Lower Columbia River Conservation and Recovery Plan for Oregon Populations of Salmon and Steelhead

12-Year Assessment
2010-2022

Appendix III. Measurable Criteria Assessment

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Disclaimer

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Biological Criteria Assessment

Measurable criteria related to biological recovery are based on the specific goals for each Lower Columbia River (LCR) salmon and steelhead population established in the Lower Columbia River Conservation and Recovery Plan for Oregon Populations of Salmon and Steelhead (Plan; ODFW 2010). With regards to the assessment of biological criteria (i.e. abundance, productivity, spatial structure, and diversity), the benchmarks are intended to serve as interim measures of progress towards achieving recovery goals absent full viability analyses (as conducted for development of the Plan), which require long term data trends to show progress. The suite of research, monitoring, and evaluation (RME) identified as necessary to evaluate these measurable criteria will also ultimately provide the foundation for more comprehensive viability analyses, such as those described in McElhany et al. (2007) that follow the viability criteria framework established by the Willamette Lower Columbia-Technical Review Team (WLC-TRT; McElhany et al. 2006).

Measurable Criteria – Abundance and Productivity

Abundance is an indicator of a more complex underlying relationship between abundance, intrinsic productivity, relative survival, and habitat capacity. Further, within this complex relationship, population viability analysis (PVA) simulations have shown that the strength of a population's intrinsic productivity and relative life cycle survival is a much better predictor of its resistance to extinction than is raw spawner abundance. Regardless, the important point is that although the conservation gaps are expressed in terms of abundance, these units are a byproduct of a more complex analysis where the population attributes of productivity and abundance are evaluated together in the context of changes in relative life history survival and expressed as an abundance estimate.

Abundance and Productivity Metric
Annual estimates of abundance of naturally-produced spawners in each coho, Chinook, or steelhead population.

Abundance and Productivity Evaluation Thresholds (delisting)

Pass – The observed spawner abundance is ≥ the abundance modeled for delisting at least six times in any 12-year period *and* the average observed spawner abundance is ≥ the average modeled abundance for delisting over that same time period.

Fail – The observed spawner abundance is ≥ the abundance modeled for delisting less than six times in any 12-year period *or* the average observed spawner abundance is < the average modeled abundance for delisting over that same time period.

Analytical Procedures: Abundance estimation methodology for independent populations of salmon and steelhead vary across the Evolutionary Significant Unit (ESU) both by time and by independent population. See ESU and population summaries below for more information. Stock-recruitment curves were developed for each Oregon LCR population of salmon and steelhead as a way of determining the abundance and productivity needed to achieve delisting and broad sense recovery. Because the abundance and productivity derived from these recruitment curves represent the long term (i.e. 100 year) average, annual benchmarks of abundance and productivity are developed that allow a timelier assessment of the progress being made to achieving recovery goals (ODFW 2010). To do this, in addition to the stock recruitment curves generated for each population, annual estimates of spawner abundance, harvest of natural origin fish, age at return, and an index of climate impact are included. Because natural fluctuations in climate conditions play such a significant role in the annual abundance of salmon and steelhead spawners, it is necessary to scale the average abundance targets to an annual index of climate.

The Plan describes a 10-step process to determine the "abundance modeled for delisting". The resulting values are intended to represent annual forecast returns if recovery goals have been met. However, when conducting the abundance and productivity evaluation the Oregon Department of Fish and Wildlife (ODFW) found that modeled goals developed using the 10-step process seldom covaried with observed abundance and often diverged significantly from the delisting scenario goals identified in the plan. Several different factors may have contributed to this, including: 1) parameters used to estimate recruits were often based on limited population monitoring data and may not accurately represent actual population productivity or capacity; 2) recovery scalars identified during plan development may have underestimated or overestimated the gap between current abundance and delisting scenario goals; and 3) the environmental covariate used to account for climate fluctuations for most populations (Crater Lake–Mount Rainier Snow Index) has displayed a negative trend and fallen far below the historical range of variation in recent years (Figure A-III: 1).

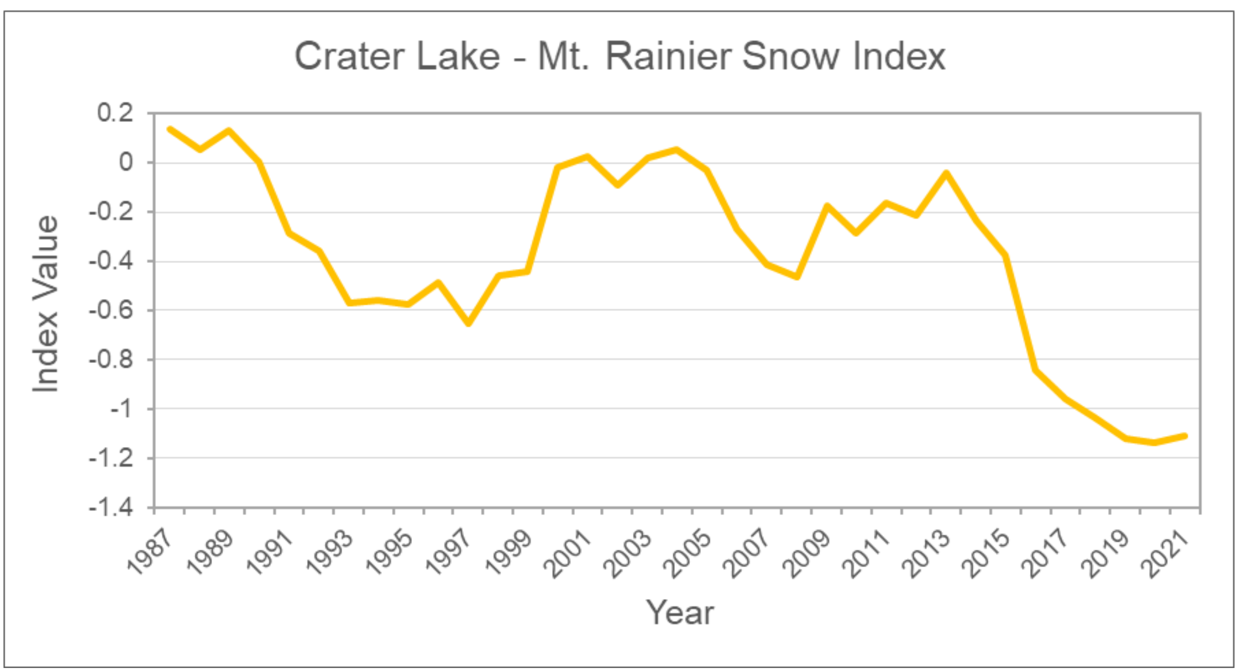

Figure A-III: 1. Crater Lake–Mt. Rainier Snow Index values, 1987–2021.

Due to these factors, annual modeled goals for a population were often consistently much lower than the delisting scenario goals. This would be expected if environmental conditions were consistently poor in the period following plan adoption. However, since 2010 a range of environmental conditions have been observed, including cohorts that experienced very favorable ocean conditions and, more recently, cohorts that experienced poor conditions in freshwater and the ocean. Thus, comparisons between observed returns and annual modeled goals are not necessarily a good indicator of progress toward delisting scenario goals.

The process for determining annual modeled goals has additional limitations that are worth noting. First, calculation of the modeled goals depends on information about the age structure of returning spawners, which is not consistently collected on an annual basis for all populations. Average values from the focal population or neighboring populations were often used for analysis, but these assumptions add uncertainty and could contribute to a mismatch between trends in observed and modeled abundance. Second, determination of a modeled goal for a given return year depends on continuous monitoring for several years beforehand to determine parental spawner abundance. In the case of Chinook salmon, this means that spawner abundance must be measured for at least five years before a modeled goal can be calculated. For several populations where monitoring was initiated after Plan adoption, this constraint limited the number of years that the interim abundance and productivity criterion could be evaluated. Furthermore, in cases where there is a break in monitoring for one or more years, spawner abundance must be assumed (typically based on an average of other years) to determine modeled goals in future years. Depending on the age structure of the species, this can have a large effect on the modeled goal.

Due to these challenges, moving into the future beyond this 12-year assessment ODFW will no longer produce modeled annual interim A/P goals. Future evaluation thresholds for the A/P metric will be, "is the annual estimated abundance greater than or equal to the delisting scenario goal at least 6 times in any 12-year period."

In the summaries below, abundance monitoring results for each population are graphed in relation to annual modeled goals and the recovery scenario goals in the Plan (Table A-III: 1) to illustrate results of the abundance and productivity criteria analysis and provide more context about recent trends in relation to recovery goals in the Plan. The graphs include abundance estimates for the 12-year period from 2010–2022 for all populations to show results since Plan adoption. For many populations, a longer time series of monitoring is available, which provides valuable perspective on trends in abundance and other metrics (e.g., proportion Hatchery on Spawning grounds (pHOS). Graphs in the population summaries below include data from 2000–2009, when it is available, to show results for a similar period before and after plan adoption. For some populations, an even longer time series of data is available. However, in many cases older estimates depend on several assumptions and may not be directly comparable to more recent results. Therefore, estimates prior to 2000 were not included in the figures (these estimates are available in Appendix C of the Plan).

Table A-III: 1. Summary of current status and delisting scenario from the Plan's scenario analysis. The desired status (overall risk class) for populations which are not part of an ESA-listed ESU are indicated by italics. For shared populations, the overall risk class for both the Oregon portion and the entire population (in parenthesis, determined by Washington), are indicated. Note that there is no current status or delisting scenario for chum salmon. Confidence tags are Plan estimations of the ability of salmonid populations to achieve the delisting scenario.

		Current		Delisting Scenario				
Species / Stratum (Run)	Population	Abundance	Overall Risk Class	Contribution to Delisting	Abundance	A&P Gap	Overall Risk Class	Confidence
COHO								
Coast								
	Youngs Bay	4	VH	Stabilizing	7	3	VH	Exceed
	Big Creek	8	VH	Stabilizing	12	4	VH	Exceed
	Clatskanie	1,363	H	Primary	3,201	1,838	VL	Achieve
	Scappoose	1,942	M	Primary	3,208	1,266	VL	Exceed
Cascade								
	Clackamas	6,548	M	Primary	11,232	4,684	VL	Exceed
	Sandy	1,622	VH	Primary	5,685	4,063	L	Achieve
Gorge								
	*Lower Gorge**	22	VH	*Support WA (L)*	962	940	H (L)	Achieve
	Upper Gorge/Hood	41	VH	Primary	5,203	5,162	L	Unlikely
CHINOOK								
Coast (Fall)								
	Youngs Bay	379	H	Stabilizing	505	126	H	Exceed
	Big Creek	216	VH	Contributing	577	361	H	Achieve
	Clatskanie	6	VH	Primary	1,277	1,271	L	Exceed
	Scappoose	356	H	Primary	1,222	866	L	Exceed
Cascade (Fall)								
	Clackamas	558	VH	Contributing	1,551	993	M	Exceed
	Sandy	144	VH	Contributing	1,031	887	M	Achieve
Gorge (Fall)								
	*Lower Gorge**	74	VH	*Support WA (M)*	387	313	H (M)	Achieve
	*Upper Gorge**	17	VH	*Support WA (M)*	87	70	VH (M)	Achieve
	Hood	33	VH	Primary	1,245	1,212	L	Unlikely
Cascade (Late Fall)								
	Sandy	1,794	L	Primary	3,858	2,064	VL	Achieve
Cascade (Spring)								
	Clackamas	1,371	M	*N / A*	8,377	7,006	(VL)	Achieve
	Sandy	714	M	Primary	1,230	516	L	Exceed
Gorge (Spring)								
	Hood	327	VH	Primary	1,493	1,166	VL	Exceed
STEELHEAD								
Coast (Winter)								
	Youngs Bay	2,486	VL	*N / A*	4,733	2,247	*(VL)*	Achieve
	Big Creek	1,143	L	*N / A*	3,182	2,039	*(VL)*	Achieve
	Clatskanie	2,451	VL	*N / A*	3,982	1,531	*(VL)*	Achieve
	Scappoose	3,245	VL	*N / A*	5,169	1,924	*(VL)*	Achieve
Cascade (Winter)								
	Clackamas	3,897	M	Primary	10,671	6,774	L	Unlikely
	Sandy	674	H	Primary	1,519	845	VL	Exceed
Gorge (Winter)								
	*Lower Gorge**	550	M (H)	*Support WA (L)*	881	331	M (L)	Achieve
	*Upper Gorge**	151	VH (H)	*Support WA (H)*	235	84	VH (H)	Achieve
	Hood	1,127	M	Primary	2,079	952	L	Exceed
Gorge (Summer)								
	Hood	35	VH	Primary	2,008	1,973	L	Unlikely

Measurable Criteria – Spatial Structure

Spatial Structure Metric #1: Percent Occupied Habitat
The occupancy of spawning adults or juveniles at spatially balanced, random survey sites.

Percent Occupied Habitat Evaluation Thresholds

Pass – The percentage of sites not occupied by spawning adults or rearing juvenile salmon or steelhead is ≤ the thresholds shown in Table A-III: 2 at least six times during a 12-year period *and* the overall average percentage of sites not occupied during that same time period is ≤ than the thresholds shown Table A-III: 2.

Fail – The percentage of sites not occupied by spawning adults or rearing juveniles is > the thresholds shown Table A-III: 2 less than six times during a 12-year period *or* the overall average percentage of sites not occupied during that same time is > the thresholds shown Table A-III: 2.

Analytical Procedures: This criterion is based on the occurrence of naturally produced adult spawners or juvenile salmonids in Generalized Random Tesselation Stratified (GRTS) spawning surveys each year. In this assessment, all evaluations were based on adult occupancy. Occupancy of coho and steelhead juveniles is evaluated annually by the ODFW at the ESU scale based on GRTS snorkel surveys, but the sample design does not provide population-scale results for evaluation of this criterion.

For coho salmon, GRTS spawning surveys were considered occupied when density was equal to or greater than 4 fish/mile. A minimum density of 4 fish/mile was selected based on spawner frequency distributions developed by Talabere and Jones (2001) and because the probability of a spawner finding a mate within a section of stream may decline at densities less than this level (Sharr et al. 2000). In addition, observation of at least one unmarked adult coho salmon was required for a site to be considered occupied. For consistency, ODFW used the same criteria to determine occupancy for Chinook salmon, although we recognize that it would be worthwhile to consider alternative criteria for Chinook due to differences in their spawning behavior and distribution. For steelhead, we defined occupancy as the percentage of sites with at least one steelhead redd observed. Relatively few live or dead steelhead were observed during spawning surveys, so we did not require observation of unmarked steelhead when determining occupancy.

In the Plan, occupancy thresholds are expressed as the percentage of sites not occupied (Table A-III: 2). However, in this assessment we express occupancy goals and observed values as the percentage of sites occupied to ease interpretation of results (i.e., higher values indicate improved status).

Table A-III: 2. Occupancy thresholds for Oregon Lower Columbia River coho salmon and steelhead populations. Watershed size is from McElhany et al. (2006). Thresholds indicate percentage of sites not occupied.

Coho					
Stratum	Population Area	Watershed Size	Delisting Risk Goal	Occupancy Threshold	
				Delisting	Broad Sense (Very Low Risk)
Coast	Youngs Bay	Small	Very High	100%	5%
	Big Creek	Small	Very High	100%	5%
	Clatskanie	Medium	Very Low	10%	10%
	Scappoose	Medium	Very Low	10%	10%
Cascade	Clackamas	Large	Very Low	15%	15%
	Sandy	Large	Low	25%	15%
Gorge	Lower Gorge	Small	High	50%	5%
	Upper Gorge/Hood	Medium	Low	20%	10%
Chinook					
Stratum	Population Area	Watershed Size	Delisting Risk Goal	Occupancy Threshold	
				Delisting	Broad Sense
Coast	Youngs Bay	Small	High	50%	5%
	Big Creek	Small	High	50%	5%
	Clatskanie	Small	Low	15%	5%
	Scappoose	Small	Low	15%	5%
Cascade	Clackamas	Large	Moderate	50%	15%
	Clackamas spring	Medium	Very Low	10%	10%
	Sandy	Medium	Moderate	40%	10%
	Sandy Late	Medium	Very Low	10%	10%
	Sandy Spring	Medium	Low	20%	10%
Gorge	Lower Gorge	Small	High	50%	5%
	Upper Gorge	Small	Very High	100%	5%
	Hood	Small	Low	15%	5%
	Hood Spring	Medium	Very Low	10%	10%
Steelhead					
Stratum	Population Area	Watershed Size	Delisting Risk Goal	Occupancy Threshold	
				Delisting	Broad Sense
Coast*	Youngs Bay	Small	NA	NA	5%
	Big Creek	Small	NA	NA	5%
	Clatskanie	Medium	NA	NA	10%
	Scappoose	Medium	NA	NA	10%
Cascade	Clackamas	Large	Low	25%	15%
	Sandy	Large	Very Low	15%	15%
Gorge	Lower Gorge	Small	Moderate	25%	5%
	Upper Gorge	Small	Very High	100%	5%
	Hood	Medium	Low	20%	10%
	Hood Summer	Medium	Low	20%	10%

* Coast stratum steelhead are not listed under ESA.

Spatial Structure Metric #2: *Geographic Distribution*
Comparison of the spatial pattern of potential spawning distribution to that observed using Sides, Vertices, and Boundaries (SVB) spatial statistics.

Geographic Distribution Evaluation Thresholds (Adults and Juveniles)

Pass – The observed distribution the SVB statistic of sites occupied by four or more adult spawning fish or one juvenile is not significantly different from a random distribution at least six times in any 12-year period.

Fail – The observed distribution the SVB statistic of sites occupied by four or more adult spawning fish or one juvenile is not significantly different from a random distribution less than six times in any 12-year period.

Analytical Procedures: The Plan describes methods for determining if the spatial distribution of occupied sites is comparable to the spatial distribution of sites where spawning may potentially occur using the SVB metric. The statistical analysis needed to evaluate this criterion has not been completed for any population in Oregon portion of the LCR ESU/DPS and so ODFW did not evaluate this criterion in the assessment.

Measurable Criteria – Diversity

Sufficient life-history diversity must exist to sustain a population through short-term environmental perturbations and to provide for long-term evolutionary processes. The metrics and measurable criteria for evaluating the diversity of a population should be evaluated over multiple generations and should include:

a. substantial proportion of the diversity of a life-history trait(s) that existed historically,
b. gene flow and genetic diversity should be similar to historical (natural) levels and origins
c. successful utilization of habitats throughout the range,
d. resilience and adaptation to environmental fluctuations

Diversity Metric #1: Effective Population Size
Effective population size relates to a minimum population level that must be maintained to minimize the genetic risks associated with small population size, such as: inbreeding depression, the loss of diversity through genetic drift, and the accumulation of maladaptive mutations. Since the population abundance goals described in the abundance/productivity metric are designed to equal or exceed abundance needed to satisfy effective population size requirements, passing the abundance and productivity thresholds described in abundance/productivity criterion will mean that effective population size requirements are met.

Diversity Metric #2: Interbreeding with hatchery fish
Annual assessment of pHOS in each LCR population.

Evaluation Thresholds for Hatchery Related Metrics – Delisting

Pass – Over a nine-year period, the average percentage of the total number of spawners that are of hatchery origin is on average less than or equal to that shown in Table A-III: 3.

Fail – Over a nine-year period, the average percentage of the total number of spawners that are of hatchery origin is on average higher than that shown in Table A-III: 3.

Analytical Procedures: Hatchery stray rates shown in Table A-III: 3 represent the pHOS that when combined with the targeted reductions in other threat categories should lead to the long-term viability of the ESU (i.e., delisting). While the target stray rates (pHOS) represent what is needed over the long term (100 years), to conduct more timely assessments of the status and trend in hatchery stray rates, a nine-year average is used for the analysis. Because coho exhibit very strong three-year cohort fidelity, the Plan called for the analysis of coho hatchery stray rates to be conducted by averaging cohorts. This approach produced results that were very similar to simply calculating a nine-year average, so averages were calculated as a whole over nine years for all species.

Assessment of hatchery stray rates (pHOS) is intended to serve as a measurable criterion for hatchery related threats under Listing Factor E: Other Natural or Manmade Factors Affecting the Continued Existence of the ESU, as well as a diversity metric for assessing biological recovery. We included hatchery stray rate results in the population summaries below because a time series is available for many independent populations. Other measurable criteria related to listing factors are discussed in the Listing Factor Criteria Assessment section because the metrics are not monitored at the population scale or are represented by single estimate since plan approval (e.g., restoration achievements).

Table A-III: 3. Hatchery stray rate targets to achieve delisting for Oregon populations of coho, fall Chinook (CHF), spring Chinook (CHS), winter steelhead (STW), and summer steelhead (STS).

Population and Species	Average Allowable Hatchery Stray Rates				
	CHF	CHS	Coho	STW	STS
Youngs	90%		86%	10%	
Big Creek	90%		86%	10%	
Clatskanie	10%		10%	5%	
Scappoose	10%		5%	5%	
Clackamas	30%	10%	9%	10%	
Sandy	30%	10%	10%	10%	
Gorge L	60%		10%	10%	
Gorge U	60%			10%	
Hood	0%	10%	0%	10%	0%
Sandy late	10%				

Diversity Metric #3: Anthropogenic mortality
See measurable criteria for Listing Factor B: Over-utilization for Commercial, Recreational, Scientific or Educational purposes.

Diversity Metric #4: Life-history traits
The Plan states that the approach for this metric is to be determined. While there is consensus that life-history diversity is important to the long-term resilience of salmon and steelhead populations, there is little consensus or guidance available on specifically how information on life-history diversity should be analyzed to assess whether salmon and steelhead populations have the range of life-history characteristics necessary for long term resilience in the face of a changing climate. As a result, it is difficult to establish a metric with a specific pass/fail threshold. To date, the Life History Traits metric has not been developed for Oregon LCR salmon or steelhead populations.

Diversity Metric #5: Habitat Diversity
As with the previous metric, the Plan states that the approach for the Habitat Diversity metric is to be determined. To date, no Habitat Diversity metric has been identified for Oregon LCR salmon or steelhead populations.

ESU: Lower Columbia River Coho Salmon
Stratum: All (Aggregate)
Population: All Oregon Populations (Aggregate)

There are no measurable criteria assigned for an aggregate abundance level for the LCR Coho ESU. Natural origin spawner abundance in the Oregon portion of the ESU has shown an increasing trend since monitoring began in most populations in 2002 and has varied from a high of over 23,000 spawners to a low of approximately 3,000 spawners since the Plan was adopted in 2010 (Figure A-III: 2).

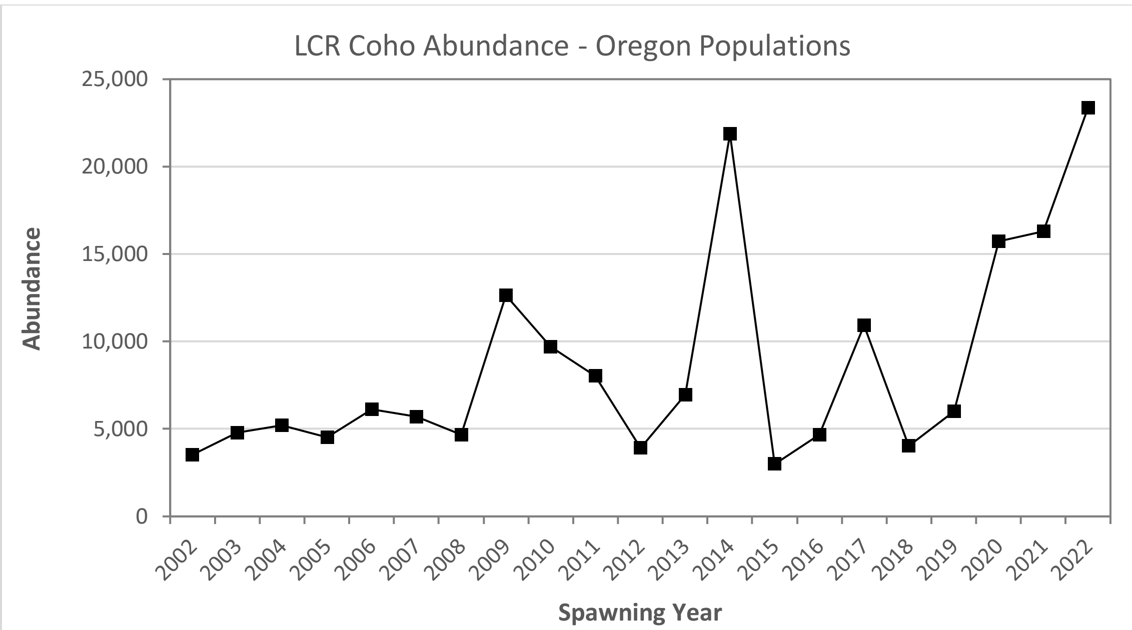

Figure A-III: 2. Natural origin coho spawner abundance in the Oregon portion of the LCR Coho ESU, 2002-2022. Spawner abundance in the Youngs Bay and Big Creek populations is not included because estimates are not available for these populations after 2012; totals include spawner abundance in the Lower Gorge and Upper Gorge/Hood populations although estimates are not available for all years. The 2020 estimate does not include the spawners in the Youngs Bay, Big Creek, Lower Gorge or Hood River populations, or spawners in the Clackamas population below North Fork Dam.

Viable Salmonid Population (VSP) metrics for LCR coho populations are estimated based on spawning surveys selected using a spatially balanced monitoring design (GRTS, Stevens 2002). Survey field methods follow those developed by the ODFW's Oregon Adult Salmonid Inventory and Sampling (OASIS) program. Abundance estimates derived from the GRTS survey design represent the annual status of coho spawner abundance in the ESU and each independent population, with the following exceptions:

- *Youngs Bay and Big Creek Coho*: The Plan directs ODFW to take a strategic approach to fluctuations in monitoring support. Due to budget shortfalls and prioritization of monitoring efforts, the department chose to reduce effort within the GRTS sampling frame for these populations as both are listed at a very high risk of extinction and neither targeted for status improvements under the delisting scenario. GRTS monitoring for these populations ended in 2012. Non-fin clipped coho are passed and enumerated at Klaskanine and Big Creek Hatcheries.

- *Clackamas Coho*: The count of natural origin coho salmon passed above the North Fork Dam is added to the abundance estimated derived from GRTS spawner surveys located below North Fork dam.

- *Upper Gorge/Hood Coho*: Due to sampling difficulties associated with low abundance, patchy distribution, and glacial till, ODFW is unable detect, with accuracy, trends in the UG/Hood population.

