Oregon Coast Coho Conservation Plan

2019 12-Year Plan Assessment

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Summary

The Oregon Coast Coho Conservation Plan was approved by the Oregon Fish and Wildlife Commission in 2007 as the State of Oregon's conservation and management plan for the Oregon Coast Evolutionarily Significant Unit of coho salmon (OC Coho ESU). The plan provides a conservation framework for attaining a broad sense desired status at which Oregon Coast coho salmon will be sufficiently abundant, productive, and diverse to be self-sustaining, *and* provide significant environmental, cultural, and economic benefits. Broad sense goals are long-term ambitions (~50 years) expected to be attained after sustained conservation actions and investments in habitat protection and restoration.

In addition to annual implementation reports, the plan calls for reviews at 12-year intervals. This review is the first 12-year review of the Oregon Coast Coho Conservation Plan. It includes an assessment of (1) ESU status, including evaluation of progress toward broad sense goals for the ESU, its constituent populations, and habitat conditions; (2) implementation progress and effectiveness of restoration and management actions; and (3) a future influenced by climate and ocean change. Key findings of this 12-year assessment are:

- An updated assessment of persistence and sustainability criteria indicates that the ESU remains persistent and sustainable despite challenging conditions for both freshwater and ocean survival over the past several years.
- Low ocean survival in the late 1990s was effectively the end of a period of low realized ocean survival (i.e., including very high rates of harvest prior to reductions in the early 1990s) that lasted at least a quarter century. Spawner abundance during recent poor ocean conditions has been higher than during the late 1990's indicating that the combination of actions to date has improved resiliency.
- Despite these positive signs, the OC Coho ESU has not yet attained broad sense recovery, a status representing a condition well beyond viable, threatened, or endangered. For example, updated population viability modeling indicates that most populations have relatively high probabilities of persistence over 100 years, but fewer than half of independent populations have attained the broad sense objective for persistence. This outcome is consistent with the expectation in the OCCCP that broad sense recovery will be achieved only after several decades of sustained conservation actions.
- Overwintering habitat continues to be the primary factor limiting freshwater capacity in most OC Coho populations. Attaining the OCCCP's broad sense goals will require continued investment in habitat protection, restoration, and enhancement with a focus on critical habitats (e.g., complex pools, off channel habitat) and processes (e.g., large wood recruitment), and a reversal of declines in highly productive habitats like alcoves and beaver pools.
- Harvest management will continue to play an important role in maintaining the genetic and life history diversity of OC Coho salmon and supporting fishing opportunity consistent with ESU recovery. Current harvest management under the Amendment 13 framework considers both parental escapement and ocean survival, and it is responsive to downturns. This framework has ensured that harvest rates remain consistently low,

while also allowing for increased fishing opportunities when ocean survival and adult abundance are high.

- Hatchery management in the OC Coho ESU will continue to focus on augmenting harvest opportunity in the ocean and select terminal areas while minimizing genetic and ecologic risks to wild fish. Recent changes in brood stock management for the North Fork Nehalem and Trask hatchery programs, which have relied on highly domesticated brood stocks for many years, are expected to further reduce genetic risks, as well as improve hatchery fish survival and harvest opportunities.
- Climate change-driven alterations of freshwater and marine habitats are expected to impact the abundance and productivity of OC Coho populations. Although some projected changes could be positive for coho salmon, negative impacts are more likely overall when the full spectrum of habitats and life stages are considered (Wainwright and Weitkamp 2013).
- The impacts of climate and ocean change for OC Coho salmon are likely to be negative overall, but there is some uncertainty in the spatial and temporal nature of impacts and how ecosystems, and species, will adapt. Impacts are expected to vary substantially across the ESU, with some populations more vulnerable than others due to current habitat status and the magnitude of expected change. Risk to population viability will also depend on the scope and effectiveness of actions taken to promote resilience and reduce vulnerability to climate impacts.
- The primary management strategy to minimize the long-term impacts of climate and ocean change on OC Coho salmon centers on the protection, restoration, and enhancement of key freshwater and estuarine habitats. Maintaining and restoring diverse and productive rearing habitats will support the expression of the full complement of life history diversity and help sustain populations through cycles in ocean productivity, which may become more extreme and unfavorable in the future.
- While winter parr capacity will continue to limit smolt production in the near term in most populations, an increasing focus on protecting and restoring water temperature and summer flows will be necessary to mitigate for ongoing and intensifying impacts from climate change.
- Achieving habitat goals and meeting the habitat challenges posed by climate change will require continued support for, and enhancement of (1) local capacity to implement habitat restoration projects and (2) capacity for state and federal natural resource agencies to provide technical support for these efforts.

The next 12-year assessment of the OCCCP will include data through run-year 2031. In the meantime, ODFW will continue to report progress through annual implementation reports, and data on measurable criteria will continue to be made publicly available through online data sharing platforms, currently the ODFW Salmon and Steelhead Recovery Tracker (*odfwrecoverytracker.org*).

Section I. Introduction

Oregon Coast Coho Evolutionarily Significant Unit/Species Management Unit

The Oregon Coast Coho Evolutionarily Significant Unit (OC Coho ESU) includes populations of coho salmon on the Oregon Coast from the Necanicum River south to the Sixes River. The OC Coho ESU is synonymous with the federal ESU designation, and Oregon has adopted the population structure proposed by the NOAA Technical Recovery Team (Lawson *et al*. 2007). This population structure includes 57 populations, of which 21 are considered Independent Populations. Independent Populations are those located in basins with sufficient historical habitat to have persisted through several hundred years of normal variations in marine and freshwater conditions. The remaining 36 populations are considered Dependent Populations, which are in smaller coastal basins where persistence is dependent upon interactions with Independent Populations. The 21 Independent Populations of OC Coho Salmon are further grouped into five geographic strata: North Coast, Mid Coast, Umpqua, Lakes, and Mid-South Coast (Fig. 1).

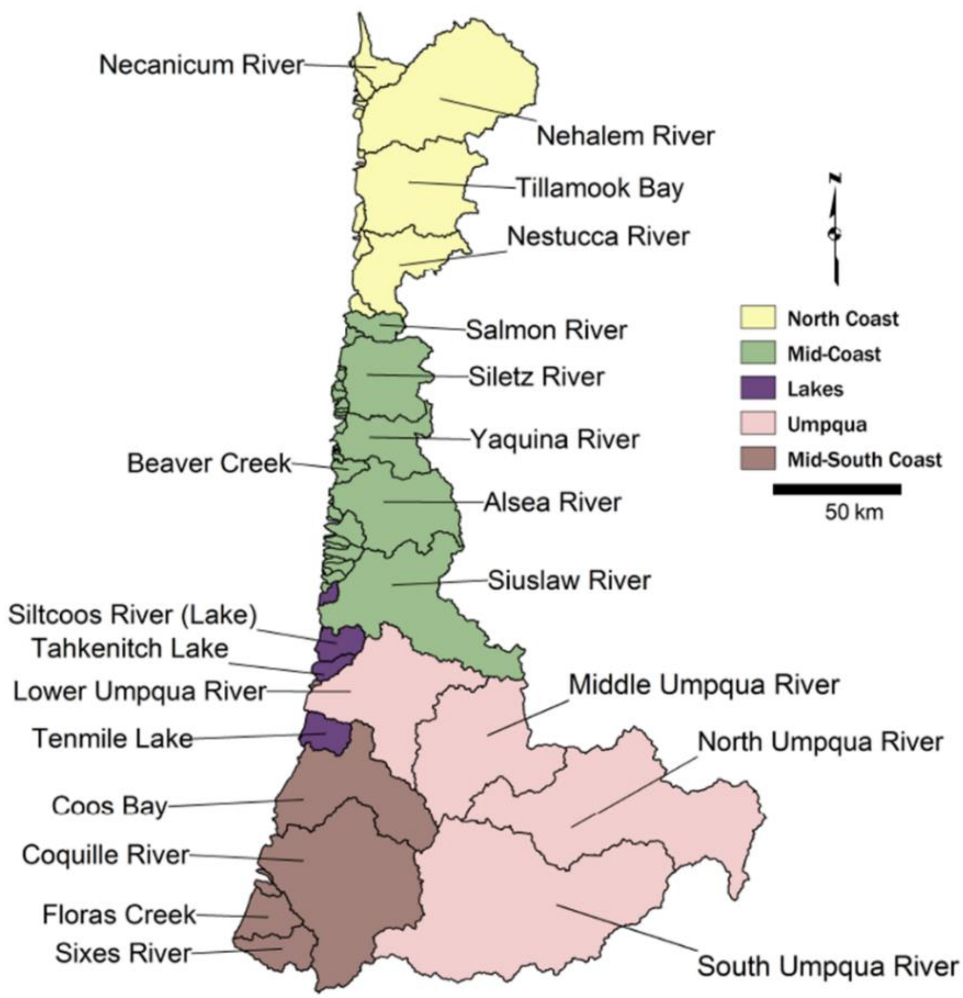

Figure 1. The 5 Strata and 21 Independent Populations comprising the Oregon Coast Coho ESU.

The Oregon Coast Coho Conservation Plan for the State of Oregon

In 1997, Oregon's Governor and its Legislature adopted the Oregon Plan for Salmon and Watersheds (Oregon Plan) *"to restore Oregon's native fish populations and the aquatic systems that support them to productive and sustainable levels that will provide substantial environmental, cultural, and economic benefits."* The Oregon Plan organized conservation actions and monitoring, and focused investments in habitat protection and enhancement to address declines in fish populations and watershed health. This concerted and sustained conservation effort has resulted in the implementation of thousands of projects to restore instream and riparian habitats throughout the OC Coho ESU.

In March 2007, the Oregon Fish and Wildlife Commission approved the Oregon Coast Coho Conservation Plan (OCCCP) as the State of Oregon's conservation and management plan for the OC Coho ESU. The OCCCP builds on the significant momentum of the Oregon Plan, with a purpose of ensuring the continued viability of the OC Coho ESU and achieving a condition that provides substantial ecological and societal benefits. The plan addresses the requirements for conservation planning under Oregon's Native Fish Conservation Policy (OAR 635-007-0502 to 0509). In addition to meeting these requirements, the OCCCP provides a strategic approach to recovery that is based on science and developed with significant stakeholder involvement. The OCCCP is intended to evolve over time with new information, including assessment of the recovery actions taken.

In the status assessment preceding the OCCCP (Chilcote *et al*. 2005), ODFW considered the OC Coho ESU to be viable, a status defined as:

> *Populations of naturally produced fish comprising the ESU are sufficiently abundant, productive, and diverse (in terms of life histories and geographic distribution) that the ESU will persist into the foreseeable future.*

This status reflected a substantial reduction in harvest, improved hatchery management, and extensive habitat restoration work initiated or maintained under the Oregon Plan. The OC Coho ESU is presently listed as Sensitive on Oregon's Sensitive Species List, and the ESU is listed as Threatened under the Federal Endangered Species Act (ESA). In the most recent federal status review, the National Marine Fisheries Service (NMFS) concluded that the OC Coho ESU should remain listed as Threatened (NWFSC 2015).

Broad Sense Goals

In addition to assessment of status at the time of plan development, the OCCCP identified a desired status for the ESU and its populations, summarized in a vision statement for the ESU:

> *Populations of naturally produced coho salmon are sufficiently abundant, productive, and diverse (in terms of life histories and geographic distribution) such that the ESU as a whole is 1) self-sustaining into the foreseeable future, and 2) providing significant ecological, cultural, and economic benefits.*

This vision statement and measurable, scientifically based objectives were developed collaboratively with stakeholders and represent consensus among members of the stakeholder team. In addition, the plan identifies specific measurable criteria for tracking progress toward broad sense goals.

To further define the vision, the OCCCP describes anticipated characteristics of the ESU, watersheds, fish and communities that should be observable when the broad sense goals are achieved. These include:

- There will be, on average, abundant numbers of coho salmon in our coastal streams including adults in the fall and winter and juveniles throughout the year;
- During return years affected by extremely poor marine survival conditions (similar to the 1990s), roughly twice as many coho will return to the ESU, compared to the numbers that were observed spawning in the 1990s; during return years affected by favorable marine survival there will be well over a half a million spawners returning to the ESU;
- Tributary, mainstem, estuarine, and wetland reaches of coastal rivers will provide sufficient high-quality habitats and water quality to support increased numbers of ocean-bound coho smolts;
- Some hatcheries in coastal basins (with program guidance provided in the OCCCP and Fish Hatchery Management Policies), will be producing hatchery coho to support consumptive fisheries that achieve societal and cultural needs not met by the natural production goals of this plan;
- Ample opportunity will exist for people to fish-for and keep naturally produced coho in the ocean and in many streams, again, consistent with population-based conservation goals;
- There will be on average, 2 to 4 times more coho carcasses in the spawning streams as there have been in the last 5 decades and these carcasses will provide ecological benefits to native fish and wildlife and the ecosystem;
- There will be a wide variety of traditional land use activities throughout the ESU, including forestry, agriculture, recreation, and industrial and housing development;
- Coho salmon will be a far more significant feature of the cultures of Native Americans across the ESU than has recently been possible; and
- Coho salmon will be a far more significant factor in the cultures and employment in coastal communities across the ESU than has recently been possible. These biological, social, and economic benefits will be widely shared across the ESU. Societal values of coho salmon will include intrinsic values (based simply on the knowledge of the resource's existence) and bequest values (which confer value to the resource for the benefit of future generations).

The OCCCP's goals are broad sense goals; they are *not* delisting goals under the federal ESA. The OCCCP broad sense goals represent a future condition and performance of the OC Coho ESU that is significantly higher than a level at which the ESU would be considered a candidate for listing under the federal ESA (Table 1). The OCCCP describes the broad sense goals as ambitious goals that are expected to be attained over 50 years of sustained conservation actions, including habitat protection, restoration, and enhancement.

Table 1. A conceptual hierarchy of biological status for a species from pristine to extinct and associated definitions. Broad sense recovery, the OCCCP desired status for OC coho salmon, represents a biological status significantly higher than status classifications consistent with listing under the federal ESA. A species' movement from pristine to extinct is not necessarily a continuous, step by step process (Table adapted from Table 2 in Chilcote *et al*. 2005).

Biological Status Classification	Definition of Biological Status Classification
Pristine	All historical populations within the ESU are healthy, and adverse impacts from human activities are insignificant at the population and ESU scale.
Broad Sense Recovery (OCCCP)	Populations of naturally produced fish comprising the ESU are sufficiently abundant, productive, and diverse (in terms of life histories and geographic distribution) that the ESU will: a) be self-sustaining, and b) provide ecological, cultural, and economic benefits.
Viable	Populations of naturally produced fish comprising the ESU are sufficiently abundant, productive, and diverse (in terms of life histories and geographic distribution) that the ESU will persist into the foreseeable future.
Threatened (Current Federal Status)	The ESU is likely to become endangered within the foreseeable future throughout all or a significant portion of its range.
Endangered	The ESU is likely to become extinct within the foreseeable future throughout all or a significant portion of its range.
Extinct	The ESU contains so few members that there is no chance that their evolutionary legacy will ever re-establish itself within its native range.

Plan Implementation

The OCCCP describes the achievement of the broad sense goals for OC coho salmon through a combination of regulatory programs and significant non-regulatory efforts. The plan does not provide lists of site-specific actions necessary to achieve broad sense goals; it is intended to provide structure and guidance to local efforts to protect and restore coho salmon and their habitat throughout the ESU while providing the flexibility for actions to be determined locally (e.g., through landowners, watershed groups, etc.) with technical guidance and funding support from state and federal natural resource agencies. Broad sense goals are long-term goals likely requiring implementation of protection and enhancement efforts over several decades.

Scope and Purpose of the 12-year Assessment

The OCCCP directs the Oregon Department of Fish and Wildlife (ODFW) to conduct a comprehensive assessment of the OC Coho ESU 12 years after plan adoption (through return year 2019). This is the first 12-year assessment of the OCCCP, and it includes a comprehensive assessment of (1) ESU status, including evaluation of progress toward broad sense goals for the ESU, its constituent populations, and habitat conditions; (2) implementation of conservation and management actions; and (3) a future influenced by climate and ocean change. Periodicity of future detailed assessments is every 12 years unless adjusted based on assessment results or other new information.

Section II. Oregon Coast Coho Monitoring Programs

Monitoring Components

In 1998, ODFW began implementing an extensive suite of programs to monitor coho salmon adults, juveniles, survival (life cycle monitoring) and habitat in the OC Coho ESU. These programs, described below, continue to provide the basis for assessing the OCCCP's measurable criteria (See Section III, *Progress Toward Broad Sense Goals*), criteria for federal status reviews (See Section IV, *Decision Support System*), and support for other conservation and management decisions (Fig. 2).

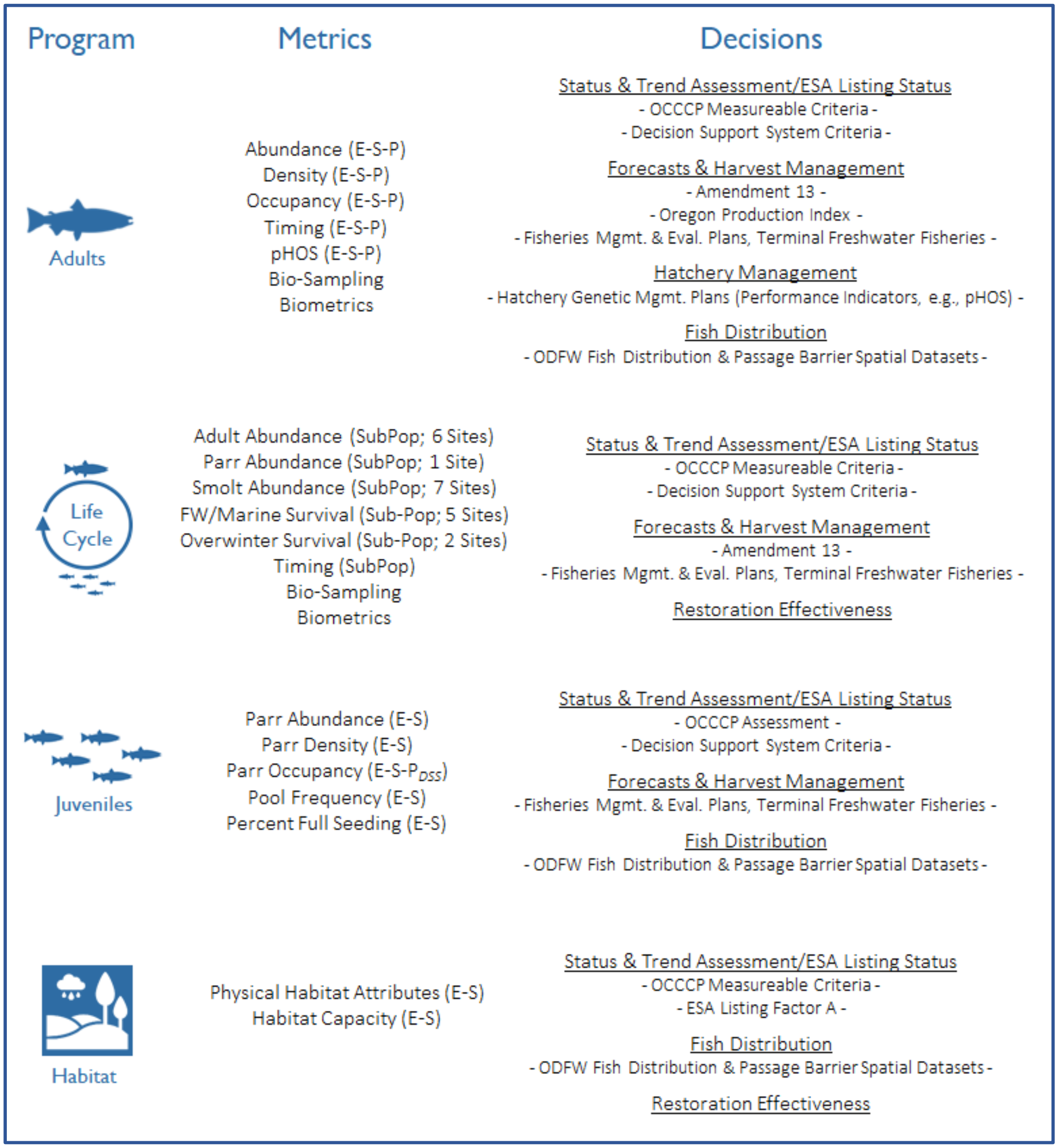

Figure 2. ODFW's Oregon Plan Monitoring Programs for OC coho salmon, metrics reported, and some of the conservation and management decisions/tools they support. The spatial scales for metrics are shown in parentheses (E, ESU; S, Stratum; P, Population; SubPop, Subpopulation). The DSS subscript on population-scale parr occupancy indicates criteria for the Decision Support System (See Section IV).

Adult Spawners – Oregon Adult Salmonid Inventory and Sampling Project (OASIS)

The earliest ODFW spawning surveys for OC Coho salmon date to the 1940s, with random sampling begun in 1990 by the OASIS program. Since 1998, the OASIS spawning surveys for OC coho salmon have been selected using a spatially balanced monitoring design (Generalized Random Tessellation Stratified Design, GRTS; Stevens 2002). Data from these surveys are used to produce spatially unbiased estimates of spawner abundance, density, distribution, timing, and the proportion of hatchery origin spawners in naturally spawning populations. Estimates are provided at three spatial scales: ESU, Stratum, and Population. There are three exceptions to this general approach:

- Annual estimates of spawner abundance in the Siltcoos, Tahkenitch and Tenmile populations (Lakes Stratum) are made using regressions of long-term standard surveys to historic mark-recapture abundance estimates and habitat measurements (Jacobs *et al*. 2002).[1]
- Since 2014 in the Alsea Population, the count of wild coho salmon passed above the Alsea Hatchery weir is added to the abundance estimate derived from GRTS spawner surveys conducted in the remainder of the basin (i.e., there are no spawning surveys in areas upstream of the hatchery weir).
- Spawner abundance in the North Umpqua Population is estimated through video counts at Winchester Dam combined with a GRTS estimate in the very small amount of coho spawning habitat below Winchester Dam (i.e., Sutherlin Creek). The Winchester Dam count is adjusted for fish collected and retained at Rock Creek Hatchery, and for angler harvest in the North Umpqua River above Winchester Dam.

The present adult OC coho monitoring design was established in 1998 as a 27-year study, but changes in geospatial technology and management needs have resulted in revisions to the initial design. Additional details regarding survey design, field methods, and analytical approaches, including significant methodological changes, are available in Sounhein *et al*. (2017). Survey effort has also varied through time; after a significant budget reduction in 2014, survey effort in the OC Coho ESU was reduced from an average of about 550 sites/year (2007-2013) to about 350 sites/year (Fig. 3). Survey effort has been further reduced to accommodate budget constraints in 2020.

The spawner survey and passage count data described above are the basis for evaluating the OCCCP's broad sense abundance criteria for the ESU and Independent Populations (Criterion 1, Spawner Abundance) and for Dependent Populations (Criterion 1: Abundance Trend). They also provide data for assessing productivity (Criterion 3) for the ESU and Independent Populations and for the population viability analysis (PVA) modeling that supports assessment of Independent Population criteria 2 (Persistence) and 5 (Diversity). Adult occurrence data from spawner surveys is the basis for assessing the distribution criterion for Independent Populations (Criterion 4).

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[1]Mark-recapture abundance estimates are derived from capturing, marking (e.g., tagging), and releasing a subset of individuals in the population and recapturing marked and unmarked individuals in a subsequent capture event or events. Standard index surveys are sites that have been consistently surveyed over a long period of time. Standard index surveys were typically selected based on the judgment of local biologists, who considered factors including access, high use for spawning, and feasibility of surveys.

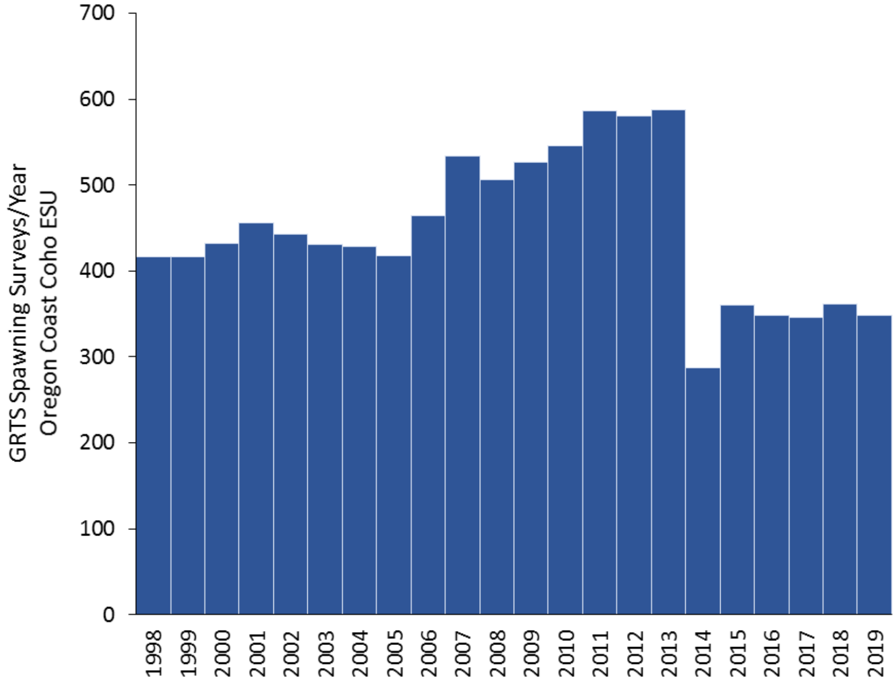

Figure 3. Annual number of GRTS coho spawner surveys in the Oregon Coast Coho ESU, 1998-2019.

In addition to providing for assessment of OCCCP measurable criteria, these adult spawner data provide the basis for the following criteria used to assess persistence and sustainability for federal status reviews: PP-1 (Population Productivity), PP-2 (Probability of Persistence), PP-3 (Critical Abundance), PD-1 (Spawner Abundance, incl. jacks), PD-2 (Artificial Influence), and PD-3 (Spawner Distribution, W-Sp). These criteria, discussed further in Section IV (*Decision Support System*, *DSS*) and Appendix III (*2020 DSS Assessment*), help to describe interim progress toward the OCCCP's broad sense goals and are an important component of five-year reviews of the ESU's listing status under the federal ESA.

Data from spawner surveys and passage counts are used to support conservation and management decisions beyond status assessment. For example, these data are used in forecasts and harvest management decisions (i.e., Amendment 13 [A13] to the Pacific Coast Salmon Fishery Management Plan). Specifically, OC Coho spawner abundance estimates are used to classify parental escapement levels in the A13 matrix for determining allowable maximum fishery impacts. The peak count of jack coho salmon from spawner surveys is used along with other monitoring data and oceanographic productivity metrics in the prediction of marine survival for OC coho and the marine survival classification for the A13 harvest matrix. These survey data and passage counts are also incorporated into decisions about terminal fisheries in freshwater (ODFW 2003; 2009). Information about the distribution and prevalence of naturally spawning hatchery fish provides information for evaluating hatchery program performance, and spawning surveys provide salmonid occurrence data and observations of natural and artificial barriers that can be incorporated into spatial data layers used by ODFW and other agencies (e.g., ODFW Fish Passage Barrier dataset; ODFW Fish Habitat Distribution dataset).

The adult spawner data are also used by ODFW, watershed councils, and other restoration practitioners to direct and prioritize habitat restoration and protection.

Juveniles – Western Oregon Rearing Project (WORP)

Spatially balanced, random surveys (GRTS) of juvenile salmonids have provided annual estimates of the summer distribution, abundance, and habitat occupancy rate of juvenile coho salmon within four of the five strata in the ESU (North Coast, Mid-Coast, Umpqua, and Mid-South Coast) since 1998. Selected survey reaches (1 km in length) are surveyed by WORP field crews using daytime snorkeling during the base flow period (mid-July to mid-October). Metrics, including site occupancy, pool frequency[2], parr abundance[3], and percent full seeding[4], are reported annually for the ESU and strata (excluding the Lakes Stratum). As with surveys for spawning adults, the juvenile coho monitoring program was established as a 27-year study, but there have been changes to sampling frames and methods though time. One important change involved pool depth criteria. Initially, only pools ≥40cm in maximum depth were snorkeled. In 2010, this criterion was expanded to include pools ≥20cm in maximum depth based on a verification study in the Smith River, Oregon that indicated the ≥20cm criterion would provide for sampling larger and more consistent portions of coho summer rearing distributions. Survey effort has also varied through time in response to resource constraints (e.g., budget reductions in 2014) and methodological changes (Fig. 4). In 2016, snorkel surveys were incorporated into habitat survey protocols to accommodate budget reductions while maintaining capacity for juvenile surveys (see *Habitat*, below). Additional details on survey design, field methods, and changes over time can be found in Constable and Suring (2020).

Metrics from juvenile surveys were not incorporated into the OCCCP measurable criteria. However, juvenile distribution metrics are incorporated into DSS Population Diversity Criterion PD-3 (Juvenile Watershed Distribution, W-ju). Juvenile data are also discussed further in the context of freshwater habitat in the present assessment (See Section V, *Habitat Trends*). As with spawner surveys, metrics from juvenile surveys are used as performance indicators for terminal fisheries in freshwater (e.g., ODFW 2009), and observations from juvenile surveys provide information for various distribution datasets (e.g., ODFW Fish Passage Barrier dataset; ODFW Fish Habitat Distribution dataset). Juvenile abundance estimates also have been used in combination with overwinter survival estimates from life cycle monitoring sites (see below) to estimate smolt abundance for the ESU (Constable and Suring 2018).

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[2] The average percent of pools in a site that contain at least one individual.

[3] Abundance estimates are based on uncalibrated snorkel counts in pools that meet size criteria; they are not estimates of total abundance but are useful for assessing trend.

[4] Percent full seeding is the percent of sites within a stratum or ESU with a site density >0.7 Coho Salmon/m^2 (Full Seeding = 1.0 coho/m^2 and observer efficiency is 70%).

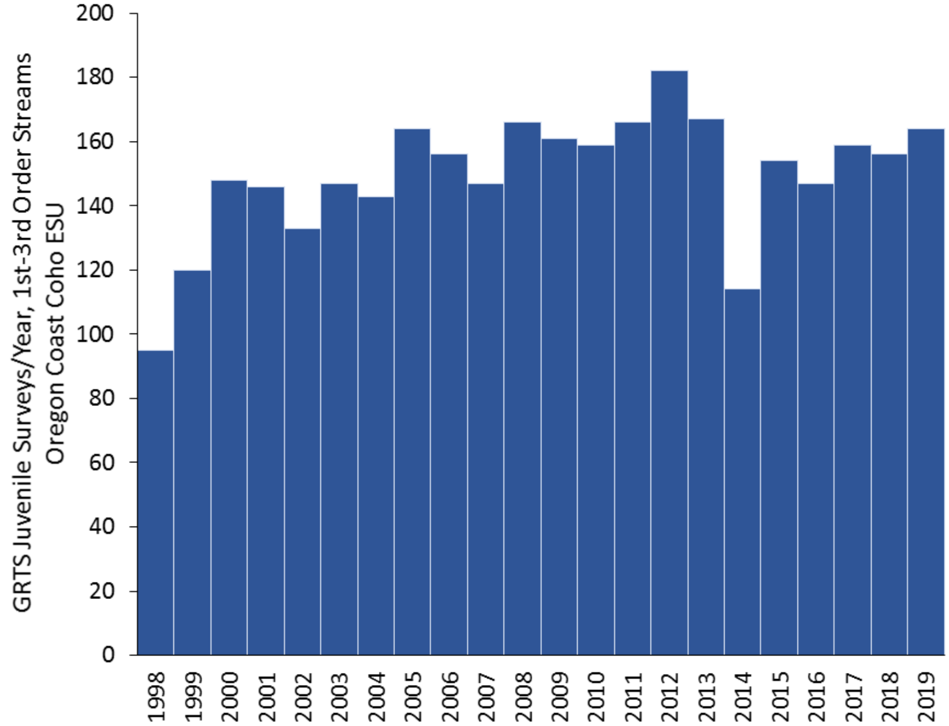

Figure 4. Number of GRTS juvenile salmonid surveys per year, 1998-2019, in the Oregon Coast Coho ESU. Surveys are snorkel surveys and include electrofishing surveys in 2000-2016, excluding 2014. Not included above are snorkel surveys in 4th and 5th order streams (~45/yr) in 2002-2008.

Life Cycle Monitoring – Salmonid Life Cycle Monitoring (LCM) Project

The LCM project began in 1998 and provides annual estimates of spawning adult coho salmon abundance, juvenile coho salmon outmigrant abundance, and freshwater and marine survival in five sub-watersheds within the OC Coho ESU: Mill Creek (Siletz basin), Mill Creek (Yaquina basin), Cascade Creek (Alsea basin), West Fork Smith River (Umpqua basin), and Winchester Creek (Coos basin) (Fig. 5). Since plan adoption, LCM sites at East Fork Trask River (Tillamook basin) and the North Fork Nehalem River were discontinued due to budget reductions. In addition to these LCM sites, juvenile outmigrant abundance is monitored in Lobster Creek (Alsea Basin) and Tenmile Creek (Direct Ocean Tributary). Depending on the site, estimates of adult spawners are based on counts at total passage barriers, mark-recapture methods, or spawning surveys. Juvenile outmigrants are captured in rotary screw traps or incline plane traps, and abundance is estimated with accounting for trap efficiency and inferring catch during high flow periods when rotary screw traps are not fished. Estimates of overwinter survival are available from Lobster Creek and Mill Creek (Siletz), where summer rearing coho parr are surveyed.

The LCM project data are used to set the marine survival classifications for the OCCCP goals for measurable criterion 1 (Adult Abundance), criterion 3 (Productivity) and criterion 4 (Distribution) as well as to support PVA modeling for OCCCP criterion 2 (Persistence), criterion 4 (Diversity) and the DSS criterion PP-2 (Probability of Persistence). Data from LCM sites are also a central component of forecasts and harvest management. The smolt-to-adult return rate, averaged across LCM sites, is a marine survival indicator for OC coho, and the jack:smolt ratio at the Mill Creek (Yaquina) LCM site is used along with the peak count of jack coho salmon on spawning surveys and ocean productivity indicators, to forecast marine survival and the marine survival category in the A13 harvest matrix. LCM data also support decisions about terminal fisheries in freshwater (e.g., ODFW 2009). Beyond this direct support for conservation and management decisions, the long-term baseline data of adult and outmigrant abundance and survival at LCM sites have also provided several valuable opportunities to monitor restoration effectiveness at the sub-basin scale (e.g., Tenmile and Cummins creeks – Johnson *et al*. 2005; Lorion *et al*. 2018; Lobster Creek – Solazzi *et al*. 2000; Lorion and Suring 2018; West Fork Smith River – Jenkins and Meister 2019).

