Science, Service, Stewardship

2022 5-year Review:
Summary & Evaluation of
Ozette Lake Sockeye Salmon

National Marine Fisheries Service
West Coast Region

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5-year Review: Ozette Lake Sockeye Salmon

Species Reviewed	Distinct Population Segment
Sockeye Salmon (*Oncorhynchus nerka*)	*Ozette Lake Sockeye*

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1. General Information

1.1 Introduction

Many West Coast salmon and steelhead (*Oncorhynchus spp.*) stocks have declined substantially from their historical numbers and now are at a fraction of their historical abundance. Several factors contribute to these declines, including overfishing, loss of freshwater and estuarine habitat, hydropower development, poor ocean conditions, and hatchery practices. These factors collectively led to the National Marine Fisheries Service's (NMFS) listing of 28 salmon and steelhead stocks in California, Idaho, Oregon, and Washington under the Federal Endangered Species Act (ESA).

The ESA, under section 4(c)(2), directs the Secretary of Commerce to review the listing classification of threatened and endangered species at least once every 5 years. A 5-year review is a periodic analysis of a species' status conducted to ensure that the listing classification of a species as threatened or endangered on the List of Endangered and Threatened Wildlife and Plants (List) (50 CFR 17.11 – 17.12; 50 CFR 223.102, 224.101) is accurate (USFWS and NMFS 2006; NMFS 2020). After completing this review, the Secretary must determine if any species should: (1) be removed from the list; (2) have its status changed from endangered to threatened; or (3) have its status changed from threatened to endangered. If, in the 5-year review, a change in classification is recommended, the recommended change will be further considered in a separate rule-making process. The most recent 5-year review analysis for West Coast salmon and steelhead occurred in 2016. This document describes the results of the 2022 5-year review for ESA-listed Ozette Lake sockeye salmon.

A 5-year review is:

- A summary and analysis of available information on a given species
- The tracking of a species' progress toward recovery
- The recording of the deliberative process used to make a recommendation on whether or not to reclassify a species
- A recommendation on whether reclassification of the species is indicated

A 5-year review is not:

- A re-listing or justification of the original (or any subsequent) listing action
- A process that requires acceleration of ongoing or planned surveys, research, or modeling
- A petition process
- A rulemaking

1.1.1 Background on salmonid listing determinations

The ESA defines species to include subspecies and distinct population segments (DPSs) of vertebrate species. A species may be listed as threatened or endangered. To identify taxonomically recognized species of Pacific salmon, we apply the Policy on Applying the

Definition of Species under the ESA to Pacific Salmon (56 FR 58612). Under this policy, we identify population groups that are evolutionarily significant units (ESUs) within taxonomically recognized species. We consider a group of populations to be an ESU if it is substantially reproductively isolated from other populations within the taxonomically recognized species and represents an important component in the evolutionary legacy of the species. We consider an ESU as constituting a DPS and, therefore, a species under the ESA.

Artificial propagation programs (hatcheries) are common throughout the range of ESA-listed West Coast salmon and steelhead. Before 2005, our policy was to include in the listed ESU or DPS only those hatchery fish deemed essential for conservation of a species. We revised that approach in response to a court decision. On June 28, 2005, we announced a final policy addressing the role of artificially propagated Pacific salmon and steelhead in listing determinations under the ESA (70 FR 37204) (Hatchery Listing Policy)[1]. This policy established criteria for including hatchery stocks in ESUs and DPSs. In addition, it (1) provides direction for considering hatchery fish in extinction risk assessments of ESUs and DPSs; (2) requires that hatchery fish determined to be part of an ESU or DPS be included in any listing of the ESU or DPS; (3) affirms our commitment to conserving natural salmon and steelhead populations and the ecosystems upon which they depend; and (4) affirms our commitment to fulfilling trust and treaty obligations with regard to the harvest of some Pacific salmon and steelhead populations, consistent with the conservation and recovery of listed salmon ESUs and steelhead DPSs.

To determine whether a hatchery program is part of an ESU or DPS, and therefore must be included in the listing, we consider the origins of the hatchery stock, where the hatchery fish are released, and the extent to which the hatchery stock has diverged genetically from the donor stock. We include within the ESU or DPS (and therefore within the listing) hatchery fish that are no more than moderately diverged from the local population.

Because the revised Hatchery Listing Policy changed the way we considered hatchery fish in ESA listing determinations, we completed new status reviews and ESA listing determinations for West Coast salmon ESUs on June 28, 2005 (70 FR 37159), and for steelhead DPSs on January 5, 2006 (71 FR 834). On August 15, 2011, we published our 5-year reviews and listing determinations for 11 ESUs of Pacific salmon and 6 DPSs of steelhead from the Pacific Northwest (76 FR 50448). On May 26, 2016, we published our 5-year reviews and listing determinations for 17 ESUs of Pacific salmon, 10 DPSs of steelhead, and the southern DPS of eulachon (*Thaleichthys pacificus)* (81 FR 33468).

1.2 Methodology Used to Complete the Review

On October 4, 2019, we announced the initiation of 5-year reviews for 17 ESUs of salmon and 11 DPSs of steelhead in Oregon, California, Idaho, and Washington (84 FR 53117). We requested that the public submit new information on these species that had become available since our 2016 5-year reviews. In response to our request, we received information from federal and state agencies, Native American Tribes, conservation groups, fishing groups, and

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[1] Policy on the Consideration of Hatchery-Origin Fish in Endangered Species Act Listing Determinations for Pacific Salmon and Steelhead

individuals. We considered this information, as well as information routinely collected by our agency, to complete these 5-year reviews.

To complete the reviews, we first asked scientists from our Northwest and Southwest Fisheries Science Centers to collect and analyze new information about ESU and DPS viability. To evaluate viability, our scientists used the Viable Salmonid Population (VSP) concept developed by McElhany et al. (2000). The VSP concept evaluates four criteria – abundance, productivity, spatial structure, and diversity – to assess species viability. By applying this concept, the science centers considered new information for a given ESU or DPS relative to the four salmon and steelhead population viability criteria. They also considered new information on ESU and DPS composition. At the end of this process, the science teams prepared reports detailing the results of their analyses (Ford 2022).

To further inform the reviews, we also asked our salmon management biologists from the West Coast Region familiar with hatchery programs to consider new information available since the previous listing determinations. Among other things, they considered hatchery programs that have ended, new hatchery programs that have started, changes in the operation of existing programs, and scientific data relevant to the degree of divergence of hatchery fish from naturally spawning fish in the same area. Finally, we consulted our Northwest biologists and other salmon management specialists familiar with habitat conditions, hydropower operations, and harvest management. In a series of structured meetings, by geographic area, these biologists identified relevant information and provided insight on the degree to which circumstances had changed for each listed entity.

In preparing this report, we considered the best available scientific information, including the work of the Northwest Fisheries Science Center (Ford 2022); the report of the regional biologists regarding hatchery programs; recovery plans for the species in question; technical reports prepared in support of recovery plans for the species in question; the listing record (including designation of critical habitat and adoption of protective regulations); recent biological opinions issued for the Ozette Lake Sockeye ESU; the information submitted by the public and other government agencies; and the information and views provided by the geographically based management teams. The present report describes the agency's findings based on all of the information considered.

1.3 Background – Summary of Previous Reviews, Statutory and Regulatory Actions, and Recovery Planning

1.3.1 Federal Register Notice Announcing Initiation of this Review

84 FR 53117, October 4, 2019

1.3.2 Listing History

In 1999, NMFS listed the Ozette Lake Sockeye Salmon ESU under the ESA and classified it as a threatened species (Table 1). In 2005, hatchery-origin sockeye from the Umbrella Creek and Big River Hatchery program were determined to be part of the ESU and listed with natural-origin sockeye as protected under the ESA (70 FR 37159).

Table 1. Summary of the listing history under the Endangered Species Act for the Ozette Lake sockeye salmon ESU.

Salmonid Species	ESU Name	Original Listing	Revised Listing
Sockeye Salmon (*Oncorhynchus nerka*)	Ozette Lake Sockeye Salmon	**FR notice:** 64 FR 14528 **Date listed:** 3/25/1999 **Classification**: Threatened	**FR notice:** 70 FR 37159 **Date:** 6/28/2005 **Re-classification**: Threatened

1.3.3 Associated Rulemakings

The ESA requires NMFS to designate critical habitat, to the maximum extent prudent and determinable, for species it lists under the ESA. Critical habitat is defined as: (1) specific areas within the geographical area occupied by the species at the time of listing, that contain physical or biological features essential to the conservation of the species, and that may require special management considerations or protection; and (2) specific areas outside the geographical area occupied by the species at the time of listing that are essential for the conservation of the species. We designated critical habitat for Ozette Lake Sockeye Salmon (hereafter referred to as Ozette Lake Sockeye) in 2005 (70 FR 52630, September 2, 2005) (Table 2). No changes have occurred since this time.

Section 9 of the ESA prohibits the take of species listed as endangered. The ESA defines take to mean harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct. For threatened species, the ESA does not automatically prohibit take, but instead authorizes the agency to adopt regulations it deems necessary and advisable for species conservation and to apply the take prohibitions of section 9(a)(1) through ESA section 4(d). In 2000, NMFS adopted 4(d) regulations for threatened salmonids that prohibit take except in specific circumstances. In 2005, we revised our 4(d) regulations for consistency between ESUs and DPSs, and to take into account our Hatchery Listing Policy.

Table 2. Summary of rulemaking for 4(d) protective regulations and critical habitat for Ozette Lake Sockeye Salmon.

Salmonid Species	ESU Name	4(d) Protective Regulations	Critical Habitat Designations
Sockeye Salmon (*O. nerka*)	Ozette Lake Sockeye Salmon	**FR notice:** 65 FR 42422 **Date:** 7/10/2000 **Revised:** 6/28/2005 (70 FR 37159)	**FR notice:** 70 FR 52630 **Date:** 9/2/2005

1.3.4 Review History

Table 3 lists the scientific assessments of the status of the Ozette Lake sockeye salmon ESU. These assessments include status reviews conducted by our Northwest Fisheries Science Center and technical reports prepared to support recovery planning for this ESU.

Table 3. Summary of previous scientific assessments for the Ozette Lake Sockeye Salmon ESU.

Salmonid Species	ESU Name	Document Citation
Sockeye Salmon (*O. nerka*)	Ozette Lake Sockeye Salmon	Ford 2022 NWFSC 2015 Ford et al. 2011 Currens et al. 2009 Rawson et al. 2009 Good et al. 2005 PSTRT and SSSG 2003 NMFS 1998 Gustafson et al. 1997

1.3.5 Species' Recovery Priority Number at Start of 5-Year Review Process

On April 30, 2019, NMFS issued new guidelines (84 FR 18243) for assigning listing and recovery priorities. Under these guidelines, we assign each species a recovery priority number, ranging from 1 (high) to 11 (low), that reflects its demographic risk (based on the listing status and species' condition in terms of its productivity, spatial distribution, diversity, abundance, and trends) and recovery potential (major threats understood, management actions that exist under United States (U.S.) authority or influence to abate major threats, and certainty that actions will be effective). Additionally, if the listed species is in conflict with construction or other development projects or other forms of economic activity, then they are assigned a 'C' and are given a higher priority over those species that are not in conflict. Table 4 lists the current recovery priority numbers for the subject species, as reported in NMFS 2019. In January 2022, NMFS issued a new report with updated recovery priority numbers. The recovery priority number for the Ozette Lake Sockeye Salmon ESU remained unchanged (NMFS 2022).

Table 4. Recovery Priority Number and Endangered Species Act Recovery Plans for the Ozette Lake Sockeye Salmon ESU.

Salmonid Species	ESU Name	Recovery Priority Number	Recovery Plans/Outline
Sockeye Salmon *(O. nerka)*	Ozette Lake Sockeye Salmon	**7C**	**Title:** Recovery Plan for Lake Ozette Sockeye Salmon (*Oncorhynchus nerka*) Available at: https://www.fisheries.noaa.gov/resource/document/recovery-plan-lake-ozette-sockeye-salmon-oncorhynchus-nerka **Date:** 5/29/2009 **Type:** Final **FR Notice:** 74 FR 25706

1.3.6 Recovery Plan or Outline

The revision of Ozette Lake sockeye's recovery priority from 1 (highest priority) to 9 (moderately low priority) in 2015 recognized that the magnitude of threat to species' recovery was relatively low. This revision reflected the overall stability in the species' viability parameters and stability in the condition of primary constituent elements of critical habitat, and its ranking as a threatened species rather than an endangered species. The recovery potential for this ESU is good, and conflicts with development projects and other economic activity are limited, given the location of Ozette Lake within a national park. The priority was re-ranked from 9 to 7C in 2019, reflecting an increase in risk to viability parameters related to regional or system-wide shifts in natural processes (e.g., streams become rain-source dominant, rather than snow-melt source dominant) that appear to be degrading habitat conditions. That priority number was in effect at the time this 5-year review began. In January 2022 a new priority report was issued, and the priority number for Ozette Lake sockeye was not changed in that report (NMFS 2022).

2. Review Analysis

In this section we review new information to determine whether the Ozette Lake Sockeye ESU delineation remains appropriate.

2.1 Delineation of Species under the Endangered Species Act

Is the species under review a vertebrate?

ESU Name	YES	NO
Ozette Lake Sockeye Salmon	X	

Is the species under review listed as an ESU?

ESU Name	YES	NO
Ozette Lake Sockeye Salmon	X	

Was the ESU listed prior to 1996?

ESU Name	YES	NO	Date Listed if Prior to 1996
Ozette Lake Sockeye Salmon		X	n/a

2.1.1 Summary of Relevant New Information Regarding Delineation of the Ozette Lake Sockeye Salmon ESU

ESU/DPS Delineation

This section provides a summary of information presented in Ford 2022: Biological viability assessment update for Pacific salmon and steelhead listed under the Endangered Species Act: Pacific Northwest.

We found no new information that would justify a change in the delineation of the Ozette Lake Sockeye ESU (Ford 2022).

Membership of Hatchery Programs

For West Coast salmon and steelhead, many of the ESU and DPS descriptions include fish originating from specific artificial propagation programs (e.g., hatcheries) that, along with their naturally produced counterparts, are included as part of the listed species. NMFS' Policy on the Consideration of Hatchery-Origin Fish in Endangered Species Act Listing Determinations for Pacific Salmon and Steelhead (Hatchery Listing Policy) (70 FR 37204, June 28, 2005) guides our analysis of whether individual hatchery programs should be included as part of the listed species. The Hatchery Listing Policy states that hatchery programs will be considered part of an

ESU/DPS if they exhibit a level of genetic divergence relative to the local natural population(s) that is not more than what occurs within the ESU/DPS.

In preparing this report, our hatchery management biologists reviewed the best available information regarding the hatchery membership of this ESU and DPS. They considered changes in hatchery programs that occurred since the last 5-year review (e.g., some have been terminated while others are new) and made recommendations about the inclusion or exclusion of specific programs. They also noted any errors and omissions in the existing descriptions of hatchery program membership. NMFS intends to address any needed changes and corrections via separate rulemaking subsequent to the completion of the 5-year review process prior to any official change in hatchery membership.

In the 2016 5-year review, the Ozette Lake sockeye ESU was defined as including naturally spawned sockeye salmon originating from the Ozette River and Lake Ozette and its tributaries. The ESU also included sockeye salmon from two artificial propagation programs: the Umbrella Creek Hatchery Program; and the Big River Hatchery Program (70 FR 37159, June 28, 2005).

Since 2016, we combined the Umbrella Creek Hatchery Program and Big River Hatchery Program, which are included in the ESU, into one program called the Umbrella Creek/Big River Hatchery Program. This integrated program uses broodstock from Umbrella Creek that were derived from natural-origin fish from Lake Ozette and releases fish into the Umbrella Creek and Big River subwatersheds (85 FR 81822, December 17, 2020).

2.2 Recovery Criteria

The ESA requires NMFS to develop recovery plans for each listed species. Recovery plans must contain, to the maximum extent practicable, objective measurable criteria for delisting the species, site-specific management actions necessary to recover the species, and time and cost estimates for implementing the recovery plan.

Evaluating a species for potential changes in ESA listing requires an explicit analysis of population or demographic parameters (the biological criteria) and also of threats under the five ESA listing factors in ESA section 4(a)(1) (listing factor [threats] criteria). Together these make up the objective, measurable criteria required under section 4(f)(1)(B).

