finding voiced concerns that the 10% catch and release mortality rate used by WDFW is too high. Many cited a recent thesis by Lubenau (2022) that found catch and release mortality rates for *O. mykiss* closer to 4% in the Lower Granite Dam area of the Snake River. A more recent publication update by Lubenau et al. (2024) reported a catch and release mortality for wild steelhead in the Snake River of 1.6% (95% credible interval of 0% to 5.2%) and encounter rates of approximately 44% to 47% for wild steelhead (slightly higher for adipose fin clipped steelhead: approximately 47% to 52%). In light of the high encounter rates in the recreational fishery it is likely that many natural-origin steelhead are hooked multiple times, and it is unclear how much this might change the catch and release mortality rate.

Additional conservation strategies since the 1990s have been implemented in commercial and recreational fisheries including: harvest restrictions, shorter seasons, and gear restrictions

¹⁰ https://www.nps.gov/olym/upload/OLYM_Fish_Brochure_2022-0502-508_all_CHARTs_REMOVED.pdf

¹¹ <https://wdfw.wa.gov/newsroom/news-release/public-invited-oct-25-virtual-town-hall-meeting-coastal-steelhead>

¹² <https://wdfw.wa.gov/publications/01918>

(Harbison et al. 2022) (see Listing Factor D). In recent years, WDFW has shortened or closed the recreational fishing season on winter-run OP steelhead at least in part due to low returns. WDFW also imposed restrictions on recreational angling by banning the use of boats (“no fishing from a floating device”) and bait¹³. In 2022-2023 sport fishing was closed on the Quinault and Queets for December 1st- April 30th because of low returns and because agreement was not reached for natural-origin steelhead harvest level. The total number of weeks for Tribal fisheries has declined in recent years (see more information below) specifically in the Queets and Quinault, and as mentioned before, harvest rates have declined. In addition, WDFW added harvest restrictions to protect Bogachiel Hatchery returns¹⁴. See links for additional specifics for gear and other restrictions. WDFW implemented similar gear and floating device restrictions for 2023-2024 and set a bag limit of two hatchery steelhead¹⁴. For the 2023-2024 season, the National Park Service closed Queets and Quinault Rivers within the ONP to sports fishing beginning on November 27th, 2023.¹⁵

In Factor D (Inadequacy of Existing Regulatory Mechanisms), we provide more detail on how fisheries are managed, specifically that OP steelhead fisheries are mainly managed for escapement goals for winter-run steelhead based on freshwater productivity (see Gibbons, Hahn and Johnson 1985). The established escapement goals vary much by river system and range from <100 (in smaller rivers on the Strait) to 5,900 natural origin winter steelhead (Table 4). In the Queets River system, the co-managers have differing escapement goals. Each year, specifically for the four major systems, the co-managers develop management plans outline forecasted run sizes, escapement goals, harvest rates, and fishing seasons. For the Upper Quinault River, escapement has been achieved in recent years (Figure 4), and overall, 76% of the time since 1977. In recent years (2021-2022) harvest rates were lowered (as noted above) because of low returns in some systems, but not necessarily to the extent needed to meet escapement goals. Specifically, in the Queets, the State-specific escapement goals were not met in 2020-2021 and 2021-2022 even with the lower harvest rates because returns were low. The returns, however, met the Tribal escapement goal, which is lower. For 2023, in the Queets the projected return was 4,150 (beginning below the State escapement goal), and State and NPS closed fishing but the harvest rate was set at 16% for the Tribal fishery, leading to an estimated escapement of less than the 4,200, lower than the State escapement goal but greater than the Quinault Tribe escapement goal. This is not the case in each system and each year. For example, in the Quillayute River, the 2022 harvest led to an escapement level above the escapement goal (Quileute-WDFW 2022 plan). The escapement goal is more consistently met in the Quillayute River (Figure 4) Similarly for the Hoh River, in 2020 harvest rates were set to achieve an escapement slightly over the goal (2,485 projected natural-origin escapement). However, like other systems, there is continued harvest in cases where escapement goals are not met in these systems.

¹³ <https://wdfw.wa.gov/publications/02349> ; <https://wdfw.medium.com/changes-to-the-coastal-steelhead-season-67131dd05ba7> ; <https://wdfw.medium.com/frequently-asked-questions-march-2022-coastal-steelhead-closure-364cfa62826f>; <https://www.peninsuladailynews.com/sports/fishing-olympic-national-park-to-shut-down-fishing-on-west-end-rivers/>

¹⁴ <https://wdfw.wa.gov/newsroom/news-release/wdfw-announces-2022-2023-coastal-fishing-season>

¹⁵ <https://www.nps.gov/olym/learn/news/temporary-sport-fishing-closure-necessary-to-protect-declining-populations-of-wild-steelhead.htm>

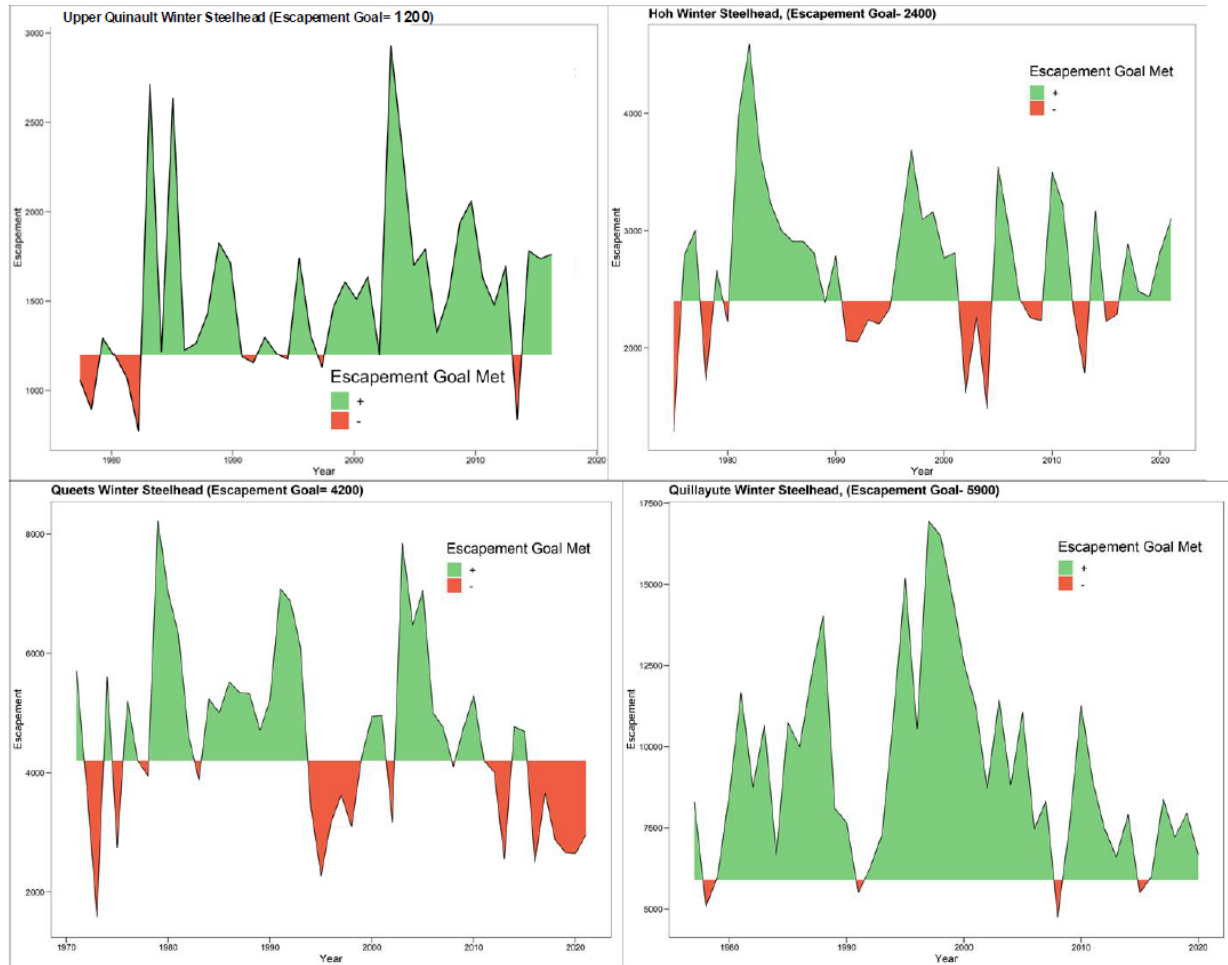


Figure 4. Winter steelhead escapement and escapement goals for the a) Upper Quinault River b) Hoh River, c) Queets River, d. Quillayute. Note that the Washington State escapement goal for the Queets River is 4200, but the Quinault Tribal escapement goal is 2500.

Forecasting accuracy certainly influences whether harvest rates are set to achieve escapement goals in the Olympic Peninsula DPS. In-season harvest monitoring provides some ability to manage escapement. The co-managers state in their 2023 review to the SRT that, “Tribal fisheries are generally shaped by time and area restrictions with in-season management based on monitoring of fishery catches,” (Co-Manager Olympic Peninsula Steelhead Working Group 2023). The co-managers provided examples of in-season management and management taken in recent years (Scott, J.B. OP steelhead follow-up questions. Email to Laura Koehn. 17 July 2024). Specifically, for the Quillayute River, in-season fishery monitoring led to an earlier closure in February of 2022 given low returns and low harvest, leading to harvest of 385 fish and escapement of 8,516 (above the escapement goal). Since the 2021/22 season which had the lowest run size of recent years, there has been an increase in on-river days to 52.7 in 2022/23 and 57.7 in 2023/24 (up from 48.7 in 2021/22) and total run sizes of 9,344 and 9,096 in these years (above escapement, with the 2023/24 escapement still being projected and not a final estimate). For the Hoh River, Tribal fishing has closed in weeks 13-16 since 2015 as this was identified as peak steelhead run time. This has increased in the Hoh recently to 17 weeks in 2024 but with less

participation in the fishery. In the Queets and Quinault rivers, total fishing days have fluctuated through the years during periods of severe changes in ocean conditions. Specifically, in the 1990s to early 2000s, fishing days on the Queets were reduced from an average of 91 to an average of 68 days, and in the Quinault, days were reduced from average 106 to 100 days, particularly later in the season (March, April) when there natural-origin spawning in both rivers. In the mid 2000s, average days of fishing increased (average 102 days on the Queets and average 104 days on the Quinault), but at roughly 50% of harvest levels observed in the 1970s. Between 2017/18 and 2020/21 seasons, fishing days were again reduced to 78 days and 88 days on average on the Queets and Quinault rivers, respectively, and early closures were implemented. Finally, in the most recent seasons (2021/2022 and 2023/24), average gillnet days have been reduced to 35 days in each system (Queets and Quinault) with early closures in February and early sport closures as well (in February or early March), leading to catch limits of natural-origin fish at around 200 fish (<10% harvest rates).

Cram et al. (2018) indicates that harvest may be affecting diversity in a number of life history traits: body sizes, age at maturation, and run-timing. Analysis of scale samples indicated that Tribal fisheries harvested more of the older fish, whereas the recreational fisheries harvested more of the younger fish (Cram et al. 2018). Additionally, for tribal-treaty fisheries, the number of fishing days per week declines during course of harvest period, possibly leading to greater fishing pressure on early-returning adults (Cram et al. 2018). McMillan et al. (2022) found evidence of a shift in peak run-timing of natural-origin winter-run to 1-2 months later and a contraction in overall run-timing by at most 26 days. One hypothesis provided is that fisheries targeting early-run time hatchery fish may have also overharvested early-run natural-fish (also see analysis in OP Steelhead DPS Status Review Team, 2024; in the section *SRT assessment of winter-run run timing changes*). We note that iteroparity (repeat spawning) has declined in the four major coastal rivers, but it is unknown if this is connected to harvest and the assessment by the (Co-Manager Olympic Peninsula Steelhead Working Group 2023) suggests it's related to climatic and biological factors (see Listing Factor E).

Further specifics on harvest in certain watersheds were described in Harbison et al. (2022) and summarized here (but see Listing factor D – Harvest Regulations as well) :

Quinault: State data from 2007-2021 and co-manager knowledge suggest that on any given day there are 10-15 recreational anglers and 2-5 guides in the upper Quinault system during the open season. Note that fishing is managed by the Quinault Indian Nation below Lake Quinault (lower Quinault) and managed above the lake by WDFW (upper Quinault). The escapement goal for upper Quinault is 1,200 steelhead.¹⁶

Queets: Fishing is managed by the state and Quinault Indian Nation outside of the ONP, and by the National Park Service within the ONP. Recreational fishing is primarily boat angling but on the Salmon River is limited to angling from the bank and portions of the Salmon River are only accessible with a Tribal guide. State data from 2007-2021 and manager knowledge suggest that on any given day there are 55-65 recreational anglers and 13-18 guides in the upper Quinault system during the open season. The escapement goal set by the state is 4,200 steelhead, and by the Quinault Tribe is 2,700.

¹⁶ The escapement goal was incorrectly stated in Harbison et al. (2022) as 1,600. It should be 1,200.

Hoh: Fishing outside of the ONP is co-managed by WDFW and the Hoh Tribe. Though the Hoh River has both bank and boat access for fishing, since 2016 limits have been placed on use of floating devices in portions or all of the river. Outside of the ONP and not including the South Fork Hoh, there are estimated to be 60-65 recreational anglers daily on the Hoh River based on creel surveys and 25-30 professional guides, during the open season. The co-managed escapement goal is 2,400 fish.

Quillayute (including Sol Duc, Bogachiel, Calawah, and Dickey): Fishing outside of ONP is managed by WDFW and Quileute Indian Nation. Both boat and bank access are used but it is difficult to wade long distances on the Sol Duc and Calawah. On the Bogachiel, there are 20-25 recreational anglers daily and 8-10 guides in the open season based on WDFW data and regional manager information. This is 30-35 recreational and 10-15 guides on the Sol Duc daily, 20-25 recreational and 5-10 guides on the Calawah, 15-20 recreational anglers and 0-2 guides on the Dickey, and 6-8 recreational and 2-4 guides on the mainstem Quillayute.

Harvest over time since the 1980s for winter-run natural-origin steelhead for the four larger systems (Hoh, Queets/Clearwater, Quillayute, and Quinault [upper + lower] rivers) was provided by the Co-managers along with estimated run size which can be used to estimate percent mortality (Table 6). As noted above, harvest and percent mortality due to harvest have declined in the most recent years (but note that harvest is mainly from November to April while escapement only concerns redds produced after March 15th when it's assumed fish are natural-origin steelhead) (Figure 5). However, analysis of larger rivers (Quillayute, Hoh, Queets, Quinault) indicated that total run size had nearly halved in size from late 1970s and 1980s to 2022, while the recent trend in escapements was slightly declining or stable (Harbison et al. 2022) (see Figures 14-18 in the status review report, section *Abundance and Productivity*, OP Steelhead DPS Status Review Team, 2024).

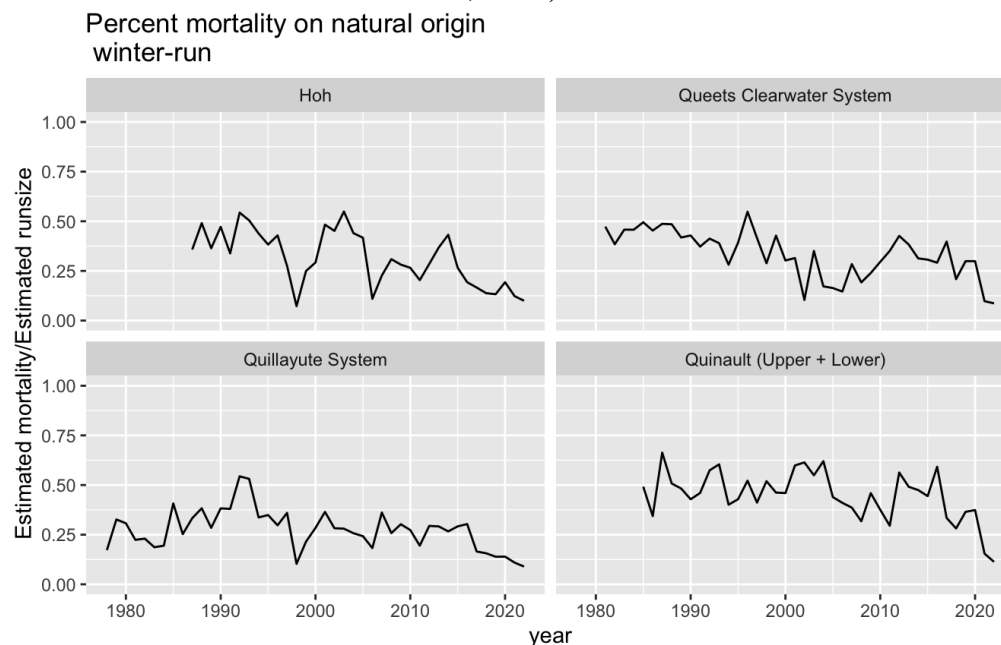


Figure 5. Percent mortality of natural-origin (escapement after March cutoff) winter-run steelhead (harvest mortality divided by estimate run-size) reported by co-managers for the four major coastal rivers. Recreational hooking mortality is only included for the Hoh River.

From a joint time series model for escapement and harvest, we can estimate population growth rate (μ) and harvest mortality for the four major systems:

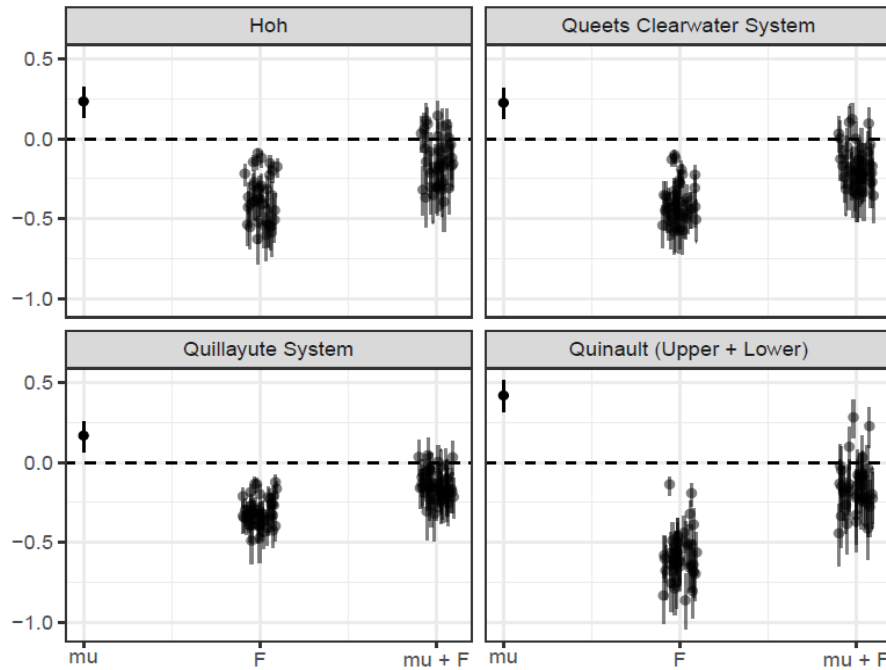


Figure 6. Estimated log scale population growth rate (μ), estimated annual harvest mortality (F), and the net population growth rate ($\mu + F$) and 95% CI for each. For F and $\mu + F$, each point represented the estimated value in a particular year.

The SRT model for harvest mortality fits and produces reasonable estimates of escapement and harvest (Estimates for this model suggest that these populations largely have an intrinsic population growth substantially greater than zero (point estimates of $\mu_i > 0.15$ for all populations). However, they are also subjected to substantial fisheries mortality and in most years this fishing mortality is greater than intrinsic mortality (i.e. generally $\mu_i - F_{it} < 0$; Figure 5), which will result in declining population growth. A small minority of years in each population were judged to have population growth greater than zero. Estimates of correlation among populations were positive and large, indicating that all four of these populations fluctuated in unison ($\theta = 0.83[0.62, 0.97]$ mean[95%CI]).

We also have harvest information for populations along the Strait of Juan de Fuca (the “Strait”) (Figure 7). For harvest in rivers along the Strait, we can plot estimates of growth rates for each population through time highlighting the time harvest ceased (Figure 8) though patterns in growth rate appear highly correlated between streams even in ones where fishing has not ceased. Therefore, it appears some other factor (freshwater and/or ocean conditions) is influencing trends in these populations.

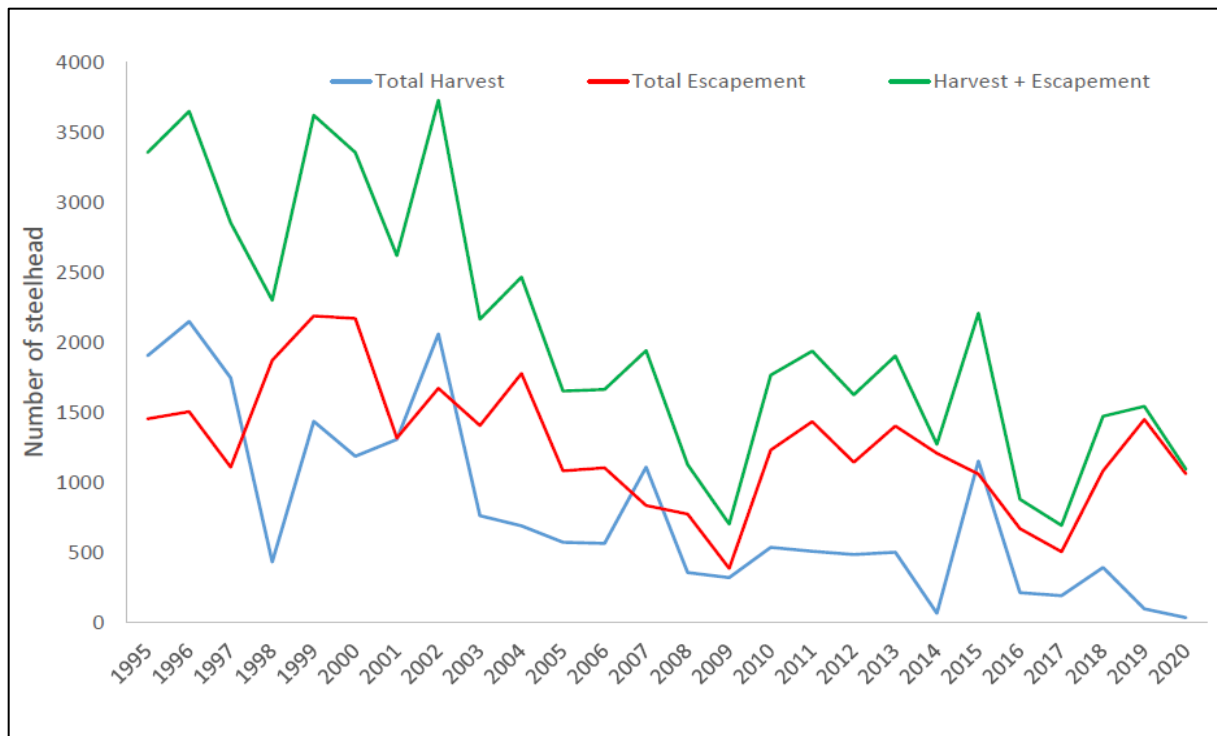


Figure 7. Harvest, escapement, and escapement + hatchery of all steelhead (hatchery and natural-origin) in the Strait system based on catch record cards. Note that in a few years since 1996, harvest has exceeded escapement.

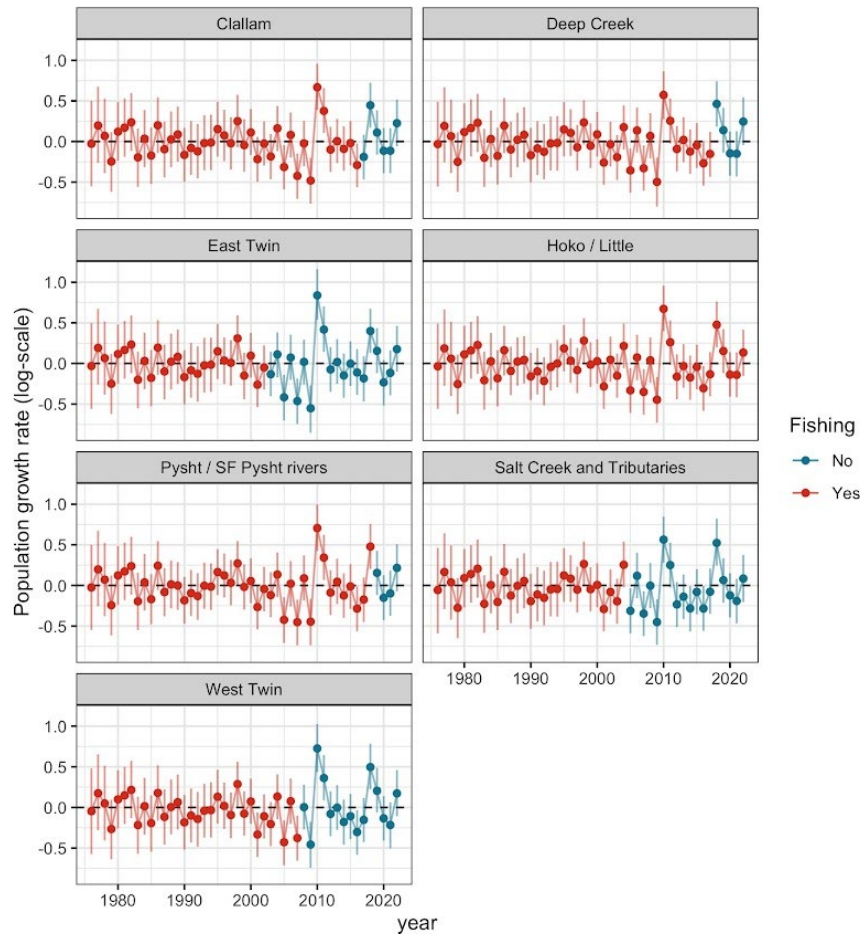


Figure 8. One-year estimates of population growth during period with and without harvest on strait populations of OP steelhead. Estimates are from the DLM output. Mean and 95% CI shown.

There are major caveats to the harvest and run size data presented above. First, we are missing hooking mortalities of natural-origin fish for both on-reservation recreational and other fisheries (except the Hoh River) in these estimates, except in the most recent years (since 2020/21). Alternatively, catch/mortality from fisheries for natural-origin steelhead is based on escapement (redd counts) after March 15th (assuming fish spawning after March 15th are all natural-origin), which may not be an accurate assumption in that natural-origin fish do occur before March 15th. This would lead to underestimates of total run sizes and an overestimate of harvest rates (see discussion in Life History-Traits about run-timing of natural-origin steelhead). For example, older data from 1979-1981 shows that in certain years, roughly on average 30-40% of redds for natural-origin steelhead occur prior to March 15th in certain tributaries of the Queets (figures show more or less for certain creeks in certain years) (Quinault Indian Nation 1981). Additionally, in the Calawah and Sol Duc rivers (Quillayute basin), peak redd abundance is in April/May; however, female natural-origin steelhead can begin spawning in January contributing on average 17% of natural-origin redds created before March 15th (McMillan, Katz and Pess 2007). Alternatively, Marston and Huff (2022) modeling work predicts that approximate 8.4% natural-origin spawning before March 15th (in Calawah and Bogachiel rivers). Since most

harvest occurs in December, January, February (Figure 9) the fishery may be selecting against early run-timing of natural-origin steelhead. Also see Quileute and Hoh harvest management plans for 2023 that show predicted catch of natural-origin fish in January, February (Quileute plan provided by co-managers; Toby Harbison on June 22nd, 2023. Hoh plan provided by co-managers).