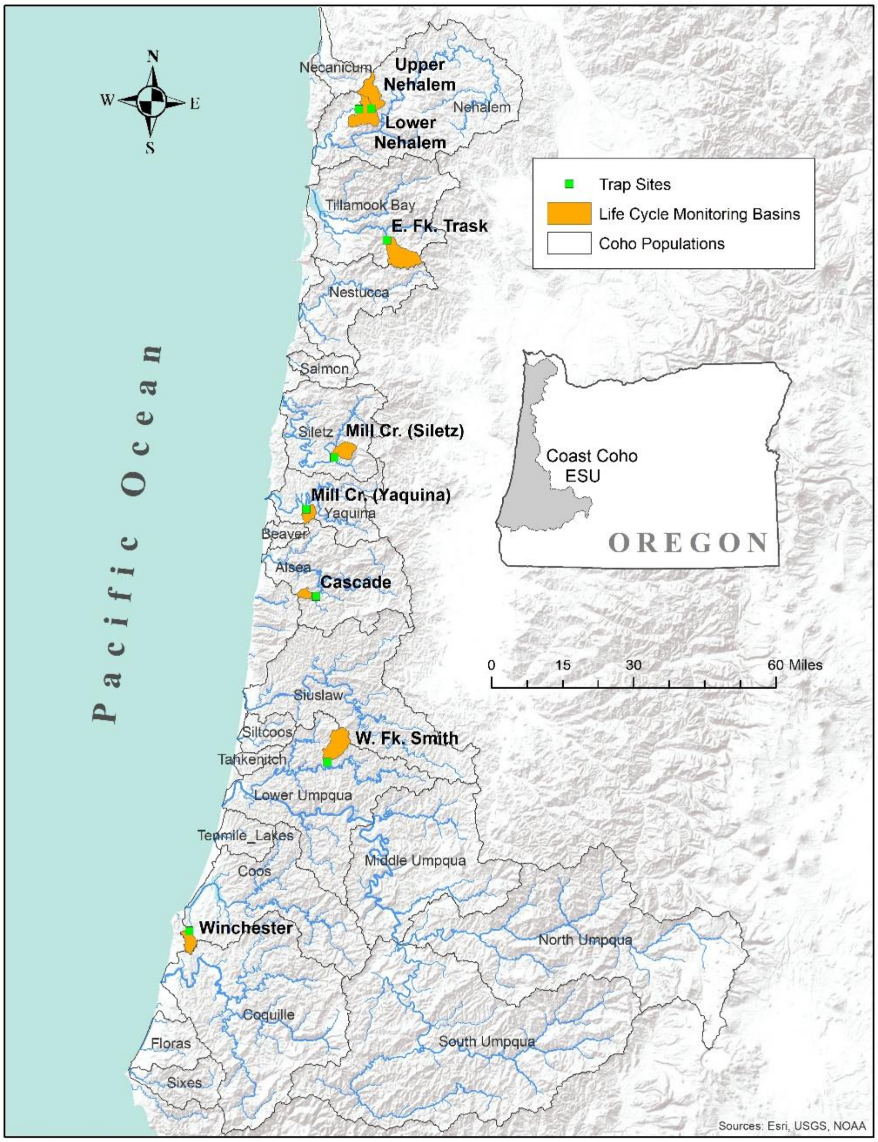

Figure 5. Salmonid Life Cycle Monitoring trap sites and basins in the OC Coho ESU. Sites in the Trask and Nehalem basins have been discontinued due to budget reductions.

Habitat – Aquatic Inventories (AQI) Projects

ODFW biologists have conducted stream habitat surveys since at least the 1950s. The AQI project conducts spatially balanced, random stream habitat surveys (GRTS) in mid-June through late September to provide estimates of a broad array of instream physical habitat, channel features, and riparian conditions in the OC Coho ESU (Fig. 6). Data are recorded for various features characterizing each survey reach and its constituent geomorphic units.[5] The survey design was intended to provide annual assessment of the condition of coho habitat in wadeable streams at the ESU and stratum scale, and every five years for each independent population and for dependent populations combined by strata. Habitat metrics are also applied to the Habitat Limiting Factors Model to estimate the capacity of habitat to support juvenile coho during winter. To accommodate budget reductions in 2016, snorkel surveys for juvenile salmonids (discussed above) were incorporated into habitat surveys. Additional details on habitat survey methods are available in Moore *et al*. (2007).

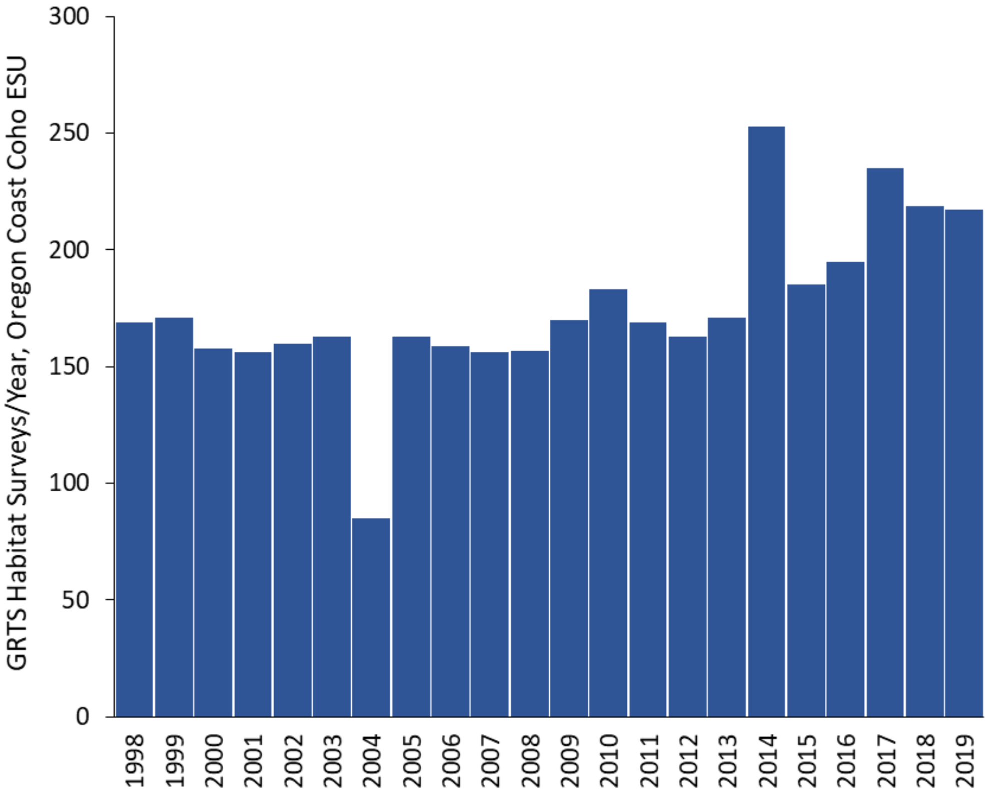

Figure 6. Number of GRTS juvenile salmonid surveys per year, 1998-2019, in the Oregon Coast Coho ESU, 1998-2019. Surveys are primarily in 1st to 3rd order streams and include sites within and above the distribution of coho salmon.

The AQI project habitat survey data provide the basis for evaluating OCCCP measurable criteria for habitat in independent and dependent OC Coho populations (Independent Population Criterion 6, Habitat Condition; Dependent Population Criterion 2, Habitat Trend). Habitat criteria are no longer included in the DSS (See Section IV), but habitat data are

[5] Channel geomorphic units are relatively homogeneous lengths of the stream that are classified by channel bed form, flow characteristics, and water surface slope.

nonetheless incorporated into evaluation of listing status under the federal ESA (i.e., Listing Factor A, Present or threatened destruction, modification, or curtailment of the species' habitat or range, e.g., NMFS 2016).

Through time, AQI has continued to refine and verify the survey design and methods and pilot new approaches (e.g., Anlauf *et al*. 2011; Strickland *et al*. 2019; Strickland and Davies 2020). AQI habitat data also have improved our understanding of coho life history and juvenile use of estuary habitats (Jones *et al.* 2014a), informed evaluation of habitat restoration effectiveness[6] (e.g., Jones *et al*. 2014b), and are used by watershed councils and other restoration practitioners to direct and prioritize habitat restoration and protection. These surveys have also been applied to identify natural and anthropogenic landscape controls on instream habitat features (Anlauf *et al*. 2011) and, along with adult and juvenile data, they have helped to clarify relationships among coho life stages and habitats (Anlauf-Dunn *et al*. 2014).

[6] Project-scale restoration effectiveness was evaluated with habitat surveys at sites monitored before and at intervals after restoration as a part of the Western Oregon Stream Restoration Program. These surveys were discontinued after 2014 due to budget constraints.

Section III. Broad Sense Goals & Measurable Criteria

Broad Sense Goals and Measurable Criteria

The OCCCP provides criteria, metrics, and goals for abundance, persistence, productivity, distribution, diversity, and habitat condition. These are summarized below for the ESU, Independent Populations, and Dependent Populations. Additional details can be found in OCCCP Appendix 2, *Desired Status: Measurable Criteria for the Oregon Coast Coho Conservation Plan for the State of Oregon,* and in Appendix I of the present review *(Measurable Criteria Assessment)*.

As previously discussed, it is important to recognize that the goals in the OCCCP are broad sense goals representing a condition of the ESU that is significantly higher than a Threatened or Endangered status under the federal ESA. The OCCCP goals will be met when:

1) all Independent Populations meet the objectives for the six measurable criteria for Independent Populations; and
2) the aggregate of Dependent Populations within a biogeographic stratum meet the objectives for the two measurable criteria for Dependent Populations.

While achieving the OCCCP broad sense goals will take time, it should be possible to observe interim improvements along the way. As a measure of interim progress, all 21 Independent Populations must pass the population sustainability criterion defined by the Oregon/Northern California Coast Technical Recovery Team (i.e., Criterion PS in Wainwright *et al*. 2008). This criterion and other criteria relevant to assessing interim progress are discussed in Section IV (*Decision Support System*).

Measurable Criteria for the ESU and Independent Populations

The OCCCP includes two measurable criteria for the OC Coho ESU (Abundance and Productivity), and six criteria for Independent Populations (Abundance, Persistence, Productivity, Distribution, Diversity, and Habitat Condition). Each criterion includes specific metrics and objectives (Table 2). The current assessment of the OCCCP measurable criteria follows Appendix 2 to the OCCCP with three adjustments, described below. Additional details on measurable criteria, metrics, and measurement, as well as ESU and population summaries are provided in Appendix I (*Measurable Criteria Assessment*).

Persistence

Assessment of the OCCCP persistence criterion was originally based on population viability analyses (PVAs) developed by the Oregon Coast Workgroup of the Oregon and Northern California Coast Technical Recovery Team (Wainwright *et al*. 2008). The PVAs are models that use information from spawner-recruit analyses to simulate population abundances into the future. For assessing the persistence criterion, the OCCCP PVAs used three spawner-recruit models (modified Ricker, modified Beverton-Holt, Hockey Stick) and the Nickelson-Lawson habitat-based life cycle model with stock-recruit data from 1958-2004. In the current assessment, PVAs were based on Ricker and Beverton-Holt recruitment models assessed over two time periods, a pre-1990 historical period and a post-1990 contemporary period. Additional details on the current PVA approach are provided in Appendix II, *Population Persistence Models*.

Diversity

In the original assessment for the OCCCP, the diversity criterion was assessed based on simulated spawner abundances from a PVA with a Ricker recruitment model, described in Chilcote *et al*. (2005). For the current assessment, ODFW has assessed the criterion based on actual spawner abundance estimates from the contemporary period (1990-2019).

Distribution

The OCCCP distribution criterion included two metrics, one based on site occupancy by adult spawners, and one based on a statistical approach called Sides, Vertices and Boundaries (SVB) (Table 2). The SVB metric has not been implemented since plan adoption; for this 12-year assessment, distribution is assessed based solely on Distribution Metric 1, Occupancy.

Measurable Criteria for Dependent Populations

Monitoring of Dependent Populations and their habitat within the OC Coho ESU has not been designed and implemented at a population scale. The OCCCP measurable criteria for these populations are instead focused on trends in spawner abundance and habitat condition in Dependent Populations aggregated by stratum (Table 3). These criteria are assessed for the Dependent Populations in the North Coast, Mid-Coast, and Mid-South Coast strata. Additional details on these criteria are available in Appendix I, *Measurable Criteria Assessment*).

Table 2. The OCCCP measurable criteria, metrics, and objectives for the ESU and Independent Populations.

Criterion	Metric	Objective
Criterion 1 Adult Abundance	Annual estimates of abundance of naturally produced spawners, excluding jacks, in each independent population and the ESU as a whole	Observed spawner abundance is greater than or equal to the marine survival-specific escapement target at least 6 times in any 12-year period.
Criterion 2 Persistence	Forecast probability of persistence for each independent population based on results from population viability simulation models	Probability of persistence is greater than or equal to 0.99.
Criterion 3 Productivity	Annual estimates of the number of naturally produced recruits per spawner (R/S) in each independent population and the ESU as a whole	Over a 12-year period, R/S values, standardized to a spawner density equal to the spawner abundance goal for each marine survival category, are statistically greater than or equal to 1.0.
Criterion 4 Distribution, Metric 1	Percentage of random, spatially balanced surveys that have at least 4 wild adult spawners/mile for each independent population (% occupancy)	Percent occupancy of wild adult spawners is greater than or equal to the marine survival-specific occupancy target at least six times in any 12-year period.
Criterion 4 Distribution, Metric 2	Comparison of the spatial pattern of potential spawning distribution to that observed using SVB or other spatial statistics for each independent population	The observed regularity ratio is not significantly different from a random distribution at least six times in any 12-year period.

Table 2. Continued.

Criterion	Metric	Objective
Criterion 5 Diversity	Average of the 100-year harmonic mean of spawner abundance for each independent population, as forecast from a population viability model	The 100-year harmonic mean of spawner abundance is greater than 1,200.
Criterion 6 Habitat Condition	Amount of available high-quality habitat (HQH) across all freshwater life stages in each independent, non-lake population	The miles of HQH (i.e., capable of producing > 2,800 smolts/mile) for independent, non-lake populations equals or exceeds the population's HQH goals.

Table 3. OCCCP measurable criteria, metrics, and objectives for Dependent Populations.

Criterion	Metric	Objective
Criterion 1 Spawner Trend	Comparison of trend lines for the three-year running average of total adult escapement for independent populations within a population stratum, and adult escapement for dependent populations within the same population stratum.	No significant difference in trend lines, except where dependent populations exhibit steeper (i.e., faster increasing) trends
Criterion 2 Habitat Trend	Amount of available high-quality habitat across all freshwater life stages	The amount of high-quality habitat for dependent populations aggregated by strata remains stable or increases as measured at five-year increments.

Assessment Results (ESU and Independent Populations)

Assessment results for the measurable criteria for the OC Coho ESU and Independent Populations are provided below. **The assessment of the OCCCP criteria is not a viability assessment. These criteria and their thresholds for attainment were developed to assess status relative to broad sense goals, not viability or ESA listing status.** Even where criteria are related to viability (e.g., persistence criterion; genetic risks associated with the diversity criterion), objectives reflect a high bar for attainment (e.g., 99% persistence probability; less than 2.5% loss of genetic heterozygosity). The assessment of Decision Support System criteria for persistence and sustainability (Section IV) is more aligned with an assessment of viability and provides additional means for considering interim progress prior to attaining broad sense recovery.

Criterion 1: Adult Abundance

The adult abundance criterion is assessed based on natural origin spawner abundance estimates (wild adults, excluding jacks) derived from spatially balanced spawning ground surveys and passage counts where applicable. To meet the objective for this criterion, spawner abundance estimates for the ESU and the Independent Populations must be greater than marine survival-specific abundance goals at least 6 times in any 12-year period.

The working hypothesis for the adult abundance criterion is based on observations of naturally produced spawners in Independent Populations during the 1993-1999 return years, which were characterized by:

1) an average estimated smolt-to-adult survival of naturally produced coho of 1.1 %; and
2) an average escapement of approximately 50,500 naturally produced adults.

The plan calls for a doubling of the average abundance observed during 1993-1999, scaled to future ocean survival rates. To achieve a desired abundance of 101,000 spawners during years with similarly low marine survival (i.e., double the average abundance from 1993-1999) would require approximately 9.9 million smolts (109,000 pre-harvest recruits[7] divided by 1.1% smolt-to-adult survival). Marine survival-specific spawner abundance goals were then calculated as:

9.9 million smolts x Marine Survival Rate x (1-Harvest Rate)

Where,

- 9.9 million smolts is the number of smolts necessary to provide for a doubling of 1990-1999 escapement (i.e., 101,000 spawners at 1.1% marine survival and 7% harvest;
- Marine Survival Rate is the average survival rate for each survival category (Extremely Low - 1.1%, Low - 4.4%, Medium - 10.3%, or High - 15.0%); and
- Harvest Rate = the maximum allowable harvest rate for each survival category (Extremely Low - 7%, Low - 15%, Medium - 30% or High - 45%) based on Amendment 13 to the Pacific Coast Salmon Fishery Management Plan.

Abundance targets for the Independent Populations comprising the OC Coho ESU were then developed based on the proportion of the total amount of Coho High Intrinsic Potential Winter Habitat in all non-lake populations that is in each population. For the populations in the Lakes Stratum (Siltcoos, Tahkenitch, and Tenmile), the targets at extremely low marine survival were set equal to the average number of spawners observed during periods of similar marine survival in the 1990's.

It is notable that the calculations above are sensitive to the marine survival rates used to calculate the smolt requirement and pre-harvest recruits. Prior to ODFW's life cycle monitoring program in 1998 (See Section II), there was little direct information available on the marine survival rates of wild OC Coho. Consequently, the OCCCP relied on estimates of marine survival of Oregon Production Index Hatchery (OPIH)[8] coho salmon to characterize marine survival for OC coho salmon during the 1993-1999 period. However, subsequent monitoring through ODFW's Oregon Plan monitoring programs (See Section II) has shown that the abundances and marine survival estimates for OPIH coho are weakly correlated to those of wild OC coho (Suring and Lewis 2013).

[7] In the OCCCP, ODFW assumed a 7% harvest rate during periods of extremely low marine survival. At a 7% harvest rate, 109,000 pre-harvest recruits would be required to result in 101,000 post-harvest adult spawners (i.e., 101,000/(1-0.07) = 108,601, rounded to 109,000).

[8] Oregon Production Index Hatchery coho are public hatchery origin coho salmon in the Oregon Production Index area, (Leadbetter Point, Washington to the U.S./Mexico border), with significant contribution by Columbia River and net pen programs.

Marine survival rates for wild OC coho based on life cycle monitoring sites (1999) and modeled with oceanographic predictors (1993-1998) suggest that the marine survival classifications for wild OC coho may have been higher than the Extremely Low classification in 1993-1995. Still, observed and modeled marine survival rates and spawner abundance estimates from 1996-1999 are similar to those used in the OCCCP's working hypothesis for goal setting. Revisions to abundance goals are not proposed in this 12-year review, but abundance goals warrant continued attention with improving knowledge of marine survival rates for wild OC coho salmon.

In the current assessment, the ESU and all 21 Independent Populations did not meet the objective for the abundance criterion (Table 4, Figs. 7; 9-13). This outcome is unchanged from the assessment in the OCCCP for the period of 1994-2005, and it is not surprising given that the broad sense goals for spawner abundance are long-term goals requiring substantial increases in abundance. Since plan adoption, ESU-scale abundance has ranged from 9% to 44% of the broad sense abundance goals, averaging 23%. Natural origin spawner abundance at the ESU scale has been higher, on average, than in the base period assessed for the OCCCP (Table 4).

Wild spawner abundance in the Independent Populations has averaged 6% (Sixes) to 51% (Siletz) of the broad sense abundance goals since plan adoption. Only two populations have exceeded the annual abundance goals since plan adoption: Siletz (3 years) and Beaver Creek (1 year) (Table 4). In the OCCCP assessment (1994-2005), the closest populations to achieving abundance goals had been the Coos Population (5 of 12 years), followed by the Beaver Creek and Tenmile, populations, which each met the abundance goal in 3 of 12 years (Table 4). The geometric mean of spawner abundances since plan implementation (2007-2019) is higher than over the period assessed in the OCCCP (1994 -2005) for 14 of the 21 Independent Populations. Geometric mean abundances are similar between assessment periods for the Beaver Creek, Tahkenitch, Floras and Sixes populations, and lower since plan implementation in the Siltcoos, Tenmile, and Coos populations (Table 4).

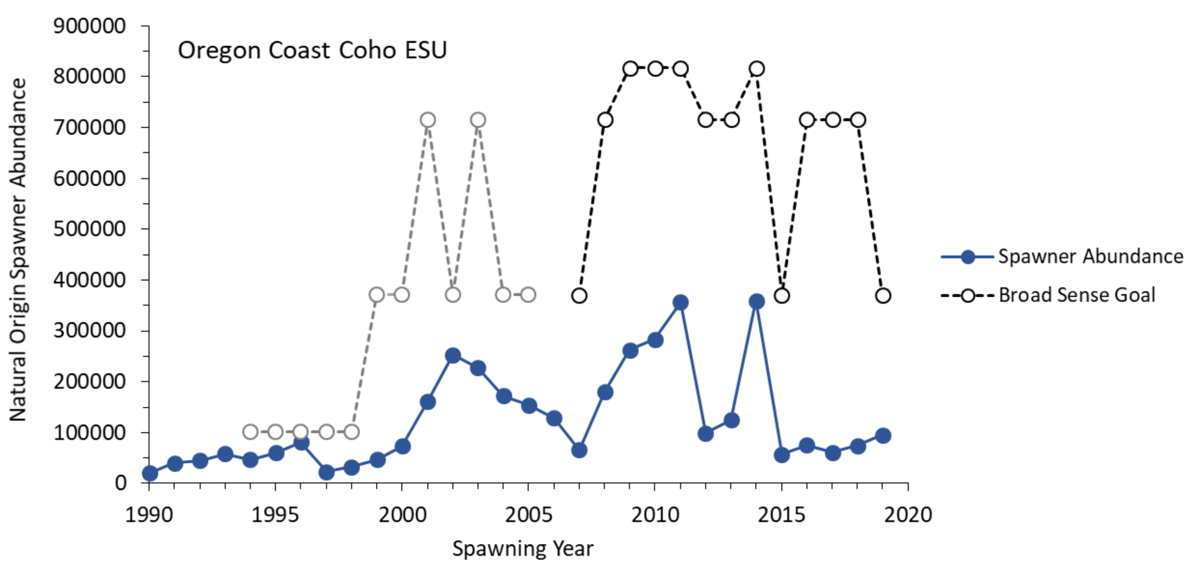

Figure 7. Post-harvest natural origin spawner abundance, Oregon Coast Coho ESU, 1990-2019 (closed circles). Broad sense abundance goals are shown for the period since plan adoption in 2007 (black open circles, black dashed line) and for the assessment period covered by the OCCCP (1994-2005) (gray open circles, gray dashed line).

Table 4. The number of years in which wild OC coho salmon spawner abundance estimates attained the annual marine survival-specific abundance goals in the OCCCP. Results are provided for the OCCCP assessment period (1994-2005) and the period covered by this 12-year assessment (2007-2019). Geometric mean abundances are provided for both periods.

Spatial Extent	Number of Years > Abundance Goal		Abundance, Geometric Mean	
	OCCCP Assessment (1994-2005)	12-Year Assessment (2007-2019)	OCCCP Assessment (1994-2005)	12-Year Assessment (2007-2019)
OC Coho ESU	0	0	85,543	128,652
Necanicum	0	0	675	3,072
Nehalem	0	0	5,261	9,735
Tillamook	0	0	1,606	5,137
Nestucca	1	0	1,396	2,195
Salmon R.	0	0	105	568
Siletz	1	3	1,464	7,001
Yaquina	1	0	2,938	5,996
Beaver Cr.	3	1	1,360	1,441
Alsea	0	0	1,918	8,479
Siuslaw	2	0	6,246	12,768
L. Umpqua	1	0	6,945	9,610
M. Umpqua	0	0	3,844	4,507
N. Umpqua	0	0	1,552	3,241
S. Umpqua	0	0	4,511	7,303
Siltcoos	2	0	3,915	2,892
Tahkenitch	1	0	2,124	2,459
Tenmile	3	0	6,651	5,277
Coos	5	0	10,374	8,639
Coquille	1	0	7,317	12,630
Floras	1	0	1,512	1,534
Sixes	1	0	143	138

Ocean conditions in the Northern California Current and marine survival were relatively good early in the current assessment period, but more recent years include relatively poor conditions for ocean productivity that were reflected in lower spawner abundances later in the assessment period. However, marine survival has been higher during recent poor ocean conditions relative to earlier similarly ranked conditions (Fig. 8).

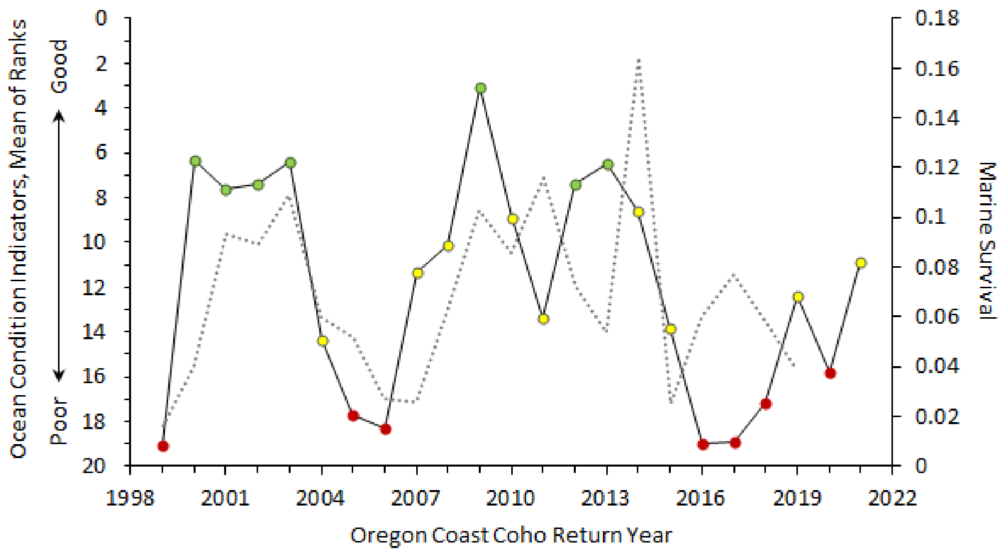

Figure 8. Mean of ranks of 16 ocean condition indicators over the period of 1998 through 2020 (adult coho return years 1999-2021) (NOAA NWFSC Stoplight Chart, available here). Green, yellow, and red markers indicate generally good, fair, or poor conditions, respectively, for marine survival in the Northern California Current. The gray dashed line is OC Coho marine survival (shown as a proportion), determined from ODFW life cycle monitoring sites for return years 1999-2019.

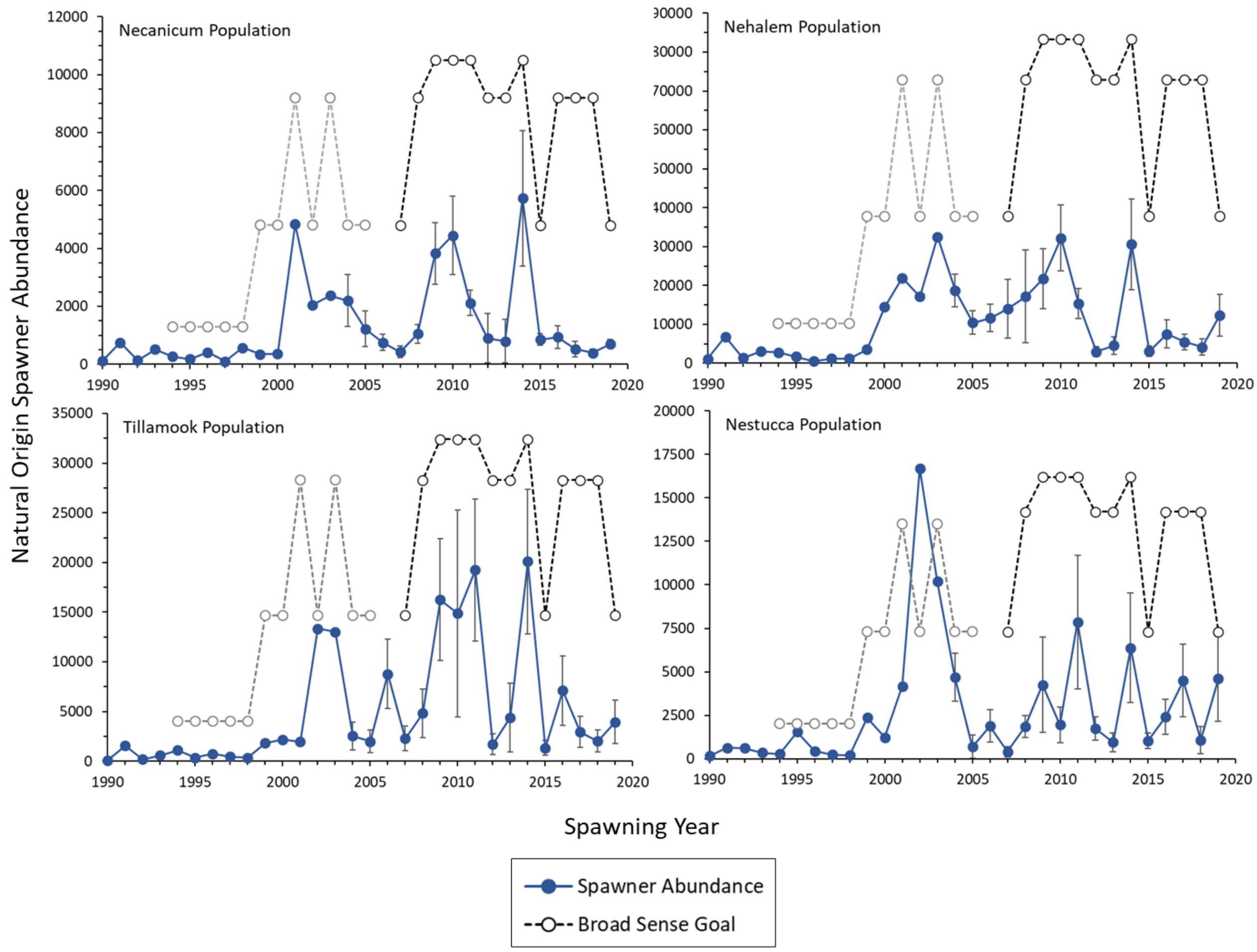

Figure 9. Natural origin spawner abundance, North Coast Stratum Independent Populations, 1990-2019 (closed circles). Error bars are 95% CIs for estimates from 2004-2019. Broad sense abundance goals are shown for the period since plan adoption in 2007 (o, black dashed line) and for the assessment period covered by the OCCCP (1994-2005) (o, gray dashed line).

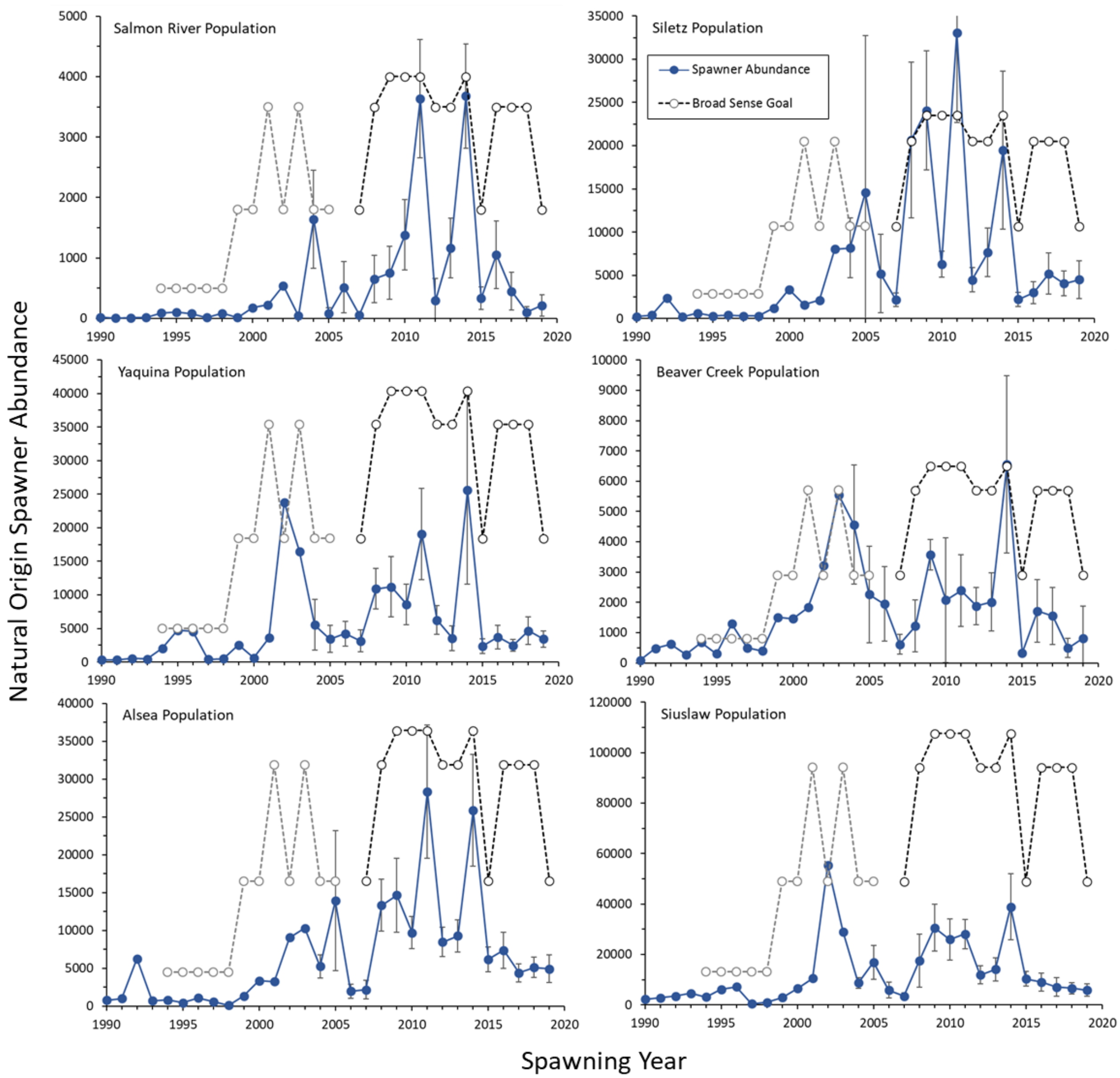

Figure 10. Natural origin spawner abundance, Mid Coast Stratum Independent Populations, 1990-2019 (closed circles). Error bars are 95% CIs for estimates from 2004-2019. Broad sense abundance goals are shown for the period since plan adoption in 2007 (o, black dashed line) and for the assessment period covered by the OCCCP (1994-2005) (○, gray dashed line).

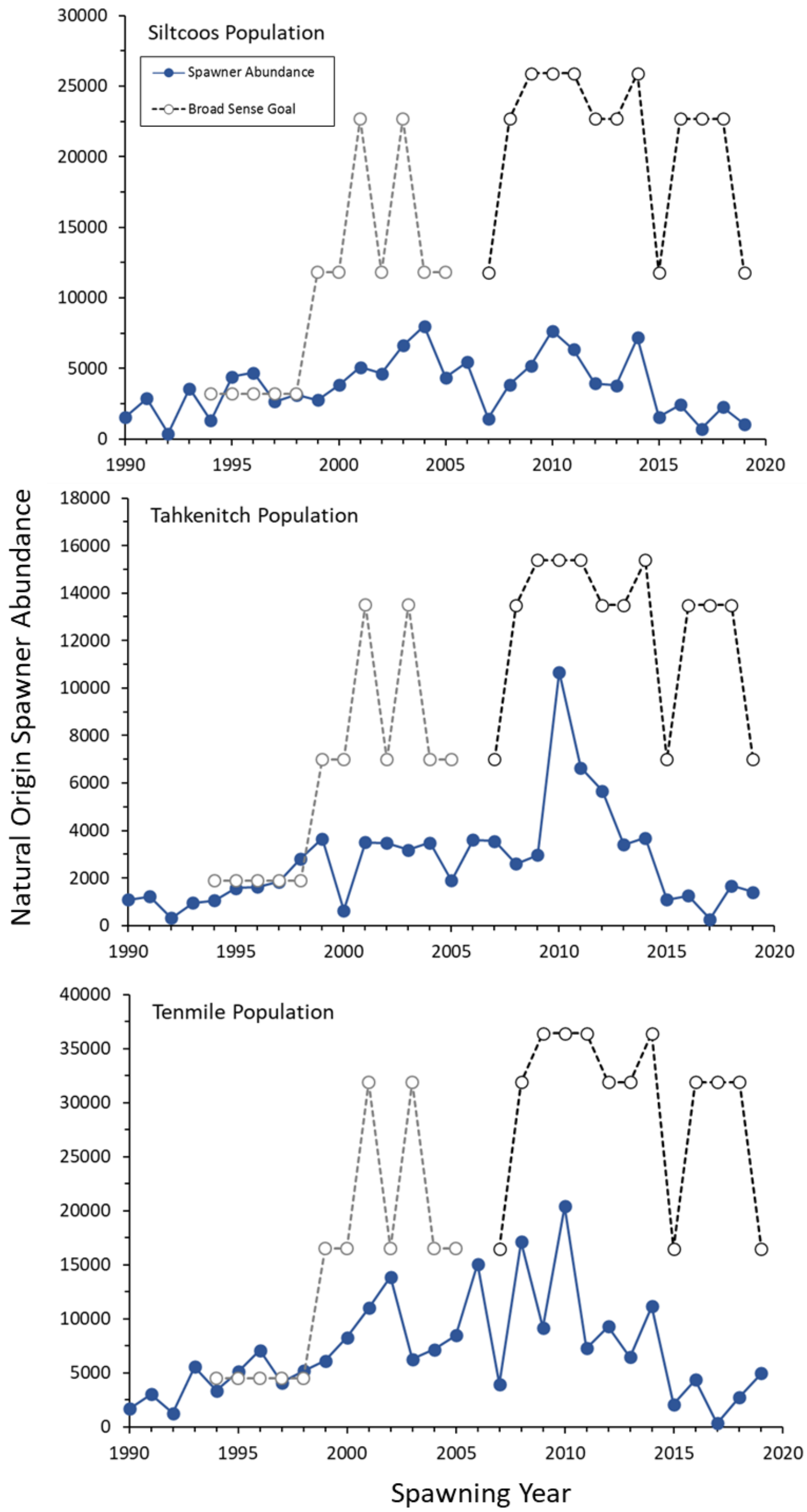

Figure 11. Natural origin spawner abundance, Lakes Stratum Independent Populations, 1990-2019 (closed circles). Broad sense abundance goals are shown for the period since plan adoption in 2007 (o, black dashed line) and for the assessment period covered by the OCCCP (1994-2005) (o, gray dashed line).