For Pacific salmon, Technical Recovery Teams (TRTs), appointed by NMFS, define criteria to assess biological viability for each listed species. NMFS adopted the TRT's viability criteria as the biological criteria for a recovery plan, based on the best available scientific information and other considerations as appropriate. NMFS also developed criteria to assess progress toward alleviating the relevant threats to a species (listing factor [threats] criteria). For the Lake Ozette Sockeye Salmon Recovery Plan (NMFS 2009b), NMFS adopted the viability criteria metrics defined by the Puget Sound Technical Recovery Team (PSTRT) (Currens et al. 2006; Rawson et al. 2008[2]) as the biological recovery criteria for the threatened Ozette Lake Sockeye Salmon ESU.

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[2] Rawson et al, 2008 was the draft technical memo available at the time that the recovery plan was in development. The technical memo was finalized as Rawson et al. 2009.

Biological review of the species continues as the recovery plan is implemented and additional information becomes available. This information along with new scientific analyses can increase certainty about whether the threats have been abated, whether improvements in population biological viability have occurred for sockeye salmon, and whether linkages between threats and changes in salmon biological viability are understood. NMFS assesses these biological recovery criteria and the delisting criteria through the adaptive management program for the plan during the ESA 5-year review (USFWS and NMFS 2006; NMFS 2020).

2.2.1 Approved Recovery Plan with Objective, Measurable Criteria

Does the species have a final, approved recovery plan containing objective, measurable criteria?

DPS Name	YES	NO
Ozette Lake Sockeye Salmon	X	

2.2.2 Adequacy of Recovery Criteria

Based on new information considered during this review, are the recovery criteria still appropriate?

ESU Name	YES	NO
Ozette Lake Sockeye Salmon	X	

Are all of the listing factors that are relevant to the species addressed in the recovery criteria?

DPS Name	YES	NO
Ozette Lake Sockeye Salmon	X	

2.2.3 Biological Recovery Criteria as they Appear in the Recovery Plan

Salmon ESUs and steelhead DPSs typically display a metapopulation structure (Schtickzelle and Quinn 2007; McElhany et al. 2000). Rather than interbreeding as one large aggregation, ESUs and DPSs function as a group of largely independent populations separated by areas of unsuitable spawning habitat. For conservation and management purposes, it is important to identify the independent populations that make up an ESU or DPS.

The Puget Sound Technical Recovery Team (PSTRT) considered the Ozette Lake sockeye salmon ESU to be composed of one historical population (Currens et al. 2009), with substantial sub-structuring of individuals into multiple spawning aggregations. The Ozette Lake sockeye salmon ESU includes naturally spawned sockeye salmon originating from the Ozette River and Ozette Lake and its tributaries. Also, this ESU includes sockeye salmon from the Umbrella Creek/Big River Hatchery Program (70 FR 37159, June 28, 2005; 85 FR 81822, December 17, 2020; Figure 1).

The extant spawning aggregations located on two beaches on Lake Ozette (Allen's and Olsen's beaches) and in two tributaries (Umbrella Creek and Big River) to Lake Ozette are considered subpopulations. The two remaining beach-spawning aggregations are probably fewer than the number of aggregations that occurred historically, but there is insufficient evidence to determine how many subpopulations occurred in the ESU historically (Currens et al. 2009). A few sockeye salmon, likely strays from beach spawning aggregations, were sporadically observed during spawning ground surveys in past years in Umbrella Creek and Big River. The low number of sockeye observed was not indicative of self-sustaining adult returns, and, the extant tributary-spawning aggregations that are now predominately natural-origin fish were initiated through a hatchery-based introduction program.

All the TRTs used the same biological principles for developing their ESU/DPS and population viability criteria. These principles are described below and in more depth in the NMFS 2000 Technical Memorandum NOAA NMFS-NWFSC-42, *Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units* (hereafter referred to as McElhany et al. 2000). Viable salmonid populations (VSP) are described in terms of four parameters: abundance, productivity or growth rate, spatial structure, and diversity. While the ESU is the listed entity under the ESA, the ESU-level viability criteria are based on the collective viability of the individual populations that make up the ESU—their characteristics and their distribution throughout the ESU's geographic range. The population viability criteria are expressed in terms of risk of extinction over a 100-year time frame.

The VSP concept identifies the attributes, provides guidance for determining the conservation status of populations and larger-scale groupings of Pacific salmonids, and describes a general framework for how many and which populations within an ESU should be at a particular status for the ESU to have an acceptably low risk of extinction. The NMFS-appointed PSTRT developed viability criteria metrics based on the McElhaney et al. 2000 VSP concepts (Rawson 2009). The 2009 Ozette Lake Sockeye Salmon Recovery Plan (NMFS 2009b) adopted the PSTRT viability criteria (Rawson et al. 2009) as the biological recovery criteria for the threatened Ozette Lake Sockeye Salmon ESU.

The viability of the ESU is based on the characteristics and distribution of the population throughout the ESU's geographic range. The Lake Ozette Sockeye Recovery Plan (NMFS 2009b) provides the following biological viability recovery criteria for naturally self-sustaining adults in the Ozette Lake sockeye ESU as described in NMFS 2009 Technical Memorandum NMFS-NWFSC-99 (Rawson et al. 2009). Because there is only one population within this ESU, all four VSP viability criteria listed below must be met for that population for the ESU to be considered viable and at low risk of extinction (McElhaney et al. 2000).

- Abundance: A viable naturally spawning sockeye population in Ozette Lake should range in abundance between 31,250 and 121,000 adult spawners, over a number of years (Rawson et al. 2009). This abundance range would put the population/species at low risk of extinction over a 100-year time frame (McElhaney et al. 2000).
- Productivity: The naturally spawning population growth rate for Lake Ozette sockeye*, once abundance viability is achieved*, should average 1. Until the ESU achieves a viable abundance, the growth rate must be greater than 1 (Rawson et al. 2009). The growth rates

would have to range between an average of 1.04 and 1.06 per year to achieve the above abundance targets in 50 years, or range between an average of 1.02 to 1.03 per year to achieve the above abundance targets in 100 years (Rawson et al. 2009).

- Spatial Structure: A viable naturally spawning Ozette Lake sockeye population should include multiple, spatially distinct and persistent spawning aggregations throughout the historical range of the population. Therefore, a viable sockeye population would have multiple spawning aggregations along the lake beaches that are the known historical spawning areas. The certainty that the population achieves a viable condition for spatial structure would be further increased if spawning aggregations in one or more tributaries to the lake were also established. Recovery cannot rely solely on the present distribution of spawners within the lake and tributary system or on a simple increase in the tributary subpopulation to the exclusion of a lakeshore subpopulation (Rawson et al. 2009). “The PSTRT noted that the current [1999], limited distribution of Lake Ozette sockeye spawners puts the ESU at high risk” (NMFS 2009b).

- Diversity: A viable naturally spawning Ozette Lake sockeye population should include one or more persistent spawning aggregations from each major genetic and life history group historically present within that population. A viable population of sockeye in Lake Ozette should also maintain the historical genetic diversity and distinctness between anadromous sockeye salmon and kokanee salmon in Ozette Lake. “A population that depends upon naturally spawning hatchery fish for its survival is not viable by our definition” (McElhany et al. 2000).

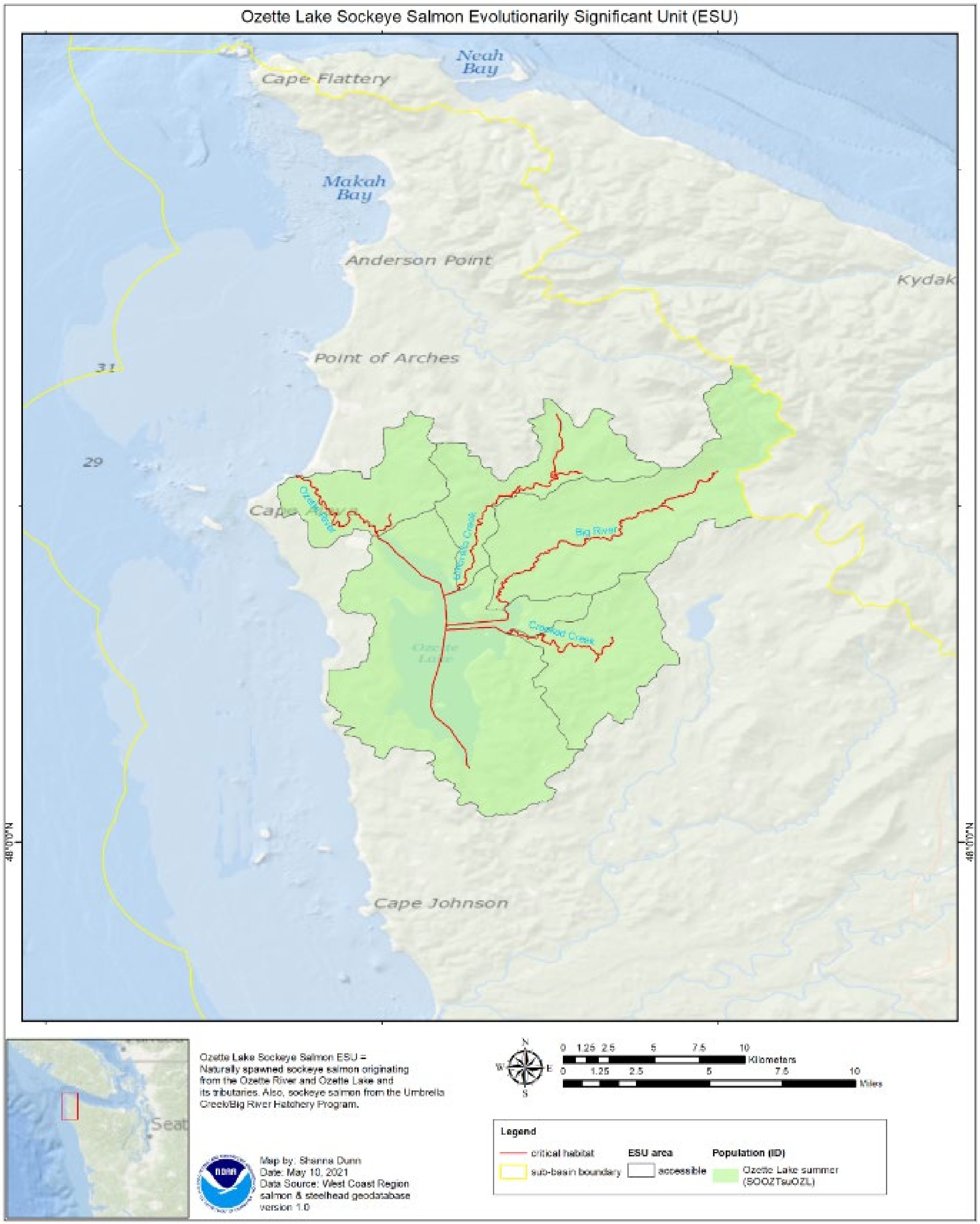

Figure 1. Ozette Lake sockeye salmon population structure.[3]

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[3] The map above generally shows the accessible areas for the Ozette Lake sockeye. salmon ESU. The area displayed

2.3 Updated Information and Current Species' Status

Information provided in this section includes a summary from Ford 2022 – Biological viability assessment update for Pacific salmon and steelhead listed under the Endangered Species Act: Pacific Northwest (Subsection 2.3.1), and our current listing factors analysis (Subsection 2.3.2).

2.3.1 Analysis of VSP Criteria (including discussion of whether the VSP criteria have been met)

Ozette Lake sockeye salmon were originally listed as a threatened species in 1999. At that time, the limited distribution of spawners was considered to put the species at high risk, though the overall risk of extinction was considered moderate. NMFS concluded that "*the Ozette Lake sockeye salmon ESU [was] not presently in danger of extinction, but, if present conditions continue into the future, it is likely to become so in the foreseeable future*." (63 FR_11750-11771, March 10, 1998). Subsequent reviews have found the overall population appeared stable, though available data was uncertain. The biological risk category remained unchanged with each review.

As presented in more detail above, the 2009 Recovery Plan for Lake Ozette Sockeye Salmon (NMFS 2009b) adopted the 2009 PSTRT viability criteria (Rawson et al. 2009) as recovery criteria for the threatened Ozette Lake Sockeye Salmon ESU. Each of the four VSP viability criteria listed below must be met for the single population in the ESU to be viable and at low risk.

- **Abundance:** A viable naturally spawning sockeye population in Ozette Lake should range in abundance between 31,250 and 121,000 adult spawners over a number of years (Rawson et al. 2009).

- **Productivity:** The naturally spawning population growth rate for Ozette Lake sockeye, once abundance viability is achieved, should average 1. Until the ESU achieves a viable abundance, the growth rate must be greater than 1 (Rawson et al. 2009).

- **Spatial Structure:** A viable naturally spawning Ozette Lake sockeye population should include multiple, spatially distinct, and persistent spawning aggregations throughout the historical range of the population. Therefore, a viable sockeye population would have multiple spawning aggregations along the lake beaches that are the known historical spawning areas. The certainty that the population achieves a viable condition for spatial structure would be further increased if spawning aggregations in one or more tributaries to the lake were also established. Recovery cannot rely solely on the present distribution of spawners within the lake and tributary system or on a simple increase in the tributary subpopulation to the exclusion of a lakeshore subpopulation (Rawson et al. 2009).

- **Diversity:** A viable naturally spawning Ozette Lake sockeye population should include one

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is consistent with the regulatory description of the composition of the Ozette Lake sockeye salmon ESU at 50 CFR17.11, 223.102, and 224.102. Actions outside the areas shown can affect this ESU. Therefore, these areas do not delimit the entire area that could warrant consideration in recovery planning or determining if an action may affect this ESU for the purposes of the ESA.

or more persistent spawning aggregations from each major genetic and life history group historically present within that population. A viable population of sockeye in Ozette Lake should also maintain the historical genetic diversity and distinctness between anadromous sockeye salmon and kokanee salmon in Ozette Lake (Rawson et al. 2009).

Updated Biological Risk Summary

In 2022, the Northwest Fisheries Science Center rated the single Ozette Lake sockeye population against the biological criteria identified in the recovery plan and assigned a current viability rating. New data available for this review include:

- Run size estimates based on expanded weir counts from 2013 to 2019.
- A spawning abundance series from 1977 to 2019 constructed from a number of different sources.
- The estimated fraction of hatchery-origin fish returning to Lake Ozette in recent years.

Based on an evolving understanding of both the status of the VSP parameters and the uncertainty in the status of the Ozette Lake sockeye beach spawning aggregates, there appears to be an increase in biological risk for Ozette Lake sockeye. Extinction risk is determined by our best prediction of the demographic probability of extinction and the uncertainty in that prediction. More uncertainty will result in a higher risk. In the case of Ozette Lake sockeye, this uncertainty contributes substantially to our evaluation of extinction risk. Stated otherwise, due to substantial uncertainty in the historical and current abundance and structure of the population, it is not possible to rule out further decline in the VSP parameters over the next couple of decades. Using the biological information presented below, we evaluate the overall risk and whether the VSP criteria are met or unmet. Overall, risk appears to be trending higher because:

1) **Abundance**: For the last four decades, the abundance of Ozette Lake sockeye natural adult spawners[4] ranged from 438 to 12,829, well below the lower viability threshold of 31,250 – 121,000 viable population range established in the 2009 NMFS Technical Memorandum (Rawson et al. 2009) and the 2009 recovery plan. The VSP criteria for Abundance remain unmet.

2) **Productivity:** Over the last few decades, estimated productivity for the total Ozette Lake population has alternated between positive and negative periods. While estimated average productivity over the most recent five- and 15-year periods has been positive, based on historical cyclical patterns in productivity, we may now be entering another negative phase. Previous downturns have generally lasted 4 to 8 years (Ford 2022). This cyclical pattern in productivity makes it difficult to interpret historical trends and predict future trends in productivity and may increase risk due to the potential for sustained periods of negative productivity. Because of the cyclical pattern of positive and negative productivity over the years, there is no evidence of sustained increases in productivity of the population, much less the necessary VSP “productivity criterion” growth rate of greater than one until the

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[4] Hatchery-origin fish contribute to annual total spawner abundance, generally at a low level.