Catch of natural-origin fish prior to the March 15th date used by management, may also create higher fishing pressure on earlier-returning natural-origin steelhead. Specifically, see the analysis presented in the Status Review in the section *SRT assessment of winter-run run timing changes* (OP Steelhead DPS Status Review Team, 2024) that showed that for Hoh, Quileute, and also in Queets but to a lesser extent, that natural-origin fish are being caught disproportionately more than hatchery fish prior to March 15th and that pressure on natural-origin fish has been increasing in recent years while pressure on hatchery-origin has decreased. This analysis also showed that in mid-January, most fish caught are natural-origin and by February basically all fish caught at natural-origin. This could be an effect of poorer survival in hatchery-origin fish, since analysis in Harbison et al. (2022) shows that the survival of hatchery smolts is substantially less than that of natural origin smolt and, further that it has diminished in recent years. The greater proportion of natural-origin caught in January, February corroborates data in the Quileute - WDFW and Hoh- WDFW management plans for 2023 that also shows a high harvest of natural-origin steelhead during January and February.

For summer-run steelhead, catch-and-release regulations have been in place from WDFW and in the ONP since 1992, and there are no established escapement goals. Steelhead fisheries occur during times to target winter-run steelhead. At the same time, data shows some harvest (and/or catch and release mortality) of summer-run steelhead in recent years (Figure 9, Figure 10). It is difficult to interpret an impact of catch when summer-run abundance is unknown (see *Summer-run escapement data* section in the status review; OP Steelhead DPS Status Review Team, 2024), but harvest of natural-origin summer-run steelhead has declined since the last NMFS review (see 1980s/early 1990s in Figure 10). Further, we did not have data on the indirect harvest of summer-run steelhead in fisheries targeting other Pacific salmon (this may be reflected in fish ticket information, although the Team did not have that data). In light of commercial gill-net fisheries and recreational fisheries, adult summer-run steelhead are susceptible¹⁷ to bycatch during their upstream migration to spawn, prespawning holding, or as seaward migrating kelts. Given that summer-run population abundances are inherently smaller, this likely increases the potential risk for these populations.

A review by Myers (2018) noted that overall, incidental catch of steelhead in non-target commercial fisheries and illegal catch of steelhead in the marine and estuarine environments is considered low but also not well documented. This includes potential incidental catch in Japanese high sea drift net fisheries targeting other salmon and Asian high sea driftnet fisheries for flying squid. Myers (2018) notes from a study by Pella et al. (1993) that illegal catches in high sea driftnet fisheries in closed areas in the 1980s-1990s may have impacted steelhead in Kamchatka and North America.

¹⁷ By catch rates depend on the specifics of the gear used, timing, and size/age of steelhead.

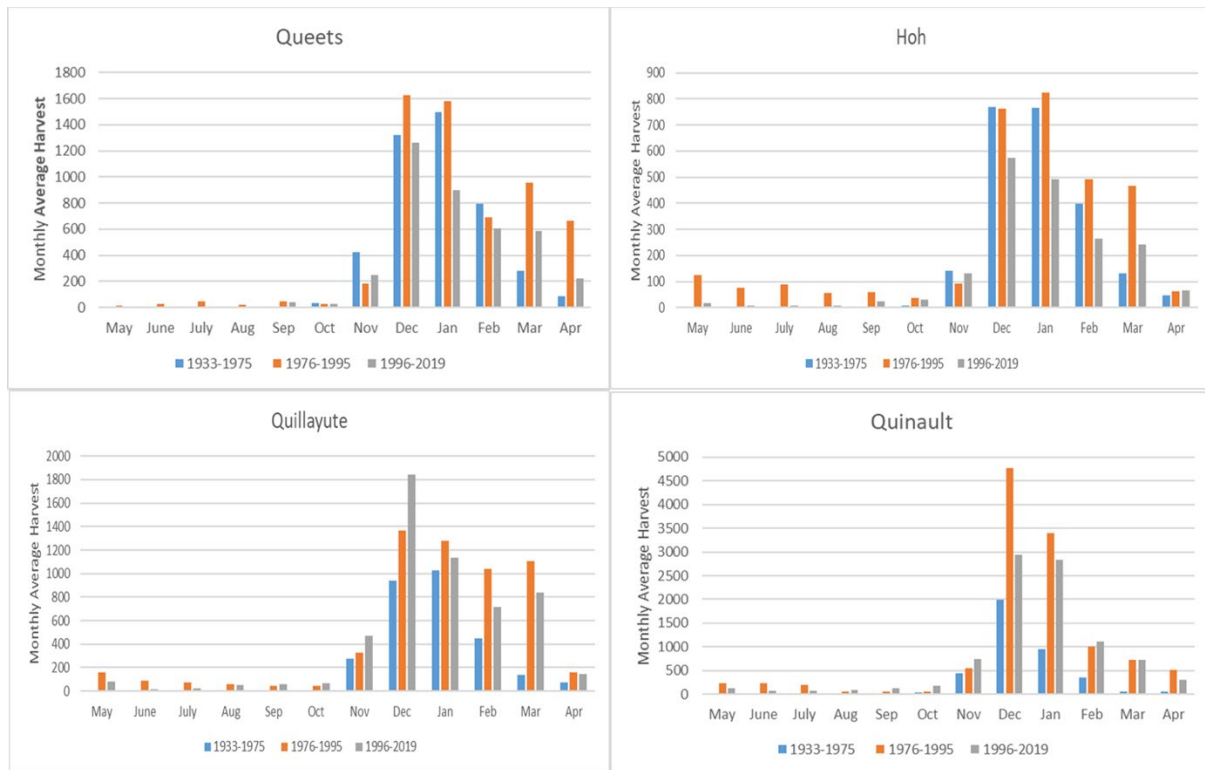


Figure 9. Tribal harvest by month for the four major systems where Nominal Winter Harvest occurs Nov-Apr and Summer Harvest from May-Oct (data provided by the petitioners; from: Rob Kirschner (The Conservation Angler) sent: June 7th, 2023 4:02 PM).

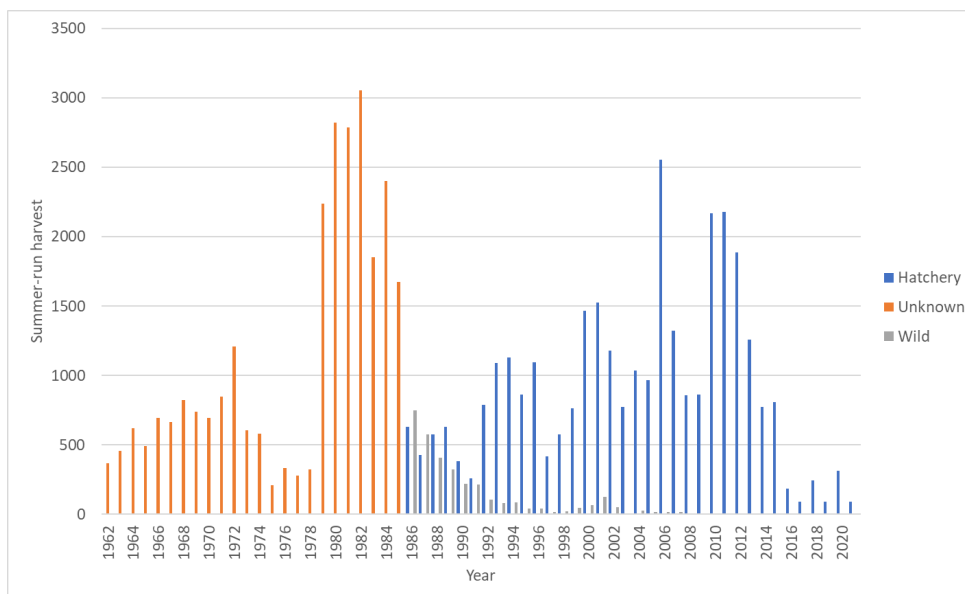


Figure 10. Summer-run harvest broken down by hatchery vs. wild. Prior to 1986 and the marking of hatchery-origin steelhead, hatchery and wild (natural-origin) steelhead harvest was combined. Data provided by the petitioners; from: Rob Kirschner (The Conservation Angler) sent: June 7th, 2023 4:02 PM).

Listing Factor C: Disease and predation

Disease

General know information about infectious disease in steelhead was summarized in NMFS (1996a) and we incorporate here. Infectious disease is one of many factors which can influence adult and juvenile survival. Steelhead are exposed to numerous bacterial, protozoan, viral, and parasitic organisms in across the freshwater and marine habitats: spawning and rearing areas, hatcheries, migratory routes, and the marine environments. Specific diseases such as bacterial kidney disease (BKD), *ceratomyxosis*, *columnaris*, Furunculosis, infectious hematopoietic necrosis (IHNV), redmouth and black spot disease, Erythrocytic Inclusion Body Syndrome (EIBS), and whirling disease among others are present and are known to affect steelhead and salmon (Foott et al. 1994; Gould and Wedemeyer 1980; Leek 1987; Rucker, Earp and Ordal 1954; Wood and WDFW 1979). Very little current or historical information exists to quantify changes in infection levels and mortality rates attributable to these diseases for steelhead. However, studies have shown that native fish tend to be less susceptible to pathogens than hatchery-reared fish (Buchanan et al. 1983; Sanders et al. 1992). Natural-origin steelhead may contract diseases which are spread through the water column (i.e., waterborne pathogens) (Buchanan et al. 1983). Natural-origin fish may also contract diseases through interbreeding with infected hatchery fish (Evelyn, Ketcheson and Prosperi-Porta 1984; Evelyn, Prosperi-Porta and Ketcheson 1986; Fryer and Sanders 1981). Salmonids typically are infected with several pathogens during their life cycle. However, specific characteristics of systems, specifically high infection titers (number of organisms per host) and stressful conditions (crowding in hatchery raceways, release from a hatchery into a riverine environment, high and low water temperatures, etc.) are usually seen prior to disease expression. At the time of the review by Naish et al. (2007), there were very few cases of direct infectious impacts of hatchery fish to wild stocks, but there are mechanisms by which this could occur. See National Marine Fisheries Service (1996a) for further review of disease cases in other systems.

As summarized in NMFS (1996a), another critical factor in controlling disease epidemics is the presence of adequate water quantity and quality during late summer. As water quantity and quality diminishes, and freshwater habitat becomes more degraded, many previously infected salmonid populations may experience large mortalities with added stress triggering the onset of disease. These factors, in combination with high water temperatures common in various rivers and streams, may increase anadromous salmonid susceptibility and exposure to diseases (Holt et al. 1975; McCullough 1999; Wood and WDFW 1979). Furthermore, under most climate change scenarios summer flows will decrease and summer temperatures increasing the susceptibility of summer-rearing juveniles or summer-holding adults to epizootics (Northwest Indian Fisheries Commission 2020).

In the ocean, steelhead may be impacted by ectoparasites. Myers (2018) and studies summarized therein note that salmon lice were highly prevalent, and had mean intensity and abundance of infection in steelhead, pink salmon, and Chinook salmon compared to other Oncorhynchids but that low abundance of steelhead meant that steelhead only hosted a small percentage of the lice *L. salmonis* (Nagasawa 2001). In extreme cases, salmon lice may cause osmoregulatory failure (Nagasawa 1987 cited in Myers 2018; Wootten, Smith and Needham 1982), but natural ocean

mortality of steelhead from lice is not known. Myers (2018) discusses that steelhead may have pathogens without any symptoms presenting and that steelhead are more resistant to salmon anemia virus than Atlantic salmon (citing Rolland and Winton 2003).

Some outbreaks of infectious hematopoietic necrosis virus (IHNV), reovirus, and Pacific salmon paramyxovirus have been documented in OP steelhead, mainly in hatchery-origin fish, though natural-origin fish are not generally sampled. Breyta et al. (2013) summarized previous outbreaks of the M genogroup (group of related viruses) of infectious hematopoietic necrosis virus (IHNV) in the Hoh, Queets, Quinault, and Quillayute river basins (as well as other coastal areas) between 2007 to 2011. M genogroup IHNV is particularly virulent for steelhead and rainbow trout, with high levels of mortality. Prior to 2007 there was only one detection in Washington coast steelhead, in the Queets watershed at the Salmon River Hatchery (in 1997). Most detections from 2007-2011 were in hatchery-origin fish, but Breyta et al. (2013) noted that natural-origin fish are less commonly sampled, and there were detections of this virus in natural-origin fish in the Hoh and Quinault river basins. No IHNV was detected in 2012, but the future risk of IHNV in OP steelhead is unknown given known fluctuations of IHNV incidences in other regions (like Columbia River basin) (Breyta et al. 2013). The effect of IHNV varied across various streams in Washington State and this variation was not fully explained by differences in virulence or hatchery water supplies (Breyta, Jones and Kurath 2014). For example, two separate hatchery populations that came from the same ancestral population had variation in mortality after exposure to a MD IHNV strain. Work by Briec et al. (2015) suggests that there is a genetic basis for resistance to IHNV and that populations have the ability to develop disease resistance, therefore reduction of genetic variation could impact future adaptation and resistance. Exposure may lead to selection of resistance to diseases, but adaptation and the rate that populations become resistant depends on the heritability of the trait (see Crozier et al. (2008)), and Briec et al. (2015) showed that resistance to IHNV is likely heritable. Sockeye salmon are frequently infected with IHNV (Dixon et al. 2016; Traxler et al. 1997) so where sockeye could interact with steelhead, particularly in hatcheries or in rivers like the Quinault or Ozette that support large sockeye runs, this could lead to further exposure to steelhead.

Similarly, we obtained data from Tony Capps (WDFW) on instances of disease, parasites, and viruses in steelhead hatcheries (state, federal, and tribal) on the Peninsula. There were four cases of reovirus in winter-run steelhead in December 2002, January 2003, December 2006, and February 2007, all in the Bogachiel system except the 2007 occurrence in the Sol Duc River. Years later in January 2020 there was another occurrence of reovirus in winter-run steelhead in the Bogachiel. There were eight instances of IHNV in winter-run steelhead in the Bogachiel Basin in winter 2009-2010, with six in December of 2009 and two in January 2010 (possibly the same as noted in Breyta et al. 2013). Finally, there were two instances of Pacific salmon paramyxovirus in Summer-run steelhead in Bogachiel River in summer 2017. Again, most of all known cases are in hatchery fish populations and limited information exists on the incidence of diseases in natural-origin steelhead in the OP. We note that to accurately assess the potential threat of disease in this population we would need annual pathology reports from each hatchery to effectively assess presence/prevalence of pathogens, viruses, bacteria (reports may exist but we were only provided instances of when a pathogen did occur for specific hatcheries).

Predation

Predation on salmonids can come from other fishes, particularly during salmonid juvenile life stages, from avian predators, and from marine mammals, including Resident Killer Whales. Public comments on the 90-day finding included mention of predation by seals, sea lions, otters, eagles, killer whales, cormorants, and/or mergansers on steelhead, including anecdotal accounts of predation in the OP steelhead systems. General information on predation of steelhead was summarized in NMFS (1996a) and for salmonids on the Peninsula in NMFS (2022a), and we draw from these reports here.

In general, predation on juvenile salmon has increased as a result of water development activities which have created ideal habitats for predators and non-native species. More specifically, anthropogenic habitat alterations like dams, irrigation diversions, man-made islands, amongst others have led to increased predation (Antolos et al. 2005; Evans et al. 2019; Hostetter et al. 2012; Moore et al. 2021). However, there are no large dams within the range of OP steelhead; therefore, OP steelhead are not being concentrated by these structures as other salmonids. Predation may significantly influence salmonid abundance in some local populations when other prey are absent and physical habitat conditions lead to the concentration of adult and juvenile salmonids in small areas (Cooper and Johnson 1992). Pearcy (1992) reviewed several studies of salmonids off of the Pacific Northwest coastline and concluded that salmonid survival was influenced by the factional responses of the predators to salmonids and alternative prey.

Invasions of non-native fish species pose threats to native fish fauna but little is known on the extent or effects on OP steelhead. The following nonnative fish species occur in waters of the OP steelhead DPS: Eastern brook trout (*Salvelinus fontinalis*), Atlantic salmon (*Salmo salar*), Westslope cutthroat trout (*Oncorhynchus clarkii lewisi*), yellow perch (*Perca flavescens*), yellow bullhead (*Ictalurus natalis*), largemouth bass (*Micropterus salmoides*), American shad (*Alosa sapidissima*), and Common carp (*Cyprinus carpio*). Non-native Brook Trout (*Salvelinus fontinalis*) were identified as a competing species in the *State of Our Watersheds* report (Northwest Indian Fisheries Commission 2020).

Natural-origin (wild) steelhead likely have greater predator avoidance relative to hatchery-origin fish. Berejikian (1995) found that natural-origin derived fry from the Quinault River had significantly better predator avoidance from prickly sculpin (*Cottus asper*) than hatchery-derived fry, and natural-origin “experienced” fry (visually exposed to sculpin) were eaten less than naïve natural-origin and hatchery-origin. Hostetter et al. (2012) also found that hatchery-origin steelhead in the Snake River were more susceptible than natural-origin to avian predation, and predation was also influenced by steelhead condition and river and rearing conditions. Osterback et al. (2014) found that predation by western gull on steelhead was greatest in intermediate sized juvenile steelhead (compared to small or large) and though natural-origin steelhead had greater predation risk than hatchery, they also had greater survival.

In addition to predation by freshwater fish species, avian predators (gulls, mergansers, herons, diving birds like cormorants and alcids, including common murre and auklets as well as others) have also been shown to impact juvenile salmonids (National Marine Fisheries Service 1996a). More recently, Caspian terns and double-crested cormorants have been documented consuming outmigrating steelhead smolts in the Snake River basin (Hostetter et al. 2012), as well as gulls in

the Columbia River (Evans et al. 2019). Avian predation on juvenile salmonids can occur as they enter the ocean as well (Tucker, Mark Hipfner and Trudel 2016; Zamon et al. 2014). Years of higher or lower availability of preferred prey may (inadvertently) increase predation on salmonids (Wells et al. 2017). With the decrease in riverine and estuarine habitat quality, increased predation by avian predators will occur. Salmonids and avian predators have co-existed for thousands of years, but with the decrease in avoidance habitat (e.g., deep pools and estuaries, large woody debris, and undercut banks), avian predation may play a role in the reduction of some localized steelhead stocks. However, Botkin et al. (1995) stressed that overall predation rates on steelhead should be considered a minor factor for their decline. We did not find information documenting an increase in predation by avian predators for OP steelhead since the last time this population was reviewed (1996), and though seabirds are present in the OP watersheds, we are unaware of any unusual or excessive predation events by seabirds or hotspots of seabird predation (based on pers. Comm. with Thomas Good, 15 October 2023, NMFS NWFSC).

Marine mammal predators of steelhead and other salmonids include harbor seals (*Phoca vitulina richardii*), fish-eating killer whales (*Orcinus orca*), California sea lions (*Zalophus californianus*), and Steller sea lions (*Eumetopias jubatus*) (and see the summary in National Marine Fisheries Service (1996a)). As noted in NMFS (2022a), recent research suggests that predation pressure on salmon and steelhead from seals, sea lions, and killer whales has been increasing in the northeastern Pacific over the past few decades; specifically models estimate that consumption of Chinook salmon by marine mammals has increased from 5 to 31.5 million individual salmon since the 1970s (Chasco et al. 2017a; Chasco et al. 2017b, Couture et al. 2024), but this research was focused on Chinook salmon. Couture et al. (2024) also discuss other salmonids, but there is limited mention of steelhead). A recent review of pinniped predation in Puget Sound and the Washington Coast concluded that pinnipeds are responsible for reduced abundance of salmon in Washington State waters, but are not likely a primary cause for salmon not recovering in those ecosystems (WSAS 2022).

Studies have found that pinnipeds can have a significant predation impact on salmon species (Thomas et al. 2017), as well as steelhead (in Puget Sound; Berejikian et al 2016; Moore et al. (2021); Moore and Berejikian (2022)) through the consumption of outmigrating juveniles. Given that Moore et al. (2021) showed reduced steelhead smolt survival from Nisqually through Puget Sound out to the Pacific Ocean, and OP steelhead along the Strait of Juan de Fuca would migrate through this area as well, seals are likely impacting to some extent steelhead smolt survival. Moore et al. (2021) also showed that this impact to smolt survival is higher in years with less anchovy (another harbor seal prey). But, work synthesized in Pearson et al. (2015) suggests that marine mammal predators can detect pings emitted by acoustic tags and target those fish, thus skewing results. Also, harbor seal predation data specific to coastal tributaries is currently limited, so the extent to which predation of outmigrating juveniles in rivers and estuaries is a threat to specific Oregon and Washington coastal salmon populations is currently unknown. Wright et al (2007) found a single bone from either steelhead or cutthroat trout in harbor seal scat in Oregon.

Hatchery releases of other salmonids may impact predation pressure on steelhead. A recent paper for steelhead in Puget Sound found a negative correlation between weekly steelhead survival and

abundance of hatchery coho smolt releases (but not Chinook salmon smolts) (Malick, Moore and Berejikian 2022). The authors hypothesize that this correlation could be related to either competition between coho and steelhead smolts for prey or shared predators where there is a negative indirect effect to steelhead when predators feed on coho co-occurring with steelhead or predators switch from coho to steelhead. Malick, Moore and Berejikian (2022) voice that the second hypothesis related to shared predators is more likely given that Puget Sound steelhead quickly migrate through the sound and there would be limited time for direct competition (steelhead likely not rearing in Puget Sound).

Environmental and climate conditions may also impact predation risk. Low flow conditions in streams can increase mortality for salmonids (Henderson et al. 2019), with may be related to predation risk and/or predator avoidance (and see discussion and references in Magoulick and Kobza 2003; Penaluna, Dunham and Andersen 2021). Increased turbidity can decrease predation risk for salmonids from fish piscivores (Gregory and Levings 1998). Warmer water temperatures due to water diversions, water development and habitat modification may affect steelhead mortality from predation directly or indirectly through stress and disease associated with wounds inflicted by pinnipeds or piscivorous predators. Similarly, future climate change (see Factor E) may also increase mortality due to predation. Alternatively, a recent study for Puget Sound steelhead showed that in warmer years (during the heat wave from 2014-2016), steelhead smolt survival probabilities increased, likely has a result of greater alternative prey (anchovy) in warm years for marine mammal predators (Moore et al. 2021).

The relative impacts of marine predation on anadromous salmonids are not well understood. However, it is evident that anadromous salmonids have historically coexisted with both marine and freshwater predators and based on catch data, some of the best catches of coho, Chinook, and steelhead along the West Coast of the United States occurred after marine mammals, kingfishers, and cormorants were fully protected by law (Cooper and Johnson 1992). Based on this, it would seem unlikely that in the absence of man's intervention, freshwater or marine predators would extirpate anadromous salmonids. It is likely that historical harvest of harbor seals and other marine mammals by Indigenous communities may have reduced predation on salmonids. Anthropogenic habitat alterations including dams, irrigation diversions, fish ladders, and man-made islands, have led to increased predation opportunities (Antolos et al 2005, Evans et al. 2012, Hostetter et al. 2015, Moore & Berejikian 2022). For OP steelhead, given there are no large dams or barriers, it seems unlikely that the level of predation would have increased from man-made barriers. There is the possibility that predation effects on steelhead has increased given the increase in pinniped populations, but we have no long-term quantitative information on predation on OP steelhead. Also, predation on steelhead in the ocean is largely unknown.

Listing Factor D: Inadequacy of regulatory mechanisms

Overall, one pending regulatory mechanism that would likely impact OP steelhead is any future implementation of the 2022 WDFW Coastal Steelhead Proviso Implementation Plan, which outlines state management strategies for the future of OP steelhead as well as other coastal steelhead populations. This was proposed to be partially funded by the Governor. Specifically,

the Governor’s proposed budget states¹⁸, “\$2,139,000 of the general fund-state appropriation for fiscal year 2025 is provided solely for expanded monitoring, evaluation, and management of coastal-river salmonid fisheries to inform decisions focused on the conservation and management of these resources,” but was not ultimately funded in the Governor’s 2024 supplemental budget. The State is pursuing, but has not acquired, other funding that would be in July 2025.

The Proviso is an application of existing state policies and is not a new policy. It was developed from the recognition of recent declines in coastal steelhead and therefore the need for adaptive management strategies. Additionally, WDFW notes in the Proviso that more region-specific Management Plans, including one for the OP steelhead DPS, have yet to be developed (but are planned). The Proviso provides an implementation strategy for addressing monitoring and evaluation, hatchery operations, fisheries, habitat, and human dimensions, but notes that the lack of crucial data is a limiting factor in management of these populations. Specifically, the Proviso Plan identified recreational fishery monitoring related to in-season management, summer-run steelhead monitoring and data collection (including genetic data), SONAR monitoring for more accurate escapement monitoring, marine survival research including estimating smolt/juvenile survival and abundance, and developing tools to link habitat restoration activities and fisheries management as important research needs. In the absence of any future implementation of the Proviso plan, summer-run steelhead monitoring remains largely unchanged since the time of Busby et al. (1996). Finally, it should be underscored that the Proviso plan is primarily focused on guidelines for management of recreational fisheries in State waters and does not include Tribal commercial or C&S component of harvest, as these are managed by Tribal partners (though the importance of these fisheries are recognized, see Harbison et al. (2022)).

Habitat-related regulations

Regulatory mechanisms related to habitat protection and restoration may be inadequate as there continues to be habitat modification and legacy impacts of past habitat modification that are likely impacting OP steelhead. However, progress towards habitat protection is hard to measure as any ongoing efforts related to habitat restoration may take decades if not centuries to show an effect. Also, there are many existing regulations that help with the general protection of salmonid habitat (which we summarize below), but none specifically directly at steelhead.

Other existing regulations that may be impacting OP steelhead and are summarized below many of which were initiated after the last review of OP steelhead by NMFS (Busby et al. 1996) or were newly implemented at the time of the last review. Because of the geographic overlap between OP steelhead and Ozette lake sockeye salmon (which fall within the OP steelhead range) and because many regulatory mechanisms apply across the state of Washington or federally, many of the habitat regulatory mechanisms that may impact OP steelhead are summarized in recent NMFS 5-year status reviews for Ozette lake sockeye, Upper Columbia River Chinook and Steelhead, Lower Columbia river salmonids, and Snake river Steelhead (amongst others), and we draw on and incorporate information from those reviews extensively for information here (NMFS 2022a, b, c, d) on state and Federal habitat regulations.

¹⁸ <https://app.leg.wa.gov/billssummary?BillNumber=5950&Initiative=false&Year=2023>

Federal

The National Forest Management Act of 1976 establishes the development of land management plans by the U.S. Forest Service (USFS) for units of the National Forest System¹⁹.