Since 2006, ODFW has conducted snorkel surveys using a GRTS design to monitor juvenile coho salmon in the LCR ESU. Snorkel surveys are typically conducted in first to third order (wadeable) streams, but surveys in larger streams were conducted in some years. Snorkel surveys provide an annual index of abundance and juvenile occupancy at the ESU scale, but do not provide population-scale information. Snorkel survey methods and results are available in annual reports at the ODFW Aquatic Inventories Project website: https://odfw-aqi.forestry.oregonstate.edu/publications.

ESU: Lower Columbia River Coho Salmon

Stratum: Coastal

Population: Youngs Bay

Abundance and Productivity

Criterion: Annual estimates of abundance of naturally produced spawners in the Youngs Bay coho population.

Objective: The observed spawner abundance is ≥ the abundance modeled for delisting at least six times in any 12-year period *and* the average observed spawner abundance is ≥ the average modeled abundance for delisting over that same period.

12-Year Assessment: *Likely Attained.*
Spawner abundance in the Youngs Bay population exceeded the annual modeled goals for return years 2011-2012. Average spawner abundance for those years (145) is greater than the averaged modeled abundance (13) over that same period (Figure A-III: 3). Attainment of the Abundance/Productivity (A/P) goal is uncertain because limited monitoring resources have been directed toward higher priority populations. However, it is likely that goal attainment occurred given the very high-risk status and low abundance goal under the delisting scenario.

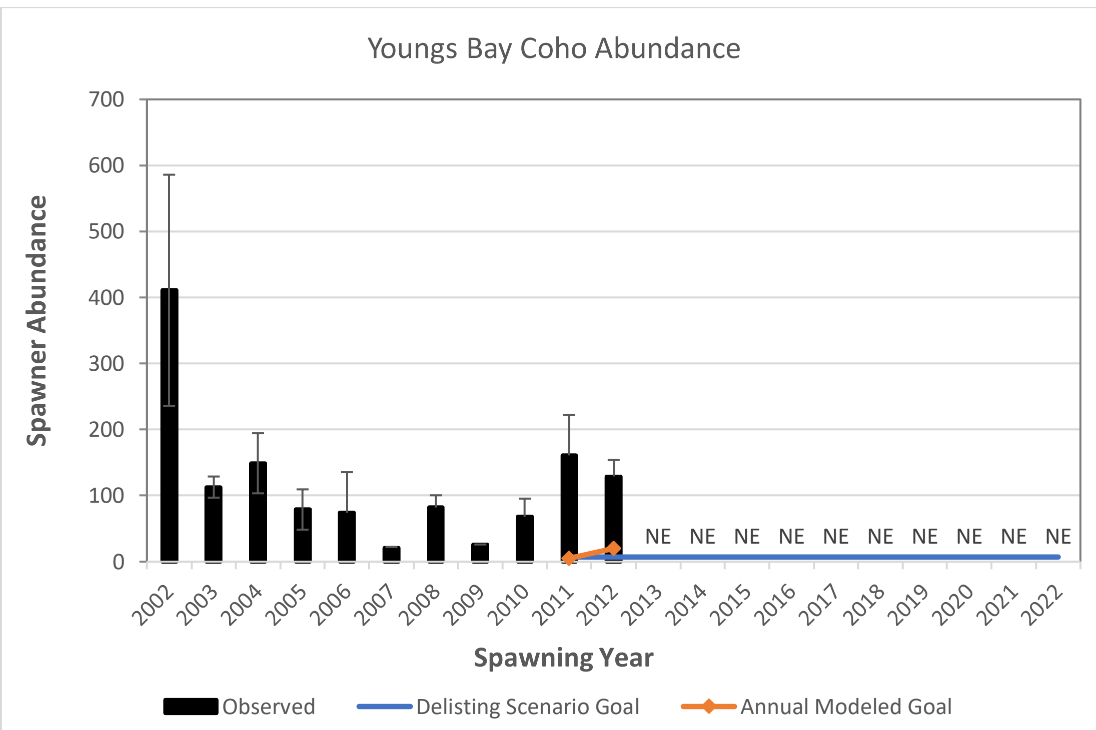

Figure A-III: 3. Natural origin coho salmon spawner abundance in the Youngs Bay population, 2002–2022. The delisting scenario goal and annual modeled goals scaled to climate conditions are shown for the period following Plan adoption in 2010. NE = No Estimate.

Spatial Structure

Criterion: The occupancy of spawning adults or juveniles at spatially balanced, random survey sites in the Youngs Bay coho population.

Objective: The percentage of sites occupied by spawning adults or rearing juvenile salmon is ≥ than the delisting threshold (zero percent) at least six times during a 12-year period *and* the overall average percentage of sites occupied during that same period is ≥ than the thresholds of zero percent.

12-Year Assessment: Attained.
The occupancy objective was considered attained despite limited monitoring information because the occupancy threshold under the delisting scenario is zero. Occupancy of spawning adults in the Youngs Bay population exceeded that threshold in 2010-2012 (Figure A-III: 4), and the average occupancy of habitat for those years (21 percent) is greater than the zero percent threshold. Juvenile coho surveys have been conducted annually in the LCR ESU since 2006, but those surveys do not provide population-scale occupancy estimates.

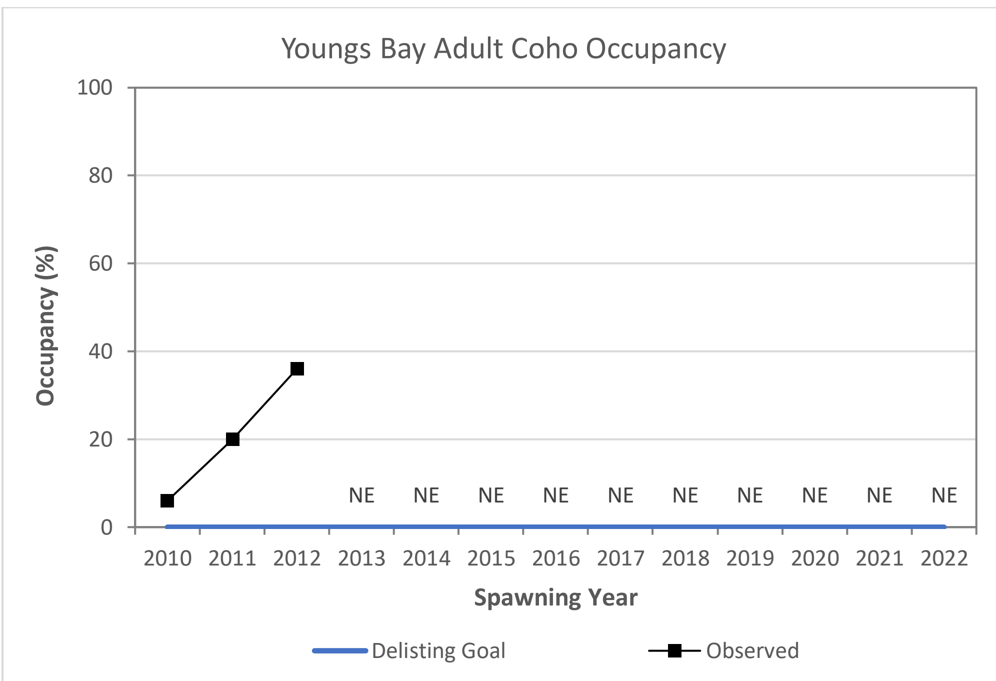

Figure A-III: 4. Percentage of sites occupied by spawning coho salmon in the Youngs Bay population, 2010–2022. NE = No Estimate.

Diversity Metric #1: Effective Population Size

Criterion: Annual estimates of abundance of naturally produced spawners in the Youngs Bay coho population.

Objective: The observed spawner abundance is ≥ the abundance modeled for delisting at least six times in any 12-year period *and* the average observed spawner abundance is ≥ the average modeled abundance for delisting over that same period.

*12-Year Assessment: Likely Attained (*see *Abundance and Productivity* metric)

Diversity Metric #2: Interbreeding with Hatchery Fish

Criterion: Annual assessments of the proportion of spawning fish that are of hatchery origin in the Youngs Bay coho population.

Objective: Over a nine-year period, the average percentage of the total number of spawners that are of hatchery origin is on average less than or equal to 86 percent.

12-Year Assessment: Not Available.
The most recent nine-year average for pHOS in the Youngs Bay coho population (64 percent) was below the delisting goal threshold of 86 percent (Figure A-III: 5). However, attainment of the objective after 2012 is unknown because limited monitoring resources were directed toward higher priority populations.

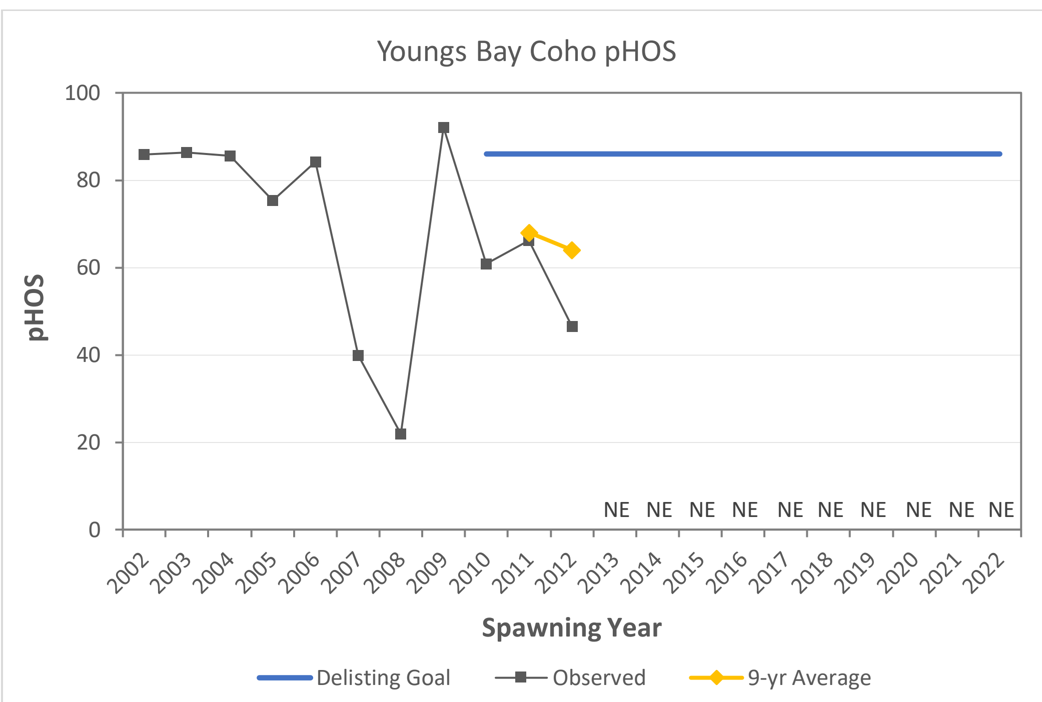

Figure A-III: 5. Percentage of hatchery origin fish on the spawning grounds in the Youngs Bay coho population, 2002–2022. The running nine-year average (yellow line) and delisting goal (blue line) are shown for the period following Plan adoption in 2010. NE = No Estimate.

ESU: Lower Columbia River Coho Salmon

Stratum: Coastal

Population: Big Creek

Abundance and Productivity

Criterion: Annual estimates of abundance of naturally produced spawners in the Big Creek coho population.

Objective: The observed spawner abundance is ≥ the abundance modeled for delisting at least six times in any 12-year period *and* the average observed spawner abundance is ≥ the average modeled abundance for delisting over that same period.

12-Year Assessment: *Likely Attained.*
Spawner abundance in the Big Creek population exceeded the annual modeled goals for return years 2011-2012. The average spawner abundance for those years (285) is greater than the averaged modeled abundance (137) over that same period (Figure A-III: 6). Attainment of the A/P goal is uncertain because limited monitoring resources have been directed toward higher priority populations. However, it is likely that goal attainment occurred given the very high-risk status and low abundance goal under the delisting scenario.

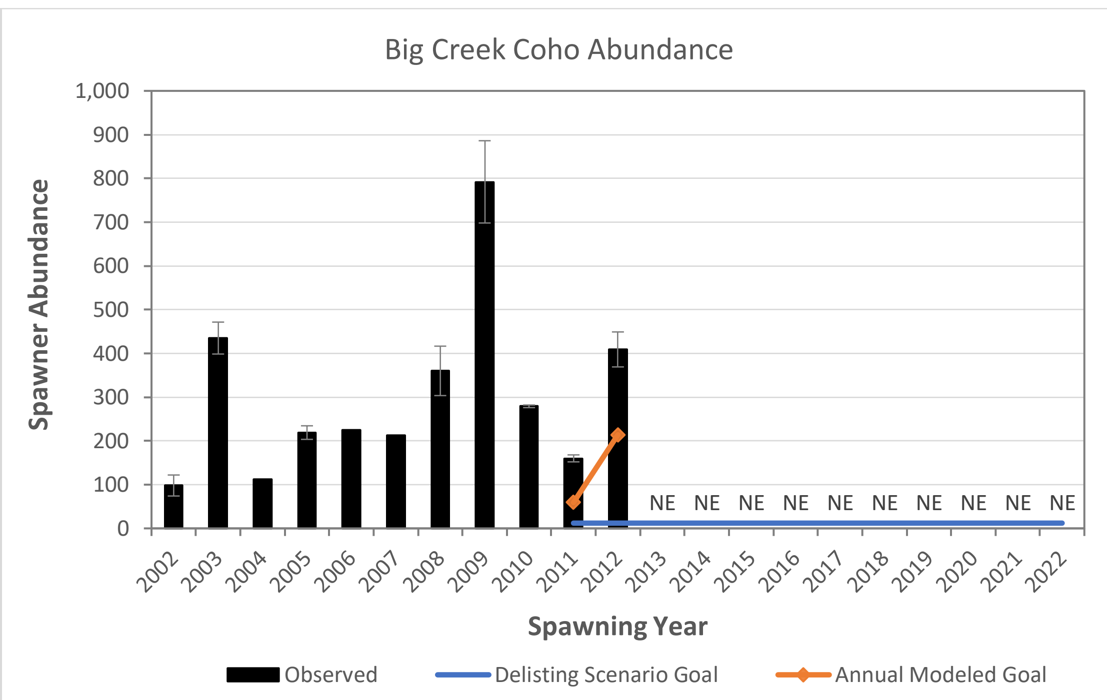

Figure A-III: 6. Natural origin coho salmon spawner abundance in the Big Creek population, 2002–2022. The delisting scenario goal and annual modeled goals scaled to climate conditions are shown for the period following Plan adoption in 2010. NE = No Estimate.

Spatial Structure

Criterion: The occupancy of spawning adults or juveniles at spatially balanced, random survey sites in the Big Creek coho population.

Objective: The percentage of sites occupied by spawning adults or rearing juvenile salmon is ≥ than the delisting threshold (zero percent) at least six times during a 12-year period *and* the overall average percentage of sites occupied during that same period is ≥ than the thresholds of zero percent.

12-Year Assessment: Attained.
The occupancy objective was considered attained despite limited monitoring information because the occupancy threshold under the delisting scenario is zero. Occupancy of spawning adults in the Big Creek population exceeded that threshold in 2010-2012 (Figure A-III: 7), and the average occupancy of habitat for those years (38 percent) is greater than the zero percent threshold. Juvenile coho surveys have been conducted annually in the LCR ESU since 2006, but those surveys do not provide population-scale occupancy estimates.

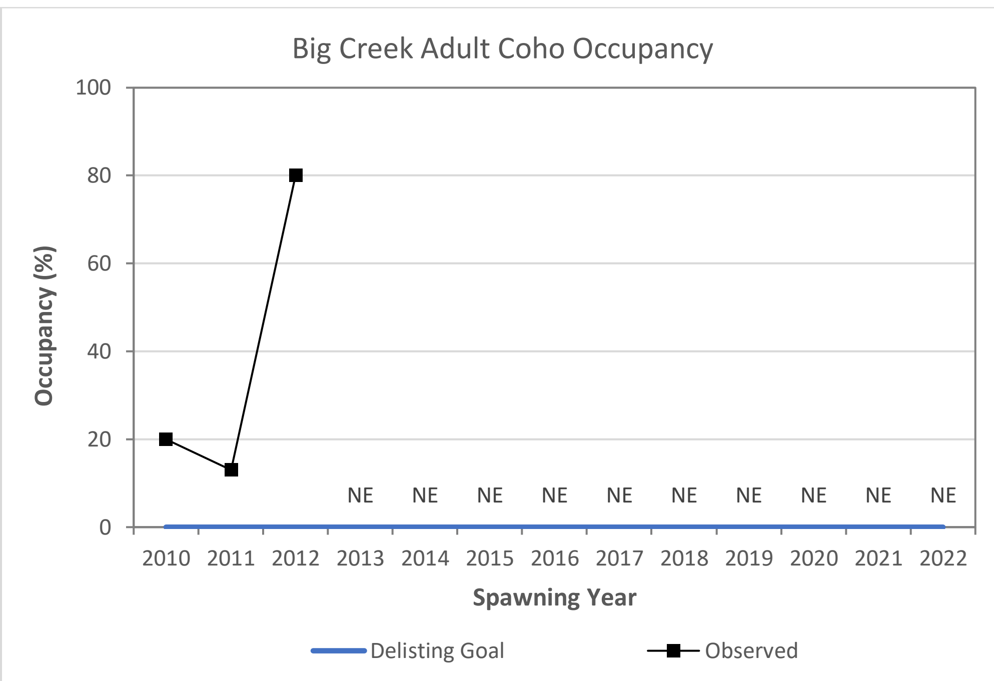

Figure A-III: 7. Percentage of sites occupied by spawning coho salmon in the Big Creek population, 2010–2022. NE = No Estimate.

Diversity Metric #1: Effective Population Size

Criterion: Annual estimates of abundance of naturally produced spawners in the Big Creek coho population.

Objective: The observed spawner abundance is ≥ the abundance modeled for delisting at least six times in any 12-year period *and* the average observed spawner abundance is ≥ the average modeled abundance for delisting over that same period.

*12-Year Assessment: Likely Attained (*see *Abundance and Productivity* metric)

Diversity Metric #2: Interbreeding with Hatchery Fish

Criterion: Annual assessments of the proportion of spawning fish that are of hatchery origin in the Big Creek coho population.

Objective: Over a nine-year period, the average percentage of the total number of spawners that are of hatchery origin is on average less than or equal to 86 percent.

12-Year Assessment: Not Available.
The most recent nine-year average for pHOS in the Big Creek coho population (41 percent) was below the delisting goal threshold of 86 percent (Figure A-III: 8). However, attainment of the objective after 2012 is unknown because limited monitoring resources were directed toward higher priority populations.

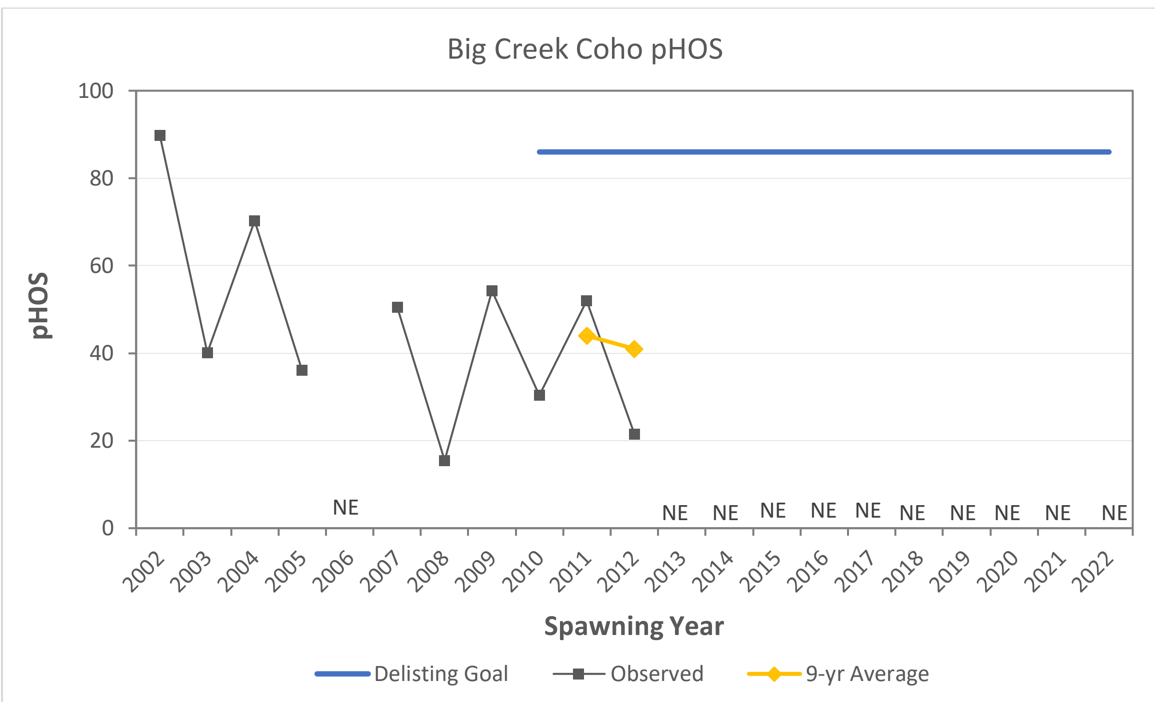

Figure A-III: 8. Percentage of hatchery origin fish on the spawning grounds in the Big Creek coho population, 2002–2022. The running nine-year average (yellow line) and delisting goal (blue line) are shown for the period following Plan adoption in 2010. NE = No Estimate.

ESU: Lower Columbia River Coho Salmon

Stratum: Coastal

Population: Clatskanie

Abundance and Productivity

Criterion: Annual estimates of abundance of naturally produced spawners in the Clatskanie coho population.

Objective: The observed spawner abundance is ≥ the abundance modeled for delisting at least six times in any 12-year period *and* the average observed spawner abundance is ≥ the average modeled abundance for delisting over that same period.

12-Year Assessment: *In Progress*.
Spawner abundance in the Clatskanie population did not meet the A/P objective (Figure A-III: 9). Observed abundance exceeded the modeled abundance in three years from 2011–2022 and average spawner abundance (859) was less than the averaged modeled abundance (1,461) over that same period.

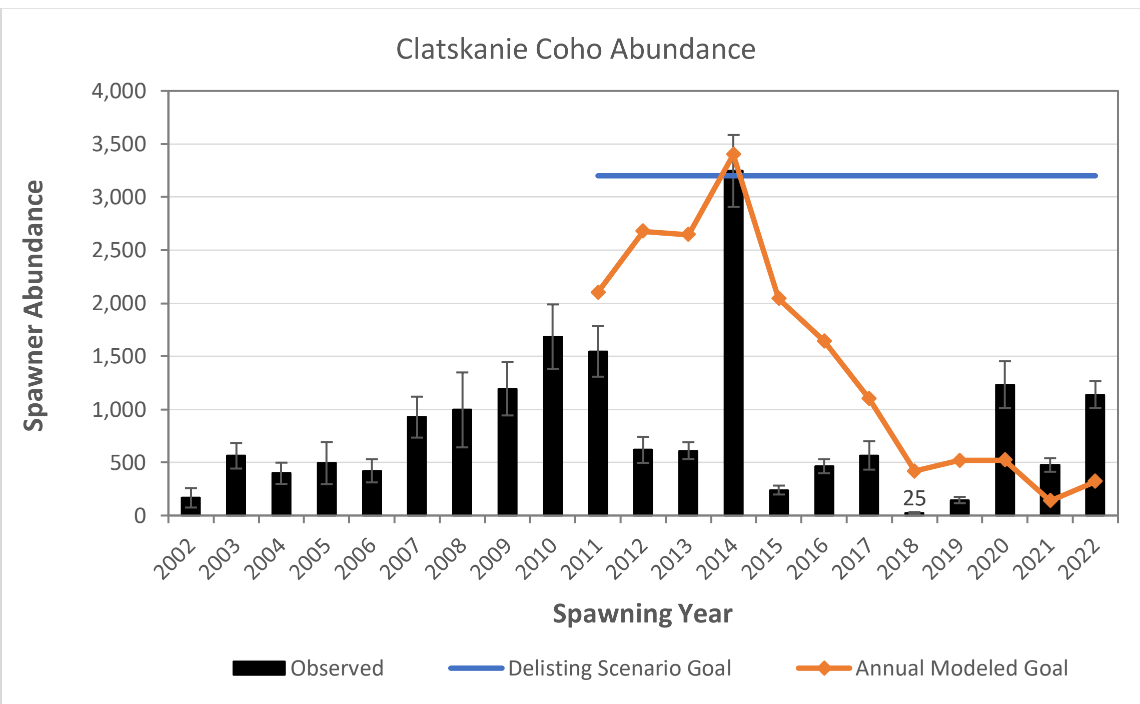

Figure A-III: 9. Natural origin coho salmon spawner abundance in the Clatskanie population, 2002–2022. The delisting scenario goal and annual modeled goals scaled to climate conditions are shown for the period following Plan adoption in 2010.

Spatial Structure

Criterion: The occupancy of spawning adults or juveniles at spatially balanced, random survey sites in the Clatskanie coho population.

Objective: The percentage of sites occupied by spawning adults or rearing juvenile salmon is ≥ than the delisting threshold (90 percent) at least six times during a 12-year period *and* the overall average percentage of sites occupied during that same period is ≥ than the threshold of 90 percent.

12-Year Assessment: In progress.
Occupancy by spawning adults in the Clatskanie population did not meet the goal of occupied sites exceeding the 90 percent threshold for six of 12 years in 2010-2022 (Figure A-III: 10). The average occupancy of habitat for those years (61 percent) is less than the 90 percent threshold. Juvenile coho surveys have been conducted annually in the LCR ESU since 2006, but these surveys do not provide population-scale occupancy estimates.