ESU achieves a viable abundance. The VSP criteria for Productivity remain unmet.

3) **Spatial Structure**: Although it currently appears that the Umbrella Creek Hatchery program has successfully introduced a tributary spawning aggregate, thereby increasing the spatial and possibly genetic structure of the population while maintaining a genetic reservoir initially established with beach spawning fish, there is accumulating evidence of a sustained reduction in abundance and distribution of beach spawners, aggravating the conditions originally identified by the PSTRT that "the limited distribution of Lake Ozette sockeye spawners [at that time] put the ESU at high risk." Critical gaps in our knowledge of the beach spawning aggregates prevent any quantitative assessment of abundance or trends for these beach spawning population aggregates, which are considered critical for recovery of the single population Ozette Lake Sockeye Salmon ESU. The VSP criteria for Spatial Structure remain unmet.

4) **Diversity**: The Ozette Lake sockeye ESU consists of a single population, which by itself increases the risk of extinction because of limited demographic diversity and redundancy. For this reason, all four population viability parameters have to be met for the population to be considered viable (See McElhaney et al. 2000).

2.3.2 ESA Listing Factor Analysis

Section 4(a)(1) of the ESA directs us to determine whether any species is threatened or endangered because of any of the following factors: (A) the present or threatened destruction, modification, or curtailment of its habitat or range; (B) overutilization for commercial, recreational, scientific, or educational purposes; (C) disease or predation; (D) inadequacy of existing regulatory mechanisms; or (E) 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. Below we discuss new information relating to each of the five factors as well as efforts being made to protect the species.

Listing Factor A: Present or threatened destruction, modification or curtailment of its habitat or range

Habitat restoration and protection actions at the federal, state, and local levels have been implemented to improve degraded habitat conditions and restore fish passage. While these efforts are expected to benefit the survival and productivity of the targeted Ozette Lake sockeye population, we do not yet have evidence demonstrating that improvements in habitat conditions have led to improvements in population viability. Improvements in monitoring, evaluation, and reporting of habitat metrics and fish population response will allow us to document the effectiveness of habitat restoration actions and progress toward the viability criteria for the Ozette Lake sockeye ESU in the future. Generally, it takes one to five decades to demonstrate such increases in viability. Below, we summarize several noteworthy restoration and protection actions that have been implemented since the last review. We also note areas where concerns remain about the habitat conditions for this ESU.

Current Status and Trends in Habitat

Below, we summarize information on the **current status and trends in habitat** conditions for the single sockeye salmon population in the Ozette Lake Sockeye Salmon ESU since our last 5-year review. We specifically address:

(1) population-specific key emergent or ongoing habitat concerns (threats or limiting factors) focusing on the top concerns that potentially have the biggest impact on independent population viability;

(2) population-specific geographic areas of habitat concern (e.g., independent population major/minor spawning areas) where key emergent or ongoing concerns about this habitat condition remain;

(3) population-specific key protective measures and major restoration actions taken since the 2016 5-year review toward achieving the recovery plan viability criteria established by the PSTRT and adopted by NMFS in the 2009 Recovery Plan for Lake Ozette Sockeye Salmon (NMFS 2009b) as efforts that substantially address a key concern noted in **above #1 and # 2**, or that represent a noteworthy conservation strategy;

(4) key regulatory measures that are either adequate or inadequate and contributing substantially to the key concerns summarized above;

(5) recommended future recovery actions over the next 5 years toward achieving population viability, including: critical near-term restoration actions that would address the key concerns summarized above; projects to address monitoring and research gaps; fixes or initiatives to address inadequate regulatory mechanisms, and address priority habitat areas when sequencing priority habitat restoration actions.

Ozette Lake Sockeye Salmon

(1) Population-Specific Key Emergent or Ongoing Habitat Concerns Since the 2016 5-Year Review

Because the Ozette Lake sockeye ESU is a single population, habitat conditions are extremely influential on the demographic characteristics for the ESU.

Ongoing Habitat Concerns.

- ***Continued poor quality and quantity of Ozette Lake beach spawning habitat***
  Historic timber practices reduced large wood in tributaries, altered the hydrograph (lowered lake level), and added sediment load that occluded spawning substrates. Twenty years of modified forest practices have reduced the sediment load; however, the lake is still low, beaches are exposed, and increased vegetation recruitment is well documented. Beach spawning declines appear to be related to the decline of necessary conditions of the beaches themselves, such as low dissolved oxygen, occlusion of spawning materials by fine sediments, lower lake hydrograph than historical levels, and vegetation encroachment, as the upper beaches are narrowed by vegetation recruitment, and several other habitat factors remain unaddressed for a variety of reasons. Water quantity and hydrologic patterns are of concern as restoration of normative hydrologic function to the

Ozette Lake watershed, as appropriate, is key to the long-term viability of the Ozette Lake sockeye ESU (Haggerty et al. 2009), including inundation patterns that would inhibit vegetation recruitment on otherwise suitable spawning areas. Action to enhance and restore spawning beaches has not been adequately pursued (Haggerty et al. 2009; LOSSC 2012-2015).

- ***Degraded Water Quality***

  Water quality remains a concern for Ozette Lake. A joint NPS/USGS study of water quality on one area, Olsen's Beach, a known historic spawning beach, indicated that the site had very low dissolved oxygen, which could be contributing to the apparent decline of spawning at formerly productive beach spawning habitat. That study evaluated vegetation removal as a potential method to reduce fine sediment and re-establish upwelling with sufficient dissolved oxygen. Preliminary results of the USGS study suggest that vegetation removal may be insufficient as a stand-alone measure to rehabilitate all the conditions necessary to attract and benefit spawning. However, this study looked at conditions over only one incubation period, and the longer-term effects of vegetation removal on the quality and function of spawning habitat are unknown. Pers. Comm., Andrew S. Gendaszek, 12/10/20.

  Other water quality concerns include mercury and PCB levels, which are among the highest in Washington State, despite the remote location of the lake (WDOE 2011). Lake Ozette is considered a highly contaminated coastal lake, and sediment core records from the lake indicate rising sedimentation rates coinciding with logging in the lakes' drainages has greatly increased the net flux of mercury to the waterbodies (Van Furl et al., 2009). Atmospheric sources are likely. With regards to effects on the ESU, tissue samples taken from adult sockeye show mercury levels that were considerably lower than in lake-resident species (WDOE 2011), However mercury levels in Lake Ozette fishes are high enough that the Washington State Department of Health issued a consumption advisory in 2015 which remains in place. Adult sockeye salmon would be expected to have lower mercury and PCB concentrations because the vast majority of growth over their life cycle occurs in the ocean, where levels of these contaminants are low. Juvenile sockeye salmon that are exposed only to lake conditions for their two-year rearing period would be expected to have elevated mercury and PCB concentrations, at levels similar to lake resident species; however, mercury levels in juvenile Ozette Lake sockeye are lower than those of juvenile sockeye found in Lake Washington and are mid-range relative to juvenile sockeye values recorded in Alaska (WDOE 2011).

- ***Sediment Load and River Bed Aggradation***

  In Ozette River, sediment load entering from Coal Creek during peak flow events and low lake level conditions is raising the stream bed elevation and altering streamflow. Similar sediment load systemically enters from tributaries to the Lake and aggregates at the edges of the spawning beaches, enhancing opportunity for vegetation encroachment.

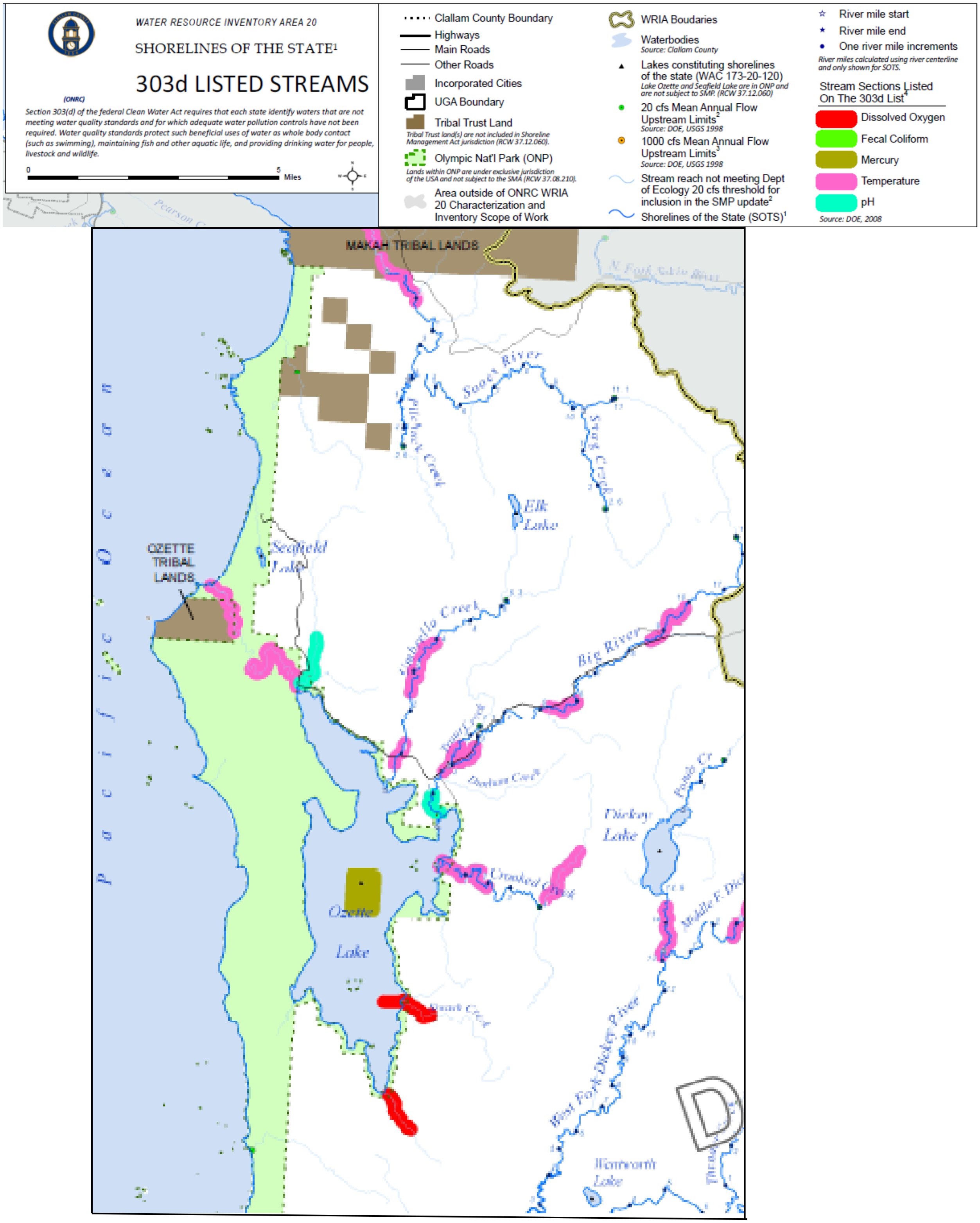

Figure 2. Water quality 303d listings affecting Ozette Lake and Tributaries.

Emerging Habitat Concerns

Climate Change. Detrimental habitat shifts associated with climate change are an emerging concern, particularly as rain-dominant watersheds, such as the Ozette Lake watershed, are sensitive to drought. Shifting climate conditions influence freshwater, ocean, and upland conditions. More information on climate change is presented later in section 2.3.2 on Listing Factor E: "Other Natural or Manmade Factors."

Freshwater Environment. The relatively unusual spring and summer drought conditions in 2015 and 2016 (Anderson et al. 2016) may have adversely affected adult returns to the tributaries within the watershed. Makah biologists note that the annual variation associated with four comparatively distinct brood lines occurred in the past, but apparently exacerbated by the droughts and warmer marine conditions, the previous moderately upward trend has reversed for the first time since the program began using Umbrella Creek-sourced adults as a brood source (Hinton 2020). An influence of climate change is a shift in temperature regimes in Lake Ozette tributaries and the lake itself. Temperature data provided by Makah tribal scientists, covering 2014-2020, suggests that the occurrence of temperatures above 20 degrees Celsius, which exceed optimum temperatures for sockeye, are shifting from early August to mid-July (pers. Comm. Angela Tetnowski, January 2021).

Delayed migration of sockeye into tributaries during October and November has been observed during extreme low base flow conditions and a delay in the onset of the wet season, and seasonal lake level changes are known to directly result in sockeye redd dewatering. This occurs when sockeye spawn in November, December, and January at elevations along the beaches that become exposed by lower lake levels before incubation and emergence. Makah biologists have observed in recent years that their hatchery has had to release fry at both sites earlier than normal because of low flow, broodstock collection have occurred later than normal due to late arrival of fall rains, and that upon the return of rains, storm events can be so large that scour of spawning materials is a concern.

Ozette Lake sockeye spawning aggregations have expanded the range of habitat utilized. Makah tribal biologists report that natural spawning is occurring further upstream in the two tributaries that have been the focus of reintroduction efforts, which suggests that habitat values are becoming re-established in these tributaries. However, this expansion may be diminished by climatic changes if stream flow and temperature levels become less hospitable to sockeye salmon survival and productivity. For example, in 2015, warmer than normal winter temperatures led to maturation of eggs at the Makah hatchery several weeks earlier than usual, and drier than normal conditions in spring required the release of juveniles from the hatchery several weeks earlier than usual. Early summer flows reduced the lake level so significantly that it was difficult, given dynamic depth and low flow conditions and the limited availability of tribal resources, to effectively operate the ARIS array in the upper Ozette River for the purposes of counting sockeye entering the lake. Further, ponding and low flows in the Ozette River impaired migration and aggravated predation, as otters took advantage of the sockeye pooling in cooler pockets of water. Mid-summer conditions saw flows at very low levels with temperatures so warm that disease risk increased at the tributary hatchery program rearing location.

Shifting climate conditions also suggest that rainfall events will carry significantly more water, increasing the risk of flooding. An example of the increasingly dynamic nature of these precipitation events occurred in 2019 when rainfall was so intense that the weir at Umbrella Creek (where broodstock is captured for spawning consistent with the terms of the conservation hatchery/supplementation Hatchery Genetic Management Plan (HGMP) was undermined.

Ocean Conditions. Other ocean conditions that appear as possible new concerns include the influence of algae. In 2019 on the Washington coast (~September), there were substantial blooms of Alexandrium spp. that produced saxitoxin (paralytic shellfish poisoning), leading to shellfish closures. Harmful algal bloom toxins have been detected in a wide range of fish species, not just planktivorous fish (see for example Lefevbre et al. 2002; Mazzillo et al. 2010). Makah biologists have detected both domoic acid and saxitoxin (paralytic shellfish toxin) in sea lions (Akmajian et al. 2017) and in fish, including salmon (unpublished and on-going), throughout the year off the northern Washington coast, even during periods of low or no apparent active bloom occurring. While toxins do not generally affect the fish themselves, the specific response depends on the species of fish and the toxin in question. For example, there is some evidence that salmonids are sensitive to saxitoxins (Cembella et al. 2002; Gubbins et al. 2000), and the Makah have documented saxitoxin (and domoic acid) in salmon caught in the Makah Usual and Accustomed fishing areas. While the Makah have not finished processing fish from 2019 (n=30 salmon), fish from 2018 (n=21 salmon) had low levels (~1-65 ng) of saxitoxin / g tissue (compared to human regulatory limit at 800 ng/g). We can assume for this review that Ozette Lake sockeye also experience exposure to these algae and carry a comparable tissue burden. More information on climate change and ocean conditions is presented later in section 2.3.2 on Listing Factor E.

Upland and Riparian Areas. A major emergent habitat concern since the 2016 5-year review is the increased frequency and severity of large, unprecedented wildfires. Fires cause significant loss of riparian habitat, as well as increased landslides and sediment input to the waterway with the subsequent loss of spawning habitat (Maina and Siirila-Woodburn 2020; Dunham 2003). While to date no such fires have occurred in the Ozette Watershed, fire frequency has increased substantially within Olympic National Park, and the Ozette watershed has commensurate increasing risk.