Since 1994, the Northwest Forest Plan (NWFP) has guided the management of 17 federal forests along with Bureau of Land Management (BLM) lands in the U.S. Pacific Northwest. The aquatic conservation strategy contained in this plan includes elements such as designation of riparian management zones, activity-specific management standards, watershed assessment, watershed restoration, and identification of key watersheds. The NWFP was accompanied by a regional monitoring program and ongoing research. It is a large, multi-agency effort to conserve biodiversity, particularly old-growth forests, northern spotted owl (*Strix occidentalis caurina*), marbled murrelet (*Brachyramphus marmoratus*), and other species associated with older forests on federal lands in western Washington and Oregon, and northwestern California. It is also designed to protect and restore salmonid habitat, and to provide forest products to support local and regional economies. The NWFP was intended to be a 100-year plan and be flexible enough to adapt to new conditions, threats, and knowledge.

As noted in the proposed listing for Ozette lake sockeye (March 10, 1998, 63 FR 11774), the most significant element of the NWFP for anadromous fish is its Aquatic Conservation Strategy (ACS), a regional scale aquatic ecosystem conservation strategy that includes the following: (1) special land allocations, such as key watersheds, riparian reserves, and late successional reserves, to provide aquatic habitat refugia; (2) special requirements for project planning and design in the form of standards and guidelines; and (3) new watershed analysis, watershed restoration, and monitoring processes. These ACS components collectively ensure that Federal land management actions achieve a set of nine ACS objectives, which include salmon habitat conservation.

Relative to forest practice rules and practices on many non-federal lands, the NWFP has large riparian management zones (1 to 2 site-potential tree heights) and relatively protective, activity-specific management standards. A retrospective on 25 years of the NWFP (Spies et al. 2019) reviewed the scientific literature published since the inception of the NWFP and reports several key findings. It has protected remaining old-growth forests from clearcutting and enabled growth and development of vegetation conditions to support threatened species, including salmonids and riparian-associated organisms (Spies et al. 2018). While the number of ESA-listed salmonid species and population units has increased, the pace of passive restoration, particularly in the face of climate perturbation, is insufficient to improve productivity at a rate necessary to achieve recovery. In addition, existing data are insufficient to determine whether basic survey and management criteria are met, and, management on federal lands alone without parallel efforts on non-federal land is not sufficient to achieve recovery (Reeves et al. 2018).

Over 990 square miles of the Olympic Peninsula are part of the Olympic National Forest (ONF) (Halofsky et al. 2011). Within the ONF, management is guided by the land and resource management plan (LRMP) which was amended by the NWFP. Therefore, with the LRMP and the associated establishment of the ACS, the ONF management activities should work to maintain and/or restore watersheds. Additionally, there is a forest strategic plan set for the ONF

¹⁹ <https://www.fs.usda.gov/emc/nfma/includes/CFR-2018-Title36-Vol2-Part219.pdf>

which helps to prioritize actions related to, “habitat restoration, road decommissioning, forest thinning, and fuel reduction treatments” (Halofsky et al. 2011), and integrating management related to wildlife, aquatics, fire, and silviculture (Halofsky et al. 2011).

According to Halofsky et al. (2011), the ONF is focused on:

“Managing for native biodiversity and promoting the development of late-successional forests. Restoring and protecting aquatic ecosystems from the impacts of an aging road infrastructure. Managing for individual threatened and endangered species as defined by the Endangered Species Act (ESA) (ESA 1973) and related policies”

The Olympic National Park (ONP) is 1,442 square miles of land encompassing several different ecosystems, from the dramatic peaks of the Olympic Mountains to old-growth forests, beaches, riverine systems, and lakes. The National Park Service carries out its responsibilities in parks and programs under the authority of Federal laws, regulations, and Executive Orders, and in accord with policies established by the Director of the National Park Service and the Secretary of the Interior. The Park sets regulations for access and activities allowed within its boundaries, such as boating and fishing regulations. The National Park Management Policies 2006, has a stated policy for Improving Resource Conditions within the Parks, inclusive of biological resources, as well as responsibility for retaining parks “in their natural condition” – which is defined as the condition of resources that would occur in the absence of human dominance over the landscape.

The ONP created a General Management Plan in 2008 (National Park Service 2008). This plan set desired outcomes for the Park over the course of the 15-20 years and also established management zones within the ONP and goals for resource conditions within those zones (see summary in Halofsky et al. (2011)).

Multiple rivers and streams where OP steelhead occur have been designated as bull trout (*Salvelinus confluentus*) critical habitat (75 FR 63875-63978, October 18, 2010), which may indirectly benefit steelhead. Listed species like Lake Ozette sockeye salmon (*Oncorhynchus nerka*), bull trout, Northern spotted owl (*Strix occidentalis caurina*), and marbled murrelet (*Brachyramphus marmoratus*) occur on the peninsula, and the NMFS and USFWS have conducted biological opinions under section 7 of ESA for Federal actions in this region, including for the Forest Management Activities in the Olympic NF. Therefore, these consultations may help to mitigate federal actions in OP steelhead range that could destroy or adversely modify critical habitat of these other species, but does not prevent actions from potentially adversely affecting these habitats and are not specific to steelhead.

Many nation-wide regulations could have an impact on OP steelhead habitat but is difficult to pinpoint exact repercussions for OP steelhead specifically. The Federal Clean Water Act of 1973 addresses the development and implementation of water quality standards, the development of Total Maximum Daily Loads (TMDLs)²⁰ filling of wetlands, point source permitting, the regulation of stormwater, discharge of dredge and fill material, and other provisions related to

²⁰ A TMDL is a pollution budget and includes a calculation of the maximum amount of a pollutant that can occur in a waterbody and allocates the necessary reductions to one or more pollutant sources. A TMDL serves as a planning tool and potential starting point for restoration or protection activities with the ultimate goal of attaining or maintaining water quality standards.

protection of U.S. waters. EPA and the Corps of Engineers retain some specific authority for clean water regulation, and some authority is delegated to the states.

The National Flood Insurance Program (NFIP) is a federal benefit program that extends access to federal monies or other benefits, such as flood disaster funds and subsidized flood insurance, in exchange for communities adopting local land use and development criteria consistent with federally established minimum standards. Under this program, development within floodplains continues to be a concern because it facilitates development without mitigation for impacts on natural habitat values.

All West Coast salmon species, including 27 of the 28 species listed under the ESA, are negatively affected by an overall loss of floodplain habitat connectivity and complex channel habitat. The reduction and degradation of habitat has progressed over decades as flood control and wetland filling occurred to support agriculture, silviculture, or conversion of natural floodplains to urbanizing uses (e.g., residential and commercial development). Loss of habitat through conversion was identified among the factors for decline for most ESA-listed salmonids. “NMFS believes altering and hardening stream banks, removing riparian vegetation, constricting channels and floodplains, and regulating flows [altering the natural hydrograph] are primary causes of anadromous fish declines (65 FR 42450 July 10, 2000)”; “Activities affecting this habitat include...wetland and floodplain alteration; (64 FR 50414 Sept. 16, 1999).”

Development proceeding in compliance with NFIP minimum standards ultimately results in impacts to floodplain connectivity, flood storage/inundation, hydrology, and to habitat forming processes. The development consequences of levees, stream bank armoring, stream channel alteration projects, and floodplain fill, combine to prevent streams from functioning properly and result in degraded habitat. Most communities (counties, towns, cities) in Washington and Oregon are NFIP participating communities, applying the NFIP minimum criteria. For this reason, it is important to note that, where it has been analyzed for effects on salmonids, floodplain development that occurs consistent with the NFIP’s minimum standards has been found to jeopardize 18 listed species of salmon and steelhead (Chinook salmon, steelhead, chum salmon, coho salmon, sockeye salmon) (National Marine Fisheries Service 2008; National Marine Fisheries Service 2016). The Reasonable and Prudent Alternative provided in NMFS 2016 (Columbia Basin species, Oregon Coast coho salmon, Southern Oregon/Northern California Coast coho salmon) has not yet been implemented.

State

The Forest Practices Act in Washington as well as the Washington State Forest Practices Rules (Title 222 WAC), establishes rules and guidelines for forest management on non-federal land in Washington State, to be “managed consistent with sound policies of natural resource protection”²¹. Washington State Department of Natural Resources states that these rules, “are designed to protect public resources such as water quality and fish habitat while maintaining a viable timber industry”²².

²¹ RCW 76.09.010 <https://apps.leg.wa.gov/RCW/default.aspx?cite=76.09>

²² <https://www.dnr.wa.gov/about/boards-and-councils/forest-practices-board/rules-and-guidelines/forest-practices-rules>

The statute (RCW 76.09) and the implementing rules and guidelines (WAC 222) govern forest practices on all private forest lands in Washington as well as all non-DNR state-owned forest lands irrespective of ESA listings. Additionally, these protections are monumented in NMFS's Habitat Conservation Plan (HCP) Biological Opinion ([NMFS 2006](#)).

In addition to protections on private and non-DNR state-owned forest lands, DNR's Habitat Conservation Plan (WADNR 2007) addresses compliance with the Federal ESA on state trust lands (NMFS 1997). The HCP covers approximately 1.9 million acres of DNR-owned forest lands within the range of the northern spotted owl (*Strix occidentalis caurina*), which includes all of the Olympic peninsula. This plan allows for timber harvest and other forest management while complying with the ESA and minimizing and/or mitigating impacts to threatened and endangered species, under section 10 of ESA. This plan may help mitigate impacts to OP steelhead where there is overlap with other Federally listed species and their critical habitat. Furthermore, the Forest Practices Habitat Conservation Plan was established in 2006 and led NMFS and USFWS to issue a 50-year Incidental Take Permit for Washington State for Federally listing species, because of assurances from Washington state that implementation of forest practice and management would comply with ESA²³.

In January 2018, the Washington Legislature passed the Streamflow Restoration law (90.94 RCW) that helps restore stream flows to levels necessary to support robust, healthy, and sustainable salmon populations while providing water for homes in rural Washington. The State law requires that enough water is kept in streams and rivers to protect and preserve instream resources and values such as fish, wildlife, recreation, aesthetics, water quality, and navigation. One of the most effective tools for protecting stream flows is to set instream flows, which are flow levels adopted into rule. Instream flows cover nearly half of the state's watersheds and the Columbia River. In Washington – and especially on the east side of the state -- out-of-stream uses, especially irrigation, exacerbate seasonally low flows, leading to passage and temperature problems, and the loss of habitat living space. Other water uses and land use (lack of recharge arising from impervious surfaces) also contribute to low streamflow levels. The Washington State Department of Ecology has a list of critical watersheds where instream flows are thought to be a contributing factor to “critical” or “depressed” fish status, as identified by the Washington Department of Fish and Wildlife.

Washington State has an anti-degradation standard in law (90.48 RCW) which is the basis for its regulations. These regulations include use-based criteria for existing and designated uses to set the Surface Water Quality Standards, (Washington Administrative Code (WAC) 173-201A). These use criteria include aquatic life criteria, and specifically name salmonid life history uses such as spawning, rearing, and migration. The EPA approved the Washington State's updated Water Quality Assessment 305(b) report and 303(d) list in 2012.

Hydraulic activities in Washington are regulated through the Revised Code of Washington (RCW) 77.55, specifically RCW 77.55.181, which was recently added the Fish Habitat Enhancement Project process, referred to as the Habitat Restoration pilot program. From this,

²³ <https://www.dnr.wa.gov/programs-and-services/forest-practices/forest-practices-habitat-conservation-plan>

any work near the salt or freshwater that changes, diverts, obstructs, or uses the water flow or bed must be sure to maintain a no-net loss of fish and their habitat.

In 2015, the Washington state legislature created the Fish Passage Barrier Removal Board ((Revised Code of Washington (RCW) 77.95.160) to establish a new statewide strategy for fish barrier removal and administering grant funding available for that purpose. The legislation established several key objectives for the new strategy including:

- Coordination with all relevant state agencies and local governments to maximize state investments in removing fish barriers.
- Realizing economies of scale by bundling projects whenever possible.
- Streamlining the permitting process whenever possible without compromising public safety and accountability.

Chaired by WDFW, the board includes representatives of Washington State Department of Transportation, Washington Department of Natural Resources, Tribes, city and county governments, and the Governor's Salmon Recovery Office. In developing the statewide strategy, the board has been working closely with salmon recovery organizations to approve statewide guidelines. Highlights of the Board's work include:

- Approving two project pathways: 1) Watershed Pathway - Remove multiple barriers within a stream system. 2) Coordinated Project Pathway - Remove additional barriers upstream or downstream of a planned and funded project.
- Approving the initial focus areas for Watershed Pathway.
- Analyzing barriers submitted for Coordinated Project Pathway.

As of June, 2020, the Washington Department of Transportation has corrected more than 73 fish passage barriers in the injunction area and opened more than 329 miles of anadromous fish habitat, including ESA-listed salmon and steelhead habitat (WSDOT 2021). The other responsive state agencies have completed their known barrier corrections and all four agencies continue to monitor their roads to ensure that newly discovered barriers are quickly corrected

Updated in 2021, RCW 77.85 includes information for guiding the monitoring, protection, and recovery of salmonids as well as the Statewide Salmon Recovery Strategy (see summary in Harbison et al. (2022)). This led to the development of Lead entities for specific geographic areas that are tasked with identifying habitat projects, prioritizing projects, and exploring funding for projects. A Salmon Recovery Board approves projects submitted by the Lead entities and local organizations implement the projects. The Co-managers in their 2023 assessment of the petition (Co-Manager Olympic Peninsula Steelhead Working Group 2023) voice that "road maintenance and abandonment plans are now complete and positive progress on addressing culvert blockages is occurring..."

Cumulatively, many laws and regulations are in place to regulate freshwater habitat in Washington; however, it is difficult to assess how effective these are specifically for protection and recovery of OP steelhead.

Harvest regulations and monitoring

This section summarizes harvest regulations, noting that the discussion in listing Factor B describes aspects of harvest regulation, many of which we repeat here for continuity, but

additional information can be found above. Certain information was adopted from the 1996 Conservation Efforts report or 1996 Factors for Decline report for steelhead (NMFS 1996a,b).

The Washington Department of Fish and Wildlife (WDFW) cooperatively manages steelhead with Treaty Native American tribes and other parties and publishes yearly sport fishing regulations for steelhead (National Marine Fisheries Service (1996b)). For background on salmonid fisheries regulations in Washington state and based on the Pacific Salmon Treaty, see the summary in Duda et al. (2018) and/or Harbison et al. (2022). At the time of the 1996 NMFS steelhead review, wild steelhead could be harvested in Washington, but only if the wild run size was projected to have surplus escapement. Per existing court orders and through agreements between the State and Tribes (including U.S. vs. Washington, aka the Boldt decision - <https://lib.law.uw.edu/c.php?g=1239321&p=9069754>), harvestable surpluses of steelhead (wild and hatchery fish) were allocated approximately equally between treaty and non-treaty fishers. The WDFW defines adult steelhead as sea-run rainbow trout over 20 inches in length and since 1985, has marked all hatchery fish with an adipose clip to facilitate the identification and conservation of wild steelhead while allowing the harvest of hatchery steelhead. Most non-treaty sport fisheries for winter steelhead were directed at hatchery fish early in the season and many seasons were closed prior to the time most natural-origin fish enter the streams. In addition, freshwater recreational regulations (e.g., springtime stream closures and an 8-inch minimum size limit on all rivers statewide) were set to prevent anglers from targeting steelhead smolts. Wild steelhead release regulations (WSR), closed seasons, or area closures were implemented as appropriate to regulate the recreational fishery. As a general strategy in mixed hatchery-wild fisheries, WDFW would institute WSR if wild runs appeared to be under-escaped (or their status was unknown), and invoked area closures.

A summary document on Traditional Ecological Knowledge (TEK) provided by the Makah for this status review provides helpful context on management and biases of certain historic data (Martin 2023). The document from Makah notes that sustainable harvest management is a core principle of traditional resource management and embedded into Tribe societal roles, salmon and steelhead have been managed since time immemorial (including their habitat) and this management included both traditional hatchery and harvest practices. They also highlight that historical documents on harvest from the 1950s-1970s were prepared by non-Tribal entities and contain biases and limitations; not adequately representing historic conditions and biases in reporting of fish. They note that “historical data” may not be reliable. We mainly focus on data since 1996 but note this context for any consideration of more historical data or management information. Makah also highlight Tribal historical documentation that notes previous poor salmon returns due to climate conditions.

Sport harvest on all streams (except the Columbia River) is calculated from returns of permit cards that all persons fishing for steelhead in Washington are required by law to have. In addition, WDFW requests that anglers also keep records of all released steelhead. Information from steelhead permit cards provide WDFW with data valuable for assessing trends in sport catch.

Tribal steelhead harvest is gathered from several sources: state licensed game fish buyers return game fish receipt tickets to WDFW, on-reservation tribal enterprises report purchases of

steelhead and steelhead taken for ceremonial/subsistence use, and reports of steelhead caught incidental to salmon fisheries and information gathered through enforcement programs.

The 2008 statewide steelhead management plan (Washington Department of Fish and Wildlife 2008) provided state management guidelines for the steelhead resource in Washington but recognized that individual regional plans were needed to include Tribes. The plan presented a framework to achieve the following goal for steelhead:

“Restore and maintain the abundance, distribution, diversity, and long-term productivity of Washington's wild steelhead and their habitats to assure healthy stocks. In a manner consistent with this goal, the Department will seek to protect and restore steelhead to achieve cultural, economic, and ecosystem benefits for current and future residents of Washington State.” (WDFW 2008 - <https://wdfw.wa.gov/publications/00149>)

To reach this goal, WDFW outlined implementation of policies related to natural production; habitat protection and restoration; fishery management; artificial production; regulatory compliance; monitoring, evaluation, and adaptive management; research; and outreach and education. More specifically, they noted prioritizing protection of wild steelhead, and protecting and/or restoring the quality, quantity, and productivity of both freshwater and marine habitat. Within fisheries management, they specified protection and restoration of the four criteria for a viable salmonid population, VSP (diversity, spatial structure, abundance, and productivity), while corporately managing resources with Tribes, and also providing diverse recreational opportunities. Within artificial production they noted striving for a net aggregate benefit to the 4 VSPs of wild stocks from artificial programs and enhancing harvest opportunities. More specific strategies and actions for these, including harvest, are detailed in the plan.

Olympic Peninsula rivers support a combination of sport fishing, as well as commercial, ceremonial, and subsistence gill-net fisheries for Pacific Salmon and steelhead. Summer and winter steelhead are collectively managed by WDFW and Treaty Tribes (in the Boldt Case Area) and the National Park Service in the Olympic National Park (ONP). WDFW has jurisdiction over recreational fisheries in Washington state waters and outside of the ONP boundaries. The Treaty Tribes regulate commercial, subsistence, and tribal-guided fisheries. ONP has exclusive federal jurisdiction to manage recreational fisheries within the park boundaries.

Currently, the OP steelhead fisheries are mainly managed for escapement goals for winter-run steelhead based on freshwater productivity (see Gibbons, Hahn and Johnson 1985). Goals are set based on maximum sustainable harvest, which became a priority after U.S. vs. Washington (Boldt decision - Tribes and state will co-manage fisheries and Tribes have the right to half the catch). More specifically, for the term “escapement goal,” Harbison et al. (2022) states for WDFW that “In this instance, it refers to the approximate number of fish needed to escape from fisheries to provide enough spawners to perpetuate the run for future generations at maximum sustainable yield (MSY).” Before the Boldt decision, harvest was managed to ensure sufficient returns to the hatcheries for production purposes without regard to returning natural origin fish; WDFW notes that “managers assumed that enough wild fish made it past the fishery to spawn,” or in some cases redd counts or abundance counts at dams were used for monitoring and management (see Harbison et al. 2022). Given the lack of data on spawners and recruits for

specific watersheds, Gibbons, Hahn and Johnson (1985) developed a Potential Parr Production model to estimate the number of steelhead offspring possible based on habitat, and used this within a modified Beverton-Holt model to determine escapement goals at MSY. Further, while Gibbons et al. is the basis for escapement goals there is some disagreement among co-managers on the escapement goals for some basins (*Escapement Data Summary* in OP Steelhead DPS Status Review Team, 2024). Specifically, a separate escapement goal for the Queets River was calculated based on the number of spawners needed for maximum sustainable yield (S_{msy}) both in the 1980s and again in the 1990s (based on a Ricker curve) and it the escapement goal used by Quinault (Scott, J.B. OP steelhead follow-up questions. Email to Laura Koehn. 17 July 2024). WDFW has yet to reevaluate these escapement goals and the assumptions from Gibbons et al. upon which they are based. WDFW has stated their intention to recalculate escapement goals based individual population models within a management strategy evaluation framework (Harbison et al. 2022).

With the escapement goals and foundation of Boldt, each year the State and the Tribes agree to yearly management plans that detail harvest of natural-origin and hatchery-origin OP steelhead for the upcoming fishing season. These plans consider forecasted returns and escapement goals to set harvest rates. In certain years and depending on the system, escapement goals are not met (see Factor B above). This may be due to errors in projected returns. The co-managers did state in their 2023 review to the SRT that, “Tribal fisheries are generally shaped by time and area restrictions with in-season management based on monitoring of fishery catches,” so there is monitoring of certain catch (Co-Manager Olympic Peninsula Steelhead Working Group 2023), and seasons have been shortened/closed early in recent years in response to monitored catches (see Listing Factor B). Additionally, differing escapement goals (e.g. Queets River) may lead to harvest rates that result in adult returns below the escapement goal, depending on if the State or Tribal escapement goal is considered. Therefore, in certain years and certain systems, projected abundance may be below a certain escapement goal but harvest still occurs, and therefore harvest may not be at MSY and escapement levels may not be at the level to maximize future returns. Note that the info on meeting escapement goals we have is for the major four systems and we do not present information on meeting escapement for rivers along the Strait of Juan de Fuca. For more on harvest that has occurred see Factor B presented above and section *Harvest Rates* above.

Escapement goals and MSY management are not directly related to extinction risk, but not meeting escapement goals suggests that harvest management has inherent impression that can result in effects to populations’ overall productivity and represent a potential risk to the DPS. In the face of a declining run size, it is unclear if current management goals and strategies will allow for maintenance or restoration of the runs.

For winter-run steelhead returning to the Olympic Peninsula, in 2016, WDFW changed the recreational fishing regulations to prohibit retention of natural-origin winter-run steelhead in OP steelhead river basins. Sport and Tribal catch of winter-run population has typically occurred from November-April. The number of natural-origin OP steelhead that are captured and released is calculated by WDFW via creel surveys, and it is estimated that catch and release has a 10 percent mortality rate. However, research by Bentley (2017) suggests that angler effort is

underestimated²⁴ and this work also suggests that some fish are caught and released more than once. Hooking mortality is assumed to be 10% by WDFW but is not included in estimates of harvest mortality presented in Listing Factor B.

In 2004, Olympic National Park implemented catch-and-release regulations for wild steelhead throughout coastal rivers of the DPS within the park. Steelhead fisheries in Olympic National Park allow for the retention of 2 hatchery-origin fish, but prohibit the retention of natural-origin steelhead (since 2016). A National Park fishing license is required to fish within the Park, rather than a Washington state recreational license, although a Washington state record card is required²⁵.

Additional strategies since the 1990s have been employed to support sustainable fishing including harvest restrictions (such as bag limits), shorter seasons, and gear restrictions in the face of declining wild steelhead populations (Harbison et al. 2022), including those listed above. In recent years, WDFW has shortened or closed the recreational fishing season on winter-run OP steelhead, at least in part due to low returns. WDFW also imposed restrictions on recreational angling by banning the use of boats (“no fishing from a floating device”) and bait (see links provided in Factor B). In 2022-2023 sport fishing was closed on the Quinault and Queets for December 1st- April 30th because of low returns and because a natural-origin steelhead harvest level was not agreed to across co-managers (see links provided in Factor B). Alternatively, tribal fisheries regulations still allow for the retention of natural-origin steelhead (commercial and ceremonial and subsistence harvest) but the total number of weeks of Tribal fisheries has declined in recent years (see Listing Factor B) specifically on the Queets and Quinault, and as mentioned before, harvest rates have also declined.

In the response to the petition to list OP steelhead, the Co-managers (Co-Manager Olympic Peninsula Steelhead Working Group 2023), explain that they develop abundance forecasts each year and develop fishery plans to meet management objectives under U.S. v. Washington. This includes that Tribal fisheries are shaped by time/area restrictions based on the monitoring of fishery catches within season. Recreational fishery management varies across locations and year but can include bag limits, non-retention of natural-origin steelhead, seasonal closures, gear and access limitations. The Co-Managers provided examples of yearly regulations as illustration of regulation responsive to OP steelhead abundance. This included that in specific past years the release by recreational fishers of unclipped fish (winter-run or summer-run) was required in State waters, including in 1997-1998 for summer-run steelhead due to ongoing concerns regarding status of summer steelhead. In certain other years, retention of unclipped winter-run steelhead was limited (example 1 fish per day, specific months, etc), before the non-retention of unclipped²⁶ steelhead regulations for recreational fishing was put into effect throughout the DPS in 2016. Currently, recreational fisheries within tribal lands on the Queets and Quinault do not prohibit the retention of natural-origin steelhead.

²⁴ <https://wdfw.wa.gov/sites/default/files/publications/01918/wdfw01918.pdf>

²⁵ https://www.nps.gov/olym/upload/OLYM_Fish_Brochure_2022-0502-508_all_CHARTs_REMOVED.pdf

²⁶ Except in the Queets and Quinault rivers where dorsal fin height is used to segregate hatchery-origin from natural-origin steelhead.

WDFW has proposed in their recent 2022 Coastal Steelhead Proviso Implementation Plan (Harbison et al. 2022) as part of their Proviso Implementation Strategy, a 3-step process for setting fishery regulations for state fisheries in Pacific coast Washington river systems. Specifically, (1) forecasting wild and hatchery-origin run sizes, (2) pre-season planning of regulations to meet management objectives, and (3) in-season update tools to assess if based on updated information if there can be increased opportunity, additional restrictions, or fishery closure. Additionally, fishery regulations depend on their Adaptive Management Framework which considers if rivers are in a “Maintenance” regime where the full spectrum of recreational fishing possibilities are explored, “Transitional” regime where hatchery-targeted fisheries or fishery limitations or closures are utilized, or “Emergency” regime where recreational steelhead fishing is closed. Finally, WDFW is continuing to pursue actions related to including steelhead impacts from other fisheries (Chinook and coho salmon) in management calculations, evaluating permanent fisheries regulations, and looking into tailoring fishery regulations on other species (i.e. Smallmouth Bass) to reduce predation on steelhead.

The following information for harvest management from for specific rivers/watersheds within the Olympic Peninsula are summarized from Harbison et al. (2022) and specific regulations are listed in Appendix 12.4 in that plan. The following descriptions are specifically for winter-run steelhead. More specifics on harvest for populations along the Strait of Juan de Fuca are not covered in similar detail as the large rivers in the OP, but as noted in the status review (see section *Population Growth and Harvest in Strait Populations*, in OP Steelhead DPS Status Review Team, 2024) most rivers along the Strait, fishing hasn’t occurred in recent years (but see the Hoko River).