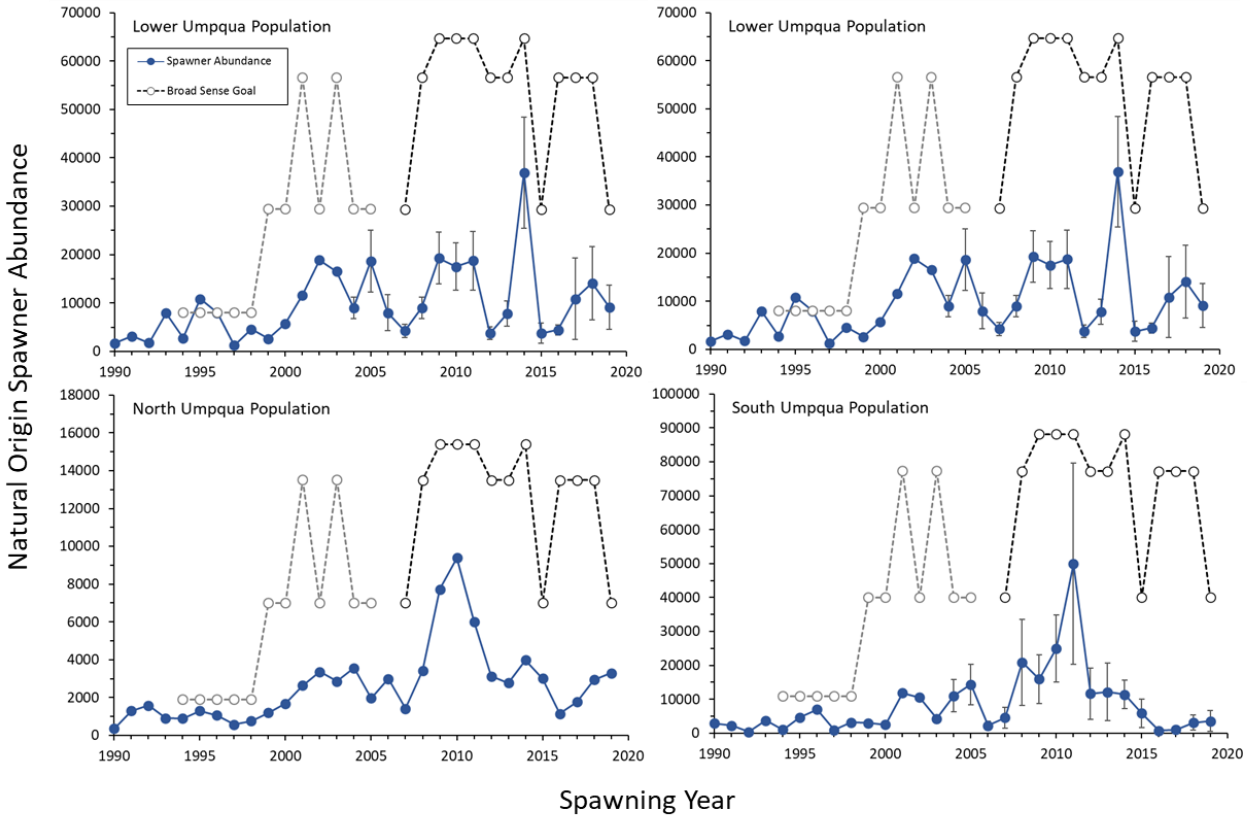

Figure 12. Natural origin spawner abundance, Umpqua Stratum Independent Populations, 1990-2019 (closed circles). Error bars are 95% CIs for estimates from 2004-2019. There are no CIs reported for the North Umpqua population, where abundance is based on passage counts rather than spawning surveys. Broad sense abundance goals are shown for the period since plan adoption in 2007 (o, black dashed line) and for the assessment period covered by the OCCCP (1994-2005) (o, gray dashed line).

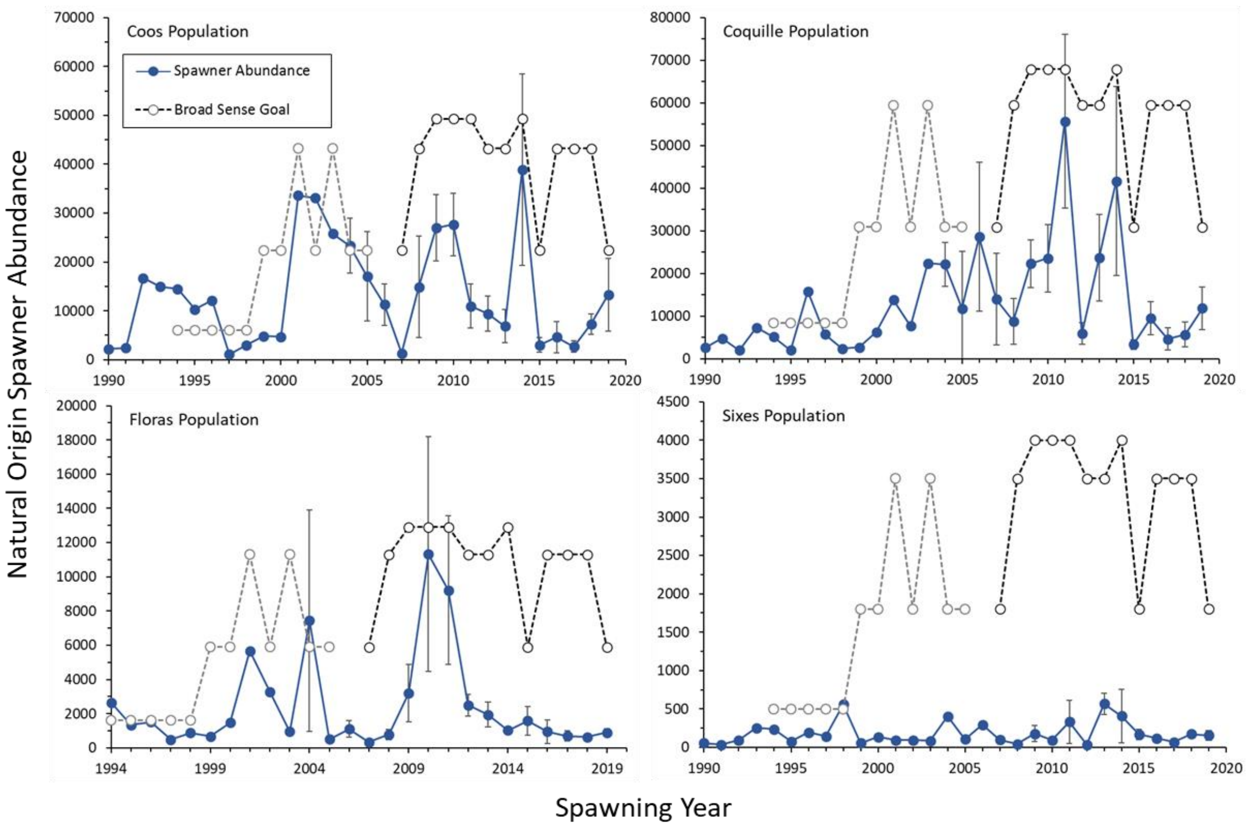

Figure 13. Natural origin spawner abundance, Mid-South Coast Stratum Independent Populations, 1990-2019 (closed circles). Error bars are 95% CIs for estimates from 2004-2019. Broad sense abundance goals are shown for the period since plan adoption in 2007 (o, black dashed line) and for the assessment period covered by the OCCCP (1994-2005) (o, gray dashed line).

Criterion 2: Persistence

The persistence criterion is based on the probability of persistence over 100 years as determined by PVA modeling. In the original OCCCP assessment, the probability of persistence for each Independent Population was averaged across outputs from four PVA models, each assessed at two quasi-extinction thresholds[9] (QET; 0 and 50), regardless of population size. The objective for the persistence criterion was a 99% or greater probability of persistence, a high goal associated with broad-sense recovery. The high persistence goal would also have been a conservative hedge against the relatively low QET thresholds, particularly for larger populations.

The four PVA models used in the original assessment were density-dependent PVAs with three recruitment models (modified Ricker [Ricker 1954]; modified Beverton-Holt [Beverton and Holt 1957]; hockey stick [Barrowman and Myers 2000]) and a stochastic, habitat-based PVA (Nickelson and Lawson 1998). Model details provided in source documents (e.g., Chilcote et al. 2005; Wainwright et al. 2008) were insufficient to precisely replicate these models, and coding

[9] A quasi-extinction threshold (QET) represents a threshold of abundance below which the population is considered functionally extinct after multiple consecutive years The QET is greater than zero to account for genetic and demographic impacts associated with persistent low abundance.

available for some (i.e., Ricker; Nickelson-Lawson) existed only in obsolete computing programs. Therefore, ODFW worked with the U.S. Geological Survey's Oregon Cooperative Fish and Wildlife Research Unit to develop new PVAs to support the current assessment.

For the current assessment, density-dependent PVAs used Ricker and Beverton-Holt stock-recruitment models to assess the probability of persistence for the Independent Populations of the OC Coho ESU. After initial efforts to fit hockey stick recruitment models resulted in unrealistic parameterizations for some populations, that recruitment model was not incorporated into the current assessment. The PVAs were run using recruitment model parameterizations for two periods (pre-1990 and post-1990), a log-normal & autoregressive error structure, and incorporation of parameter uncertainty.

The current assessment of the persistence criterion relies primarily on stock-recruit data from 1990-2019 though some comparisons also are drawn to a pre-1990 historical period, which begins in 1958 for most populations. We focused more strongly on contemporary data than the previous assessment, which used the available stock-recruit data from ~1958 through 2004 to parameterize recruitment models. The reasons for this are two-fold:

- The survey designs used to estimate population abundance have been more robust in the recent period than historically. The first statistical survey of OC coho was initiated in 1990, and the GRTS design was employed starting in 1998. Prior to this, abundance was estimated using standard index surveys.
- Conditions currently experienced by OC Coho populations are quite different than they were historically. Hatchery releases in the coastal basins are less than 1% of the historical peak[10], harvest rates are much lower, ocean productivity regimes have changed, and climate change is occurring.

Because of these issues, recruitment in more recent years is likely to more accurately reflect current and near-term future conditions.

There are arguments for starting the contemporary time frame even later than 1990 (e.g., 1999). In the period from 1990 to 1998, hatchery releases and harvest rates both declined significantly, and the effects from periods of higher harvest rates and larger hatchery influence may still have been affecting recruitment during this period. In this respect, the period starting in 1999 would more accurately reflect the conditions that OC Coho populations experience now. A later start date would also weight the effects of climate change more strongly and thus would be a more accurate representation of conditions that we see now and expect to see in the future. However, starting the time series in 1999 eliminates the influence of a period of poor ocean conditions that occurred in the 1990s. Cycles of ocean productivity in this region occur on the scale of decades, and starting the analysis in 1999 might indicate a higher recruitment rate than we might observe over longer time scales. Starting the series in 1990 also increases the number of stock-recruit pairs, potentially improving the fit of recruitment models.

The QET thresholds used in the current assessment were also adjusted to account for relative population size. Populations were classified as small, medium, or large based on evaluation of spawning distribution kilometers (ODFW Fish Habitat Distribution dataset) and estimates of

[10] There currently are releases of hatchery coho into only three populations (Nehalem, Tillamook, South Umpqua) and in the Columbia River.

historical population size (Lawson *et al*. 2007). Small, medium, and large populations were defined by spawning distributions of less than 200 km, 200 to 400 km, and greater than 400 km, respectively.

Small Populations
Necanicum, Salmon River, Beaver Creek, Siltcoos, Tahkenitch, Tenmile, Floras, Sixes

Medium Populations
Nestucca, Siletz, Yaquina, North Umpqua

Large Populations
Nehalem, Tillamook, Alsea, Siuslaw, Lower Umpqua, Middle Umpqua, South Umpqua, Coos, Coquille

The eight populations classified as small correspond to those classified by Lawson *et al*. (2007) as potentially independent; medium and large populations correspond to those classified as functionally independent. The QETs were set to 50 (small), 150 (medium), and 250 (large), following the approach in the Coastal Multi-species Conservation and Management Plan (ODFW 2014) and approximately cover a range of QETs previously applied to coho populations in the Pacific Northwest (Busch *et al*. 2013). For most populations, QETs were set higher than those used in the PVAs for the original OCCCP assessment.

To select the best recruitment model (Ricker vs. Beverton-Holt) for each population in each assessment period, we used the Deviance Information Criterion (DIC), a generalization of the Akaike Information Criterion (AIC). Like the AIC, models with the smallest values of the DIC represent the best fitting model; therefore, the model with the smallest value of the DIC was initially selected as the best model. Where the DIC did not clearly discriminate between the two candidate models, the probability of persistence was estimated as a weighted average probability of persistence from both models, with weighting based on DIC weights. Additional details regarding model selection and results across all models can be found in Appendix II, *Population Persistence Models*.

The PVA models indicate that probabilities of persistence are relatively high for most populations provided that the environment conditions of the last ~30 years persist for the next 100 years (Table 5, Fig. 14). In the contemporary period, eight populations meet the OCCCP's high bar for persistence (≥ 99%), and only four populations have less than a 90% probability of persistence (Table 5). At a coarse scale, the probability of persistence across populations has remained high in both the historical period (n = 18 populations; median = 0.99, interquartile range = 0.95 – 1.00) and the contemporary period (n = 21 populations; median = 0.95, interquartile range = 0.93 – 0.99).

As previously noted, ODFW believes that the post-1990 period best represents current management and environmental conditions. Therefore, persistence probabilities from this period are the primary basis of the current 12-year assessment of the OCCCP. Assessment of the pre-1990 historical period is provided for context, but caution should be exercised when inferring changes in biological performance based on differences in the probabilities of persistence estimated for the historical and contemporary periods. Prior to 1990, estimates of spawner abundance and harvest rates are subject to greater uncertainty and potential biases that are not accounted for in the PVA models. Similarly, persistence probabilities herein are not directly comparable to those in the original OCCCP assessment because the current and original PVAs use different formulations of the recruitment models, were parameterized over different stock-recruit periods, and apply different QETs to most populations. PVA results are sensitive to these changes, as demonstrated in Wainwright et al. (2008). Given this sensitivity to methodology and uncertainty about how well a retrospective analysis reflects future extinction risk in a changing climate, the results presented here should be considered primarily as indicators of relative risk among populations.

Although the probabilities of persistence are relatively high for most populations, fewer than half of the Independent Populations meet the OCCCP objective for persistence. In several cases (e.g., Nestucca, Alsea, Coos), post-1990 persistence probabilities are a weighted average of results from recruitment models that predicted very different outcomes (particularly the Nestucca and Coos, See Appendix II, *Population Persistence Models*). Discrepancies in model outputs were generally larger in the post-1990 period than in the pre-1990 period. Given these differences, and the lower confidence in abundance estimates in the historical period, caution is warranted when interpreting changes in persistence probabilities between the historical and contemporary periods. Given this, and the uncertainties posed by climate change, ODFW will continue to focus effort on refining PVA analyses to improve understanding of extinction risks for OC Coho populations.

The probability of persistence in the Salmon River Population is notably lower than for other populations (Fig. 14). For this population, PVAs using the Ricker and Beverton-Holt recruitment models predicted substantially different persistence probabilities, but both were very low (0.12 and 0.41, respectively). This is likely attributable partly to the legacy of hatchery and habitat impacts but also to (1) natural habitat limitations (e.g., gradient; geology) and (2) the influence on the PVAs from spawner abundances near or below the QET (i.e., 50) through much of the 1990s. Hatchery releases have already been discontinued in this population, and it will be important to ensure that habitat degradation does not further exacerbate natural limitations.

Table 5. Estimates of 100-year persistence probabilities for the Independent Populations of the OC Coho ESU. Quasi-extinction thresholds are 50, 150, and 250 for small, medium, and large populations, respectively. Persistence probabilities are based on the best fitting recruitment model (Ricker or Beverton-Holt) or a weighted average of both model results where both candidate models were retained for assessment.

Population	Population Size	QET	Probability of Persistence	
			Pre-1990	Post-1990
Necanicum	Small	50	1.00	0.93
Nehalem	Large	250	0.83	0.94
Tillamook	Large	250	0.88	0.94
Nestucca	Medium	150	0.95	0.84
Salmon	Small	50	*N/A*[1]	0.13
Siletz	Medium	150	0.99	0.95
Yaquina	Medium	150	0.94	1.00
Beaver	Small	50	0.95	1.00
Alsea	Large	250	0.99	0.86
Siuslaw	Large	250	1.00	0.98
Siltcoos	Small	50	1.00	1.00
Tahkenitch	Small	50	1.00	1.00
Tenmile	Small	50	1.00	0.98
Lower Umpqua	Large	250	1.00	1.00
Middle Umpqua	Large	250	0.99	0.99
North Umpqua	Medium	150	0.83	0.92
South Umpqua	Large	250	0.97	0.99
Coos	Large	250	1.00	0.84
Coquille	Large	250	0.99	0.96
Floras	Small	50	*N/A*[1]	0.99
Sixes	Small	50	*N/A*[1]	0.93

[1] Stock-recruit time series for the Salmon River and Sixes populations begin in brood year 1990; the time series for the Floras Population begins in brood year 1994.

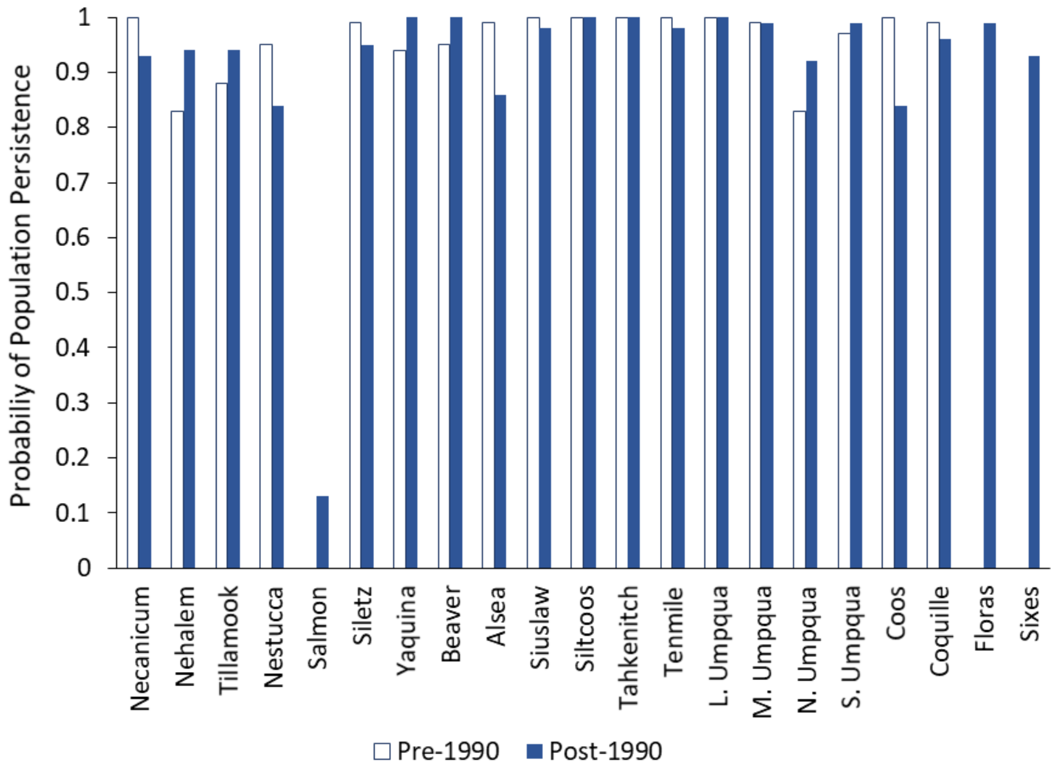

Figure 14. Probabilities of persistence for Independent Populations of Oregon Coast Coho Salmon, estimated from PVA modeling for two periods, a pre-1990 historical period (open columns) and a post-1990 contemporary period (solid columns). Persistence probabilities are based on the best fitting recruitment model (Ricker or Beverton-Holt) or a weighted average of both model results where both candidate models were retained for assessment. It is notable that, prior to 1990, estimates of spawner abundance and harvest rates are subject to greater uncertainty and potential biases that are not explicitly accounted for in the PVA models.

Criterion 3: Productivity

The productivity criterion is based on estimates of pre-harvest natural origin adult recruits per spawner (R/S). This ratio is calculated by dividing natural origin pre-harvest recruits by the number of spawners in the basin three years previously (i.e., the parents). Only naturally produced fish are counted as recruits. However, both natural origin fish and hatchery fish (if present) are counted as parents. Harvest impacts are estimated through the Fishery Regulation Assessment Model (FRAM) and ODFW fishery sampling programs and angler reporting. Pre-harvest R/S reflects the biological potential of OC coho salmon populations in the absence of losses to harvest but realized productivity (post-harvest R/S) is also reported in Appendix I, *Measurable Criteria Assessment*.

Estimates of R/S are influenced by parental abundance and marine survival rates. For example, R/S is likely to be low when parental abundance is high and/or when marine survival rates are low; R/S is likely to be high when parental abundance is low and/or when marine survival rates are high. In the OCCCP, ODFW anticipated development of an approach to standardize R/S estimates to account for the influences of both marine survival and parental spawner abundance. No means to accomplish that standardization was available at the time of plan development, and no method to do so has been developed. However, the OCCCP also describes an interim approach for evaluation based on the concept that, for any marine survival category, if parental spawner abundances are equal to or lesser than the spawner abundance goal, the observed R/S should be greater than or equal to 1.0. R/S should not be less than 1.0 until parental spawner abundances are equal to or above the marine-survival-specific abundance goals. For this review, ODFW applied the interim approach for evaluating the productivity criterion.

While the status of the ESU and its constituent Independent Populations relative to broad sense goals for productivity are evaluated as described above, ODFW also assessed productivity at low spawner abundance (i.e., R/S when parental spawner abundance is less than the median of the 12-year assessment period[11]). This approach to evaluate productivity was developed by the Oregon/Northern California Coast Technical Recovery Team (Wainwright *et al*. 2008; See also Section IV, *Decision Support System*) and provides a means to assess the biological potential for the OC Coho ESU and Independent Populations to withstand protracted periods of poor environmental conditions and low spawner abundance. These results are related to viability, not broad sense goals; they are not used to assess whether the objective for the OCCCP criterion has been met. Rather, these results are discussed below and in Appendix I, *Measurable Criteria Assessment*, to provide additional information about the productivity of the OC Coho ESU.

Pre-harvest adult R/S in the OC Coho ESU has ranged from 0.19 to 4.11 since plan adoption, with a geometric mean of 0.93. The R/S estimates have been higher than 1.0 in 7 of the 13 return years since 2007 (Fig. 15). Although R/S estimates have not been standardized to marine survival-specific spawner abundance, the objective for the criterion has been assessed as not met based on the interim approach for evaluation. Over the past 12 brood years (2005-2016; Return Years 2008-2019), R/S has begun to approach or fall below replacement at spawner abundances lower than marine survival-specific spawner abundance goals (Fig. 15).

Consistent with results for the ESU, none of the 21 Independent Populations met the objective for the productivity criterion, with R/S tending to approach or fall below replacement at spawner abundances lower than marine survival-specific abundance goals (Figs. 16-20). For Independent Populations, the geometric mean of pre-harvest adult R/S since plan adoption (return years 2007-2019) ranged from 0.50 (Salmon River) to 1.22 (Nestucca).

Although the interim evaluation approach indicates that the ESU and Independent Populations do not meet the objectives for the OCCCP productivity criterion, this evaluation is provisional and subject to change pending methods to standardize for marine survival and parental abundance. While the ESU has not attained the OCCCP broad sense goal for productivity, the geometric mean R/S at low abundance is 1.42 with a high probability (94%) that the OC Coho ESU can rebuild (R/S > 1.0) from low abundances at a rate sufficient to avoid extinction. Sixteen Independent Populations also had high probabilities (> 80%) of R/S > 1.0 at low spawner abundances, and two populations had more moderate probabilities of sufficient productivity at low abundance (Siltcoos and North Umpqua, 76%). Likelihoods of R/S greater than 1.0 at low spawner abundances were lower for the remaining populations (Beaver Creek, 56%; South Umpqua, 59%, and Salmon River 13%).

[11] The 12-year evaluation period corresponds to four coho generations.

The R/S estimates discussed above reflect biological potential of the ESU and Independent Populations in absence of losses to harvest, which are managed. Estimates of realized productivity (post-harvest R/S) are generally similar to pre-harvest estimates due to low rates of harvest for most populations. Differences are larger in the Siltcoos and Tahkenitch populations, reflecting higher rates of harvest in these populations relative to the other Independent Populations. Both pre- and post-harvest R/S estimates are provided in the population summaries in Appendix I, *Measurable Criteria Assessment*.

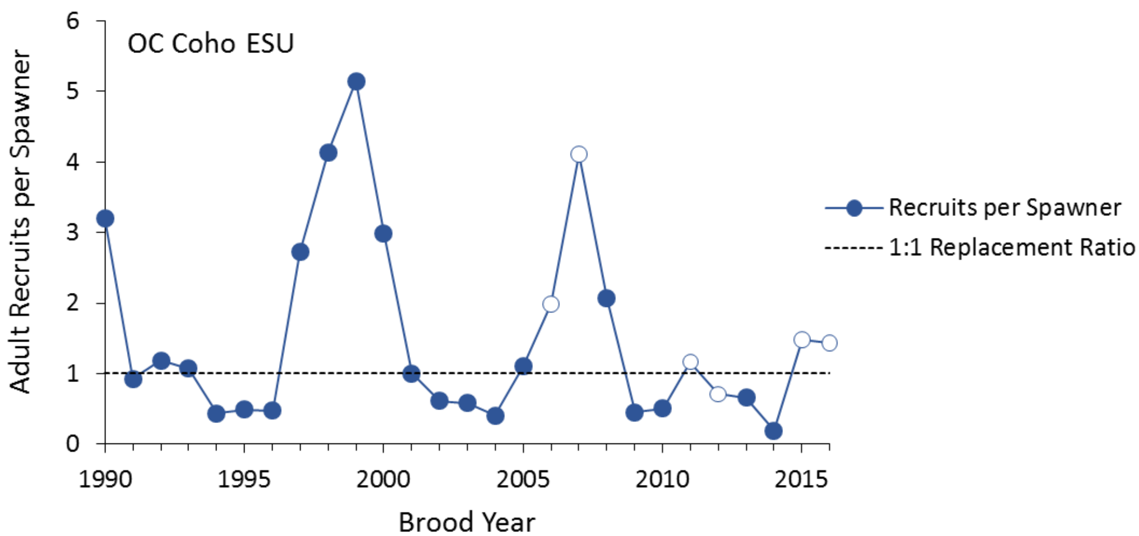

Figure 15. Pre-Harvest Adult Recruits per Spawner, OC Coho ESU, brood years 1990-2016 (return years 1993-2019). The dashed line is the 1:1 replacement ratio (i.e., R/S = 1.0). Open circles represent wild recruits per spawner during the last 12-years (brood years 2005-2016) when brood year total spawner abundance (hatchery + wild) was less than the median abundance for brood years 2005-2016. These R/S values are used for assessing productivity at low abundance.

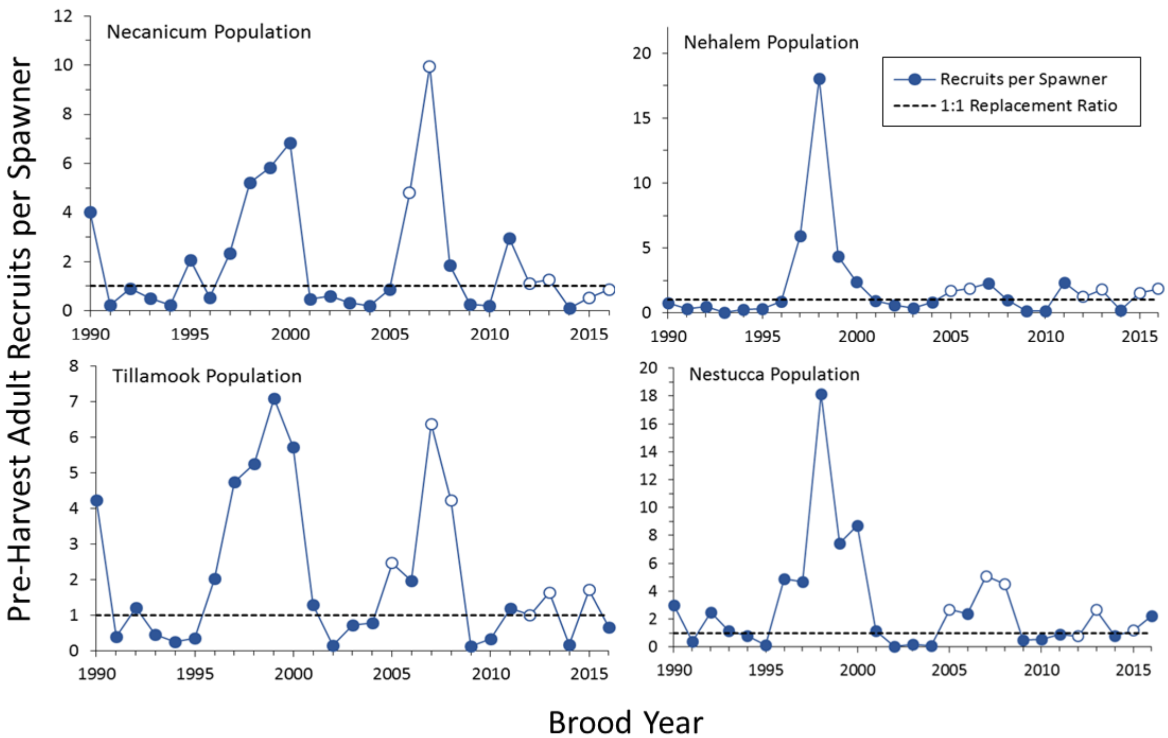

Figure 16. Pre-Harvest Adult Recruits per Spawner, North Coast Stratum Independent Populations, brood years 1990-2016 (return years 1993-2019). The dashed line is the 1:1 replacement ratio (i.e., R/S = 1.0). Note differences in scale among panels. Open circles represent wild recruits per spawner during the last 12-years (brood years 2005-2016) when brood year total spawner abundance (hatchery + wild) was less than the median abundance for brood years 2005-2016. These R/S values are used for assessing productivity at low abundance.

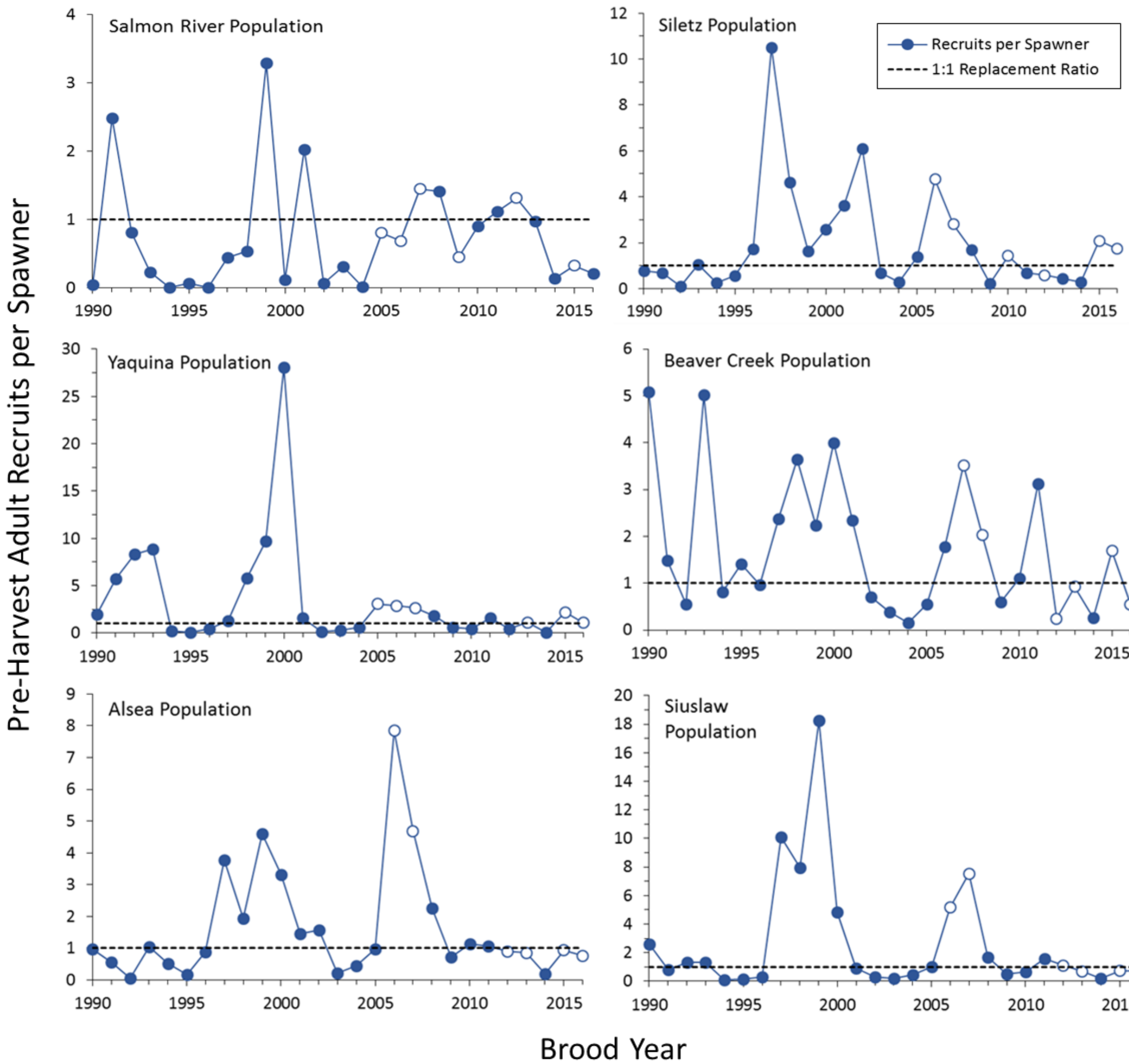

Figure 17. Pre-Harvest Adult Recruits per Spawner, Mid Coast Stratum Independent Populations. The dashed line is the 1:1 replacement ratio (i.e., R/S = 1.0). Note differences in scale among panels. Open circles represent wild recruits per spawner during the last 12-years (brood years 2005-2016) when brood year total spawner abundance (hatchery + wild) was less than the median abundance for brood years 2005-2016. These R/S values are used for evaluating productivity at low abundance.