- ***Invasive Species***
  In the summer of 2019, fieldwork found invasive freshwater Asian clams at Lake Ozette. Similar to zebra mussels, infestations of Asian clams can clog water intake pipes and alter local ecosystems by excreting significant amounts of inorganic nutrients, particularly nitrogen. Excess nitrogen can stimulate the growth of algae and foul the

water. The degree of this species' presence is being evaluated. At this time, the invasive freshwater Asian clam has also spread to Umbrella Creek.

(2) Population-Specific Geographic Areas of Habitat Concern Since the 2016 5-Year Review

Significant habitat concerns remain regarding spawning beach conditions at Allen's Beach and Olsen's Beach, which are the current spawning areas for Ozette Lake sockeye, and which are affected by hydrologic patterns that are legacy effects of streamside timber practices and large wood removal. It will take decades to ameliorate these effects without affirmative restoration activities. The low productivity of the beach spawning aggregation(s) is a continuing concern. It will require corrective habitat measures on the part of the co-managers and the Olympic National Park in order for viability benefits to accrue. Climate change also portends an increasing frequency of detrimental conditions similar to those experienced throughout 2015.

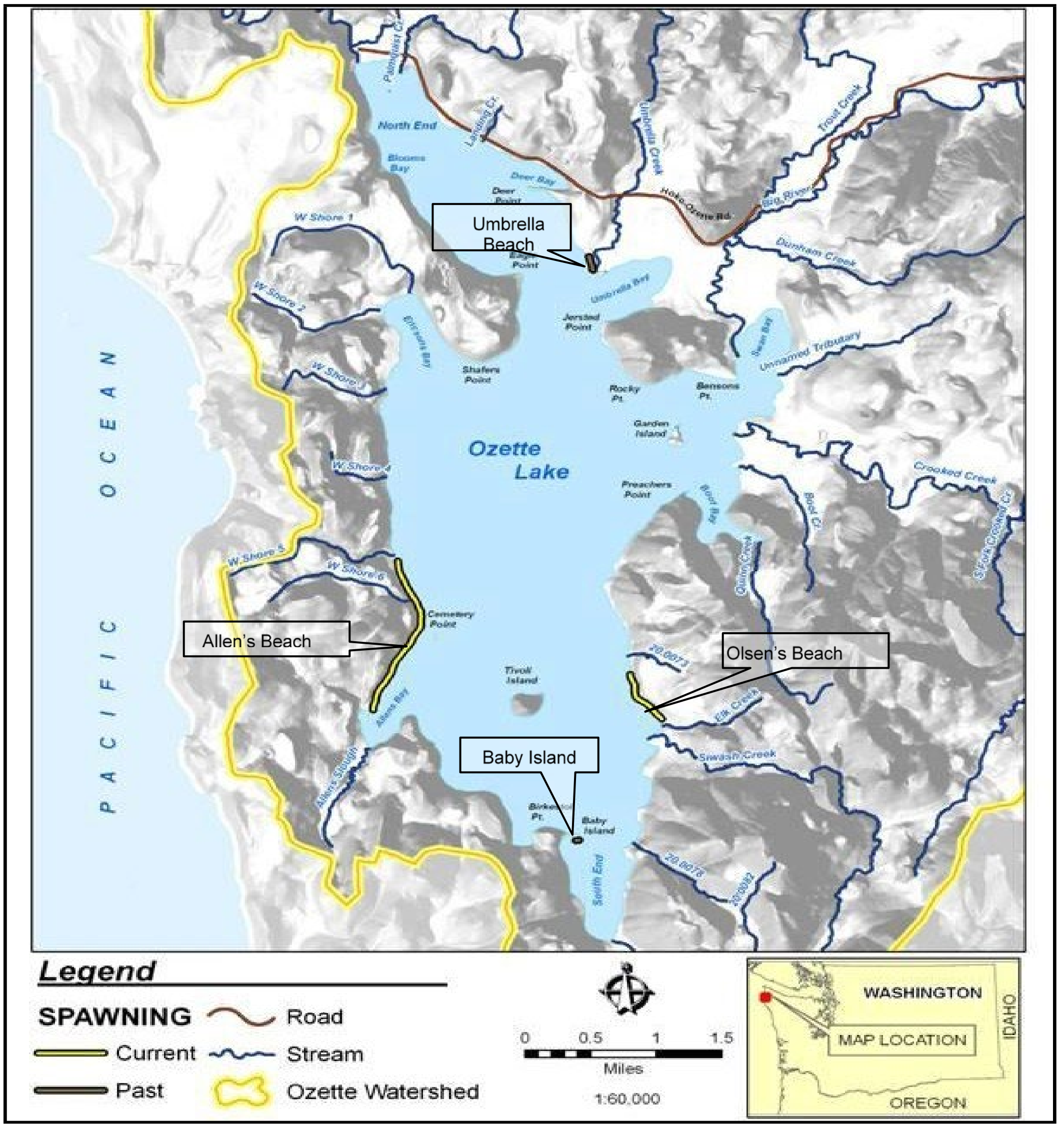

Figure 3. Known current and historical Ozette Lake sockeye beach spawning location (modified from Haggerty et al. 2009).

Predation continues to appear to be a significant factor limiting productivity (Haggerty et al. 2009; LOSSC 2012-2015) in Lake Ozette, Ozette River, and Umbrella Creek; however, the 2018 partial removal of the weir at Ozette River is anticipated to alleviate a predation point because the sockeye will not have to congregate in a concentrated area to move past the weir. More information is presented in Section 2.3.2 on Listing Factor C, Predation and Disease.

Clallam County has identified knotweed as an invasive noxious weed that requires eradication. Giant Knotweed, (*Polygonum sachalinense*), Bohemian Knotweed, (*P. bohemicum*), and Japanese Knotweed, (*P. cuspidatum*) are each considered Class B weeds, with mandatory control to prevent spreading. Control and prevention of spread is mandatory in stream channel, riparian and FEMA 100-year flood zones of the Big, Hoko, Clallam, and Sekiu Rivers and their associated tributaries; Big River is a tributary to Lake Ozette. Control and preventing spread is also mandated in ditches or roadside areas with high potential to disturb and spread knotweed, since knotweed poses a significant threat to fish and wildlife habitat along rivers. Knotweed can rapidly colonize and displace native plants communities and densely colonize stream areas in a manner that occludes fish access to habitat.

New knotweed infestations are being discovered in pits and mineral/ soil/mulch product stockpiling areas each year. Because invasive knotweed spreads easily by small root or stem fragments, knotweed contaminated soil/mulch or gravel presents a very high potential for spreading and creating new infestations countywide, including in tributaries to Lake Ozette. Roadside knotweed infestations where routine maintenance activity such as cleaning, blading or mowing ditches or shoulders occurs, have become the main vector for infesting pits through contaminated spoils or equipment. These necessary maintenance measures, as well as natural disturbances, inadvertently spread invasive knotweed along roads and ditches, onto private property, and even into natural areas, and are a source that can be eliminated or avoided altogether. Control in these areas is a necessary preventative measure.

(3) Population-Specific Key Protective Measures and Major Restoration Actions Taken since the 2016 5-Year Review

Numerous commitments and actions to improve habitat conditions in the Lake Ozette area have been implemented; however, monitoring data and evaluation of such actions demonstrating a positive impact to the viability of the Ozette Lake sockeye is not yet available. Key protective measures and major restoration actions taken since the 2016 5-year review include several systemic improvements, as well as discrete and site-specific restorative actions to improve freshwater habitat conditions:

- In 2018, the Makah Tribe partially removed a weir on Ozette River that had served for sockeye enumeration purposes. The weir had become a predation point for pikeminnow and otters, and removal of this obstruction alleviated a noted source of predation. Enumeration is currently conducted using an ARIS array.
- In 2019, Olympic National Park developed plans to remove two derelict cabins from the Lake Ozette floodplain and an associated dock in order to improve in-water and floodplain habitat conditions. These have not yet been removed due to Covid restrictions.

- In 2017, a study was initiated by Makah Tribal biologists to evaluate the abundance of otters and their predation pattern on Ozette Lake sockeye.
- In 2020, preliminary results from a water quality study by the Olympic National Park and USGS to evaluate dissolved oxygen levels at an area that appears suitable for beach spawning but not utilized were presented, evaluating if water quality conditions are inhibiting its use for spawning. The study found that dissolved oxygen levels were poor.
- Since 2016, several years of knotweed treatment in waterways have occurred. Today, very limited invasive knotweed remains and control is now considered feasible.
- In 2007, Forterra acquired three parcels of land slated for development totaling 240 acres, including a portion of Umbrella Creek. Of this acreage, 160 acres were transferred to the Makah Tribe in 2014 (Forterra 2014), with the remaining 80 acres transferred in 2015 (not reported in the previous 2016 review).
- The replacement of the Coal Creek culvert to a bridge at the north end of Lake Ozette, allowed access to approximately 4,850 feet of additional habitat for all life stages of fish.

(4) Key Regulatory Measures since the 2016 5-Year Review

The NMFS 2009 Recovery Plan for Lake Ozette Sockeye Salmon (NMFS 2009b) and the previous 5-year review did not identify regulatory mechanisms as a priority issue affecting Ozette Lake sockeye. Various federal, state, county and tribal regulatory mechanisms are in place to minimize or avoid habitat degradation caused by human use and development. Many of these mechanisms have been updated in the past 5 years. However, the implementation and effectiveness of regulatory mechanisms has not been adequately documented. See *"Listing Factor D: Inadequacy of Regulatory Mechanisms"* below in this document for details.

(5) Recommended Future Recovery Actions over the Next 5 Years toward Achieving Population Viability

- Improve stream-typing to correctly identify fish habitat and corollary forest practices consistent with the Forest Practices HCP.
- Place large wood to modify the lake hydrograph for more regular inundation of spawning beaches/inhibition of plant recruitment.
- Evaluate and determine if modifying conservation hatchery practices to include spawning beach supplementation is appropriate or feasible.
- Remediate spawning beaches, by removing encroaching vegetation and removing fine sediments occluding spawning substrate.

Listing Factor A Conclusion

A review of new information on habitat factors indicates that habitat values on spawning beaches continue to decline. We remain concerned about the previously identified encroachment of riparian vegetation on beaches that had previously supported spawning. Recent information developed by the USGS in partnership with the Olympic National Park (ONP) indicates that upwelling water does not contain sufficient dissolved oxygen to support spawning/redd success. Riparian conditions in public and private forest lands continue to provide passive improvements for stream temperatures in some locations, but in many locations the lack of large wood contributes to “flashy” hydrograph (higher peak flows, lower low flows, more abrupt changes in hydrograph) in both stream and lake habitats.

Although hatchery supplementation has shown success in expanding population spatial structure into new stream habitat, primarily in Umbrella Creek, the contemporaneous decline in beach spawning coupled with the persistent decline in spawning beach conditions are significant for both diversity and spatial structure for the ESU. The remaining spawning area diversity will need to be safeguarded and augmented with additional habitat protective measures and habitat restorative actions, particularly with regard to beach spawning, and predation factors.

We conclude that since the last 5-year review, the risk to Ozette Lake sockeye continues to persist because degradation of habitat conditions is increasing, and the increase in tributary access is countered by a concurrent decrease in beach spawning habitat conditions.

Recommendations

Implement habitat restoration actions within areas under the jurisdiction of the Olympic National Park, including remediation of spawning beaches (such as removal of encroaching vegetation, loosening and removal of sediments that occlude spawning substrate), and placement of large wood or rock to provide refracted wave energy to help keep spawning substrate free of fine sediments.

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

Harvest

Changes in harvest management were implemented in the 1980s and no commercial or recreational harvest of Ozette Lake sockeye has been authorized since 1982. There have been no commercial salmon fisheries allowed in the Lake Ozette Basin since 1982. The Makah Tribe conducts a steelhead fishery in the area. Based on low interaction between Ozette Lake sockeye and harvest of other target species, incidental take from other fisheries (e.g., ocean harvest) is not likely a risk factor (NMFS 2009b; pers. comm. Susan Bishop).

Within the Olympic National Park, several fishing restrictions to reduce incidental take of Ozette Lake sockeye have been in place since 2004. These include:

- Anglers may only use a single, barbless hook with no bait.
- Recreational fisheries for salmonids other than sockeye in the Ozette River are only open from Aug. 1 - Feb 28 and closed the remainder of the year to avoid the late-winter and spring juvenile and adult sockeye migration periods in the river. This truncated fishing season minimizes the risk of incidental capture, injury, and mortality of listed sockeye salmon.

- Fisheries directed at other fish species in Lake Ozette are restricted to open on the last Saturday of April and run to October 31. This restriction reduces the risk of incidental capture, injury, and mortality of adult sockeye spawning in beach spawning areas and on adult fish staging to enter Umbrella Creek and Big River.
- There are no recreational fishery harvest limits in the Ozette River and Lake Ozette when open on bass, perch, bullhead, or pikeminnow. This measure is implemented to maximize removal of potential sockeye predator and competitor species and reduce the abundance of the species for the benefit of juvenile sockeye survival in the basin.

NMFS believes overutilization is not currently an active factor limiting productivity of the ESU. While the legacy of prior overutilization in fisheries, habitat alteration, and habitat degradation, combined with current habitat conditions, continues to be expressed as overall low abundance, current harvest restrictions and conditions of NMFS' 2015 biological opinion minimize take associated with the Makah resource management plan and reduce the impacts of the fisheries (NMFS 2015e). Harvest restrictions and other restrictions to reduce incidental take are expected to remain in place while efforts continue to improve habitat values, and this combination is likely to result in improved viability of the Ozette Lake sockeye ESU.

Research and Monitoring

In the preceding 5-year review, we recommended increasing technical support to the Makah Tribe to improve ARIS use and performance in tracking of adult sockeye returns. NMFS contracted with Keith Denton in 2017 to provide training in ARIS deployment and data review.

The quantity of Ozette Lake sockeye salmon take authorized under ESA sections 10(a)(1)(A) and 4(d) for scientific research and monitoring remains low. Much of the work being conducted is to fulfill state and federal agency obligations under the ESA to ascertain the species' status. Authorized mortality rates associated with scientific research and monitoring are generally capped at 0.5 percent across the West Coast Region for all listed salmonid ESUs and DPSs. As a result, the mortality levels that research causes are very low throughout the region. The research program, as a whole, has only a very small impact on overall population abundance, insufficient to impact productivity, and no measurable effect on spatial structure or diversity.

Any time we seek to issue a permit for scientific research, we consult on the effects that the proposed work would have on each listed species' natural- and hatchery-origin components. However, because research has never been identified as a threat or a limiting factor for any listed species, and because most hatchery fish are considered excess to their species' recovery needs, examining the quantity of hatchery fish taken for scientific research would not inform our analysis of the threats to a species' recovery. Therefore, we only discuss the research-associated take of naturally produced fish in these sections. From 2015 through 2019, researchers were approved to take an average of fewer than 30 adult (12 or fewer lethally) and fewer than 80 juvenile (four or fewer lethally) Ozette Lake sockeye salmon per year (NMFS APPS database; https://apps.nmfs.noaa.gov/). For the vast majority of scientific research permits, history has shown that researchers generally take far fewer salmonids than the number authorized every year. Over the same 5-year period, no lethal or non-lethal take was reported for Ozette Lake sockeye salmon.

The majority of the requested take has been and is expected to continue to be capture and release of juvenile Ozette Lake sockeye salmon with minnow traps, electrofishing units, and hoop nets. The screw trap in the Ozette River likely is an additional source of a small amount of annual unintentional take of natural-origin sockeye along with the weir in Umbrella Creek where capture for broodstock occurs. Take of adult Ozette Lake sockeye salmon has been and is expected to continue to be requested primarily as capture via trawls and gill or trammel nets. A small number of adults or juveniles may be captured by hook and line methods (NMFS APPS database; https://apps.nmfs.noaa.gov/). Our records indicate that mortality rates for backpack electrofishing are typically less than three percent. Unintentional mortality rates from minnow traps, hoop nets, trammel nets, and hook and line methods are also limited to no more than three percent. A small number of adult fish may die as an unintended result of research because of interactions with trawl sampling equipment, although this has not occurred in the past 5 years.

The quantity of take authorized for naturally produced fish over the past 5 years has increased compared to the prior 5 years. The total take authorized from 2015 through 2019 was over four times higher than the total take authorized from 2010 to 2014, and the lethal take authorized from 2015 through 2019 was more than twice as high as what had been authorized from 2010 through 2014. Still, the absolute numbers authorized per year have remained low, and actual total take and mortalities have declined to zero over the past 5 years (compared to a few individuals from 2010 through 2014).