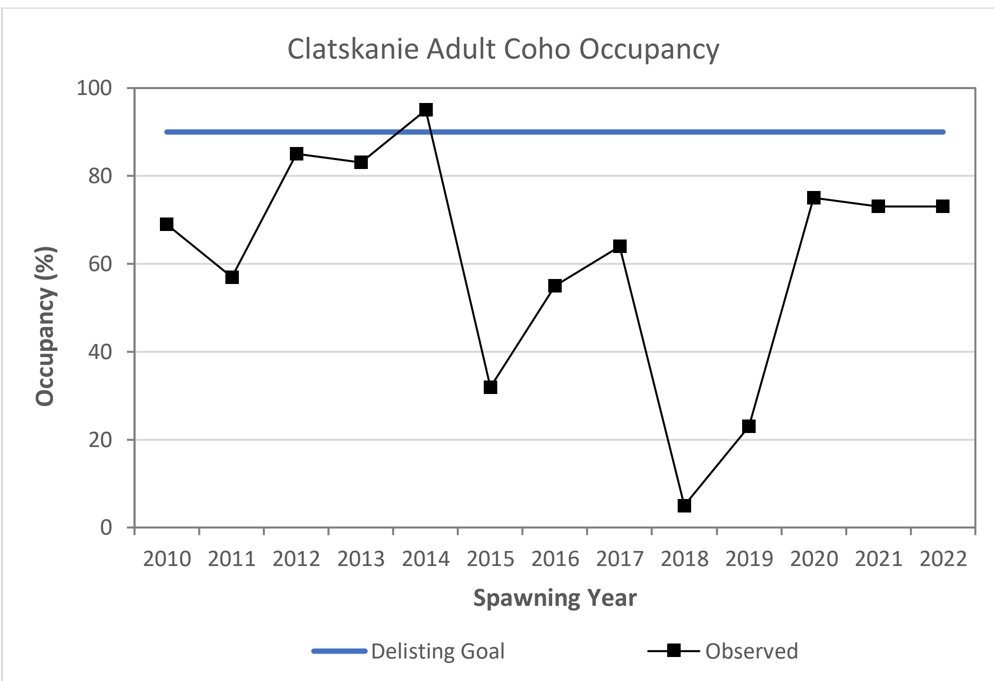

Figure A-III: 10. Percentage of sites occupied by spawning coho salmon in the Clatskanie population, 2010–2022.

Diversity Metric #1: Effective Population Size

Criterion: Annual estimates of abundance of naturally produced spawners in the Clatskanie coho population.

Objective: The observed spawner abundance is ≥ the abundance modeled for delisting at least six times in any 12-year period *and* the average observed spawner abundance is ≥ the average modeled abundance for delisting over that same period.

12-Year Assessment: In Progress (see *Abundance and Productivity* metric).

Diversity Metric #2: Interbreeding with Hatchery Fish

Criterion: Annual assessments of the proportion of spawning fish that are of hatchery origin in the Clatskanie coho population.

Objective: Over a nine-year period, the average percentage of the total number of spawners that are of hatchery origin is on average less than or equal to 10 percent.

12-Year Assessment: In progress.
The most recent nine-year average for pHOS in the Clatskanie coho population indicates that this objective is not being met (Figure A-III: 11). Average pHOS has been trending upward in recent years due to low returns of natural origin fish and the influence on straying into Plympton Creek.

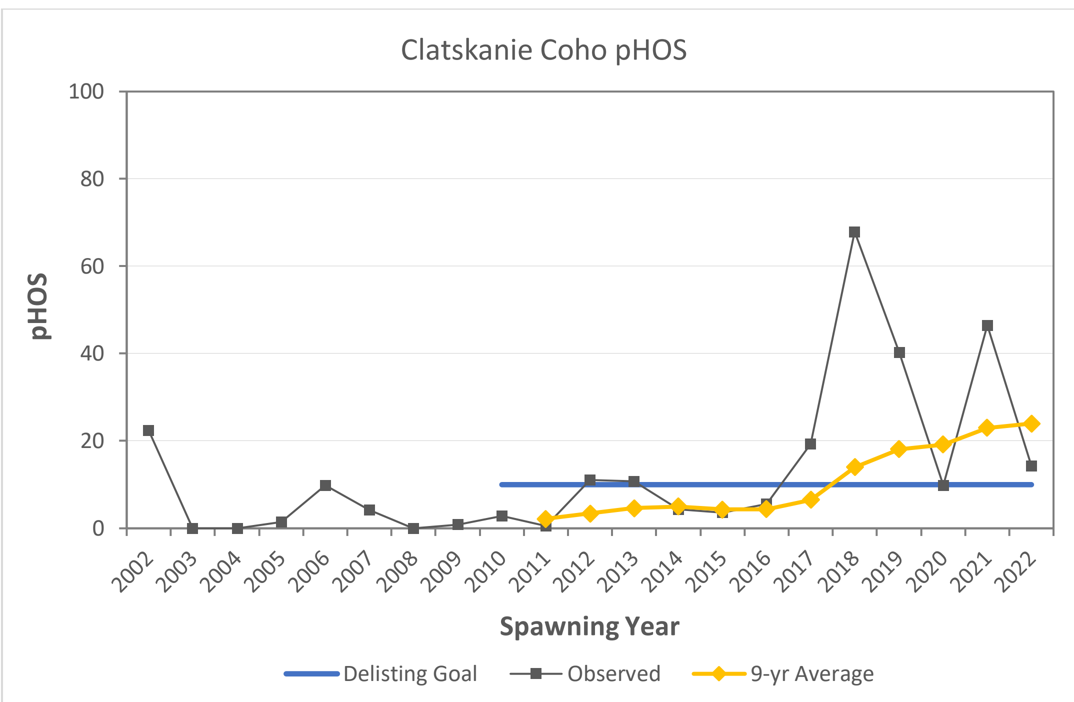

Figure A-III: 11. Percentage of hatchery origin fish on the spawning grounds in the Clatskanie coho population, 2002–2022. The running nine-year average (yellow line) and delisting goal (blue line) are shown for the period following Plan adoption in 2010.

ESU: Lower Columbia River Coho Salmon

Stratum: Coastal

Population: Scappoose

Adult Abundance and Productivity

Criterion: Annual estimates of abundance of naturally produced spawners in the Scappoose coho population.

Objective: The observed spawner abundance is ≥ the abundance modeled for delisting at least six times in any 12-year period *and* the average observed spawner abundance is ≥ the average modeled abundance for delisting over that same period.

12-Year Assessment: *In Progress.*
Spawner abundance in the Scappoose population did not meet the A/P objective (Figure A-III: 12). Observed abundance exceeded the modeled abundance twice during the period from 2011–2022 and the average spawner abundance (649) was less than the averaged modeled abundance (1,286) over that same period.

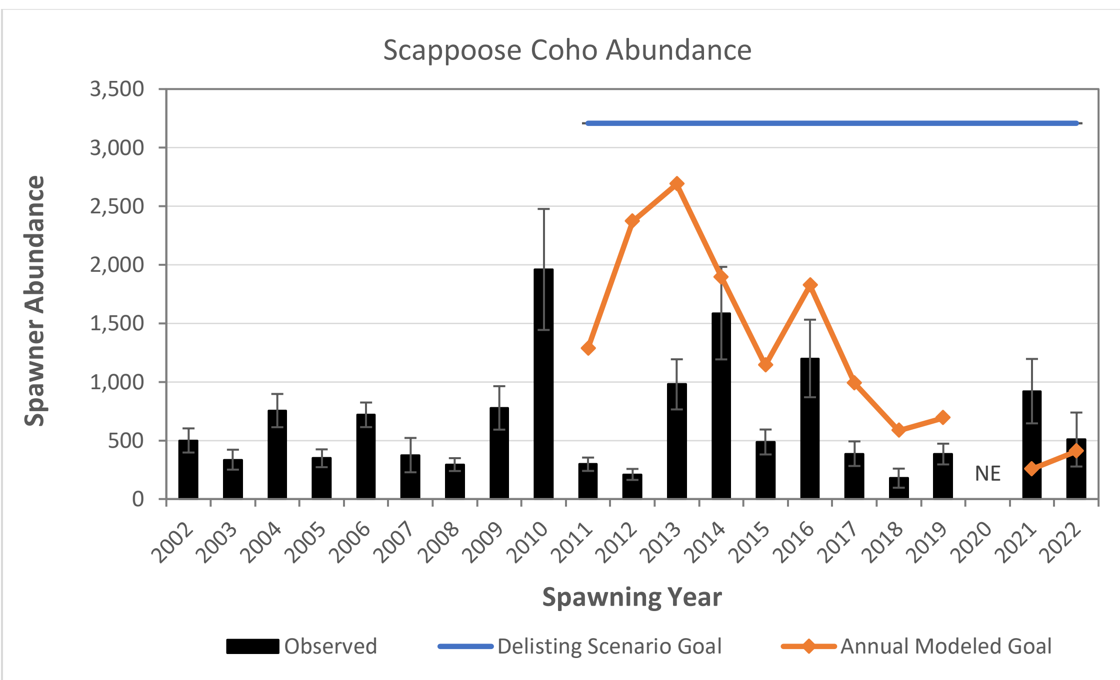

Figure A-III: 12. Natural origin coho salmon spawner abundance in the Scappoose population, 2002–2022. The delisting scenario goal and annual modeled goals scaled to climate conditions are shown for the period following Plan adoption in 2010. NE = No Estimate.

Spatial Structure

Criterion: The occupancy of spawning adults or juveniles at spatially balanced, random survey sites in the Scappoose coho population.

Objective: The percentage of sites occupied by spawning adults or rearing juvenile salmon is ≥ than the delisting threshold (90 percent) at least six times during a 12-year period *and* the overall average percentage of sites occupied during that same time is ≥ than the threshold of 90 percent.

12-Year Assessment: In Progress.
Occupancy by spawning adults in the Scappoose population did not meet the goal of occupied sites exceeding the 90 percent threshold for six of 12 years for return years 2010-2022 (Figure A-III: 13). The average occupancy of habitat for those years (44 percent) is less than the 90 percent threshold. Juvenile coho surveys have been conducted annually in the LCR ESU since 2006, but these surveys do not provide population-scale occupancy estimates.

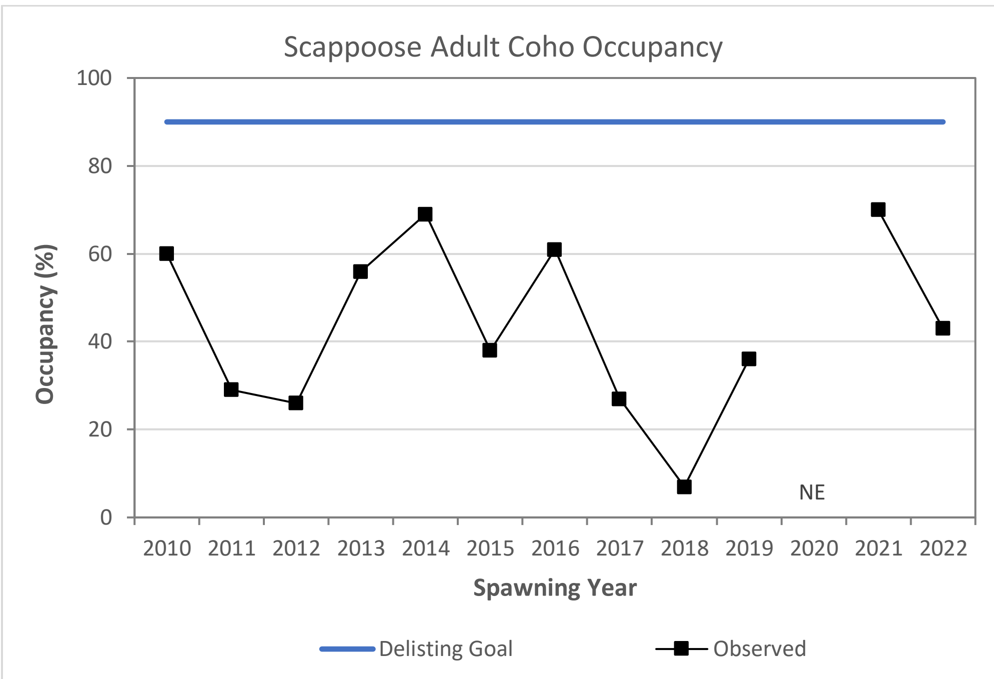

Figure A-III: 13. Percentage of sites occupied by spawning coho salmon in the Scappoose population, 2010–2022. NE = No Estimate.

Diversity Metric #1: Effective Population Size

Criterion: Annual estimates of abundance of naturally produced spawners in the Scappoose coho population.

Objective: The observed spawner abundance is ≥ the abundance modeled for delisting at least six times in any 12-year period *and* the average observed spawner abundance is ≥ the average modeled abundance for delisting over that same period.

12-Year Assessment: In Progress (see *Abundance and Productivity* metric).

Diversity Metric #2: Interbreeding with Hatchery Fish

Criterion: Annual assessments of the proportion of spawning fish that are of hatchery origin in the Scappoose coho population.

Objective: Over a nine-year period, the average percentage of the total number of spawners that are of hatchery origin is on average less than or equal to five percent.

12-Year Assessment: Attained.
The nine-year average for pHOS in the Scappoose coho population has consistently been below the delisting goal threshold of 5 percent since 2010 (Figure A-III: 14).

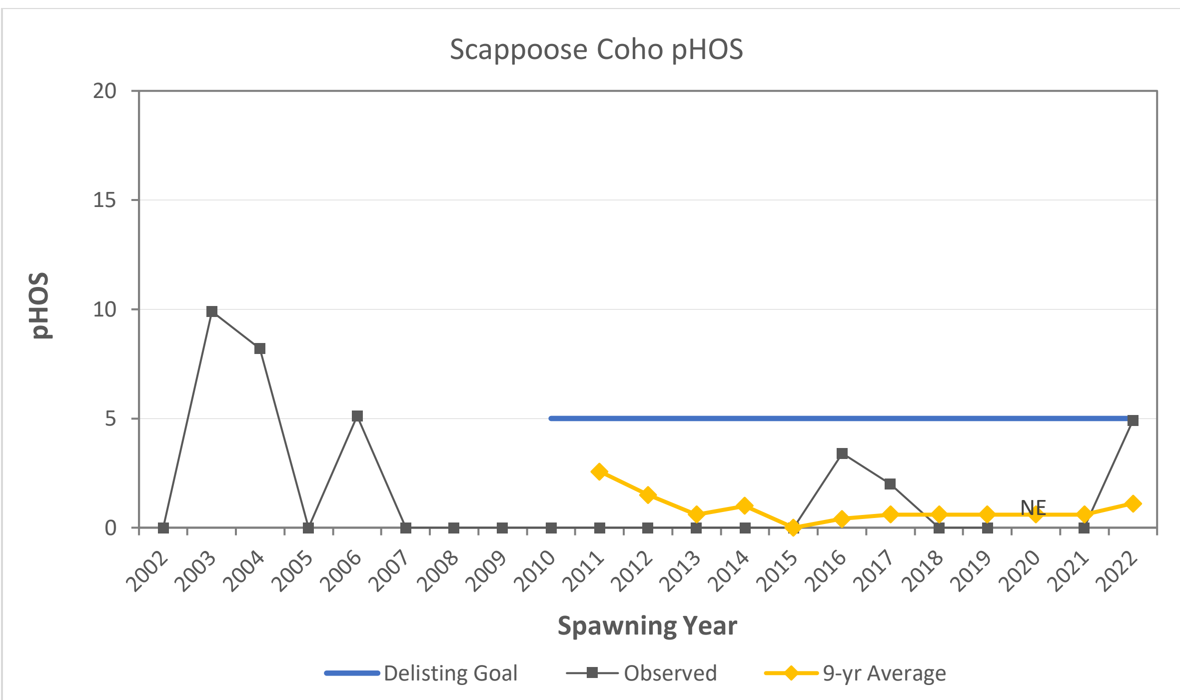

Figure A-III: 14. Percentage of hatchery origin fish on the spawning grounds in the Scappoose coho population, 2002–2022. The running nine-year average (yellow line) and delisting goal (blue line) are shown for the period following Plan adoption in 2010. NE = No Estimate.

ESU: Lower Columbia River Coho Salmon

Stratum: Cascade

Population: Clackamas

Adult Abundance and Productivity

Criterion: Annual estimates of abundance of naturally produced spawners in the Clackamas coho population.

Objective: The observed spawner abundance is ≥ the abundance modeled for delisting at least six times in any 12-year period *and* the average observed spawner abundance is ≥ the average modeled abundance for delisting over that same period.

12-Year Assessment: *Attained.*
Spawner abundance in the Clackamas population met the A/P objective (Figure A-III: 15). Observed abundance exceeded the modeled abundance seven times during the period from 2011–2022 and the average spawner abundance (5,865) was greater than the averaged modeled abundance (4,382) over that same period. Due to constraints related to the COVID-19 pandemic, an estimate of total population abundance in 2020 is not available. However, the count at North Fork Dam, which has represented 77 percent (± eight percent) of the total population estimate in 2004–2022, exceeded the annual modeled goal in 2020 (Figure A-III:15).

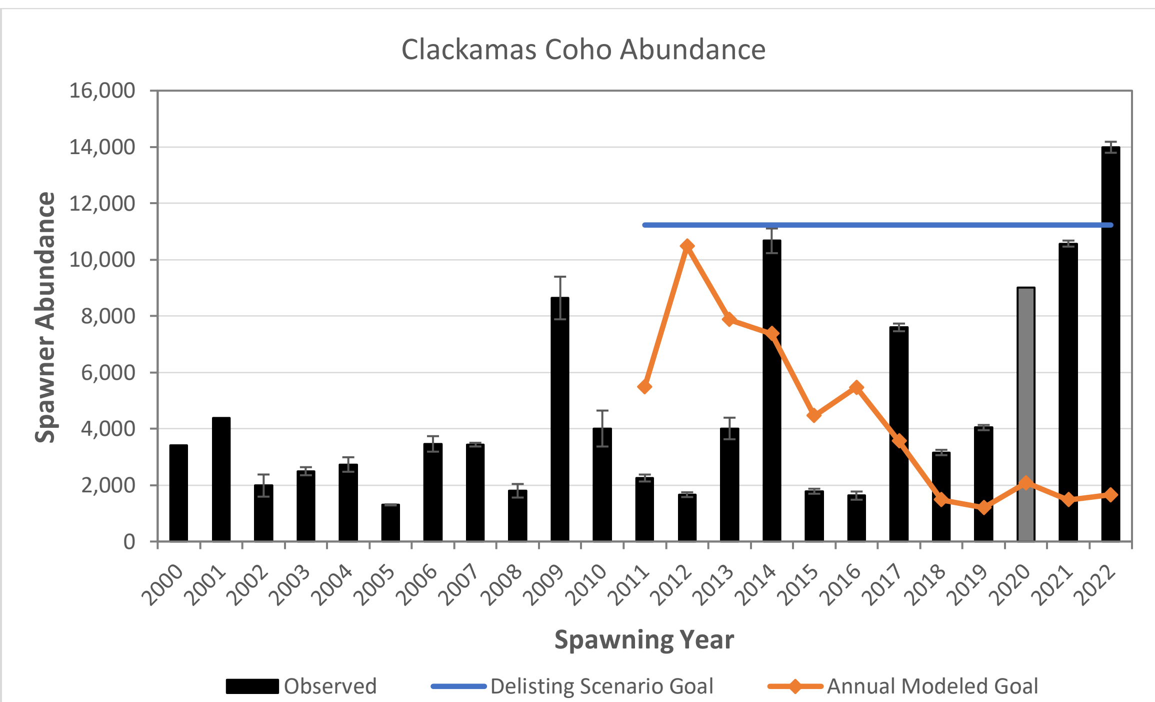

Figure A-III: 15. Natural origin coho salmon spawner abundance in the Clackamas population, 2000–2022 (2020 estimate is North Fork Dam count only). The delisting scenario goal and annual modeled goals scaled to climate conditions are shown for the period following Plan adoption in 2010.

Spatial Structure

Criterion: The occupancy of spawning adults or juveniles at spatially balanced, random survey sites in the Clackamas coho population.

Objective: The percentage of sites occupied by spawning adults or rearing juvenile salmon is ≥ than the delisting threshold (85 percent) at least six times during a 12-year period *and* the overall average percentage of sites occupied during that same period is ≥ than the threshold of 85 percent.

12-Year Assessment: Not Available.
Pacific General Electric's (PGE) hydroelectric project on the Clackamas River provides a unique opportunity for a complete count of fish populations migrating into the upper watershed, which represents approximately two thirds of the spawning habitat within the population. As a result, spawning surveys are only conducted in the population below the dam. Occupancy by spawning adults in the surveyed portion of Clackamas population did not meet the goal of exceeding the 85 percent threshold for six of 12 years for return years 2010-2022 (Figure A-III: 16). The average occupancy of habitat below the dam for those years was 34 percent. However, a significant portion of this habitat is in the urban area and highly degraded. Therefore, occupancy of habitat determined by monitoring downstream of the dam does not represent the spatial structure of the entire population. Juvenile coho surveys have been conducted annually in the LCR ESU since 2006, but these surveys do not provide population-scale occupancy estimates.

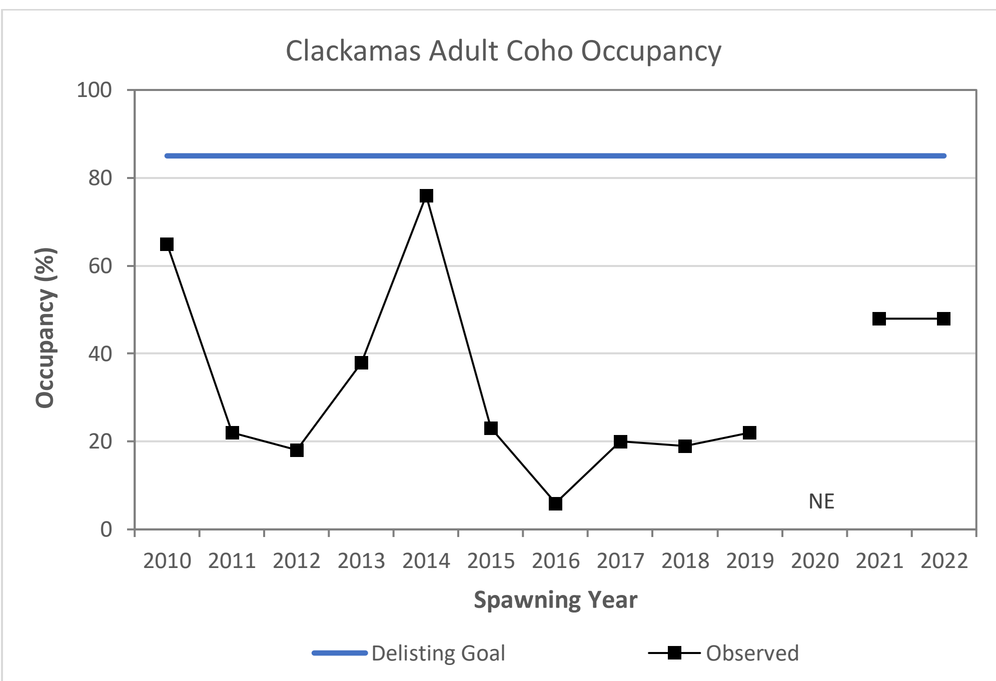

Figure A-III: 16. Percentage of sites occupied by adult spawning salmon in the Clackamas population below North Fork Dam, 2010–2022. NE = No Estimate.

Diversity Metric #1: Effective Population Size

Criterion: Annual estimates of abundance of naturally produced spawners in the Clackamas coho population.

Objective: The observed spawner abundance is ≥ the abundance modeled for delisting at least six times in any 12-year period *and* the average observed spawner abundance is ≥ the average modeled abundance for delisting over that same period.

12-Year Assessment: Attained (see *Abundance and Productivity* metric).

Diversity Metric #2: Interbreeding with Hatchery Fish

Criterion: Annual assessments of the proportion of spawning fish that are of hatchery origin in the Clackamas coho population.

Objective: Over a nine-year period, the average percentage of the total number of spawners that are of hatchery origin is on average less than or equal to ten percent.

12-Year Assessment: Attained.
The nine-year average for pHOS in the Clackamas coho population has been declining since 2011 and the most recent estimate (8 percent) is below the delisting goal threshold of 10 percent (Figure A-III: 17).

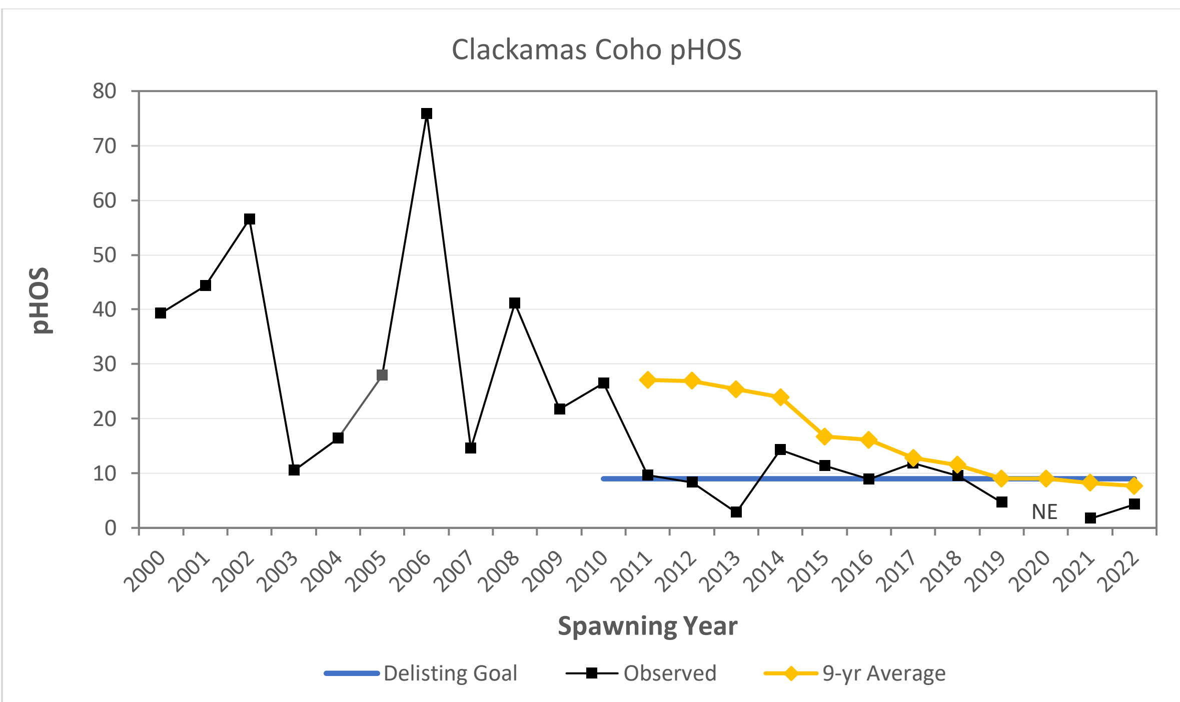

Figure A-III: 17. Percentage of hatchery origin fish on the spawning grounds in the Clackamas coho population, 2000–2022. The running nine-year average (yellow line) and delisting goal (blue line) are shown for the period following Plan adoption in 2010. NE = No Estimate.

ESU: Lower Columbia River Coho Salmon

Stratum: Cascade

Population: Sandy

Adult Abundance and Productivity

Criterion: Annual estimates of abundance of naturally produced spawners in the Sandy coho population.