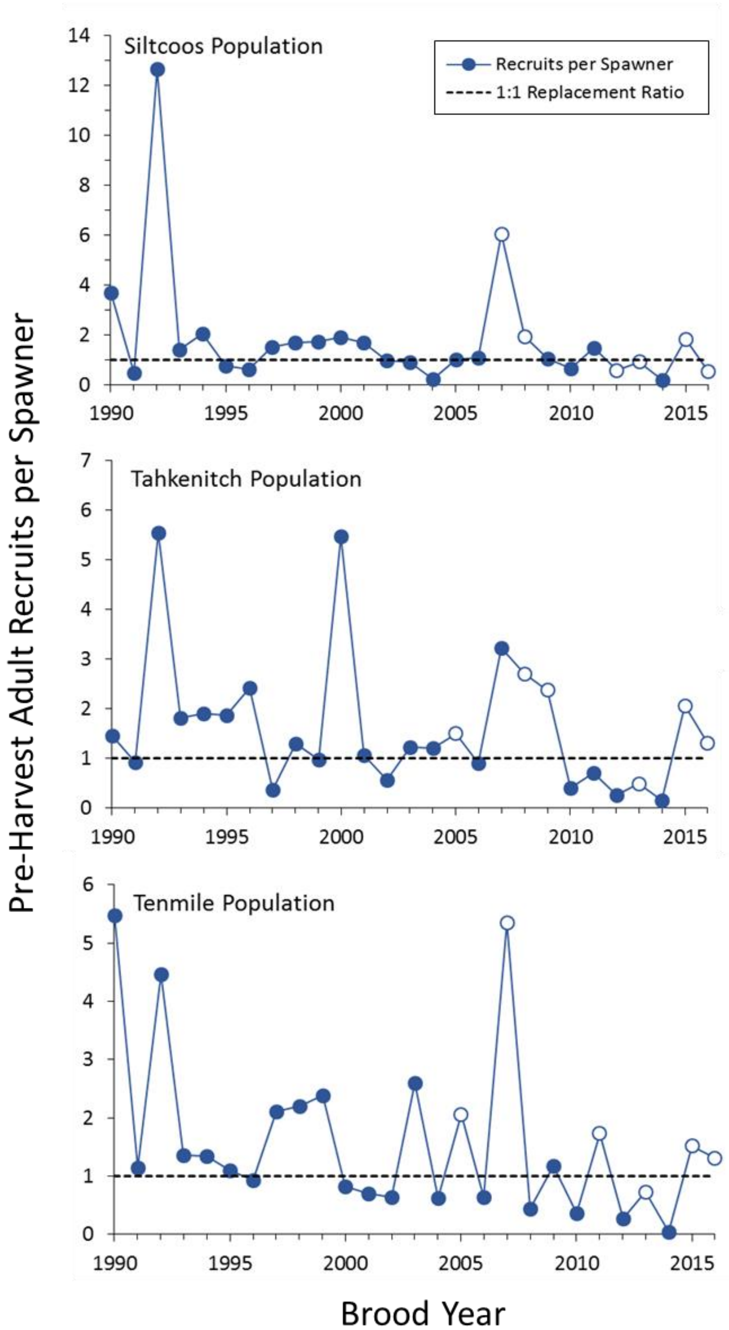

Figure 18. Pre-Harvest Adult Recruits per Spawner, Lakes Stratum Independent Populations. The dashed line is the 1:1 replacement ratio (i.e., R/S = 1.0). Note differences in scale among panels. Open circles represent wild recruits per spawner during the last 12-years (brood years 2005-2016) when brood year total spawner abundance (hatchery + wild) was less than the median abundance for brood years 2005-2016. These R/S values are used for assessing productivity at low abundance.

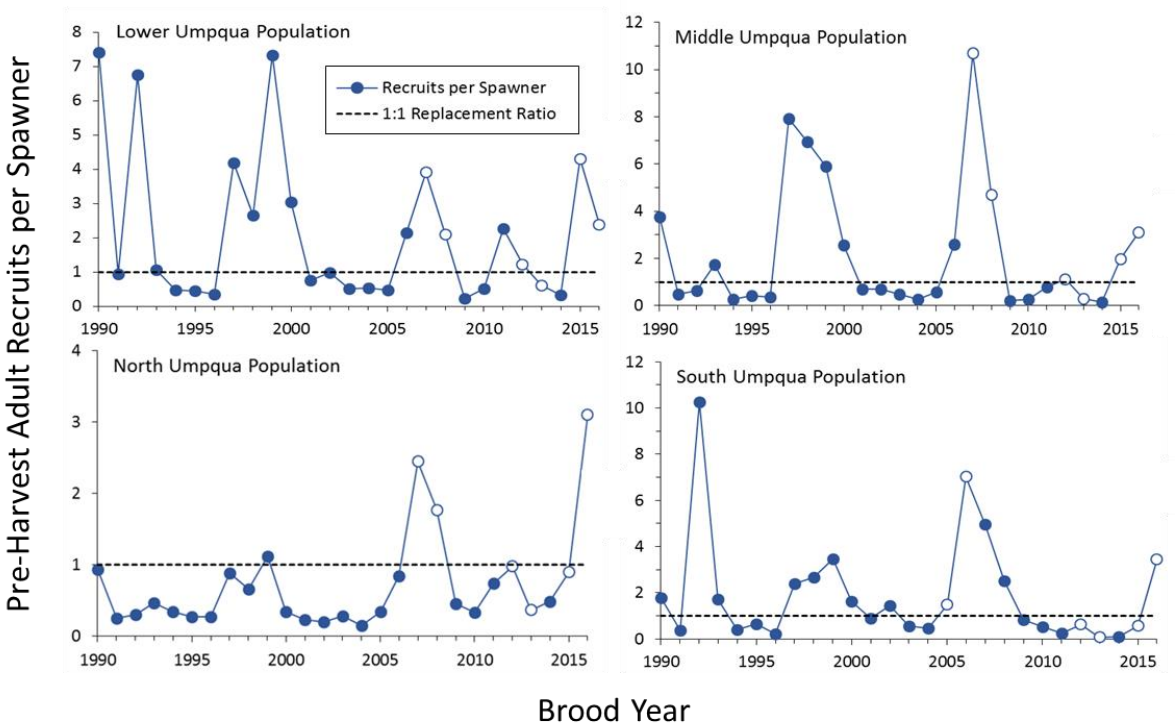

Figure 19. Pre-Harvest Adult Recruits per Spawner, Umpqua Stratum Independent Populations. The dashed line is the 1:1 replacement ratio (i.e., R/S = 1.0). Note differences in scale among panels. Open circles represent wild recruits per spawner during the last 12-years (brood years 2005-2016) when brood year total spawner abundance (hatchery + wild) was less than the median abundance for brood years 2005-2016. These R/S values are used for assessing productivity at low abundance.

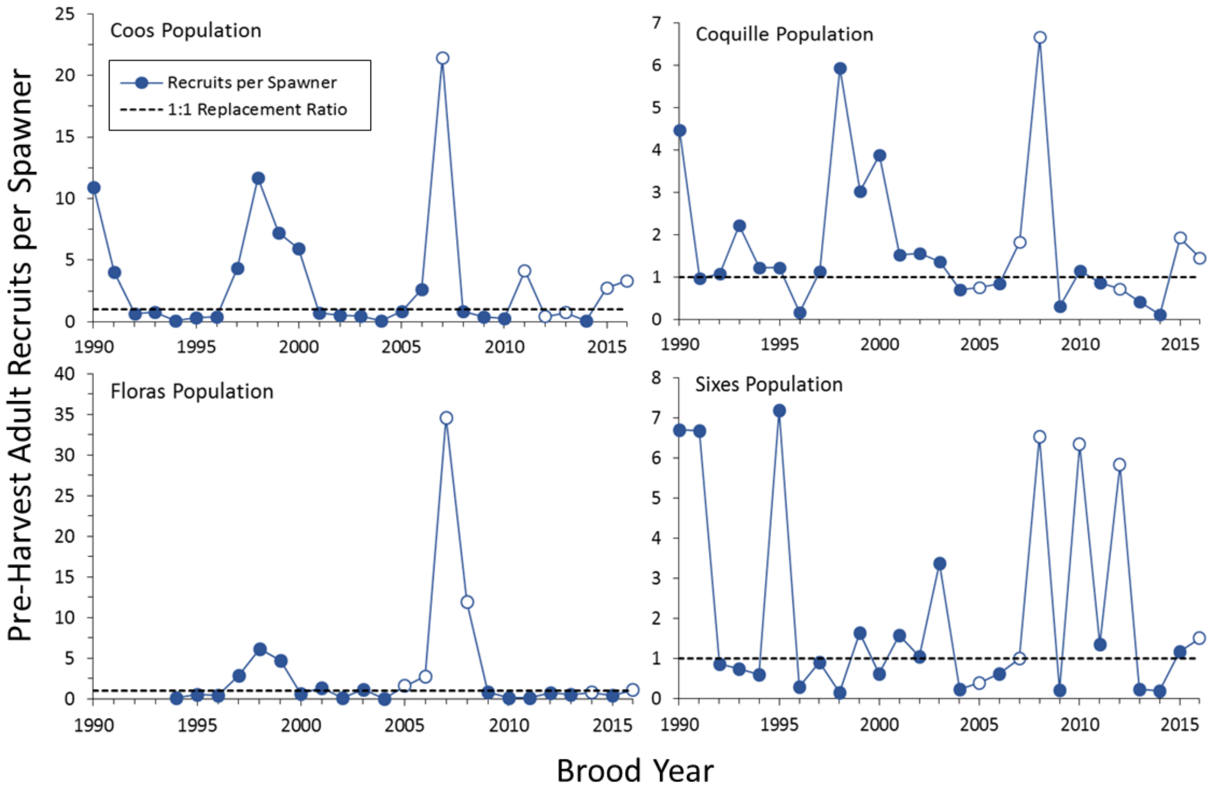

Figure 20. Pre-Harvest Adult Recruits per Spawner, Mid-South Coast Stratum Independent Populations. The dashed line is the 1:1 replacement ratio (i.e., R/S = 1.0). Note differences in scale among panels. Open circles represent wild recruits per spawner during the last 12-years (brood years 2005-2016) when brood year total spawner abundance (hatchery + wild) was less than the median abundance for brood years 2005-2016. These R/S values are used for assessing productivity at low abundance.

Criterion 4: Distribution (Within Population)

The distribution criterion is based on the annual occurrence (% occupied) of naturally produced adult spawners in GRTS spawning surveys in each Independent Population. Surveys are considered to be occupied by coho salmon when density is equal to or greater than 4 fish/mile. Occupied sites are considered to be wild coho occupied based on the observation of at least one unmarked adult coho salmon. To meet the objective for this criterion, the percentage of occupied sites must be greater than or equal to the marine survival-specific occupancy goals at least six times in any 12-year period.

To develop the marine survival-specific goals for occupancy, a curve was fit to the occupancy percentages observed for each population from 1990-2005, assuming an exponential rise to a maximum occupancy ≤ 100%. The percent occupancy goal for each marine survival-specific spawner goal was then determined by the point where the spawner abundance goal intersected the occupancy curve. For most populations, the empirical data used to determine the goals indicated relatively high occupancy even at low marine survival. In the lakes populations (Siltcoos, Tahkenitch and Tenmile), areas for spawning are more limited and, hence, occupancy was generally high. It was not possible to construct curves relating population size to occupancy for these populations, so thresholds for these populations were set to 100%.

Only the Beaver Creek and Alsea populations met the objective for the distribution metric, meeting marine survival-specific occupancy goals in 10 (11 of the 13 years since plan adoption) and 7 years, respectively, over the past 12 years. After these populations, the closest populations to meeting objectives were the Nehalem (5 of 12 years) and the Tillamook, Siletz, Siuslaw, and Coquille populations (3 of 12 years). The distribution criterion was not assessed for the North Umpqua Population or for populations in the Lakes Stratum (Siltcoos, Tahkenitch, Tenmile). The GRTS spawner surveys were discontinued in these areas in 2012 and 2014, respectively.[12] The OCCCP also did not include occupancy goals for the Floras and Sixes populations due to inadequate data; goals for these populations will be developed with continued data collection.

Table 6. The number of years in which occupancy rates of wild adult coho salmon spawners met or exceeded marine survival-specific occupancy goals and the average annual proportion of the occupancy goals attained for Independent Populations in the Oregon Coast Coho ESU, 2007-2019. Results are shown for the current 12-year assessment; the OCCCP assessment did not include an assessment of the distribution criterion. Green shading indicates that the population met the objective (green, goal attained in at least 6 of 12 years).

Spatial Extent	Wild Occupancy	
	Number of Years Goal Attained (2007-2019)	Average Proportion of Goal (2007-2019)
Necanicum	2	0.73
Nehalem	5	0.88
Tillamook	3	0.74
Nestucca	2	0.77
Salmon River	1	0.67
Siletz	3	0.91
Yaquina	2	0.87
Beaver Creek	11	0.95
Alsea	7	0.95
Siuslaw	3	0.84
Lower Umpqua	2	0.78
Middle Umpqua	1	0.61
North Umpqua	Not Assessed[1]	
South Umpqua	1	0.57
Siltcoos	Not Assessed[2]	
Tahkenitch		
Tenmile		
Coos	2	0.77
Coquille	3	0.83
Floras	Not Assessed[3]	
Sixes		

[1]Random spawning surveys were discontinued in the North Umpqua Population above Winchester Dam in 2012 due to budget constraints; the distribution criterion currently cannot be evaluated for this population.

[12] GRTS surveys above Winchester Dam on the North Umpqua River were discontinued after 2012; GRTS surveys in the North Umpqua Population are now restricted to the small amount of coho habitat in the basin below the dam.

[2]Random spawning surveys were discontinued in the lakes populations in 2014 due to budget reductions; the distribution criterion currently cannot be evaluated for these populations.
[3]The OCCCP did not include occupancy targets for the Floras and Sixes populations due to inadequate data.

Metrics from surveys of juvenile coho within the OC Coho ESU have not been incorporated into OCCCP criteria. However, site occupancy by coho parr has been stable and relatively high since plan adoption (Fig. 21). Site occupancy by coho parr has generally been highest in the Mid Coast and Mid-South Coast strata, lowest in the Umpqua Stratum, and the most variable in the North Coast Stratum (Constable and Suring 2021).

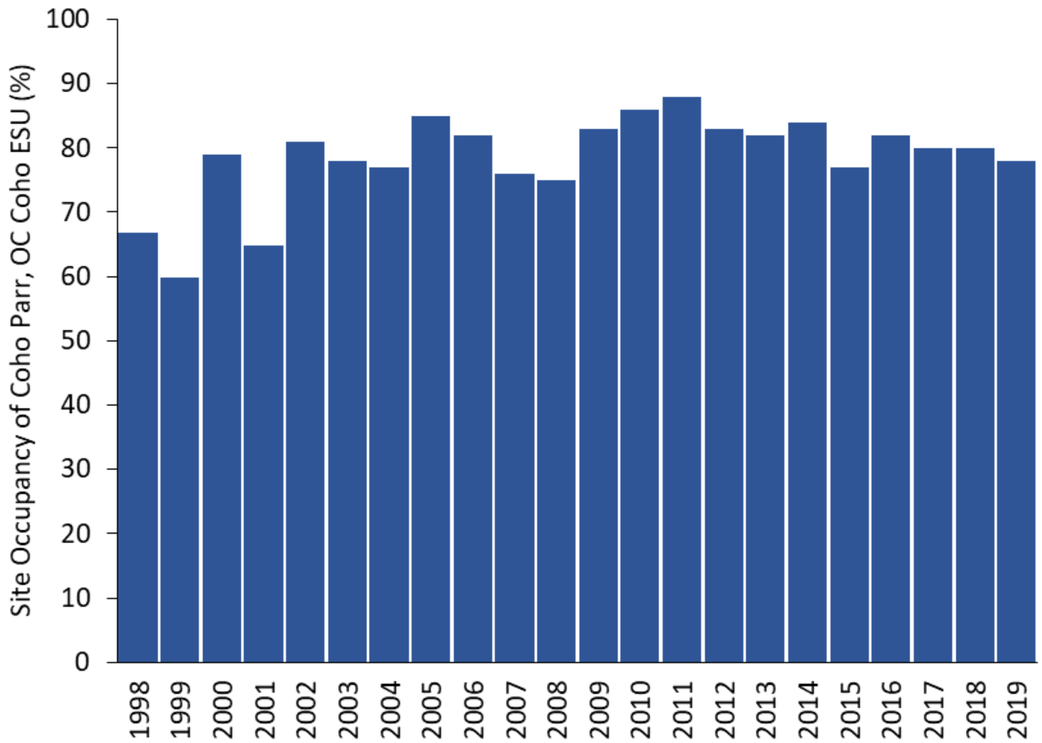

Figure 21. The percent of sites where at least one individual coho parr was observed. Site occupancy was calculated by dividing the number of sites where coho parr were observed by the number of sites that were surveyed in the ESU.

Criterion 5: Diversity

The OCCCP diversity criterion is modeled after the diversity criterion in Chilcote *et al*. (2005), which is rooted in the concept that loss of genetic variation due to small population size poses a risk to long-term population viability. Given a theoretical relationship between effective population size and the rate at which genetic variation is lost (expressed as percent heterozygosity), Chilcote *et al*. (2005) estimated a population size necessary to avoid loss of heterozygosity at rates exceeding 5% over 100 years. This target abundance (600) included correction factors to account for unequal probabilities of reproductive success among spawners and the effect of year-to-year variation in recruitment for overlapping generations (i.e., jacks). The use of a harmonic mean abundance tends to emphasize lower abundances in the time series. Additionally, the simulated abundances were adults, excluding jacks. Since the effect of jacks (overlapping generations) is built into the criterion, reliance on a harmonic mean of adults, excluding jacks, is conservative (e.g., the criterion overestimates risk).

The OCCCP mirrored this approach to the diversity criterion, but with a lower tolerance for loss of heterozygosity (2.5% over 100 years), resulting in a desired harmonic mean spawner abundance of 1,200. This lower tolerance for loss of heterozygosity was selected because the criterion in the OCCCP is intended to assess broad sense recovery, a status well beyond viability. Additional methodological details are available in Chilcote *et al*. (2005).

In the assessment for the OCCCP, the diversity criterion was assessed based on simulated abundances projected using a Ricker recruitment model with stock-recruit data from 1958-2003 and a density dependent PVA (Chilcote *et al*. 2005). The criterion was calculated as the mean of the harmonic mean abundance from each 100-year simulation. In the current 12-year assessment, the criterion was evaluated using actual abundance estimates rather than simulated abundances. Additionally, ODFW assessed the criterion using a more recent period (1990-2019). As previously discussed, this period is likely to represent contemporary management and environmental conditions but retains a period of generally low abundances in the 1990s.

In the current assessment, 13 Independent Populations met the diversity objective. With respect to meeting the criterion, these results are similar to the original OCCCP assessment despite harmonic means that in some cases differ substantially from the previous simulations (Table 7). However, it is important to recognize that these estimates are not directly comparable due to different methods (simulated vs. actual abundance); *differences in results should not be interpreted as indicative of trends across the assessments*. Substantial disagreement between simulated and actual abundances in many populations were also evident in the original assessment; harmonic means of actual abundance estimates in the current period are more similar to those calculated from actual abundance estimates from 1958-2003, as reported in Chilcote et al. (2005) (Table 7).

Table 7. Harmonic mean population abundances predicted by a Ricker simulation model for the OCCCP assessment (based on stock-recruit data from 1958-2003, where values in parentheses are harmonic means of actual abundance estimates for the same period) and the current 12-year assessment (based on abundance estimates from 1990-2019). Blue shading indicates populations that meet the diversity objective. *Comparisons of results across the two assessments should not be used to infer temporal trends*; differences may be attributable to different assessment methods (simulation vs. abundance estimates) rather than changes in biological performance.

Population	Harmonic Mean Abundance		
	Broad Sense Goal	OCCCP Assessment (Harmonic Mean of Simulated Abundances)	12-year Assessment (Harmonic Mean of Abundance Estimates, 1990-2019)
Necanicum	1,200	777 (427)	450
Nehalem	1,200	2,926 (3,727)	3,294
Tillamook	1,200	721 (888)	1,098
Nestucca	1,200	2,850 (1,091)	735
Salmon	1,200	1 (22)	43
Siletz	1,200	401 (684)	961
Yaquina	1,200	2,591 (534)	1,400
Beaver	1,200	1,389 (488)	677
Alsea	1,200	1,505 (1,063)	1,277
Siuslaw	1,200	10,320 (4.206)	4,189
Siltcoos	1,200	5,118 (1,989)	2,111
Tahkenitch	1,200	2,786 (1,092)	1,389
Tenmile	1,200	14,891 (3,162)	3,237
Lower Umpqua	1,200	10,219 (3,321)	5,052
Middle Umpqua	1,200	4,477 (1,349)	2,759
North Umpqua	1,200	252 (113)	1,737
South Umpqua	1,200	3,319 (935)	2,632
Coos	1,200	15,241 (5,191)	5,388
Coquille	1,200	12,439 (4,568)	6,102
Floras	1,200	1,110 (1,151)	1,076[1]
Sixes	1,200	2 (94)	102

[1]The period of record available for the current assessment is 1994-2019 for the Floras Population.

Criterion 6: Habitat Condition

The habitat condition criterion is based on estimates of high-quality habitat (HQH). High-quality habitat is habitat capable of producing greater than 2,800 coho smolts per mile (Nickelson 1998). The amount of HQH needed to achieve spawner abundance goals in each non-lake independent population is based on the smolt density (smolts/mile) needed to support replacement of adult spawners during protracted periods of low marine survival. The calculations used to estimate the OCCCP's HQH goals for non-lake populations include two important assumptions:

1) during poor ocean conditions smolts are only produced from high quality habitat; and
2) high quality habitat is strictly defined as habitat that can produce 2,800 smolts/mile.

Under these assumptions, the HQH goals were calculated as the smolt abundance required to support the pre-harvest adult recruitment goal at 3% marine survival divided by 2,800 smolts/mile. Feasibility of attaining HQH goals was not assessed; like other criteria, HQH goals are intended to be achieved through sustained, long-term implementation of habitat restoration and enhancement actions.

Prior to the adoption of the OCCCP, there were inadequate data to calculate the miles of HQH in each independent population based on physical habitat surveys. Instead, the quantity of HQH was inferred from average spawner abundance estimates during years with a 3% marine survival rate during the period from 1990 through 2003.[13] For the current assessment, the quantity of HQH is based on random, spatially balanced (GRTS) physical habitat surveys in wadeable streams within 18 independent populations. The Necanicum, Beaver Creek, and North Umpqua populations were not surveyed as population blocks due to resource and budget constraints. Habitat capacity for winter coho parr was calculated using the Habitat Limiting Factors Model (HLFM), and HLFM estimates were expanded based on the total coho distribution in each population. Additional field and methodological details are available in Strickland *et al*. (2018).

None of the assessed Independent Populations have met OCCCP high quality habitat goals; estimates of HQH range from 18% (Middle Umpqua) to 86% (Floras) of goals, with an average of 35% (Table 8). Although HQH mileages are currently low relative to the broad sense goals in most populations, this is not unexpected given the deficit of HQH identified in the OCCCP and the protracted time periods required to broadly restore landscape and geophysical processes and instream habitat. It is important to note that HQH estimates from the OCCCP assessment, and from the current 12-year assessments are not directly comparable due to different methods of calculation; comparisons should not be interpreted as indications of trends through time. The current estimates, based on habitat surveys, are a more direct, reliable way to gauge progress on this criterion.

[13] Estimated HQH = (Spawner Abundance @ 3% marine survival/0.03)/2,800 smolts/mile

Table 8. OCCCP goals and estimates of High-Quality Habitat miles inferred from spawner abundance at low marine survival (OCCCP Assessment) and based on subsequent physical habitat surveys and habitat capacity modeling (12-year Assessment). HQH goals were not met in any populations in either assessment. Note that HQH estimates from the OCCCP assessment, and from the current 12-year assessments are not directly comparable due to different methods of calculation; comparisons should not be interpreted as indications of trends through time. Estimates based on habitat surveys are a more direct, reliable way to gauge progress on this criterion.

Spatial Extent	Miles of High-Quality Habitat		
	OCCCP Broad Sense Goal	OCCCP Assessment	12-year Assessment
Necanicum	50	9	Not Assessed[1]
Nehalem	393	82	158
Tillamook	153	27	42
Nestucca	76	32	54
Salmon R.	19	3	5
Siletz	111	32	58
Yaquina	191	55	44
Beaver Cr.	31	19	Not Assessed[1]
Alsea	172	43	56
Siuslaw	508	127	172
L. Umpqua	306	110	63
M. Umpqua	359	58	65
N. Umpqua	73	21	Not Assessed[1]
S. Umpqua	416	68	81
Siltcoos	Not Applicable[2]	Not Assessed[2]	0
Tahkenitch			0
Tenmile			7
Coos	233	175	48
Coquille	321	108	117
Floras	61	19	53
Sixes	19	3	4

[1]Not Assessed. Habitat condition in the Necanicum, Beaver Creek, and North Umpqua populations were not assessed using habitat surveys due to resource and budget constraints.
[2]Not Applicable. The habitat condition criterion pertains to non-lakes populations; it does not apply to populations in the Lakes Stratum. Habitat condition was not assessed for Lakes populations in the OCCCP.

Assessment Results (Dependent Populations)

Criterion 1: Adult Abundance Trend

The adult abundance criterion for Dependent Populations is based on the expected similarity in abundance trends between the Dependent and Independent Populations within a stratum (i.e., a departure from a similarity in trends would be unexpected). The criterion is assessed based on a comparison of trends in the three-year running averages of adult abundances for the Dependent and Independent Populations aggregated by stratum. To meet the objective for the criterion, there must be no significant difference in the slopes of the trend lines, except where dependent populations exhibit steeper trends (i.e., greater relative increases in abundance through time).

The OCCCP provides several examples for assessment of this criterion, all based on expectations of either stable (no linear trend) or positive (increasing) linear trends through time (See OCCCP, Appendix 2). In the current assessment, negative trends over the assessment period were common. The plan provides no guidance for assessing negative trends, particularly when both Independent and Dependent populations exhibit negative linear trends through the available time series. Regardless, analyses of abundance trends in cyclical populations are sensitive to starting and ending points, and the intent of the criterion is to determine whether spawner abundances in Dependent Populations are deviating from those of Independent Populations in a manner that is inconsistent with the concept that the two population types are interrelated. Given no significant difference in the slopes of Dependent and Independent Population abundance trends, and because the Dependent Populations tend to track the Independent Populations (Fig. 22), the criterion has been assessed as meeting the objective of the criterion in the North Coast, Mid Coast, and Mid-South Coast strata.

Criterion 2: Habitat Condition Trend

The amount of HQH in the dependent populations is based on physical habitat surveys and coho parr capacities estimated using the HLFM model (described above for Independent Population Criterion 6). However, data are currently inadequate to assess trends in habitat condition in the Dependent Populations aggregated by stratum. Estimates of HQH mileages in the North Coast, Mid Coast, and Mid-South Coast dependent populations are 7 miles (10% of total coho habitat miles as HQH), 40 miles (22% of total coho habitat miles as HQH), and 0 miles (0% of total coho habitat miles as HQH), respectively.

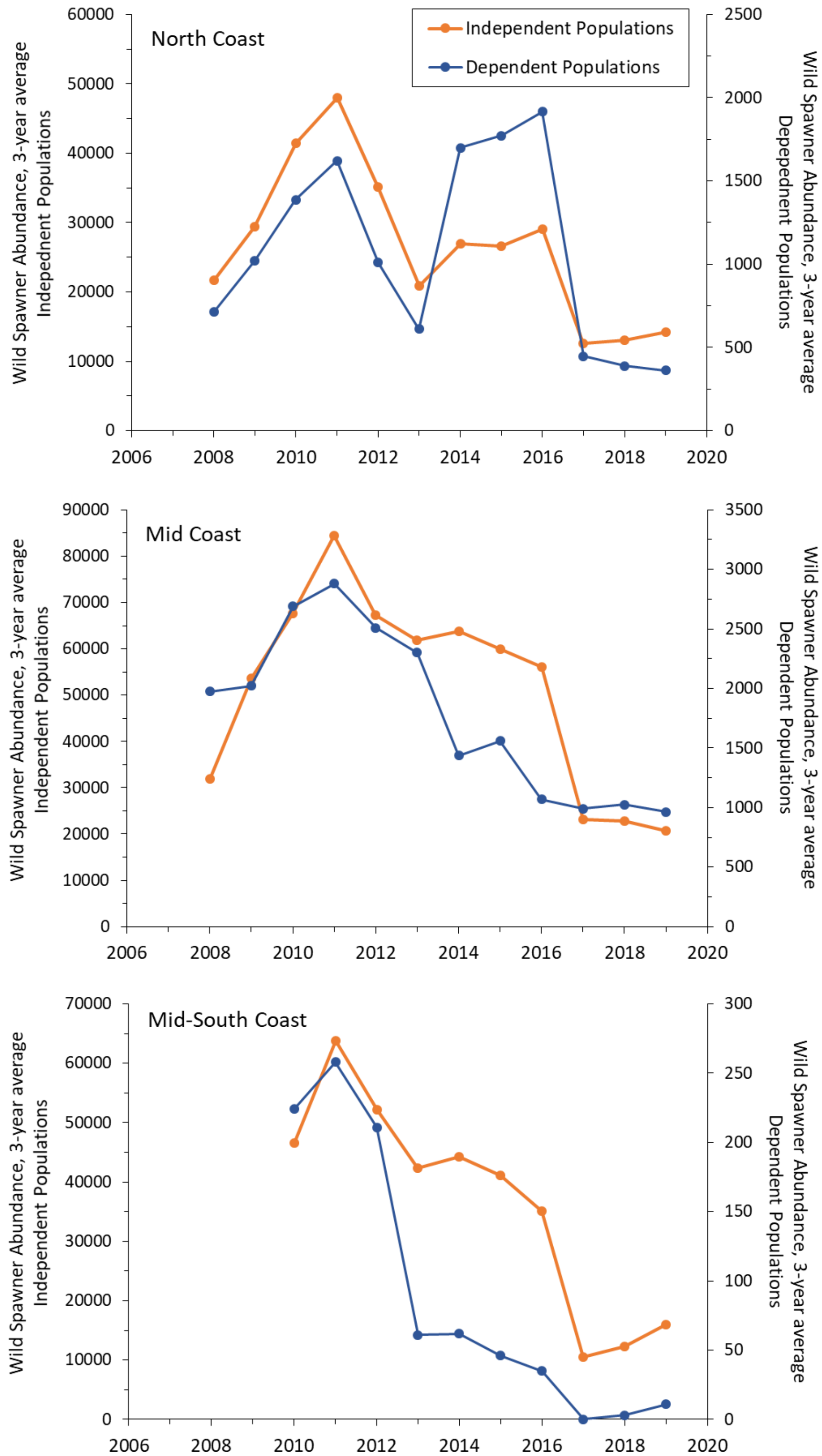

Figure 22. Three-year moving average abundances of wild OC coho salmon in Independent (orange) and Dependent (blue) Populations in the North Coast, Mid Coast, and Mid-South Coast strata, 2008-2019. Three-year average abundances for Dependent Populations in the Mid-South Coast stratum are only available beginning in 2010. Note differences in scale between axes.

Section IV. Decision Support System (DSS)

Overview of the Decision Support System

Separate from the OCCCP, the Oregon Coast Workgroup of the Oregon and Northern California Coast Technical Recovery Team developed a formal decision support framework for assessing the biological status of the OC Coho ESU with respect to listing under the federal ESA (Wainwright *et al*. 2008).[14] This framework, the Oregon Coast Coho Decision Support System (DSS), integrates numerous metrics from multiple monitoring projects and data analyses into a logical structure for decisions regarding biological status with respect to ESA listing. The DSS acknowledges that the OCCCP's desired status for the OC Coho ESU (i.e., broad-sense recovery) is substantially beyond recovery under the federal ESA (i.e., delisting). The DSS does not include specific criteria for broad-sense recovery. Rather than assessing status relative to broad sense recovery, the DSS provides criteria for assessing the ESU's sustainability and persistence along the path to the OCCCP's broad sense goals.

DSS Criteria and Scoring

Metrics for assessing DSS criteria are calculated largely based on data from ODFW monitoring programs (described in Section II). The DSS criteria reflect varying spatial scales including the entire ESU, individual strata, individual populations, and watersheds within populations. Criteria are centered on two concepts: persistence and sustainability. Wainwright *et al*. (2008) define persistence criteria as those related to the ability of the population or ESU to maintain its genetic legacy and long-term adaptive potential for the foreseeable future. Sustainability criteria are those related to stability of habitat availability and other conditions necessary for the full expression of the population's life history diversity into the foreseeable future. Additional details on criteria and linkages among criteria are available in Wainwright *et al*. (2008) and Appendix III of this 12-year assessment (*2020 DSS Assessment*).

The DSS criteria are not assessed with pass/fail thresholds. Rather, the DSS acknowledges uncertainty[15] in the decision framework by scoring metrics using "truth values", which reflect the degree of confidence for each metric. Scores conceptually range from +1.0 (True with 100% Certainty) to -1.0 (False with 100% Certainty); a value of 0 is completely uncertain. Additional details about how each metric is assigned membership to varying degrees of certainty can be found in Wainwright *et al*. (2008).

For the present assessment, ODFW updated DSS metrics using data collected through run year 2019. The DSS results are summarized below and compared to two previous assessments (2012, data through run-year 2009; 2015, data through run-year 2014).

Persistence Assessment

In the current assessment, population persistence scores indicate that most populations have a moderate or higher certainty of persisting for the next 100 years (Nehalem; Tillamook; Nestucca; Siletz; Yaquina; Alsea; Siuslaw; Siltcoos; Tahkenitch; Tenmile; L. Umpqua; M. Umpqua; N. Umpqua; Coos; Coquille; Floras). Remaining populations were characterized as low-to-moderate certainty of persistence (Beaver Creek; S. Umpqua) or some degree of certainty that the population will not persist (Necanicum; Salmon; Sixes). Scores for population persistence are

[14] The Oregon Coast Workgroup was comprised of staff from the NOAA Northwest Fisheries Science Center, ODFW, the U.S. Forest Service, Oregon Watershed Enhancement Board, and Clearwater Biostudies, Inc.

[15] Uncertainty refers to both the parameters included in the DSS as well as uncertainty associated with measurement/calculation of metrics.

generally slightly lower than in the last DSS assessment (2015) but higher than in the 2012 DSS assessment (Table 9). Some notable exceptions are:

- Scores for the South Umpqua Population have declined across DSS runs; the score for the Beaver Creek Population has declined more substantially since the 2015 assessment.
- Scores for the Floras and North Umpqua Population have continued to improve, moving from scores reflecting a moderate or high certainty of failing to persist to a score that reflects a moderate-to-high certainty of persistence.
- Scores for the Salmon and Sixes populations have been -1.0 (False with 100% Certainty) across all three DSS runs. This is a result of both populations having a -1.0 truth value for one of the component criteria (PP-2, a criterion based on PVA modeling) and the means by which component criteria are rolled up to a score for population persistence. Since the PVA models used to score criterion PP-2 in the 2012 DSS run have not been updated in the DSS, the Salmon River and Sixes population persistence scores cannot change.

Table 9. Scores for the DSS Population Persistence criterion (PP) from assessments in 2012, 2015 and 2020 using data through run years 2009, 2014 and 2019, respectively. Green shading indicates moderate or higher certainty of persistence, yellow shading indicates low certainty of persistence, and red shading indicates low to high certainty of failing to persist.

Stratum	Population	PP Population Persistence		
		2012	2015	2020
North Coast	Necanicum	-0.24	-0.21	-0.26
	Nehalem	0.84	0.91	0.76
	Tillamook	0.55	0.68	0.65
	Nestucca	0.57	0.63	0.61
Mid Coast	Salmon River	-1.00	-1.00	-1.00
	Siletz	0.36	0.81	0.76
	Yaquina	0.65	0.85	0.87
	Beaver Creek	0.80	0.82	0.17
	Alsea	0.28	0.81	0.76
	Siuslaw	0.38	0.85	0.71
Lakes	Siltcoos	0.92	0.95	0.42
	Tahkenitch	0.78	0.82	0.72
	Tenmile	0.98	0.90	0.93
Umpqua	Lower Umpqua	0.74	0.81	0.85
	Middle Umpqua	0.45	0.61	0.43
	North Umpqua	-0.95	-0.30	0.52
	South Umpqua	0.80	0.75	0.26
Mid-South Coast	Coos	0.75	0.89	0.80
	Coquille	0.91	0.93	0.79
	Floras	-0.21	0.43	0.61
	Sixes	-1.00	-1.00	-1.00
	Mean	*0.35*	*0.52*	*0.45*

Stratum persistence scores indicate moderate or higher certainty that all strata will persist for the next 100 years. These scores tend to be lower than in the 2015 assessment; scores were higher than the 2012 assessment in three strata (North Coast, Mid Coast, Mid-South Coast) and lower than the 2012 assessment in the Lakes and Umpqua Strata. The declines in the scores for the Lakes and Umpqua strata are attributable to the declines in the population productivity scores for the Siltcoos and South Umpqua populations, respectively (Table 10).