Overall, research impacts remain minimal due to the low mortality rates authorized under research permits and the fact that research is spread across the species' range. In addition, because the amount of take and number of mortalities remain low in terms of absolute numbers, the overall effect of research on listed populations remains essentially unchanged since the time of the last 5-year review (NMFS 2016). Consequently, the risk to the species' persistence from these factors remains low.

Listing Factor B Conclusion

Harvest. The legacy of prior overutilization in fisheries appears to have created a low abundance of the species in the 1940s. This low abundance has been influenced subsequently by poor habitat conditions and continues to be expressed as overall continuing low abundance. However, given the harvest restrictions, conditions of NMFS' biological opinion minimizing take associated with the Makah resource management plan, and fishing restrictions that prevent target harvest of Ozette Lake sockeye, NMFS believes overutilization is not currently an active factor limiting productivity of the ESU. Harvest restrictions and restrictions to reduce incidental take are expected to be kept in place while efforts continue to improve habitat values, and this combination is likely to retain the current level of viability of the Ozette Lake sockeye ESU.

Scientific Research and Monitoring. Scientific research impacts authorized through the West Coast Region have remained low (NMFS APPS database; https://apps.nmfs.noaa.gov/). Impacts from these sources of mortality are not considered to be major limiting factors for this ESU. Therefore, the risk to the species' persistence because of overutilization remains essentially unchanged since the 2016 5-year review, with harvest and research/monitoring sources of mortality continuing to have little to no impact on the recovery of the Ozette Lake sockeye salmon ESU.

We, therefore, conclude that since the last 5-year review, the risk to Ozette Lake sockeye persistence because of overutilization and scientific study remains low. No direct take occurs from any commercial or recreational fishery and the amount of take for scientific study is limited.

Listing Factor C: Disease and Predation

Predation

Predation on listed sockeye can occur among mammals, birds, and other fishes.

Piscivorous Predation: Fishing regulations implemented in 2004 removed catch limits on the harvest of non-native predator fish species, such as largemouth bass, yellow perch, and yellow bullhead, which may reduce piscivorous fish predation on juvenile sockeye. In July 2012, an error was remedied by striking northern pikeminnow from the list of non-native predator fish species. Although a native species, the NPS's most recent fishing regulations included northern pikeminnow with non-native fish species removed from harvest catch limits. This measure will help reduce predation risks to listed sockeye salmon rearing in Lake Ozette.

Avian Predation: Avian predation on juvenile salmon, including sockeye, can occur as they enter the ocean (Zamon et al. 2014; Tucker et al. 2016) and higher or lower seabird production may mean greater impacts on the salmon. Years of higher or lower availability of preferred prey may (inadvertently) increase predation on salmon (Wells et al. 2017).

Mammalian Predation: In 2016, the Lake Ozette Sockeye Steering Committee, via contribution from NMFS and ONP, held a workshop with predation experts to improve our understanding of sockeye predation. Information presented there led to Andrea Woodward from the USGS, developing with Patrick Crain of Olympic National Park, and Mike Haggerty, an interactive lifecycle model that can help demonstrate the relative impact of predation versus other factors in improving sockeye abundance and productivity (Woodward et al. 2019). The model synthesizes the results of the limiting factors analysis in a form that resource managers and the public can easily manipulate to create scenarios, test hypotheses, and observe sensitivities of results to changes in parameters. The tool enables research, monitoring, and management to focus on the most impactful elements and processes, including identifying the information gaps that are most critical to fill.

The workshop also revealed the difficulty in resolving predation as a limiting factor, particularly relative to otters and other marine mammals. Scordino et al. (2016) indicated that river otter predation on Ozette Lake sockeye was occurring mainly in Ozette River rather than in lake habitat, which may have been linked to the weir. Almost 80 percent of salmon consumed by the otters were Ozette Lake sockeye, with predation peaking at 25 percent in July, somewhat after the peak of the adult return run. Prior studies had indicated predation by otters also occurred at beach spawning locations.

A second by-product of the predation workshop has been the Makah study of otter predation. This study by Shannon Murphie reveals that salmonids are a significant part of the otter diet, but

Covid–19 quarantine requirements delayed an analysis of the relative components of sockeye versus coho. Absent the study results that could suggest otherwise, a continuing concern is that predation, especially by marine mammals, is amplified when drought conditions impair riverine migration habitat.

Fortunately, partial removal of the weir at Ozette River has reduced the constraint on sockeye migration and delays in both upstream and downstream fish passage. This is likely to have reduced piscivorous and mammalian predation on migrating juvenile and/or adult sockeye at this location. Additionally, the Makah biologists are using acoustic harassment devices near the weir in Umbrella Creek to deter otters (Scordino et al. 2016). Reduced predation at these sites on both adult and juvenile sockeye would be expected to improve productivity by reducing pre-spawn mortality and increasing spawner abundance as the rate of juvenile-to-adult survival increases.

Marine Mammal Predation:

The four main marine mammal predators of salmonids in the eastern Pacific Ocean are harbor seals (*Phoca vitulina richardii*), fish-eating killer whales (*Orcinus orca*), California sea lions (*Zalophus californianus*), and Steller sea lions (*Eumetopias jubatus*).

Recent research over the past 5 years suggests that predation pressure on ESA-listed salmon and steelhead from seals, sea lions, and killer whales has been increasing in the northeastern Pacific over the past few decades (Chasco et al. 2017a; Chasco et al. 2017b). Models developed by Chasco et al. (2017a) estimate that consumption of Chinook salmon in the eastern Pacific Ocean by three species of seals and sea lions and fish-eating (Resident) killer whales may have increased from 5 to 31.5 million individual salmon of varying ages since the 1970s, even as fishery harvest of Chinook salmon has declined during the same time period (Marshal et al. 2016; Chasco et al. 2017a; Ohlberger 2019). This modeling also suggests that these increasing trends have continued across all regions of the northeastern Pacific over the past 5 years. The potential predation impacts of specific marine mammal predators of ESA-listed salmonids on the West Coast are discussed individually below.

Pinnipeds

The three main seal and sea lion (pinniped) predators of ESA-listed salmonids in the eastern Pacific Ocean are harbor seals (*Phoca vitulina richardii*), California sea lions (*Zalophus californianus*), and Steller sea lions (*Eumetopias jubatus*). With the passing of the Marine Mammal Protection Act (MMPA) in 1972, these pinniped stocks along the West Coast of the United States have steadily increased in abundance (Carretta et al. 2019). California and Steller sea lion abundance along the Washington coast has increased by roughly 8 percent over the last decades (Allyn and Scordino 2020). With their increasing numbers and expanded geographical range, marine mammals consume more Pacific salmon and steelhead, and some have an adverse impact on some ESA-listed species (Chasco et al. 2017a; Thomas et al. 2016; Marshall et al. 2016).

Status of Pinnipeds Populations in Washington

California Sea Lion (United States Stock)[5]

The current population size of California sea lions (CSL) is 257,606 (Carretta et al. 2019). The stock is estimated to be approximately 40 percent above its maximum net productivity level[6] (183,481 animals) and is within the range of its optimum sustainable population (OSP)[7] size (Carretta et al. 2019).

Steller Sea Lion (Eastern United States Stock)[8]

The current population size of Steller sea lions (SSL) is 71,562 (52,139 non-pups and 19,423 pups) (Muto et al. 2019). Muto et al. (2017) conclude that the eastern stock of SSL is likely within its OSP range; however, NMFS has made no determination of the stock's status relative to OSP.

Harbor Seals (Oregon and Washington Coast Stock)

The current population size of the Oregon and Washington Coast stock of harbor seals (HS) is 15,533 (Pearson and Jeffries 2018). This stock's status relative to OSP is unknown.

Marine Mammal Predation Summary

On a Pacific Coast-wide scale, models converting juvenile Chinook salmon into adult equivalents estimated that by 2015 pinnipeds consumed an amount of Chinook salmon six times greater than the combined commercial and recreational catches (Chasco et al. 2017a). In the Columbia Basin, recent research found that survival of adult spring-summer Chinook salmon through the estuary and lower Columbia River is negatively impacted by higher sea lion abundance for populations with run timing that overlaps with seasonal increases in Steller and California sea lions (Rub et al. 2019; Sorel et al. 2020). It is unclear whether the increasing sea lion populations in Oregon and Washington are associated with decreased survival of sockeye salmon adults through estuarine and freshwater migration corridors on the coasts because there have not been similar survival assessments of populations in coastal estuaries/rivers. Some studies have found that pinnipeds like harbor seals can have a significant predation impact on coho salmon and other salmon species of conservation concern (Thomas et al. 2016), as well as steelhead (Moore et al. 2021), through the consumption of outmigrating juveniles. Harbor seal predation data specific to coastal tributaries is not currently available, 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. The impact on the beach spawning population of sockeye salmon resulting from predation by harbor seals is also uncertain. Predation effects in nearshore areas merit further evaluation to inform the development of management alternatives.

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[5] For a complete description of stock status, definition and geographic range see Carretta et al. (2019).

[6] Maximum net productivity level (MNPL) has been expressed as a range of values (between .50 and .70 of K, K = carrying capacity) determined on a theoretical basis by estimating what stock size, in relation to the original stock size, will produce the maximum net increase in population.

[7] OSP is a population size that is at or greater than its MNPL, which is the population size that produces the maximum net productivity (e.g., greatest net change in the population). OSP = a population size ≥ MNPL (>K*.60).

[8] For a complete stock status, definition and geographic range see Muto et al. (2019).

Information available since the last 5-year review clearly indicates that predation by pinnipeds on Pacific salmon and steelhead continues to pose a significant negative impact on the recovery of these ESA-listed fish species. Pinniped populations in Washington have continued to increase over the past 5 years. While there is no new evidence that avian and mammalian predation is a significant factor limiting recovery of this ESU, recent predation studies have raised sufficient concerns for some salmon populations that predation monitoring is warranted.

Disease

Sediment deposition and the modified hydrograph likely increase water temperatures and may thereby exacerbate ambient disease risks. Warmer and drier conditions associated with climate change also aggravate the risk of disease, particularly where hatchery supplementation is involved. The last disease outbreak that led to fish mortality occurred in 2011. Subsequently, the Makah biologists altered the rearing protocols twice due to virulent (infectious hematopoietic necrosis virus) IHN detections in the sockeye adults. In 2014 and 2017, they detected IHN and segregated the eggs associated with high virus loads.

Because all of the adult sockeye spawned in 2017 tested positive for IHN, the Makah cautiously reared and released them earlier than normal (due to drought, see climate and streamflow sections elsewhere in this document) but without experiencing any disease impacts. Disease in returning adults has required cautious practices at the hatchery, but it is unclear if the prevalence of disease (or the type of disease observed) is suppressing return adult abundance.

Methods to address sediment and hydrology in non-drought conditions need further investigation as identified in the recovery plan.

Listing Factor C Conclusion

We conclude that since the last 5-year review, the risk to Ozette Lake sockeye persistence because of disease or predation remains high because, although disease does not appear to be an issue with Ozette Lake sockeye, predation is a limiting factor. We have no additional information available that would change our current understanding of the disease or predation dynamics.

Listing Factor D: Inadequacy of Regulatory Mechanisms

Various federal, state, county, and tribal regulatory mechanisms are in place to reduce habitat loss and degradation caused by human use and development and harvest impacts. New information available since the last 5-year review indicates that the adequacy of some regulatory mechanisms has improved, while the adequacy of other regulatory mechanisms has not. Examples of regulatory mechanisms for **Habitat** and for **Harvest** are listed below, followed by our conclusion and a bulleted summary of concerns regarding the current adequacy of existing regulatory mechanisms.

Habitat

Habitat concerns are described throughout Listing Factor A as having either a system-wide influence, or more localized influence on Ozette Lake sockeye. The habitat conditions across all habitat components (tributaries, mainstems, estuary, and marine) necessary to recover Ozette

Lake sockeye are influenced by a wide array of federal, state, and local regulatory mechanisms. The influence of regulatory mechanisms on listed salmonids and their habitat resources is based in large degree by the underlying ownership of the land and water resources as federal, state, or private holdings.

One factor affecting habitat conditions across all land or water ownerships is climate change, the effects of which are discussed under Section 2.3.2.5 (Listing Factor E: Other natural or manmade factors affecting its continued existence). We reviewed summaries of national and international regulations and agreements governing greenhouse gas emissions, which indicate that while the number and efficacy of such mechanisms have increased in recent years there has not yet been a substantial deviation in global emissions from the past trend, and upscaling and acceleration of far-reaching, multilevel, and cross-sectoral climate mitigation will be needed to reduce future climate-related risks (IPCC 2014; IPCC 2018). These findings suggest that current regulatory mechanisms, both in the U.S. and internationally, are not adequate to address the rate at which climate change is negatively impacting habitat conditions for many ESA-listed salmon and steelhead.

Habitat concerns identified in Section A include forest and riparian conditions and their effects on water quality, spawning habitat conditions within Lake Ozette, mercury levels in Lake Ozette, temperature and flow conditions in tributaries, influenced by climate change, and predation.

Tributary habitat falls largely within the framework of federal land management, as Lake Ozette and proximate portions of its tributaries are predominantly within the Olympic National Park.

Regulatory Mechanisms Resulting in Adequate or Improved Protection

Overall, new information available since the previous 2016 5-year review does not indicate that the adequacy of federal and state land and water management regulatory mechanisms has improved or increased protection of Ozette Lake Sockeye salmon.

Regulatory Mechanisms Resulting in Inadequate or Decreased Protection

We are concerned about the adequacy of existing federal and state regulatory mechanisms with regard to stream conditions influenced by riparian areas, such as temperature, sufficiency of large wood recruitment (affected by state and federal timber regulations) stream and lake water quality conditions, particularly high mercury levels (which fall under state clean water laws), base flows (which fall within state regulation), as well as lake habitat conditions that fall within the jurisdiction of Olympic National Park. These concerns are governed by the federal and state land and water regulatory mechanisms described below.

1. Northwest Forest Plan

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.

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, including that conservation of at-risk species within national forests is challenging in the face of threats that are beyond the control of federal managers, even while the NWFP made substantial progress toward meeting several of its goals. It 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). The number of ESA-listed salmonid species and population units has increased, however 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).

2. Olympic National Park Laws, Regulations, and 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, including the entirety of Lake Ozette. 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 ONP maintains regulations on fishing at Lake Ozette to ensure the protection of Ozette Lake Sockeye, and these regulatory measures have been in place for several years. 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. This second element has been used by ONP for many years as a basis for not taking more habitat modifying restoration actions to achieve the first element of improving conditions for Ozette Lake Sockeye.

3. Wildfire Management and Suppression in Oregon and Washington

As a general matter, extensive wildfires (http://gacc.nifc.gov/nwcc/information/firemap.aspx) have affected habitat quality in burned areas, which are likely to incorporate areas of or near salmonid habitat, with a range of potential effects. Wildfires are naturally occurring, but the frequency and intensity of fires have increased due to shifting climate and to a history of fire suppression, which has caused the development of unnatural tree species mixes and an unnaturally high density of trees and resulted in a higher-than-normal mortality of trees due to insect infestations and disease (Agee 1993). Management of forests to restore natural species and tree density can reduce the intensity and frequency of wildfires and subsequently reduce impacts of fire on fish habitat. Several federal land management agencies have or are developing fire management and response plans. For example, because of the increasing frequency and size of forest fires, the Olympic National Park in 2018 prepared a Fire Management and Response Plan. This plan is being evaluated by NMFS under ESA section 7 for its effects on Ozette Lake sockeye and other listed salmonids, and for effects on Essential Fish Habitat designated under the Magnuson-Stevens Act (MSA). This plan would affect Ozette habitat conditions if fire were to occur within the watersheds that affect the lake and its tributaries.

4. Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) and Toxics

The Environmental Protection Agency (EPA) sets label criteria for a number of registered chemicals under the Federal Insecticide, Fungicide, and Rodenticide Act, a United States federal law that sets up the basic U.S. system of pesticide regulation to protect applicators, consumers, and the environment. Pesticides can be applied on land such as forest lands, BLM lands, state and federal road rights of way, agricultural lands, and in aquatic locations. NMFS has conducted eight consultations for the effects on 28 West Coast species from 21 commonly applied chemical insecticides, herbicides, and fungicides, which are authorized for use per EPA label criteria: In a 2017 biological opinion NMFS determined Ozette Lake sockeye to be jeopardized by 2,4D, Chlopyrifos, and Malathion, used in forest management. The opinion also found these chemicals adversely modify the Ozette Lake Sockeye designated critical habitat (NMFS 2017). A “reasonable and prudent alternative” was issued with that consultation, but it is unclear whether full implementation is occurring.

5. Washington Forest Practices Regulations

The Forest and Fish rules governing timber management practices adjacent to 60,000 miles of streams running through 9.3 million acres of state and private forestland. In 2006, the Forests & Fish Law was endorsed by the services through a statewide Habitat Conservation Plan. This framework includes Road Maintenance and Abandonment Plans intended to reduce significant sediment loads to streams and rivers and is applicable to both small and large forest landowners. Within the Lake Ozette watershed, two large forest landowners, Merrill Ring and Green Crow, have met their RMAP obligations on time, improving water quality and river sediment conditions in Lake Ozette tributaries. Additionally, state forest practice regulations have increased restrictions on timber harvest within riparian buffers based on stream type, allowing canopy cover, detrital input, shade, and large wood recruitment, to slowly re-establish natural habitat characteristics in and adjacent to fish-bearing tributaries.

Since NMFS approved the State’s Forest Practice Rules as ESA-compliant by signing the Washington State Forest Practices Habitat Conservation Plan (HCP) in 2006, we have helped the state implement that HCP which protects all species of salmonids on commercial forestlands in Puget Sound. A total of 3.7 million acres of commercial forestlands promotes salmon recovery in Puget Sound, including state-owned forestlands managed per another HCP approved 1999. Each of these HCPs has compliance monitoring components, with annual reporting.

However, in 2015, stream-typing protocols in Washington State were specifically noted by NMFS and the USFWS to be inaccurate, and thus under-identify streams as fish habitat, such that protective value of the regulations are not carried forward adequately across the state, including in the Lake Ozette watershed, calling the effectiveness of the Forest Practices HCP into question. Since our 2016 5-year review, the Forest Practices Board approved a fish habitat assessment method (FHAM) in May 2017 as the field protocol for delineating the upper extent of fish habitat within a stream segment. Part of the application of FHAM includes identifying field measurable geomorphic features, called potential habitat breaks, which with reasonable certainty impede upstream fish movement, indicating the end of fish habitat. However, stream typing protocols and corollary stream protections remain a point of significant concern. We have data of warmer than expected water under the typing method, but the adaptive management process has yet to respond. The delay in developing a model-based stream typing tool has caused corollary delays that are now a point of discussion between the Federal Caucus and the State of Washington.

The 2017-18 Habitat Conservation Plan Annual Reports by the Washington State Department of Natural Resources also indicate

- Forest Practices Operations staff processed 4,657 Forest Practices Applications/Notifications and 726 water type modification forms.
- There were 13,517 active (non-expired) forest practices applications at the end of the reporting period. During this time, DNR issued 78 Notices to Comply and 41 Stop Work Orders. Of these enforcement actions, 108 were for violations of the forest practices rules.
- Rivers and Habitat Open Space Program has established 1,121 acres of conservation easements on channel migration zones and 25 acres of conservation easements on critical habitats of state-listed threatened and endangered species since the inception of this conservation easement program in 2001, but none since the 2017 report.

The modifications in timber practices have largely created a passive restoration strategy for the riparian corridors of streams and rivers within forest land areas. A recent review of this passive restoration strategy within the Olympic Peninsula shows that while some parameters of stream health improve (i.e., summer stream temperatures), the pace of passive habitat improvements is unlikely to increase salmonid abundance or productivity in the near future (Martens et al. 2019).

6. Water Pollution Control Act.

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.

(http://www.ecy.wa.gov/programs/Wq/303d/index.html). Lake Ozette is regularly monitored by the Washington State Department of Ecology for high levels of mercury, however as sources are likely to be atmospheric, mechanisms to reduce mercury sources or remediate mercury levels have not been identified.

7. Streamflow Restoration 90.94 RCW:

In January 2018, the Washington Legislature passed the Streamflow Restoration law that helps restore streamflows 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 streamflows 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.

The Department of Ecology has instream flow and water management rules to implement state law requiring 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. Instream flow requirements cover nearly half of the state's watersheds and the Columbia River (Figure 2).

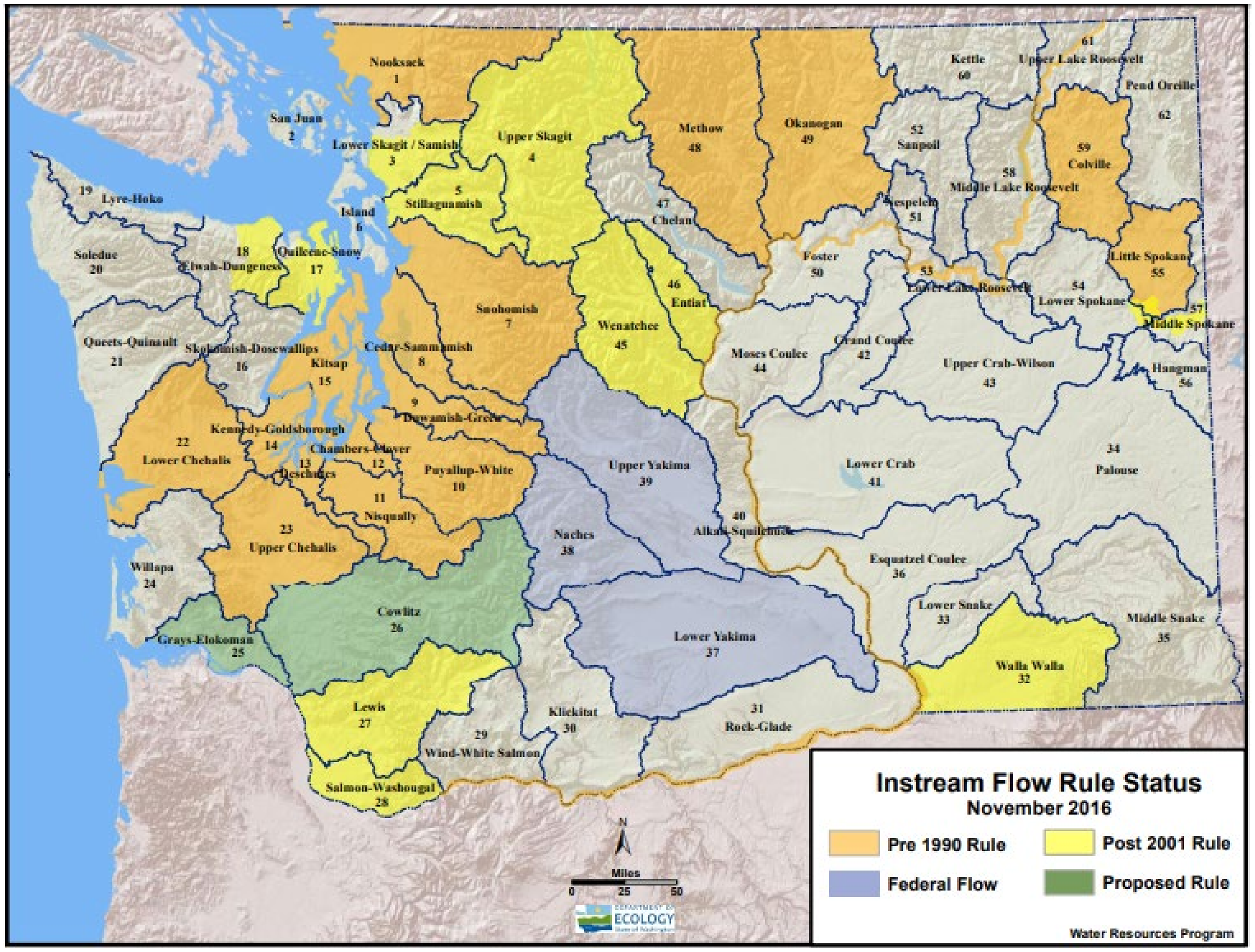


Figure 4. Basins in Washington State with Instream Flow Requirements.

The geography supporting the Ozette Lake sockeye ESU is not in an area with instream flow concerns that require rules on withdrawal because development pressures/demand for groundwater are low. However, delayed migration of sockeye into tributaries during October and November has been observed during extreme low base flow conditions and a delay in the onset of the wet season, and seasonal lake level changes are known to directly result in sockeye redd dewatering. This occurs when sockeye spawn in November, December, and January at elevations along the beaches that become exposed by lower lake levels before incubation and emergence. Makah biologists have observed in recent years that their hatchery has had to release fry at both sites earlier than normal because of low flow, broodstock collection have occurred later than normal due to late arrival of fall rains, and that upon the return of rains, storm events can be so large that scour of spawning materials is a concern.

Harvest

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. While all species of salmon fall under the jurisdiction of the current plan (PFMC 2021), the FMP currently contains fishery management objectives only for Chinook salmon, Coho, pink (odd-numbered years only), and any salmon species listed under the ESA measurably impacted by PFMC fisheries. Incidental catches of Ozette Lake sockeye in harvests targeting other species are inconsequential (low hundreds of fish each year) to very rare (PFMC 2021).

The effects of the salmon fisheries on ESA listed salmonids is limited by fishery management measures implemented under the MSA, as well as terms and conditions and reasonable and prudent alternatives developed by NMFS through consultations under ESA section 7. These measures take a variety of forms including FMP conservation objectives, limits on the time and area during which fisheries may be open, ceilings on fishery impact rates, and reductions from base period impact rates. NMFS annually issues a guidance letter to the PFMC reflecting the most current information for developing management objectives (e.g., Thom 2020).

Since 1974, commercial sockeye salmon harvest has ceased, and there has been no direct sockeye harvest of any kind since 1982. NMFS does not allow a fishery on Lake Ozette sockeye. This restriction remains unchanged since 2016.

Listing Factor D Conclusion

As a general matter, environmental regulations serve as a method to limit but not prevent resource degradation at a project-by-project scale. When considered programmatically, we conclude that the risk to the species' persistence because of the inadequacy of existing regulatory mechanisms persists, despite some improvements noted above. Of particular note is the inadequacy of compliance with the Forest Practices HCP for stream typing and corollary buffer protections for salmonids including, Ozette Lake sockeye, that have not been met after 20 years. In addition, there remain several concerns regarding existing regulatory mechanisms, including:

- Lack of documentation or analysis of the effectiveness of land-use regulatory mechanisms and land-use management plans.
- Contradictory mandates, policies, and/or implementation of regulations by federal agencies. For example, one agency may take actions to improve riparian vegetation and instream habitat in one area while, a short distance away, another federal authority requires removal of vegetation and instream structures.
- Certain federal, state, and local land and water use decisions continue to occur without the benefit of ESA review. State and local decisions have no federal nexus to trigger the ESA Section 7 consultation requirement. Thus, certain permitting actions allow direct and indirect species take and/or adverse habitat effects.
- With regard to federal actions, there continues to be confusion among some entities as to the relationship between ESA mandates, federal preemption, and the primacy of regulatory obligations that impairs the consultation process or even prevents consultation from occurring.
- Lack of reporting and enforcement for some regulatory programs.

We conclude the amount of risk to Ozette Lake sockeye persistence resulting from the inadequacy of regulatory mechanisms has increased.

Listing Factor E – Other Natural or Manmade Factors affecting the Species Continued Existence.

Climate Change

Major ecological realignments are already occurring in response to climate change (Crozier et al. 2019). As observed by Siegel and Crozier in 2019, 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. 2018a), have been attributed directly to anthropogenic warming in the annual special issue of Bulletin of the American Meteorological Society on extreme events (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 2019). Conservation strategies now need to account for geographical patterns in traits sensitive to climate change, as well as climate threats to species-level diversity.

To provide such information, Crozier et al. (2019) conducted a climate vulnerability assessment that included all anadromous Pacific salmon and steelhead (*Oncorhynchus* spp.) population units listed under the U.S. Endangered Species Act. Using an expert-based scoring system, they ranked 20 attributes for the 28 listed units and five additional units. The 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 to modify phenotypes to cope with new climatic conditions. Each listing unit was then assigned one of four vulnerability categories. Five Chinook, one coho, and one sockeye salmon ESUs ranked very high in total vulnerability to climate change due to a combination of high and very high scores for sensitivity and exposure. Bootstrap analyses indicated that two additional ESUs, Southern Oregon/Northern California Coast coho and Mid-Columbia spring-run Chinook, were borderline between high and very high. Among species, Chinook salmon had the highest vulnerability rankings overall (mostly very high and high rankings), followed by coho and sockeye. Steelhead DPS and chum ESU scores were generally lower and nearly equally spread across high and moderate vulnerability categories. Units ranked most vulnerable overall were the California Central Valley Chinook, California and Southern Oregon coho, Snake River sockeye, Interior Columbia spring Chinook, and Willamette River Basin spring Chinook (Crozier et al. 2019).

Projected Climate Change

Climate change is systemic, influencing ocean temperatures, ocean salinity, ocean acidity, and the composition and presence of a vast array of oceanic species. Other systems are also being influenced by changing climatic conditions. Siegel and Crozier (2019) 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, Siegel and Crozier (2019) observe that a newer study projects nearly complete loss of existing tidal wetlands along the U.S. West Coast, due to sea-level rise (Thorne et al. 2018). California and Oregon showed the greatest threat to tidal wetlands (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.

Updated projections of change are similar to or greater than previous projections. NMFS is increasingly confident in our projections because every year brings stronger validation of previous predictions in both physical and biological realms. Strategies that retain and restore habitat complexity and access to climate refuges (both flow and temperature) and improve growth opportunities in both freshwater and marine environments are strongly advocated in the recent literature (Siegel and Crozier 2019).

Impacts on Salmon

As Siegel and Crozier (2019) describe, for salmon, correlations between freshwater and marine survival have important consequences for population dynamics. Synchrony between terrestrial and marine environmental conditions (e.g., coastal upwelling, precipitation, and river discharge) has increased in spatial scale, causing the highest levels of synchrony in the last 250 years (Black et al. 2018). Salmon productivity (recruits/spawner) has also become more synchronized across 24 wild Chinook populations from Oregon to the Yukon (Dorner et al. 2018). Contrary to previous summaries that found that northern and southern stocks had inverse responses to ocean temperatures, the current analysis found positive pairwise correlations between nearly all stocks. Although a few populations tended to be less correlated with others, there was no latitudinal trend in correlations. Nearly all listing units faced high exposures to projected increases in stream temperature, sea-surface temperature, and ocean acidification, but other aspects of exposure peaked in particular regions. Anthropogenic factors, especially migration barriers, habitat degradation, and hatchery influence, have reduced the adaptive capacity of most steelhead and salmon populations (Crozier et al. 2019).

At the individual scale, climate impacts in one life stage generally affect body size or timing in the next life stage and can be negative across multiple life stages (Healey 2011; Wade et al. 2013; Wainwright and Weitkamp 2013). Changes in winter precipitation will likely affect the incubation and/or rearing stages of most populations. Changes in the intensity of cool-season precipitation could influence migration cues for fall and spring adult migrants, such as coho and steelhead. Egg survival rates may suffer from more intense flooding that scours or buries redds. Changes in hydrological regime, such as a shift from mostly snow to more rain, could drive changes in life history, potentially threatening diversity within an ESU (Beechie et al. 2006). Changes in summer temperature and flow will affect both juvenile and adult stages in some populations, especially those with yearling life histories and summer migration patterns (Quinn 2005; Crozier and Zabel 2006; Crozier et al. 2010).

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. Upper thermal limits and hypoxia tolerance are likely to be important traits in determining the effects of climate change on fish populations. For example, Healy et al. (2018) compared genetic diversity associated with thermal and hypoxia tolerance in two sub-species of Atlantic killifish, *Fundulus heteroclitus*, which have previously been shown to differ in these traits. Single nucleotide polymorphisms were found related to each trait independently, but none were shared between both traits. These results suggest that, at least in Atlantic killifish, thermal and hypoxia tolerance are genetically independent traits. At present, more than half of all anadromous Pacific salmon and steelhead DPSs remaining in the contiguous U.S. are threatened with extinction. Suboptimal climate conditions within the historical range of climate variability have been associated with detectable declines in many DPSs, highlighting their sensitivities to climatic drivers. In some cases, the synergistic effects of suboptimal climate conditions and intense anthropogenic stressors precipitated the population declines that led to these listing decisions (Crozier et al. 2019).