Objective: The observed spawner abundance is ≥ the abundance modeled for delisting at least six times in any 12-year period *and* the average observed spawner abundance is ≥ the average modeled abundance for delisting over that same period.

12-Year Assessment: *In Progress.*
Spawner abundance in the Sandy population may pass the A/P objective, but an additional year of data is needed to definitively assess the 12-year criteria (Figure A-III: 18). Observed abundance exceeded the modeled abundance five times during the period from 2011–2022 (no estimate is available for 2020) and the average spawner abundance (2,509) was less than the averaged modeled abundance (2,802) over that same period.

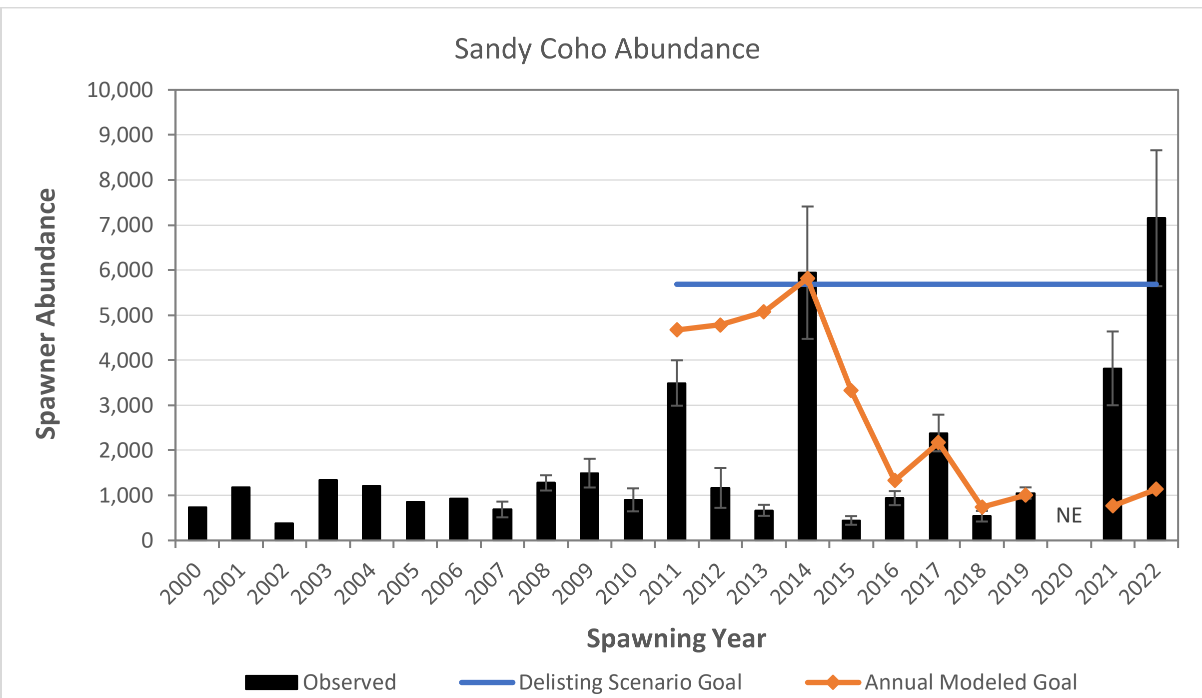

Figure A-III: 18. Natural origin coho salmon spawner abundance in the Sandy population, 2000–2022. The delisting scenario goal and annual modeled goals scaled to climate conditions are shown for the period following Plan adoption in 2010. NE = No Estimate.

Spatial Structure

Criterion: The occupancy of spawning adults or juveniles at spatially balanced, random survey sites in the Sandy coho population.

Objective: The percentage of sites occupied by spawning adults or rearing juvenile salmon is ≥ than the delisting threshold (75 percent) at least six times during a 12-year period *and* the overall average percentage of sites occupied during that same period is ≥ than the threshold of 75 percent.

12-Year Assessment: In Progress.
Occupancy by spawning adults in the Sandy population did not meet the goal of occupied sites exceeding the 75 percent threshold for six of 12 years for return years 2010-2022 (Figure A-III: 19). The average occupancy of habitat for those years (42 percent) is less than the 75 percent threshold. Juvenile coho surveys have been conducted annually in the LCR ESU since 2006, but these surveys do not provide population-scale occupancy estimates.

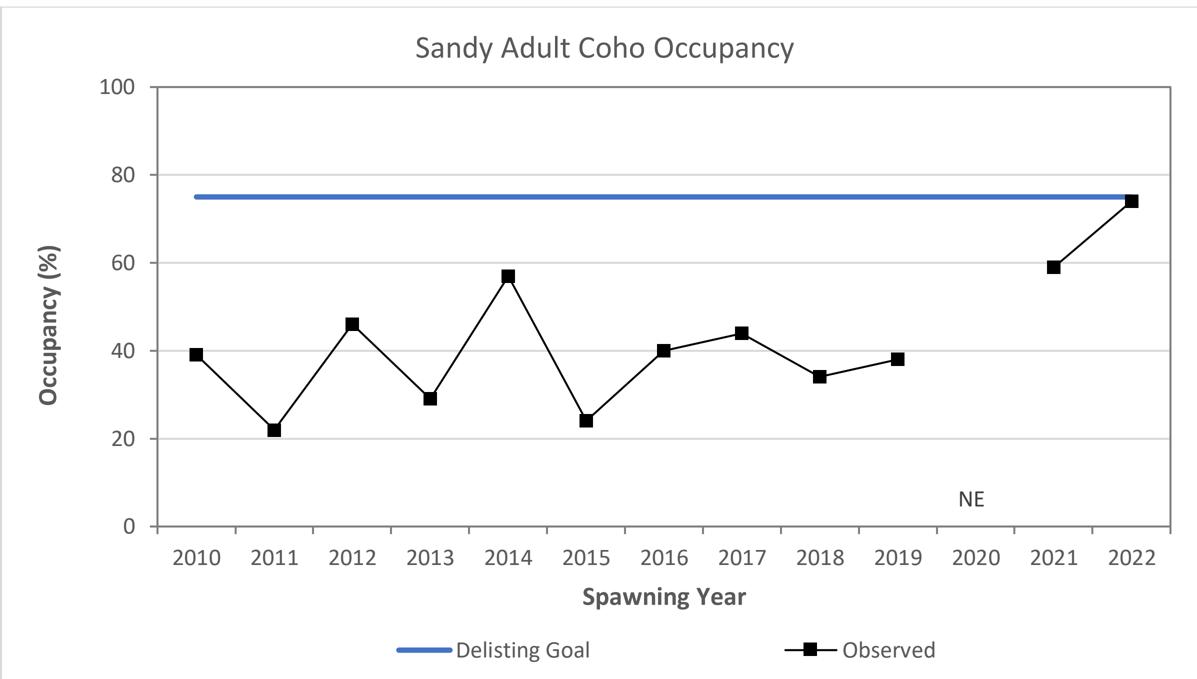

Figure A-III: 19. Percentage of sites occupied by spawning coho salmon in the Sandy population, 2010–2022. NE = No Estimate.

Diversity Metric #1: Effective Population Size

Criterion: Annual estimates of abundance of naturally produced spawners in the Sandy coho population.

Objective: The observed spawner abundance is ≥ the abundance modeled for delisting at least six times in any 12-year period *and* the average observed spawner abundance is ≥ the average modeled abundance for delisting over that same period.

12-Year Assessment: In Progress (see *Abundance and Productivity* metric).

Diversity Metric #2: Interbreeding with Hatchery Fish

Criterion: Annual assessments of the proportion of spawning fish that are of hatchery origin in the Sandy coho population.

Objective: Over a nine-year period, the average percentage of the total number of spawners that are of hatchery origin is on average less than or equal to nine percent.

12-Year Assessment: Attained.
The nine-year average for pHOS in the Sandy coho population has consistently been below the delisting goal threshold of nine percent since 2011 (Figure A-III: 20).

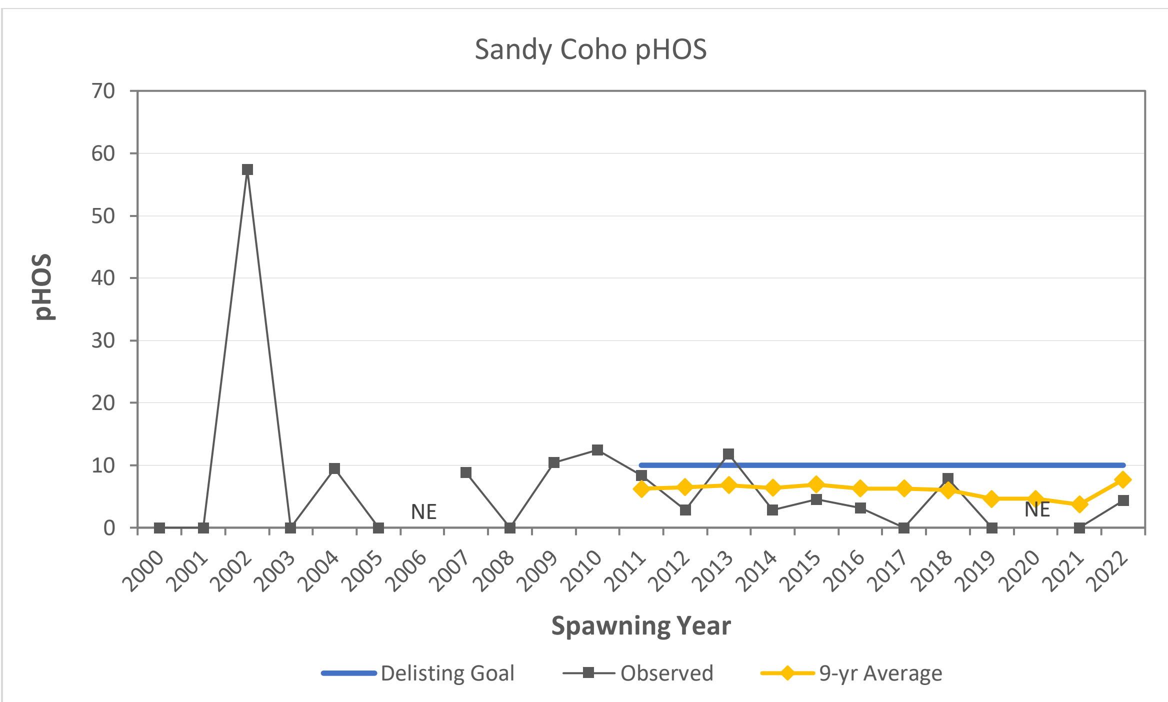

Figure A-III: 20. Percentage of hatchery origin fish on the spawning grounds in the Sandy coho population, 2000–2022. The running nine-year average (yellow line) and delisting goal (blue line) are shown for the period following Plan adoption in 2010. NE = No Estimate.

ESU: Lower Columbia River Coho Salmon
Stratum: Gorge
Population: Lower Gorge

Abundance and Productivity

Criterion: Annual estimates of abundance of naturally produced spawners in the Lower Gorge coho population.

Objective: The observed spawner abundance is ≥ the abundance modeled for delisting at least six times in any 12-year period *and* the average observed spawner abundance is ≥ the average modeled abundance for delisting over that same period.

12-Year Assessment: *In Progress*
Spawner abundance in the Lower Gorge population likely did not meet the A/P objective, although additional years of data are needed to definitively assess the 12-year criteria (Figure A-III: 21). Observed abundance exceeded the modeled abundance three times during the period from 2011–2022 (no estimate is available for 2017, 2020, and 2021) and the average spawner abundance (219) was less than the averaged modeled abundance (381) over that same period.

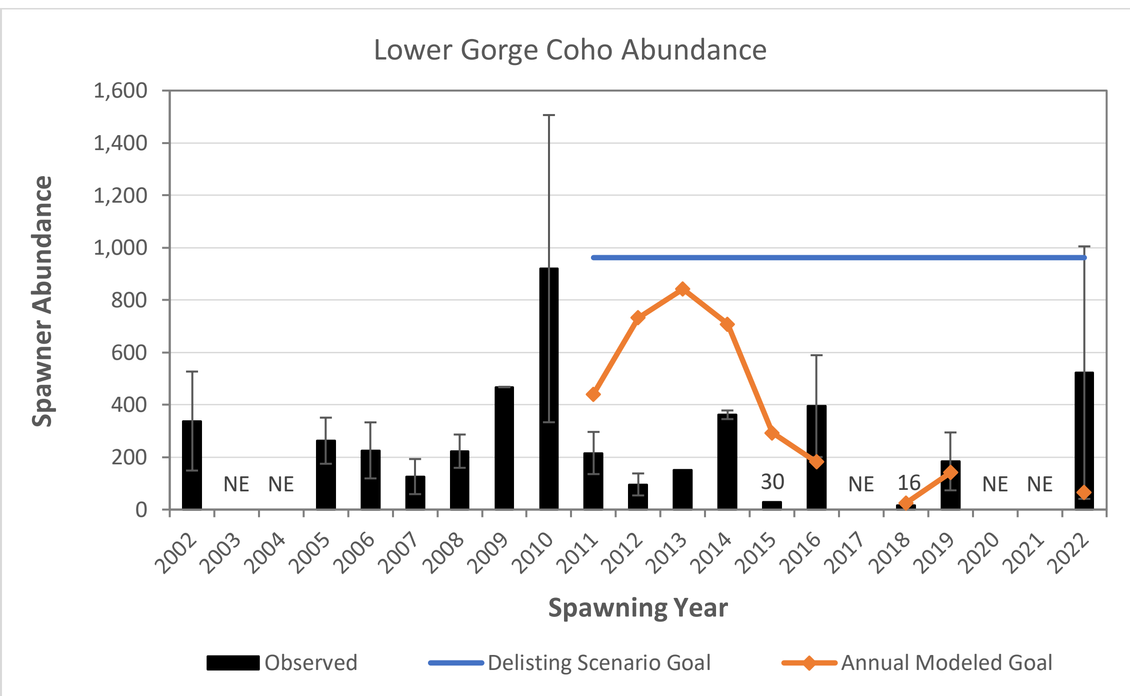

Figure A-III: 21. Natural origin coho salmon spawner abundance in the Lower Gorge population, 2002–2022. The delisting scenario goal and annual modeled goals scaled to climate conditions are shown for the period following Plan adoption in 2010. NE = No Estimate.

Spatial Structure

Criterion: The occupancy of spawning adults or juveniles at spatially balanced, random survey sites in the Lower Gorge coho population.

Objective: The percentage of sites occupied by spawning adults or rearing juvenile salmon is ≥ than the delisting threshold (50 percent) at least six times during a 12-year period *and* the overall average percentage of sites occupied during that same period is ≥ than the threshold of 50 percent.

12-Year Assessment: Attained.
Although estimates are not available for all years, occupancy by spawning adults in the Lower Gorge population met the goal of occupied sites exceeding the 50 percent threshold for six of 12 years for return years 2010-2022 (Figure A-III: 22). The average occupancy of habitat for those years (74 percent) was greater than the 50 percent threshold. Juvenile coho surveys have been conducted annually in the LCR ESU since 2006, but these surveys do not provide population-scale occupancy estimates.

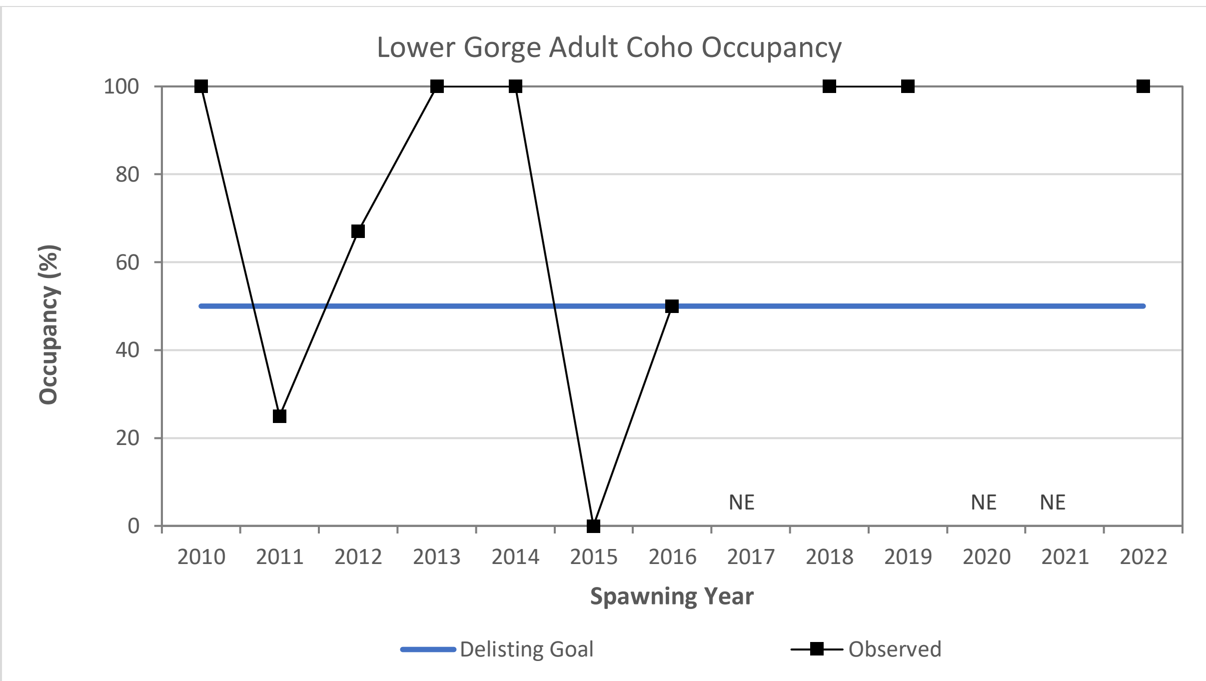

Figure A-III: 22. Percentage of sites occupied by spawning coho salmon in the Lower Gorge population, 2010–2022. NE = No Estimate.

Diversity Metric #1: Effective Population Size

Criterion: Annual estimates of abundance of naturally produced spawners in the Lower Gorge coho population.

Objective: The observed spawner abundance is ≥ the abundance modeled for delisting at least six times in any 12-year period *and* the average observed spawner abundance is ≥ the average modeled abundance for delisting over that same period.

12-Year Assessment: In progress (see *Abundance and Productivity* metric).

Diversity Metric #2: Interbreeding with Hatchery Fish

Criterion: Annual assessments of the proportion of spawning fish that are of hatchery origin in the Lower Gorge coho population.

Objective: Over a nine-year period, the average percentage of the total number of spawners that are of hatchery origin is on average less than or equal to 10 percent.

12-Year Assessment: In Progress.
The nine-year average for pHOS in the Lower Gorge coho population has consistently been above the delisting goal threshold of 10 percent since 2013 (Figure A-III: 23), but a declining trend has been observed over time.

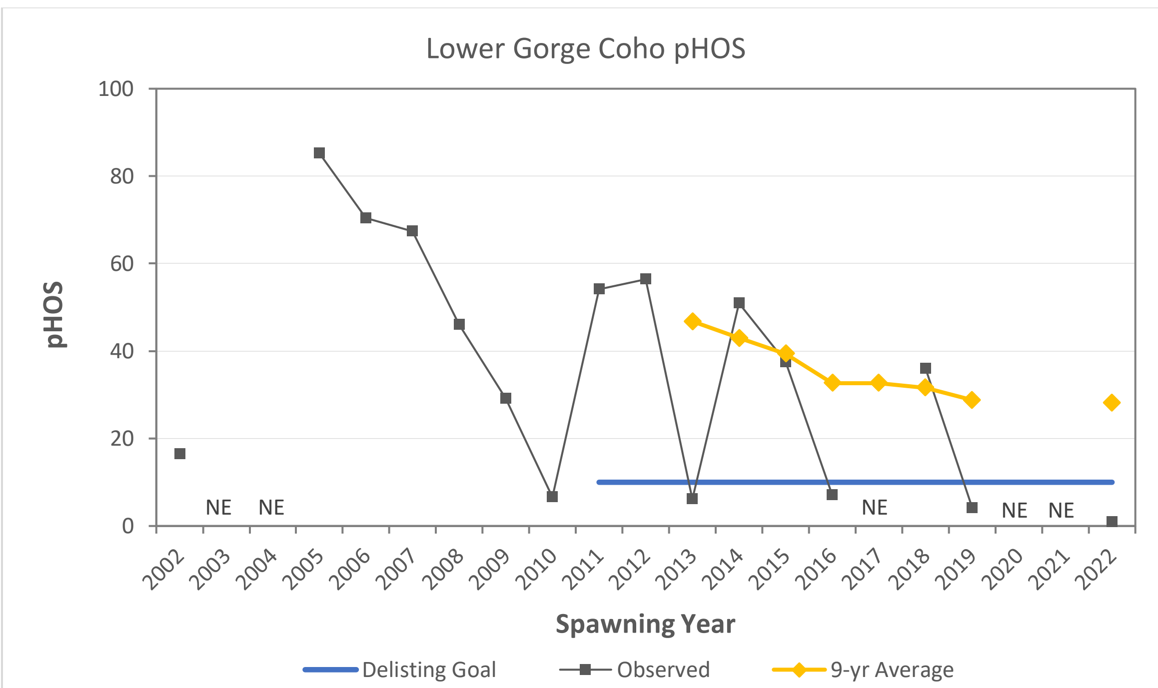

Figure A-III: 23. Percentage of hatchery origin fish on the spawning grounds in the Lower Gorge coho population, 2002–2022. The running nine-year average (yellow line) and delisting goal (blue line) are shown for the period following Plan adoption in 2010. NE = No Estimate.

ESU: Lower Columbia River Coho Salmon

Stratum: Gorge

Population: Upper Gorge/Hood River

Abundance and Productivity

Criterion: Annual estimates of abundance of naturally produced spawners in the Upper Gorge/Hood coho population.

Objective: The observed spawner abundance is ≥ the abundance modeled for delisting at least six times in any 12-year period *and* the average observed spawner abundance is ≥ the average modeled abundance for delisting over that same period.

12-Year Assessment: *In Progress.*
Spawner abundance in the Upper Gorge/Hood population likely did not meet the A/P objective, although additional years of data are needed to definitively assess the 12-year criteria (Figure A-III: 24). Observed abundance exceeded the modeled abundance three times during the period from 2011–2022 (estimates are not available for 2017 and 2020) and the average spawner abundance (194) was less than the averaged modeled abundance (922) over that same period.

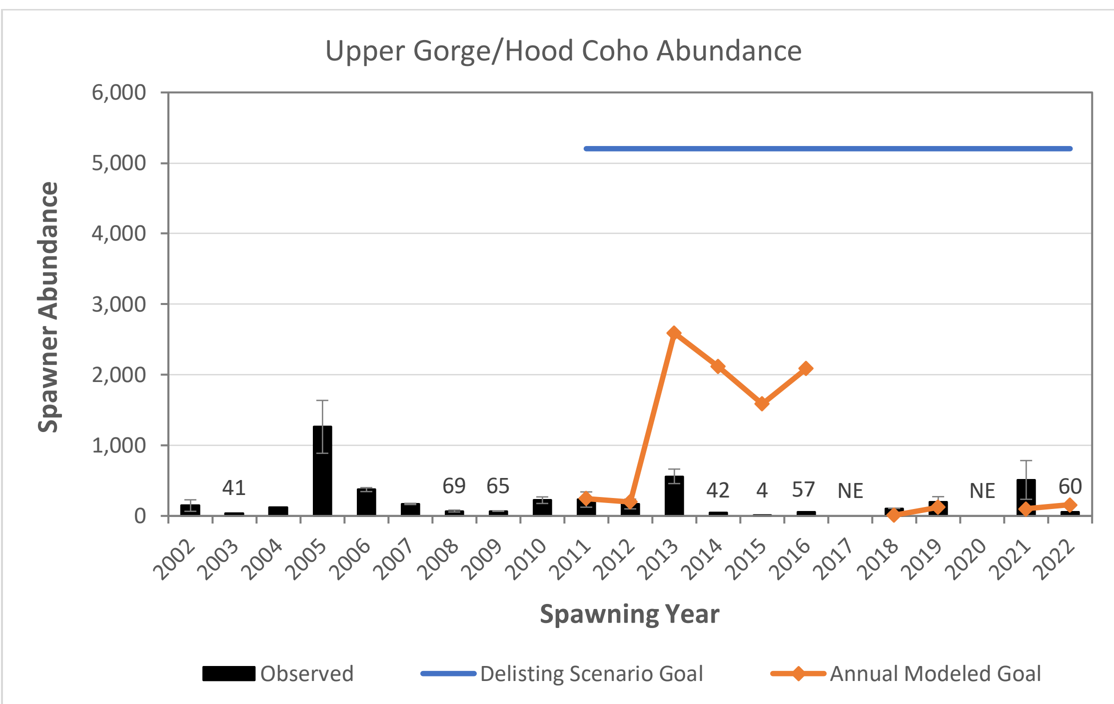

Figure A-III: 24. Natural origin coho salmon spawner abundance in the Upper Gorge/Hood population, 2002–2022. The delisting scenario goal and annual modeled goals scaled to climate conditions are shown for the period following Plan adoption in 2010. NE = No Estimate.

Spatial Structure

Criterion: The occupancy of spawning adults or juveniles at spatially balanced, random survey sites in the Upper Gorge/Hood coho population.

Objective: The percentage of sites occupied by spawning adults or rearing juvenile salmon is ≥ than the delisting threshold (80 percent) at least six times during a 12-year period *and* the overall average percentage of sites occupied during that same period is ≥ than the threshold of 80 percent.

12-Year Assessment: In Progress.
Additional years of adult coho monitoring are needed to determine whether the spatial structure objective has been attained. Occupancy by spawning adults in the Upper Gorge/Hood population met or exceeding the 80 percent threshold in five of 11 years in 2010-2022 (Figure A-III: 25). Average occupancy of habitat over this period was 74 percent. Juvenile coho surveys have been conducted annually in the LCR ESU since 2006, but these surveys do not provide population-scale occupancy estimates.