Quinault: The Quinault River steelhead management is divided into areas either above and below Lake Quinault. Above the lake, but below the ONP boundary (“upper Quinault”), recreational fishing is managed by WDFW, in the ONP it is managed by NPS, and below the lake (“Lower Quinault”), the Quinault Indian Nation manages a tribal gill net fishery and recreational fishing. The entirety of the Quinault system falls within the usual and accustomed fishing grounds of the Quinault Indian Nation. The escapement goal set by WDFW for upper Quinault is 1,200 steelhead. Motorized boats are currently not permitted on Lake Quinault nor the upper Quinault River. Hatchery fish are not adipose fin clipped in the Quinault Basin, making retention targeting hatchery fish difficult. Currently, state regulations allow for retention of steelhead with a dorsal fin of less than 2 1/8 inches, the height of a credit card so named the “credit card rule”, because hatchery fish are assumed to have eroded dorsal fins. This system for identification is inexact, and misidentification likely occurs. Other regulations related to prohibiting bait, limits on hooks, size limits etc. are listed in Appendix 12.4 of Harbison et al. (2022). Recreational fisheries on tribal lands do not prohibit the retention of natural-origin steelhead. Monitoring of this system is currently solely spawning ground surveys by the Quinault Indian Nation and ONP.

Queets/Clearwater: Most of the Queets River flows through ONP and therefore, sport fisheries are managed by the NPS within the park boundaries. Only the lower four river miles exists out of the park with fisheries in this portion co-managed by WDFW and the Quinault Indian Nation. WDFW manages sport fishing in the Clearwater River. The entirety of the Queets system falls within the usual and accustomed fishing grounds of the Quinault Indian Nation. WDFW’s

natural origin escapement goal is 4,200 fish. Similar to the Quinault artificial propagation program, hatchery fish are not adipose fin clipped in this river system. So, as in the Quinault River currently, regulations allow for retention of steelhead with a dorsal fin of less than 2 1/8 inches, the height of a credit card so named the “credit card rule”, because hatchery fish are assumed to have eroded dorsal fins. But again, there is uncertainty if this rule can achieve management objectives based on variations in dorsal fin lengths. Other regulations related to prohibiting bait, limits on hooks, size limits etc. are listed in Appendix 12.4 of Harbison et al. (2022). Recreational fisheries on tribal lands do not prohibit the retention of natural-origin steelhead. Monitoring consists of solely spawning ground surveys with 90% covered by the Quinault Indian Nation and 10% covered by WDFW.

Hoh: 58% of this watershed is contained within the ONP. The whole watershed is within the usual and accustomed fishing groups of the Hoh Tribe. The escapement goal agreed to by co-managers is 2,400 fish. Due to emergency regulations in recent years for recreational fishing, floating devices have not been allowed on the Hoh River, for a portion of the river in 2016 that extended to the whole river in 2020/2021. Other regulations related to prohibiting bait, limits on hooks, size limits etc. are listed in Appendix 12.4 of Harbison et al. (2022). Spawning ground surveys are conducted by the Hoh Tribe, ONP, and WDFW. The Hoh River is also monitored through creel surveys but often suffers from limitations in resources leading to the inability to estimate total steelhead encounters and angling effort. Annual harvest management plans for winter steelhead are prepared by WDFW and the Hoh Tribe including the most recent in 2022-2023 (Hoh Tribe and WDFW 2022-2023 management plan provided by co-managers). For the Tribal fishery, days fished/week are set and have been limited to 15-18 days in recent years (pers. comm Brian Hoffman, Hoh Tribe, Natural Resources, June 21, 2023). Ceremonial-and-Subsistence fisheries can be conducted at other times and included harvest rates of 10 natural-origin and 30 hatchery fish in 2022-2023 (Hoh Tribe and WDFW 2022-2023 management plan). Evidence of depressed run size or exceedance of harvest, can trigger discussions among the co-managers. Commercial catch, harvest returns, and winter steelhead sport catch are monitored and each party (Hoh Tribe, WDFW) enforces its own regulations.

Quillayute River: This includes the Quillayute mainstem and four major tributaries: Calawah, Sol Duc, Bogachiel, and Dickey rivers. A portion of the watershed falls within the ONP and fisheries are managed by the NPS there, and the whole system falls in usual and accustomed fishing areas of the Quileute Indian Nation and a portion falls within usual and accustomed fishing areas of the Hoh Tribe. The co-managers agreed that the escapement level for wild steelhead in the Quillayute system is 5,900 fish. Monitoring is conducted by WDFW, the Quileute Tribe, and ONP and includes on-the-ground surveys as well as aerial surveys, where ground to air conversion factors are used and surveyed areas are extrapolated to unsurveyed reaches for escapement totals. In recent years landslides have limited surveys. Also, some creel surveying has occurred but not comprehensively. Scale collection by the Quileute Tribe also helps to estimate run timing and age class. Other regulations related to prohibiting bait, limits on hooks, size limits etc. are listed in Appendix 12.4 of Harbison et al. (2022). WDFW and Quileute Tribe also prepare an annual harvest management agreement for winter-run steelhead in the Quillayute with predicted returns (for example “Annual Agreement for the 2022-23 Harvest Management of Winter Steelhead in the Quillayute River System”). Quileute Tribe fishing is

conducted based on a fixed schedule set forth in the annual management plan. These annual plans also outline agreements for enforcement and evaluation of causes of mortality.

Independent streams: This includes Tsoo-Yess-Waatch, Ozette River, Goodman Creek, Mosquito Creek, Kalaloch Creek, Moclips River, Copalis River and others. Spawning ground surveys have only been consistently done on Goodman Creek by WDFW. There have also been sporadic spawning ground surveys conducted by WDFW and Tribes on Mosquito Creek, Kalaloch Creek, Cedar Creek, Raft River, and the Moclips River, as well as others.

We note that most estimates of population size, used to inform harvest management, are based on redd counts/surveys that occur after March 15th. Though the majority of natural-origin fish likely spawn after March 15th, a proportion does spawn before this date and therefore are missed in counts and estimates. We discuss the likely effects of the March 15th cut-off date above in Listing Factor B and extensively in the status review (particularly, see *Abundance, Winter-run Steelhead*). Finally, many public comments during the 90-day finding comment period voiced concerns about the inadequacy of state monitoring of OP steelhead especially in relation to being able to make an accurate assessment of the current status of the population. Many of these mentioned seeing redds not counted earlier in the season and voiced support for redd surveys from December-May to count earlier returning natural-origin steelhead. Others noted that they are often not creel checked by management.

Summer-run steelhead

As mentioned above, Harbison et al. (2022) specifies critical research needs including summer-run steelhead monitoring and data collection, a conclusion voiced earlier by Busby et al. (1996). Similarly, Cram et al. (2018) noted that there was insufficient data for all summer-run populations to assess trends or extinction risk. In 1992, WDFW and ONP implemented catch-and-release-only fishing regulations for summer steelhead; although there is still mortality associated with non-retention fisheries (i.e. hook mortality). Specifically, the onset of the WDFW ruling to protect and release wild summer steelhead occurred in the April 16, 1992-1993 fishing pamphlet (page 22 of 40) and included releasing wild steelhead from June 1-November 30 throughout all rivers in Region 6, which includes the Olympic Peninsula. There are no directed commercial fisheries for summer steelhead in the DPS. The Treaty tribes develop annual regulations for sport fishing on-reservations and those regulations include daily limits for steelhead that are caught during summer months. Time-series of estimates of harvest of summer steelhead are provided in Listing factor B and in the Status review (section *Summer-run steelhead population harvest*). Also, there are no established management goals between Washington State and Treaty Tribes for summer-run steelhead. Therefore, though fisheries management appears responsive to winter-run steelhead, there is no formal management of summer-run (outside of ONP) and no definitive monitoring plans making the adequacy of existing management for summer-run uncertain. And again, this was the case at the time of the last OP steelhead review by NMFS.

Pacific Fishery Management Council Harvest Management

Salmon fisheries in the exclusive economic zone (three to 200 nautical miles offshore) of Washington, Oregon, and California have been managed under salmon Fishery Management

Plans (FMPs) of the Pacific Fishery Management Council (PFMC) since 1977 (as summarized in NMFS 2022a). While all species of salmon fall under the jurisdiction of the current plan (Pacific Fishery Management Council 2022), the FMP currently contains fishery management objectives only for Chinook salmon, coho, pink salmon (odd-numbered years only), and any salmon species listed under the ESA measurably impacted by PFMC fisheries. The FMP contains no fishery management objectives for sockeye salmon (*O. nerka*), even-numbered year pink salmon, chum salmon (*O. keta*), steelhead (*O. mykiss*), sea-run cutthroat (*O. clarki*), or spring run Chinook salmon from mid-Columbia River, states that the Council does not manage fisheries for these species, and also states that incidental catches of these are inconsequential (low hundreds of fish annually) to rare (citing PFMC and NMFS 2011). There is also a prohibition on take or retention of steelhead by any persons other than Indians with judicially-declared rights and licensed recreational fishermen, within the EEZ²⁷.

Hatchery regulations

Here we describe overall hatchery regulations and then in listing Factor E, we discussed potential negative impacts of hatchery production on natural-origin OP steelhead. WDFW operations of hatcheries is currently regulated by the Statewide Steelhead Management Plan (SSMP) and the Anadromous Salmon and Steelhead Hatchery Policy C-3624 (Fish and Wildlife Commission 2021), superseding the policy from 2009 (Hatchery and Fishery Reform Policy C-3619). However, the state and Tribal co-managers are currently working to develop Hatchery Management Plans (Harbison et al. 2022). Furthermore, the state Coastal Steelhead Proviso Implementation Plan (Harbison et al. 2022) aligns with the existing policies, and hatcheries on the West Coast are focused on the primary goal of harvest.

Co-Manager Olympic Peninsula Steelhead Working Group (2023) review of the petition noted that after a 2008 assessment of gene flow (Scott and Gill 2008) certain segregated hatchery programs were discontinued as part of the 2008 SSMP. Specifically, Scott and Gill (2008) showed gene flow of early Winter Chambers creek stock into Hoko, Pysht, and Sol Duc, (5.5-14.5%, 12-75%, and 2.5-6% gene flow respectively). Based on this and other information, the SSMP included the action “Where risks are inconsistent with watershed goals, implement one or more of the following actions:...eliminate the segregated hatchery program.” (Co-Manager Olympic Peninsula Steelhead Working Group 2023). Therefore, winter steelhead smolt release into Pysht was eliminated in 2009, similarly in Goodman Creek, Clallam River, and Lyre River in 2009, and in 2012 the Sol Duc River was designated by WDFW as a Wild Stock Gene Bank, terminating summer smolt releases in 2011 and winter in 2013 (winter-run was local-origin broodstock steelhead). Local-origin broodstock releases occurred in Calawah and Bogachiel until 2021 when the program was terminated (Co-Manager Olympic Peninsula Steelhead Working Group 2023).

The 2009 Hatchery and Fishery Reform policy was evaluated by Murdoch and Marston (2020) (<https://wdfw.wa.gov/publications/02133>), but they determined that there was not enough data to evaluate the effectiveness at meeting management goals, including supporting fisheries, of the 159 hatcheries. However, they did look at the effectiveness of policy implementation. The

²⁷ <https://www.pcouncil.org/documents/2022/12/pacific-coast-salmon-fmp.pdf/>

review's conclusions identified several concerns including: a lack of harvest program goals, lack of a comprehensive monitoring and evaluation program, lack of program success definitions, and lack of data analysis for further adaptive management. On the other hand, regulations that were found to be well implemented included hatchery fish external marking (State Hatcheries only), Chinook smolt survival, and compliance of facilities with environmental regulations.

The 2009 plan was superseded by the 2021 Anadromous Salmon and Steelhead Hatchery Policy C-3624²⁸, which outlines guidelines for operations at WDFW-run hatcheries for salmon and steelhead. Specifically, the policy says, “ The purpose of the Anadromous Salmon and Steelhead Hatchery Policy (Policy) is to guide hatcheries and their individual rearing programs to advance the conservation and recovery of wild salmon and steelhead by implementing hatchery reform measures; to perpetuate salmon and steelhead in accordance with existing mitigation programs and agreements for permanently lost or impaired habitat; and to provide sustainable economic and stability benefits to recreational, commercial and tribal fisheries in Washington State as appropriate.” And “The intent of this Policy is to provide direction, goals, and objectives to improve hatchery effectiveness and ensure compatibility between hatchery salmon and steelhead production and wild salmon and steelhead conservation and recovery in a manner that optimally achieves the stated purpose of this Policy.” Furthermore, this policy will be superseded when joint policies with Tribal co-managers are completed.

The C-3624 Hatchery Policy lists 10 policy guidelines for managing state hatcheries. Specifically, (1) minimizing genetic risks to wild salmon and steelhead via provisions in Hatchery Management Plans (HMPs), (2) minimizing ecological risks to wild fish through provisions in HMPs, (3) provide benefits, such as boosting recovery of wild populations, maintaining genetic traits, supporting fisheries, supporting at-risk predators, and benefits should be provided based on provisions in HMPs, (4) an HMP will be developed for every hatchery program under this Policy, (5) levels of hatchery production are based on deliberative, transparent, science-based process, (6) hatchery production for Southern Resident killer whale recovery is top priority, (7) all Chinook and coho salmon and steelhead that are hatchery produced will be marked (**with exceptions**), (8) the department shall strive to secure the funding needed for these hatcheries, (9) high protection to wild populations that have had limited negative impacts of hatcheries, and (10) WDFW will plan for and implement technologies for separating wild and hatchery salmonids such as weirs and other emerging technologies.

This policy provides general guidelines and points repeatedly to future HMPs for specifics. We did not find any evidence of completed HMPs at this point. This policy applies to State hatcheries and not to Federal or Tribal facilities. The C-3624 policy is only that, a policy, and not regulation.

Harbison et al. (2022), following the policies listed above, states that WDFW will consider ecological impacts, the ability for angling opportunities, and mitigation agreements when designing hatchery operations. Hatcheries will be designed based on the criteria outlined in the CSPIP depending on the status of the river/system, specifically “maintenance” regime, “transitional”, and “emergency” (i.e. different requirements for hatchery operations or different responses depending on the status of the system). This includes that in an emergency regime,

²⁸ <https://wdfw.wa.gov/about/commission/policies/anadromous-salmon-and-steelhead-hatchery-policy>

hatchery programs may be discontinued if fisheries frequently need to close due to low natural-run steelhead returns.

Furthermore, within the CSPIP, WDFW notes that they will pursue additional actions as well when designing or updating hatcheries. Specifically: (1) developing adult production goals; (2) minimizing ecological impacts through: (a) techniques for reducing residual juveniles, (b) volitional hatchery releases and transporting non-migratory smolts, (c) field sampling of juvenile dispersion, residual rates, and competition, (d) using predation competition disease risk models, and/or (e) collecting genetic data for specific rivers; (3) relocating surplus smolts or adults; (4) optimization of trapping and hatchery attraction; (5) reducing spatial and temporal overlap between hatchery and natural-origin through release locations; (6) prioritizing hatchery research. WDFW will be conducting modeling to look into how many smolts could be released while staying within the genetic thresholds. Finally, the state will also be looking into potential designations of Wild Stock Gene Banks as the SSMP states that there will be at least one gene bank for each Major Population Group but currently only the Sol Duc River has been identified as a steelhead gene bank (2012). Stock use/placement of the gene bank will follow guidelines/criteria set by the SSMP: each stock used must be sufficiently abundant and self-sustaining, no releases of hatchery steelhead in rivers used by the stocks, and fisheries may occur on stocks if management objectives are met. WDFW also expanded criteria and considerations for gene banks in their CSPIP including: populations must have stable trends and over 300 spawners on average over 6 years, populations may not be where on-station hatchery releases occur but could be where off-station releases occur, consideration of usefulness of populations for research, and considerations of designating other populations in that overlap (Harbison et al. 2022).

Though the CSPIP (Harbison et al. 2022) outlines overall plans for state hatcheries (e.g. only the Bogachiel Hatchery in the OP DPS), co-manager Hatchery Management Plans are still being developed and it is unclear how much of the CSPIP is currently being implemented. We outline current potential impacts of hatcheries below (in Listing Factor E), noting: (1) the use of out-of-DPS origin broodstock, (2) not all hatchery fish are adipose fin clipped, and (3) possible current levels of proportion of hatchery-origin adults spawning (pHOS) with natural origin steelhead that are above desired levels.

Listing Factor E: Other natural or manmade factors

Climate Change

General information on climate change impacts for salmonids is summarized recently in the 5-year status review for Ozette lake sockeye salmon (NMFS 2022b; along with other 5-year reviews cited above), and we extensively incorporate information from recent 5-year ESA status reviews for information on climate change impacts more generally. Major ecological realignments are already occurring in response to climate change (Crozier et al. 2019). As reviewed by Siegel and Crozier (2020), the scientific literature published in 2019 showed that long-term trends in warming have continued at global, national, and regional scales. Globally, 2014 through 2018 were the warmest years on record both on land and in the ocean (2018 was

the fourth warmest). Events such as the 2013-2016 marine heatwave (Jacox et al. 2018), have been attributed directly to anthropogenic warming (Herring et al. 2018). Global warming and anthropogenic loss of biodiversity represent profound threats to ecosystem functionality. These two factors are often examined in isolation, but likely have interacting effects on ecosystem function (Siegel and Crozier 2020). Conservation strategies now need to account for geographical patterns in traits sensitive to climate change, as well as climate threats to species-level diversity. Recent 5-year status reviews for listed species of salmonids including steelhead have summarized literature on ongoing (including warming and heatwaves) and projected climate change for the U.S. West Coast and mechanisms for climate change impacts to salmonids (see National Marine Fisheries Service 2022b, c, d).

Crozier et al. (2019), conducted a climate vulnerability assessment that included all anadromous Pacific salmon and steelhead (*Oncorhynchus* spp.) population units listed under the federal ESA. Using an expert-based scoring system, they ranked 20 attributes for the 28 listed units and 5 additional units. Attributes captured biological sensitivity, or the strength of linkages between each listing unit and the present climate; climate exposure, or the magnitude of projected change in local environmental conditions; and adaptive capacity, or the ability of salmon to adjust to cope with new climatic conditions via genetic adaptation or phenotypic plasticity (Crozier et al. 2019; Pachauri et al. 2014). Among species, Chinook salmon had the highest vulnerability rankings overall (mostly very high and high rankings), followed by coho and sockeye, while steelhead and chum DPS scores were generally lower and nearly equally spread across high and moderate vulnerability categories.

Climate change is projected to alter habitat conditions in freshwater, estuarine, and ocean environments. Siegel and Crozier (2020) provide the following observations: as stream temperatures increase, many native salmonids face increased competition with more warm-water tolerant invasive species. Changes in flow regimes may alter the amount of habitat available for spawning. This could lead to a restriction in the distribution of juveniles, further decreasing productivity through density dependence. Along with warming stream temperatures and concerns about sufficient groundwater to recharge streams, another recent study projects nearly complete loss of existing tidal wetlands along the U.S. West Coast, due to sea-level rise (Thorne et al. 2018). Tidal wetlands in California and Oregon are most threatened (expected loss of 100%), while 68 percent of Washington tidal wetlands are expected to be submerged by the end of this century. Coastal development and steep topography prevent horizontal migration of most wetlands, causing the net contraction of this crucial habitat. Finally, climate change is expected to have profound influences on the ocean environment, influencing ocean temperatures, currents, salinity, acidity, and the composition and presence of a vast array of oceanic species (Crozier et al. 2019).

Increasing stream temperatures can affect salmon and steelhead at multiple life stages depending on species (Hicks 2002), including reproduction (egg viability) (Berman 1990), incubation survival (eggs in the gravel), juvenile rearing (Bear, McMahon and Zale 2007; Fogel et al. 2022), smoltification, adult survival (Keefer, Peery and Caudill 2008), and migration timing. For example, average temperatures above 15-16°C can stop the smoltification process, while average temperatures below 12-13°C are ideal for this process. Temperatures above 21-22°C can create a migration block and extreme temperatures (generally >23 degrees C) can kill fish in seconds to

hours depending on the circumstances and the degree of acclimation. Warm temperatures can also lead to greater risk of disease and parasites. Siegel and Crozier (2020) suggest that for some salmon populations, climate change may drive mismatches between juvenile arrival timing and prey availability in the marine environment. However, phenological diversity can contribute to metapopulation-level resilience by reducing the risk of a complete mismatch.

Changes in winter precipitation intensity and flood magnitudes will likely affect the incubation and/or rearing stages of most populations. Egg survival rates may decrease due to increasingly intense flooding that scours or buries redds (Goode et al. 2013; Nicol et al. 2022). Changes in hydrological regime, such as a shift from mostly snow to predominantly rain, could drive changes in life history, potentially threatening diversity within an ESU/DPS (Beechie et al. 2006). Changes in summer temperature and flow will affect both juvenile and adult stages in some populations, especially those with extended juvenile freshwater rearing (steelhead most commonly emigrating as two-year old smolts) or adult summer adult migration patterns (Beechie et al. 2023; Crozier and Zabel 2006; Crozier et al. 2010; Quinn 2007).

In the Pacific Northwest and Olympic Peninsula

In Washington State, increases in freshwater temperatures for salmon streams are predicted in addition to large shifts in hydrology (Climate Impacts Group 2009). Projected changes in climate for the Olympic Peninsula were summarized in Halofsky et al. (2011); Dalton (2016); the 2020 State of Our Watershed Reports from Northwest Treaty Tribes (Northwest Indian Fisheries Commission 2020) (<https://nwifc.org/publications/state-of-our-watersheds/>). Northwest Indian Fisheries Commission (2020) summarizes potential climate change impacts within the Olympic Peninsula stating, “the observed and projected trends include warmer air temperatures; shrinking glaciers and snowpack; lower summer streamflows; higher winter flood flows; shifts in streamflow patterns and timing; higher stream temperatures; larger and more frequent wildfires; warmer ocean temperatures; rising sea levels; and changing ocean chemistry, including ocean acidification and lower levels of dissolved oxygen.” On the OP, warming has already occurred, and is projected to further affect all seasonal temperatures, with the largest increases occurring during summer. Projected decreases in precipitation in summer in combination with increased summer evapotranspiration will further impact stream flows for both juvenile and adult steelhead. Additionally, increases in winter precipitation quantity, combined with an increase in event intensity in the western portion of the DPS, will likely result in redd scouring and habitat degradation (see Halofsky et al. (2011) and references therein). Changes in precipitation and timing of peak streamflow may lead to increased runoff and flood risk, with an increased frequency and magnitude of flooding. Warming is likely to reduce snowpack (less winter snow accumulation) which would in turn decrease the risk of floods in springtime, but also reduce stream cooling and flow augmentation in the late spring and summer from snow melt. The biggest changes in streamflow are projected where rivers flow from the Olympic Mountain Range; where snowpack is likely to decline rapidly, especially for areas that will transition from a mix of rain/snow to rain dominant with warming (Yoder and Raymond 2022). Specifically, model projections show up to 30% decline in average summer flow in reaches of low intrinsic potential (<20% in medium to high intrinsic potential) by 2040 (Reeves et al. 2018), and average winter flows of at least 30% higher (Reeves et al. 2018; Safeeq et al. 2015).

Many of these ongoing changes have already been observed on the OP. On USFS land within the OP, there has been a decrease in wetted bank extent and increases in August temperatures from <14 °C in 2002 to 14-18°C in the late 2010s, with data ending in 2018 (Dunham et al. 2023). Additionally, WDOE stream temperature data from Sol Duc shows warming water temperatures in April and May in certain recent years²⁹. Peak winter flows have already increased while summer low flows have already decreased. An assessment of peak flood flows between 1976 and 2019 found that peak flows have increased for the Hoko, Hoh, Calawah, and Quinault rivers, by 5% to 18% with the Hoh River increasing by 18.4% (Northwest Indian Fisheries Commission 2020). In both the Calawah and Bogachiel rivers, it is becoming common for peak flows to be at or above flood stage. Examination of the peak discharges for the coastal drainages of the OP DPS watersheds found that the two-year flood event has been 10 to 35% greater over the last 40 years, relative to over the entire length of the stream-gage record (East et al. 2017). In the Hoh River basin, the three largest peak flow events recorded have occurred since 2002 (East et al. 2018). The 2-year flood peak calculated for the Hoh River for water years 1978–2013 was 1024 cms, whereas the 2-year flood for the entire period of record at the Hoh River gaging station (12041200) was 924 cms (East et al. 2018). The Hoh, Queets, and Quinault rivers have all widened since 1970 consistent with greater flood activity, and Hoh River is showing greater braiding likely related to increased sediment loads from retreating glaciers (East et al. 2017). The general increase in flood activity throughout the OP after the mid-1970s coincided with the onset of a wet phase of the Pacific Decadal Oscillation (PDO, an index of monthly sea-surface temperature anomalies over the North Pacific) (Mantua et al. 1997). This mid-1970s climatic transition has been identified as a major atmospheric and hydrologic shift that affected a large region of the Pacific in both the northern and southern hemispheres (Castino, Bookhagen and Strecker 2016; East et al. 2018). Summer low flows have decreased further over time in the Calawah River basin, where the average low flow in the late 1970s through the 1990s was 2.0cms, while in the 2000s average summer low flow has been 1.5cms.

Northwest Indian Fisheries Commission (2020) provided information on observed system-specific climate changes. For the Quinault Basin glaciers are receding, including those that supply steady streamflow to Quinault and Queets rivers. Further, glacier loss has been observed, including the complete loss of the Anderson Glacier (Northwest Indian Fisheries Commission 2020). They note that glacier loss results in “less fish habitat, higher stream temperatures and greater sediment load”. Adequate streamflow is needed for fish survival and productivity and with climate change, rain dominated watersheds (for example Chehalis River) will likely have increased frequency of low flows in the summer and Glacier-fed watersheds (e.g. Queets) may become rain dominated and have more extreme low summer flows and more frequent intense winter flows. For the Quileute Tribe and the Quillayute River basin, they note increased spring precipitation and winter streamflows with decreased spring snowpacks and summer flows. Within the Calawah river, there have been increasing peak flows along with decreasing low flows over the last 40 years. Sea level rise, coastal storms, and hydrological events contribute to flooding and erosion that may lead to habitat loss. Within the Hoh watershed, glaciers have already been reduced by 40% from 1981-2015. This impacts streamflows and temperature and water quality within fish spawning and rearing habitat. Increasing trends in peak flows and

²⁹ Washington Department of Ecology. 2023. Freshwater DataStream, <https://apps.ecology.wa.gov/ContinuousFlowAndWQ/StationDetails?sta=20A070>; provided in a public comment on the 90 day finding from The Conservation Angler and Wild Fish Conservancy

decreasing trends in low flows have occurred. Makah Tribe also note increasing trends in peak flows and decreasing summer low flows in the Hoko River. On the marine side, ocean warming and associated heatwaves, as well as hypoxia and harmful algal blooms have impacted marine areas of interest for Tribes on the Olympic Peninsula.

A paper by Riedel et al. (2015) looked at glacial extent in the Olympic Mountains and current contribution of glacial melt to stream flow. This paper showed that all glaciers combined in the Olympics have decreased by 34% over 30 years, resulting in only 4 of the remaining 184 remaining glaciers with an area $>1 \text{ km}^2$. The greatest losses in area and volume have been on the southern side of the glaciers, at lower elevations, and in northeastern parts of the Olympics. This glacial loss has resulted in a $\sim 20\%$ decline in contribution to summer streamflow of glacial runoff, but still there is significant contribution in the Hoh. For all other major watersheds in the Olympics, glaciers only contribute $<5\%$ of summer streamflow.