Another potential limitation in the ability of salmon populations to adapt to climate change is the reduced level of existing genetic diversity compared to historic levels. Johnson et al. (2018) compared genetic variation in Chinook salmon from the Columbia River Basin between contemporary and ancient samples. A total of 84 samples determined to be Chinook salmon were collected from vertebrae found in ancient middens and compared to 379 contemporary samples. Results suggest a decline in genetic diversity, as demonstrated by a loss of mitochondrial haplotypes and reductions in haplotype and nucleotide diversity. Genetic losses in this comparison appeared larger for Chinook from the mid-Columbia than those from the Snake River Basin.

Relative to sockeye, three or four-year cycles are common in sockeye salmon stocks with returns varying by an order of magnitude or more between high and low points in the cycles. Longer-term cycles are also apparent but less regular. These seem to be associated with changes in ocean conditions that affect survival during the feeding migration (Phillips and Perez-Ramirez, eds 2018); accordingly, shifting ocean conditions may shift the range of the highs and lows downward.

Terrestrial and Ocean Conditions and Marine Survival

The following is excerpted from Siegel and Crozier (2019) who present a review of recent scientific literature evaluating effects of climate change.

“Cooper et al. (2018) examined whether the magnitude of low river flows in the western U.S., which generally occur in September or October, are driven more by summer conditions or the prior winter’s precipitation. They found that while low flows were more sensitive to summer evaporative demand than to winter precipitation, interannual variability in winter precipitation was greater. Malek et al. (2018b) predicted that summer evapotranspiration is likely to increase in conjunction with declines in snowpack and increased variability in winter precipitation. Their results suggest that low summer flows are likely to become lower, more variable, and less predictable.”

The effect of climate change on groundwater availability is likely to be uneven. Sridhar et al. (2018) coupled a surface-flow model with a ground-flow model to improve predictions of surface water availability with climate change in the Snake River Basin. Combining the VIC and MODFLOW models (VIC-MF), they predicted flow for 1986-2042. Comparisons with historical data show improved performance of the combined model over the VIC model alone. Projections using RCP 4.5 and 8.5 emission scenarios suggested an increase in water table heights in downstream areas of the basin and a decrease in upstream areas. Such assessments will help stakeholders manage water supplies more sustainably.

Forests

Climate change will impact forests of the western U.S., which dominate the landscape of many watersheds in the region. Forests are already showing evidence of increased drought severity, forest fire, and insect outbreak. Additionally, climate change will affect tree reproduction, growth, and phenology, which will lead to spatial shifts in vegetation. Halofsky et al. (2018b) projected that the largest changes will occur at low- and high-elevation forests, with expansion of low-elevation dry forests and diminishing high-elevation cold forests and subalpine habitats. Halofsky et al. (2018a) also assessed climate adaptation strategies for forest management in the region.

Forest fires affect salmon streams by altering sediment load, channel structure, and stream temperature through the removal of canopy. Holden et al. (2018) examined environmental factors contributing to observed increases in the extent of forest fires throughout the western U.S. They found strong correlations between the number of dry-season rainy days and the annual extent of forest fires, as well as a significant decline in the number of dry-season rainy days over the study period (1984-2015). Consequently, predicted decreases in dry-season precipitation, combined with increases in air temperature, will likely contribute to the existing trend of more extensive and severe forest fires.

Beyond environmental factors, management practices have left forests more dense and less diverse than in the past, which increases vulnerability to fire damage. Attempting to restore forest composition to a state more similar to historical conditions would likely increase fire resiliency, though methods to do so are often contentious (Johnston et al. 2018).

Agne et al. (2018) reviewed literature on insect outbreaks and other pathogens affecting coastal Douglas-fir forests in the Pacific Northwest and examined how future climate change may influence disturbance ecology. They suggest that Douglas-fir beetle and black stain root disease could become more prevalent with climate change, while other pathogens will be more affected by management practices. Agne et al. (2018) also suggested that due to complex interacting effects of disturbance and disease, climate impacts will differ by region and forest type."

Freshwater environments

As cited in Siegel and Crozier (2019), Isaak et al. (2018) examined recent trends in stream temperature across the Western U.S. using a large regional dataset. Stream-warming trends paralleled changes in air temperature and were pervasive during the low-water warm seasons of 1996-2015 (0.18-0.35°C/decade) and 1976-2015 (0.14-0.27°C/decade). Their results show how continued warming will likely affect the cumulative temperature exposure of migrating sockeye salmon. Isaak et al. (2018) concluded that most stream habitats will likely remain suitable for salmonids in the near future, with some becoming too warm.

Streams with intact riparian corridors and in mountainous terrain are likely to be more resilient to changes in air temperature. These areas may provide refuge from climate change for a number of species, including Pacific salmon. Krosby et al. (2018), identified potential stream refugia throughout the Pacific Northwest based on a suite of features thought to reflect the ability of streams to serve as such refuges. Analyzed features include large temperature gradients, high canopy cover, large relative stream width, low exposure to solar radiation, and low levels of human modification. They created an index of refuge potential for all streams in the region, with mountain area streams scoring highest. Flat lowland areas, which commonly contain migration corridors, were generally scored lowest, and thus were prioritized for conservation and restoration.

Siegel and Crozier (2019) point out concern 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. Carr-Harris et al. (2018) explored phenological diversity of marine migration timing in relation to zooplankton prey for sockeye salmon from the Skeena River of Canada. They found that sockeye migrated over a period of more than 50 days. Populations from a higher elevation and further inland streams arrived in the estuary later, and different populations encountered distinct prey fields. They recommended that managers maintain and augment such life-history diversity.

Marine survival

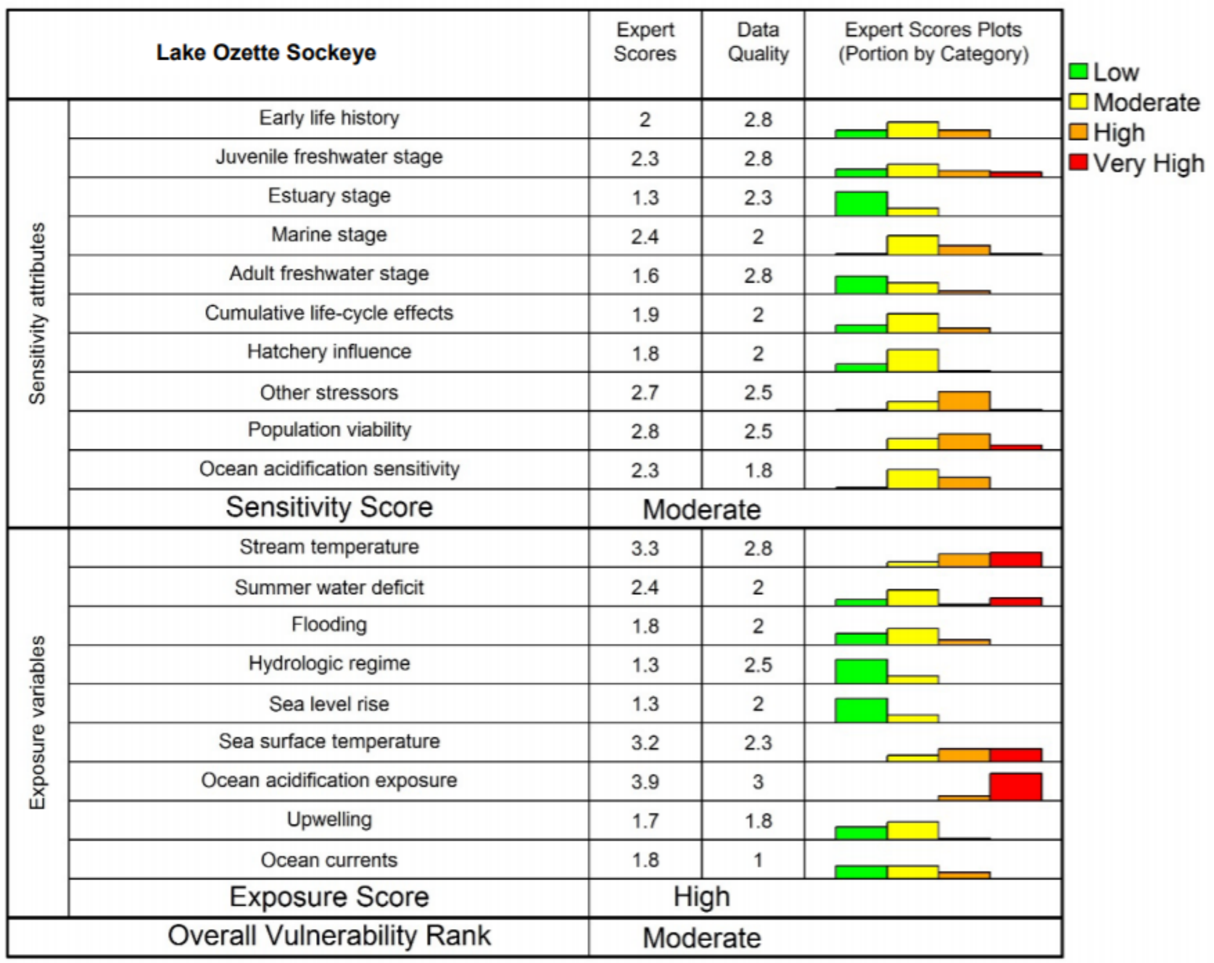
Marine survival of salmonids is affected by a complex array of factors, including prey abundance, predator interactions, and the physical condition of salmon within the marine environment. Siegel and Crozier (2019) observe that changes in marine temperature are likely to have a number of physiological consequences on fishes themselves. 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 tuna 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). Reproduction rates of many marine fish species are also likely to be altered with temperature (Veilleux et al. 2018). The ecological consequences of these effects and their interactions add complexity to predictions of climate change impacts in marine ecosystems.

Species-Specific Climate Effects (from Crozier et al. 2019)

Climate Effects on Abundance and Distribution - Ozette Lake sockeye scored mostly moderate and low in life stage sensitivity to climate change. Adult migrants might face higher predation during low flow periods and can experience some temperature stress if heat spells coincide with migration periods (Haggerty 2009). However, the migration is short and occurs in spring and early summer, so adults can likely avoid both high temperatures and low flows. Lake temperatures are relatively cool and do not pose an imminent threat at either the adult or juvenile freshwater stages. High flows might reduce suitable spawning habitat because of conditions during redd construction or fine sediment accumulation, lowering incubation survival.

Marine survival presumably fluctuates with climate for this ESU, as has been observed widely in other sockeye populations. However, the relatively large body size of smolts from this ESU appears to have buffered it historically from severely depressed returns during poor climate years. In terms of exposure attributes, this ESU was scored high for sea surface temperature and stream temperature, and very high for ocean acidification.

Climate Effects Adaptive Capacity - Ozette Lake sockeye scored low in adaptive capacity. Sockeye are unlikely to respond to climate change by changing life-history characteristics. Furthermore, little habitat exists that could potentially be improved to become more suitable for these fish. Low population abundance and spatial diversity suggest limited genetic heterogeneity that would support rapid adaptation. At present, adult migration spans a broad temporal window (April to mid-August), but this period may contract as adults attempt to avoid high temperatures and low flows in summer.



Lake Ozette Sockeye		Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Early life history	2	2.8	
	Juvenile freshwater stage	2.3	2.8	
	Estuary stage	1.3	2.3	
	Marine stage	2.4	2	
	Adult freshwater stage	1.6	2.8	
	Cumulative life-cycle effects	1.9	2	
	Hatchery influence	1.8	2	
	Other stressors	2.7	2.5	
	Population viability	2.8	2.5	
	Ocean acidification sensitivity	2.3	1.8	
	Sensitivity Score	Moderate		
Exposure variables	Stream temperature	3.3	2.8	
	Summer water deficit	2.4	2	
	Flooding	1.8	2	
	Hydrologic regime	1.3	2.5	
	Sea level rise	1.3	2	
	Sea surface temperature	3.2	2.3	
	Ocean acidification exposure	3.9	3	
	Upwelling	1.7	1.8	
	Ocean currents	1.8	1	
	Exposure Score	High		
Overall Vulnerability Rank		Moderate		

Figure 5. Ozette Lake Sockeye Climate Effects Exposure and Vulnerability (Crozier et al. 2019).

Hatchery Effects

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). Hatchery programs can provide short-term demographic benefits, 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 the risk depends on the status of affected populations and on specific practices in the hatchery program.

Since the previous 5-year review, fisheries management staff of the Makah Tribe have continued to implement and monitor hatchery management of the Umbrella Creek/Big River Hatchery Program within the Ozette Lake Sockeye ESU. This program, while providing positive contributions to spatial structure, abundance, and diversity for the ESU, also furnishes an essential safety net for the core beach spawning population while habitat concerns are being addressed.

Since the previous 2016 5-year review, the Umbrella Creek/Big River Hatchery Program has demonstrated effectiveness in producing increased levels of natural-origin adult fish recruitment and smolt production in Lake Ozette tributaries (Haggerty 2015; Hinton 2010; Peterschmidt and Hinton 2005; Peterschmidt and Hinton 2006; Peterschmidt et al. 2007). It appears that the Umbrella Creek component has successfully introduced a tributary spawning aggregate, thereby increasing the spatial and possibly genetic structure of the population. The addition of the tributary aggregate may have increased or stabilized overall abundance, although this is not yet obvious in the abundance trends (Ford 2022).

Production of fry occurs at the Umbrella Creek Hatchery (0.1 mi up a tributary at RM 4.5 of Umbrella Creek) and the Stony Creek acclimation site (0.1 mi up a tributary at RM 7.2 of Umbrella Creek). An approximate total of 200,000 fry are annually released into Umbrella Creek and Big River. Hatchery fry have been released at various times and places over the years, but release dates generally are later than the wild fry dispersal period (Makah Fisheries Management, 2015). The relative abundance of fry that are from natural tributary spawning, tributary hatchery releases, and beach spawning is thought to be 60:20:20, respectively (expert opinion based on NMFS 2015c).

While overall, Umbrella Creek has performed well and consistently in meeting conservation goals for increasing spatial structure and diversity, Big River has not. However, Big River does maintain a genetic reservoir that provides a conservation 'safety net' relative to the lake spawning needs/goals of this species. Because of the very low return in 2019, the Makah biologists, per consultation with NMFS, spawned 13 of the ripe females using a full cross matrix to maximize genetic diversity. They also chose to live-spawn and release the males, in order to make them available for the limited, naturally spawning, population in Umbrella Creek. Returns have been very low for several years (2018-19), and it requires evaluation whether this is part of a regular cycle, or a more concerning downturn

Straying of tributary fish onto the beach spawning locations may pose a threat to the beach spawning aggregate given the relative sizes of the tributary and beach spawning aggregates. However, to date, there appears to be little exchange between the beach spawning and tributary spawning aggregates (Ford 2022). The estimated proportion of beach spawners that are hatchery origin has been very low, with pHOS estimates ranging from 0.5 percent to 0.8 percent (Makah Fisheries Management 2015). Furthermore, (1) there is some evidence that the tributary and beach spawning aggregates coexisted in the past; (2) the source of the hatchery program is Ozette fish; (3) the hatchery broodstock is currently derived from fish returning to the tributaries; (4) there is little evidence of resource limitations in the lake for rearing; and, (5) the level of hatchery intervention into the natural sockeye salmon life cycle is minimal (egg boxes producing fry).

We conclude that hatchery effects continue to present negligible introgression risks to the persistence of the Ozette Lake sockeye salmon ESU, while resulting in positive gains for abundance, spatial structure, and diversity. However, interactions between the beach spawning and tributary spawning aggregates should continue to be monitored. In recent years, very few carcasses have been recovered, making it difficult to detect any potential changes in the hatchery fraction (only 1 carcass recovered from 2015-2018; Hinton and Cooke 2019; Makah Fisheries Management 2020).