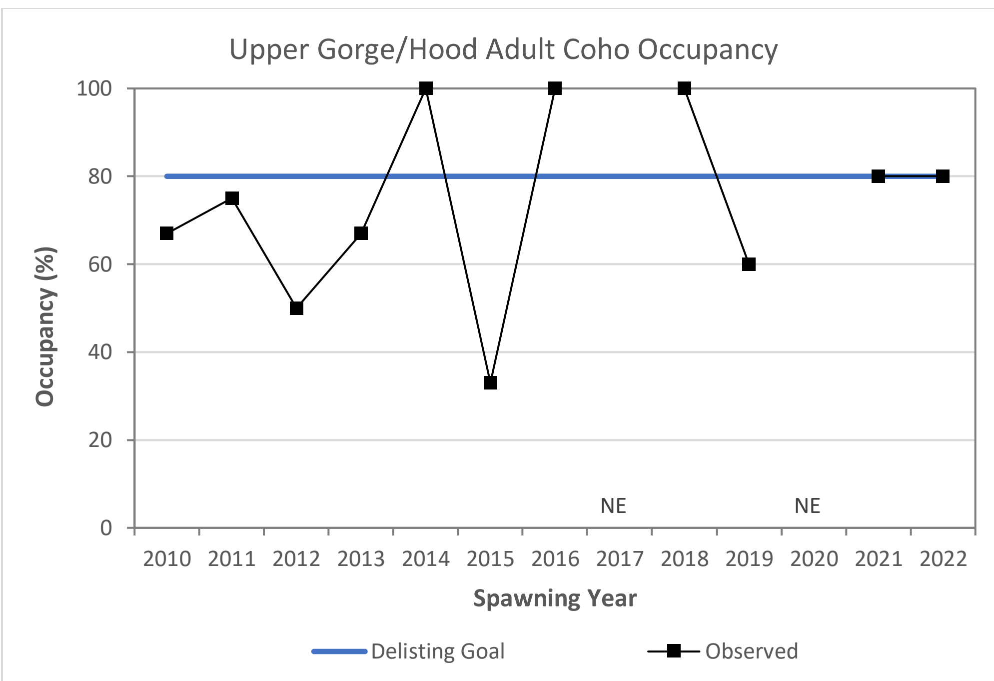

Figure A-III: 25. Percentage of sites occupied by spawning coho salmon in the Upper Gorge/Hood population, 2010–2022. NE = No Estimate.

Diversity Metric #1: Effective Population Size

Criterion: Annual estimates of abundance of naturally produced spawners in the Upper Gorge/Hood River coho population.

Objective: The observed spawner abundance is ≥ the abundance modeled for delisting at least six times in any 12-year period *and* the average observed spawner abundance is ≥ the average modeled abundance for delisting over that same period.

12-Year Assessment: Attainment Uncertain (see *Abundance and Productivity* metric).

Diversity Metric #2: Interbreeding with Hatchery Fish

Criterion: Annual assessments of the proportion of spawning fish that are of hatchery origin in the Upper Gorge/Hood River coho population.

Objective: Over a nine-year period, the average percentage of the total number of spawners that are of hatchery origin is on average less than or equal to zero percent.

12-Year Assessment: In Progress.
The nine-year average for pHOS in the Upper Gorge/Hood coho population has consistently been above the delisting goal threshold of zero percent since 2013 (Figure A-III: 26). There is no hatchery program in this basin and high pHOS relative to the delisting goal is due to out-of-basin straying and very low natural origin coho abundance in most years.

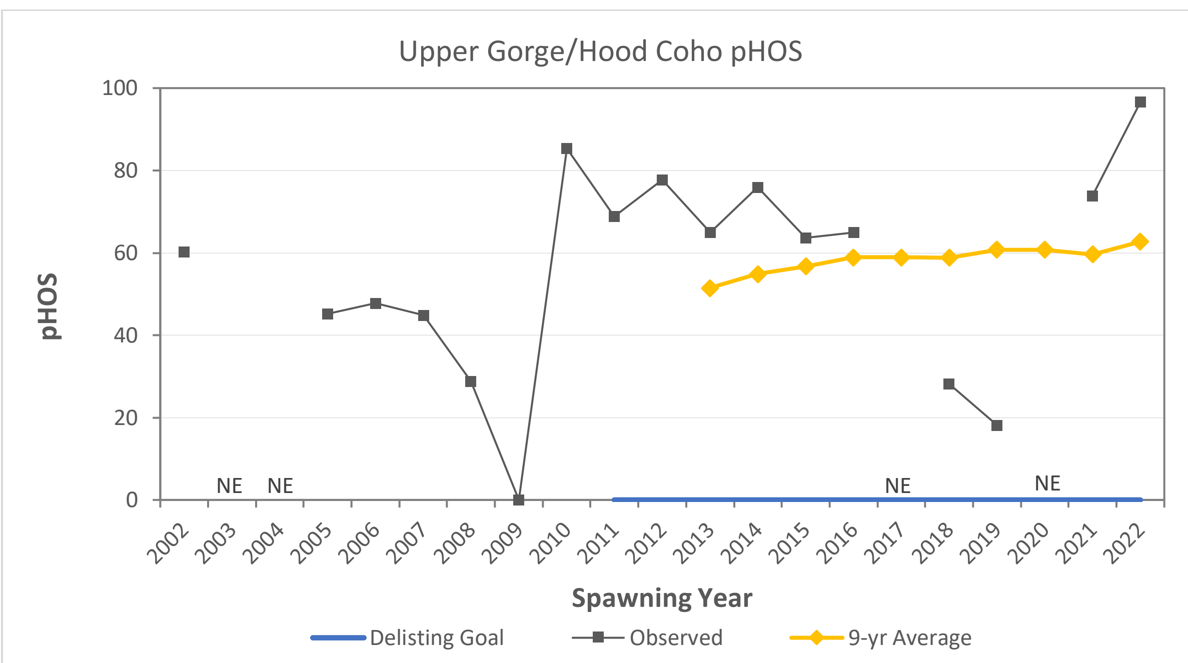

Figure A-III: 26. Percentage of hatchery origin fish on the spawning grounds in the Upper Gorge/Hood coho population, 2002–2022. The running nine-year average (yellow line) and delisting goal (blue line) are shown for the period following Plan adoption in 2010. NE = No Estimate.

ESU: Lower Columbia River Chinook Salmon

Stratum: All (Aggregate)

Population: All Fall and Late Fall Populations (Aggregate)

There are no measurable criteria assigned for an aggregate abundance level for the LCR Chinook Salmon ESU. The ESU includes nine fall Chinook populations and one late fall Chinook population (Sandy). Currently, there is no way to reliably differentiate fall and late fall Chinook in the Sandy River and so all VSP metrics are based on combined results for fall and late fall Chinook. Natural origin spawner abundance of fall and late fall Chinook in the Oregon portion of the ESU has shown an increasing trend since 2012, when monitoring data became consistently available for most populations (Figure A-III: 27). Sandy fall and late fall Chinook consistently account for a majority of the total fall Chinook return to the Oregon portion of the ESU and are primarily responsible for the increasing trend in aggregate abundance.

Aggregate fall Chinook abundance in Figure A-III: 27 does not include the Upper Gorge, Lower Gorge, and Hood River populations. ODFW regularly conducted spawning surveys in these populations during the period from 2010-2022. However, the number of surveys conducted annually was typically very low and the available monitoring information is not adequate to assess biological criteria for these populations.

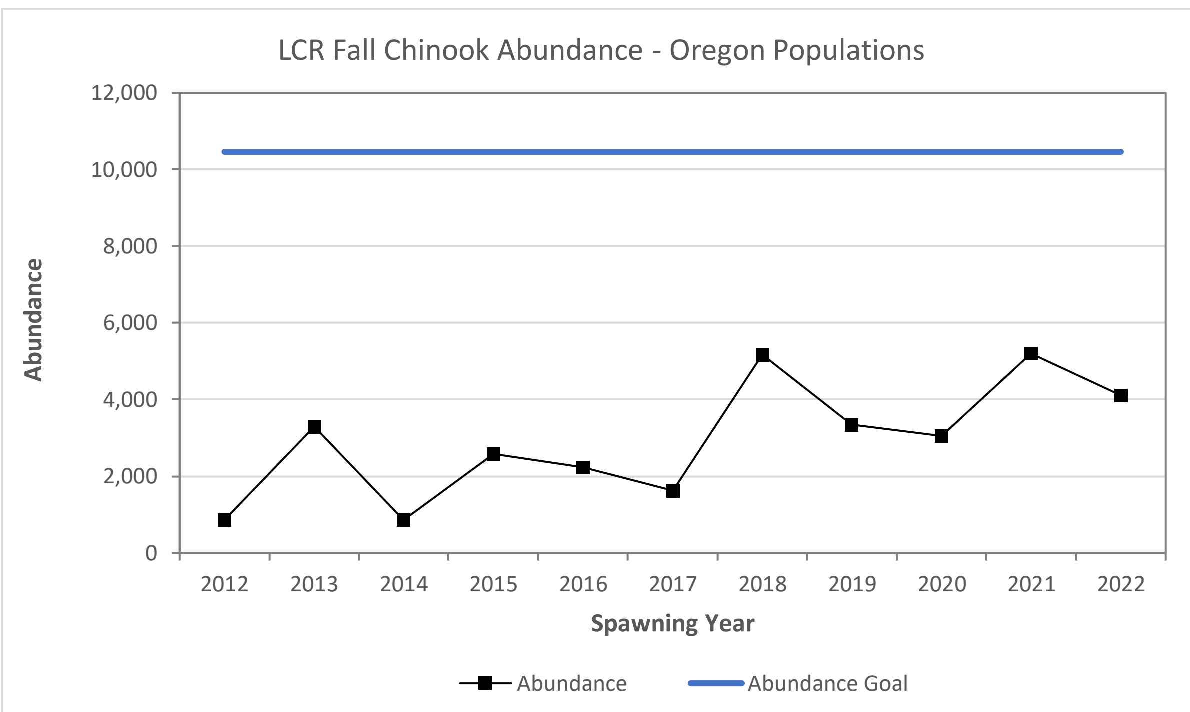

Figure A-III: 27. Natural origin fall and late fall Chinook spawner abundance in the Oregon portion of the LCR Chinook ESU, 2012–2022. Spawner abundance in the Lower Gorge, Upper Gorge, and Hood populations is not included because estimates are not available for these populations during this period. In addition, no spawner abundance estimate is available for the Youngs Bay population in 2019.

VSP metrics for fall chinook spawners are estimated based on spawning surveys selected using a spatially balanced monitoring design (GRTS, Stevens 2002). Survey field methods follow those developed by ODFW's OASIS program. Abundance estimates derived from the GRTS survey design represent the annual status of fall Chinook spawner abundance in the ESU and each independent population, with the following notes:

- *Sandy Fall/late Fall Chinook*: Combined fall and late fall Chinook abundance was historically based on an expansion of index counts, and estimates developed with this methodology were used in the Plan status assessment and recovery scenario analysis. Since 2012, ODFW has estimated combined fall and late fall Chinook abundance in the Sandy population using a GRTS survey design with increased coverage and better spatial representation of fall Chinook spawning areas. For this assessment, we considered the GRTS estimates the best available information about Sandy fall Chinook abundance. Estimates developed using the two different methodologies have been comparable in some years but have widely diverged in others, so we did not include index survey expansion estimates in the figures below or when assessing the abundance and productivity criterion. Delisting scenario goals in the Plan for late fall Chinook are based on the index survey expansion estimates and there is a need to determine whether comparison of GRTS-based estimates with these goals is appropriate. In addition, there is a need to determine what goals should be applicable to the combined fall/late fall Chinook population, as there does not appear to be a feasible way to calculate separate VSP parameters for the two run types.
- *Lower Gorge, Upper Gorge, and Hood Fall Chinook*: The Plan directs ODFW to take a strategic approach to fluctuations in monitoring support. Due to budget shortfalls and prioritization of monitoring efforts, the department chose to reduce effort within the GRTS sampling frame for these populations.

ESU: Lower Columbia River Chinook Salmon

Stratum: Coastal

Population: Youngs Bay Fall Chinook

Abundance and Productivity

Criterion: Annual estimates of abundance of naturally produced spawners in the Youngs Bay fall Chinook population.

Objective: The observed spawner abundance is ≥ the abundance modeled for delisting at least six times in any 12-year period *and* the average observed spawner abundance is ≥ the average modeled abundance for delisting over that same period.

12-Year Assessment: *Not Available*
The A/P criterion could not be assessed for the Youngs Bay population because annual modeled goals were only available for four years (Figure A-III: 28). Observed abundance was greater than the annual modeled goal in two of these four years during the period from 2011–2022 (estimates are not available for 2019) and the average spawner abundance (169) was greater than the averaged modeled abundance (50) over that same period.

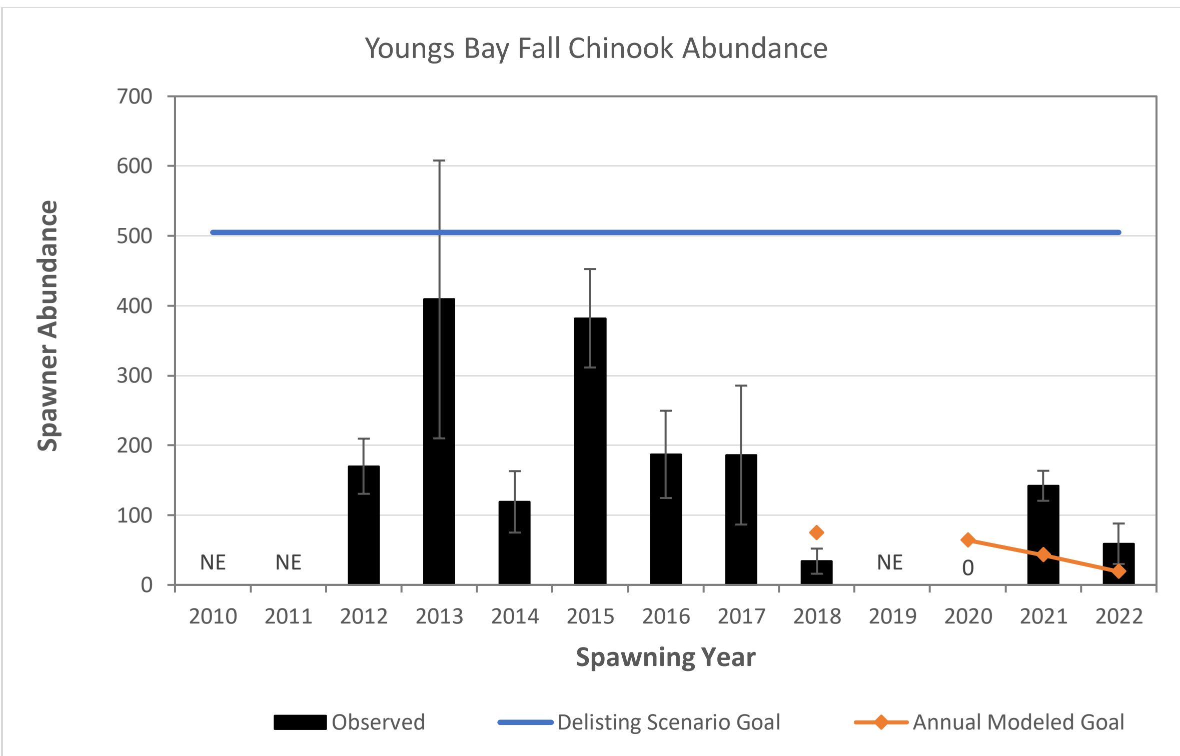

Figure A-III: 28. Natural origin fall Chinook salmon spawner abundance in the Youngs Bay population, 2010–2022. The delisting scenario goal and annual modeled goals scaled to climate conditions are shown, where available, for the period following Plan adoption in 2010. NE = No Estimate.

Spatial Structure

Criterion: The occupancy of spawning adults or juveniles at spatially balanced, random survey sites in the Youngs Bay fall Chinook population.

Objective: The percentage of sites occupied by spawning adults or rearing juvenile salmon is ≥ than the delisting threshold (50 percent) at least six times during a 12-year period *and* the overall average percentage of sites occupied during that same time is ≥ than the thresholds of 50 percent.

12-Year Assessment: Attained.
Occupancy by spawning adults in the Youngs Bay population met or exceeded the 50 percent threshold in 9 of 12 years from 2011-2022 (Figure A-III: 29) and the average occupancy of habitat for those years (54 percent) was greater than the 50 percent threshold.

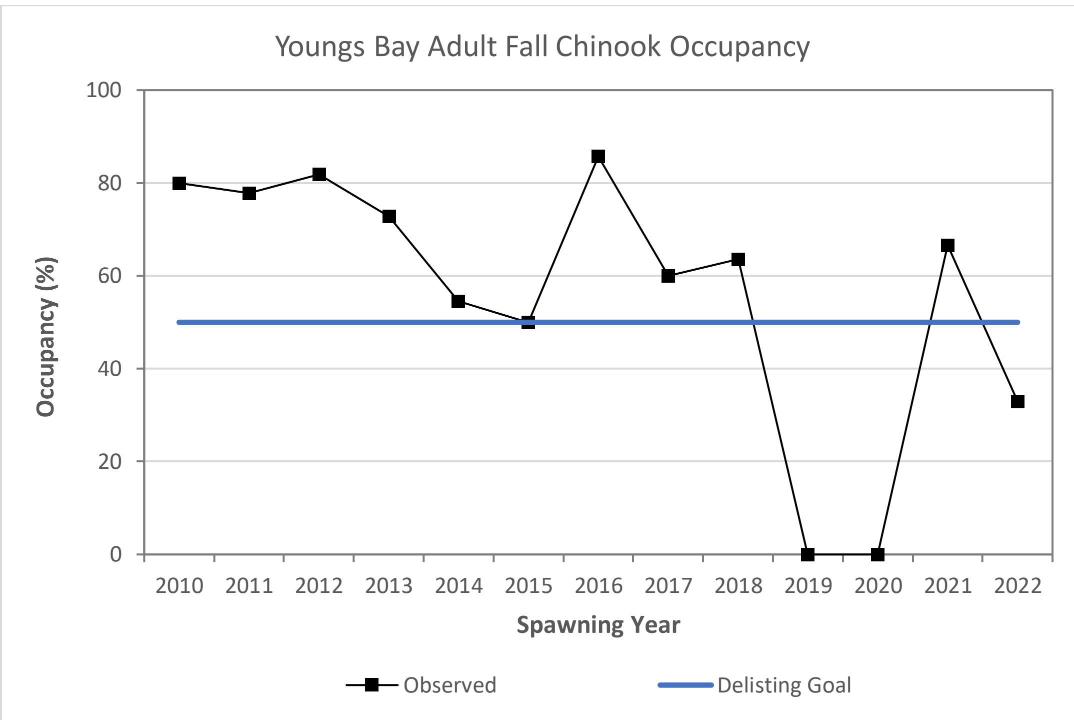

Figure A-III: 29. Percentage of sites occupied by spawning fall Chinook in the Youngs Bay population, 2010–2022.

Diversity Metric #1: Effective Population Size

Criterion: Annual estimates of abundance of naturally produced spawners in the Youngs Bay fall Chinook population.

Objective: The observed spawner abundance is ≥ the abundance modeled for delisting at least six times in any 12-year period *and* the average observed spawner abundance is ≥ the average modeled abundance for delisting over that same period.

12-Year Assessment: Not Available (see *Abundance and Productivity* metric).

Diversity Metric #2: Interbreeding with Hatchery Fish

Criterion: Annual assessments of the proportion of spawning fish that are of hatchery origin in the Youngs Bay fall Chinook population.

Objective: Over a nine-year period, the average percentage of the total number of spawners that are of hatchery origin is on average less than or equal to 90 percent.

12-Year Assessment: Attained.
The nine-year average for pHOS in the Youngs Bay fall Chinook population (85 percent) is slightly below the delisting goal threshold of 90 percent (Figure A-III: 30).

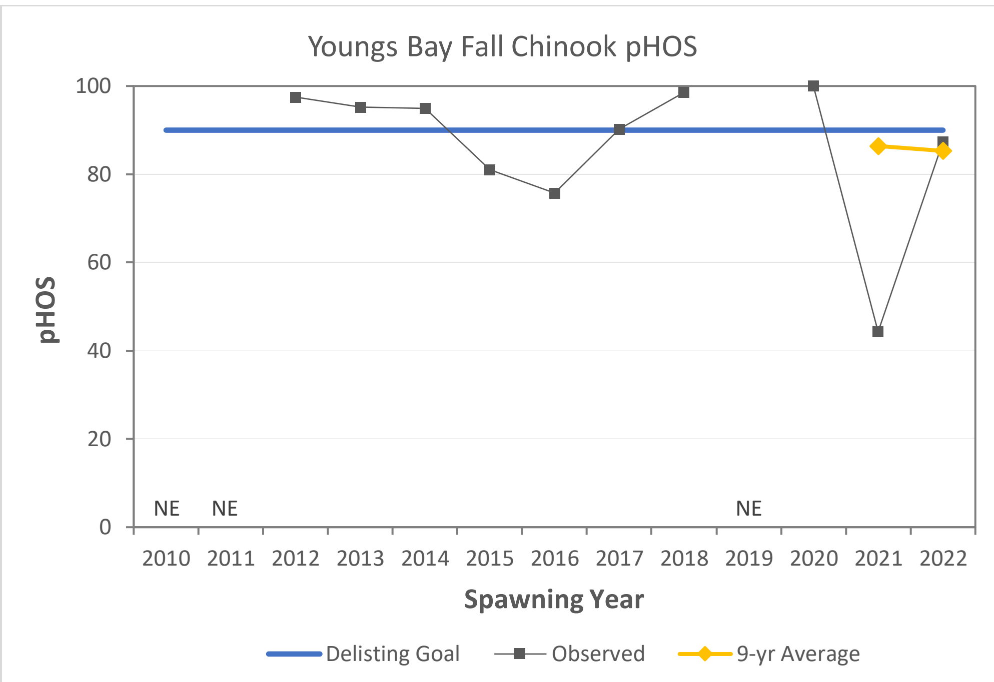

Figure A-III: 30. Percentage of hatchery origin fish on the spawning grounds in the Youngs Bay fall Chinook population, 2010–2022. The running nine-year average (yellow point) and delisting goal (blue line) are shown for the period following Plan adoption in 2010. NE = No Estimate.

ESU: Lower Columbia River Chinook Salmon

Stratum: Coastal

Population: Big Creek Fall Chinook

Abundance and Productivity

Criterion: Annual estimates of abundance of naturally produced spawners in the Big Creek fall Chinook population.

Objective: The observed spawner abundance is ≥ the abundance modeled for delisting at least six times in any 12-year period *and* the average observed spawner abundance is ≥ the average modeled abundance for delisting over that same period.

12-Year Assessment: *Not Available*
The A/P criterion could not be assessed for the Big Creek population because annual modeled goals were only available for seven years (Figure A-III: 31). Observed abundance was greater than the annual modeled goal in five of these six years during the period from 2011–2022 (estimates are not available for 2013, 2015, and 2019). The average spawner abundance (105) was greater than the averaged modeled abundance (20) over that same period, but annual modeled goals were consistently very low relative to delisting scenario goals.

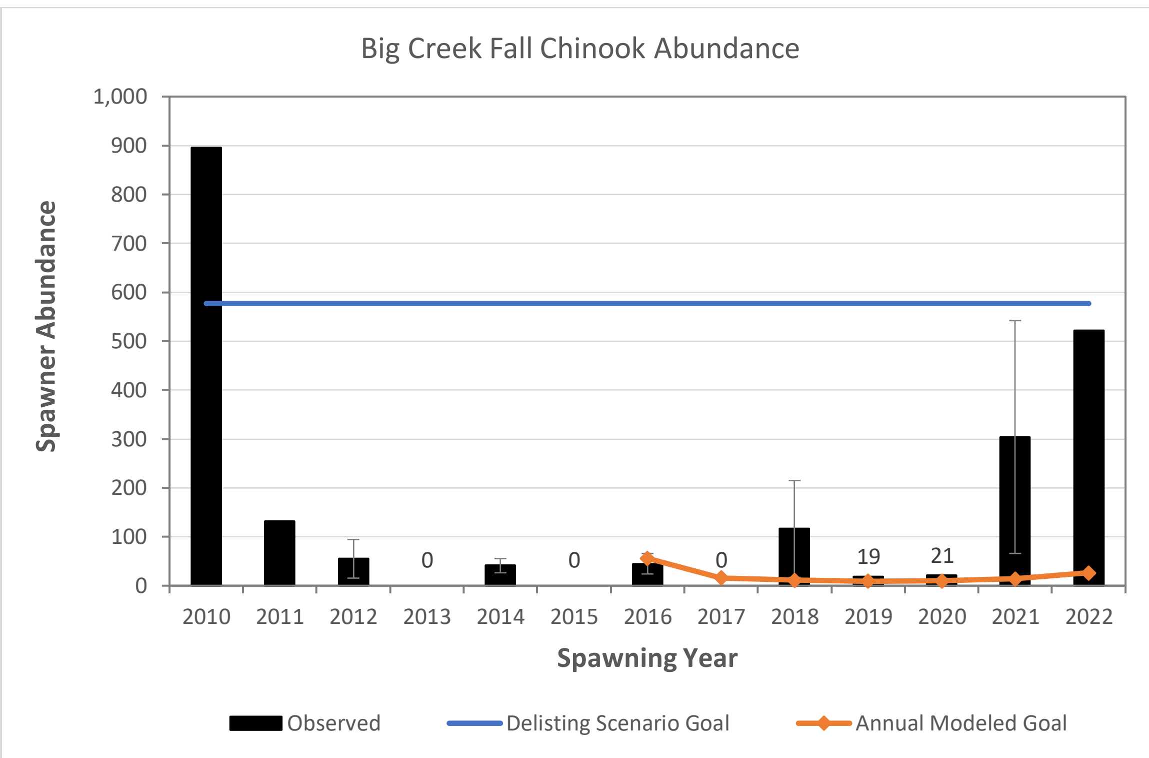

Figure A-III: 31. Natural origin fall Chinook salmon spawner abundance in the Big Creek population, 2010–2022. The delisting scenario goal and annual modeled goals scaled to climate conditions are shown, where available, for the period following Plan adoption in 2010.

Spatial Structure

Criterion: The occupancy of spawning adults or juveniles at spatially balanced, random survey sites in the Big Creek fall Chinook population.

Objective: The percentage of sites occupied by spawning adults or rearing juvenile salmon is ≥ than the delisting threshold (50 percent) at least six times during a 12-year period *and* the overall average percentage of sites occupied during that same time period is ≥ than the threshold of 50 percent.

12-Year Assessment: In Progress.
Occupancy by spawning adults in the Big Creek population met or exceeded the 50 percent threshold in 4 of 12 years from 2011-2022 (Figure A-III: 32) and the average occupancy of habitat for those years (38 percent) was lower than the 50 percent threshold. A negative trend in occupancy was observed during this period.