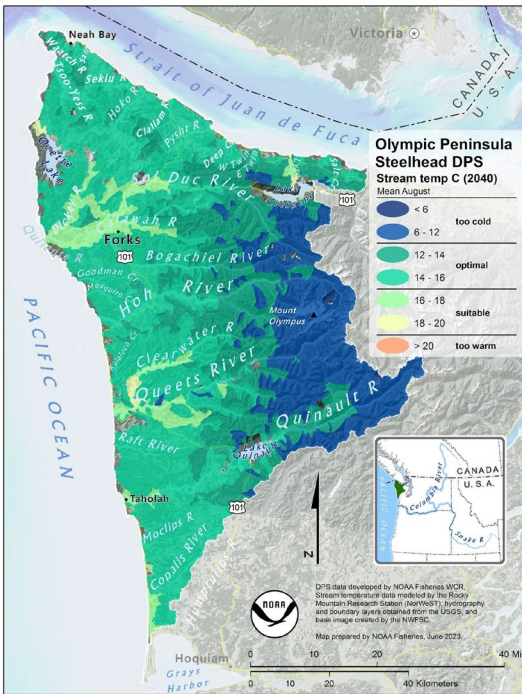
Additionally, a recent study looked at the changes in number of glaciers and glacial extent over time and predicted future loss of glaciers in the Olympic Mountains due to climate warming (Fountain et al. 2022). Using aerial photograph inventories of the mountains in September 1990, 2009, and 2015, authors determined that the current total ice-covered area is around half of the area in 1900 and that since 1980, glaciers have shrunk -0.59 km^2 per year which has led to the loss of 35 glaciers and 16 perennial snowfields. Models showed that warming winters lead to less snow precipitation accumulating (falling as rain instead of snow), and warming summers result in greater ice melt. Finally, Regional Glaciation Models paired with a “business as usual” carbon emission climate scenario showed that Olympic Mountain glaciers will largely disappear by 2070.

Dalton (2016) describes vulnerability due to climate change within the OP, but notes that certain future conditions that may not be as extreme on the OP as elsewhere, due to the influence of the Pacific Ocean. Further, temperatures and spring precipitation on the Peninsula have increased over the past century, while snowpack and streamflow over the last half century have decreased. Projections from Dalton (2016) suggest a 30% decline in average summer flows that could disrupt migrations, but this may be mitigated by the short migration distances and variation in water temperature throughout the day. Alternatively, there is a predicted 30% increase in winter flows that may impact younger fish through scour but this is likely stream-dependent. Virtual watersheds created in NetMap presented in Dalton (2016) show that temperatures will likely increase in summer in Quinault, Queets, Hoh, and Quillayute rivers but much of the habitat will remain within suitable thermal ranges for salmonids through the 2040s (but growth, predation, and competition could still be impacted). Similarly, a presentation provided to the SRT by Mara Zimmerman on May 15, 2023 and cited by the Co-Manager Olympic Peninsula Steelhead Working Group (2023) noted that throughout the range of the DPS, with climate change, systems are likely to retain either optimal or suitable water temperatures both for juvenile and adult steelhead, based on estimates of future mean water temperatures (Zimmerman presentation to SRT, May 15, 2023). Updated spatial stream network models for the Washington coast region from WDFW show that current August mean, minimum, and maximum temperatures are 14.9° , 1.8 , and 25.0°C and in 2080 are projected to be 15.6 , 2.4 , and 25.8°C (Winkowski 2023).

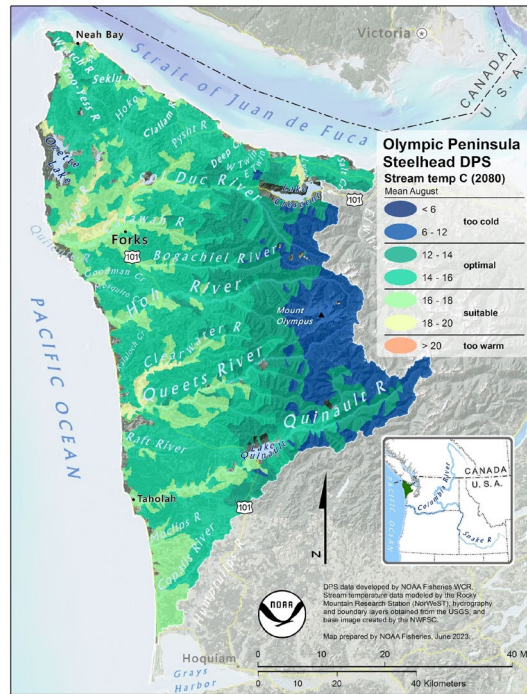
Using stream temperature and flow data from the USDA and USFS Rocky Mountain Research Station³⁰, the SRT considered projections of temperature and flow into the future (2040, 2080) for the OP steelhead population range. Average August temperatures projected into the future show minimal areas of unsuitable habitat due to warming but mean weekly maximum temperatures do show larger areas of unsuitable temperatures from high temperatures (Figure 11). For flow, projections into 2040 show extreme change within the Olympic mountains but minimal change in the lowlands, while projections into 2080 show substantial to extreme changes across most of the region (Figure 12).

³⁰ <https://www.fs.usda.gov/rm/boise/AWAE/projects/NorWeST/ModeledStreamTemperatureScenarioMaps.shtml> , https://www.fs.usda.gov/rm/boise/AWAE/projects/modeled_stream_flow_metrics.shtml

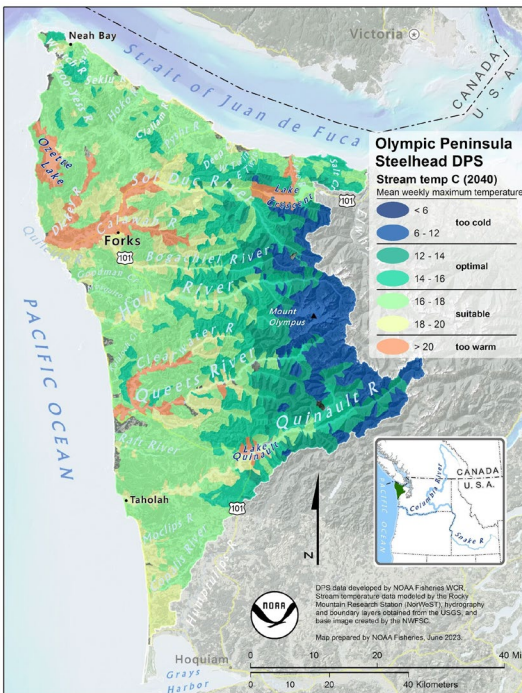
(A)



(B)



(C)



(D)

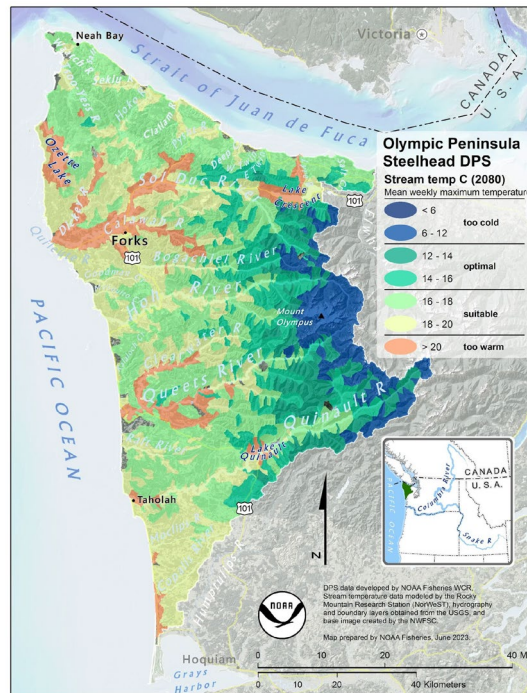
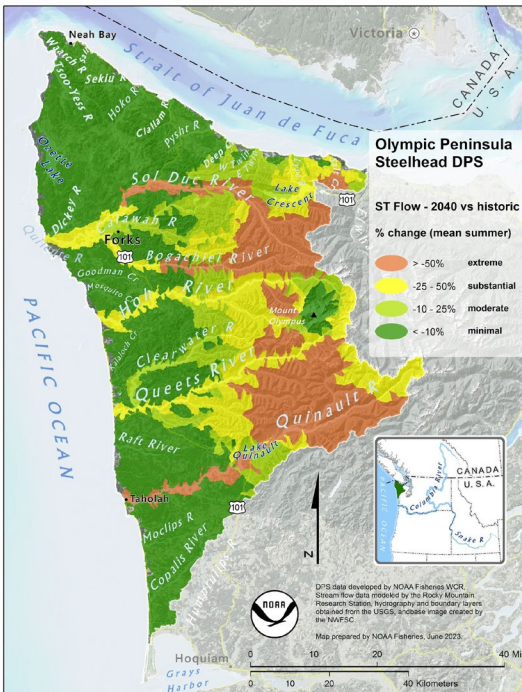


Figure 11. Projected average August stream temperature in 2040 (A) and 2080 (B) and projected maximum August temperature in 2040 (C) and 2080 (D).

(A)



(B)

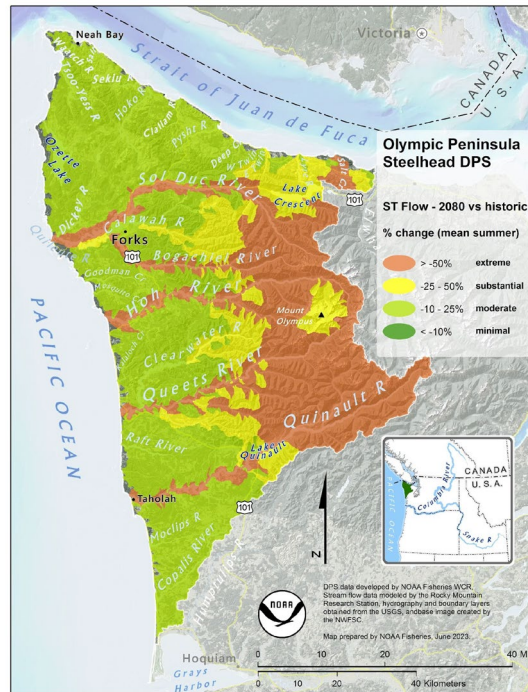


Figure 12. Projected changes in stream flow in 2040 (A) and 2080 (B)

Using stream temperature and flow data from the USDA and USFS Rocky Mountain Research Station³¹, the SRT reviewed projected changes in temperature, flow, and 25 year flood cubic feet per second for individual rivers/streams (Table 7). Changes in summer flow are more likely to affect returning and holding summer-run steelhead, although juvenile and adult winter-run steelhead in the Upper Quinalt and Queets rivers and Salt-creek independents tributaries may also be affected. The highest temperatures experienced now and likely into the future are predicted to impact the Lyre winter-run and Clearwater summer-run populations. Summer low flows are predicted to decrease anywhere between 5% and 43% by 2040 in the Quillayute River Basin with the largest changes predicted to occur in the Sol Duc, Upper Bogachiel, and Quillayute River proper. Summer-low flows are already a limiting factor for the range of the DPS, so further declines in low flows due to climate change may restrict the range of the DPS even further.

³¹ <https://www.fs.usda.gov/rm/boise/AWAE/projects/NorWeST/ModeledStreamTemperatureScenarioMaps.shtml> , https://www.fs.usda.gov/rm/boise/AWAE/projects/modeled_stream_flow_metrics.shtml

Table 7 Summary values by population and reaches for future climate change projections including stream flow percent change (now vs. 2040 or 2080), 25 years flood cubic feet per second percent changes (now vs. 2040 or 2080), and mean max temperature now (~2011) vs 2040 and 2080. Summarized for all use types. For flow, green to red gradient is smaller to greater change and for temperature, green to red are lower to higher temperatures.

Population	Run	Use Length m	Stream Flow CFS (% change)				NorWeST Temp Mean Max Week °C A1B Scenario		
			Summer season mean NOW vs 2040	Summer season mean NOW vs 2080	25yr Flood NOW vs 2040	25yr Flood NOW vs 2080	2011	2040	2080
Salt Creek-Independents	winter	31011	-0.401	-0.478	-0.081	0.206	14.7	15.7	16.4
Lyre	winter	14836	-0.270	-0.345	0.007	0.129	18.8	19.8	20.5
Pysht-Independents (including the Twins)	winter	91861	-0.102	-0.181	-0.019	0.041	15.6	16.6	17.3
Clallam	winter	42838	-0.056	-0.141	-0.057	-0.087	16.3	17.2	17.9
Hoko	winter	117457	-0.056	-0.145	-0.066	-0.077	16.0	17.0	17.7
Sekiu	winter	44658	-0.050	-0.143	-0.051	-0.042	16.2	17.2	17.9
Sail	winter	11449	-0.053	-0.157	-0.006	0.006	15.0	16.0	16.7
Tsoo-Yess-Waatch	winter	80989	-0.052	-0.148	-0.018	-0.027	15.9	16.9	17.6
Ozette	winter	149053	-0.051	-0.142	-0.024	0.000	17.6	18.6	19.3
Quillayute-Bogachiel	winter	188336	-0.286	-0.398	-0.001	0.058	17.2	18.2	18.9
Dickey	winter	185791	-0.054	-0.142	-0.035	-0.005	17.6	18.6	19.3
Sol Duc	winter	250733	-0.319	-0.456	0.054	0.128	16.7	17.7	18.4
Calawah	winter	139831	-0.158	-0.246	-0.018	0.040	17.9	18.8	19.5
Hoh	winter	276356	-0.277	-0.495	0.200	0.376	15.1	16.0	16.7
Goodman Creek	winter	44652	-0.065	-0.147	0.034	0.005	16.5	17.5	18.2
Mosquito Creek	winter	20269	-0.065	-0.147	0.047	0.027	16.6	17.5	18.2
Kalaloch Creek	winter	11076	-0.076	-0.158	0.048	0.049	15.4	16.4	17.1

Population	Run	Use Length m	Stream Flow CFS (% change)				NorWeST Temp Mean Max Week °C A1B Scenario		
			Summer season mean NOW vs 2040	Summer season mean NOW vs 2080	25yr Flood NOW vs 2040	25yr Flood NOW vs 2080	2011	2040	2080
Queets	winter	220090	-0.386	-0.575	0.114	0.187	16.1	17.1	17.8
Clearwater	winter	156294	-0.142	-0.224	0.014	0.019	18.1	19.1	19.8
Raft	winter	39724	-0.070	-0.144	0.100	40.135	16.8	17.8	18.5
Lower Quinault	winter	152089	-0.263	-0.397	0.110	0.143	16.1	17.1	17.8
Upper Quinault	winter	183483	-0.488	-0.698	0.111	0.197	14.8	15.8	16.5
Moclips	winter	17988	-0.067	-0.134	0.213	0.325	17.1	18.1	18.8
Copalis	winter	37636	-0.064	-0.128	0.128	0.339	18.1	19.1	19.8
Quillayute-Bogachiel	summer	115484	-0.389	-0.514	0.011	0.076	17.4	18.4	19.1
Sol Duc	summer	186606	-0.434	-0.591	0.098	0.187	16.1	17.1	17.8
Calawah	summer	123122	-0.147	-0.235	-0.019	0.040	17.9	18.9	19.6
Hoh	summer	123949	-0.308	-0.572	0.265	0.507	15.1	16.1	16.8
Queets	summer	106666	-0.398	-0.612	0.127	0.225	16.4	17.4	18.1
Clearwater	summer	62959	-0.164	-0.247	0.013	0.020	19.2	20.1	20.8
Quinault	summer	127968	-0.476	-0.688	0.091	0.155	16.7	17.7	18.4

A new Climate Adaptation Framework by the Coast Salmon Partnership looked at the resilience to climate change of salmon watershed habitats along the Washington coast³². This work includes a tool to explore the resiliency of various watersheds - https://coast-salmon-partnership.shinyapps.io/CRI_app/. Overall, most of the watersheds on the coast in the OP steelhead DPS range were found to have higher overall resiliency to climate change than watersheds further south. But, certain watersheds in WRIA 20 had lower resiliency, mainly due to metrics around summer low flows. Though this work was made public after the status review teams finalized scoring for the risk assessment, it corroborates that low summer flow is likely going to impact certain streams in the range of the DPS but there also may be some areas where climate change will be less impactful. See the user guide for the tool (Adams and Zimmerman 2024) for more information on the metrics used.

³² <https://www.coastsalmonpartnership.org/current-initiatives/climate-framework/>

Effects to OP steelhead

For OP steelhead, increases in summer stream temperatures may especially pose risks to juvenile summer- and winter-run OP steelhead that spend multiple summers in freshwater (Halofsky et al. 2011). Adult summer steelhead require cool water holding pools (Baigún 2003; Baigun 1994; Nakamoto 1994; Nielsen, Lisle and Ozaki 1994) which may be less available with warming temperatures, resulting in higher mortality and/or lower reproductive success (Dalton 2016). Low summer stream flows may affect summer-run steelhead migration by dewatering stream reaches or limiting the accessibility of waterfall or cascades (Halofsky et al. 2011). Increases in flows other times of year may displace juvenile fish and/or reduce the availability of suitable slow-water habitat for young fish. However, winter-run steelhead spawn after peak flow events and may be less susceptible to their redds being scoured (Halofsky et al. 2011). Still, future changes in streamflow could increase stream scouring impacting eggs and embryos, while warmer temperatures may result in early emergence leading to smaller individuals (Dalton 2016). Authors note that salmon fry in low gradient streams may be less vulnerable to displacement from high winter stream flows than fish that emerge later in the year in steeper streams (such as summer steelhead) (Dalton 2016). Changes in flows and temperatures could also impact smolt migration timing (Dalton 2016). Climate Impacts Group (2009) highlighted that salmonids with extended freshwater rearing such as steelhead may experience particularly large increases in temperature and hydrologic stress in summer (from stream temperature increases and lower stream flows), that may result in lower reproductive success. There may be positive impacts from climate change as well, mainly possibly longer growing seasons due to temperature increases, increased productivity within the food-web, and more rapid growth at certain times and life stages (Dalton 2016; Halofsky et al. 2011). Specifically, warmer conditions in summer would likely reduce growth but warmer conditions at other times of year could increase growth rates (Dalton 2016). Warmer temperatures also potentially increase competition with other (especially invasive) species (or predation) and increase susceptibility to disease as well.

For context, Beechie et al. (2023) provided a diagram of overlap of key life stages and effects of climate change based on salmonid populations in the Chehalis basin. We replicate part of Figure 3 from Beechie et al. (2023) to show timing of how climate change would likely impact different stages of winter-run steelhead in the Pacific Northwest and on the OP.

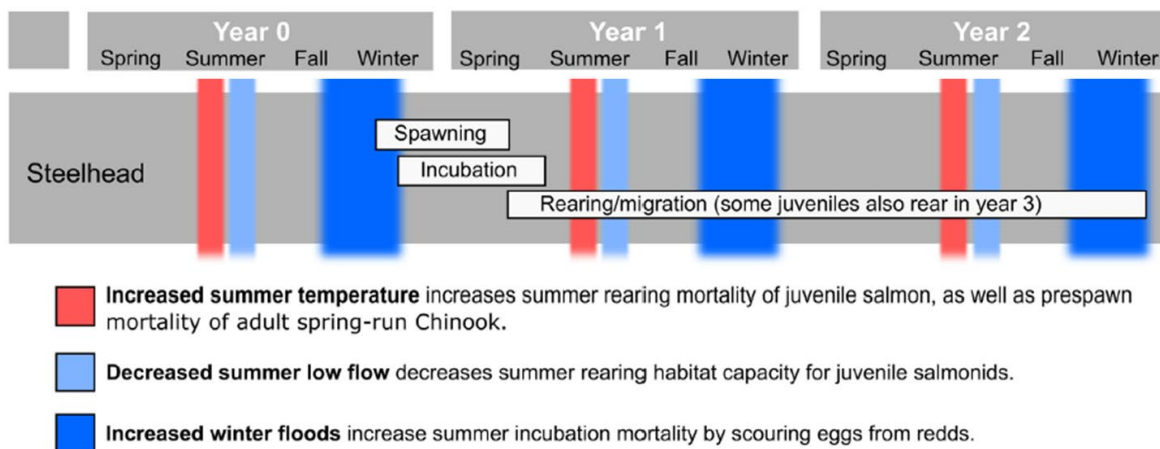


Figure 13. Modified from Beechie et al. (2023), timing of effects of climate change on different life stages of winter-run steelhead.

Within the 2020 State of Watershed Report, the Northwest Treaty Tribes describe that the overall increase in stream temperature leads to salmon being exposed for longer to temperatures outside of their ranges for reproduction and survival (Northwest Indian Fisheries Commission 2020). Also increased temperatures along with changes in streamflow result in lower dissolved oxygen, increased sediment, higher disease susceptibility, competition with other species, and variation in prey for salmonid species. Many of the individual watershed/Tribal reports in the State of Our Watersheds Report note impacts on streamflow and temperature changes to salmon productivity and survival. Within the Quileute report, they note that warmer stream temperatures may lead to accelerated growth and early emergence as well as hydrological impacts on smolting and migration behavior, with overall negative impacts on reproductive success.

At the population level, the ability of organisms to genetically adapt to climate change depends on how selection on multiple traits interact, and whether those traits are linked genetically. Factors that affect genetic diversity can thus limit the ability of a population to adapt to climate change. These include, but are not limited to small population size, domestication in hatchery environments, or introgression by introduced non-native stocks. Though populations may be able to adapt to changes if within the range of what they've experienced historically (Waples, Pess and Beechie 2008), it is unknown if Olympic Peninsula steelhead can adapt quickly enough to the rapid pace of changing climate and habitat conditions. Further, any directional selection effects (i.e. harvest selection on run timing) or general decrease in diversity will decrease the ability of steelhead populations to adapt to these changes. McMillan et al. (2022) note that winter-run steelhead in warmer streams migrate and spawn earlier and that early-run time may be important to the resilience of the population with future climate change, but that there has been a decline in early-returning natural-origin fish.

Dalton (2016) state that climate change driven changes in freshwater ecosystems will be relatively small by the mid-century but that more challenges may present in the marine environment.

Marine Climate Change impacts and OP steelhead

A 2013 report for the Olympic Coast National Marine Sanctuary (OCNMS) reviewed and summarized literature on projected climate change in the marine environment of the Pacific Northwest (including the area within the OCNMS) (Miller et al. 2013). This includes that ocean water could warm by 1 degree Celsius by 2050 with “corrosive ocean water” within shallower areas (water that has a more acidic pH outside of the contemporary values and reduced carbonate ions). Additionally, sea level could rise by over 1 meter by 2100. Changes in the frequency and intensity of storms and upwelling are more uncertain, but the report notes that it is unlikely that climate change will cause any measurable changes in upwelling favorable winds by 2100. Dissolved oxygen is expected to decrease with warming surface waters and there have been declines in dissolved oxygen in specific locations near the OCNMS. This report also notes likely changes in flows and flooding in the Sol Duc, Hoh, Queets, and Quinault rivers.

In the marine ecosystem, salmon may be affected by warmer water temperatures, increased stratification of the water column, intensity and timing changes of coastal upwelling, loss of coastal habitat due to sea level rise, ocean acidification, and changes in water quality and freshwater inputs (Independent Scientific Advisory Board 2007; Mauger et al. 2015). Salmon marine migration patterns could be affected by climate-induced contraction of thermally suitable habitat. Climate change in the marine environment may also reduce forage fish prey for steelhead and other salmonids. Ocean acidification will likely disrupt the food web (through impacts to calcifying planktonic organisms) and warmer temperatures may constrict salmon habitat, affecting adult returns and reproductive success (if fish are smaller returning) (summarized in Dalton et al. 2016). Bioenergetics models informed by data on steelhead mainly from the Central North Pacific Ocean suggest that growth of steelhead in the ocean environment varies with prey quality, consumption rates, overall total consumption, and temperature, though more consumption can compensate for low quality prey (Atcheson et al. 2012). Models suggest that steelhead growth declines with temperatures that deviate from the optimum and there is a narrow range of temperature that results in optimal growth (Atcheson et al. 2012). Also, a study by Abdul-Aziz, Mantua and Myers (2011) predicted an 8 to 43 percent contraction of steelhead species' marine habitat due to climate change between the 2020s and 2080s (depending on time period). A recent assessment of the vulnerability to climate change for 64 different species in the California Current marine ecosystem ranked steelhead as having both high exposure and high sensitivity to climate change and all salmon species considered ranked either very high or high for vulnerability, likely related to their anadromous life history (McClure et al. 2023). Northward range shifts of marine species, including for salmonids, are an expected climate change response (Cheung et al. 2015). However, salmon populations are strongly differentiated in the northward extent of their ocean migration, and hence would likely respond individualistically to widespread changes in sea surface temperature (see Shelton et al. 2021).

Siegel and Crozier (2020) observe that changes in marine temperature are likely to have a number of physiological consequences on fishes themselves (and literature related to this is summarized in NMFS 2022a). For example, in a study of small planktivorous fish, Gliwicz et al. (2018) found that higher ambient temperatures increased the distance at which fish reacted to prey. Numerous fish species (including many tunas and sharks) demonstrate regional endothermy, which in many cases augments eyesight by warming the retinas. However, Gliwicz et al. (2018) suggest that ambient temperatures can have a similar effect on fish that do not demonstrate this trait. Climate change is likely to reduce the availability of biologically essential omega-3 fatty acids produced by phytoplankton in marine ecosystems. Loss of these lipids may induce cascading trophic effects, with distinct impacts on different species depending on compensatory mechanisms (Gourtay et al. 2018). The ecological consequences of these effects and their interactions add complexity to predictions of climate change impacts in marine ecosystems.

As stated in Ford (2022) – “Historically, ocean conditions cycled between periods of high and low productivity. However, global climate change is likely to disrupt this pattern, in general, leading to a preponderance of low productivity years, with an unknown temporal distribution (Crozier et al. 2019). Recent (2015–19) ensemble ocean indicator rankings include four of the worst seven years in the past 20, meaning that an entire Chinook salmon generation has been

subjected to poor ocean productivity conditions.” Additionally, a NOAA presentation by Brian Burke provided in comments to the 90-day finding, noted the increase frequency and magnitude of marine heatwaves in the N.E. Pacific (citing the California Current Ecosystem Status Report - <https://www.integratedecosystemassessment.noaa.gov/regions/california-current/california-current-marine-heatwave-tracker-blobtracker>)

The assessment by Co-Manager Olympic Peninsula Steelhead Working Group (2023) suggested that interannual variation in recruitment and kelt survival were both partially explained by summer sea surface temperature (SST) (and also pink salmon abundance; as well as North Pacific Gyre Oscillation for recruitment). In other words, this analysis showed a negative correlation between recruitment and summer SST and a negative correlation between kelt survival and summer SST. Work by Kendall, Marston and Klungle (2017) showed variability in smolt survival consistently for Washington coast and Strait populations (but with less magnitude fluctuations for Washington Coast, on average). There is uncertainty in how smolt survival and recruitment and kelt survival will change overtime, but this analysis strongly suggests that ocean survivals are likely to decrease in warm years and the frequency of these warm years will increase with climate change.