Table 10. Scores for the DSS Stratum Persistence Criterion (SP) from assessments in 2012, 2015 and 2020 using data through run years 2009, 2014 and 2019, respectively. Green shading indicates moderate or higher certainty true. Yellow shading indicates low certainty true, gray shading indicates uncertain, and red shading indicates low to high certainty false.

Stratum	SP Stratum Persistence		
	2012	2015	2020
North Coast	0.56	0.65	0.63
Mid Coast	0.37	0.82	0.73
Lakes	0.92	0.90	0.72
Umpqua	0.60	0.68	0.47
Mid-South Coast	0.27	0.66	0.70
Mean	*0.54*	*0.74*	*0.65*

The ESU persistence score for the 2020 assessment (0.60) indicates a high certainty that the ESU will persist for the next 100 years. The value for the current assessment is slightly lower than the previous assessment (0.70, High Certainty Persistent) but higher than the assessment in 2012 (0.44, Moderate to High Certainty Persistent).

Sustainability Assessment

Population Diversity. Scores for population diversity for most populations indicated a moderate or higher certainty that the population has sufficient diversity and distribution to ensure continued fitness in the face of environmental change (Nehalem; Tillamook; Nestucca; Siletz; Yaquina; Beaver Creek; Alsea; Siuslaw; Siltcoos; Tahkenitch; Tenmile; M. Umpqua; L. Umpqua; Coos; Coquille; Floras). Remaining populations were characterized as low-to-moderate certainty of sufficient diversity and distribution (Necanicum), uncertain (South Umpqua), or some degree of certainty that the population has insufficient diversity and distribution (North Umpqua; Salmon; Sixes). Scores were generally similar to the 2012 and 2015 assessments (Table 11). Some additional changes are highlighted below:

- Scores for the South Umpqua Population have declined since the 2012 DSS run. One of the drivers of the South Umpqua Population diversity score is related to hatchery influence. For the South Umpqua Population, the score for the current assessment was influenced by a high value of the percentage of hatchery spawners (pHOS) in 2016 (37%). In other years since plan adoption, hatchery influence has been low (generally pHOS <10%).

- Scores for the North Umpqua Population remain low but have continued to improve through the three assessments.
- Scores for the Tenmile Population have continued to improve through the assessment periods; much of the change has been driven by improvements in juvenile distribution.

Table 11. Scores for the DSS Population Diversity (PD) and Population Sustainability criteria from assessments in 2012, 2015 and 2020 using data through run years 2009, 2014 and 2019, respectively. Green shading indicates moderate or higher certainty true, yellow shading indicates low certainty true, gray shading indicates uncertain, and red shading indicates low to high certainty false.

Stratum	Population	PD Population Diversity		
		2012	2015	2020
North Coast	Necanicum	0.28	0.33	0.27
	Nehalem	0.57	0.69	0.55
	Tillamook	0.25	0.40	0.43
	Nestucca	0.37	0.36	0.31
Mid Coast	Salmon River	-1.00	-1.00	-1.00
	Siletz	0.34	0.45	0.48
	Yaquina	0.57	0.64	0.66
	Beaver Creek	0.39	0.41	0.41
	Alsea	0.43	0.54	0.57
	Siuslaw	0.70	0.86	0.93
Lakes	Siltcoos	0.75	0.77	0.74
	Tahkenitch	0.58	0.61	0.59
	Tenmile	-0.04	0.12	0.82
Umpqua	Lower Umpqua	0.58	0.87	0.88
	Middle Umpqua	0.25	0.48	0.35
	North Umpqua	-0.95	-0.60	-0.54
	South Umpqua	0.15	0.31	0.09
Mid-South Coast	Coos	0.86	0.86	0.84
	Coquille	0.83	0.90	0.81
	Floras	0.35	0.48	0.47
	Sixes	-0.96	-0.95	-0.93
	Mean	*0.25*	*0.36*	*0.37*

Scoring for the stratum diversity criterion indicates a moderate or higher certainty that most Independent Populations in the North Coast, Mid Coast, Lakes, and Mid-South Coast strata are presently sustainable. Scoring for the Umpqua Stratum indicated a low to moderate certainty of that most independent populations are presently sustainable. The 2020 scores tend to be comparable to or lower than the 2015 scores; scores were higher than the 2012 scores except in the Umpqua Stratum (Table 12).

Table 12. Summary of Stratum-Scale DSS Criteria scores from assessments in 2012, 2015 and 2020 using data through run years 2009, 2014 and 2019, respectively. Green shading indicates moderate or higher certainty true, yellow shading indicates low certainty true, gray shading indicates uncertain, and red shading indicates low to high certainty false.

Stratum	SD Stratum Diversity		
	2012	2015	2020
North Coast	0.39	0.47	0.46
Mid Coast	0.42	0.61	0.61
Lakes	0.66	0.70	0.64
Umpqua	0.32	0.49	0.26
Mid-South Coast	0.35	0.66	0.66
Mean	*0.43*	*0.59*	*0.53*

Population Sustainability. Population sustainability is a combination of the population persistence and population diversity scores. In the current assessment, scores for the population sustainability criterion for most populations indicated a moderate or higher certainty that the population will be able to sustain itself into the future (Nehalem; Tillamook; Nestucca; Siletz; Yaquina; Alsea; Siuslaw; Siltcoos; Tahkenitch; Tenmile; M. Umpqua; L. Umpqua; Coos; Coquille; Floras). Remaining populations were characterized as having a low to moderate certainty of sustainability (Beaver Creek; S. Umpqua) or some degree of certainty that populations will not be able to sustain themselves (Necanicum; Salmon; N. Umpqua; Sixes). On average, scores for population sustainability were slightly lower than in the 2015 assessment but higher than in the 2012 assessment (Table 13). Some specific trends are highlighted below:

- Sustainability scores for the South Umpqua Population declined substantially from the 2012 to 2020 DSS runs. The score for the Beaver Creek Population has declined more significantly since the 2015 assessment. These changes are largely attributable to declining scores for population productivity.
- Sustainability scores for the Tenmile Population increased through the three assessment periods. This change is largely attributable to improvement in the population's diversity scores, particularly for juvenile distribution.
- Sustainability scores for the North Umpqua Population have remained low but have continued to improve through the three assessment periods. This improvement is attributable to improvements in both population persistence and diversity criteria.
- Sustainability scores for the Floras Population have continued to improve through the three assessment periods. This improvement is largely attributable to improvements in criteria related to improvements in spawner density at low abundance and spawner distribution.
- Scores for the Salmon River and Sixes Populations have been -1.0 (False with 100% Certainty) across all three DSS runs. As noted in the population persistence section, this is related to both populations having a -1.0 truth value for the PP-2 metric and the methods used to roll up scores (Wainwright *et al*. 2008). The PVA models used for the

PP-2 score in the 2012 DSS run have not been updated, thus the Salmon River and Sixes population sustainability scores cannot change.

Table 13. Scores for the DSS Population Diversity (PD) and Population Sustainability criteria from assessments in 2012, 2015 and 2020 using data through run years 2009, 2014 and 2019, respectively. Green shading indicates moderate or higher certainty true, yellow shading indicates low certainty true, gray shading indicates uncertain, and red shading indicates low to high certainty false.

Stratum	Population	PS Population Sustainability		
		2012	2015	2020
North Coast	Necanicum	-0.14	-0.10	-0.16
	Nehalem	0.67	0.78	0.63
	Tillamook	0.35	0.50	0.51
	Nestucca	0.44	0.45	0.41
Mid Coast	Salmon River	-1.00	-1.00	-1.00
	Siletz	0.35	0.58	0.58
	Yaquina	0.60	0.73	0.74
	Beaver Creek	0.53	0.56	0.24
	Alsea	0.33	0.64	0.64
	Siuslaw	0.49	0.85	0.80
Lakes	Siltcoos	0.83	0.85	0.53
	Tahkenitch	0.66	0.70	0.64
	Tenmile	0.20	0.34	0.87
Umpqua	Lower Umpqua	0.65	0.84	0.87
	Middle Umpqua	0.31	0.53	0.38
	North Umpqua	-0.95	-0.57	-0.41
	South Umpqua	0.33	0.45	0.14
Mid-South Coast	Coos	0.80	0.87	0.82
	Coquille	0.87	0.91	0.80
	Floras	-0.10	0.45	0.52
	Sixes	-1.00	-1.00	-1.00
	Mean	*0.25*	*0.40*	*0.36*

ESU Sustainability. For the current assessment, the ESU-scale sustainability criterion (0.24), indicated a low to moderate certainty that the ESU will be self-sustaining into the foreseeable future. This result is similar to scores in the 2012 (0.23, Low to Moderate Certainty Sustainable) and 2015 (0.29, Moderate Certainty Sustainable) assessments.

Summary of the 2020 DSS Assessment

Overall, the 2020 DSS assessment indicates:

- a high certainty that the OC Coho ESU will persist into the foreseeable future; and
- a low-to-moderate certainty that the ESU will be self-sustaining into the foreseeable future.

The 2020 ESU persistence assessment conclusion is consistent with the most recent federal status review (NWFSC 2015); the ESU sustainability assessment conclusion is slightly lower than the previous assessment (Low-to-Moderate Certainty vs. Moderate Certainty). More specific details on metrics and scores are available in Appendix III, *2020 DSS Assessment*. It is notable that several criteria in the DSS are influenced by PVA results, which have not been updated in the DSS since Wainwright *et al*. 2008. ODFW will work with NOAA to incorporate revised PVAs into the DSS assessment for the next five-year ESA status assessment.

It is important to reiterate that the criteria and assessment methods in the DSS and the OCCCP were designed to assess ESU status relative to two different bars for recovery. The DSS criteria and assessment methods are used to assess whether the ESU is persistent and sustainable with respect to viability and ESA listing status; the OCCCP criteria and assessment methods are used to assess whether the ESU has achieved broad sense recovery, a status well beyond viability (See Table 1). Even where criteria are similar, the OCCCP sets higher objectives. For example, both assessments have a criterion based on the probability of persistence as determined by PVA modeling (OCCCP Persistence Criterion, DSS Criterion PP-2). In a DSS assessment, a population with a persistence probability of 0.975 (2.5% extinction risk) would be considered to have a moderate to high certainty of persisting into the foreseeable future. If the same persistence probability were assessed against the OCCCP objective for persistence (0.99), the population would not meet the objective, indicating that the population has not achieved broad sense recovery goals despite having a very low extinction risk. A DSS assessment indicating some degree of certainty that the ESU is likely to be persistent and sustainable into the foreseeable future is not in conflict with an OCCCP assessment indicating that the ESU has yet to attain broad sense recovery goals.

Interim Progress toward Broad Sense Goals

In addition to the measurable criteria in Section III, the OCCCP includes a goal for assessing interim progress toward broad sense goals that is based on the assessment of the DSS Population Sustainability criterion, PS: all 21 Independent Populations must pass the DSS population sustainability (PS) criterion. The DSS criteria do not have pass/fail thresholds, nor was such a threshold identified in the OCCCP. For the current assessment, populations were considered to pass the PS criterion with positive scores greater than 0.1 (i.e., some degree of certainty that the population will be sustainable into the foreseeable future).

In the current assessment, only four populations did not meet the objective for the PS assessment, each with negative scores indicating some degree of certainty that the populations will not be sustainable (Necanicum; Salmon; N. Umpqua; Sixes). These four populations have been consistently low scoring for sustainability across DSS runs (Table 13). However, it is important to recognize that the population sustainability criterion is a combined criterion that incorporates scores for criteria based on spawner abundance, productivity, persistence (PVA results), and diversity (abundance, hatchery influence, adult and juvenile distribution). Until component criteria based on PVAs are updated and show improvements over the original assessment (Wainwright *et al*. 2008), the Necanicum and North Umpqua populations are unlikely to receive positive scores even with improvements in other constituent criteria, and the Salmon and Sixes populations will remain at -1.0 even if all other component metrics improve to +1.0.

Section V. Habitat Trends

The OCCCP notes that achieving broad sense goals for the OC Coho ESU will require roughly a doubling of productive capacity of OC coho and their supporting habitat. As a component of the implementation of the Oregon Plan, ODFW has been monitoring instream habitat conditions across Western Oregon for over 20 years. Sites are chosen at random and visited on a temporal rotating panel. This sampling design enables a non-biased portrayal of the status and trends in habitat conditions. The stream habitat surveys describe components and processes that contribute to the structure and productivity of a stream and fish community. Habitat survey methods are further described in Moore *et al*. (2007).

For the current assessment, we evaluated trends in five habitat variables summarized at the reach scale (500 – 1000m survey lengths) (Table 7). The attributes describe important indicators of sediment supply and quality, instream habitat complexity, and riparian forest community. The response of salmonid fishes to the character of aquatic habitat varies by species, life stage, and time of year. The variables chosen for this analysis are those that broadly represent habitat conditions, are well-behaved statistically, and are responsive to management actions.

Table 7. Habitat variables evaluated in trend analysis, their relevance to rearing coho salmon, and desired trend directions.

Metric	Relevance to Coho Salmon	Desired Trend
Pool Frequency (Pools/100m)	Pool habitats are primary habitats for juvenile salmonids rearing in freshwater. Pool spacing depends on large woody debris loading and channel type, slope, and width. Having ample pool habitats throughout a reach ensures fish can distribute and not suffer density dependent mortalities.	Increasing
Channel Shade (%)	Shading of stream channels helps cool streams, particularly in the summer. Riparian vegetation also provides nutrient inputs and prey for rearing fish and stabilize the banks, reducing fine sedimentation.	Increasing
Fine Sediments in Riffle Habitat (%)	Riffle habitats are primary spawning habitats for adult salmon. Cold, clean gravel and cobble substrates provide suitable locations for redd formation and egg incubation. Fine sediment (silt, sand, and organics) in riffles can reduce egg survival by reducing oxygenation.	Decreasing
Wood Volume (m^3/100m)	Wood creates complexity in stream habitats and is a natural component of coastal streams. It can trap sediments, create pools, and provide nutrients and food for rearing fish. This metric reflects the presence of larger pieces or key pieces of wood.	Increasing
Winter Parr Capacity (parr/km)	This is a modeled estimate of winter parr/km of stream based on habitat conditions. This metric is a function of pool habitat types and instream wood. Pools are weighted based on rearing densities associated with specific pool types. Pools with high wood volumes, beaver pools, and/or off-channel habitats provide the highest capacity for winter parr.	Increasing

We also included winter parr capacity to further assess habitat conditions specifically for coho salmon. This metric is derived from the Habitat Limiting Factors Model (HLFM) (Nickelson *et al*. 1998) and is based on empirical habitat data. The HLFM integrates individual habitat attributes to provide an overall assessment of the quality and carrying capacity of habitat for juvenile coho salmon. This variable is evaluated only within the distribution of coho salmon. The HLFM assigns the highest rearing densities to off-channel or side-channel habitats and other pool habitats with complexity (e.g., wood accumulation). Trends in several of these key habitat attributes are also discussed given their relevance to winter rearing capacity (Table 8).

Table 8. The Habitat Limiting Factors Model (HLFM) assigns high rearing capacities to side- and off-channel habitats and complex pools. Some of these habitat types, their relevance to rearing coho salmon, and the desired trend are provided below.

Metric	Relevance	Desired Trend
Lateral Scour Pools with ≥ Pieces of Large Wood	Pools that are generally deepest along either the left or right side of a stream, commonly formed by stream meanders and wood. Scour pools are the most common pool type encountered in coastal watersheds. They are often associated with undercut banks. Wood increases the complexity of these pools providing additional benefits to rearing salmonids.	Increasing
Scour Pools	Pool habitat created from scouring of the channel. Pools created by flow velocity and channel shape. Important rearing habitat for salmonids and most common pool type encountered.	Stable or Increasing
Alcoves and beaver pools (m^2)	Alcoves are off channel habitats and are among the most valued habitats for rearing salmonids given their depth, connection to the floodplain, and off-set from the main channel providing flow refuge. Beavers create large surface area pools that are deep, connected to the floodplain, providing high-capacity habitats with increased prey and forage opportunities.	Increasing

Data Details and Limitations

The majority of ODFW's habitat sampling occurs in wadeable, 1st through 3rd order streams. While there are some exceptions, these data can only be assumed to reflect conditions in wadeable streams. The data are derived from spatially balanced, random stream habitat surveys (GRTS). The spatial design is intended to provide a broad, landscape view of status and trends in habitat conditions on the Oregon coast. Because we have a relatively large sample size at this scale, we can post-stratify at other regional scales (e.g., Ownership). Given that much of the agriculture in the coast is concentrated in the lower portions of each basin, our data are not well distributed across all agriculture lands. Therefore, trends detected on agriculture lands should be interpreted with caution.

Linear Trends

We used linear mixed models to evaluate habitat trends through time. We define trend as a directional change over time in a habitat feature. We used site-specific trends to draw inferences about trends at regional (e.g., stratum, ownership) scales. We represented the response variable (e.g., wood volume) measured at the *k*th revisit to site *j* in monitoring stratum *h* during year *i* as:

$$zhij = \alpha h + \beta ht + sj\ (h) + ehij$$

t = the time in years;
αh = the monitoring stratum intercept parameter;
βh = the monitoring stratum linear trend (slope) parameter;
$sj\ (h)$ = site component;
$ehij$ = residual error component.

This formulation models the habitat response as a monitoring stratum specific linear function of time, variance being determined by two independent normally distributed random effects attributable to inherent site variability ($\sigma s2$) and residual error variability ($\sigma e2$). We used restricted maximum likelihood to estimate the variance components and based all hypothesis tests on the type III test of fixed effects. Several habitat variables required transformation to satisfy the assumption of normality. The linear mixed model was fit using the lmer function in R from the lme4 package (Bates *et al*. 2015).

Habitat Trends by Stratum

Direction of trends in pool frequency, channel shade, fine sediment in riffles, wood volume, and winter parr capacity are provided in Table 9 based on surveys across all habitat (both within and outside of the distribution of coho salmon) and only within the distribution of coho salmon. Trends in individual metrics contributing strongly to modeled estimates of coho winter parr capacity are provided in Table 10 based on surveys within the distribution of coho salmon.

Table 9. Trends in habitat metrics within all habitat and within the distribution of coho (coho habitat) by stratum for the non-lakes strata of the OC Coho ESU. Arrows indicate the direction of trend: increasing (up), decreasing (down) or none (horizontal). Arrow color indicates whether trend is in the desired direction (blue), opposite of the desired direction (red), or where there is no directional trend detected (yellow).

Stratum	Pool Frequency (Pools/100m)		Channel Shade (%)		Fine Sediments in Riffles (%)		Wood Volume (m^3/100m)		Capacity (Winter Parr/km)
Desired Trend	*Increasing*		*Increasing*		*Decreasing*		*Increasing*		*Increasing*
Scale	*All Habitat*	*Coho Habitat*	*All Habitat*	*Coho Habitat*	*All Habitat*	*Coho Habitat*	*All Habitat*	*Coho Habitat*	*Coho Habitat*
North Coast	↑	↔	↑	↑	↔	↔	↓	↔	↓
Mid Coast	↑	↑	↑	↑	↔	↔	↔	↔	↓
Umpqua	↔	↑	↑	↑	↓	↔	↔	↑	↔
Mid-South Coast	↑	↑	↑	↑	↔	↔	↓	↔	↓

Table 10. Trends in several habitat attributes with considerable influence on winter rearing capacity, estimated using the Habitat Limiting Factors Model. Arrows indicate the direction of trend: increasing (up), decreasing (down) or none (horizontal). Arrow color indicates whether trend is in the desired direction (blue), opposite of the desired direction (red), or where there is no directional trend detected (yellow).

Stratum	Lateral Scour Pools with ≥ 3 Pieces of Large Wood	Scour Pools (%)	Alcoves and Beaver Pools (m^2)
Desired Trend	*Increasing*	*Increasing*	*Increasing*
North Coast	↔	↑	↓
Mid Coast	↔	↔	↓
Umpqua	↑	↔	↔
Mid-South Coast	↔	↑	↓

North Coast Stratum

Pool Frequency. In the North Coast Stratum, an increasing trend in pool frequency across all habitat reflects increases in scour pools forming as a result of variable flows and sediment redistribution. However, this trend is not detected when analyses include only surveys located within the distribution of coho salmon. The lack of an increasing trend within the coho distribution indicates that improvements in pool frequency are occurring higher in watersheds.

Channel Shade. The increasing trend in channel shade in wadeable habitats within the coho distribution, with broad generalization, likely reflects alder and other deciduous trees and shrubs in riparian areas. Hardwoods, primarily red alder, are more common along streams for several reasons, regardless of management type:

1) Hardwoods tend to be more adapted to the fluvial environment (e.g., water table, flooding frequency) or when soil moisture is high. Conifers tend to lose their competitive advantage as they are relatively intolerant of high water tables. Species like red cedar and Sitka spruce are more tolerant of fluvial conditions but may be limited by competition; less water-tolerant species like Douglas fir occur more commonly on southerly aspects, steeper slopes, and farther from the stream.

2) Conifer basal area is positively correlated with elevation and gradient and negatively correlated with stream width, all of which relate to stream order. Conifers dominate in first order streams often because of the steep slopes and narrow streams. Hardwoods comprise a greater proportion of basal area along second and third order streams.

It is also possible that the apparent trend is influenced by methodological adjustments through time.[16]

Fine Sediments in Riffle Habitat. There was no trend in fine sediments in riffles within the coho distribution or when sites outside of the coho distribution were included in the analysis.

Wood Volume. A decreasing trend in wood volume was detected across all habitat survey sites, but no trend was detected within the coho distribution. The negative trend across all habitats is driven by a lack of large pieces of wood in streams higher in watersheds.

Winter Parr Capacity. A decreasing trend in winter parr capacity likely reflects a decreasing trend in off-channel, alcove, and beaver pool habitats, given increasing trends in other pool habitats in the North Coast Stratum (e.g., scour pools).

Mid Coast Stratum

Pool Frequency. The increasing trend in pool frequency detected in the Mid Coast Stratum reflects increases in scour pools forming as a result of variable flows and sediment redistribution. No trends or decreasing trends were detected in pools with more complexity (e.g., pools with wood, subunit pools such as alcoves or beaver pools).

Channel Shade. The increasing trend in channel shade detected in the Mid Coast Stratum likely reflects alder and other deciduous trees and shrubs in riparian areas. As described previously, this is a relatively broad generalization and may not reflect riparian composition across the spectrum of stream order.

Fine Sediments in Riffle Habitat. There was no trend detected for fine sediments in the Mid Coast Stratum.

Wood Volume. There was no trend detected for wood volume in the Mid Coast Stratum.

Winter Parr Capacity. The decreasing trend in winter parr capacity detected in the Mid Coast generally reflects a decreasing trend in off-channel, alcove and beaver pool habitats.

Umpqua Stratum

Pool Frequency. There is no trend in pool frequency when assessed across all habitat surveys in the Umpqua Stratum. The increasing trend in pool frequency detected within the coho distribution reflects increases in scour pools forming as a result of variable flows and sediment redistribution. No trends were detected in pools with more complexity (e.g., pools with wood, subunit pools such as alcoves or beaver pools).

Channel Shade. The increasing trend in channel shade detected in the Umpqua Stratum likely reflects alder and other deciduous trees and shrubs in riparian areas. As described previously, this is a relatively broad generalization and may not reflect riparian composition across the spectrum of stream order.

Fine Sediments in Riffle Habitat. A decreasing trend in fine sediments in riffle habitats in the Umpqua Stratum is a positive result that could be due to strong flushing winter flows, retention of instream wood to trap sediments, or reduced upslope disturbances. However, no trend was

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[16] Over time, several methodological changes have been made with respect to channel shade. Shade is currently measured at the beginning of the habitat unit (downstream end) rather than at the most representative location. Shade height is now recorded as the highest point in the canopy rather than an average canopy height.

detected within the distribution of coho, indicating that positive changes are occurring in streams that are in the upper portions of watersheds.

Wood Volume. No trend in wood volume was detected in the Umpqua Stratum when assessed across all habitats, but an increasing trend was detected within the distribution of coho salmon.

Winter Parr Capacity. There was no trend detected in winter parr capacity in the Umpqua Stratum. While lateral scour pools with at least 3 pieces of large wood have increased, there was no trend in alcoves and beaver pool habitats or scour pools.

Mid-South Coast Stratum

Pool Frequency. The increasing trend in pool frequency detected in the Mid-South Coast Stratum reflects increases in scour pools forming as a result of variable flows and sediment redistribution. No trends or decreasing trends were detected in pools with more complexity (e.g., pools with wood, subunit pools such as alcoves or beaver pools).

Channel Shade. The increasing trend in channel shade detected in the Mid-South Coast Stratum likely reflects alder and other deciduous trees and shrubs in the riparian. As described previously, this is a relatively broad generalization and may not reflect riparian composition across the spectrum of stream order.

Fine Sediments in Riffle Habitat. No trend in fine sediments was detected in the Mid-South Coast Stratum.

Wood Volume. A decreasing trend in wood volume was detected in the Mid-South Coast Stratum across all habitat surveys. Within the distribution of coho, no trend in wood volume was detected indicating that much of the negative change is occurring in streams higher in watersheds.

Winter Parr Capacity. The decreasing trend in winter parr capacity detected in the Mid-South Coast Stratum generally reflects the decreasing trend in off-channel, alcove and beaver pool habitats, given increasing trends in other pool habitats (e.g., scour pools).

Habitat Trends by Ownership

Land ownership in the OC Coho ESU is dominated by federal forest, state forest, and private industrial forest, but proportions and dominant ownership varies across strata (Table 11; Fig. 23). At the ESU scale, we assessed trends for the five habitat attributes above (Table 7) within these three forest ownerships (Table 12).

Table 11. Land Use/Ownership Proportions by Stratum within the OC Coho ESU.

Land Use/Ownership	North Coast	Mid Coast	Umpqua	Mid-South Coast
Federal Forest	14.6%	55.2%	54.3%	32.4%
State Forest	25.6%	1.9%	3.5%	7.6%
Private Industrial Forest	49.8%	34.4%	27.0%	41.8%
Private Non-Industrial Forest	3.8%	4.3%	1.7%	8.4%
Agriculture	3.2%	2.3%	11.9%	6.2%
Urban	2.6%	1.7%	1.3%	2.2%
Other	0.5%	0.3%	0.3%	1.4%

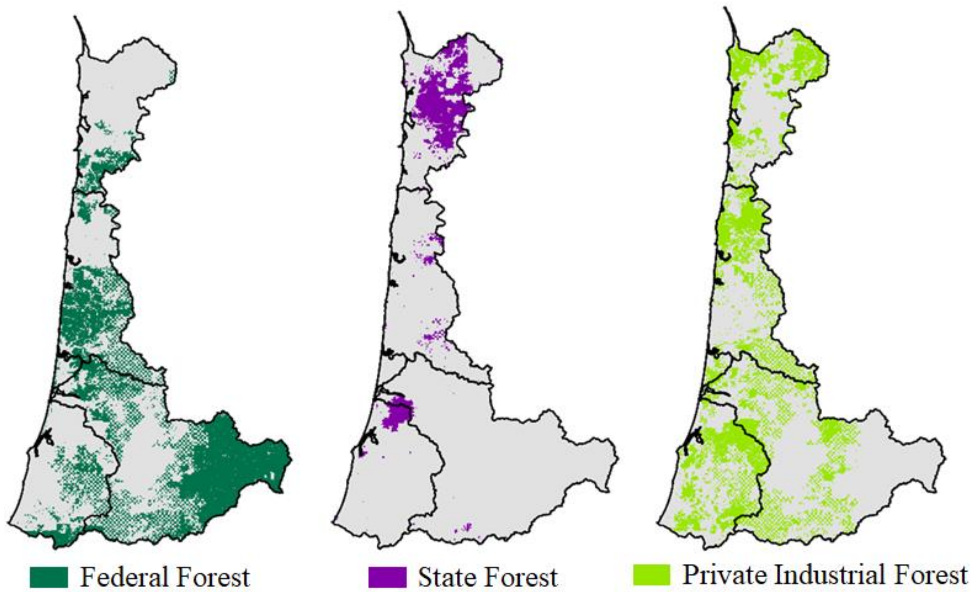

Figure 23. Distribution of federal forest, state forest, and private industrial forest in the OC Coho ESU.

Federal Forest

Pool Frequency

There was no trend in pool frequency detected within the distribution of coho. However, across all habitat (including surveys outside of the coho distribution), an increasing trend in pool frequency reflects increases in scour pools forming as a result of variable flows and sediment redistribution. No trends or decreasing trends were detected in pools with more complexity (e.g., pools with wood, subunit pools such as alcoves or beaver pools).

Channel Shade

There was an increasing trend in channel shade within federal ownership.

Fine Sediments in Riffle Habitat

There was no trend detected in fine sediments in riffles within the distribution of coho.

Wood Volume

There was no trend detected in wood volume within the distribution of coho.

Winter Parr Capacity

There was no trend detected in winter parr capacity on federal forest within the OC Coho distribution.

State Forest

Pool Frequency

There was no trend in pool frequency detected within the distribution of coho. However, an increasing trend in pool frequency was detected in streams outside coho distribution. This trend reflects increases in scour pools forming as a result of variable flows and sediment redistribution. No trends or decreasing trends were detected in pools with more complexity (e.g., pools with wood, subunit pools such as alcoves or beaver pools).

Channel Shade
There was an increasing trend in channel shade within state forest ownership.

Fine Sediments in Riffle Habitat
There was no trend detected in fine sediments in riffles within the distribution of coho.

Wood Volume
There was no trend detected in wood volume within the distribution of coho. However, a decreasing trend in wood volume was detected across all habitats (i.e., including surveys outside of the coho distribution). No trend was detected in wood pieces generally indicating that this decrease is a result of the lack of large pieces of wood in streams. Larger pieces of wood are retained longer in-stream and will tend to decompose and provide additional benefits to aquatic biota.

Winter Parr Capacity
There was a decreasing trend detected in winter parr capacity on state forest within the OC Coho distribution. Given increases in other pool habitats, this generally reflects the lack of off-channel, alcove and beaver pool habitats.

Private Industrial Forest

Pool Frequency
There was no trend in pool frequency detected within the distribution of coho. However, an increasing trend in pool frequency was detected in streams outside coho distribution. This trend reflects increases in scour pools forming as a result of variable flows and sediment redistribution. No trends or decreasing trends were detected in pools with more complexity (e.g., pools with wood, subunit pools such as alcoves or beaver pools).

Channel Shade
There was an increasing trend in channel shade in private industrial ownership.

Fine Sediments in Riffle Habitat
There was no trend detected in fine sediments in riffles within the distribution of coho.

Wood Volume
There was no trend detected in wood volume within the distribution of coho. However, a decreasing trend in wood volume was detected across all habitats (i.e., including surveys outside of the coho distribution). No trend was detected in wood pieces generally indicating that this decrease is a result of the lack of large pieces of wood in streams. Larger pieces of wood are retained longer in-stream and will tend to decompose and provide additional benefits to aquatic biota.

Winter Parr Capacity
There was a decreasing trend detected in winter parr capacity on private industrial forests within the OC Coho distribution. Given increases in other pool habitats, this generally reflects the lack of off-channel, alcove and beaver pool habitats.

Trends on Agricultural Lands

We also assessed trends in habitat attributes within agricultural ownership, but these trends should be interpreted with caution due to relatively few surveys within agricultural ownership. On agricultural lands within the distribution of OC Coho, we detected declining trends in pools/100m, fine sediments in riffles, and large wood volume, and increasing trends in channel shade and winter parr capacity. However, key habitat attributes like channel shade and large wood volume tend to be lower on agricultural lands relative to forestlands.

Habitat as a Dominant Limiting Factor

Physical habitat conditions in the wadeable streams of the OC Coho ESU are influenced by legacy effects from past land management as well as effects from current management. The detection of desired trends or the lack of undesirable trends for some key habitat attributes suggests progress in arresting further declines in habitat condition or at least that degradation in some areas is offset by improvements in others. However, some important habitat-forming processes are lagging needs (e.g., wood recruitment), and high-quality habitat mileages remain low relative to the OCCCP's broad sense goals (See Section II, *Measurable Criteria*). Though efforts to restore stream habitat in the OC Coho ESU have been significant, the number of miles treated is low relative to the coho distribution. Restoring simplified habitat and disrupted ecological processes (e.g., wood recruitment; riparian stand development) will take time to manifest as significant improvements to physical habitat attributes and, ultimately, rearing capacity across large spatial scales.

Freshwater productivity continues to be a primary factor limiting the ability of the ESU to attain the OCCCP's broad sense goals. Surveys of juvenile coho salmon indicate that freshwater productivity may become limited at spawner abundances lower than OCCCP abundance goals (Figs. 24; 25), and recent modeling analyses have provided no evidence for a recent significant change in smolt recruitment performance (Falcy and Suring 2018). These results are consistent with the lack of positive trends in winter parr capacity. It is possible that more time is needed for habitat attributes and freshwater productivity to reflect current land management actions, habitat restoration efforts, and contemporary hatchery management. However, attaining the broad sense goals of the OCCCP will require significant and sustained investment in habitat restoration focused on critical habitats (e.g., complex pools, off channel habitat) and processes (e.g., large wood recruitment) and a reversal of declines in highly productive habitats like alcoves and beaver pools.

Table 12. Trends in several key habitat features in the OC Coho ESU assessed by forest ownership. Trends are based on habitat surveys within all habitat and within the distribution of coho salmon (coho habitat). Arrow color indicates whether trend is in the desired direction (blue), opposite of the desired direction (red), or where there is no directional trend detected (yellow).

Ownership	Pool Frequency (Pools/100m)		Channel Shade (%)		Fine Sediments in Riffles (%)		Wood Volume (m^3/100m)		Capacity (Winter Parr/km)
Desired Trend	*Increasing*		*Increasing*		*Decreasing*		*Increasing*		*Increasing*
Scale	*All Habitat*	*Coho Habitat*	*All Habitat*	*Coho Habitat*	*All Habitat*	*Coho Habitat*	*All Habitat*	*Coho Habitat*	*Coho Habitat*
Federal Forest	↑	↔	↑	↑	↔	↔	↔	↔	↔
State Forest	↔	↔	↑	↑	↔	↔	↓	↔	↓
Private Industrial Forest	↑	↔	↑	↑	↔	↔	↓	↔	↓

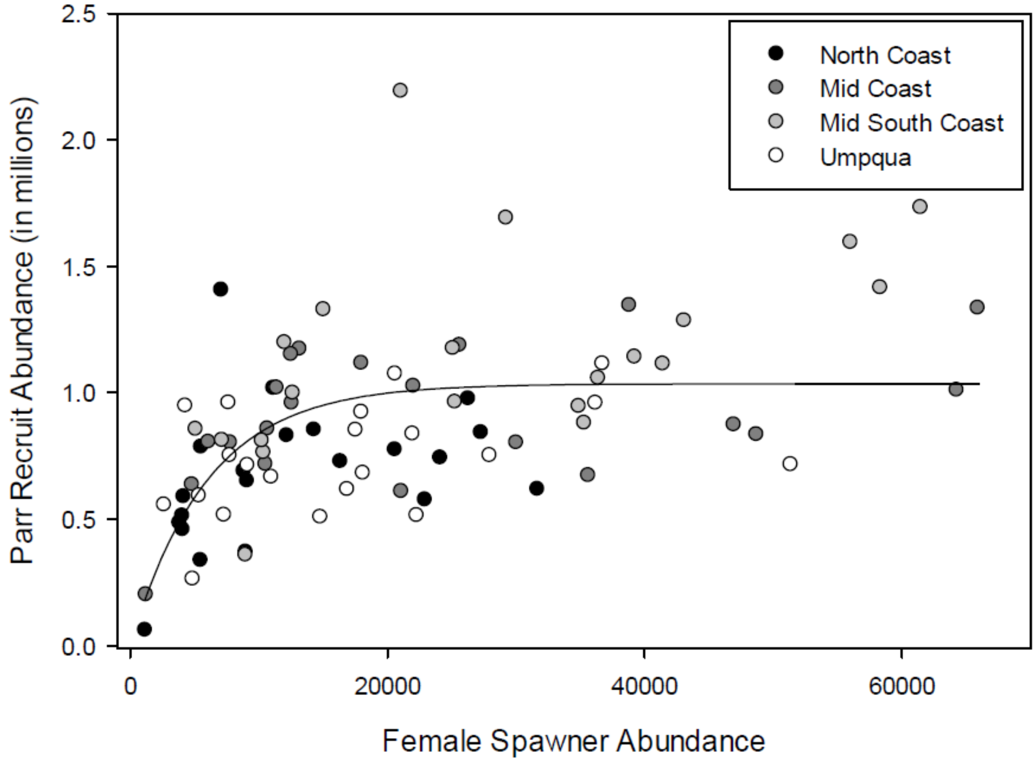

Figure 24. The relationship between the abundance of coho salmon parr recruits and female spawners in the strata of the Oregon Coast Coho ESU for brood years 1998-2019. Parr abundance is from uncalibrated snorkel surveys in 1^{st}-3^{rd} order streams (actual parr abundance is likely ~185% higher, Constable and Suring, 2018); spawner abundance is from spawning ground surveys. Figure from Constable and Suring (2021).