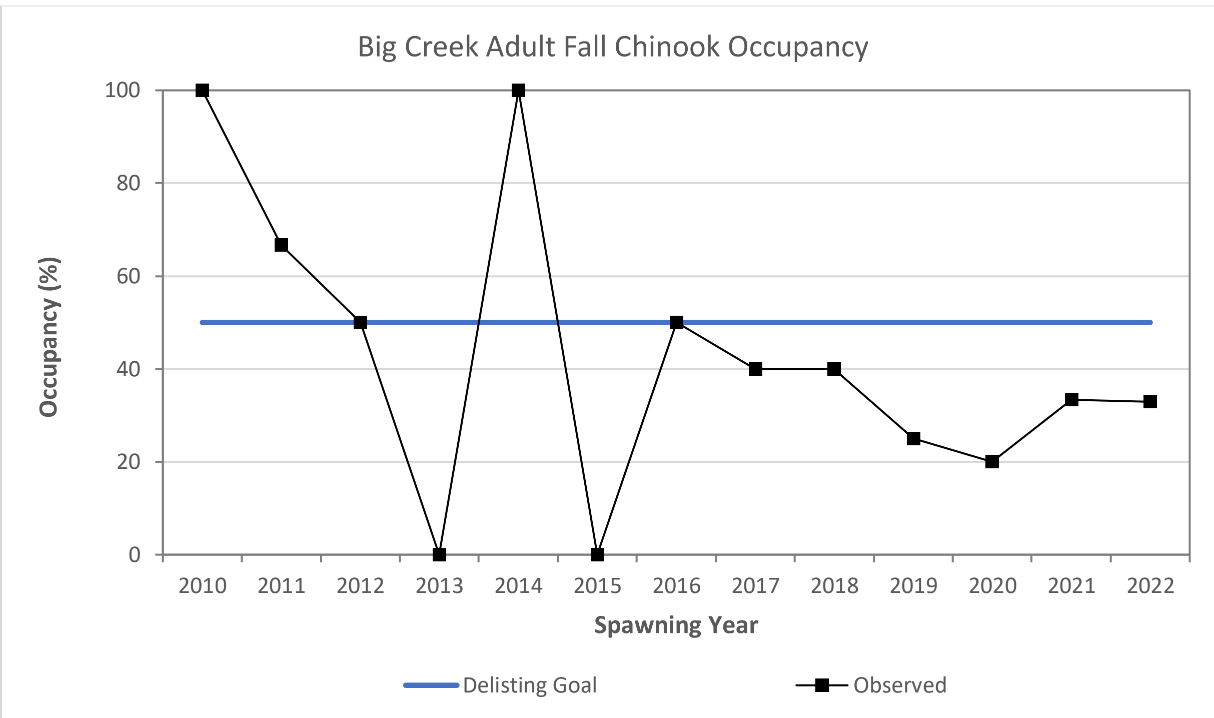

Figure A-III: 32. Percentage of sites occupied by spawning fall Chinook in the Big Creek population, 2010–2022.

Diversity Metric #1: Effective Population Size

Criterion: Annual estimates of abundance of naturally produced spawners in the Big Creek fall Chinook population.

Objective: The observed spawner abundance is ≥ the abundance modeled for delisting at least six times in any 12-year period *and* the average observed spawner abundance is ≥ the average modeled abundance for delisting over that same period.

12-Year Assessment: Not Available (see *Abundance and Productivity* metric).

Diversity Metric #2: Interbreeding with Hatchery Fish

Criterion: Annual assessments of the proportion of spawning fish that are of hatchery origin in the Big Creek fall Chinook population.

Objective: Over a nine-year period, the average percentage of the total number of spawners that are of hatchery origin is on average less than or equal to 90 percent.

12-Year Assessment: In Progress.
The nine-year average for pHOS in the Big Creek fall Chinook population has consistently been above the delisting goal threshold of 90 percent (Figure A-III: 33).

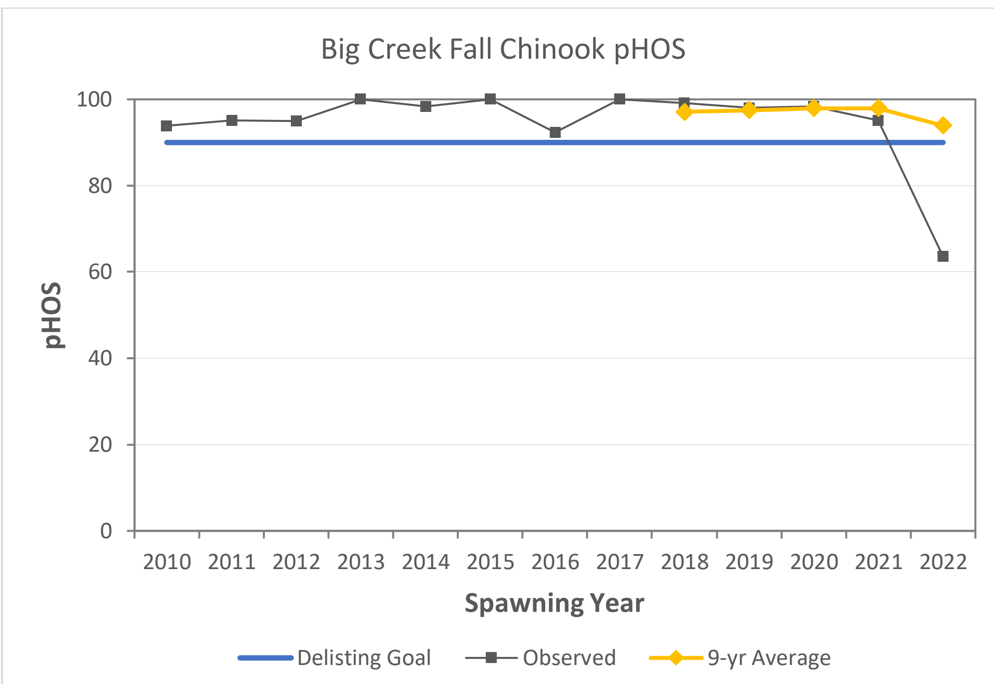

Figure A-III: 33. Percentage of hatchery origin fish on the spawning grounds in the Big Creek fall Chinook population, 2010–2022. The running nine-year average (yellow line) and delisting goal (blue line) are shown for the period following Plan adoption in 2010.

ESU: Lower Columbia River Chinook Salmon

Stratum: Coastal

Population: Clatskanie Fall Chinook

Abundance and Productivity

Criterion: Annual estimates of abundance of naturally produced spawners in the Clatskanie fall Chinook population.

Objective: The observed spawner abundance is ≥ the abundance modeled for delisting at least six times in any 12-year period *and* the average observed spawner abundance is ≥ the average modeled abundance for delisting over that same period.

12-Year Assessment: *In Progress*.
Spawner abundance in the Clatskanie fall Chinook population did not meet the A/P objective (Figure A-III: 34). Observed spawner abundance was less than the annual modeled goal every year from 2011-2022, and average spawner abundance (four) was less than the average modeled abundance (643) over that same period. Monitoring results indicate that this population is functionally extirpated.

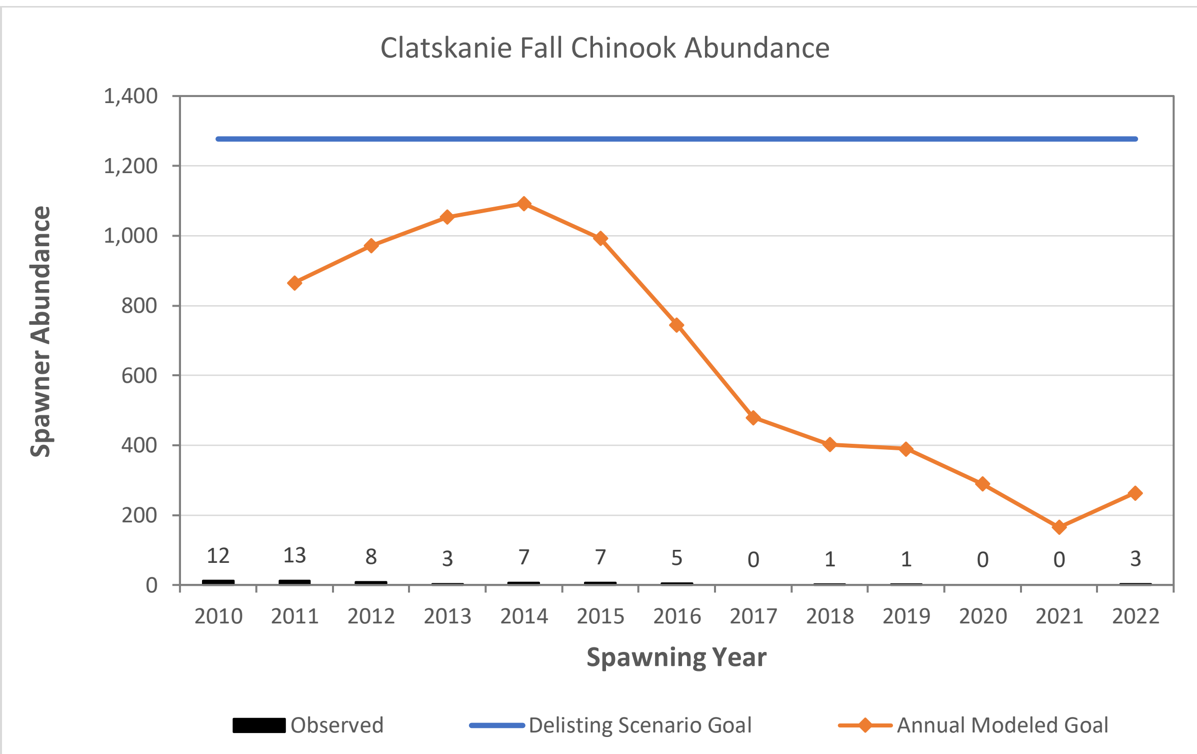

Figure A-III: 34. Natural origin fall Chinook salmon spawner abundance (numbers above bars indicate total estimated abundance) in the Clatskanie population, 2010–2022. The delisting scenario goal and annual modeled goals scaled to climate conditions are shown for the period following Plan adoption in 2010.

Spatial Structure

Criterion: The occupancy of spawning adults or juveniles at spatially balanced, random survey sites in the Clatskanie fall Chinook population.

Objective: The percentage of sites occupied by spawning adults or rearing juvenile salmon is ≥ than the delisting threshold (85 percent) at least six times during a 12-year period *and* the overall average percentage of sites occupied during that same period is ≥ than the thresholds of 85 percent.

12-Year Assessment: In Progress.
The Clatskanie fall Chinook population did not meet the spatial structure objective. Occupancy by spawning adults in the Clatskanie population did not meet or exceed the 85 percent threshold in any year from 2010-2022 (Figure A-III: 35) and the average occupancy of habitat for those years (27 percent) was below the 85 percent threshold.

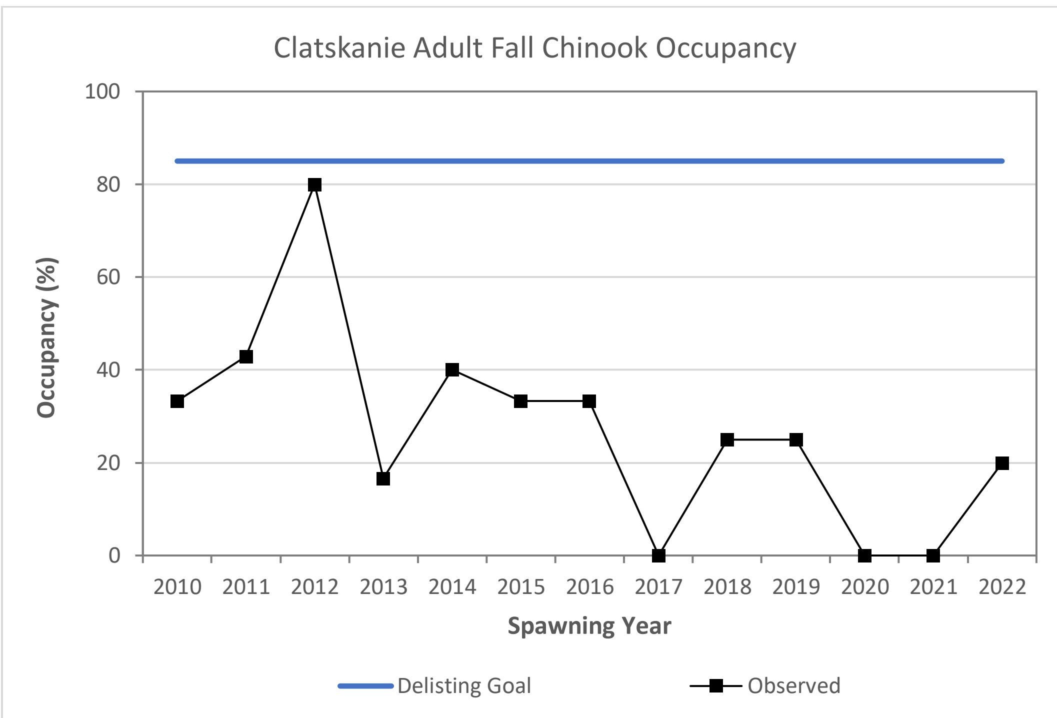

Figure A-III: 35. Percentage of sites occupied by spawning fall Chinook in the Clatskanie population, 2010–2022.

Diversity Metric #1: Effective Population Size

Criterion: Annual estimates of abundance of naturally produced spawners in the Clatskanie fall Chinook population.

Objective: The observed spawner abundance is ≥ the abundance modeled for delisting at least six times in any 12-year period *and* the average observed spawner abundance is ≥ the average modeled abundance for delisting over that same period.

12-Year Assessment: In progress (see *Abundance and Productivity* metric).

Diversity Metric #2: Interbreeding with Hatchery Fish

Criterion: Annual assessments of the proportion of spawning fish that are of hatchery origin in the Clatskanie fall Chinook population.

Objective: Over a nine-year period, the average percentage of the total number of spawners that are of hatchery origin is on average less than or equal to 10 percent.

12-Year Assessment: In Progress.
The nine-year average for pHOS in the Clatskanie fall Chinook population has consistently been above the delisting goal threshold of 10 percent (Figure A-III: 36). There is no hatchery program in this basin and high pHOS relative to the delisting goal is due to out-of-basin straying (primarily in Plympton Creek) and very low natural origin fall Chinook abundance.

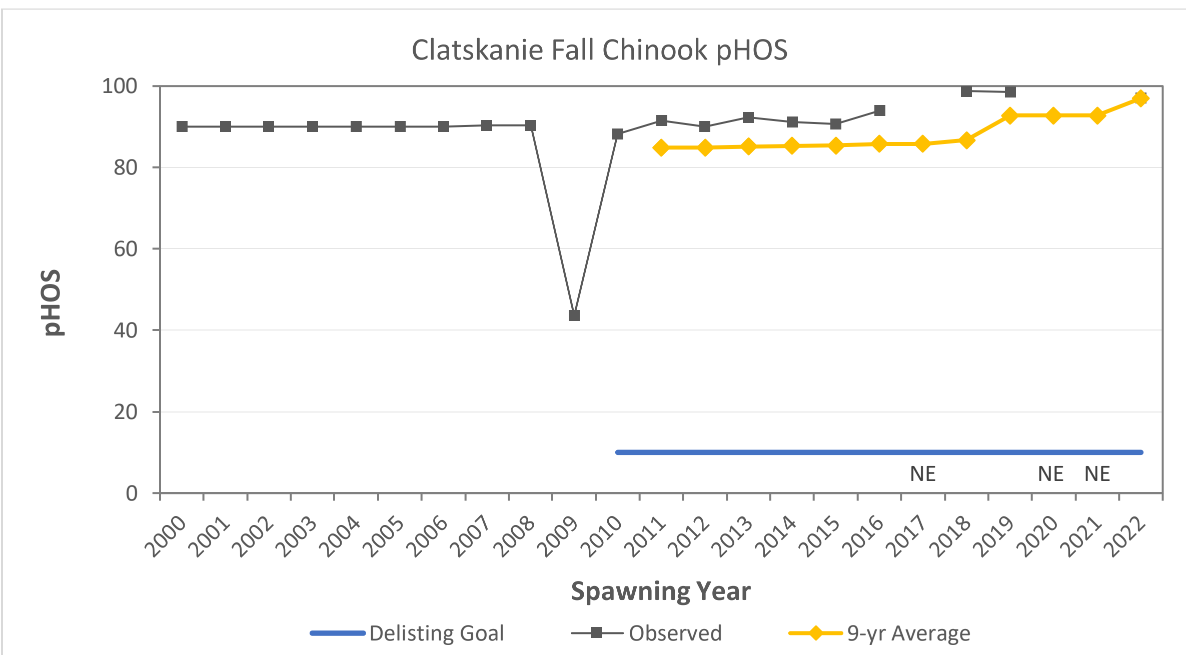

Figure A-III: 36. Percentage of hatchery origin fish on the spawning grounds in the Clatskanie fall Chinook population, 2000–2022. The running nine-year average (yellow line) and delisting goal (blue line) are shown for the period following Plan adoption in 2010. NE = No Estimate.

ESU: Lower Columbia River Chinook Salmon

Stratum: Coastal

Population: Scappoose Fall Chinook

Abundance and Productivity

Criterion: Annual estimates of abundance of naturally produced spawners in the Scappoose fall Chinook population.

Objective: The observed spawner abundance is ≥ the abundance modeled for delisting at least six times in any 12-year period *and* the average observed spawner abundance is ≥ the average modeled abundance for delisting over that same period.

12-Year Assessment: *In progress*.
ODFW monitored the Scappoose population from 2012-2022 and encountered no fall Chinook spawners (natural origin or hatchery). Monitoring results indicate that this population is functionally extirpated.

Spatial Structure

Criterion: The occupancy of spawning adults or juveniles at spatially balanced, random survey sites in the Scappoose fall Chinook population.

Objective: The percentage of sites occupied by spawning adults or rearing juvenile salmon is ≥ than the delisting threshold (85 percent) at least six times during a 12-year period *and* the overall average percentage of sites occupied during that same period is ≥ than the thresholds of 85 percent.

12-Year Assessment: In Progress.
ODFW monitored the Scappoose population from 2012-2022 and encountered no fall Chinook spawners (natural origin or hatchery).

Diversity Metric #1: Effective Population Size (see Abundance and Productivity metric)

Diversity Metric #2: Interbreeding with Hatchery Fish

Criterion: Annual assessments of the proportion of spawning fish that are of hatchery origin in the Scappoose fall Chinook population.

Objective: Over a nine-year period, the average percentage of the total number of spawners that are of hatchery origin is on average less than or equal to 10 percent.

12-Year Assessment: Not Available.
This metric could not be assessed because no fall Chinook spawners (natural or hatchery origin) were observed during spawning surveys in 2012-2022.

ESU: Lower Columbia River Chinook Salmon
Stratum: Cascade
Population: Clackamas Fall Chinook

Abundance and Productivity

Criterion: Annual estimates of abundance of naturally produced spawners in the Clackamas fall Chinook population.

Objective: The observed spawner abundance is ≥ the abundance modeled for delisting at least six times in any 12-year period *and* the average observed spawner abundance is ≥ the average modeled abundance for delisting over that same period.

12-Year Assessment: *Not Available*
The A/P criterion could not be assessed for the Clackamas population because annual modeled goals were only available for eight years (Figure A-III: 37). Observed abundance was greater than the annual modeled goal in four of these eight years. Average abundance (274) was greater than average modeled abundance (160) during this period, but annual modeled goals were consistently very low relative to delisting scenario goals.

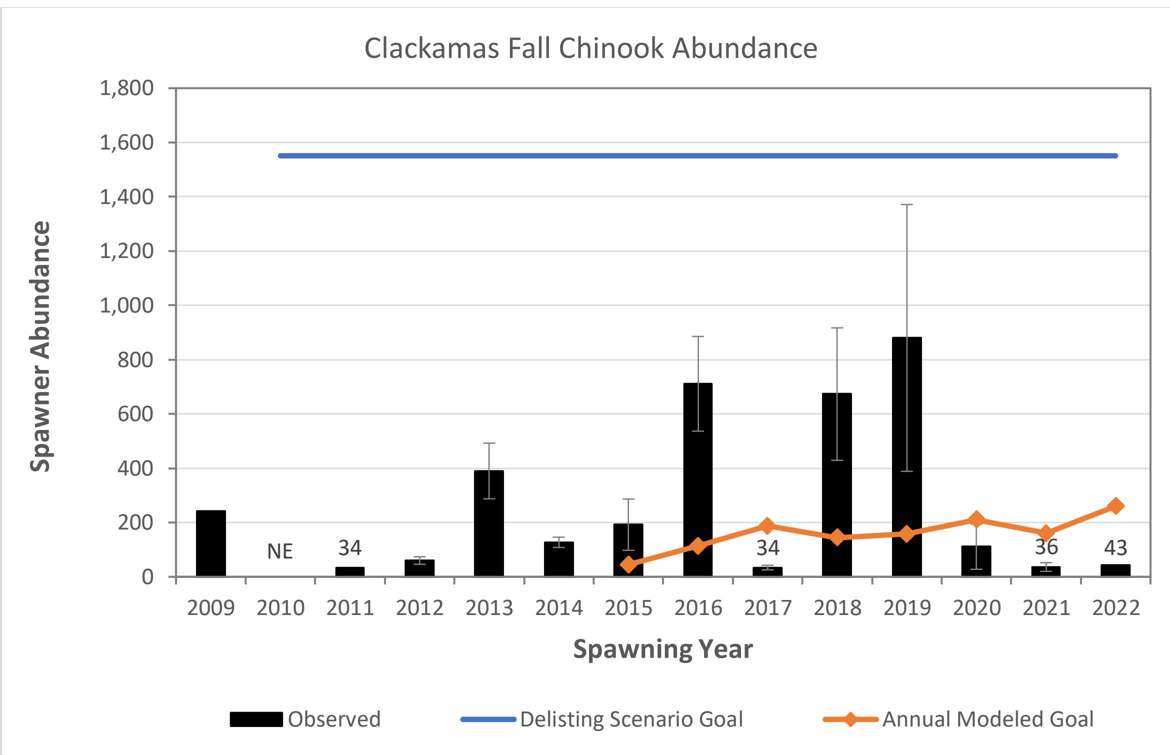

Figure A-III: 37. Natural origin fall Chinook salmon spawner abundance in the Clackamas population, 2009–2022. The delisting scenario goal and annual modeled goals scaled to climate conditions are shown, where available, for the period following Plan adoption in 2010. NE = No Estimate.

Spatial Structure

Criterion: The occupancy of spawning adults or juveniles at spatially balanced, random survey sites in the Clackamas fall Chinook population.

Objective: The percentage of sites occupied by spawning adults or rearing juvenile salmon is ≥ than the delisting threshold (50 percent) at least six times during a 12-year period *and* the overall average percentage of sites occupied during that same period is ≥ than the thresholds of 50 percent.

12-Year Assessment: In Progress.
The Clackamas fall Chinook population did not meet the spatial structure objective. Occupancy by spawning adults in the Clackamas population did not meet or exceed the 50 percent threshold in any year from 2010-2022 (Figure A-III: 38) and the average occupancy of habitat for those years (21 percent) was below the 50 percent threshold.

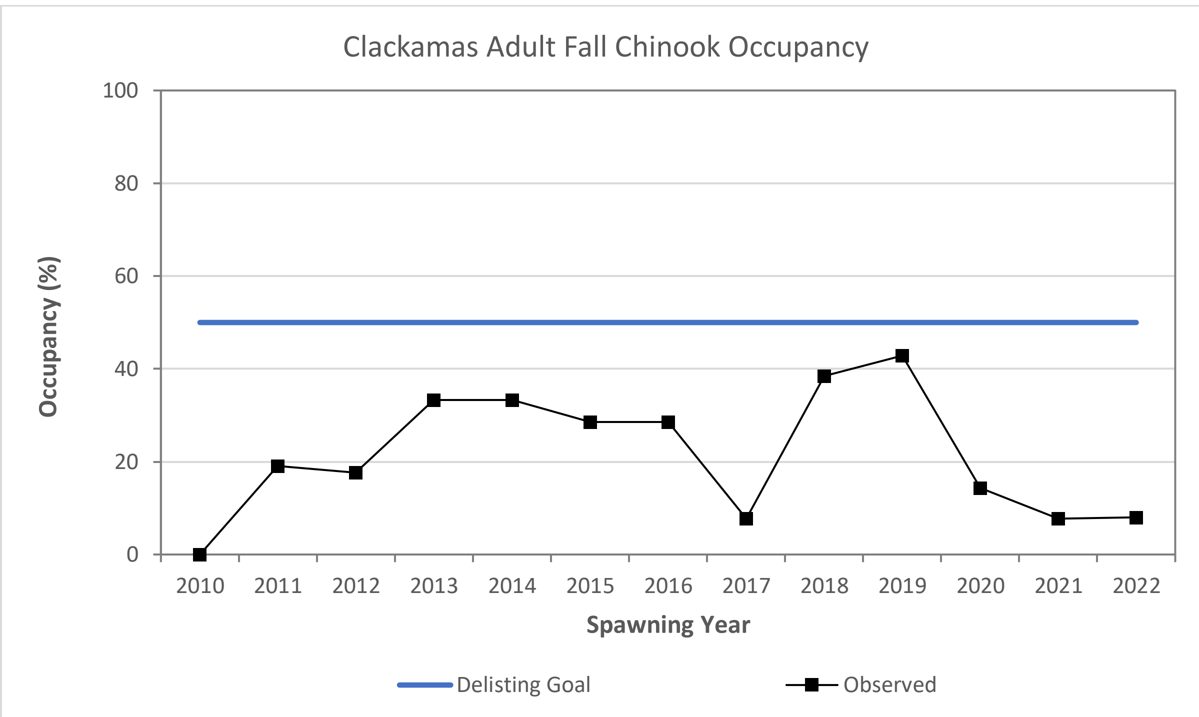

Figure A-III: 38. Percentage of sites occupied by spawning fall Chinook in the Clackamas population, 2010–2022.

Diversity Metric #1: Effective Population Size

Criterion: Annual estimates of abundance of naturally produced spawners in the Clackamas fall Chinook population.

Objective: The observed spawner abundance is ≥ the abundance modeled for delisting at least six times in any 12-year period *and* the average observed spawner abundance is ≥ the average modeled abundance for delisting over that same period.

12-Year Assessment: Not Available (see *Abundance and Productivity* metric).

Diversity Metric #2: Interbreeding with Hatchery Fish

Criterion: Annual assessments of the proportion of spawning fish that are of hatchery origin in the Clackamas fall Chinook population.

Objective: Over a nine-year period, the average percentage of the total number of spawners that are of hatchery origin is on average less than or equal to 30 percent.

12-Year Assessment: Attained.
The most recent nine-year average for pHOS in the Clackamas fall Chinook population (19 percent) is below the delisting goal threshold of 30 percent (Figure A-III: 39).