Hatchery impacts

The effects of hatchery fish on the status of an ESU or DPS depends upon which of the four key attributes -- abundance, productivity, spatial structure, and diversity -- are currently limiting the ESU/DPS, and how the hatchery fish within the ESU/DPS affect each of the attributes (70 FR 37204). In general, hatchery programs can provide short-term demographic benefits to salmon and steelhead, such as increases in abundance during periods of low natural abundance. They also can help preserve genetic resources until limiting factors can be addressed. However, the long- term use of artificial propagation may pose risks to natural productivity and diversity. The magnitude and type of risk depends on the status of affected populations, the stock(s) utilized in the hatchery, and on specific practices in the hatchery program. NMFS has extensively summarized hatchery program information in Washington and general hatchery impacts to salmonids (that also apply to OP steelhead) in various other documents including recent 5-year status reviews (like for Ozette Lake sockeye, NMFS 2022a), and in previous listings for steelhead (see 71 FR 15666, March 29, 2006) which we incorporate here.

Within Washington state there are two types of hatchery programs – integrated and segregated (Harbison et al. 2022). Segregated programs use eggs only from returning hatchery fish while integrated incorporate natural-origin broodstock (Harbison et al. 2022). In order to reduce risks from hatcheries, the WDFW Statewide Steelhead Management Plan (SSMP) and the Hatchery Scientific Review Group (HSRG) (a now disbanded independent scientific panel that reviewed Pacific Northwest hatchery operations), set thresholds of allowable levels of proportion of hatchery origin spawners (pHOS) for segregated programs (the proportion of hatchery-origin fish spawning naturally), as well as proportion of natural influence (PNI) for integrated programs (the proportion of natural-origin fish utilized in the hatchery broodstock). In the case of OP hatchery programs, most of the hatcheries maintain broodstocks that were founded by non-native stocks and are operated as segregated programs to minimize introgression with natural-origin steelhead.

Extensive hatchery programs have been implemented throughout the range of West Coast steelhead (and was summarized in 71 FR 15666, March 29, 2006). While these programs may have succeeded in providing harvest opportunities and increasing the total number of naturally spawning fish, the programs have also likely increased risks to natural populations. Hatchery programs and hatchery-produced steelhead can affect naturally produced populations of salmon and steelhead in a variety of ways, including competition (for spawning sites and food) and predation effects, disease effects, genetic effects (e.g., outbreeding depression, hatchery-influenced selection (i.e. domestication)), broodstock collection effects (inadvertent selection for run timing or size, or limited numbers of broodstock), and facility effects (e.g., water withdrawals, effluent discharge) (Hatchery Scientific Review Group 2014; McMillan et al. 2023; Ohlberger et al. 2018; Rand et al. 2012), as well as masking of trends in natural populations through straying of hatchery fish. Additionally, hatchery influence can result in reduced genetic diversity and reproductive fitness through interbreeding between natural and hatchery-origin steelhead, and the masking of trends in natural populations through the straying of hatchery-origin fish onto spawning grounds. State natural resource agencies have adopted or are developing policies designed to ensure that the use of artificial propagation is conducted in a manner consistent with the conservation and recovery of natural, indigenous populations. The role of artificial propagation in the conservation and recovery of salmonid populations continues to be the subject of vigorous scientific research.

A recent paper by McMillan et al. (2023) summarized literature on effects of hatchery programs on salmonids. For steelhead, 23/35 papers reviewed found adverse or minimally adverse effects of hatcheries on the corresponding natural steelhead population. Chilcote, Goodson and Falcy (2011) found a negative relationship between recruitment and proportion of hatchery fish spawning naturally for steelhead, Chinook, and coho populations in Oregon, Washington, and Idaho (even after corrections to this publication). One study of steelhead in the Hood River, OR found evidence that hatchery produced steelhead increased numbers on the spawning grounds but reduced the effective population size substantially (especially if >10% of the naturally spawning fish are hatchery-origin) (Christie et al. 2012). On the beneficial effects side, two studies reported on effects of a long-term experiment of a captive breeding program for steelhead (using all wild fish as broodstock), including a paper in 2018 that found that the breeding program led to greater redd abundance, expected heterozygosity, and also allelic richness (though not significant) for a depleted steelhead population (Berejikian et al. 2008; Berejikian and Van Doornik 2018). However, another study reported decreased productivity from a recovery program for steelhead, specifically decreased reproductive fitness of wild-born fish from captive parents (Araki, Cooper and Blouin 2009). A recent paper by Courter et al. (2019) found no negative effect of the hatchery summer steelhead spawner abundance on winter steelhead recruitment.

In its 1996 review, NMFS noted that past hatchery practices and practices at the time of the review were a major threat to the genetic integrity of OP steelhead (Busby et al. 1996). Where hatchery-origin and natural-origin steelhead co-occur on the Olympic Peninsula, there is concern about genetic introgression due to interbreeding, especially because all of the current hatchery broodstocks were founded or have been significantly influenced by out-of-DPS stocks. Estimates of the proportion of naturally spawning steelhead that were of hatchery-origin ranged

from 16 to 44 percent, but with the largest runs (Queets and Quillayute) having the lowest proportions of hatchery-origin spawners (Busby et al. 1996).

The recent review of Washington steelhead population include OP steelhead from WDFW (Cram et al. 2018) also named hatchery operations as “a threat to genetic integrity of wild steelhead populations” in the area occupied by OP steelhead. Cram et al. (2018) stated that, as of 2014, there were 11 hatchery programs on the Olympic Peninsula with an average annual release of 1,393,022 smolts from 2000 to 2008 and 1,072,781 from 2009 to 2013. Most hatchery programs (10 of 11) are used for harvest augmentation and most of these were founded from two steelhead populations not native to the Olympic Peninsula – Chambers Creek early winter (Puget Sound) and Skamania early summer (Columbia River: the use of which is being eliminated elsewhere on the West Coast due to impacts on listed steelhead, see Ford (2022)). Of the hatchery programs in the Olympic Peninsula, five are off-site release programs that transfer smolts from their hatchery to another watershed for release. Cram et al. (2018) notes that if adults from these programs are not caught by fisheries, they place natural-origin OP steelhead at risk genetically and ecologically. An integrated hatchery program was initiated in the Bogachiel River in 2013 using hook and line caught natural-origin broodstocks, but has since been discontinued, additionally the program on the Sol Duc River ended and steelhead there are now managed as a “Wild Steelhead Gene Bank” (Cram et al. 2018).

The recent paper by McMillan et al. (2022) discusses potential hatchery impacts on early-returning winter run natural-origin steelhead on the Olympic Peninsula. Specifically, hatchery-origin winter-run steelhead migration overlaps with the historical early-run timing of natural-origin winter-run steelhead so there is high likelihood of interaction between the early-run natural-origin and hatchery-origin steelhead. Additionally, commercial and recreational fisheries targeting hatchery-origin steelhead with early run-timing may be harvesting early-run natural-origin steelhead as well, potentially creating directional selection against early run-timing given that run-timing is a heritable trait. Recent research suggests that hatchery introgression can reduce variation in run timing and even despite reduced fitness of hatchery fish, hatchery alleles can quickly assimilate into natural populations (May et al. 2024).

In the Co-manager’s 2023 assessment of the petition (Co-Manager Olympic Peninsula Steelhead Working Group 2023), they state that – Currently, three hatchery stocks are propagated and released in the OP DPS: early winter (Puget Sound origin, sometimes referred to as Chambers Creek origin), early summer (Lower Columbia origin, sometimes referred to as Skamania origin), and Cook Creek early hatchery winters (putatively Olympic Peninsula origin). Currently, there is limited data to understand the genetic relationships of Cook Creek stock hatchery fish and OP native steelhead. All three hatchery stocks are operated as segregated programs, i.e., they use only hatchery origin fish as broodstock. While this management strategy prevents removing natural spawners from the spawning grounds, it does not prevent hatchery-origin adults from spawning naturally, potentially hybridizing with native steelhead. In addition, the progeny of naturally-spawning hatchery fish would be indistinguishable from native fish. Thus, the co-managers state that these hatchery populations should retain their genetic identity, i.e., should not be introgressed with wild OP steelhead populations and, given the origins of the early winter and early summer stocks, we would expect to be able to genetically distinguish them from wild OP *O. mykiss*.

Specific hatchery information for specific watersheds/rivers is summarized in Harbison et al. (2022) and as well as in our Status Review report; specifically see Table 15 in OP Steelhead DPS Status Review Team (2024) with information on all currently operating hatcheries. A few points on certain hatcheries are worth mentioning. Hatchery fish released in Quinault and Queets rivers are not adipose fin clipped, thus preventing any quantification of hatchery influence except through scale sampling and interpretation or genetics. In the Hoh River, there is a tribal program on the Chalaat Creek which, since 2019, uses broodstock from the Bogachiel or natural-origin Hoh River steelhead. Prior to 2019, broodstock came from Quinault National Fish Hatchery. According to the 2022-2023 Management season report from Hoh Tribe and WDFW, the goal is to produce 100,000 smolts (but this has been closer to 52,000 on average in recent years; pers. comm Brian Hoffman, Hoh Tribe, Natural Resources, June 21, 2023), and 100% of smolts are adipose fin clipped.

In OP Steelhead DPS Status Review Team (2024) in the section *Hatchery Operations in the Olympic Peninsula Steelhead DPS* summarizes extensively the hatchery programs and hatchery outputs. Hatchery releases have stayed consistent since the late 1970s/early 1980s to the present both for winter-run and summer-run hatchery output. Smolt output depending on the run timing, system, and year can range from <10,000 to >700,000.

In the NMFS 1996 review (Busby et al. 1996), NMFS noted the estimated proportion of hatchery stocks on natural spawning grounds ranged from 16 to 44 percent. This proportion was lowest for the two rivers with the largest production of natural-origin steelhead - Queets and Quillayute Rivers. At the time, according to Busby et al. (1996) percent hatchery origin spawners was 43% for the Pysht River, 16% for the Quillayute River, 19% for the Queets River, 44% for the Quinault River, and 37% for the Moclips. As noted in the status review, more recently, the Washington Coast Sustainable Salmon Partnership (WCSSP, 2013) estimated the proportion of hatchery-origin adults that were naturally spawning in Olympic Peninsula DPS basins based on the professional opinion of local biologists. In general, smaller basins with hatchery programs (Tsoo-Yess River, Goodman Creek) and the Quinault River were thought to have higher pHOS levels (26-50%), other basins less so (>25%); although a number of basins were not reported. Most summer-run steelhead pHOS is unknown, however the following website was reported by the petitioners from WDFW³³ which shows that for 2009, pHOS for summer-run steelhead for the hatchery program on the Bogachiel River were 23% and 9% for winter-run.

Scott and Gill (2008) showed gene flow of early Winter steelhead from Chambers creek stock into the Hoko, Pysht, and Sol Duc rivers, (5.5-14.5%, 12-75%, and 2.5-6% gene flow respectively). This led to elimination of winter steelhead smolt release into the Pysht river in 2009, as well as Goodman Creek, Clallam River, and Lyre River. In 2012, the Sol Duc River was designated by WDFW as a Wild Stock Gene Bank, terminating summer smolt releases in 2011 and winter in 2013 (winter-run was local-origin broodstock steelhead) (see Hatchery regulations above).

A recent review by Marston and Huff (2022) looked at the compliance of the WDFW operated Bogachiel Hatchery with standards set in the SSMP. This report also summarized existing

³³ https://fortress.wa.gov/dfw/score/score/hatcheries/hatchery_details.jsp?hatchery=Bogachiel%20Hatchery

hatcheries and then looked at compliance of WDFW operated programs. Specific conclusions included that stray rates from the Bogachiel programs are unknown, for early winter steelhead they modeled – 6% of hatchery fish spawning in the overlap period when natural-origin fish are spawning, and for summer steelhead – less than 1% of hatchery fish spawning in the overlap period with natural-origin fish. Marston and Huff (2022) recommended assessing the status, spawn timing, and spatial distribution of summer natural-origin steelhead, and also re-evaluating the March 15th hatchery origin/natural origin spawner cut-off date, amongst other recommendations. Recommendations also included specifics for discontinuing or continuing State-run programs and how to better manage them.

Kassler et al. (2011) provided evidence of hatchery-origin ancestry for collections of natural-origin fish; indicating at some point there was natural-origin spawning with hatchery fish. The absence of up-to-date comprehensive genetic sampling of natural and hatchery populations makes it difficult to draw conclusions on the impact of hatcheries. All genetic samples are at least 6 years old and some nearly 30 years old, and few directed studies have been conducted to specifically evaluate hatchery introgression or genetic impacts on the wild populations. We therefore do not know the current introgression levels of hatchery genes in the natural population. However, hatchery output has continued for multiple decades, while natural-origin populations have declined, the impacts of hatcheries outlined above are likely continuing and may be impacting more as the natural-origin population declines. At the same time, natural-origin survival is higher than hatchery smolt survival and hatchery smolt survival has declined in recent years (Harbison et al. 2022), so there may be some selection against the maintenance of non-native (hatchery-origin) genes.

We note that many public comments on the 90-day finding voiced support for more broodstock hatchery programs in the OP as a way to continue to have fisheries; we assume because many of these pointed to Oregon programs that use natural-origin stock that this was encouraging the use of natural-origin steelhead as broodstock in hatcheries. Other comments noted that Chinook hatchery releases may be competing with steelhead. Another comment provided reference to epigenetics in steelhead; certain recent studies have found epigenetic differences in natural-origin versus hatchery-origin steelhead but no studies for steelhead have shown if these differences lead to difference in fitness (Gavery et al. 2018; Koch, Nuetzel and Narum 2023).

Competition and indirect food-web interactions

Ruggerone and Nielsen (2004) summarized literature on competition between pink salmon and other salmonids. Research summarized therein found that pink salmon alter the prey abundance of other species (such as abundance of zooplankton, squid), and that this then can lead to an altered diet, reduced consumption, reduced growth, delayed maturation, and reduced survival depending on the salmon species and location. However, some steelhead specific studies indicate that steelhead abundance increased because spawning pink salmon can provide greater prey (in the form of pink fry or eggs) for steelhead, with pink salmon eggs enhancing steelhead parr growth and survival. Additional papers have looked at possible connections between pink salmon abundance and other salmonid growth and survival (Ruggerone and Irvine 2018; Ruggerone et al. 2023). The assessment by the Co-Manager Olympic Peninsula Steelhead Working Group (2023) that interannual variation in recruitment and kelt survival were both

partially explained by Pink salmon abundance (and also SST; as well as North Pacific Gyre Oscillation for recruitment). In other words, this analysis showed a negative correlation between recruitment and Pink salmon abundance and a negative correlation between kelt survival and Pink summer abundance. We note that the co-manager analysis however did not sufficiently consider impacts of pinniped predation on kelt survival or smolt survival because of a lack of data for seal/sea lion (pinniped) abundance (shorter time series compared to other factors) and so there is still uncertainty about impacts of predation on survival for steelhead.

Similarly, potential food web impacts due to loss of in-river chum salmon abundance is discussed in Appendix A to the Status Review (NMFS 2024). Specifically, the decrease in steelhead abundance in the Lyre River may be related to the decline of chum salmon (Goin 1990). Chum salmon spawning escapement estimates for the Lyre were close to 10,000 fish annually (Goin 1990) but by 1996, abundance levels were reduced to 500 to 1,000 annually (McHenry, Lichatowich and Kowalski-Hagaman 1996). Chum fry would emerge from the gravels in the spring, similar to timing of outmigration for steelhead smolts, and so chum fry were hypothesized as a food resource for steelhead smolts.

References

- Abbe, T. B., and D. R. Montgomery. 2003. Patterns and processes of wood debris accumulation in the Queets river basin, Washington. *Geomorphology* 51(1-3):81-107.
- Abdul-Aziz, O. I., N. J. Mantua, and K. W. Myers. 2011. Potential climate change impacts on thermal habitats of Pacific salmon (*Oncorhynchus* spp.) in the North Pacific Ocean and adjacent seas. *Canadian Journal of Fisheries and Aquatic Sciences* 68(9):1660-1680.
- Adams, G. and M. S. Zimmerman. 2023. Salmon Restoration and Resilience in a Changing Climate: A Guide to “Future Proofing” Salmon Habitat in the Washington Coast Region. <https://coastsalmonpartnership.egnyte.com/dl/MnHu1VmItV>
- Coast Salmon Partnership Special Publication 2023-01. Coast Salmon Partnership (Aberdeen, Washington).
- Anderson, J. H., G. R. Pess, R. W. Carmichael, M. J. Ford, T. D. Cooney, C. M. Baldwin, and M. M. McClure. 2014. Planning Pacific salmon and steelhead reintroductions aimed at long-term viability and recovery. *North American Journal of Fisheries Management* 34(1):72-93.
- Anderson, M. 1993. Pacific Salmon and Federal Lands: A Regional Analysis : a Report of the Wilderness Society's Bolle Center for Forest Ecosystem Management. Bolle Center for Ecosystem Management Wilderness Society.
- Antolos, M., D. D. Roby, D. E. Lyons, K. Collis, A. F. Evans, M. Hawbecker, and B. A. Ryan. 2005. Caspian tern predation on juvenile salmonids in the mid-Columbia River. *Transactions of the American Fisheries Society* 134(2):466-480.
- Araki, H., B. Cooper, and M. S. Blouin. 2009. Carry-over effect of captive breeding reduces reproductive fitness of wild-born descendants in the wild. *Biology Letters* 5(5):621-4.
- Atcheson, M. E., K. W. Myers, D. A. Beauchamp, and N. J. Mantua. 2012. Bioenergetic Response by Steelhead to Variation in Diet, Thermal Habitat, and Climate in the North Pacific Ocean. *Transactions of the American Fisheries Society* 141(4):1081-1096.
- Baigún, C. R. 2003. Characteristics of deep pools used by adult summer steelhead in Steamboat Creek, Oregon. *North American Journal of Fisheries Management* 23(4):1167-1174.
- Baigun, C. R. M. 1994. Characteristics of pools used by adult summer steelhead (*Oncorhynchus mykiss*) in the Steamboat Creek Basin, North Umpqua River, Oregon.
- Bash, J., C. H. Berman, and S. Bolton. 2001. Effects of turbidity and suspended solids on salmonids. University of Washington Water Center.
- Bear, E. A., T. E. McMahon, and A. V. Zale. 2007. Comparative thermal requirements of westslope cutthroat trout and rainbow trout: implications for species interactions and development of thermal protection standards. *Transactions of the American Fisheries Society* 136(4):1113-1121.
- Beechie, T., E. Buhle, M. Ruckelshaus, A. Fullerton, and L. Holsinger. 2006. Hydrologic regime and the conservation of salmon life history diversity. *Biological Conservation* 130(4):560-572.
- Beechie, T. J. 1998. Rates and pathways of recovery for sediment supply and woody debris recruitment in northwestern Washington streams, and implications for salmonid habitat restoration. University of Washington.
- Beechie, T. J., C. Fogel, C. Nicol, J. Jorgensen, B. Timpane-Padgham, and P. Kiffney. 2023. How does habitat restoration influence resilience of salmon populations to climate change? *Ecosphere* 14(2):e4402.

- Beechie, T. J., C. N. Veldhuisen, E. M. Beamer, D. E. Schuett-Hames, R. H. Conrad, and P. DeVries. 2005. Monitoring treatments to reduce sediment and hydrologic effects from roads. *Monitoring stream and watershed restoration*. American Fisheries Society, Bethesda, Maryland:35-66.
- Bentley, K. 2017. Evaluation of creel survey methodology for steelhead fisheries on the Quillayute and Hoh Rivers. W. D. o. F. a. Wildlife, editor Washington Department of Fish and Wildlife. Washington Department of Fish and Wildlife, Olympia, WA.
- Berejikian, B. A. 1995. The effects of hatchery and wild ancestry and experience on the relative ability of steelhead trout fry (*Oncorhynchus mykiss*) to avoid a benthic predator. *Canadian Journal of Fisheries and Aquatic Sciences* 52(11):2476-2482.
- Berejikian, B. A., T. Johnson, R. S. Endicott, and J. Lee-Waltermire. 2008. Increases in steelhead (*Oncorhynchus mykiss*) redd abundance resulting from two conservation hatchery strategies in the Hamma Hamma River, Washington. *Canadian Journal of Fisheries and Aquatic Sciences* 65(4):754-764.
- Berejikian, B.A., M.E. Moore, and S. J. Jeffries. 2016. Predator-prey interactions between harbor seals and migrating steelhead trout smolts revealed by acoustic telemetry. *Marine Ecology Progress Series*, 543, pp.21-35.
- Berejikian, B. A., and D. M. Van Doornik. 2018. Increased natural reproduction and genetic diversity one generation after cessation of a steelhead trout (*Oncorhynchus mykiss*) conservation hatchery program. *PLoS One* 13(1):e0190799.
- Berg, L., and T. Northcote. 1985. Changes in territorial, gill-flaring, and feeding behavior in juvenile coho salmon (*Oncorhynchus kisutch*) following short-term pulses of suspended sediment. *Canadian Journal of Fisheries and Aquatic Sciences* 42(8):1410-1417.
- Berman, C. H. 1990. The effect of elevated holding temperatures on adult spring Chinook salmon reproductive success. University of Washington.
- Beschta, R. L. 1979. Debris removal and its effects on sedimentation in an Oregon Coast Range stream. *Northwest Science* 53:71-77.
- Bisson, P. A., and R. E. Bilby. 1998. Organic matter and trophic dynamics. *River ecology and management: Lessons from the Pacific coastal ecoregion*:373-398.
- Bisson, P. A., R. E. Bilby, M. D. Bryant, C. A. Dolloff, G. B. Grette, R. A. House, M. L. Murphy, K. V. Koski, and J. R. Sedell. 1987. Large woody debris in forested streams in the Pacific Northwest: past, present, and future. *Streamside management: forestry and fishery interactions* (57):143.
- Bisson, P. A., G. H. Reeves, R. E. Bilby, and R. J. Naiman. 1997. Watershed management and Pacific salmon: desired future conditions. Pages 447-474 *in* *Pacific Salmon & their Ecosystems: Status and Future Options*. Springer.
- Bisson, P. A., and J. R. Sedell. 1984. Salmonid populations in streams in clearcut vs. old-growth forests of western Washington. Pages 121-129 *in* W. R. Meehan, J. Merrell, T.R., and T. A. Hanley, editors. *Fish and wildlife relationships in old-growth forests*. Proceedings of the symposium. Asheville, NC: American Institute of Fishery Research Biologists.
- Botkin, D., K. Cummins, T. Dunne, H. Regier, M. Sobel, L. Talbot, and L. Simpson. 1995. Status and future of salmon of western Oregon and northern California: findings and options. The Center for the Study of the Environment, Santa Barbara, California.
- Bottom, D. L., P. Howell, and J. Rogers. 1985. The effects of stream alterations on salmon and trout habitat in Oregon.

- Bowler, D. E., R. Mant, H. Orr, D. M. Hannah, and A. S. Pullin. 2012. What are the effects of wooded riparian zones on stream temperature? *Environmental Evidence* 1:1-9.
- Brennan, S. R., D. E. Schindler, T. J. Cline, T. E. Walsworth, G. Buck, and D. P. Fernandez. 2019. Shifting habitat mosaics and fish production across river basins. *Science* 364(6442):783-786.
- Breyta, R., A. Jones, and G. Kurath. 2014. Differential susceptibility in steelhead trout populations to an emergent MD strain of infectious hematopoietic necrosis virus. *Diseases of Aquatic Organisms* 112(1):17-28.
- Breyta, R., A. Jones, B. Stewart, R. Brunson, J. Thomas, J. Kerwin, J. Bertolini, S. Mumford, C. Patterson, and G. Kurath. 2013. Emergence of MD type infectious hematopoietic necrosis virus in Washington State coastal steelhead trout. *Diseases of Aquatic Organisms* 104(3):179-95.
- Brieuc, M. S. O., M. K. Purcell, A. D. Palmer, and K. A. Naish. 2015. Genetic variation underlying resistance to infectious hematopoietic necrosis virus in a steelhead trout (*Oncorhynchus mykiss*) population. *Diseases of Aquatic Organisms* 117(1):77-83.
- Brown, L. R., and P. B. Moyle. 1991. Status of coho salmon in California. Report to the National Marine Fisheries Service 81.
- Bryant, G. J. 1994. Status review of coho salmon populations in Scott and Waddell creeks, Santa Cruz County, California.
- Buchanan, D., J. Sanders, J. Zinn, and J. Fryer. 1983. Relative susceptibility of four strains of summer steelhead to infection by *Ceratomyxa shasta*. *Transactions of the American Fisheries Society* 112(4):541-543.
- Busby, P. J., T. C. Wainwright, G. J. Bryant, L. J. Lierheimer, R. S. Waples, F. W. Waknitz, and I. V. Lagomarsino. 1996. Status review of West Coast steelhead from Washington, Idaho, Oregon, and California. C. Z. Northwest Fisheries Science Center, editor National Oceanic and Atmospheric Administration. National Oceanic and Atmospheric Administration, Seattle, WA.
- California Advisory Committee on Salmon and Steelhead Trout. 1988. Restoring the balance, 1988 annual report, Sacramento, California.
- California Department of Fish and Game. 1965. California fish and wildlife plan. California Department of Fish and Game, Sacramento, California.
- California Department of Fish and Game. 1991. Sport fishing for anadromous salmonid fishes.
- California Department of Fish and Game. 1994. Petition to the Board of Forestry to list coho salmon (*Oncorhynchus kisutch*) as a sensitive species. California Department of Fish and Game, Sacramento, California.
- California State Lands Commission. 1993. California's rivers, a public trust report. California State Lands Commission.
- Carr-Harris, C. N., J. W. Moore, A. S. Gottesfeld, J. A. Gordon, W. M. Shepert, J. D. Henry Jr, H. J. Russell, W. N. Helin, D. J. Doolan, and T. D. Beacham. 2018. Phenological diversity of salmon smolt migration timing within a large watershed. *Transactions of the American Fisheries Society* 147(5):775-790.
- Castino, F., B. Bookhagen, and M. Strecker. 2016. River-discharge dynamics in the Southern Central Andes and the 1976–77 global climate shift. *Geophysical Research Letters* 43(22):11,679-11,687.
- Cederholm, C., R. Bilby, P. Bisson, T. Bumstead, B. Fransen, W. Scarlett, and J. Ward. 1997. Response of juvenile coho salmon and steelhead to placement of large woody debris in a

- coastal Washington stream. *North American Journal of Fisheries Management* 17(4):947-963.
- Cederholm, C., and L. Reid. 1987. Impact of forest management on coho salmon (*Oncorhynchus kisutch*) populations of the Clearwater River, Washington: a project summary. Chapter Thirteen, In: Ernest O. Salo and Terrance W. Cundy (eds.), *Streamside Management: Forestry and Fishery Interactions*, Proceedings of a Symposium held at University of Washington, 12-14 February 1986 Contribution no. 57, Institute of Forest Resources, Seattle, Washington. p. 373-398.
- Cederholm, C. J., L. M. Reid, and E. O. Salo. 1981. Cumulative effects of logging road sediment on salmonid populations in the Clearwater River, Jefferson County, Washington. Pages 35 *in* P. S. R. Station, editor *Salmon-Spawning Gravel: A Renewable Resource in the Pacific Northwest*, Seattle, WA.
- Cederholm, C. J., and E. O. Salo. 1979. The Effects of Logging Road Landslide Siltation on the Salmon and Trout Spawning Gravels of Stequaleho Creek and the Clearwater River Basin, Jefferson County, Washington, 1972 - 1978. Pages 108 *in* F. R. Institute, editor *Washington State Department of Natural Resources*. University of Washington, Seattle, WA.
- Chasco, B., I. C. Kaplan, A. Thomas, A. Acevedo-Gutiérrez, D. Noren, M. J. Ford, M. B. Hanson, J. Scordino, S. Jeffries, S. Pearson, K. N. Marshall, and E. J. Ward. 2017a. Estimates of Chinook salmon consumption in Washington State inland waters by four marine mammal predators from 1970 to 2015. *Canadian Journal of Fisheries and Aquatic Sciences* 74(8):1173-1194.
- Chasco, B. E., I. C. Kaplan, A. C. Thomas, A. Acevedo-Gutierrez, D. P. Noren, M. J. Ford, M. B. Hanson, J. J. Scordino, S. J. Jeffries, K. N. Marshall, A. O. Shelton, C. Matkin, B. J. Burke, and E. J. Ward. 2017b. Competing tradeoffs between increasing marine mammal predation and fisheries harvest of Chinook salmon. *Scientific Reports* 7(1):15439.
- Cheung, W. W., R. D. Brodeur, T. A. Okey, and D. Pauly. 2015. Projecting future changes in distributions of pelagic fish species of Northeast Pacific shelf seas. *Progress in Oceanography* 130:19-31.
- Chilcote, M. W., K. W. Goodson, and M. R. Falcy. 2011. Reduced recruitment performance in natural populations of anadromous salmonids associated with hatchery-reared fish. *Canadian Journal of Fisheries and Aquatic Sciences* 68(3):511-522.
- Christie, M. R., M. Marine, R. French, R. S. Waples, and M. Blouin. 2012. Effective size of a wild salmonid population is greatly reduced by hatchery supplementation. *Heredity* 109(4):254-260.
- Climate Impacts Group. 2009. *The Washington Climate Change Impacts Assessment: Evaluating Washington's Future in a Changing Climate*. University of Washington, Seattle, WA.
- Co-Manager Olympic Peninsula Steelhead Working Group (COPSWG). 2023. *Co-Manager Science Assessment of Proposed ESA-Listing of the Olympic Peninsula Steelhead Distinct Population Segment*. Unpublished report available from the Northwest Indian Fisheries Commission, Lacey, WA, and the Washington Department of Fish and Wildlife, Olympia, WA. 128 pgs.
- Cooper, R., and T. H. Johnson. 1992. Trends in steelhead (*Oncorhynchus mykiss*) abundance in Washington and along the Pacific coast of North America. Washington Department of Wildlife, Fisheries Management Division.