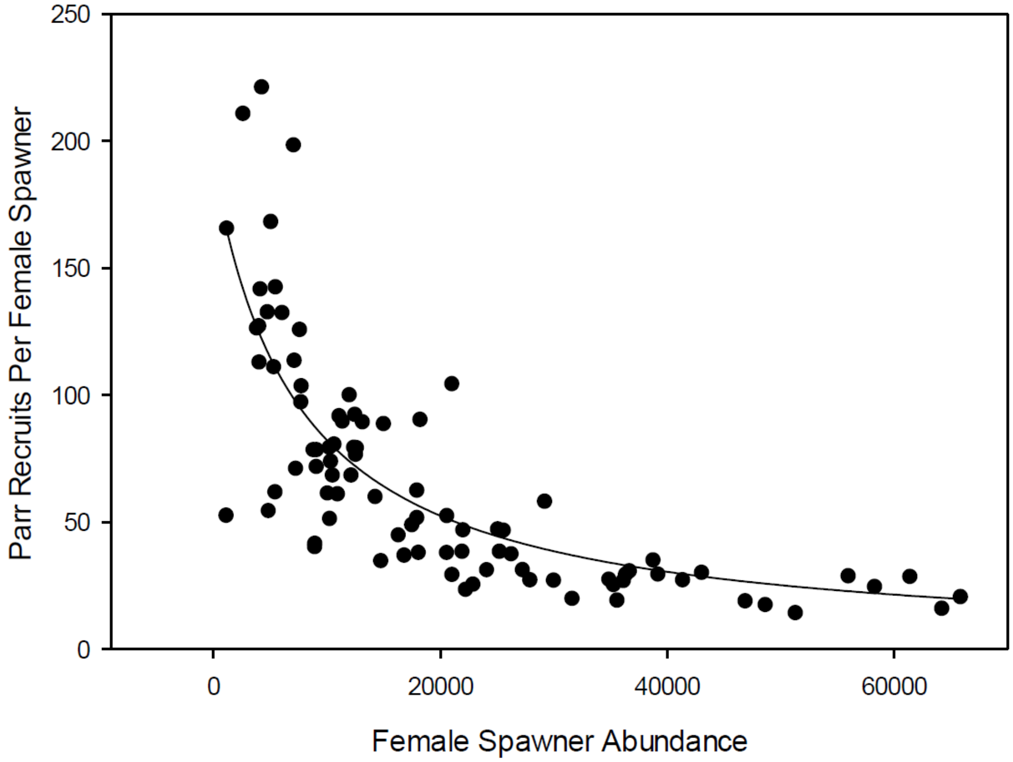

Figure 25. The relationship between the abundance of coho salmon female spawners and the number of parr recruits per female spawner in the Oregon Coast Coho ESU for brood years 1998-2019. Parr abundance is from uncalibrated snorkel surveys in 1st-3rd order streams (actual parr abundance is likely ~185% higher, Constable and Suring, 2018); spawner abundance is from spawning ground surveys. Figure from Constable and Suring (2021).

Estuary Rearing

Since adoption of the OCCCP, new information has emerged regarding the use of estuaries for rearing by juvenile coho salmon. Estuaries can provide important rearing capacity for sub-yearling migrants, which were previously thought to be largely insignificant contributors to subsequent adult returns (Bennett *et al*. 2014; Rebenack *et al*. 2015; Weybright and Giannico, 2016). Studies on the Oregon Coast designed to evaluate juvenile coho salmon use of estuarine habitat, life history composition, growth, and survival (Jones *et al*. 2014a; Weybright and Giannico, 2017) found that 1) juvenile coho salmon express a variety of alternative rearing and migration patterns to use all available habitat opportunities in the watershed; 2) juveniles that move from natal streams during their first year are not necessarily lost to the population. Rather, they may be expressing alternative life histories that, in some cases, may provide significant contributions to adult returns; and 3) juveniles of various sizes and ages occur in the estuary all months of the year, with some remaining there weeks or months before entering the ocean. The significance of alternative rearing strategies to OC coho productivity or resilience across OC Coho populations is not yet fully understood.

Juvenile coho salmon depend on estuary environments as they transition from freshwater to marine environments. During this transition, the quantity and quality of food available highly influence the size and condition of juvenile salmon when they enter the ocean. Therefore, the rate of prey consumption and energy accrual during estuarine residence are important for survival. Freshwater and ocean habitat conditions including freshwater flow patterns, stream temperature, sea level rise, sea surface temperature, upwelling patterns, and ocean acidity all affect the estuary condition and subsequently, the prey available to juvenile coho salmon. Warming effects in the estuaries due to climate change are expected to cause increased physiological stress to juvenile coho salmon and an increase in susceptibility to disease, parasites, and predation (Wainwright and Weitkamp, 2013).

Section VI. Limiting Factors

Limiting factors are those influences likely to inhibit the OC Coho ESU from achieving the OCCCP's broad sense goals. These limiting factors were determined in the 2005 Oregon Coast Coho Assessment (Chilcote *et al.* 2005) and reported in the OCCCP. Numerous factors contribute to the gap between the current status and broad sense goals for populations comprising the Oregon Coast Coho ESU. Ocean conditions were determined to be the primary factor influencing adult coho abundance, and stream habitat complexity was determined to be the primary factor limiting achievement of broad sense goals (Chilcote *et al.* 2005). Ocean conditions, or the availability of food resources for coho in the marine environment, determine the rate at which coho smolts will survive to become adults. These conditions are influenced by cyclic and periodic fluctuations in ocean currents and cannot be consistently predicted or managed. For this reason, the OCCCP recognized the importance of ocean conditions on coho survival and abundance, but the plan focuses on those limiting factors that can be influenced by management actions (Table 13).

Table 13. Primary and secondary limiting factors for achieving broad sense goals for independent populations in the Oregon Coast coho ESU. Table is revised from Table 4 in the OCCCP. Asterisks indicate changes from the OCCCP table.

Population	Primary Limiting Factor	Secondary Limiting Factor
Necanicum	Stream Complexity	--
Nehalem	Stream Complexity	Water Quality[1]
Tillamook	Stream Complexity	Water Quality
Nestucca	Stream Complexity	--
Salmon	Stream Complexity*	Water Quality*
Siletz	Stream Complexity	Water Quality
Yaquina	Stream Complexity	Water Quality
Beaver	Spawning Gravel	Stream Complexity
Alsea	Stream Complexity	Water Quality
Siuslaw	Stream Complexity	Water Quality
Lower Umpqua	Stream Complexity	Water Quality
Middle Umpqua	Water Quantity	Stream Complexity; Water Quality
North Umpqua	Water Quality*	Stream Complexity
South Umpqua	Water Quantity	Stream Complexity; Water Quality
Siltcoos	Exotic Fish Species	Stream Complexity; Water Quality
Tahkenitch	Exotic Fish Species	Stream Complexity; Water Quality
Tenmile	Exotic Fish Species	Stream Complexity; Water Quality
Coos	Stream Complexity	Water Quality
Coquille	Stream Complexity	Water Quality
Floras	Stream Complexity	Water Quality
Sixes	Stream Complexity	Water Quality

[1]Water quality limiting factors include excess fine sediment and high summer water temperature.
*Primary and secondary limiting factors for the Salmon River Population were previously hatchery impacts and stream complexity, respectively. Hatchery impacts were previously considered the primary limiting factor for the North Umpqua Population.

Stream complexity refers to the ability of a stream to provide a variety of habitats. The type of habitat most limiting in the OC Coho ESU is high quality over-winter rearing habitat. High quality over-wintering habitat for juvenile coho is usually recognizable by one or more of the following features: large wood, a lot of wood, pools, connected off-channel alcoves, beaver ponds, lakes, connected floodplains and wetlands. Therefore, more than one set of habitat conditions can provide high over-winter survival. High quality over-wintering habitat is almost always present only in areas where the stream is low gradient and there are broad valley areas alongside the stream. Because high quality over-winter rearing habitat can take many forms, the term stream complexity is used to define this limiting factor.

The secondary limiting factors, such as water quality, are important to address or maintain, and may become the primary limiting factors as efforts are made to address the current primary limiting factors and achieve broad sense goals or as environmental conditions change (e.g., climate change, See Section VIII, *Climate and Ocean Change*). However, it is expected that many of the actions taken through the OCCCP to address stream complexity will support maintenance or improvement of water quality suitable to native aquatic species, including coho salmon.

For this assessment, ODFW biologists reviewed the current limiting factors for each population to incorporate changes that may have occurred since 2005. During this review, few changes in current limiting factors were identified, and no new emerging limiting factors were found. Stream complexity and water quality continue to be the primary and secondary limiting factors for most of the populations in this ESU. However, it is notable that, where hatchery impacts were previously considered primary limiting factors (Salmon River and North Umpqua Populations), ODFW ended releases of hatchery coho smolts, resulting in substantial declines in the occurrence of naturally spawning hatchery fish (See Section VII. *Conservation Strategy and Actions*, below). Although these two populations may still have a genetic legacy from the discontinued hatchery programs, hatchery impacts are no longer considered a primary limiting factor.

Predation as a Limiting Factor

The importance of predation as a threat to coastal coho populations remains somewhat unclear, largely because of the inherent challenge in demonstrating clear cause-and-effect relationships in complex, multispecies food webs (Sih *et al.* 1998, Yodzis 2001). However, an emerging body of work suggests predation may exert a considerable influence on survival of Pacific salmon within, if not across, several life stages.

During the juvenile outmigration and early ocean period, predation by marine mammals (Thomas *et al*. 2017, Chasco *et al*. 2017, Nelson *et al*. 2018), avian predators (Osterback *et al*. 2013, Lyons 2016, Phillips *et al*. 2017, BRNW 2020), and fish (Beamish *et al*. 1992, Emmett and Sampson 2007) can be high, and it appears that predation during the early marine period may be a major driver of life-cycle scale mortality (Beamish and Mahnken 2001, Miller *et al.* 2013). Similarly, research suggests that predation on adult coho following return to their natal rivers can potentially reduce spawner abundance considerably (Wright *et al*. 2007). The impact of predation on salmonids is also likely to vary by species. In the Coquille basin, a recent downturn in Fall Chinook salmon returns may be due in part to the illegal introduction of smallmouth bass in 2010, but stream complexity and summer water quality likely remain the primary and secondary limiting factors for coho salmon. Across the ESU, available evidence does not appear to support the hypothesis that predation is currently a primary or secondary limiting factor for most local populations within the Oregon Coast coho ESU. This is primarily because elevated predation mortality would ultimately act on populations by depressing spawner abundance; however, habitat capacity for juvenile fish rather than spawner abundance currently appears to be the ultimate limiting factor across the ESU.

If spawner abundance or smolt-to-adult return rates for local populations consistently fail to meet management objectives, a closer evaluation of the effects of predation on ESU recovery may be warranted. ODFW also recognizes that the importance of predation may vary across spatial and temporal scales and may interact with periodic or ongoing environmental changes. For example, changes in ocean conditions across a variety of scales (e.g., ocean warming across the Northeast Pacific, regional-scale marine heat waves, changes in local upwelling patterns) could cause increased predator consumption of salmon as a result of a scarcity of alternative prey (Zamon *et al*. 2014, Weitkamp *et al*. 2016). This scenario has been demonstrated for several avian predators in the Columbia River estuary, which appear to consume far fewer juvenile salmonids during periods when northern anchovy and other alternative prey are locally abundant (Lyons *et al*. 2014, Collar *et al*. 2017, BRNW 2020). Additional work is needed to clarify potential interactions between predation and environmental change, particularly in relation to ongoing climate warming, which will likely become increasingly important as an ecological driver.

An exception to the above generalizations about predation applies to coho populations in the Lakes basins (Tahkenitch, Siltcoos, and Tenmile), which are primarily limited by interactions (including predation) with exotic (warmwater) fish species. Current ODFW fish management for these Lake basins recognize (1) these coho populations are currently viable; (2) there are negative effects of warmwater fish species on coho salmon; (3) there are ecological and feasibility issues with removing warmwater species; and (4) various social and economic entities support continuing fisheries associated with warmwater species.

Section VII. OCCCP Conservation Strategy and Actions

Overview of the OCCCP Conservation Strategy/Implementation of Oregon Plan

A conservation strategy to address the limiting factors for the OC Coho ESU is essential for achieving the OCCCP's broad sense goals. Even before the adoption of the OCCCP, ODFW had already taken actions to minimize adverse impacts from harvest and hatcheries on the ESU. In addition to continuing those actions, a primary focus of the OCCCP conservation strategy is on habitat, specifically to (1) protect the existing productive capacity of habitat to maintain viability of the ESU[17], and (2) enhance habitat to improve productive capacity. This strategy depends on implementation of programmatic regulatory and non-regulatory efforts, initiated through the Oregon Plan by multiple entities and at multiple spatial scales within the ESU.

Harvest Actions

One of the areas where ODFW began to take conservation actions prior to development of the OCCCP is harvest management. Oregon Coast coho salmon were subject to intense commercial and recreational fisheries in the ocean and freshwater for decades prior to significant fisheries reforms in the early 1990s (Fig. 26). In 1997, ODFW developed a harvest management plan that reduced harvest rates on OC coho salmon, made the annual allowable harvest rate dependent upon parental escapement and ocean survival, and implemented a "weak stock" management approach to protect the weakest sub-aggregate of coho stocks in ocean mixed stock fisheries. Oregon's coho harvest management plan was adopted by the Pacific Fisheries Management Council as Amendment 13 to the Pacific Salmon Fishery Management Plan for ocean fishery management.

A primary goal of Amendment 13 is *"to assure that fishery related impacts will not act as a significant impediment to the recovery of depressed OCN coho and to more uniformly rebuild each component population subgroup to a higher level"* (PFMC 1999). Since adoption of the OCCCP, Amendment 13 has continued to guide allowable harvest impacts on OC coho salmon in ocean fisheries and inland freshwater fisheries. Additional considerations for freshwater harvest of OC coho salmon are provided in Fisheries Management and Evaluation Plans for coastal lakes (ODFW 2003) and coastal rivers (ODFW 2009).

Amendment 13 establishes an annual allowable maximum fishery impact based on categorical rankings of parental spawners and projected marine survival. When Amendment 13 was developed, the Oregon Production Index Hatchery Coho[18] jack/smolt ratio was used as a predictor of marine survival because of limited data on marine survival of wild OC coho salmon. However, subsequent monitoring indicated that abundance and survival of Oregon Production Index Hatchery Coho are weakly correlated to the abundance and survival of wild OC coho. In 2013, ODFW recommended updates to the Amendment 13 harvest matrix that rely on ocean productivity metrics and ODFW coho monitoring data to significantly improve the marine survival forecast method (Suring and Lewis 2013). The harvest matrix now relies on smolt-to-

[17] In this context, the term protecting does not necessarily imply that all existing high-quality habitats will be preserved in their current state and location, because watershed conditions naturally evolve over time. Protection of existing productive capacity of the ESU implies that no long-term loss of productive capacity of habitat will occur across the ESU and the constituent populations.

[18] Oregon Production Index Hatchery coho are public hatchery origin coho salmon in the Oregon Production Index area, (Leadbetter Point, Washington to the U.S./Mexico border), with significant contribution by Columbia River and net pen programs. Additional details are available in PFMC (2020).

adult return rates of wild coho aggregated across all ODFW LCM sites as an index of marine survival; the trap catch of jacks at LCM sites and the peak jack count from OASIS spawning ground surveys are now two biological indicators, along with several ocean productivity indicators, for forecasting marine survival.

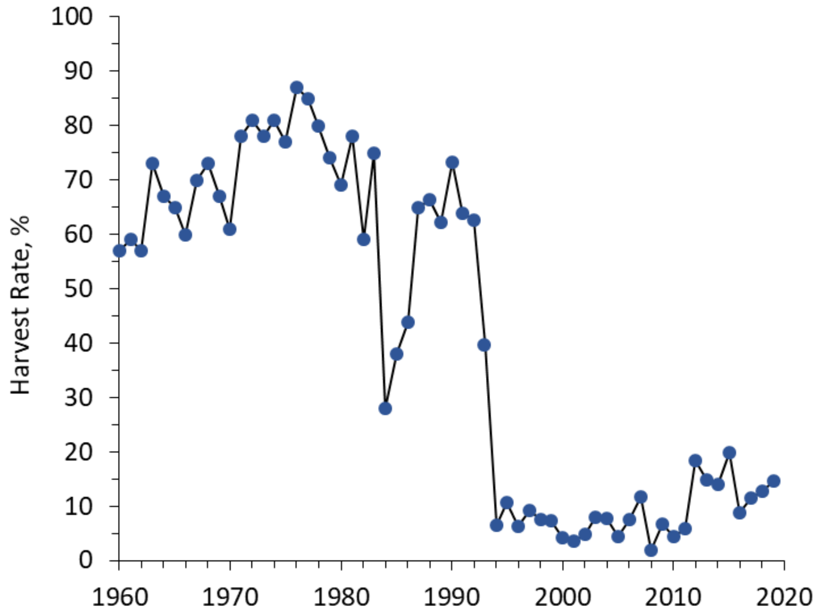

Figure 26. Harvest rates, 1960-2019, for the OC Coho ESU. Rates shown are total marine and freshwater exploitation rates.

Hatchery Actions

A second area where ODFW began to take coho conservation actions prior to development of the OCCCP is hatchery management. During the 1980s, releases of hatchery coho into Oregon coastal basins from public and private hatcheries regularly exceeded 20 million smolts per year. These hatchery releases were significantly reduced in the mid-1990s, resulting in substantial reductions in naturally spawning hatchery fish (Fig. 27). In the OCCCP, ODFW further committed to discontinuing hatchery smolt releases in the Salmon and North Umpqua rivers to improve the long-term viability of these populations. ODFW also committed to the incremental reduction of annual hatchery smolt releases from 520,000 to 260,000 ESU-wide. As a result, the occurrence of naturally spawning hatchery coho has remained low (Fig. 24; population-specific estimates are provided in *Appendix I, Measurable Criteria Assessment*).

Currently, the 260,000 hatchery coho smolts are released into three populations: Nehalem (100,000/yr - North Fork Nehalem), Tillamook (100,000/yr - Trask), and South Umpqua (60,000/yr). Hatchery releases in the North Fork Nehalem and Trask are for harvest augmentation; South Umpqua releases are intended to produce adult fish for harvest as mitigation for natural production lost in Cow Creek above Galesville Dam. At the North Fork Nehalem and Trask hatcheries, ODFW has initiated a transition from the current segregated hatchery broodstock to an integrated broodstock that regularly incorporates wild fish, with the first collections and egg take in 2020. The goal is to replace the long-term hatchery stock, further reducing the risk of impacts to wild OC coho while improving the fishery for hatchery coho in the future.

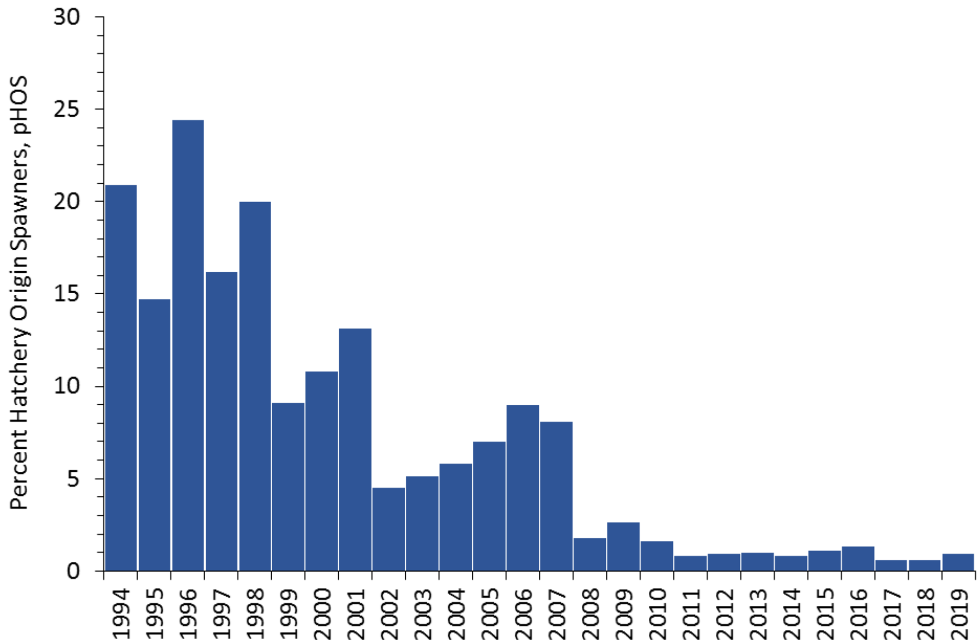

Figure 27. Percent hatchery origin spawners, pHOS, in the Oregon Coast Coho ESU, 1994-2019.

The last hatchery coho smolt releases into the Salmon River and North Umpqua River were in 2007 and 2006, respectively. Elimination of these releases resulted in significant reductions in naturally spawning hatchery fish in these populations (Fig. 28). Jones *et al*. (2018) documented some subsequent biological improvements in the Salmon River Population, and many DSS criteria for the North Umpqua Population (See Section III) have improved across the past three DSS assessments.

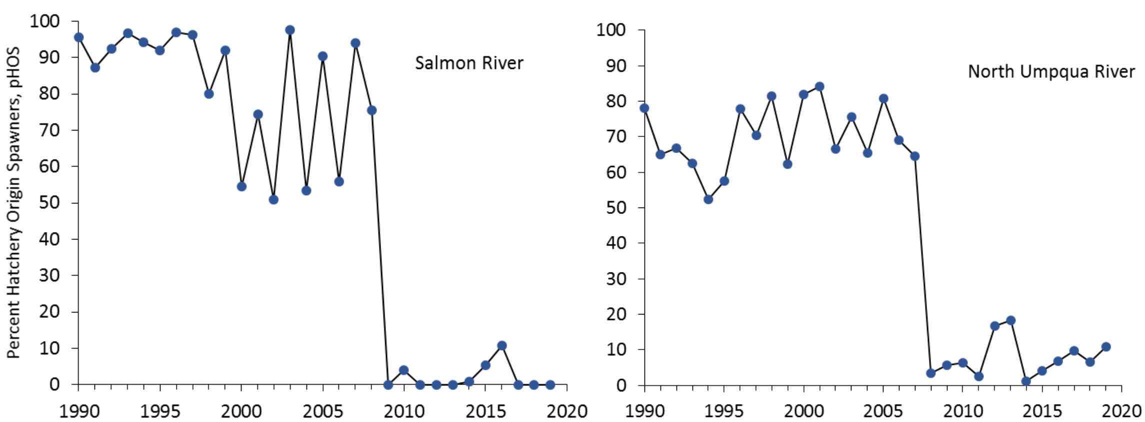

Figure 28. Reductions in the percent hatchery origin spawners following termination of coho smolt releases in the Salmon River Population (Left Panel, final substantial hatchery returns in 2008) and North Umpqua Population (Right Panel, final substantial hatchery returns in 2007).

Habitat Actions

A number of regulatory mechanisms protect habitat for OC coho salmon. However, Oregon believes that a combination of non-regulatory and regulatory mechanisms and a focus on building partnerships is more effective over the long term than relying solely on regulation. Through the Oregon Plan and implementation of the OCCCP, Oregon has made significant investments in non-regulatory programs and actions to improve water quality and quantity and restore habitat. Together with regulatory programs, these non-regulatory actions comprise Oregon's framework for habitat restoration and protection in the OC Coho ESU. Some of the significant updates to regulatory and voluntary programs since adoption of the OCCCP are highlighted below, and a detailed description of programs is provided in Appendix IV, *Oregon's Regulatory and Non-Regulatory Framework for Aquatic Habitat Restoration and Protection*.

Forestry

The Oregon Department of Forestry (ODF) protects, manages, and promotes stewardship of Oregon's forests. The ODF administers the Oregon Forest Practices Act (FPA), which sets standards for timber harvest, road construction and maintenance, treatment of slashing following harvest, use of forest chemicals, and reforestation on non-federal forestlands in Oregon. Since the adoption of the OCCCP in 2007, revisions to the FPA and associated rules include:

- Timber harvest operators are required to leave standing trees along non-fish bearing streams in debris torrent-prone areas (2007). The purpose of this rule is to provide a source of large wood that can be recruited into fish bearing streams by rapidly moving landslides.
- Streamside buffer and management rules were updated in 2015 to protect water quality, specifically the Protecting Cold Water criterion[19], following certain types of forest harvest. Updated rules increased stream buffer protections and basal area requirements in some riparian management areas.

Beyond FPA requirements, ODF encourages voluntary actions by private forest landowners to assist the recovery of threatened and endangered fish species as part of the Oregon Plan.[20] These actions extend beyond FPA requirements.

The Board of Forestry has also directed the ODF to evaluate a Habitat Conservation Plan (HCP) for western Oregon as a means of programmatic compliance with the ESA. HCPs are a mechanism for Endangered Species Act compliance intended to ensure species protection and conservation while also providing greater certainty to landowners. Staff from ODFW have worked on HCP planning and scoping teams with multiple agencies and entities, including ODF, the Oregon Department of Environmental Quality, the Oregon Department

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[19] The purpose of the Protecting Cold Water (PCW) criterion is to prevent anthropogenic warming in stream reaches that consistently meet the numeric temperature criteria throughout the summer. The PCW criterion limits new sources and activities to a cumulative warming of no more than 0.3 °C above the current ambient summer maximum temperature in streams that: a) contain salmon, steelhead or bull trout, b) streams designated as critical habitat for salmonids, or c) streams that are necessary to provide cold water to a) and b). This PCW criterion is intended to prevent or minimize degradation of these high quality and ecologically important streams by giving a quantitative limit to warming.

[20] See *Private Forest Owners and the Oregon Plan* (2012) at: http://www.oregon.gov/ODF/Documents/WorkingForests/Oregon_Plan_PFguide.pdf

of State Lands, the U.S. Fish and Wildlife Service, NOAA Fisheries, and Oregon State University.

Agriculture

In 1993, the Oregon Legislature adopted the Agricultural Water Quality Management Act creating the Agricultural Water Quality Management Program administered by the Oregon Department of Agriculture (ODA). Through this program, ODA works with Soil and Water Conservation Districts and Local Advisory Committees (farmers, ranchers, and stakeholders) to develop water quality management plans and adopt regulations in Oregon's 38 water quality regions. Since adoption of the OCCCP in 2007, all agricultural water quality management plans within the OC Coho ESU have been updated. The Oregon Legislature has continued to authorize and provide significant funding to ODA, the Oregon Watershed Enhancement Board (OWEB) and soil and water conservation districts to implement outreach, technical and financial assistance, project development, and compliance actions where needed.

In 2015, ODA began implementing a Strategic Implementation Area program to assess water quality conditions associated with agricultural lands and strategically focus resources and compliance actions to improve conditions where needed. In this approach, selected areas receive targeted outreach and education to address priority water quality concerns. Following an ODA-led Compliance Evaluation, ODA and its partners work with agricultural landowners to concentrate technical and financial assistance to change agricultural activities that may be reducing water quality. Following outreach and assistance, ODA may enforce regulations where problems persist. To date, eight Strategic Implementation Areas have been selected within the OC Coho ESU: 4 within the Nehalem Population, 2 within the Coquille Population, and 1 each within the Tillamook and Yaquina populations.

Water Quality and Quantity

The Oregon Department of Environmental Quality (ODEQ) is charged with restoring, maintaining and enhancing Oregon's waters. Since adoption of the OCCCP, ODEQ has continued efforts to improve water quality within the OC Coho ESU, including TMDL[21] development and implementation, updating and issuing discharge permits, and providing technical assistance and grant funding to guide water quality restoration. The Oregon Water Resources Department (OWRD) manages Oregon's water resources. The OWRD administers water rights, including instream water rights, manages a network of stream flow gages across Oregon (in cooperation with the U.S. Geological Survey and other gage operators), and provides water resource support through technical assistance and grants including Place-Based Planning Grants, Feasibility Study Grants, and Water Project Grants and Loans. Both agencies have recently completed significant strategic planning efforts to guide Oregon's water programs into the future:

- In 2015, ODEQ developed the Water Quality 2035 Vision and Strategy, which sets a vision for the agency's water quality programs in 2035 and provides strategic priorities, tactics, and five-year work plans to move toward that vision.

[21] TMDLs are Total Maximum Sustainable Loads, which are plans to restore impaired waters so that they meet state water quality standards. A TMDL is the highest amount (load) of a pollutant that can enter a surface water body while still meeting the standard for that pollutant.

- In December 2012, the Water Resources Commission adopted Oregon's first Integrated Water Resources Strategy. Updated in 2017, the strategy provides a framework for better understanding and meeting instream and out-of-stream water needs, including water quantity, water quality, and ecosystem needs.

Other recent water-related developments include:

- Place-Based Integrative Water Resources Planning is a voluntary, locally led effort for water resources planning, with OWRD providing significant investment to support planning efforts. The Mid Coast planning region, encompassing the Salmon River, Siletz, Yaquina, Beaver Creek, and Alsea coho populations (and several dependent populations) was initiated in 2016 as one of the first Place-Based Planning grant awards (*https://www.midcoastwaterpartners.com/*). In 2019, the Oregon Legislature approved additional funding for Place-Based-Planning.
- In 2020, ODEQ completed the 2018/2020 Integrated Report, which represents the state's most comprehensive evaluation of water quality data and information about Oregon's waters, including those within the OC Coho ESU. This assessment will help guide water quality programs and efforts to restore water quality.
- Staff at ODFW are currently modeling potential future stream temperature and flow conditions under various climate change scenarios to understand the scope of changes expected and to help prioritize watersheds for protection and restoration based on their climate resilience (see Section VIII below).

Waterway Regulation, Instream Activities and Impacts to Wetlands

The Oregon Department of State Lands (DSL) protects and conserves waterways through administration of a statewide program to regulate fill and removal in waters of the State of Oregon. In 2015, the DSL collaborated with NOAA-Fisheries and ODFW on internal guidance to DSL staff on how to regulate the placement or removal of pilings in key coastal lakes that have been identified as sensitive habitat for OC Coho. This guidance helps reduce risks for OC Coho in coastal lakes that have coho use and/or Designated Critical Habitat.

Development and Land Use Planning

The Oregon Land Use Program (Oregon Department of Land Conservation and Development) directs most new development in Oregon into areas already impacted by development. This is achieved statewide utilizing three strategies: 1) confining new urban development to development zones, which are only allowed within established urban growth boundaries; 2) restricting the siting of new structures and roads that do not serve a commercial agriculture or forestry use within farm and forest zones; 3) restricting the rezoning of rural lands in farm and forest zones to other rural zones, such as rural residential or rural industrial. Since OCCCP adoption, very little land has been added to coastal urban growth boundaries, and conversion of exclusive farm use and forest zones to other rural uses has stayed low. The result is that there has been much less rural residential development than would have occurred without Oregon's land use laws.[22]

[22] For a comparison of farm/forest land conversion in Oregon and Washington since 1974 see, *Land Use Change on Non-Federal Land in Oregon & Washington*, Oregon Department of Forestry and US Forest Service, 2013

Estuary Protection and Restoration

Oregon's Statewide Planning Goal 16 (Estuarine Resources) applies an added layer of protection for estuaries in Oregon's Coastal Management Area. Overall, nearly 94% of Oregon's existing estuarine area is designated in local estuary management plans as either natural or conservation. These plans have had only minor changes since their original adoption more than 30 years ago. No major tracts of natural or conservation estuary management units have been re-designated in a manner that would permit higher intensity development such that outright loss of estuarine habitat has effectively been halted. While significant historical losses of estuarine habitat due to past land use and development activity pre-date implementation of the statewide planning program, the current management approach established through local estuary plans has provided a high level of protection for remaining critical resources.

In addition to the protective measures above, Oregon has worked to restore estuarine habitats and to provide fish passage in tidally influenced areas. Examples include:

- The OWEB commissioned a review and synthesis of knowledge on the ecological effects of tide gate upgrade or removal (Souder *et al*. 2018).
- Staff with ODFW's Fish Passage and Fish Research projects are collaborating to develop a tide gate prioritization tool to identify locations where improved fish passage is likely to have the greatest benefit for salmonids and other native fish. Local tide gate inventories and prioritizations for restoration also have been recently completed by watershed councils and other partnerships in some coastal areas.
- With the collaboration of many state, federal, and local partners, the Southern Flow Corridor project combined flood mitigation with habitat restoration by restoring over 500 acres of tidal wetland and reconnecting 14 miles of historical lower river tributaries. Along with projects in the Miami wetlands, lower Kilchis tidewater, and Tillamook River wetlands (not yet implemented), projects have reached approximately 600-700 acres and will provide significant over-winter rearing habitat for juvenile salmonids in the Tillamook basin.
- In 2018, the Winter Lake Restoration Project was completed on working lands in the Coquille Watershed with the collaboration of multiple state, federal, and local partners. The project reconnected nearly 8 miles of tidal channel, restored 408 acres of tidal wetlands, and installed 7 new tide gates. The project improves water control on 1,700 acres of land, allows cattle to graze in the summer for several additional weeks, and improves conditions for winter rearing juvenile salmonids.
- In 2018, the Oregon Central Coast Estuaries Collaborative, a network of estuary conservation and restoration practitioners, completed a Strategic Action Plan to guide implementation of priority restoration projects in estuaries on Oregon's central coast, from Nehalem Bay to the Siuslaw Estuary (https://www.orcentralcoastestuaries.com).

Above tidewater, there have also been significant efforts to restore access throughout the ESU. For example, the Salmon SuperHwy Project and partners have completed a number of passage improvement projects in the Tillamook and Nestucca basins, with a goal of restoring access to approximately 95% of historic habitat (http://www.salmonsuperhwy.org/).

Beaver Management

The ODFW continues to promote beaver dams in OC Coho rearing habitats, and Oregon has adopted statutes likely to benefit beaver and the habitat they provide for OC Coho. These include:

- *Relocation/Reintroduction* (ODFW; ORS 497.308; 498.002): Trapping, transporting, and releasing beaver on public land or across property boundaries requires a permit and monitoring.
- *Beaver Dam Removal* (DSL; OAR 141-085): A permit for dam removal recently became required (as *Large Woody Debris*, defined at OAR 141-085-0510(47)); a permit is required for any removal at sites within Essential Salmonid Habitat (ESH), except 1 cubic yard (cy) per site may be removed by hand; a permit is required for removal of equal to or greater than 50 cy outside of ESH.

In addition to these regulatory measures, Oregon has implemented a beaver workgroup comprised of ODFW staff and members from a variety of agencies/interests to work collaboratively to achieve the following mission:

"Using existing rules and statutes, identify research and information gaps to help us improve our understanding of beaver ecology and beaver management so we can maximize the ecological benefits that beaver provide (especially for ESA-listed coast coho), and minimize any negative economic (or other) impacts."