Listing Factor E Conclusions

Climate Effects

Climate change influences on ocean conditions/ocean survival appear to be the biggest single habitat factor influencing the abundance and productivity of the Ozette Lake Sockeye ESU, with additional influence on the suitability of spawning conditions for both tributary and lake spawning aggregates. Viability risks appear to be increasing due to the influence of climate change.

Hatchery Effects

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 depend on the affected population's status and specific practices in the hatchery program. Hatchery programs can affect naturally produced populations of salmon and steelhead in a variety of ways, including through competition (for spawning sites and food) and predation effects, disease effects, genetic effects (e.g., outbreeding depression, hatchery-influenced selection), broodstock collection effects (e.g., to population diversity), and facility effects (e.g., water withdrawals, effluent discharge) (NMFS 2018).

At the time of the last review, we concluded that the tributary hatchery reintroduction programs have reduced risks to the Ozette Lake sockeye ESU by increasing abundance, productivity, diversity, and spatial structure of the species. The total abundance of natural-origin sockeye salmon spawning in the tributaries has increased, and spatial structure of the population has benefited from the extension of annual adult returns, natural spawning, and fry production in the tributaries. Beach spawning aggregations are at low risk from introgression by large numbers of hatchery tributary spawners. Best management practices have been applied through the ESA-approved hatchery program (NMFS 2015d) to reduce these risks, and very low stray rate levels of hatchery-origin fish to beach spawning sockeye areas have been demonstrated. These trends lend support to a finding that the Umbrella Creek/Big River Hatchery Program will not substantially reduce genetic diversity or fitness of the core beach spawning aggregations, or the population in total, as a result of past and continued implementation of the program.

Recommendations

While hatchery impacts are negligible in terms of concerns such as introgression and competition, the positive gains associated with the conservation hatchery may be insufficient to achieve the full suite of recovery objectives. The above information developed for the 5-year status update information is relevant to:

- Re-evaluating recovery plan objectives and strategies to achieve objectives.
- Re-evaluating the role of the conservation hatchery in supporting objectives and achievable actions.

Engagement with co-managers to discuss recovery goals and strategies, including the hatchery and HGMP, needs to take place. If new goals or new strategies to achieve existing objectives are developed, engagement with the lead entity, National Park Service, Makah, Quileute, the State of Washington and others will need to be undertaken to develop necessary actions for implementation. This may be particularly necessary as a factor within our capacity to influence and in light of climate change influences that cannot be appreciably modified.

Research, Monitoring, and Evaluation

While the Lake Ozette recovery plan identifies multiple research, monitoring, and evaluation needs and activities, with the exception of actions specified in the NMFS-approved Resource Management Plan implemented by the Makah Tribe, most of these remain unfunded and unperformed.

Additional research should be undertaken to determine the best habitat restoration strategies for lake spawning:

- Implement a consistent and reliable method for surveying and enumerating the beach spawning aggregate annually. This is essential for evaluating the status of the population.
- Conduct occasional surveys that are more spatially extensive and which capture the beginning and end of the spawn timing distribution in order to characterize any spatial or temporal changes in beach spawning.
- Develop and implement regular sampling to estimate hatchery fraction and age structure for each of the aggregates. Also investigate alternative approaches for estimating overall hatchery origin and age structure.
- Resurvey beach spawning habitat to assess status and trends in spawning habitat availability.
- Place large wood or rock on former spawning beaches or other beaches that appear likely to support suitable spawning to evaluate if refracted wave energy will reduce encroachment by vegetation and diminish occlusion of spawning gravels by fine sediments.
- Strategically place large wood to determine if it can sufficiently modify the lake level to reconnect the lake and former spawning areas.
- If beach habitat restoration is planned, then spawner and habitat surveys at those sites before and after must occur to allow for monitoring of restoration effectiveness.
- Plant eyed eggs on former spawning beaches and other beaches that appear to have suitable spawning conditions to ascertain if such efforts are desirable to re-establish beach spawning.

In addition, NMFS should identify funding sources (internally and/or externally) to establish sufficient staffing for interpreting and converting collected monitoring and data into reports on annual population status. Reports must include:

- Improved estimates of total population size. The current method of enumeration, imaging sonar, was only recently adopted. Further experimentation with placement and additional resources devoted to review of imagery and analysis will be necessary to ensure reliable estimates.
- Improved estimates of the tributary spawners. Specifically, re-evaluate the mark-recapture methodology for Umbrella Creek estimates and investigate other potential approaches. In addition, investigate methods for estimating run size in the other tributaries.
- Improved understanding of genetic structure within the population through additional genetic analysis. Build on previous work that suggests there are genetic differences (i.e., diversity) between spawning aggregates and between cohort lineages. Use available tissue samples, augmented if necessary with new samples, to establish the contemporary genetic structure. Compare this baseline with periodic sampling to monitor for changes in the genetic structure. Specifically, monitor for changes in the relationship between the tributary and beach aggregates.

2.4 Synthesis

The ESA defines an endangered species as one that is in danger of extinction throughout all or a significant portion of its range, and a threatened species as one that is likely to become an endangered species in the foreseeable future throughout all or a significant portion of its range. Under ESA section 4(c)(2), we must review the listing classification of all listed species at least once every 5 years. While conducting these reviews, we apply the provisions of ESA section 4(a)(1) and NMFS's implementing regulations at 50 CFR part 424.

To determine if a reclassification is warranted, we review the status of the species and evaluate the five factors, as identified in ESA section 4(a)(1): (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) inadequacy of existing regulatory mechanisms; and (5) other natural or man-made factors affecting a species continued existence. We then make a determination based solely on the best available scientific and commercial information, taking into account efforts by states and foreign governments to protect the species.

Biological Viability Assessment Update (Ford 2022)

Assessment of the Ozette Lake Sockeye population status is impossible to fully assess because of gaps in our knowledge of population abundance and structure. In particular, because the beach spawning aggregate is considered the core group of interest for recovery (NMFS 2009), and the abundance of the beach spawning aggregate is not estimated, we cannot fully assess the population status.

Current status of Abundance and Productivity

There is sufficient data to determine that the total Ozette Lake abundance is well below the desired lower bound, although the population has increased since that last review and over the past 15 years. Over the last few decades productivity for the total Ozette Lake population has exhibited a 10 to 20-year cyclical pattern alternating between negative and positive values. Average rates over the last five- and 15-year periods have been slightly positive, although we may be entering a negative phase.

Current status of Spatial Structure and Diversity

Currently, it appears that the Umbrella Creek Hatchery program has successfully introduced a tributary spawning aggregate. This has increased the spatial and possibly genetic structure of the population while maintaining a genetic reservoir initially established with beach spawning fish. The addition of the tributary aggregate may have stabilized or increased overall abundance, although this is difficult to confirm given the high degree of variability of annual abundances.

There is also accumulating evidence of a sustained reduction in abundance and distribution of beach spawners, aggravating the conditions originally identified by the PSTRT that "the limited distribution of Lake Ozette sockeye spawners [at that time] put the ESU at high risk." Because information of annual beach spawning abundance and extent is constrained by limitations of data collection, high levels of uncertainty remain regarding the full spatial structure of the ESU, and the level of demographic risk cannot be fully evaluated.

Straying of tributary fish into the beach spawning locations may pose a threat to the beach spawning aggregate since the tributary spawning aggregate appears to be much larger than the beach spawning aggregate for some years. To date, there appears to be little exchange between the beach spawning and tributary spawning aggregates. Because the tributary spawners are derived from an original beach spawner broodstock, if there has been local adaptation among the tributary spawners to a tributary life history strategy this improves diversity as a factor for viability, so long as tributary spawner introgression with beach spawners does not occur in a manner that further reduces beach spawner success.

2022 ESA Listing Factor Analysis

Listing Factor A (habitat): We conclude that since the last 5-year review, the risk to Ozette Lake sockeye persistence because of habitat conditions is increasing, as the increase in tributary access is countered by a concurrent decrease in beach spawning conditions.

Listing Factor B (overutilization): We conclude that since the last 5-year review, the risk to Ozette Lake sockeye persistence because of overutilization and scientific study remains low, because no direct take occurs from any commercial or recreational fishery, and the amount of take for scientific study is limited.

Listing Factor C (disease and predation): We conclude that since the last 5-year review, the risk to Ozette Lake sockeye persistence because of disease or predation remains high because, although disease does not appear to be an issue with Ozette Lake sockeye, predation is a limiting factor, and we have no additional information available that would change our current understanding of disease or predation dynamics.

Listing Factor D (inadequacy of regulatory mechanisms): We conclude that since the last 5-year review, the risk to persistence of Ozette Lake sockeye because of the inadequacy of regulatory mechanisms has increased and is higher with regards to compliance with the Forest Practices HCP for stream typing and corollary buffer protections that have not been met after 20 years, and, within the ONP, a lack of park action on implementing habitat restoration work.

Listing Factor E (other manmade or natural factors): We conclude that since the last 5-year review, the overall risk to Ozette Lake sockeye persistence because of other manmade and natural factors remains high since the risk from hatchery effects is low, but the risk from climate change and drought causing deleterious freshwater and ocean conditions is high.

Conclusion

A review of our 2022 Listing Factor analysis in the context of the original listing issues reveals that most conditions, with the exception of establishing a run of tributary spawners in one stream, have continued largely unchanged since 1999. Concerns at the time of listing that remain valid at this time include vegetation encroachment on sockeye spawning beaches, high water temperatures in Lake Ozette and Ozette River, and low water flows that create thermal blocks to migration, and a paucity of data about lake spawning, raising the concern first noted by the Biological Review Team in 1997 that if conditions remained unchanged, risk of extinction would become high. Moreover, dissolved oxygen issues in the lake and changing climate conditions appear to be on a trajectory of impairing marine and freshwater habitat characteristics necessary for persistence of the Ozette Lake sockeye salmon ESU. Overall, despite the apparent slight increase in abundance, the risk of extinction at this time is increasing.

2.4.1 Ozette Lake Sockeye salmon ESU Delineation and Hatchery Membership

- The Northwest Fisheries Science Center's review (Ford 2022) found that no new information had become available that would justify a change in the delineation of the Ozette Lake sockeye salmon ESU.
- The West Coast Regional Office's 2022 review of new information since the previous 2016 5-year review regarding the ESU/DPS membership status of various hatchery programs indicates no changes in the current Ozette Lake sockeye salmon program membership are warranted.

2.4.2 ESU Viability and Statutory Listing Factors

The Northwest Fisheries Science Center's review of updated information (Ford 2022) indicates an increasing biological extinction risk of the Ozette Lake sockeye salmon ESU since the time of the previous 2016 5-year review, based on a greater appreciation of the uncertainty surrounding spatial structure, diversity, and climate stochasticity. Listing Factors overall have not improved in the last 5 years. However, current abundance and productivity ranges are within levels consistent with previous review periods, denoting current stability in these viability metrics.

3. Results

3.1 Classification

Listing Status:

Based on the information identified above, we recommend that the Ozette Lake Sockeye ESU remain classified as a threatened species.

ESU Delineation:

The Northwest Fisheries Science Center's review (Ford 2022) found that no new information has become available that would justify a change in the delineation for the Ozette Lake Sockeye Salmon ESU.

Hatchery Membership:

For the Ozette Lake Sockeye Salmon ESU we do not recommend any changes to the current hatchery program membership.

3.2 New Recovery Priority Number

Since the previous 2016 5-year review, NMFS revised the recovery priority number guidelines and twice evaluated the numbers (NMFS 2019, NMFS 2022). Table 4 indicates the numbers in place at the beginning of the current review. In January 2022, the number remained 7C.

As part of this 5-year review we reevaluated the numbers based on the best available information, including the new viability assessment (Ford 2022), and concluded that the current recovery priority number remains 7C.

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4. Recommendations for Future Actions

In our review of the listing factors and the Northwest Fisheries Science Center's biological viability assessment, we identified many recommended actions to improve factors influencing the status of the ESU. Here we present those actions that provide the greatest opportunity to improve the VSP parameters, and advance the recovery Ozette Lake sockeye salmon:

- Improve funding and protocols for consistent abundance monitoring in lake and streams in order to improve estimates of total population size.
- Continue efforts to enumerate the beach spawning aggregates with the goal of moving from an index-based estimate to a total abundance estimate, including occasional spatially extensive surveys that capture the beginning and end of the spawn timing distribution, to provide a more concrete picture of distribution.
- Continue to implement regular sampling to estimate hatchery fraction and age structure for each of the aggregates. Also investigate alternative approaches for estimating overall hatchery-origin contribution to the total ESU and population age structure.
- Re-evaluate the mark-recapture methodology for Umbrella Creek estimates and develop a method for estimating run size in the other tributaries.
- Remediate spawning beaches by removing encroaching vegetation. Follow up with a coordinated study by NMFS, ONP, and Makah biologists on the planting of eyed eggs on spawning beaches within ONP boundaries to evaluate the survival and suitability of actively recolonizing these beaches.
- Evaluate feasibility and desirability of modifying conservation hatchery practices to incorporate supplementation of spawning beaches.
- Improve the hydraulic model for design of instream wood debris structures (including an estimate of natural wood recruitment rates) and evaluate potential flood hazards around the lake and the flood risks for property owners and ONP infrastructure.
- Identify criteria that would trigger prioritizing placement of large wood to modify the lake hydrograph for more regular inundation of spawning beaches/inhibition of plant recruitment, particularly for Middle and Upper Ozette River.
- Place habitat structures on former spawning beaches or other beaches that appear likely to support suitable spawning to evaluate if refracted wave energy will reduce encroachment by vegetation and diminish occlusion of spawning gravels by fine sediments.

5. References

5.1 Federal Register Notices

June 15, 1990 (55 FR 24296). Notice: Endangered and Threatened Species; Listing and Recovery Priority Guidelines.

November 20, 1991 (56 FR 58612). Notice of Policy: Policy on Applying the Definition of Species Under the Endangered Species Act to Pacific Salmon.

February 7, 1996 (61 FR 4722). Notice of Policy: Policy Regarding the Recognition of Distinct Vertebrate Population Segments Under the Endangered Species Act.

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June 14, 2004 (69 FR 33102). Final Rule: Endangered and Threatened Species: Proposed Listing Determinations for 27 ESUs of West Coast Salmonids.

June 28, 2005 (70 FR 37159). Final Rule: Endangered and Threatened Species: Final Listing Determinations for 16 ESUs of West Coast Salmon, and Final 4(d) Protective Regulations for Threatened Salmonid ESUs.

June 28, 2005 (70 FR 37204). Final Policy: Policy on the Consideration of Hatchery-Origin Fish in Endangered Species Act Listing Determinations for Pacific Salmon and Steelhead.

September 2, 2005 (70 FR 52630). Final Rule: Endangered and Threatened Species; Designation of Critical Habitat for 12 Evolutionarily Significant Units of West Coast Salmon and Steelhead in Washington, Oregon, and Idaho.

January 5, 2006 (71 FR 834). Final Rule: Endangered and Threatened Species: Final Listing Determinations for 10 Distinct Population Segments of West Coast Steelhead.

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December 17, 2020 (85 FR 81822). Final Rule: Revisions to Hatchery Programs Included as Part of Pacific Salmon and Steelhead Species Listed Under the Endangered Species Act.

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NATIONAL MARINE FISHERIES SERVICE
5-YEAR REVIEW
Ozette Lake Sockeye Salmon ESU

Current Classification: Threatened

Recommendation resulting from the 5-Year Review

☐ Downlist to Threatened
☐ Uplist to Endangered
☐ Delist
☒ No change is needed

Review Conducted By (Name and Office):

West Coast Region Ozette Lake Sockeye Salmon ESU Evaluation Team

REGIONAL OFFICE APPROVAL:

Lead Regional Administrator, NOAA Fisheries

Approve Scott Rumsey Digitally signed by Scott M. Rumsey Date: 2022.09.23 11:43:59 -07'00' Date: 9/23/22

Cooperating Regional Administrator, NOAA Fisheries

☐ Concur ☐ Do Not Concur ☒ N/A

Signature________________ Date: _______

HEADQUARTERS APPROVAL:

Assistant Administrator, NOAA Fisheries

☒ Concur ☐ Do Not Concur

Signature RAUCH.SAMUEL.D.III.1365850948 Digitally signed by RAUCH.SAMUEL.D.III.1365850948 Date: 2022.10.07 14:18:41 -04'00' Date: _______