- Cordone, A. J., and D. W. Kelley. 1961. The influences of inorganic sediment on the aquatic life of streams. California Department of Fish and Game California.
- Courter, I. I., G. J. Wyatt, R. W. Perry, J. M. Plumb, F. M. Carpenter, N. K. Ackerman, R. B. Lessard, and P. F. Galbreath. 2019. A natural-origin steelhead population's response to exclusion of hatchery fish. *Transactions of the American Fisheries Society* 148(2):339-351.
- Courtney, M. B., E. A. Miller, A. M. Boustany, K. S. Van Houtan, M. R. Catterson, J. Pawluk, J. Nichols, and A. C. Seitz. 2022. Ocean migration and behavior of steelhead *Oncorhynchus mykiss* kelts from the Situk River, Alaska. *Environmental Biology of Fishes* 105(8):1081-1097.
- Cram, J., N. Kendall, A. Marshall, T. Buehrens, T. Seamons, B. Leland, K. Ryding, and E. Neatherlin. 2018. Steelhead At Risk Report: Assessment of Washington's Steelhead Populations. Washington Department of Fish and Wildlife, Olympia, WA.
- Crawford, B. 1979. Origin and History of the Trout Brood Stocks of the Washington Department of Game. Science.
- Crozier, L., and R. W. Zabel. 2006. Climate impacts at multiple scales: evidence for differential population responses in juvenile Chinook salmon. *Journal of Animal Ecology* 75(5):1100-9.
- Crozier, L. G., A. P. Hendry, P. W. Lawson, T. P. Quinn, N. J. Mantua, J. Battin, R. G. Shaw, and R. B. Huey. 2008. Potential responses to climate change in organisms with complex life histories: evolution and plasticity in Pacific salmon. *Evolutionary Applications* 1(2):252-70.
- Crozier, L. G., M. M. McClure, T. Beechie, S. J. Bograd, D. A. Boughton, M. Carr, T. D. Cooney, J. B. Dunham, C. M. Greene, M. A. Haltuch, E. L. Hazen, D. M. Holzer, D. D. Huff, R. C. Johnson, C. E. Jordan, I. C. Kaplan, S. T. Lindley, N. J. Mantua, P. B. Moyle, J. M. Myers, M. W. Nelson, B. C. Spence, L. A. Weitkamp, T. H. Williams, and E. Willis-Norton. 2019. Climate vulnerability assessment for Pacific salmon and steelhead in the California Current Large Marine Ecosystem. *PLoS One* 14(7):e0217711.
- Crozier, L. G., R. W. Zabel, E. E. Hockersmith, and S. Achord. 2010. Interacting effects of density and temperature on body size in multiple populations of Chinook salmon. *Journal of Animal Ecology* 79(2):342-349.
- Dalton, M. 2016. Climate Change Vulnerability Assessment for the Treaty of Olympia Tribes. Oregon State University,, Corvallis, OR.
- Dixon, P., R. Paley, R. Alegria-Moran, and B. Oidtmann. 2016. Epidemiological characteristics of infectious hematopoietic necrosis virus (IHNV): a review. *Veterinary Research* 47(1):1-26.
- Dunham, J., C. Hirsch, S. Gordon, R. L. Flitcroft, N. Chelgren, M. N. Snyder, D. P. Hockman-Wert, G. H. Reeves, H. V. Andersen, and S. K. Anderson. 2023. Northwest Forest Plan—The first 25 years (1994–2018): Watershed condition status and trends. US Department of Agriculture, Forest Service.
- East, A. E., K. Jenkins, T. Beechie, J. Bountry, M. Mastin, and T. Randle. 2018. 4.1.3. River Geomorphology. R. McCaffery, and K. Jenkins, editors. Natural resource condition assessment: Olympic National Park. Natural Resource Report NPS/OLYM/NRR—2018/1826. National Park Service, Fort Collins, Colorado.
- East, A. E., K. J. Jenkins, P. J. Happe, J. A. Bountry, T. J. Beechie, M. C. Mastin, J. B. Sankey, and T. J. Randle. 2017. Channel-planform evolution in four rivers of Olympic National

- Park, Washington, USA: The roles of physical drivers and trophic cascades. *Earth Surface Processes and Landforms* 42(7):1011-1032.
- Evans, A. F., Q. Payton, B. M. Cramer, K. Collis, N. J. Hostetter, D. D. Roby, and C. Dotson. 2019. Cumulative effects of avian predation on Upper Columbia River steelhead. *Transactions of the American Fisheries Society* 148(5):896-913.
- Evelyn, T., J. Ketcheson, and L. Prosperi-Porta. 1984. Further evidence for the presence of *Renibacterium salmoninarum* in salmonid eggs and for the failure of povidone-iodine to reduce the intra-ovum infection rate in water-hardened eggs. *Journal of fish diseases* 7(3):173-182.
- Evelyn, T., L. Prosperi-Porta, and J. Ketcheson. 1986. Experimental intra-ovum infection of salmonid eggs with *Renibacterium salmoninarum* and vertical transmission of the pathogen with such eggs despite their treatment with erythromycin. *Diseases of Aquatic Organisms* 1(3):197-202.
- Fish and Wildlife Commission. 2021. Anadromous Salmon and Steelhead Hatchery Policy. Pages 1-12 in F. a. W. Commission, editor Washington Department of Fish and Wildlife. Washington Department of Fish and Wildlife.
- Fogel, C. B., C. L. Nicol, J. C. Jorgensen, T. J. Beechie, B. Timpane-Padgham, P. Kiffney, G. Seixas, and J. Winkowski. 2022. How riparian and floodplain restoration modify the effects of increasing temperature on adult salmon spawner abundance in the Chehalis River, WA. *PLoS One* 17(6):e0268813.
- Foott, J., R. Walker, J. Williamson, and K. True. 1994. Health and physiology monitoring of chinook and steelhead smolts in the Trinity and Klamath Rivers. Pages 110-121 in *Proceedings of the Klamath Basin Fisheries Symposium*. California Cooperative Fishery Research Unit, Arcata, California.
- Ford, M. J. 2022. Biological Viability Assessment Update for Pacific Salmon and Steelhead Listed Under the Endangered Species Act: Pacific Northwest. Pages 338 in N. F. S. Center, editor National Oceanic and Atmospheric Administration. National Oceanic and Atmospheric Administration, Seattle, WA.
- Forest Ecosystem Management Assessment Team. 1993. Forest Ecosystem Management: An Ecological, Economic, and Social Assessment Report of the Forest Ecosystem Management Assessment Team.
- Fountain, A. G., C. Gray, B. Glenn, B. Menounos, J. Pflug, and J. L. Riedel. 2022. Glaciers of the Olympic Mountains, Washington-The Past and Future 100 Years. *Journal of Geophysical Research-Earth Surface* 127(4).
- Frissell, C. A. 1992. Cumulative effects of land use on salmon habitat in southwest Oregon coastal streams. Oregon State University.
- Fryer, J., and J. Sanders. 1981. Bacterial kidney disease of salmonid fish. *Annual Reviews in Microbiology* 35(1):273-298.
- Gavery, M. R., K. M. Nichols, G. W. Goetz, M. A. Middleton, and P. Swanson. 2018. Characterization of genetic and epigenetic variation in sperm and red blood cells from adult hatchery and natural-origin steelhead, *Oncorhynchus mykiss*. *G3: Genes, Genomes, Genetics* 8(11):3723-3736.
- Gibbons, D. R., and E. O. Salo. 1973. An annotated bibliography of the effects of logging on fish of the western United States and Canada. Pacific Northwest Forest and Range Experiment Station, US Department of

- Gibbons, R. G., P. K. Hahn, and T. H. Johnson. 1985. Methodology for Determining MSH Steelhead Spawning Escapement Requirements. Pages 72 in W. S. G. Department, editor Washington State Game Department. Washington State Game Department.
- Gliwicz, Z. M., E. Babkiewicz, R. Kumar, S. Kunjiappan, and K. Leniowski. 2018. Warming increases the number of apparent prey in reaction field volume of zooplanktivorous fish. *Limnology and Oceanography* 63(S1):S30-S43.
- Goin, D. 1990. Roll call of the lost. Unpublished report on file with the Lower Elwha Klallam Tribe, Port Angeles, WA.
- Goode, J. R., J. M. Buffington, D. Tonina, D. J. Isaak, R. F. Thurow, S. Wenger, D. Nagel, C. Luce, D. Tetzlaff, and C. Soulsby. 2013. Potential effects of climate change on streambed scour and risks to salmonid survival in snow-dominated mountain basins. *Hydrological Processes* 27(5):750-765.
- Gould, R. W., and G. A. Wedemeyer. 1980. The role of diseases in the decline of Columbia River anadromous salmonid populations. U.S. Fish and Wildlife Service, National Fisheries Research Center, (Seattle, Wash.).
- Gourtay, C., D. Chabot, C. Audet, H. Le Delliou, P. Quazuguel, G. Claireaux, and J.-L. Zambonino-Infante. 2018. Will global warming affect the functional need for essential fatty acids in juvenile sea bass (*Dicentrarchus labrax*)? A first overview of the consequences of lower availability of nutritional fatty acids on growth performance. *Marine Biology* 165(9):143.
- Greene, C. M., J. E. Hall, K. R. Guilbault, and T. P. Quinn. 2010. Improved viability of populations with diverse life-history portfolios. *Biology Letters* 6(3):382-386.
- Gregory, R. S., and C. D. Levings. 1998. Turbidity reduces predation on migrating juvenile Pacific salmon. *Transactions of the American Fisheries Society* 127(2):275-285.
- Gregory, S., Ashkenas, L., Wildman, R., Lienkaemper, G., Arismendi, I., Lamberti, G.A., Meleason, M., Penaluna, B.E. and Sobota, D., Long-term dynamics of large wood in old-growth and second-growth stream reaches in the Cascade Range of Oregon. *River Research and Applications*. Pages 1-15. DOI: 10.1002/rra.4294
- Groot, C., and L. Margolis. 1991. Pacific salmon life histories. UBC press.
- Hagans, D. K., W. E. Weaver, and M. A. Madej. 1986. Long-term on-site and off-site effects of logging and erosion in the Redwood Creek Basin, northern California. Pages 38-65 in American Geophysical Union meeting on cumulative effects. Technical bulletin.
- Haggerty, M. 2008. Draft Clallam River Watershed Stream Habitat Inventory and Assessment. Unpublished report submitted to Clallam County., Port Angeles, Washington.
- Halofsky, J. E., D. L. Peterson, K. A. O'Halloran, and C. Hawkins Hoffman. 2011. Adapting to climate change at Olympic National Forest and Olympic National Park. Pages 130 in P. N. R. Station, editor U.S. Department of Agriculture. U.S. Department of Agriculture, Portland, OR.
- Hansen, W. F. 2001. Identifying stream types and management implications. *Forest Ecology and Management* 143(1-3):39-46.
- Harbison, T., J. Losee, J. Ohlberger, and A. Huff. 2022. Coastal Steelhead Proviso Implementation Plan. Pages 142 in Washington Department of Fish and Wildlife, editor Washington Department of Fish and Wildlife. Washington Department of Fish and Wildlife., Olympia, WA.
- Hatchery Scientific Review Group. 2014. On the science of hatcheries: an updated perspective on the role of hatcheries in salmon and steelhead management in the Pacific Northwest.

- A. Appleby, H.L. Blankenship, D. Campton, K. Currens, T. Evelyn, D. Fast, T. Flagg, J. Gislason, P. Kline, C. Mahnken, B. Missildine, L. Mobrand, G. Nandor, P. Paquet, S. Patterson, L. Seeb, S. Smith, and K. Warheit.
- Hayes, S. A., A. J. Ammann, J. A. Harding, J. L. Hassrick, L. deWitt, and C. A. Morgan. 2016. Observations of steelhead in the California current lead to a marine-based hypothesis for the “half-pounder” life history, with climate change implications for anadromy. *North Pacific Anadromous Fish Commission Bulletin* 6:97-105.
- Henderson, M. J., I. S. Iglesias, C. J. Michel, A. J. Ammann, and D. D. Huff. 2019. Estimating spatial–temporal differences in Chinook salmon outmigration survival with habitat- and predation-related covariates. *Canadian Journal of Fisheries and Aquatic Sciences* 76(9):1549-1561.
- Herring, S. C., N. Christidis, A. Hoell, J. P. Kossin, C. J. Schreck III, and P. A. Stott. 2018. Explaining extreme events of 2016 from a climate perspective. *Bulletin of the American Meteorological Society* 99(1):S1-S157.
- Hicks, B. J. 1990. The influence of geology and timber harvest on channel morphology and salmonid populations in Oregon Coast Range streams. Oregon State University, Corvallis, Oregon.
- Hicks, B. J., J. D. Hall, P. Bisson, and J. R. Sedell. 1991. Responses of salmonids to habitat changes.
- Hicks, M. 2002. Evaluating Standards for Protecting Aquatic Life in Washington's Surface Water Quality Standards Temperature Criteria Draft Discussion Paper and Literature Summary. Pages 197 in W. Q. Program, editor Washington State Department of Ecology. Washington State Department of Ecology, Olympia, WA.
- Higgins, P., S. Dobush, and D. Fuller. 1992. Factors in northern California threatening stocks with extinction. Humboldt Chapter of the American Fisheries Society.
- Hilborn, R., T. P. Quinn, D. E. Schindler, and D. E. Rogers. 2003. Biocomplexity and fisheries sustainability. *Proceedings of the National Academy of Sciences* 100(11):6564-6568.
- Holt, R., J. Sanders, J. Zinn, J. Fryer, and K. Pilcher. 1975. Relation of water temperature to *Flexibacter columnaris* infection in steelhead trout (*Salmo gairdneri*), coho (*Oncorhynchus kisutch*) and chinook (*O. tshawytscha*) salmon. *Journal of the Fisheries Board of Canada* 32(9):1553-1559.
- Hostetter, N. J., A. F. Evans, D. D. Roby, and K. Collis. 2012. Susceptibility of Juvenile Steelhead to Avian Predation: the Influence of Individual Fish Characteristics and River Conditions. *Transactions of the American Fisheries Society* 141(6):1586-1599.
- Independent Scientific Advisory Board. 2007. Climate change impacts on Columbia River basin fish and wildlife.
- Isaak, D. J., S. J. Wenger, E. E. Peterson, J. M. Ver Hoef, S. W. Hostetler, C. H. Luce, J. B. Dunham, J. L. Kershner, B. B. Roper, D. E. Nagel, G. L. Chandler, S. P. Wollrab, S. L. Parkes, and D. L. Horan. 2016. NorWeST modeled summer stream temperature scenarios for the western U.S. Fort Collins, CO: Forest Service Research Data Archive.
- Jacox, M. G., M. A. Alexander, N. J. Mantua, J. D. Scott, G. Hervieux, R. S. Webb, and F. E. Werner. 2018. Forcing of multi-year extreme ocean temperatures that impacted California Current living marine resources in 2016. *Bull. Amer. Meteor. Soc* 99(1).
- Jaeger, K. L., S. W. Anderson, and S. B. Dunn. 2023. Changes in suspended-sediment yields under divergent land-cover disturbance histories: A comparison of two large watersheds, Olympic Mountains, USA. *Earth Surface Processes and Landforms*.

- Jensen, D. W., E. A. Steel, A. H. Fullerton, and G. R. Pess. 2009. Impact of Fine Sediment on Egg-To-Fry Survival of Pacific Salmon: A Meta-Analysis of Published Studies. *Reviews in Fisheries Science* 17(3):348-359.
- Jin, S., J. Dewitz, C. Li, D. Sorenson, Z. Zhu, M. R. I. Shogib, P. Danielson, B. Granneman, C. Costello, and A. Case. 2023. National Land Cover Database 2019: A Comprehensive Strategy for Creating the 1986–2019 Forest Disturbance Product. *Journal of Remote Sensing* 3:0021.
- Jorgensen, J. C., C. Nicol, C. Fogel, and T. J. Beechie. 2021. Identifying the potential of anadromous salmonid habitat restoration with life cycle models. *PLoS One* 16(9).
- Kassler, T., S. Brenkman, J. Gilbertson, M. Gross, D. Low, and A. Spidle. 2011. Genetic Analysis of Steelhead (*Oncorhynchus mykiss*), Coho (*O. kisutch*), and Chinook (*O. tshawytscha*) from Washington's Olympic Peninsula with an Emphasis on the Hoh River. Pages 42 *in* Washington Department of Fish and Wildlife, National Park Service, Hoh Indian Tribe, and Northwest Indian Fisheries Commission, editors. National Park Service, Washington Department of Fish and Wildlife, and Hoh Indian Tribe. National Park Service, Washington Department of Fish and Wildlife, and Hoh Indian Tribe.
- Keefer, M. L., C. A. Peery, and C. C. Caudill. 2008. Migration timing of Columbia River spring Chinook salmon: effects of temperature, river discharge, and ocean environment. *Transactions of the American Fisheries Society* 137(4):1120-1133.
- Kemp, P. S. 2015. Impoundments, barriers and abstractions: impact on fishes and fisheries, mitigation and future directions. *Freshwater fisheries ecology*:717-769.
- Kendall, N. W., G. W. Marston, and M. M. Klungle. 2017. Declining patterns of Pacific Northwest steelhead trout (*Oncorhynchus mykiss*) adult abundance and smolt survival in the ocean. *Canadian Journal of Fisheries and Aquatic Sciences* 74(8):1275-1290.
- Koch, I. J., H. M. Nuetzel, and S. R. Narum. 2023. Epigenetic effects associated with salmonid supplementation and domestication. *Environmental Biology of Fishes* 106(5):1093-1111.
- Koski, K. V., and R. Walter. 1978. Forest practices in relation to management of Alaska's coastal zone resources: A review with management and guideline recommendations. US Department of Commerce, National Oceanic and Atmospheric Administration
- Leek, S. L. 1987. Viral erythrocytic inclusion body syndrome (EIBS) occurring in juvenile spring chinook salmon (*Oncorhynchus tshawytscha*) reared in freshwater. *Canadian Journal of Fisheries and Aquatic Sciences* 44(3):685-688.
- Leopold, L. B. 1968. Hydrology for urban land planning: A guidebook on the hydrologic effects of urban land use, volume 554. US Geological Survey.
- Li, H. W., C. Schreck, C. Bond, and E. Rexstad. 1987. Factors influencing changes in fish assemblages of Pacific Northwest streams. Pages 193-202 *in* W. J. Mathews, and D. C. Heins, editors. Community and evolutionary ecology of North American stream fishes. University of Oklahoma Press, Norman, OK.
- Lloyd, D. S. 1987. Turbidity as a water quality standard for salmonid habitats in Alaska. *North American Journal of Fisheries Management* 7(1):34-45.
- Logan, R. L., K. L. Kaler, and P. K. Bigelow. 1991. Prediction of Sediment Yield from Tributary Basins along Huelsdonk Ridge, Hoh River, Washington. W. D. o. G. a. E. Resources, editor Washington Division of Geology and Earth Resources. Washington State Department of Natural Resources, Olympia, WA.
- Lubenau, W. J. 2022. Encounter Rates and Catch-And-Release Mortality of Steelhead in the Snake River Basin. University of Idaho.

- Lubenau, W. J., T. R. Johnson, B. J. Bowersox, T. Copeland, J. L. McCormick, and M. C. Quist. 2024. Encounter rates and catch-and-release mortality of steelhead in the Snake River basin. *North American Journal of Fisheries Management* 10.1002/nafm.10965.
- Magoulick, D. D., and R. M. Kobza. 2003. The role of refugia for fishes during drought: a review and synthesis. *Freshwater Biology* 48(7):1186-1198.
- Malick, M. J., M. E. Moore, and B. A. Berejikian. 2022. Higher Early Marine Mortality of Steelhead Associated with Releases of Hatchery Coho Salmon but Not Chinook Salmon. *Marine and Coastal Fisheries* 14(6):e10225.
- Mantua, N. J., S. R. Hare, Y. Zhang, J. M. Wallace, and R. C. Francis. 1997. A Pacific interdecadal climate oscillation with impacts on salmon production. *Bulletin of the American Meteorological Society* 78(6):1069-1080.
- Marston, G., and A. Huff. 2022. Modeling Hatchery Influence: Estimates of Gene Flow and pHOS for Washington State Coastal Steelhead Hatchery Programs. Pages 72 in W. D. o. F. a. Wildlife, editor Washington Department of Fish and Wildlife. Washington Department of Fish and Wildlife, Olympia, WA.
- Martens, K. D. 2018. Washington State Department of Natural Resources' Riparian Validation Monitoring Program (RVMP) for salmonids on the Olympic Experimental State Forest – 2017 Annual Report. Pages 41 in F. R. Division, editor Washington State Department of Natural Resources. Washington State Department of Natural Resources, Olympia, WA.
- Martens, K. D., and W. D. Devine. 2023. Pool Formation and The Role Of Instream Wood In Small Streams In Predominantly Second-growth Forests. *Environmental Management* 10.1007/s00267-022-01771-z.
- Martens, K. D., W. D. Devine, T. V. Minkova, and A. D. Foster. 2019. Stream Conditions after 18 Years of Passive Riparian Restoration in Small Fish-bearing Watersheds. *Environmental Management* 63(5):673-690.
- Martin, S. 2023. Makah traditional ecological knowledge briefing in regards to the ESA petition to list Olympic Peninsula steelhead., Makah Fisheries Management, Makah Tribe.
- Mauger, G. S., J. H. Casola, H. A. Morgan, R. L. Strauch, B. Jones, B. Curry, T. M. B. Isaksen, L. W. Binder, M. B. Krosby, and A. K. Snover. 2015. State of Knowledge: Climate Change in Puget Sound. Climate Impacts Group, University of Washington, Seattle.
- May, S.A., Shedd, K.R., Gruenthal, K.M., Hard, J.J., Templin, W.D., Waters, C.D., Adkison, M.D., Ward, E.J., Habicht, C., Wilson, L.I. and Wertheimer, A.C., 2024. Salmon hatchery strays can demographically boost wild populations at the cost of diversity: quantitative genetic modelling of Alaska pink salmon. *Royal Society Open Science*, 11(7), p.240455.
- McClure, M. M., M. A. Haltuch, E. Willis-Norton, D. D. Huff, E. L. Hazen, L. G. Crozier, M. G. Jacox, M. W. Nelson, K. S. Andrews, and L. A. Barnett. 2023. Vulnerability to climate change of managed stocks in the California Current large marine ecosystem. *Frontiers in Marine Science* 10:1103767.
- McCullough, D. 1999. A Review and Synthesis of Effects of Alterations to the Water Temperature Regime on Freshwater Life Stages of Salmonids, with Special Reference to Chinook Salmon. Pages 291 in W. D. R. 10, editor Environmental Protection Agency. Environmental Protection Agency, Seattle, WA.
- McElhany, P., M. H. Ruckelshaus, M. J. Ford, T. C. Wainwright, and E. P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. *N. F. S.*

- Center, editor National Oceanic and Atmospheric Administration. National Oceanic and Atmospheric Administration, Silver Spring, MD.
- McEwan, D., and T. Jackson. 1996. Steelhead restoration and management plan for California. California Department of Fish and Game, Inland Fisheries Division, Sacramento. Management Report.
- McHenry, M., R. McCoy, and M. Haggerty. 2004. Salt Creek Watershed: An Assessment of Habitat Conditions, Fish Populations and Opportunities for Restoration. North Olympic Salmon Coalition, Port Angeles, WA.
- McHenry, M. L., J. Lichatowich, and R. Kowalski-Hagaman. 1996. Status of Pacific Salmon & Their Habitats on the Olympic Peninsula, Washington. Department of Fisheries, Lower Elwha Klallam Tribe.
- McHenry, M. L., E. Shott, R. H. Conrad, and G. B. Grette. 1998. Changes in the quantity and characteristics of large woody debris in streams of the Olympic Peninsula, Washington, U.S.A. (1982-1993). *Canadian Journal of Fisheries and Aquatic Sciences* 55(6):1395-1407.
- McMillan, J. R., S. L. Katz, and G. R. Pess. 2007. Observational evidence of spatial and temporal structure in a sympatric anadromous (winter steelhead) and resident rainbow trout mating system on the Olympic Peninsula, Washington. *Transactions of the American Fisheries Society* 136(3):736-748.
- McMillan, J. R., B. Morrison, N. Chambers, G. Ruggerone, L. Bernatchez, J. Stanford, and H. Neville. 2023. A global synthesis of peer-reviewed research on the effects of hatchery salmonids on wild salmonids. *Fisheries Management and Ecology* 30(5):446-463.
- McMillan, J. R., M. R. Sloat, M. Liermann, and G. Pess. 2022. Historical Records Reveal Changes to the Migration Timing and Abundance of Winter Steelhead in Olympic Peninsula Rivers, Washington State, USA. *North American Journal of Fisheries Management* 42(1):3-23.
- Miller, I. M., C. Shishido, L. Antrim, and C. E. Bowlby. 2013. Climate Change and the Olympic Coast National Marine Sanctuary: Interpreting Potential Futures. Pages 249 in N. M. Sanctuaries, editor National Oceanic and Atmospheric Administration. National Oceanic and Atmospheric Administration, Silver Spring, MD.
- Moore, M. E., and B. A. Berejikian. 2022. Coastal infrastructure alters behavior and increases predation mortality of threatened Puget Sound steelhead smolts. *Ecosphere* 13(4):e4022.
- Moore, M. E., B. A. Berejikian, C. M. Greene, and S. Munsch. 2021. Environmental fluctuation and shifting predation pressure contribute to substantial variation in early marine survival of steelhead. *Marine Ecology Progress Series* 662:139-156.
- Moore, R. B., and T. G. Dewald. 2016. The Road to NHDP lus—Advancements in Digital Stream Networks and Associated Catchments. *JAWRA Journal of the American Water Resources Association* 52(4):890-900.
- Munsch, S. H., C. M. Greene, N. J. Mantua, and W. H. Satterthwaite. 2022. One hundred-seventy years of stressors erode salmon fishery climate resilience in California's warming landscape. *Global Change Biology* 28(7):2183-2201.
- Murdoch, A., and G. Marston. 2020. WDFW Hatchery and Fishery Reform Policy Implementation Assessment: Final Report, 2009-2019. W. D. o. F. a. Wildlife, editor Washington Department of Fish and Wildlife. Washington Department of Fish and Wildlife, Olympia, WA.