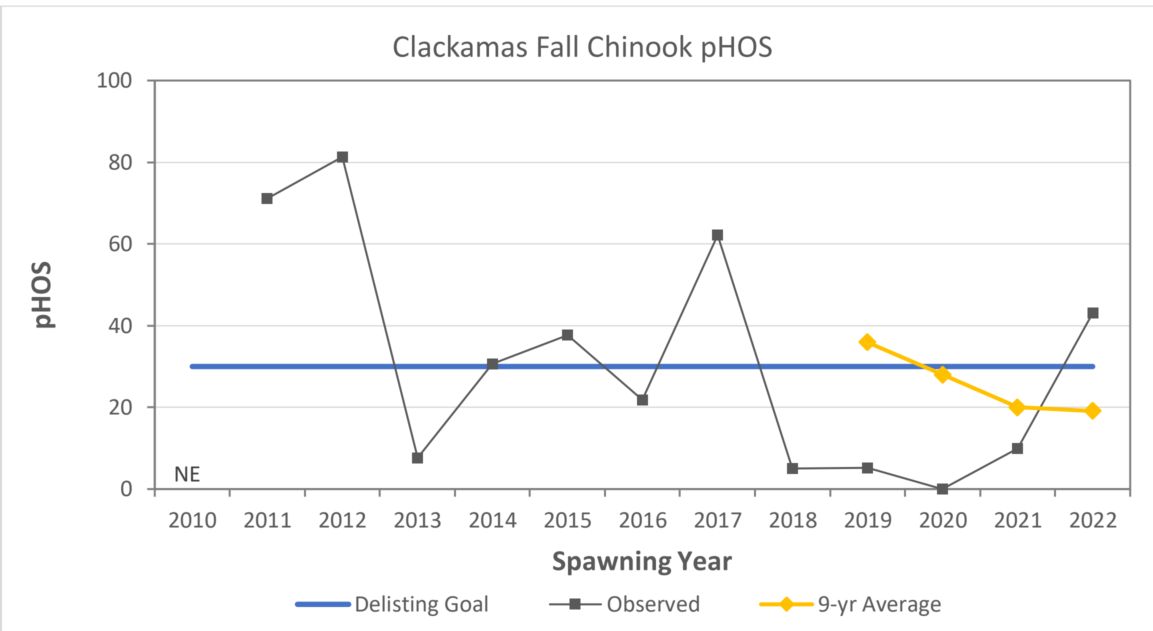

Figure A-III: 39. Percentage of hatchery origin fish on the spawning grounds in the Clackamas fall Chinook population, 2010–2022. The running nine-year average (yellow line) and delisting goal (blue line) are shown for the period following Plan adoption in 2010. NE = No Estimate.

ESU: Lower Columbia River Chinook Salmon

Stratum: Cascade

Population: Sandy Fall and Late Fall Chinook

Abundance and Productivity

Criterion: Annual estimates of abundance of naturally produced spawners in the Sandy fall and late fall Chinook populations.

Objective: The observed spawner abundance is ≥ the abundance modeled for delisting at least six times in any 12-year period *and* the average observed spawner abundance is ≥ the average modeled abundance for delisting over that same period.

12-Year Assessment: *Attained*.
The combined fall and late fall spawner abundance in the Sandy population met the A/P objective (Figure A-III: 40). Observed spawner abundance exceeding the modeled abundance in eight of 11 years from 2012-2022 (Figure A-III: 40) and average spawner abundance (2,385) was greater than the average modeled abundance (1,269) over that same period. Annual modeled goals are based on combined fall and late-fall Chinook abundance, and abundance estimates used to calculate annual goals were made with different methods prior to 2012 (see page 39 for more information).

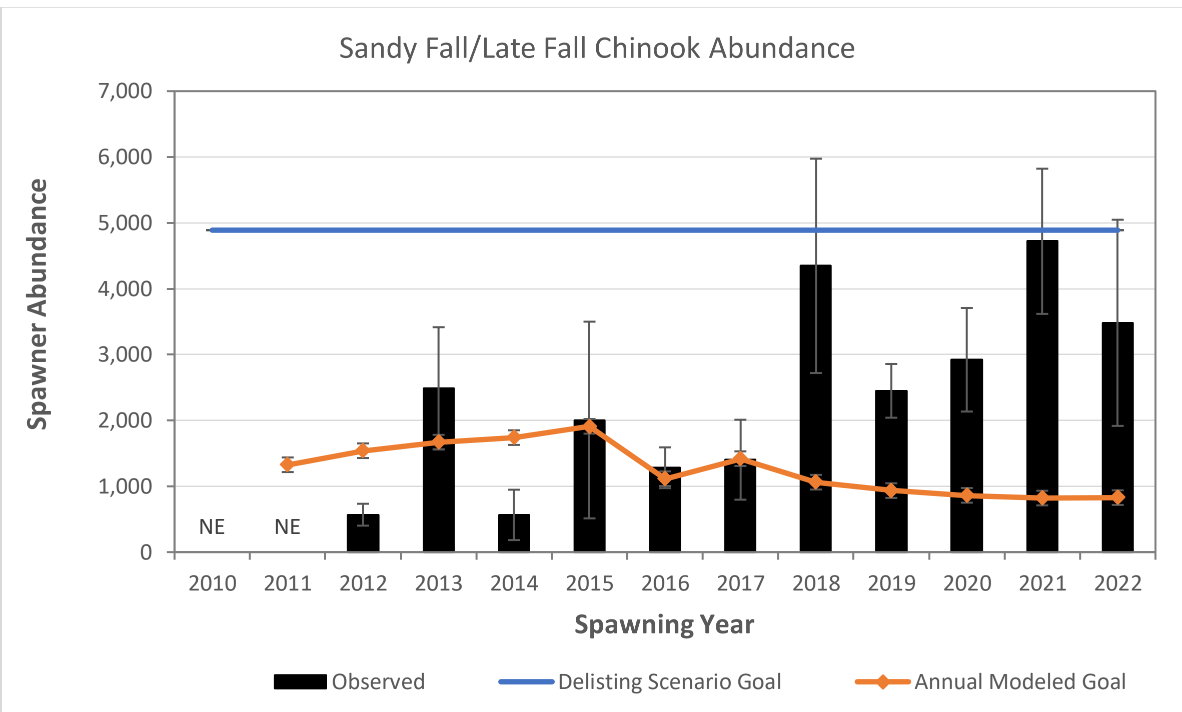

Figure A-III: 40. Natural origin fall and late fall Chinook salmon spawner abundance in the Sandy population, 2010–2022. The delisting scenario goal and annual modeled goals scaled to climate conditions are shown for the period following Plan adoption in 2010. NE = No Estimate. See pages 38-39 for important details about Sandy fall and late-fall Chinook abundance monitoring.

Spatial Structure

Criterion: The occupancy of spawning adults or juveniles at spatially balanced, random survey sites in the Sandy fall and late fall Chinook populations.

Objective: The percentage of sites occupied by spawning adults or rearing juvenile salmon is ≥ than the delisting threshold (90 percent) at least six times during a 12-year period *and* the overall average percentage of sites occupied during that same period is ≥ than the thresholds of 90 percent.

12-Year Assessment: In Progress.
Sandy fall and late fall Chinook did not meet the spatial structure objective. Occupancy by spawning adults in the Sandy population did not meet or exceed the 90 percent threshold in any year from 2010-2022 (Figure A-III: 41) and the average occupancy of habitat for those years (45 percent) was below the 90 percent threshold.

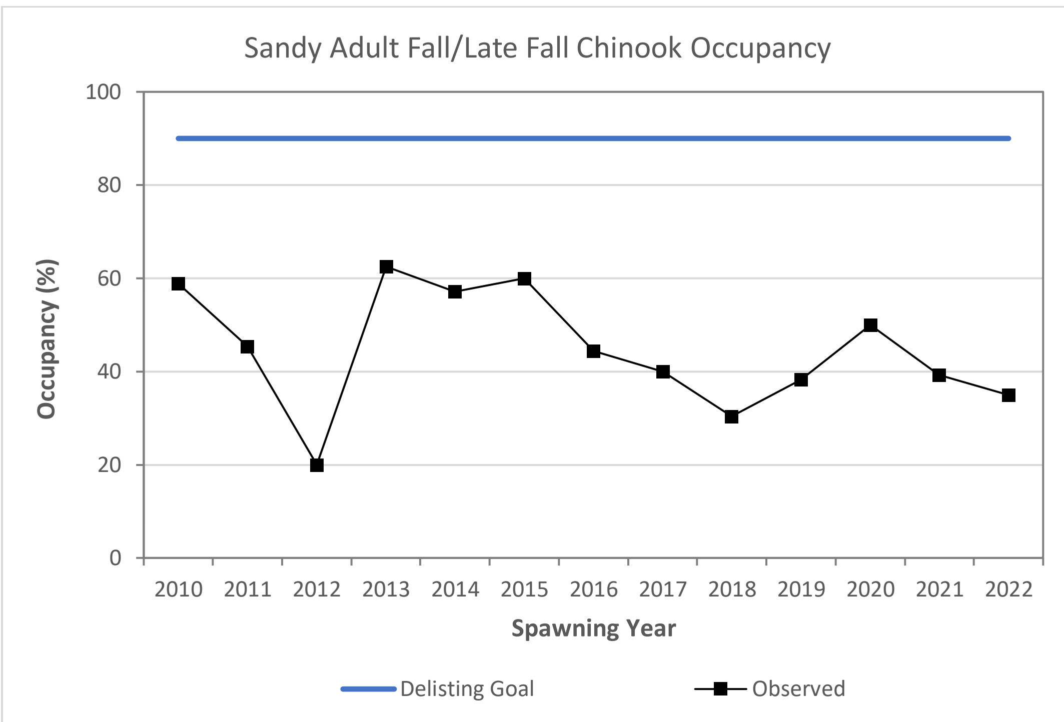

Figure A-III: 41. Percentage of sites occupied by spawning fall and late fall Chinook in the Sandy population, 2010–2022.

Diversity Metric #1: Effective Population Size

Criterion: Annual estimates of abundance of naturally produced spawners in the Sandy fall and late fall Chinook populations.

Objective: The observed spawner abundance is ≥ the abundance modeled for delisting at least six times in any 12-year period *and* the average observed spawner abundance is ≥ the average modeled abundance for delisting over that same period.

12-Year Assessment: Attained (see *Abundance and Productivity* metric).

Diversity Metric #2: Interbreeding with Hatchery Fish

Criterion: Annual assessments of the proportion of spawning fish that are of hatchery origin in the Sandy fall and late fall Chinook populations.

Objective: Over a nine-year period, the average percentage of the total number of spawners that are of hatchery origin is on average less than or equal to 10 percent.

12-Year Assessment: Attained.
The nine-year average pHOS for Sandy fall and late fall Chinook has been declining since 2011 and has consistently been below the delisting goal threshold of 10 percent since 2016 (Figure A-III: 42).

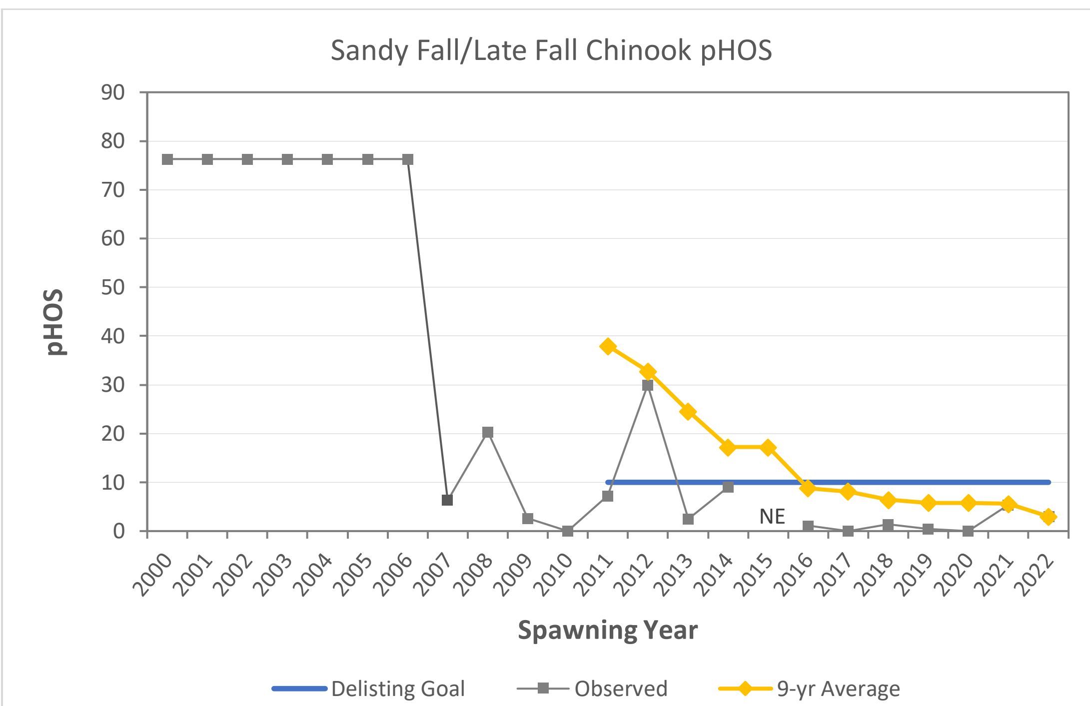

Figure A-III: 42. Percentage of hatchery origin fish on the spawning grounds for Sandy fall and late fall Chinook, 2000–2022. The running nine-year average (yellow line) and delisting goal (blue line) are shown for the period following Plan adoption in 2010. NE = No Estimate.

ESU: Lower Columbia River Chinook Salmon

Stratum: All (Aggregate)

Population: All Spring Chinook Populations (Aggregate)

There are no measurable criteria assigned for an aggregate abundance level for the LCR Chinook Salmon ESU. There are two historical spring Chinook populations in the Oregon portion of the ESU, the Sandy and Hood populations. The indigenous stock of Hood River spring Chinook is believed to have been extirpated by the early 1970s. The current population of naturally reproducing Hood River spring Chinook salmon was introduced as part of the Hood River Production Program (HRPP) using stock from the Deschutes Basin (stock 66), which is part of the Middle Columbia River Spring Chinook ESU. The naturally produced progeny of hatchery-origin adults from the program are not considered part of the LCR ESU and are not listed under the federal Endangered Species Act (ESA) (50 C.F.R. 17§ 223.4 2014). Monitoring methods for VSP metrics in each population are summarized below.

- *Sandy*: Spawning surveys for spring Chinook salmon consist of carcass recovery and redd counts (all spawning areas for spring Chinook are surveyed on a 7–10-day cycle), following the standard methods used in previous years (Gallagher et al. 2007, Schroeder et al. 2013). These surveys are designed to recover all observed carcasses and to provide a complete census of redds in the primary spawning areas. Data collected from carcasses include pre-spawning mortality (based on females), hatchery–natural origin composition (based on the presence or absence of fin clips or thermal marks in otoliths), and age composition and freshwater life history in natural origin fish (based on analysis of scales). Redd counts are used to estimate spawner escapement (the number of adult fish that reach the spawning grounds), total run size when combined with other metrics, and to describe spawning distribution.
- *Hood*: Since its inception, the foundation of the Hood River Production Program (HRPP) monitoring and evaluation program has been based on mark-recapture methods to estimate salmon and steelhead smolt production, as well as managing and summarizing adult salmonid biological data collected at upstream migrant fish collection facilities. Since the removal of the Powerdale Dam and associated adult trapping facilities in 2010 (which captured all upstream migrant fish), adult migrants have been collected using resistance board weirs on the East Fork Hood River and Neal Creek and an adult trap located on the West Fork Hood River. Adult abundance is currently assessed using model estimation methods as opposed to a census-based population survey.

ESU: Lower Columbia River Chinook Salmon

Stratum: Cascade

Population: Sandy Spring Chinook

Abundance and Productivity

Criterion: Annual estimates of abundance of naturally produced spawners in the Sandy spring Chinook population.

Objective: The observed spawner abundance is ≥ the abundance modeled for delisting at least six times in any 12-year period *and* the average observed spawner abundance is ≥ the average modeled abundance for delisting over that same period.

12-Year Assessment: *Attained*.
Spring Chinook spawner abundance in the Sandy population met the A/P objective (Figure A-III: 43). Observed spawner abundance exceeding the modeled abundance in 11 of 12 years from 2011-2022 and average spawner abundance (3,237) was greater than the average modeled abundance (1,469) over that period. There has been a positive trend in spawner abundance since 2000 and average spawner abundance since 2011 has been more than double the delisting scenario goal.

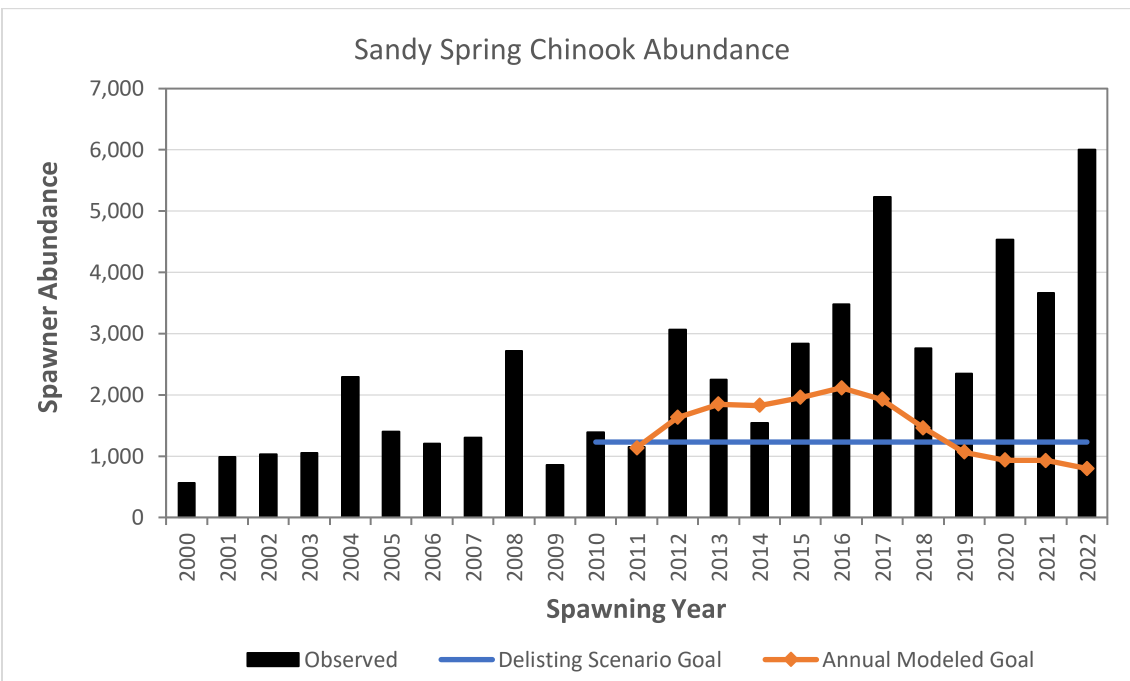

Figure A-III: 43. Natural origin spring Chinook salmon spawner abundance in the Sandy population, 2000–2022. The delisting scenario goal and annual modeled goals scaled to climate conditions are shown for the period following Plan adoption in 2010.

Spatial Structure

Criterion: The occupancy of spawning adults or juveniles at spatially balanced, random survey sites in the Sandy spring Chinook populations.

Objective: The percentage of sites occupied by spawning adults or rearing juvenile salmon is ≥ than the delisting threshold (80 percent) at least six times during a 12-year period *and* the overall average percentage of sites occupied during that same period is ≥ than the thresholds of 80 percent.

12-Year Assessment: Not Available.
Current population monitoring is not based on spatially balanced, random survey sites.

Diversity Metric #1: Effective Population Size

Criterion: Annual estimates of abundance of naturally produced spawners in the Sandy spring Chinook population.

Objective: The observed spawner abundance is ≥ the abundance modeled for delisting at least six times in any 12-year period *and* the average observed spawner abundance is ≥ the average modeled abundance for delisting over that same period.

12-Year Assessment: Attained (see *Abundance and Productivity* metric).

Diversity Metric #2: Interbreeding with Hatchery Fish

Criterion: Annual assessments of the proportion of spawning fish that are of hatchery origin in the Sandy spring Chinook population.

Objective: Over a nine-year period, the average percentage of the total number of spawners that are of hatchery origin is on average less than or equal to 10 percent.

12-Year Assessment: Attained.
The nine-year average for pHOS in the Sandy spring Chinook population has been declining since 2016 and the most recent average (9 percent) is below the delisting goal threshold of 10 percent (Figure A-III: 44).

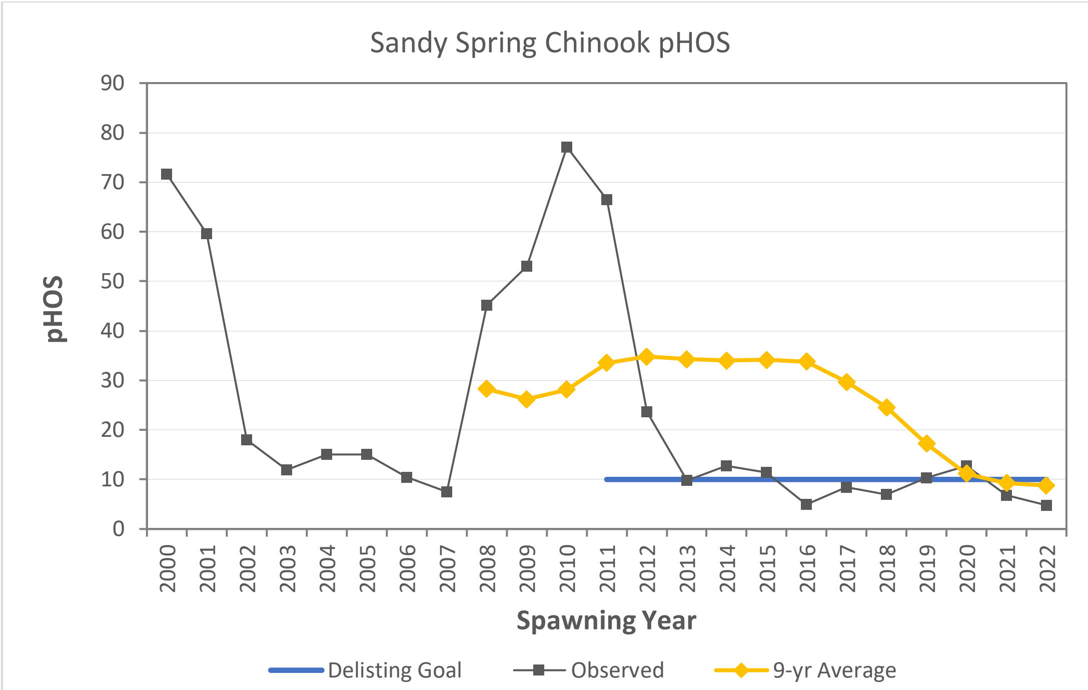

Figure A-III: 44. Percentage of hatchery origin fish on the spawning grounds in the Sandy spring Chinook population, 2000–2022. The running nine-year average (yellow line) and delisting goal (blue line) are shown for the period following Plan adoption in 2010.

ESU: Lower Columbia River Chinook Salmon

Stratum: Gorge

Population: Hood River Spring Chinook

Abundance and Productivity

Criterion: Annual estimates of abundance of naturally produced spawners in the Hood River spring Chinook population.

Objective: The observed spawner abundance is ≥ the abundance modeled at least six times in any 12-year period *and* the average observed spawner abundance is ≥ the average modeled abundance over that same period.

12-Year Assessment: *In Progress.*
Based on available monitoring data, which may underestimate the abundance of natural origin spawners in years following removal of Powerdale Dam, spawner abundance in the Hood River spring Chinook population did not meet the A/P objective (Figure A-III: 45). See page 56 for background on the status of this population in relation to delisting goals.

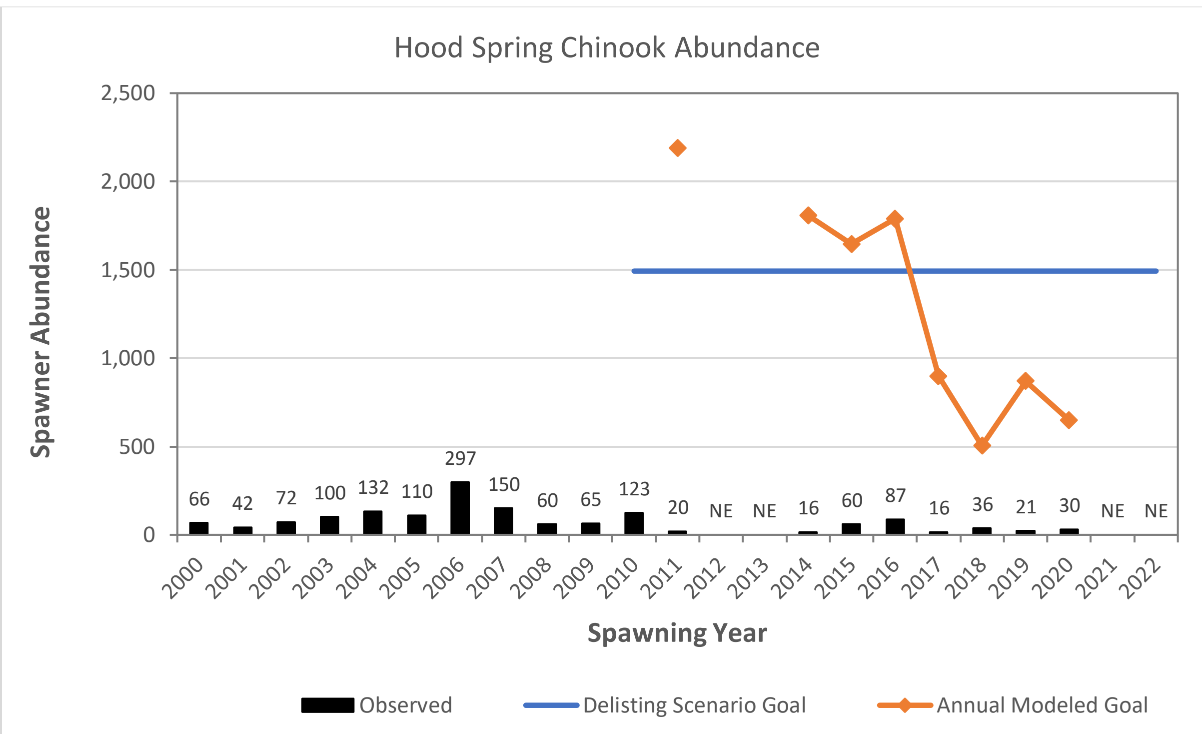

Figure A-III: 45. Natural origin spring Chinook salmon spawner abundance in the Hood population, 2000–2022. The delisting scenario goal and annual modeled goals scaled to climate conditions are shown for the period following Plan adoption in 2010. NE = No Estimate.