This workgroup has encouraged, supported and disseminated beaver-related research and has produced relocation guidelines, a landowner incentives and tolerances survey (Needham and Morzillo 2011), a bibliography of beaver-related research, and map products consistent with encouraging beaver conservation. Key needs around beaver management to benefit coho salmon into the future include (1) judiciously managing riparian, floodplain, and stream habitats to foster beaver presence, (2) building a better understanding of the factors that influence dam building by beavers, (3) promoting circumstances that allow beaver to build dams, and (4) working to develop and efficiently provide non-lethal solutions to beaver damage issues.

The ODFW has also partnered with the Upper Nehalem Watershed Council, NOAA Restoration Center and National Fish and Wildlife Foundation to implement a beaver dam analogue pilot study. The goal of the study is to evaluate beaver dam analogues as dam building foundations and for their ability to provide persistent pools comparable to the natural beaver pools known to provide high quality over-winter rearing habitat for juvenile coho salmon.

Coho Business Plan and Strategic Action Plans (SAPs)

In 2014, ODFW partnered with OWEB, NOAA Fisheries, the NOAA Restoration Center, the Wild Salmon Center, and the National Fish and Wildlife Foundation to advance regional recovery goals for Oregon's coast coho salmon with local implementation of the two coastal coho conservation and recovery plans (the OCCCP and the NOAA Fisheries Recovery Plan for the Southern Oregon/Northern California Coast Coho ESU). The goals of this partnership were 1) to develop and facilitate a repeatable methodology for aiding local partnerships in prioritizing habitat protection and restoration actions for independent coho populations on the

Oregon coast; and 2) coordinate funding for locally led implementation of priority actions identified in the completed plans.

The foundation of the repeatable methodology was formed by using existing ODFW and NOAA Fisheries terminology and standardized concepts from the *Open Standards for the Practice of Conservation (Open Standards)*[23] to establish a consistent approach for describing and classifying ecosystems, ecological processes, species, and associated natural and human-made threats. The methodology is compatible for use at different scales (reach, sub-watershed, watershed, ESU) allowing for a consistent approach in evaluating the status of the current conditions of the physical and biological habitat features essential to the conservation and recovery of coho salmon, and the development of appropriate goals and metrics to evaluate ecosystem function. This foundation became the "Common Framework" used by the partnership as an integral part of the Coho Business Plan in creating consistency in the methodology used to develop population specific strategic action plans (SAPs) for coho salmon on the Oregon coast.

Each SAP contains four key elements: 1) conservation goals; 2) priority actions to achieve the goals; 3) implementation cost summaries; and 4) quantitative performance measures. The SAP assists in keeping focus on the goals and key actions through clear identification of a strategy. Each SAP may have a different final implementation strategy with the three key approaches being: Working Lands, Community Resilience, and All Lands. The Wild Salmon Center manages the project on behalf of the partnership and works with each of the local SAP teams to determine the strategy that works best for the local community.

In 2015, three coastal watershed teams were selected to participate in the first round of SAP development, with the Elk, Nehalem and Siuslaw populations serving as pilot projects. Since then, three more coho salmon populations (Siletz, Coos, and Upper Rogue) have been selected for SAP development and are in process. Completed SAPs can be found here.

Continuing Investments in Habitat Restoration and Protection

In addition to the programs described above and in Appendix IV, continued investment in habitat restoration and protection is an integral component of the strategy for attaining broad sense goals for the OC Coho ESU and its constituent populations. Since the initial ESA-listing of OC coho salmon, Oregon has implemented a unique and significant effort to conserve OC coho through the Oregon Plan and implementation of the OCCCP. The Oregon Lottery Revenues for Parks and Conservation Act (1998 Oregon Ballot Measure 66) initiated a constitutional amendment dedicating 15% of lottery revenues to parks, beaches, salmon protection, wildlife habitat restoration, and watershed protection. This dedicated funding was made permanent in 2010 with the passage of Oregon Ballot Measure 76,[24] establishing a reliable, long-term source of funds for habitat restoration. These funds are leveraged with

[23] Information on Open Standards can be found at *http://www.conservationstandards.org/*

[24] Oregon Constitution, Article XV, Section 4(8) reads, *"Effective July 1, 1999, 15% of the net proceeds from the State Lottery shall be deposited in a parks and natural resources fund created by the Legislative Assembly. Of the moneys in the parks and natural resources fund, 50% shall be deposited in a parks subaccount and distributed for the public purposes of financing the protection, repair, operation, and creation of state, regional and local public parks, ocean shore and public beach access areas, historic sites and recreation areas, and 50% shall be deposited in a natural resources subaccount and distributed for the public purposes of financing the restoration and protection of native fish and wildlife, watersheds and water quality in Oregon. The Legislative Assembly shall not limit expenditures from the parks and natural resources fund, or from the parks or natural resources subaccounts. The Legislative Assembly may appropriate other moneys or revenue to the parks and natural resources fund."*

other funds, including the Pacific Coastal Salmon Recovery Fund. Established by Congress in 2000, the Pacific Coastal Salmon Recovery Fund has provided critical support for OC coho monitoring programs and for projects to restore habitat, remove barriers to fish passage, improve water quality, and track restoration progress. This concerted effort has resulted in the implementation of thousands of projects to restore instream and riparian habitats throughout the OC Coho ESU.

The OWEB Investment Tracking Tool (Oregon Explorer) provides a means for identifying restoration activities funded through OWEB to support habitat restoration and protection in each OC Coho population area. Table 14 summarizes investments in restoration and protection since OCCCP adoption for project categories including watershed council support, education and outreach, monitoring, restoration, and technical assistance. Although investment categories like council support and education/outreach are not necessarily project specific, they are crucial for building and maintaining the capacity and support for on-the-ground restoration. Projects include a variety of implementers, including watershed councils, tribes, soil and water conservation districts, state agencies, and federal agencies. Table 15 summaries implementation results (e.g., number of stream miles treated, etc.).

These summaries do not include projects implemented prior to the OCCCP, and investment amounts do not include leveraged funds associated with these projects or significant investments through other federal funding mechanisms such as the conservation programs of the National Resources Conservation Service. Federal agencies like the National Resources Conservation Service provide funding for voluntary conservation and restoration work, including riparian restoration, wetland conservation, irrigation management and on-farm conservation practices, and barrier removal projects, among other actions. The Farm Services Agency is another federal agency that contributes to voluntary restoration in Oregon, primarily via the Conservation Reserve and Enhancement Program. The focus of this program is to establish long-term riparian buffers on eligible land. While the summaries provided in Tables 14 and 15 are not comprehensive, they provide an indication of the magnitude of efforts to protect and restore habitat within the OC Coho ESU.

In 2016, OWEB established a new grant program, Focused Investment Partnerships, which can provide partnerships with up to $12 million over six years to address one of seven ecological priorities for Oregon. One of these priorities is Coho Habitat and Populations along the Oregon Coast. The Focused Investment Partnerships apply adaptive management and monitoring around a framework linking restoration strategies to desired outcomes (The Focused Investment Partnerships Coho Results Chain is available here). This grant program adds another tool for continued investment in habitat restoration and protection in the OC Coho ESU.

Table 14. Cumulative annual investments by category for each OC Coho population for actions implemented by organizations including watershed councils, tribes, Soil and Water Conservation Districts, state, and federal agencies from 2007-2019. The table was created using the OWEB Investment Tracking Tool to identify annual investments in capacity building, outreach/education/stakeholder engagement, monitoring, restoration, and technical assistance funded by OWEB to support conservation and recovery of healthy watersheds within the OC Coho ESU. Some grants are also awarded by strata (actions target more than one population); stratum totals reflect these grants + constituent populations. Investments reported here do not show significant funds leveraged by association with these awards.

Spatial Extent	Investment Category					Total
	Council Support	Education & Outreach	Technical Assistance	Monitoring	Restoration	
North Coast Stratum	$2,654,915	$32,892	$1,076,588	$643,917	$7,051,536	$11,459,848
Necanicum	$446,875	$32,892	$125,523	-	$209,317	$814,607
Nehalem	$928,745	-	$498,978	$141,621	$3,247,270	$4,816,614
Tillamook	$595,441	-	$137,694	$492,097	$2,588,163	$3,813,395
Nestucca	$565,429	-	$211,989	-	$1,006,786	$1,784,204
Mid-Coast Stratum	$1,427,254	$564,562	$1,772,284	$2,832,228	$3,651,339	$10,247,667
Salmon	-	$34,000	$223,394	$624,557	$200,359	$1,082,310
Siletz	-	-	$49,985	$361,303	$1,425,898	$1,837,186
Yaquina	-	-	$128,891	$84,450	$283,500	$496,841
Beaver	-	-	-	-	$303,663	$303,663
Alsea	-	-	$340,955	$362,676	$589,676	$1,293,307
Siuslaw	$644,311	$380,672	$701,329	$177,423	$741,325	$2,645,060
Lakes Stratum	$526,498	$10,285	$28,424	$454,538	$1,487,447	$2,507,192
Siltcoos	-	$10,285	-	-	$154,793	$165,078
Tahkenitch	-	-	-	-	$1,047,750	$1,047,750
Tenmile	$526,498	-	$18,424	$454,538	$278,337	$1,277,797
Umpqua Stratum	$1,563,475	$170,886	$1,089,814	$964,792	$5,301,966	$9,090,933
L. Umpqua	$447,678	$159,690	$303,617	$3,673	$1,131,382	$2,046,040
M. Umpqua	$541,885	-	$98,819	$571,400	$2,018,018	$3,230,122
N. Umpqua	$118,425	-	$492,463	$57,614	$702,736	$1,371,238
S. Umpqua	$455,487	$11,196	$194,915	$332,105	$1,449,830	$2,443,533
Mid-South Coast Stratum	$1,048,625	$215,968	$1,547,990	$1,205,958	$8,321,008	$12,339,549
Coos	$437,909	$182,267	$753,174	$1,047,271	$3,820,327	$6,240,948
Coquille	$610,716	-	$710,103	$53,290	$4,313,861	$5,687,970
Floras	-	-	$48,240	$7,644	$156,803	$212,687
Sixes	-	-	$36,473	$97,753	$30,017	$164,243
ESU Total	$7,220,767	$994,593	$5,515,100	$6,101,433	$25,813,296	$45,645,189

Table 15. Summary of projects implemented with funding through OWEB within the OC Coho ESU since adoption of the OCCCP (2007-2019). The table was generated with the OWEB Investment Tracking Tool and may include a small number of projects located within the Elk River basin and small direct ocean tributaries adjacent to the southern boundary of the OC Coho ESU.

Project Result	Quantity
Number of Projects Implemented	3,262
Road/Stream Crossings Improved for Fish Passage (Number of Crossings)	718
Fish habitat Made Accessible due to Road/Stream Crossing Improvements (Total Miles)	719
Instream Activities (Total Miles of Stream Treated)	741
Riparian Activities (Total Linear Stream Miles Treated)	1,168
Riparian Activities (Total Acres Treated)	8,140
Upland Activities (Total Acres Treated)	19,527
Wetland Activities (Total Acres Treated)	943
Estuarine Activities (Total Acres Treated)	2,058
Flow Rate of Water Diverted by Screened Diversions (cfs)	149

Section VIII. Climate and Ocean Change

Background

Records spanning up to several thousand years demonstrate that warming of the global climate system, as well as warming and acidification of the ocean, are occurring and that the rate of change since the 1950s is unprecedented (IPCC 2014). There is strong scientific support for projections that warming will continue through the 21st century and that the magnitude and rate of change will be influenced substantially by the amount of greenhouse gas emissions (IPCC 2014). Ocean acidification is also expected to continue through the end of the century under most greenhouse gas emission scenarios and could accelerate as the ocean's buffering capacity diminishes (Jiang *et al*. 2019).

In 2020, the Oregon Fish and Wildlife Commission adopted a Climate and Ocean Change Policy (OAR 635-900-0001) to ensure that ODFW prepares for and responds appropriately to the impacts of a changing climate and ocean. The policy provides high level direction to ensure that ODFW understands the risks and opportunities associated with changing climate and ocean conditions and incorporates that understanding into agency actions. Consistent with that direction, this section of the 12-year assessment summarizes climate and ocean change projections, describes possible effects on OC coho salmon, and identifies adaptation strategies and actions to ameliorate potential negative impacts and promote population resilience.

Climate Change and Ocean Acidification on the Oregon Coast

Increases in global air temperature, ocean temperature, and ocean acidification will continue to drive changes in climate and ocean conditions in the Pacific Northwest. If greenhouse gas emissions continue at current levels, the average annual air temperature in Oregon is projected to increase by 5°F (2.8°C) by the 2050s and 8.2°F (4.6°C) by the 2080s, with the largest seasonal increases occurring in summer (Dalton and Fleishman 2021). Seasonal changes in precipitation and increased drought frequency are also expected (Dalton and Fleishman 2021), with important consequences for stream flow volume and timing. The following sub-sections outline changes expected to occur, based on currently available science, for several key metrics (*stream temperature*, *flow volume and timing*, *sea level rise*, *sea surface temperature*, *upwelling*, and *ocean acidification*) linked to OC coho salmon freshwater or marine habitat. These changes could affect coho salmon growth and survival through numerous pathways during their life cycle (Wainwright and Weitkamp 2013).

Stream Temperature

High stream temperatures have been linked to reduced coho salmon parr abundance (Ebersole *et al*. 2009), higher susceptibility to disease (Cairns *et al*. 2005), and lower freshwater production (Lawson *et al*. 2004) in the OC Coho ESU. Poor water quality, which generally includes high summer water temperatures and excess fine sediment, is currently a secondary limiting factor for most OC coho salmon populations (Table 13). Water quality may become a primary limiting factor if increases in summer stream temperatures outpace management actions that increase shade and reduce water temperatures.

In the absence of counteracting management actions, summer stream temperatures in the OC Coho ESU are expected to increase in the future due to rising air temperatures and decreased base flows (see Flow Volume and Timing section below). The projected scope of temperature change and ecological consequences for coho salmon will vary across the ESU. Maximum Weekly Maximum Temperature (MWMT), the peak annual seven-day average daily maximum temperature for a given stream reach (Fig. 29)[25], is projected to increase by less than 1°C to over 1.5°C by the 2040s, depending on location in the ESU (Fig. 30). By the 2080s, MWMT increases ranging from less than 1°C to over 2.5°C are projected (Fig. 31). The biggest increases are projected for larger streams and mainstem river reaches in the southern half of the ESU. Many of these stream reaches already have limited rearing potential due to high stream temperatures (Fig. 29).

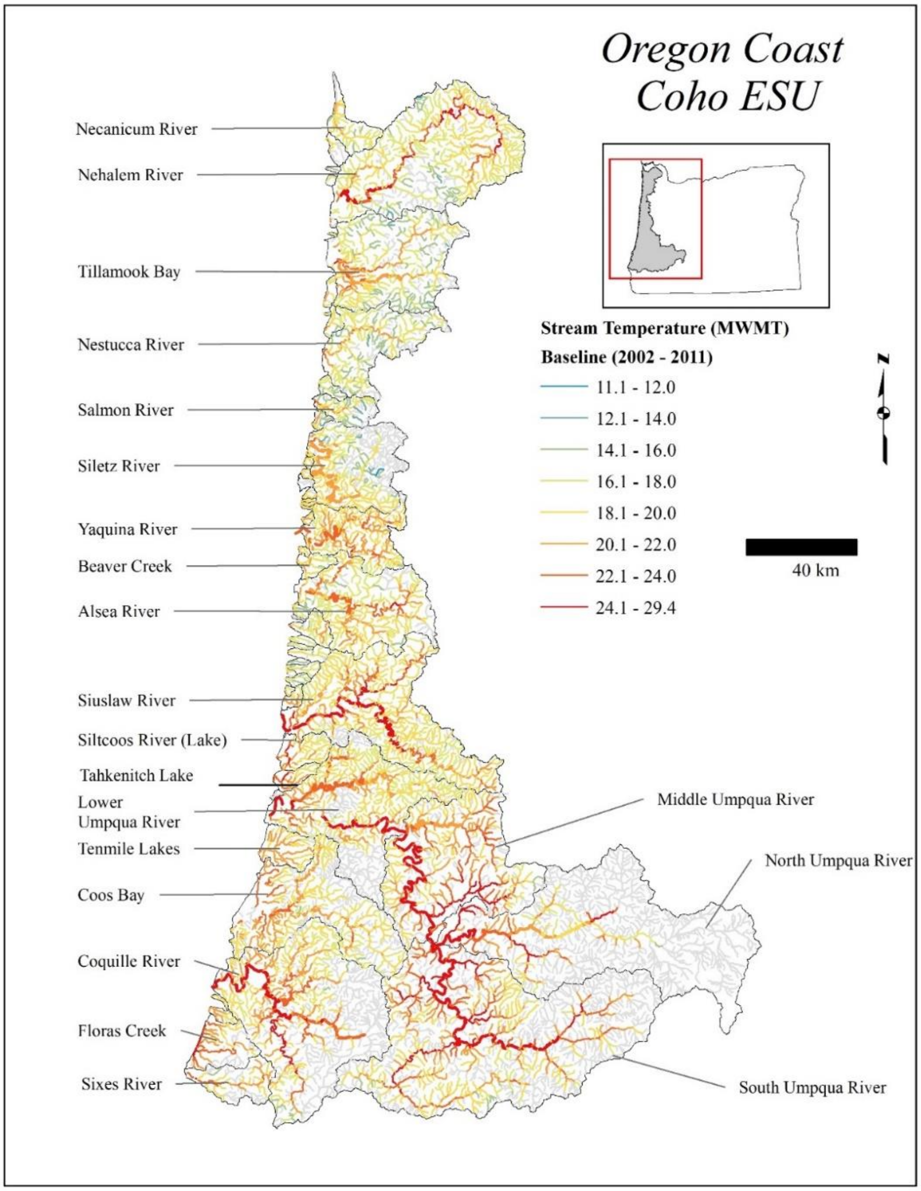

Figure 29. Baseline (2002-2011 average) Maximum Weekly Maximum Temperature (MWMT) estimates (°C) for stream reaches in the OC Coho ESU. Reach specific estimates were obtained from NorWeST (Isaak *et al*. 2016).

[25] Reach specific MWMT estimates were obtained from NorWeST (Isaak *et al*. 2017). Baseline (historical) values are based on estimates from 2002-2011; future projections are ensemble model averages for the 2040s (2030-2059) and 2080s (2070-2099) based on the A1B emissions scenario (Isaak *et al*. 2016).

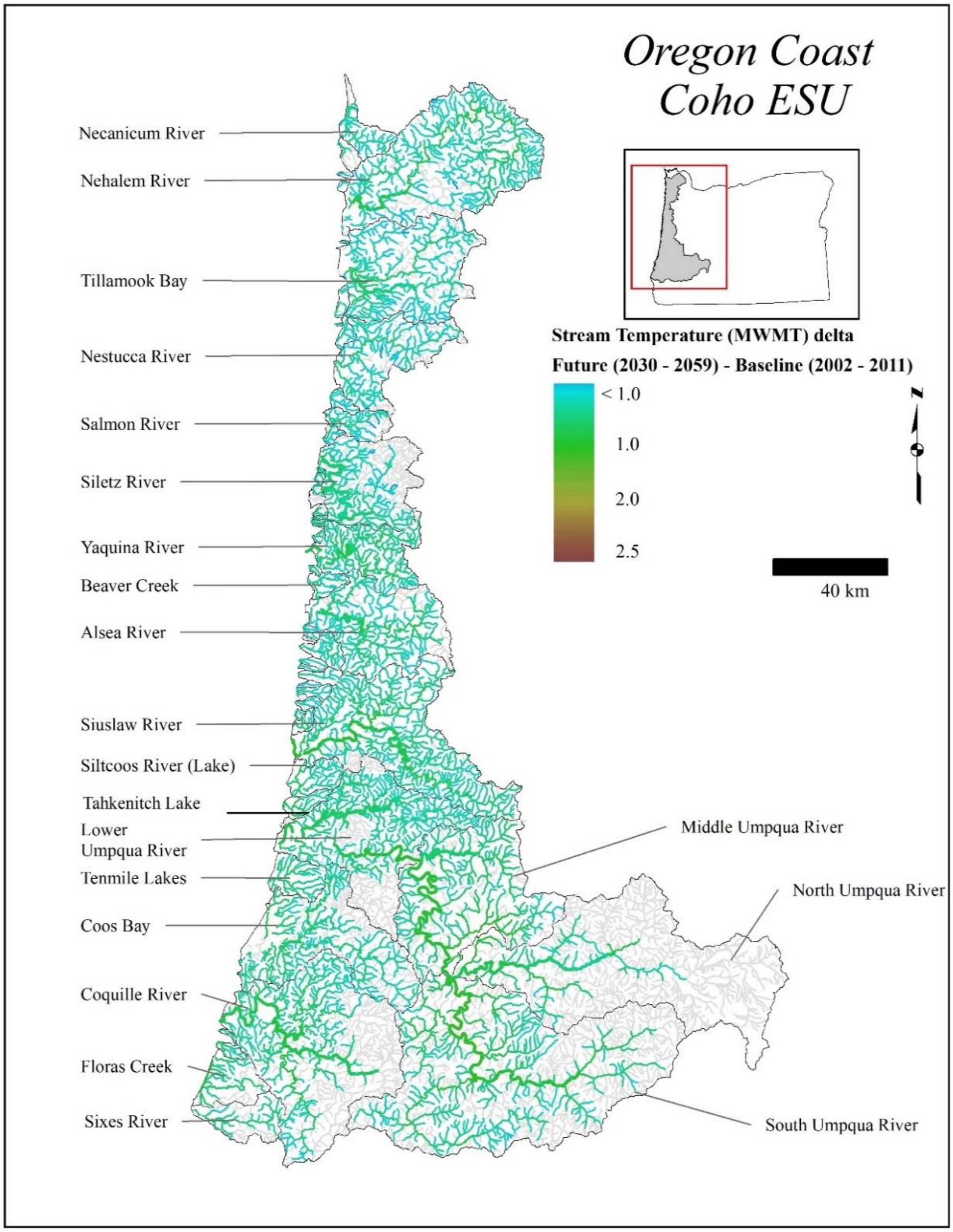

Figure 30. Projected change (°C) in Maximum Weekly Maximum Temperature (MWMT) between baseline (2002-2011) and the 2040s (2030-2059) under the A1B emissions scenario. Reach specific estimates were obtained from NorWeST (Isaak *et al*. 2016). NorWeST predictions of stream temperature change in the future assume no changes to surrounding land management, which can either exacerbate or mitigate the changes expected as a result of climate change.

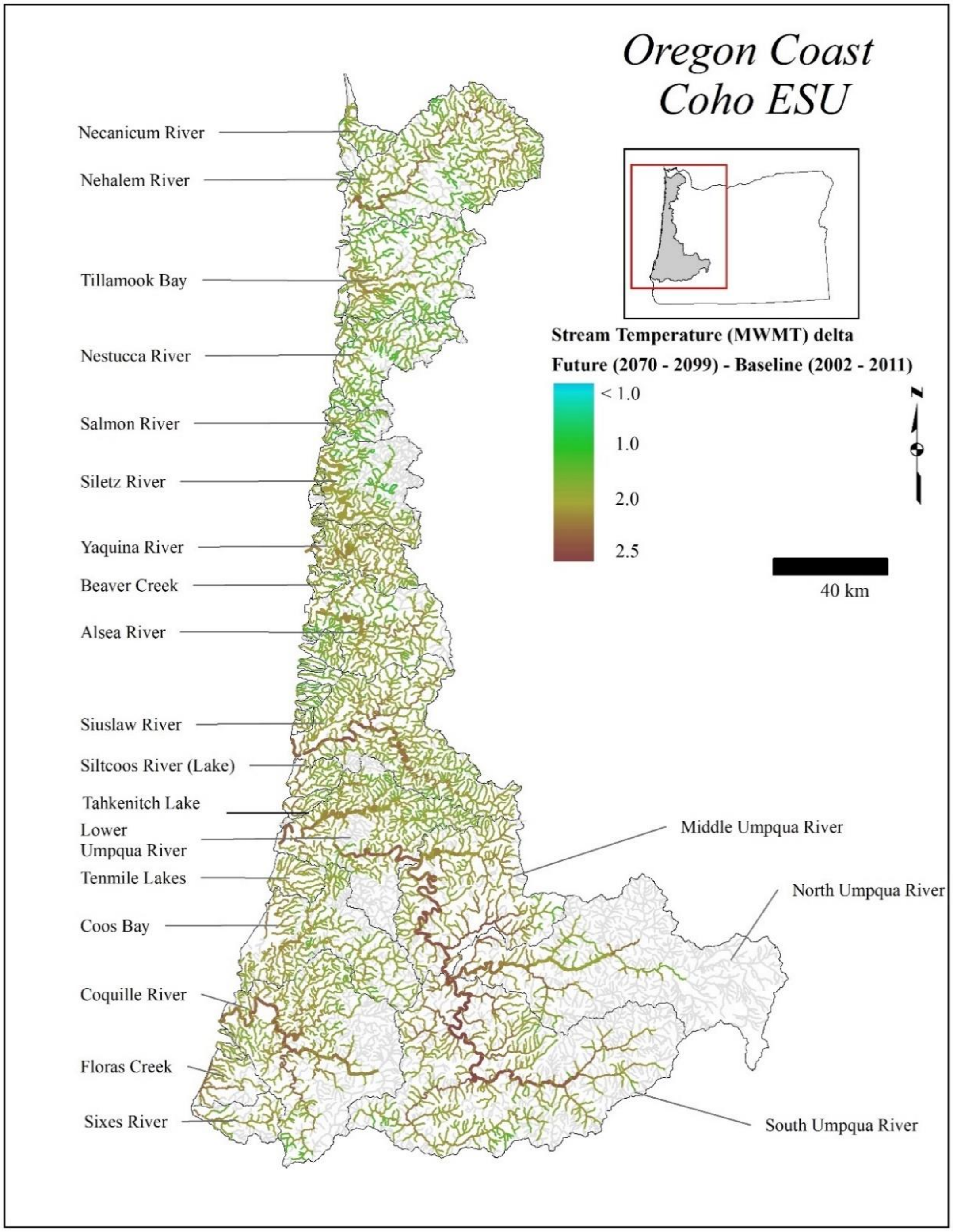

Figure 31. Projected change (°C) in Maximum Weekly Maximum Temperature (MWMT) between baseline (2002-2011) and the 2080s (2070-2099) under the A1B emissions scenario. Reach specific estimates were obtained from NorWeST (Isaak *et al*. 2016). NorWeST predictions of stream temperature change in the future assume no changes to surrounding land management, which can either exacerbate or mitigate the changes expected as a result of climate change.

Increased stream temperatures have the potential to impact juvenile coho production throughout the ESU by limiting growth, abundance, and distribution. For example, streams with a MWMT (7-day average maximum temperature) ≤ 18°C meet the State of Oregon's temperature criterion for protecting the temperature-sensitive, beneficial use of salmon and trout rearing and migration (OAR 340-041-0028). Although juvenile coho salmon commonly rear in stream reaches with MWMT higher than 18°C, stream reaches with MWMT ≤ 18°C are most likely to provide optimal conditions for juvenile coho growth (Richter and Kolmes 2005). In the absence of counteracting management actions, the percentage of total stream kilometers with MWMT ≤ 18°C[26] is projected to decrease substantially in the future in all populations (Table 15). Projected short- and long-term losses vary considerably among populations depending on current temperatures and the scope of warming expected.

Table 15. Baseline (2002-2011 average) and projected future (2040s and 2080s) stream length with MWMT ≤ 18°C in each of the 21 independent populations of the OC Coho ESU. Reach specific estimates were obtained from NorWeST (Isaak *et al*. 2016); future estimates are based on the A1B emissions scenario. NorWeST predictions of stream temperature change in the future assume no changes to surrounding land management, which can either exacerbate or mitigate the changes expected as a result of climate change.

Population	Total Length (km)	Total stream length (km) ≤ 18°C			Percent stream length (%) ≤ 18°C		
		Baseline	2040s	2080s	Baseline	2040s	2080s
Necanicum	149	71	43	17	47.6	28.7	11.1
Nehalem	1,487	594	340	147	39.9	22.8	9.9
Tillamook Bay	980	483	405	261	49.3	41.3	26.6
Nestucca	610	328	264	160	53.7	43.2	26.3
Salmon	168	83	67	49	49.4	40.1	29.0
Siletz	870	192	139	88	22.1	16.0	10.1
Yaquina	550	43	13	2	7.8	2.4	0.4
Beaver	63	26	13	7	40.7	21.4	11.1
Alsea	841	215	168	33	25.5	20.0	3.9
Siuslaw	1,462	205	64	2	14.0	4.4	0.1
Lower Umpqua	1,448	212	95	13	14.6	6.5	0.9
Middle Umpqua	1,258	39	14	9	3.1	1.1	0.7
North Umpqua	2,195	65	32	3	3.0	1.5	0.2
South Umpqua	3,091	165	148	33	5.3	4.8	1.1
Siltcoos	135	25	8	0	18.2	6.1	0.0
Tahkenitch	63	12	5	0	19.3	7.8	0.0
Tenmile	157	11	0	0	6.8	0.0	0.0
Coos	1,169	160	62	14	13.7	5.3	1.2
Coquille	1,930	177	86	28	9.2	4.5	1.5
Floras	207	0	0	0	0.0	0.0	0.0
Sixes	209	13	8	6	6.1	3.9	2.9

[26] Reach-specific MWMT values from NorWeST shown in Figure 26 and summarized in Table 15 are modeled estimates (Isaak *et al*. 2017) and are not indicative of status relative to Oregon water quality standards.

The effect of increasing summer water temperature on juvenile coho abundance and smolt production will depend on many factors, including temperature heterogeneity and the presence of thermal refuges within reaches, food resource availability to support increased metabolic needs, and the quality and quantity of overwinter habitat available to juvenile fish that survive the summer period. It is also crucial to note that future temperature projections presented here do not account for management actions that can mitigate increases due to warming air temperatures. For example, the potential to cool water by increasing stream shading can be greater than projected water temperature increases due to climate change (Wondzell *et al*. 2019).

Finally, warming air temperatures are expected to drive increased water temperature across all seasons, not just summer. The scope of these changes will vary geographically depending on seasonal shifts in flow volume and timing (see below) and other factors. Increased temperatures in winter, spring, or fall could affect egg incubation and fry emergence timing, juvenile growth and survival, and pre-spawn mortality in returning adults (Reeves *et al*. 2018). There is low certainty about these effects and their potential impact on productivity at the population scale.

Flow Volume and Timing

The timing and magnitude of stream flow affects all aspects of coho salmon life history during the freshwater portion of their life cycle, including spawn timing and distribution, redd scour and egg survival, habitat quantity and quality for rearing juveniles, overwinter survival of coho salmon parr, and outmigration timing of smolts. The impact of climate change on stream flows is expected to vary within the ESU and between seasons. Across all strata, late fall and winter flows are projected to increase, while spring, summer, and early fall flows are expected to decrease (Fig. 32). The largest percentage change in flows are expected in the Umpqua stratum, which extends into the Cascade Range. Higher temperatures and reduced snowpack in the Umpqua basin are projected to result in larger decreases in late spring and summer flows compared to other strata (Fig. 32).

Decreased summer and early fall flows would directly affect rearing capacity by reducing the depth and volume of stream habitats available to juvenile coho salmon, changes that could be exacerbated by water temperature increases described above. Connectivity within stream reaches could also be reduced, limiting the ability of fish to make adaptive movements between habitats or seek out temperature refuges. These effects may be particularly important in Umpqua basin, where water quantity is already considered a primary limiting factor in the Middle Umpqua and South Umpqua populations (Table 13). It is important to note that flow projections presented here are for late century, will not necessarily result in a corresponding decrease in habitat, and may be mitigated by management actions.

Projected changes in stream flow in other seasons are smaller in scope but could have important positive or negative consequences for coho salmon. For example, increased winter flows and flooding may reduce habitat quality and overwinter survival in the short term but could also improve habitat conditions in the long term if sources of large wood are available (Reeves *et al*. 2018). Reduced spring flows could affect smolt out-migration timing and survival, as well as dispersal and survival of newly emerged fry. Additional details on projected seasonal changes in flow are presented in the sections below.

Figure 32. Projected percentage change in median monthly stream flow in 2080 relative to the historical baseline (1915–2006) for the five strata in the Oregon Coast Coho ESU. Projections were developed using the Variable Infiltration Capacity (VIC) model (Liang *et al*. 1994; Hamman *et al*. 2018) based on the A1B emissions scenario.

Fall Stream Flow

Median stream flow during fall (October–December) is projected to increase in most of the ESU due to increased precipitation. Projected increases are ≤10% for most streams, but larger changes are expected in higher elevation areas in the northern portion of the ESU. Although fall flows are expected to increase overall, early fall flows are expected to decrease along with late summer flows (Fig. 33).

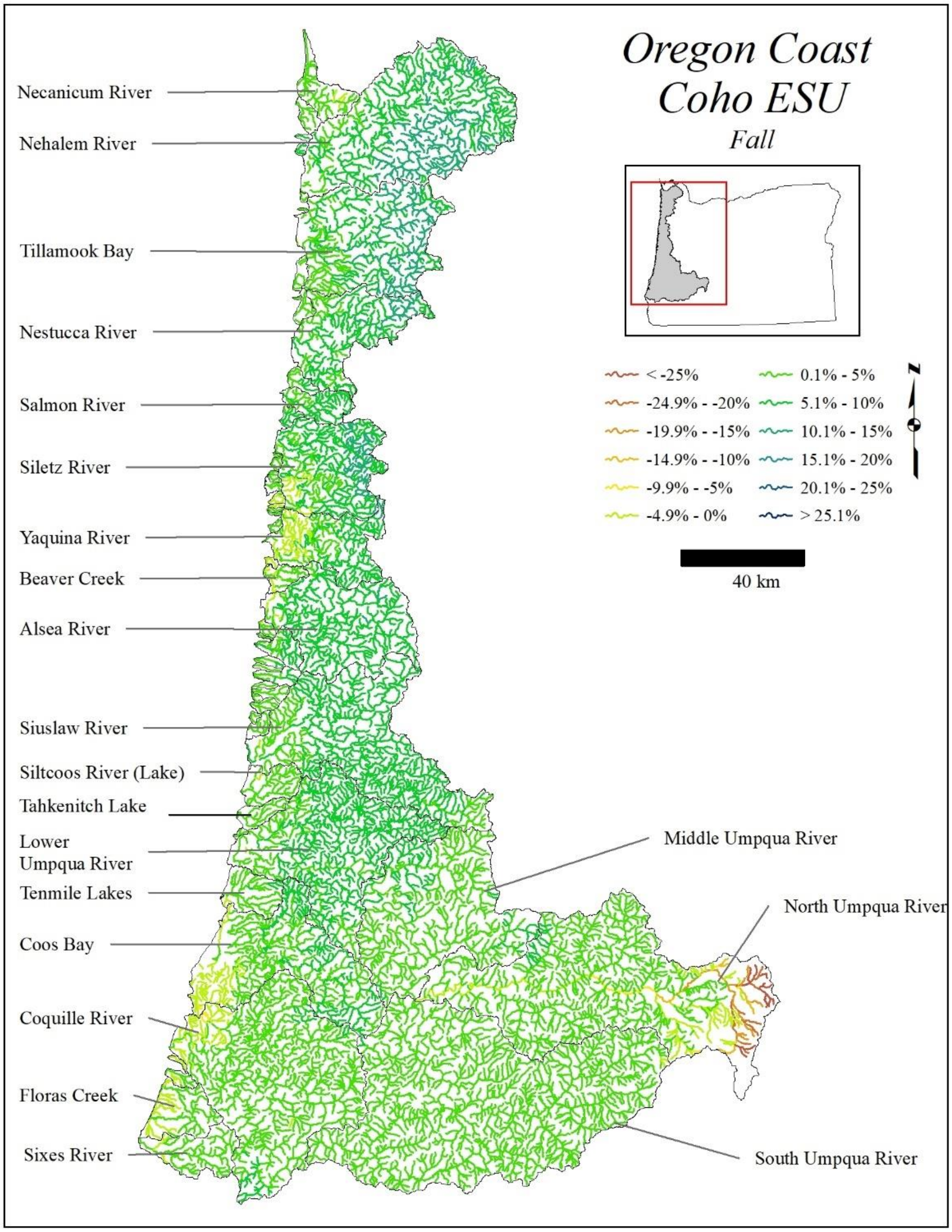

Figure 33. Projected percentage change in median fall stream flow in 2080 relative to the historical baseline (1915–2006) in the OC Coho ESU. Projections were developed using the VIC model (Liang *et al*. 1994; Hamman *et al*. 2018) based on the A1B emissions scenario.