- Myers, J. M., J. J. Hard, E. J. Connor, R. A. Hayman, R. G. Kope, G. Lucchetti, A. R. Marshall, G. R. Pess, and B. E. Thomson. 2015. Identifying historical populations of steelhead within the Puget Sound distinct population segment.
- Myers, K. W. 2018. Ocean Ecology of Steelhead. Pages 779-904 in R. J. Beamish, editor. The Ocean Ecology of Pacific Salmon and Trout 10.47886/9781934874455.ch8. American Fisheries Society, Bethesda, MD.
- Myers, K. W., N. D. Davis, R. V. Walker, and M. Atcheson. 2013. Potential Mechanisms of Ocean Mortality of Juvenile Salmon and Steelhead Due to Ingestion of Plastic Marine Debris. Pages 169-170 in North Pacific Anadromous Fish Commission, editor 3rd International Workshop on Migration and Survival Mechanisms of Juvenile Salmon and Steelhead in Ocean Ecosystems. North Pacific Anadromous Fish Commission, Honolulu, Hawaii.
- Nagasawa, K. 1987. Prevalence and abundance of *Lepeophtheirus salmonis* (Copepoda: Caligidae) on high-seas salmon [*Oncorhynchus* spp.] and trout [*Salmo gairdneri*] in the north Pacific Ocean. Bulletin of the Japanese Society of Scientific Fisheries.
- Nagasawa, K. 2001. Annual changes in the population size of the salmon louse *Lepeophtheirus salmonis* (Copepoda: Caligidae) on high-seas Pacific Salmon (*Oncorhynchus* spp.), and relationship to host abundance. *Hydrobiologia* 453-454(1):411-416.
- Naman, Sean M., Kara J. Pitman, Dylan S. Cunningham, Anna Potapova, Shawn M. Chartrand, Matthew R. Sloat, and Jonathan W. Moore. 2024. Forestry impacts on stream flows and temperatures: A quantitative synthesis of paired catchment studies across the Pacific salmon range. *Ecological Solutions and Evidence* 5, no. 2: e12328.
- Naiman, R., K. Fetherston, S. McKay, and J. Chen. 1998. Riparian Forests in River Ecology and Management: Lessons from the Pacific Coastal Ecoregion., ed. RJ Naiman and RE Bilby. New York: Springer-Verlag.
- Naiman, R. J., T. J. Beechie, L. E. Benda, D. R. Berg, P. A. Bisson, L. H. MacDonald, M. D. O'Connor, P. L. Olson, and E. A. Steel. 1992. Fundamental elements of ecologically healthy watersheds in the Pacific Northwest coastal ecoregion. *Watershed management: balancing sustainability and environmental change*:127-188.
- Naish, K. A., J. E. Taylor, 3rd, P. S. Levin, T. P. Quinn, J. R. Winton, D. Huppert, and R. Hilborn. 2007. An evaluation of the effects of conservation and fishery enhancement hatcheries on wild populations of salmon. *Advances in Marine Biology* 53:61-194.
- Nakamoto, R. J. 1994. Characteristics of pools used by adult summer steelhead overwintering in the New River, California. *Transactions of the American Fisheries Society* 123(5):757-765.
- Narum, S. R., J. S. Zendt, D. Graves, and W. R. Sharp. 2008. Influence of landscape on resident and anadromous life history types of *Oncorhynchus mykiss*. *Canadian Journal of Fisheries and Aquatic Sciences* 65(6):1013-1023.
- National Marine Fisheries Service. 1996a. Factors for decline: A supplement to the notice of determination for West Coast Steelhead under the Endangered Species Act. NOAA Fisheries, Protected Species Branch, Portland, Oregon, 83p.(Available from NOAA Fisheries Protected Resources Division, 525 NE Oregon Street, Portland, Oregon 97232).
- National Marine Fisheries Service. 1996b. Steelhead Conservation Efforts: A Supplement to the Notice of Determination for West Coast Steelhead Under the Endangered Species Act. NOAA National Marine Fisheries Service.

- National Marine Fisheries Service (NMFS). 1997. Endangered Species Act Section 7 Conference Report, Unlisted Species Analysis, and Section 10 Findings for the Washington State Department of Natural Resources Habitat Conservation Plan. January 29, 1997. NMFS NW Region. 44p.
- National Marine Fisheries Service. 1998. Factors contributing to the decline of Chinook salmon: an addendum to the 1996 West Coast steelhead factors for decline report. NMFS, Protected Species Branch Portland, Oregon.
- National Marine Fisheries Service (NMFS). 2006b. Endangered Species Act Section 7 Consultation Biological Opinion and Section 10 Statement of Findings And Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation: Washington State Forest Practices Habitat Conservation Plan. June 5, 2006. NMFS Northwest Region. NMFS Tracking No. 2005/07225. 337 p.
- National Marine Fisheries Service. 2008. Endangered Species Act – Section 7 Consultation Final Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation Implementation of the National Flood Insurance Program in the State of Washington Phase One Document – Puget Sound Region.
- National Marine Fisheries Service. 2015. Designation of Critical Habitat for Lower Columbia River Coho Salmon and Puget Sound Steelhead Final Biological Report. National Oceanic and Atmospheric Administration. National Oceanic and Atmospheric Administration.
- National Marine Fisheries Service. 2016. Endangered Species Act (ESA) Section 7(a)(2) Jeopardy and Destruction or Adverse Modification of Critical Habitat Biological Opinion and Section 7(a)(2) “Not Likely to Adversely Affect” Determination for the Implementation of the National Flood Insurance Program in the State of Oregon.
- NMFS (National Marine Fisheries Service). 2019. ESA Recovery Plan for the Puget Sound Steelhead Distinct Population Segment (*Oncorhynchus mykiss*). National Marine Fisheries Service. Seattle, WA.
- National Marine Fisheries Service. 2022a. 2022 5-year Review: Summary & Evaluation of Ozette Lake Sockeye Salmon. 10.25923/8ej9-tc77.
- National Marine Fisheries Service. 2022b. 2022 5-Year Review: Summary & Evaluation of Upper Columbia River Spring-run Chinook Salmon and Upper Columbia River Steelhead. 10.25923/p4w5-dp31.
- National Marine Fisheries Service. 2022c. 2022 5-Year Review: Summary & Evaluation of Snake River Basin Steelhead. <https://repository.library.noaa.gov/view/noaa/45368>
- National Marine Fisheries Service. 2022d. 2022 5-Year Review: Summary & Evaluation of Lower Columbia River Chum Salmon, Lower Columbia River Coho Salmon, and Lower Columbia River Steelhead. <https://repository.library.noaa.gov/view/noaa/48670>
- National Marine Fisheries Service (NMFS). 2024. Olympic Peninsula Steelhead DPS Watershed Summaries: Appendix A to NOAA Technical Memorandum NMFS-NWFSC-198. U.S. Department of Commerce, NOAA Processed Report NMFS-NWFSC-PR-2024-02.
- National Park Service. 2008. Final General Management Plan / Environmental Impact Statement Volume 1: Olympic National Park Washington. <https://parkplanning.nps.gov/document.cfm?parkID=329&projectID=10233&documentID=22448>.
- Nehlsen, W., J. E. Williams, and J. A. Lichatowich. 1991. Pacific Salmon at the Crossroads: Stocks at Risk from California, Oregon, Idaho, and Washington. *Fisheries* 16(2):4-21.

- Nickelson, T., J. Nicholas, A. McGie, R. Lindsay, D. Bottom, R. Kaiser, and S. Jacobs. 1992. Status of anadromous salmonids in Oregon coastal basins. Oregon Department of Fish and Wildlife, Corvallis, Oregon.
- Nicol, C. L., J. C. Jorgensen, C. B. Fogel, B. Timpane-Padgham, and T. J. Beechie. 2022. Spatially overlapping salmon species have varied population response to early life history mortality from increased peak flows. *Canadian Journal of Fisheries and Aquatic Sciences* 79(2):342-351.
- Nielsen, J. L., T. E. Lisle, and V. Ozaki. 1994. Thermally stratified pools and their use by steelhead in northern California streams. *Transactions of the American Fisheries Society* 123(4):613-626.
- North Olympic Peninsula Lead Entity for Salmon (NOPE). 2015. Water Resource Inventory Area 19 (Lyre-Hoko) Salmonid Recovery Plan. North Olympic Peninsula Lead Entity for Salmon (NOPE), Clallam County, WA.
- Northwest Indian Fisheries Commission. 2020. 2020 State of Our Watersheds A Report by the Treaty Tribes in Western Washington. Northwest Indian Fisheries Commission,, Olympia, WA.
- Ohlberger, J., E. J. Ward, D. E. Schindler, and B. Lewis. 2018. Demographic changes in Chinook salmon across the Northeast Pacific Ocean. *Fish and Fisheries* 19(3):533-546.
- OP Steelhead Status Review Team. 2024. Biological Status of the Olympic Peninsula Steelhead Distinct Population Segment: Report of the Status Review Team. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-198.
- Osterback, A.-M. K., D. M. Frechette, S. A. Hayes, M. H. Bond, S. A. Shaffer, and J. W. Moore. 2014. Linking individual size and wild and hatchery ancestry to survival and predation risk of threatened steelhead (*Oncorhynchus mykiss*). *Canadian Journal of Fisheries and Aquatic Sciences* 71(12):1877-1887.
- Pachauri, R. K., M. R. Allen, V. R. Barros, J. Broome, W. Cramer, R. Christ, J. A. Church, L. Clarke, Q. Dahe, and P. Dasgupta. 2014. Climate change 2014: synthesis report. Contribution of Working Groups I, II and III to the fifth assessment report of the Intergovernmental Panel on Climate Change. Ipcc.
- Pacific Fishery Management Council. 2022. Pacific Coast Salmon Fishery Management Plan for Commercial and Recreational Salmon Fisheries off the Coasts of Washington, Oregon, and California as Revised through Amendment 23. PFMF, Portland, OR.
- Pearcy, W. 1992. Ocean ecology of North Pacific salmon. Washington Sea Grant Program.
- Pearson, S.F., S.J. Jeffries, M.M. Lance and A.C. Thomas. 2015. Identifying potential juvenile steelhead predators in the marine waters of the Salish Sea. Washington Department of Fish and Wildlife, Wildlife Science Division, Olympia.
- Pella, J., R. Rumbaugh;, L. Simon;, M. Dahlberg;, S. Pennoyer;, and M. Rose. 1993. Incidental and illegal catches of salmonids in North Pacific driftnet fisheries. *International North Pacific Fisheries Commission Bulletin* 53(III):325-358.
- Penaluna, B. E., J. B. Dunham, and H. V. Andersen. 2021. Nowhere to hide: The importance of instream cover for stream-living Coastal Cutthroat Trout during seasonal low flow. *Ecology of Freshwater Fish* 30(2):256-269.
- Pess, G. R., M. L. McHenry, M. C. Liermann, K. M. Hanson, and T. J. Beechie. 2022. How does over two decades of active wood reintroduction result in changes to stream channel features and aquatic habitats of a forested river system? *Earth Surface Processes and Landforms* 10.1002/esp.5520.

- Phillips, R. W., R. L. Lantz, E. W. Claire, and J. R. Moring. 1975. Some effects of gravel mixtures on emergence of coho salmon and steelhead trout fry. *Transactions of the American Fisheries Society* 104(3):461-466.
- Quinault Indian Nation. 1981. Quinault Indian Nation Fisheries Management Second Quarter Report FY 81.
- Quinn, T. P. 2007. *The behavior and ecology of Pacific salmon and trout*. University of British Columbia Press.
- Rand, P. S., B. A. Berejikian, T. N. Pearsons, and D. L. G. Noakes. 2012. Ecological interactions between wild and hatchery salmonids: an introduction to the special issue. *Environmental Biology of Fishes* 94(1):1-6.
- Reeves, G. H., F. H. Everest, and J. R. Sedell. 1993. Diversity of juvenile anadromous salmonid assemblages in coastal Oregon basins with different levels of timber harvest. *Transactions of the American Fisheries Society* 122(3):309-317.
- Reeves, G. H., D. H. Olson, S. M. Wondzell, P. A. Bisson, S. Gordon, S. A. Miller, J. W. Long, and M. J. Furniss. 2018. The aquatic conservation strategy of the northwest forest plan—A review of the relevant science after 23 years. Pages 461-624 *in* T. A. Spies, P. A. Stine, R. Gravenmier, J. W. Long, and M. J. Reilly, editors. *Synthesis of Science to Inform Land Management Within the Northwest Forest Plan Area*. U.S. Department of Agriculture, Portland, OR.
- Reynolds, F. L., T. J. Mills, R. Benthin, and A. Low. 1993. Restoring Central Valley streams: a plan for action. California Department of Fish and Game.
- Richardson, J. S., and R. J. Danehy. 2007. A synthesis of the ecology of headwater streams and their riparian zones in temperate forests. *Forest Science* 53(2):131-147.
- Riedel, J. L., S. Wilson, W. Baccus, M. Larrabee, T. J. Fudge, and A. Fountain. 2015. Glacier status and contribution to streamflow in the Olympic Mountains, Washington, USA. *Journal of Glaciology* 61(225):8-16.
- Rolland, J. B., and J. R. Winton. 2003. Relative resistance of Pacific salmon to infectious salmon anaemia virus. *Journal of fish diseases* 26(9):511-520.
- Ruckelshaus, M. H., K. P. Currens, W. H. Graeber, R. R. Fuerstenberg, K. Rawson, N. J. Sands, and J. B. Scott. 2006. Independent populations of Chinook salmon in Puget Sound.
- Rucker, R. R., B. J. Earp, and E. J. Ordal. 1954. Infectious diseases of Pacific salmon. *Transactions of the American Fisheries Society* 83(1):297-312.
- Ruggerone, G. T., and J. R. Irvine. 2018. Numbers and Biomass of Natural- and Hatchery-Origin Pink Salmon, Chum Salmon, and Sockeye Salmon in the North Pacific Ocean, 1925-2015. *Marine and Coastal Fisheries* 10(2):152-168.
- Ruggerone, G. T., and J. L. Nielsen. 2004. Evidence for competitive dominance of Pink salmon (*Oncorhynchus gorbusha*) over other Salmonids in the North Pacific Ocean. *Reviews in Fish Biology and Fisheries* 14(3):371-390.
- Ruggerone, G. T., A. M. Springer, G. B. van Vliet, B. Connors, J. R. Irvine, L. D. Shaul, M. R. Sloat, and W. I. Atlas. 2023. From diatoms to killer whales: impacts of pink salmon on North Pacific ecosystems. *Marine ecology. Progress series (Halstenbek)* 719:1-40.
- Safeeq, M., G. E. Grant, S. L. Lewis, and B. Staab. 2015. Predicting landscape sensitivity to present and future floods in the Pacific Northwest, USA. *Hydrological Processes* 29(26):5337-5353.

- Sanders, J., J. Long, C. Arakawa, J. Bartholomew, and J. Rohovec. 1992. Prevalence of *Renibacterium salmoninarum* among downstreammigrating salmonids in the Columbia River. *Journal of Aquatic Animal Health* 4(1):72-75.
- Schindler, D. E., J. B. Armstrong, and T. E. Reed. 2015. The portfolio concept in ecology and evolution. *Frontiers in Ecology and the Environment* 13(5):257-263.
- Schindler, D. E., R. Hilborn, B. Chasco, C. P. Boatright, T. P. Quinn, L. A. Rogers, and M. S. Webster. 2010. Population diversity and the portfolio effect in an exploited species. *Nature* 465(7298):609-12.
- Scott, J. B., and W. T. Gill. 2008. *Oncorhynchus mykiss*: Assessment of Washington State's Steelhead Populations and Programs. Pages 424 in W. D. o. F. a. Wildlife, editor Washington Department of Fish and Wildlife. Washington Department of Fish and Wildlife, Olympia, WA.
- Sedell, J., and K. Luchessa. 1982. Using the historical record as an aid to salmonid habitat enhancement. Pages 210-223 in N. B. Armantrout, editor. Acquisition and utilization of aquatic inventory information. Proceedings of the symposium, Bethesda, Maryland. American Fisheries Society, Western Division.
- Sedell, J. R., P. A. Bisson, J. A. June, and R. W. Speaker. 1982. Ecology and Habitat Requirements of Fish Populations in South Fork Hoh River, Olympic National Park. E. E. Starkey, J. F. Franklin, and J. W. Matthews, editors. Ecological Research in National Parks of the Pacific Northwest: Proceedings. Oregon State University Forest Research Laboratory, San Francisco, CA.
- Sedell, J. R., and C. Maser. 1994. From the forest to the sea: the ecology of wood in streams, rivers, estuaries, and oceans. St. Lucie Press.
- Siegel, J. E., and L. G. Crozier. 2020. Impacts of Climate Change on Salmon of the Pacific Northwest: A review of the scientific literature published in 2019.
- Shelton, A.O., Sullaway, G.H., Ward, E.J., Feist, B.E., Somers, K.A., Tuttle, V.J., Watson, J.T. and Satterthwaite, W.H., 2021. Redistribution of salmon populations in the northeast Pacific ocean in response to climate. *Fish and Fisheries*, 22(3):503-517.
- Smith, C. J. 2000. Salmon and Steelhead Habitat Limiting Factors in the North Washington Coastal Streams of WRIA 20. Washington State Conservation Commission. Washington State Conservation Commission, Lacey, Washington.
- Smith, C. J. 2005. Salmon Habitat Limiting Factors in Washington State. Pages 222 in W. S. C. Commission, editor Washington State Conservation Commission. Washington State Conservation Commission, Olympia, WA.
- Smith, C. J., and J. Caldwell. 2001. Salmon and Steelhead Habitat Limiting Factors in the Washington Coastal Streams of WRIA 21. W. T. A. G. f. H. L. Factors, editor Washington State Conservation Commission. Washington State Conservation Commission, Lacey, WA.
- Spies, T. A., J. W. Long, S. Charnley, P. F. Hessburg, B. G. Marcot, G. H. Reeves, D. B. Lesmeister, M. J. Reilly, L. K. Cervený, and P. A. Stine. 2019. Twenty-five years of the Northwest Forest Plan: what have we learned? *Frontiers in Ecology and the Environment* 17(9):511-520.
- Spies, T. A., J. W. Long, P. Stine, S. Charnley, L. Cervený, B. G. Marcot, G. Reeves, P. F. Hessburg, D. Lesmeister, and M. J. Reilly. 2018. Integrating ecological and social science to inform land management in the area of the Northwest Forest Plan. Spies TA, Stine PA, Gravenmier R, et al:3.

- Stout, J. C., I. D. Rutherford, J. Grove, A. J. Webb, A. Kitchingman, Z. Tonkin, and J. Lyon. 2018. Passive Recovery of Wood Loads in Rivers. *Water Resources Research* 54(11):8828-8846.
- StreamNet GIS Data. 2019. Fish Distribution - All Species Combined., StreamNet, Portland, OR.
- Sullivan, K., T. E. Lisle, C. A. Dolloff, G. E. Grant, and L. M. Reid. 1987. Stream channels: the link between forests and fishes. *Streamside management: forestry and fishery interactions* 39.
- Suttle, K. B., M. E. Power, J. M. Levine, and C. McNeely. 2004. How fine sediment in riverbeds impairs growth and survival of juvenile salmonids. *Ecological Applications* 14(4):969-974.
- Swanson, F. J., G. W. Lienkaemper, and J. R. Sedell. 1976. History, physical effects, and management implications of large organic debris in western Oregon streams, volume 56. Department of Agriculture, Forest Service, Pacific Northwest Forest and
- SWIFD GIS Data. 2014. Statewide Washington Integrated Fish Distribution – SWIFD. Olympia (WA): NWIFC, WDFW.
- Tagart, J. 1984. Coho salmon survival from egg deposition to emergence. *Proceedings of the Olympic Wild Fish Conference, 1984*. Peninsula College, Fisheries Technology Program.
- Thomas, A. C., B. W. Nelson, M. M. Lance, B. E. Deagle, and A. W. Trites. 2017. Harbour seals target juvenile salmon of conservation concern. *Canadian Journal of Fisheries and Aquatic Sciences* 74(6):907-921.
- Thorne, K., G. MacDonald, G. Guntenspergen, R. Ambrose, K. Buffington, B. Dugger, C. Freeman, C. Janousek, L. Brown, and J. Rosencranz. 2018. US Pacific coastal wetland resilience and vulnerability to sea-level rise. *Science Advances* 4(2):eaao3270.
- Titus, R. G., D. C. Erman, and W. M. Snider. 2003. History and status of steelhead in California coastal drainages south of San Francisco Bay. Manuscript dated 19.
- Traxler, G., J. Roome, K. Lauda, and S. LaPatra. 1997. Appearance of infectious hematopoietic necrosis virus (IHNV) and neutralizing antibodies in sockeye salmon *Onchorynchus nerka* during their migration and maturation period. *Diseases of Aquatic Organisms* 28(1):31-38.
- Tucker, S., J. Mark Hipfner, and M. Trudel. 2016. Size-and condition-dependent predation: A seabird disproportionately targets substandard individual juvenile salmon. *Ecology* 97(2):461-471.
- U.S. Forest Service and U.S. Bureau of Land Management. 1994. Final supplemental environmental impact statement on management of habitat for late-successional and old-growth forest related species within the range of the northern spotted owl / lead agencies, U.S. Department of Agriculture, Forest Service, U.S. Department of the Interior, Bureau of Land Management ; cooperating agencies, U.S. Department of the Interior, Fish and Wildlife Service ... [et al.] : v.1. U.S. Dept. of Agriculture, Forest Service : U.S. Dept. of the Interior, Bureau of Land Management, District of Columbia.
- U.S. Geological Survey (USGS) Gap Analysis Project (GAP). 2022. Protected Areas Database of the United States (PAD-US) 3.0. U.S. Geological Survey data release.
- Wade, A. A., T. J. Beechie, E. Fleishman, N. J. Mantua, H. Wu, J. S. Kimball, D. M. Stoms, and J. A. Stanford. 2013. Steelhead vulnerability to climate change in the Pacific Northwest. *Journal of Applied Ecology* 50(5):1093-1104.
- Waples, R. S., G. R. Pess, and T. Beechie. 2008. Evolutionary history of Pacific salmon in dynamic environments. *Evolutionary Applications* 1(2):189-206.

- Washington Coast Sustainable Salmon Partnership. 2013. Washington Coast Sustainable Salmon Plan. Washington Coast Sustainable Salmon Partnership, Ocean Shores, WA.
- Washington Department of Fish and Wildlife. 2008. Statewide Steelhead Management Plan: Statewide Policies, Strategies, and Actions. Pages 48 *in* Washington Department of Fish and Wildlife, editor Washington Department of Fish and Wildlife. Washington Department of Fish and Wildlife, Olympia, WA.
- Washington State Department of Natural Resources (WADNR). 1997. Final Habitat Conservation Plan. September 1997. 546 p.
- Wells, B. K., J. A. Santora, M. J. Henderson, P. Warzybok, J. Jahncke, R. W. Bradley, D. D. Huff, I. D. Schroeder, P. Nelson, and J. C. Field. 2017. Environmental conditions and prey-switching by a seabird predator impact juvenile salmon survival. *Journal of Marine Systems* 174:54-63.
- Wenger, S. J., C. H. Luce, A. F. Hamlet, D. J. Isaak, and H. M. Neville. 2010. Macroscale hydrologic modeling of ecologically relevant flow metrics. *Water Resources Research* 46(9).
- Winkowski, J. J. 2023. Updating Spatial Stream Network Models of August Stream Temperature for the Washington Coast Salmon Recovery Region. Washington Department of Fish and Wildlife. Olympia, Washington. FPT 23-04.
- Withler, I. 1966. Variability in life history characteristics of steelhead trout (*Salmo gairdneri*) along the Pacific coast of North America. *Journal of the Fisheries Board of Canada* 23(3):365-393.
- Wohl, E. 2017. Bridging the gaps: An overview of wood across time and space in diverse rivers. *Geomorphology* 279:3-26.
- Wood, C. C. 1995. Life history variation and population structure in sockeye salmon. *Evolution and the aquatic ecosystem defining unique units in population conservation*:195-216.
- Wood, J. W., and WDFW. 1979. Diseases of Pacific salmon: their prevention and treatment. State of Washington, Department of Fisheries, Hatchery Division.
- Wootten, R., J. W. Smith, and E. Needham. 1982. Aspects of the biology of the parasitic copepods *Lepeophtheirus salmonis* and *Caligus elongatus* on farmed salmonids, and their treatment. *Proceedings of the Royal Society of Edinburgh, Section B: Biological Sciences* 81(3):185-197.
- Wright, B.E., Riemer, S.D., Brown, R.F., Ougzin, A.M. and Bucklin, K.A., 2007. Assessment of harbor seal predation on adult salmonids in a Pacific Northwest estuary. *Ecological Applications*, 17(2), pp.338-351.
- WSDOT. 2021. WSDOT fish passage performance report. Environmental Services Office, Biology Branch, Stream Restoration Program.
- Yang, L., S. Jin, P. Danielson, C. Homer, L. Gass, S. M. Bender, A. Case, C. Costello, J. Dewitz, and J. Fry. 2018. A new generation of the United States National Land Cover Database: Requirements, research priorities, design, and implementation strategies. *ISPRS journal of photogrammetry and remote sensing* 146:108-123.
- Yoder, J., and C. Raymond. 2022. Climate Change and Stream flow: Barriers and Opportunities. Issue June, Water Resources Program Washington State Department of Ecology Olympia, Washington.
- Zamon, J. E., J. M. Mannas, B. P. Sandford, A. Evans, and B. Cramer. 2014. Measuring estuary avian predation on juvenile salmon by electronic recovery of passive integrated

transponder tags from nesting colonies, 2013. Report of research for the US Arm Corps of Engineers, Portland District, Nothwestern Division 69.



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