Winter Stream Flow

Winter stream flow is projected to increase throughout most of the ESU due to increased precipitation (Fig. 34). Projected increases are ≤10% for most streams, but larger changes are expected in the upper Umpqua basin due to a shift in winter precipitation from snow to rain. In addition to overall increases in winter flow, the frequency of major storms and high flow events is expected to increase in the future. Major winter storm events tend to be associated with the occurrence of atmospheric rivers that carry large quantities of warm, wet air from the Pacific Ocean (Warner *et al*. 2015). Warner *et al*. (2015) project a 20% increase in the frequency of atmospheric river events by 2080 relative to the period 1970-99. Similarly, Mote *et al*. (2019) projected a 10% increase in extreme precipitation events in winter in western Oregon by mid-century.

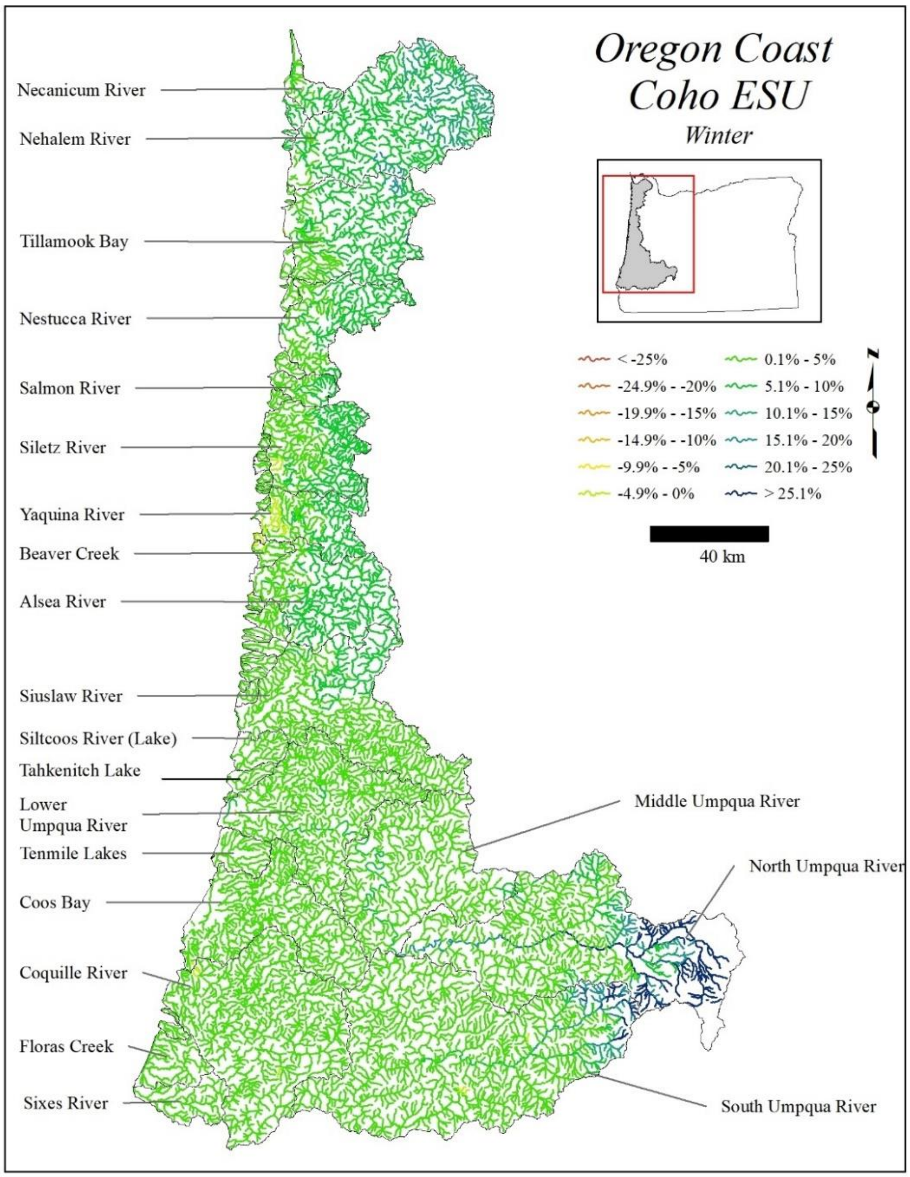

Figure 34. Projected percentage change in median winter stream flow in 2080 relative to the historical baseline (1915–2006) in the OC Coho ESU. Projections were developed using the VIC model (Liang *et al*. 1994; Hamman *et al*. 2018) based on the A1B emissions scenario.

Spring Stream Flow

Reduced spring flows are projected for most of ESU, with the largest decreases projected for the southern half of the ESU (Fig. 35). In the upper Umpqua basin, a significant decrease in spring flow is projected for some mid-elevation streams due to reduced snowpack, while significant increases are projected for the highest elevation streams due to earlier snowmelt.

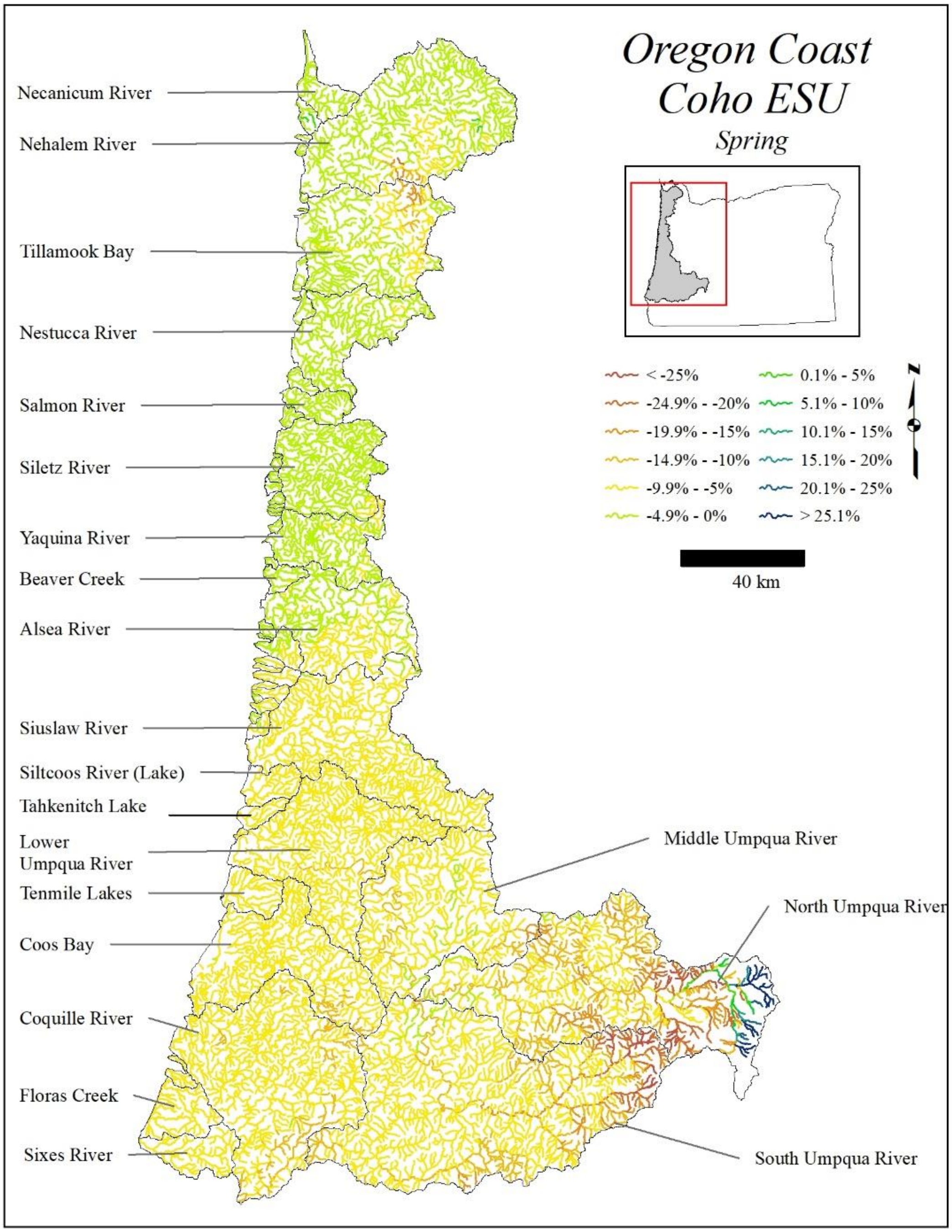

Figure 35. Projected percentage change in median spring stream flow in 2080 relative to the historical baseline (1915–2006) in the OC Coho ESU. Projections were developed using the VIC model (Liang *et al*. 1994; Hamman *et al*. 2018) based on the A1B emissions scenario.

Summer Stream Flow

Summer stream flow is projected to decrease throughout the ESU (Fig. 36), with reductions ranging from 5–20% in most streams. Larger decreases are expected in the upper Umpqua basin due to decreased snowpack and earlier snowmelt (Halofsky *et al*. 2020). Summer stream flow could also be affected by aspects of climate change that are not incorporated in the modeling presented below. For example, changes in vegetation due to increased wildfire or insect induced tree mortality may initially increase water yield by decreasing canopy interception and transpiration (Halofsky *et al*. 2020), but if such disturbances keep forests in earlier seral stages, an increase in transpiration may reduce low flows (Perry and Jones 2017).

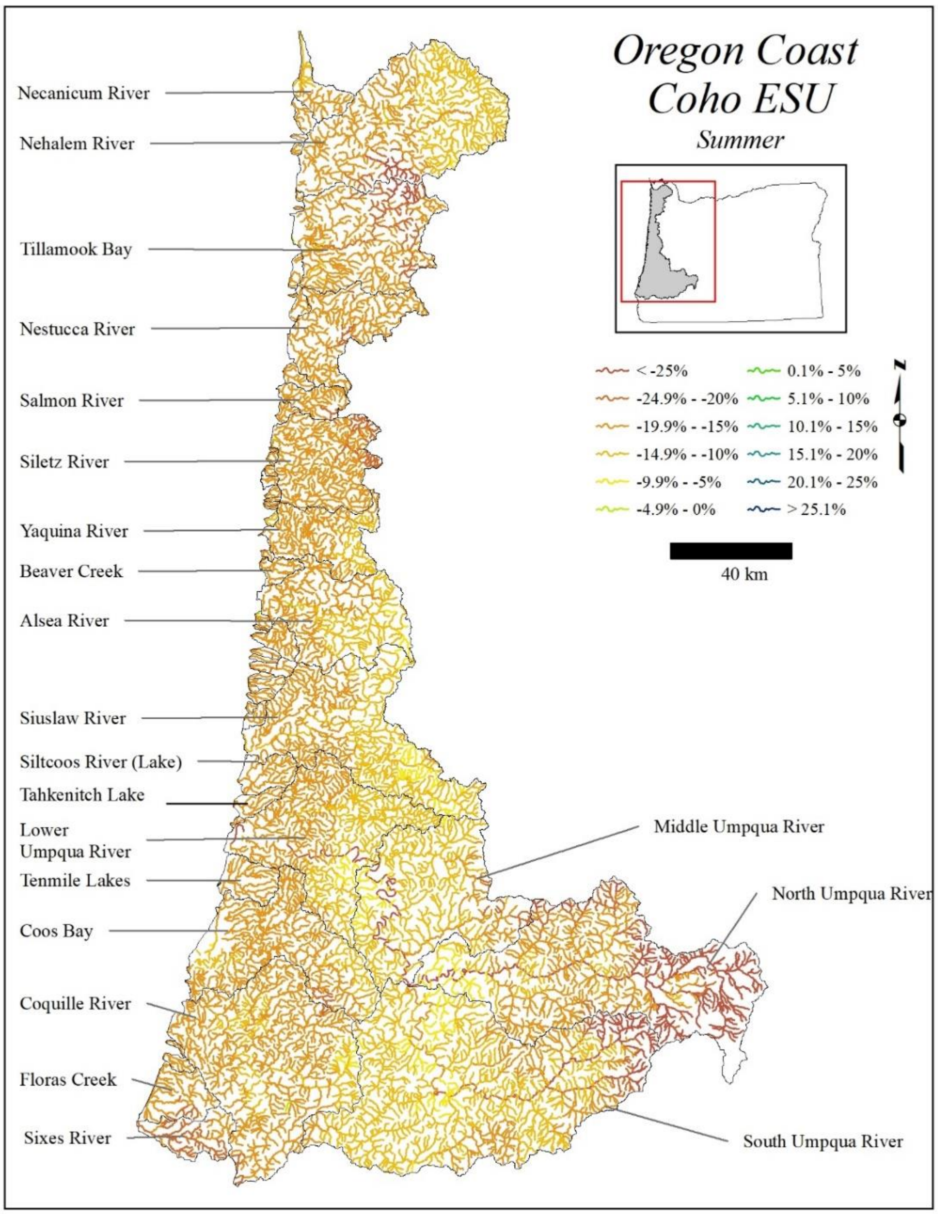

Figure 36. Projected percentage change in median summer stream flow in 2080 relative to the historical baseline (1915–2006) in the OC Coho ESU. Projections were developed using the VIC model (Liang *et al*. 1994; Hamman *et al*. 2018) based on the A1B emissions scenario.

Sea Level Rise

Estuarine habitats utilized by OC coho salmon for rearing and migration will be affected by ongoing sea level rise, which is projected to continue past 2100 under all likely climate scenarios (IPCC 2019). Under Representative Concentration Pathway (RCP) 8.5, the highest greenhouse gas concentration trajectory adopted by the IPCC (IPCC 2014; see Schwalm *et al*. [2020] for additional details on RCP 8.5), the projected global mean sea level rise is 0.71 m (likely range: 0.51–0.92 m) for 2081–2100 and 0.84 m (likely range: 0.61–1.10 m) in 2100 (IPCC 2019). Effects of sea level rise on estuary habitat quality and quantity for coho salmon are complex and depend on estuary topography and anthropogenic impacts that constrain tidal influence and habitat development (Flitcroft *et al*. 2013). Many estuaries have limited scope for migration and are thus expected to experience major shifts in estuarine habitat type with sea level rise (Thorne *et al*. 2018). These changes have the potential to affect growth and survival of coho salmon that migrate through or have alternate life history strategies with extended rearing in the estuaries (Wainwright and Weitkamp, 2013). The Nehalem, Tillamook Bay, Yaquina, Alsea, Siuslaw, Umpqua, and Coos Bay systems have the largest estuaries in the ESU and could be most affected by sea level rise.

Sea Surface Temperature

Coho salmon marine survival is generally correlated with patterns of sea surface temperature (SST) and large-scale climate indices such as the Pacific Decadal Oscillation, North Pacific Gyre Oscillation, and various El Niño-Southern Oscillation indices (Mantua *et al*. 1997; Logerwell *et al*. 2003; Malick *et al*. 2015). Annual average sea surface temperature is projected to increase by 2.4–3.6°F by the end of century (based on RCP 8.5 scenario) within the northeastern Pacific (Fig. 37). The largest increases are expected to occur in the northern portion of the northeastern Pacific. Additionally, marine heat waves have doubled in frequency since 1982 and are increasing in intensity. They are projected to further increase in frequency, duration, extent and intensity. Their frequency will be 20 times higher at 3.6°F warming, compared to pre-industrial levels. They will occur 50 times more often if emissions continue to increase strongly (IPCC 2019).

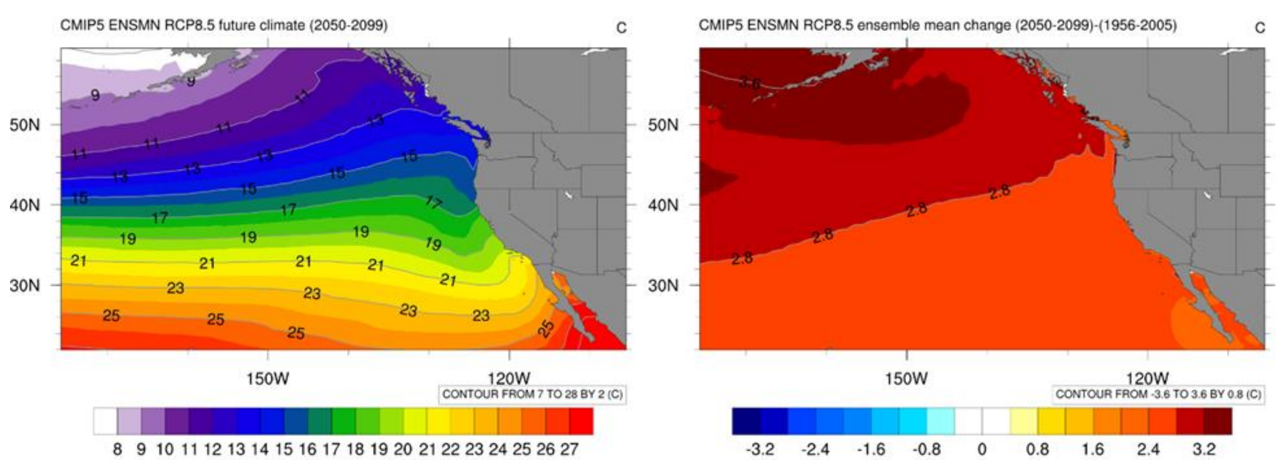

Figure 37: Left Panel: RCP 8.5 future SST for the period 2050-2099; Right Panel: Difference in mean SST between future (2050-99) and reference period (1956-2005). SST interpolated on a 1°x1° grid for the entire year. Figure downloaded from the Climate Change Web Portal of the NOAA Earth Systems Research Laboratory (https://www.esrl.noaa.gov/psd/ipcc/ocn/).

Upwelling

The marine survival of coho salmon, particularly at ocean entry, is also closely linked to the occurrence and intensity of upwelling (Nickelson 1986; Holtby *et al*. 1990; Logerwell *et al*. 2003), which drives the input and retention of cold, nutrient-rich waters to the euphotic zone[27]. Timing, intensity, and inter-annual variability of upwelling varies across the ocean range of OC coho salmon, with the highest intensity and variability occurring off northern California (Bograd *et al*. 2009). The most recent models suggest that in the northern California Current System (CCS), upwelling will become more intense in the spring and less intense in the summer as a result of anthropogenic climate change (Rykaczewski *et al*. 2015). Changes in upwelling due to climate change will emerge primarily late in the second half of the century (Brady *et al*. 2017). There remains substantial uncertainty in upwelling predictions because the ensembles include relatively coarse-resolution global models from which it is difficult to resolve local dynamics in the CCS (Rykaczewski *et al*. 2015).

Ocean Acidification

Ocean pH levels have been declining as a result of uptake of CO_2 from the atmosphere. The California Current Large Marine Ecosystem (CCLME) is experiencing greater ocean acidification because of the combination of upwelling currents that transport dissolved inorganic carbon rich water from the deep ocean and high productivity of the shelf that increases potential for remineralization (Chan *et al*. 2017). Within the CCLME, the nearshore region (<10 km from shore) is most strongly affected by current, and likely future, acidification resulting in reduced abundance and increased corrosion in the shells of calcifying organisms (Feely *et al*. 2016). In offshore areas (>10 miles from shore) within the ocean feeding grounds of OC coho salmon, surface pH is expected to decrease by 0.24-0.32 units by the end of the century (Fig. 38). Data collected off the Oregon coast indicate that ocean pH is significantly lower within the nearshore area (<10 miles from shore) (pH 7.43) than the global mean (pH 8.1), and it is expected that this area will be more susceptible to acidification (Chan *et al*. 2017). Although direct impacts of pH have been shown for many taxa in the CCLME (Busch and McElhany 2016), including salmon (Williams *et al*. 2019), there is considerable uncertainty in projecting future impacts.

[27] The euphotic zone is a surface water layer in which the penetration of solar radiation is sufficient for photosynthesis.

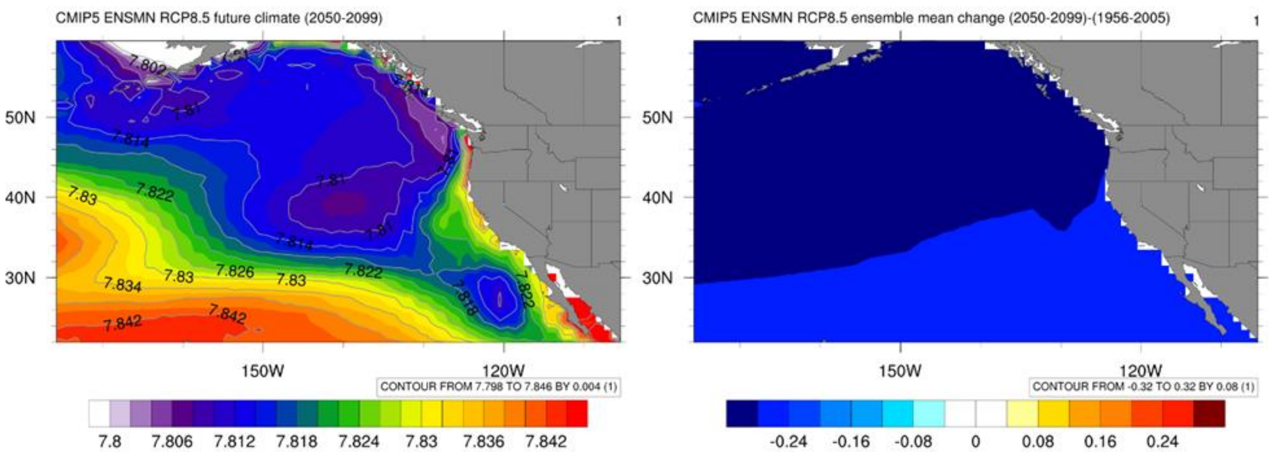

Figure 38: Left Panel: RCP 8.5 future surface pH for the period 2050-2099; Right Panel: Difference in mean surface pH between future (2050-99) and reference period (1956-2005). Surface pH interpolated on a 1°x1° grid for the entire year. Figure downloaded from: https://www.esrl.noaa.gov/psd/ipcc/ocn/.

Future Outlook and Management

Climate change-driven alterations of freshwater and marine habitat are expected to impact the abundance and productivity of OC coho salmon populations. Although some projected changes could be positive for coho salmon, negative impacts are more likely overall when the full spectrum of habitats and life stages are considered (Wainwright and Weitkamp 2013). While the impacts of climate and ocean change for OC Coho salmon are likely to be negative overall, there is some uncertainty in the spatial and temporal nature of impacts and how ecosystems, and species, will adapt. Impacts are expected to vary substantially across the ESU, with some populations more vulnerable than others due to current habitat status and the magnitude of expected change. Risk to population viability will also depend on the scope and effectiveness of actions taken to promote resilience and reduce vulnerability of OC coho salmon populations to climate change impacts.

Vulnerability as described by the IPCC (2007) is a function of the sensitivity of a particular species or system to climate changes, its exposure to those changes, and its capacity to adapt to those changes. Crozier *et al*. (2019) completed a formal vulnerability assessment of ESA-listed Pacific salmon and steelhead ESUs based on these three elements of vulnerability and concluded that OC coho salmon had high vulnerability to climate change due to high exposure and sensitivity. The assessment concluded that the Oregon Coast Coho ESU had moderate adaptive capacity. These findings are consistent with the potential impacts described above and highlight the importance of implementing actions to increase the resilience of these populations.

The primary management strategy to minimize the long-term impacts of climate and ocean change on OC coho salmon centers on the protection, restoration, and enhancement of key freshwater and estuarine habitats. Maintaining and restoring diverse and productive rearing habitats will support the expression of the full complement of life history diversity and help sustain populations through cycles in ocean productivity, which may become more extreme and unfavorable in the future. Many of the changes in the freshwater habitat expected with climate change are lower in magnitude than those observed following alteration of habitat for human uses, so there is clear potential to mitigate against climate effects with actions to restore or enhance habitat. Table 16 lists specific habitat-focused strategies and actions that could reduce risk from climate and ocean change. Many of the actions in Table 16 are also identified in the Final ESA Recovery Plan for Oregon Coast Coho Salmon (NMFS 2016) and are being implemented in the ESU to address primary and secondary limiting factors. To provide the greatest long-term benefit, these actions need to be targeted at locations that are most likely to support OC coho now and in the future. Therefore, climate change projections and considerations should be incorporated into the development of population-specific strategic action plans (SAPs) to the extent possible.

Changes in summer stream flow and temperature are among the more certain climate change effects (Wainwright and Weitkamp 2013) and are likely to reduce the quantity and quality of rearing habitat for juvenile coho salmon in the absence of counteracting management actions (Table 16). In most populations, winter parr capacity will continue to limit smolt production in the near term due to a lack of stream complexity. However, increasing water temperatures and decreasing base flows in the future could eventually create an even more severe summer habitat bottleneck. In addition, thermally stressful summer rearing conditions could reduce subsequent overwinter survival (Ebersole *et al*. 2006), worsening the winter bottleneck that may also be exacerbated by increased flows. Thus, there is a need to continue work to restore stream complexity, while also prioritizing actions that mitigate expected changes in summer temperature and flow (Table 16). Many actions to reduce stream temperatures or increase base flows could take many years to produce peak benefits, and so initiating these actions now in priority locations is critical. This is particularly important in the southern half of the ESU, where summer temperature and flow conditions are most likely to become a primary limiting factor in the foreseeable future. Staff at ODFW are also working with partners to improve stream temperature monitoring throughout the ESU, which will increase our understanding of the thermal characteristics of streams in all seasons and track changes in temperature over time.

Projected changes in the ocean environment are largely outside of management control, and so adaptation strategies are focused primarily on restoring and enhancing freshwater and estuarine habitats (Table 16). However, there may be opportunities to mitigate the impacts of increasing ocean acidification and hypoxia by reducing other stressors. In 2017, the Oregon Coordinating Council on Ocean Acidification and Hypoxia (OAH Council) was created to provide recommendations and guidance for the State of Oregon on how to respond to this issue. The ODFW has had a leadership role in the OAH Council and will continue to look for ways to mitigate and respond to OAH.

Habitat protection, restoration, and enhancement are the key to reducing climate and ocean change risk and ensuring continued progress toward desired status for the OC Coho ESU. Nevertheless, harvest and hatchery management will continue to play an important role in maintaining the genetic and life history diversity of OC coho salmon and supporting fishing opportunity consistent with ESU recovery. Current harvest management under the Amendment 13 framework considers both parental escapement and ocean survival and is responsive to downturns. This framework has ensured that harvest rates remain consistently low, while also allowing for increased fishing opportunities when ocean survival and adult abundance are high. Robust monitoring programs focused on OC coho salmon and their ocean habitats have facilitated implementation of Amendment 13, and will be critical for adaptive management in the face of changing ocean conditions. Hatchery management in the OC Coho ESU will continue to focus on augmenting harvest opportunity in the ocean and select terminal areas while minimizing genetic and ecologic risks to wild fish. Recent changes in brood stock management for the North Fork Nehalem and Trask hatchery programs, which have relied on highly domesticated brood stocks for many years, are expected to further reduce genetic risks, as well as improve survival and harvest opportunities.

Table 16. Key projected climate and ocean change effects, potential consequences, adaptation strategies, and priority actions for coho salmon in the OC Coho ESU. Adapted from Beechie *et al*. (2013), Wainwright and Weitkamp (2013), and Reeves *et al*. (2018).

Projected Effect	Potential Consequences	Adaptation Strategies	Priority Actions
Increased summer water temperatures	• Reduced juvenile rearing habitat • Reduced or increased juvenile growth rates depending on temperature and food resources • Increased susceptibility to disease • Increased predation risk from non-native warmwater fish species	• Prioritize restoration actions in watersheds (e.g., fifth field HUCs) with cooler water • Increase stream shading • Protect and restore instream flows • Increase surface-subsurface water exchange • Restore lateral and longitudinal connectivity	• Increase temperature monitoring • Restore riparian vegetation • Purchase or lease water rights from willing sellers to place instream • Restore incised channels • Increase floodplain connectivity • Remove artificial barriers to restore access to cooler water
Reduced summer flows	• Reduced juvenile rearing habitat • Reduced juvenile growth rates	• Protect and restore instream flows • Restore floodplain aquifer storage • Manage watersheds to reduce evapotranspiration loss	• Purchase or lease water rights from willing sellers to place instream • Promote beavers and beaver-related pond habitat • Restore incised channels • Research forest management options to increase base flows
Increase in winter flows and major storm events	• Increased sediment input and transport • Increased large wood recruitment and transport • Increased redd scour and egg mortality • Reduced juvenile overwinter survival	• Increase stream complexity • Increase estuary rearing habitat	• Restore riparian vegetation • Protect and enhance large wood sources in landslide-prone areas • Restore incised channels • Increase floodplain connectivity • Promote beavers and beaver-related pond habitat

Projected Effect	Potential Consequences	Adaptation Strategies	Priority Actions
			• Restore and improve access to key estuary habitats
Sea level rise	• Reduced tidal wetland habitat • Altered estuarine food web • Reduced or increased estuarine rearing habitat	• Reduce anthropogenic barriers to tidal influence and estuarine habitat expansion • Improve estuary water quality • Improve fish access to estuary habitat	• Restore natural tidal flow where possible • Support land acquisition and easements along estuaries • Reduce nonpoint pollution to improve coastal water quality • Prioritize and implement tidegate fish passage improvements
Increased sea surface temperature	• Altered marine food web • Increased predation risk • Increased thermal stress • Reduced marine growth and survival	• Increase freshwater and estuarine rearing habitat • Promote life history diversity	• Monitor ocean ecosystem indicators • *See freshwater and estuarine habitat actions listed above*
Increased ocean acidification	• Altered marine food web • Sensory impacts • Reduced marine growth and survival	• Increase freshwater and estuarine rearing habitat • Promote life history diversity • Reduce local stressors that increase ocean acidification impacts	• Monitor ocean ecosystem indicators • *See freshwater and estuarine habitat actions listed above* • Reduce nonpoint pollution to improve coastal water quality

Section IX. Conclusions and Next Steps

This first 12-year assessment of the OCCCP’s measurable criteria broadly indicates that the OC Coho ESU has not yet achieved the plan’s broad sense desired status. This result is consistent with the expectation in the OCCCP that broad sense recovery will be achieved only after several decades of sustained conservation actions. While the ESU has not yet reached the high bar of broad sense recovery, an updated assessment of DSS criteria indicated that the ESU has remained persistent and sustainable despite challenging conditions for both freshwater and ocean survival over the past several years.

Low ocean survival in the late 1990s was effectively the end of a period of low realized ocean survival (i.e., including high rates of harvest prior to reductions in the early 1990s) that lasted at least a quarter century. Substantial reductions in harvest, coupled with improved conditions for ocean survival, resulted in some recent spawner abundances that include some of the highest in decades. Spawner abundance during recent poor ocean conditions also has been higher than during the late 1990's indicating that the combination of actions to date has improved resiliency.

Updated population viability modeling indicates that most populations have relatively high probabilities of persistence. However, fewer than half of the independent populations have obtained the OCCCP objective for persistence. Assessment of DSS criteria indicate generally favorable outcomes for many populations, with notable improving trends for some (e.g., North Umpqua, Floras). For others (e.g., South Umpqua, Beaver Creek) declining trends were observed across assessment periods in DSS criteria for persistence, diversity, and/or sustainability, and these populations will warrant continued attention to understand and ameliorate causes of decline.

Despite the recent biological performance of the ESU, fluctuations should be expected. Future periods of poor ocean survival and/or poor freshwater conditions will likely cause low spawner abundances, mitigated to the extent that hatchery and harvest impacts have been greatly reduced. The inevitability of future cycles of poor ocean survival and periodic low abundance underscores the importance of resiliency to the ESU’s long-term sustainability. Existing freshwater productivity has sustained the ESU through a prolonged period of low ocean survival, supported subsequent improvement in its biological status, and relatively strong performance during the most recent downturn in ocean productivity. This offers some assurance that the ESU will be resilient to similar periods in the future, but confidence in future performance rests on an assumption of stable or improving freshwater productivity.

A predominant role of ocean survival in recent increases in abundance does not imply an insignificant role of density dependent freshwater mortality in the regulation of OC Coho spawner abundance. Continued improvements in freshwater productivity through habitat protection, restoration, and management will be necessary to consistently achieve the OCCCP’s measurable criteria and to provide substantial ecological and societal benefits. Aside from harvest management, few actions are available to directly address fluctuations in ocean survival. However, continued efforts to address freshwater limiting factors will enhance resiliency of OC coho populations under fluctuating ocean conditions and a changing climate.

In the OCCCP, ODFW concluded that significant improvements to freshwater productivity would be necessary to achieve the broad sense goals for the OC Coho ESU. Actions to improve the status of the OC Coho ESU through the habitat, hatchery, and harvest actions of the OCCCP conservation strategy have improved the ESU’s viability and resiliency to unfavorable environmental conditions. However, this 12-year assessment indicates that current freshwater productivity remains insufficient to achieve broad sense goals. Habitat protection, restoration, and enhancement will be crucial for reducing climate and ocean change risk and providing for continued progress toward broad sense recovery for the OC Coho ESU.

Through this 12-year assessment, ODFW has identified several actions to facilitate progress toward the OCCCP's broad sense goals:

- Overwintering habitat continues to be the primary factor limiting freshwater capacity in most OC Coho populations. Much work has already targeted this limitation, and future management actions and continued investments in protection and restoration should continue to seek restoration of key habitat forming processes (e.g., large wood recruitment) and habitats with high rearing capacities that are currently relatively rare or declining (e.g., alcoves, beaver pools, etc.).
- Achieving habitat goals and meeting the habitat challenges posed by climate change will require continued support for, and enhancement of (1) local capacity to implement habitat restoration projects and (2) capacity for state and federal natural resource agencies to provide technical support for these efforts.
- While winter parr capacity will continue to limit smolt production in the near term in most populations, an increasing focus on protecting and restoring water temperature and summer flows will be necessary to mitigate for ongoing and intensifying impacts from climate change.
- Climate change projections and considerations should be incorporated into the development of conservation, restoration and management action plans for OC Coho to the extent possible. The ODFW will continue to develop tools to support this, including temperature and flow projections and work to improve understanding of thermal tolerances for Oregon's native fishes, including coho salmon.

In addition to the actions above, there are several areas for potential improvements to monitoring and measurable criteria to support future status assessments:

- The OCCCP's measurable criteria were designed to assess attainment of broad sense goals; most were not designed to assess viability or to identify significant declines in status. In this 12-year assessment ODFW reported on additional criteria related to ESU persistence and sustainability (DSS criteria) to provide additional context around ESU status. Given the uncertainties around how climate and ocean change may impact the ESU, ODFW will evaluate how these criteria and other existing information (e.g., juvenile coho monitoring, marine survival rates) can be integrated into future assessments to provide additional insights into status and progress toward broad sense goals.
- There are currently no distribution (adult occupancy) goals for the Floras or Sixes populations due to insufficient data for defining the relationship between adult site occupancy and spawner abundance in these two populations. ODFW will develop occupancy goals as continued monitoring augments that datasets for these populations.
- Monitoring of temperature and flow and data sharing will need to be expanded and coordinated across monitoring entities to support validation of models and to further our understanding of these important attributes now and as conditions continue to evolve through time.

- ODFW's Oregon Plan monitoring programs for the OC Coho ESU (Section II) are nearing the end of the planned 27-year monitoring panels. ODFW will evaluate monitoring programs to ensure continued support for status assessment, harvest and hatchery management, while also addressing decision support for emerging challenges.

The next 12-year assessment of the OCCCP will include data through run year 2031. In the meantime, ODFW will continue to report progress through annual implementation reports, and data on measurable criteria will continue to be made publicly available through online data sharing platforms, currently the ODFW Salmon and Steelhead Recovery Tracker (*odfwrecoverytracker.org*).

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