Spatial Structure

Criterion: The occupancy of spawning adults or juveniles at spatially balanced, random survey sites in the Hood River spring Chinook populations.

Objective: The percentage of sites occupied by spawning adults or rearing juvenile salmon is ≥ than the delisting threshold (90 percent) at least six times during a 12-year period *and* the overall average percentage of sites occupied during that same period is ≥ than the thresholds of 90 percent.

12-Year Assessment: Not Available.
Current population monitoring is not based on spatially balanced, random survey sites.

Diversity)

Diversity Metric #1: Effective Population Size

Criterion: Annual estimates of abundance of naturally produced spawners in the Hood River spring Chinook population.

Objective: The observed spawner abundance is ≥ the abundance modeled for delisting at least six times in any 12-year period *and* the average observed spawner abundance is ≥ the average modeled abundance for delisting over that same period.

12-Year Assessment: Not Available (see *Abundance and Productivity* metric).

Diversity Metric #2: Interbreeding with Hatchery Fish

Criterion: Annual assessments of the proportion of spawning fish that are of hatchery origin in the Hood River spring Chinook population.

Objective: Over a nine-year period, the average percentage of the total number of spawners that are of hatchery origin is on average less than or equal to 10 percent.

12-Year Assessment: In Progress.
The nine-year average for pHOS in the Hood spring Chinook population has consistently been above the goal of ten percent (Figure A-III: 46). As discussed previously in the assessment, the current Hood spring Chinook population is the result of a reintroduction using out-of-ESU hatchery stock. High pHOS relative to the plan goal is the result of ongoing hatchery supplementation of the population with the goal of establishing a self-sustaining, locally adapted population.

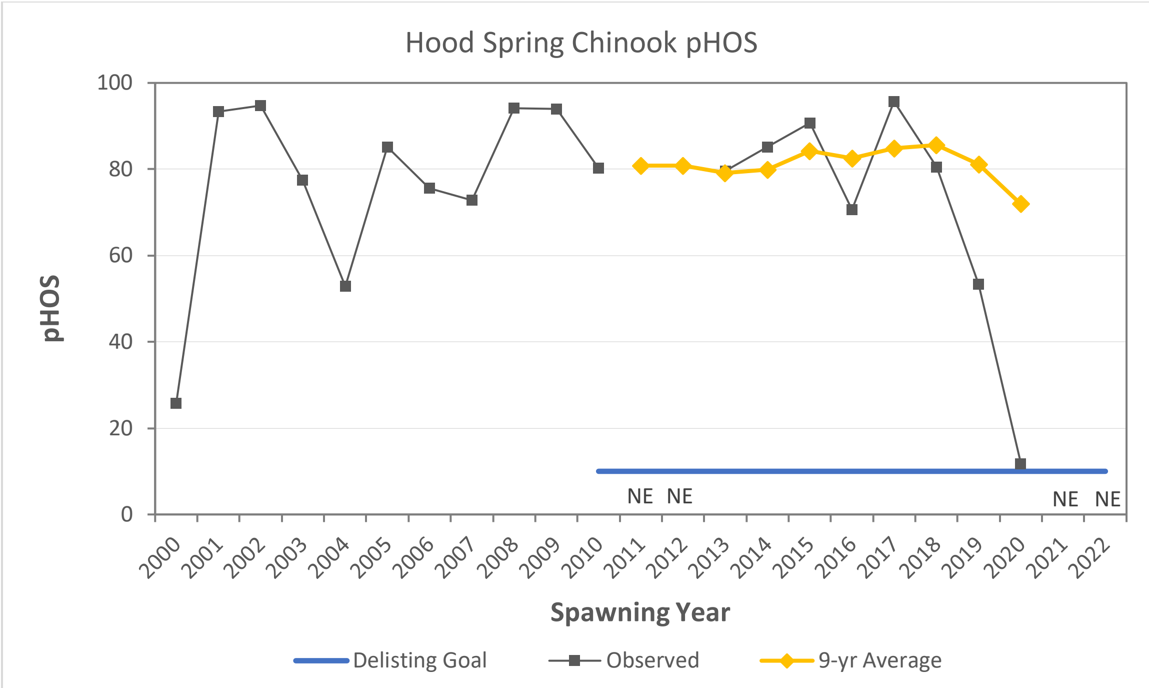

Figure A-III: 46. Percentage of hatchery origin fish on the spawning grounds in the Hood spring Chinook population, 2000–2022. The running nine-year average (yellow line) and plan goal (blue line) are shown for the period following Plan adoption in 2010. NE = No Estimate. See text for important details about the status of this population.

DPS: Lower Columbia River Steelhead
Stratum: All (Aggregate)
Population: All Steelhead Populations (Aggregate)

There are no measurable criteria assigned for an aggregate abundance level for the LCR Steelhead ESU. There are five winter steelhead populations in the Oregon portion of the ESU, three of which have been consistently monitored over time (Clackamas, Sandy, and Hood). ODFW has not monitored the Lower Gorge or Upper Gorge winter steelhead populations, which are shared with the state of Washington, since 2012 due to limited resources and other higher monitoring priorities. Therefore, progress toward delisting goals could not be assessed for these populations. Aggregate winter steelhead abundance in the Clackamas, Sandy, and Hood populations has varied from a high of over 10,000 spawners to a low of approximately 2,000 spawners since Plan adoption in 2010 (Figure A-III: 47). There is only one summer steelhead population (Hood) in the Oregon portion of the ESU. Monitoring methods for VSP metrics in each population are summarized below.

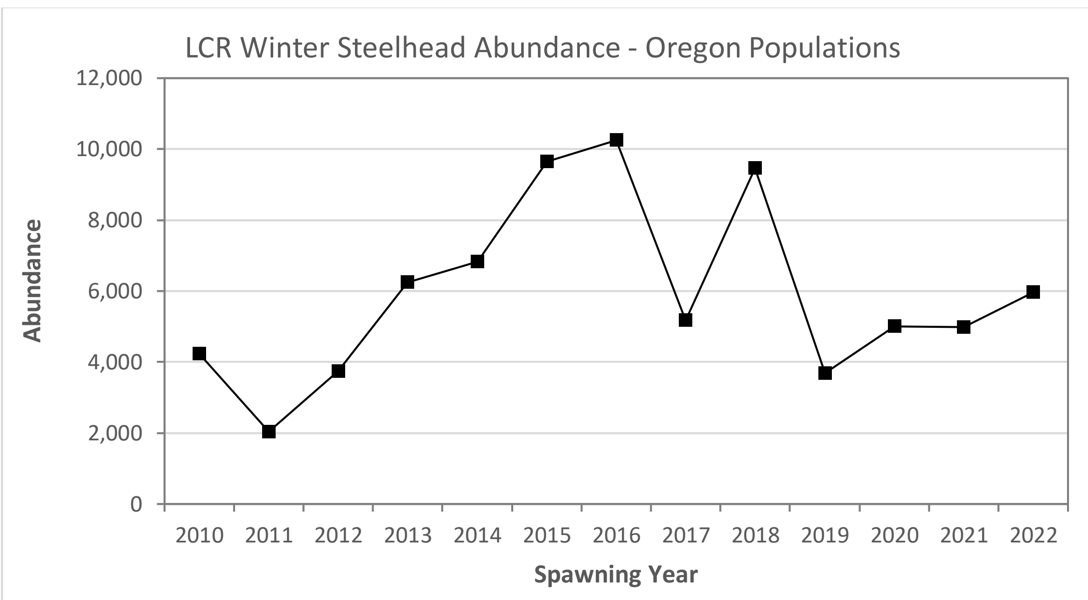

Figure A-III: 47. Natural origin winter steelhead spawner abundance in the Oregon portion of the LCR Steelhead ESU, 2010–2022. Spawner abundance does not include Lower Gorge and Upper Gorge populations; in addition, no spawner abundance estimate is available for the Hood population in 2021 or 2022 and the 2020 estimate for the Clackamas only includes fish counted at North Fork Dam.

- *Clackamas and Sandy (also SWW DPS Populations: Clatskanie and Scappoose)*
  A spatially balanced, probabilistic sampling design (Stevens 2002) was used to randomly select survey sites across a stream network of winter steelhead spawning habitat. Areas above dams or fish traps where counts of winter steelhead are available are not sampled;

these include North Fork Dam (Clackamas River) and Sandy Hatchery weirs. The Bonnie Falls Trap (Scappoose Basin) is no longer a counting station. Surveys above the former trap were not added to the survey frame in 2020 but resumed in 2021. In accordance with prior work conducted by ODFW in coastal streams (Susac and Jacobs 1998), monitoring of winter steelhead abundance is based on counts of redds. Repeat visits to each site are conducted, at least once every 14 days, from February through May to generate a total redd count for each survey. Specific descriptions of project protocols can be found in the annual survey procedures manual (ODFW 2021). Steelhead redd abundance estimates are converted to fish abundance using a standard redd-to-fish conversion factor (ODFW 2013).

Survey sites adjacent to hatcheries and/or their acclimation areas typically have a higher proportion of both hatchery fish and redd densities and can therefore bias estimates of natural origin abundance. To reduce bias and increase accuracy of winter steelhead estimates, use of a stratified approach was initiated in 2016. These efforts differ slightly between the various monitoring units. In the Southwest Washington (SWW) Distinct Population Unit (DPS), the Clatskanie population is divided into two strata: Plympton Creek and the remaining Clatskanie basin. There are no hatchery steelhead releases in the Clatskanie population, but hatchery fish are abundant in Plympton Creek. In the LCR ESU, in each of the Sandy and Clackamas populations, strata are defined as: migration corridors, areas adjacent to hatchery releases, and the remaining portions of each population (i.e. areas outside of direct hatchery influence). In each case, individual strata estimates are calculated, then rolled up to final population estimates.

- *Hood***:** Since its inception, the foundation of the HRPP monitoring and evaluation program has been based on mark-recapture methods to estimate salmon and steelhead smolt production, as well as managing and summarizing adult salmonid biological data collected at upstream migrant fish collection facilities. Since the removal of the Powerdale Dam and associated adult trapping facilities in 2010 (which captured all upstream migrant fish), adult migrants have been collected using resistance board weirs on the East Fork Hood River and Neal Creek and an adult trap located on the West Fork Hood River. Adult abundance is currently assessed using model estimation methods as opposed to a census-based population survey.

- *Lower Gorge* and *Upper Gorge*: The Plan directs ODFW to take a strategic approach to fluctuations in monitoring support. Due to budget shortfalls and prioritization of monitoring efforts, GRTS surveys in these two populations were discontinued after 2012.

Since 2006, ODFW has conducted snorkel surveys using a GRTS design to monitor juvenile steelhead in the LCR and SWW DPSs. Snorkel surveys are typically conducted in first to third order (wadeable) streams, but surveys in larger streams have been conducted in some years. Snorkel surveys provide an annual index of abundance and juvenile occupancy at the ESU scale, but do not provide population-scale information. Snorkel survey methods and results are available in annual reports at the ODFW Aquatic Inventories Project website: https://odfw-static.forestry.oregonstate.edu/freshwater/inventory/juv_reports.html.

DPS: Lower Columbia River Steelhead

Stratum: Cascade

Population: Clackamas Winter Steelhead

Abundance and Productivity

Criterion: Annual estimates of abundance of naturally produced spawners in the Clackamas winter steelhead population.

Objective: The observed spawner abundance is ≥ the abundance modeled for delisting at least six times in any 12-year period *and* the average observed spawner abundance is ≥ the average modeled abundance for delisting over that same period.

12-Year Assessment: *In Progress.*
Spawner abundance in the Clackamas winter steelhead population did not meet the A/P objective (Figure A-III: 48). Observed abundance was below the annual modeled goal every year from 2011-2022 and average spawner abundance (2,443) was less than the average modeled abundance (7,092) over that same period. Although the A/P objective was not attained, average abundance from 2011-2022 was over twice the average observed during the 10-year period prior to Plan adoption.

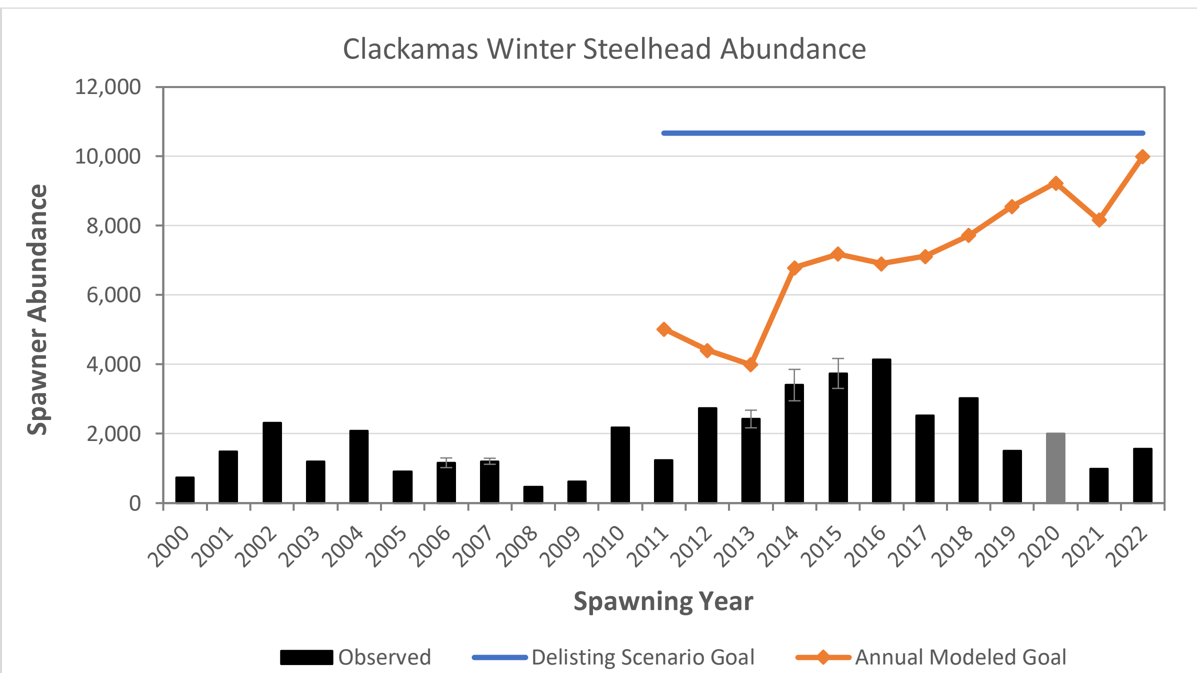

Figure A-III: 48. Natural origin winter steelhead spawner abundance in the Clackamas population, 2000–2022 (2020 estimate is North Fork Dam count only). The delisting scenario goal and annual modeled goals scaled to climate conditions are shown for the period following Plan adoption in 2010.

Spatial Structure

Criterion: The occupancy of spawning adults or juveniles at spatially balanced, random survey sites in the Clackamas winter steelhead population.

Objective: The percentage of sites occupied by spawning adults or rearing juvenile steelhead is ≥ than the delisting threshold (75 percent) at least six times during a 12-year period *and* the overall average percentage of sites occupied during that same period is ≥ than the thresholds of 75 percent.

12-Year Assessment: Not Available.
PGE's hydroelectric project on the Clackamas River provides a unique opportunity for a complete count of fish populations migrating into the upper watershed, which represents approximately half of the spawning habitat within the population. As a result, spawning surveys are only conducted in the population below North Fork Dam. Occupancy by spawning adults in the surveyed portion of Clackamas population did not exceed the 75 percent threshold in any return year from 2012-2022 (Figure A-III: 49), and the average occupancy of habitat below the dam for those years was 52 percent. However, a significant portion of this habitat is in the urban area and highly degraded. Therefore, occupancy of habitat determined by monitoring downstream of the dam does not represent the spatial structure of the entire population. Juvenile steelhead surveys have been conducted annually in the LCR DPS since 2006, but these surveys do not provide population-scale occupancy estimates.

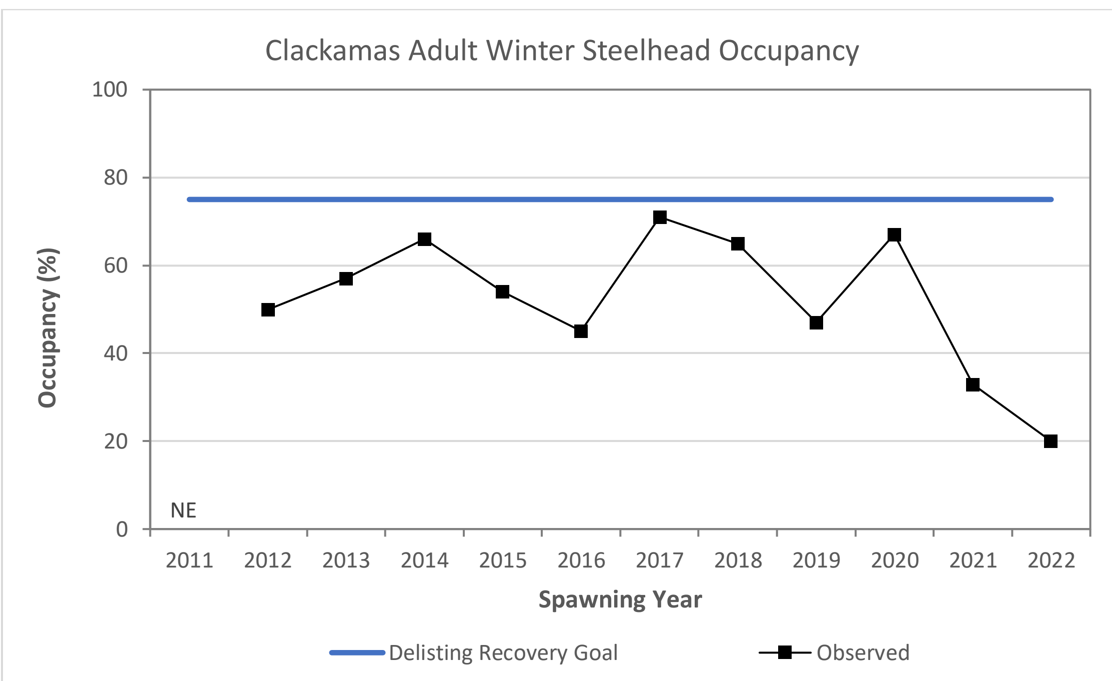

Figure A-III: 49. Percentage of sites occupied by spawning winter steelhead in the Clackamas population below North Fork Dam, 2011–2022. NE = No Estimate.

Diversity Metric #1: Effective Population Size

Criterion: Annual estimates of abundance of naturally produced spawners in the Clackamas winter steelhead population.

Objective: The observed spawner abundance is ≥ the abundance modeled for delisting at least six times in any 12-year period *and* the average observed spawner abundance is ≥ the average modeled abundance for delisting over that same period.

*12-Year Assessment: In Progress (*see *Abundance and Productivity* metric).

Diversity Metric #2: Interbreeding with Hatchery Fish

Criterion: Annual assessments of the proportion of spawning fish that are of hatchery origin in the Clackamas winter steelhead population.

Objective: Over a nine-year period, the average percentage of the total number of spawners that are of hatchery origin is on average less than or equal to 10 percent.

12-Year Assessment: Attained.
The most recent nine-year average for pHOS in the Clackamas winter steelhead population (8 percent) is below the delisting goal threshold of 10 percent (Figure A-III: 50).

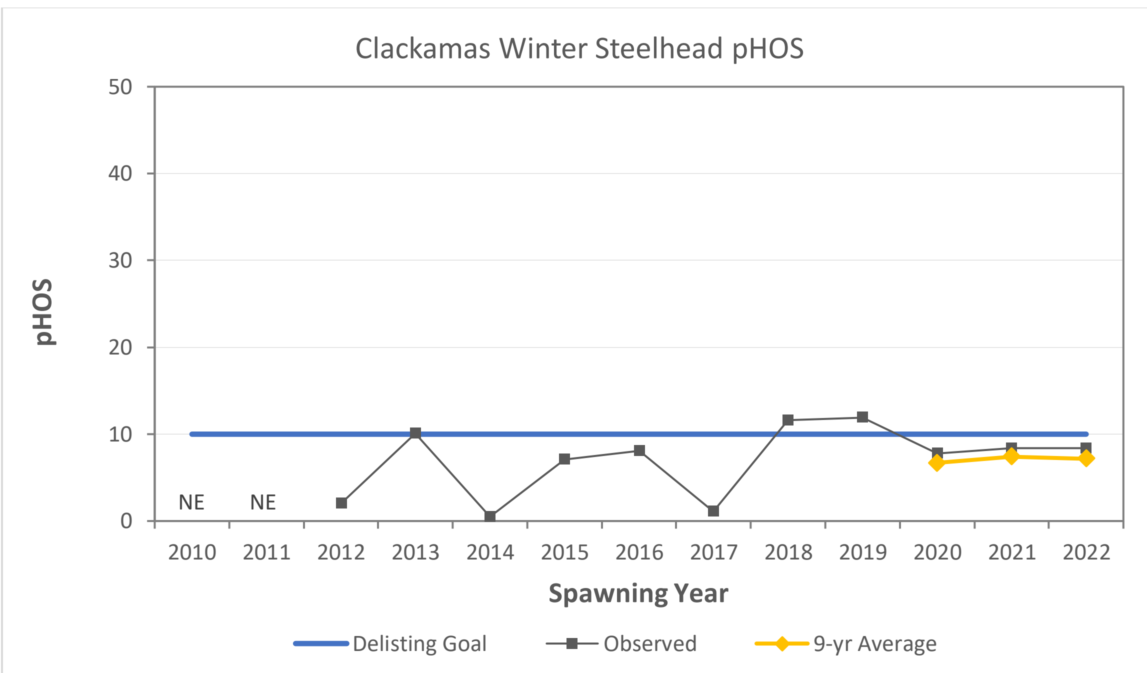

Figure A-III: 50. Percentage of hatchery origin fish on the spawning grounds in the Clackamas winter steelhead population, 2010–2022.The running nine-year average (yellow line) and delisting goal (blue line) are shown for the period following Plan adoption in 2010. NE = No Estimate.

DPS: Lower Columbia River Steelhead

Stratum: Cascade

Population: Sandy Winter Steelhead

Abundance and Productivity

Criterion: Annual estimates of abundance of naturally produced spawners in the Sandy winter steelhead population.

Objective: The observed spawner abundance is ≥ the abundance modeled for delisting at least six times in any 12-year period *and* the average observed spawner abundance is ≥ the average modeled abundance for delisting over that same period.

12-Year Assessment: *Attained.*
Winter steelhead spawner abundance in the Sandy population met the A/P objective (Figure A-III: 51). Observed spawner abundance exceeding the modeled abundance in nine of 12 years from 2011-2022 and average spawner abundance (3,224) was greater than the average modeled abundance (1,496) over that period. There has been a positive trend in spawner abundance since 2000 and average spawner abundance since 2011 has been more than double the delisting scenario goal.

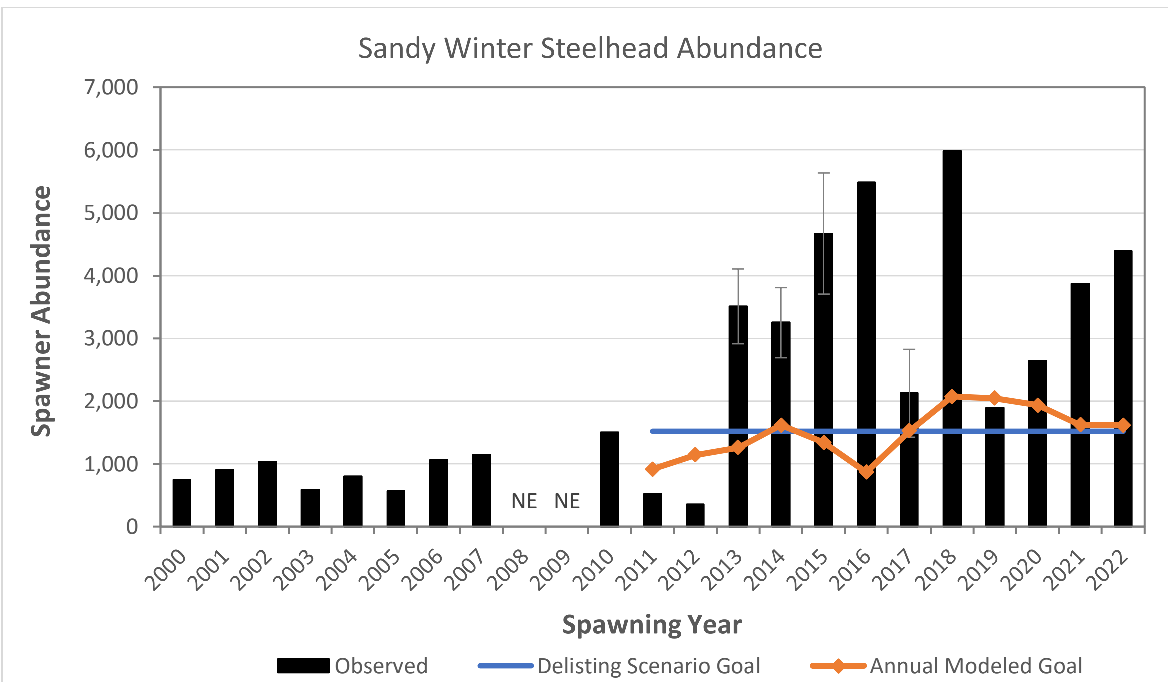

Figure A-III: 51. Natural origin winter steelhead spawner abundance in the Sandy population, 2000–2022. The delisting scenario goal and annual modeled goals scaled to climate conditions are shown for the period following Plan adoption in 2010. NE = No Estimate.

Spatial Structure

Criterion: The occupancy of spawning adults or juveniles at spatially balanced, random survey sites in the Sandy winter steelhead population.

Objective: The percentage of sites occupied by spawning adults or rearing juvenile steelhead is ≥ than the delisting threshold (85 percent) at least six times during a 12-year period *and* the overall average percentage of sites occupied during that same period is ≥ than the thresholds of 85 percent.

12-Year Assessment: In Progress.
The Sandy winter steelhead population did not meet the spatial structure objective. Occupancy by spawning adults in the Sandy population exceeded the 85 percent threshold once from 2012-2022 (Figure A-III: 52) and the average occupancy of habitat for those years (74 percent) was below the 85 percent threshold. Juvenile steelhead surveys have been conducted annually in the LCR DPS since 2006, but these surveys do not provide population-scale occupancy estimates.

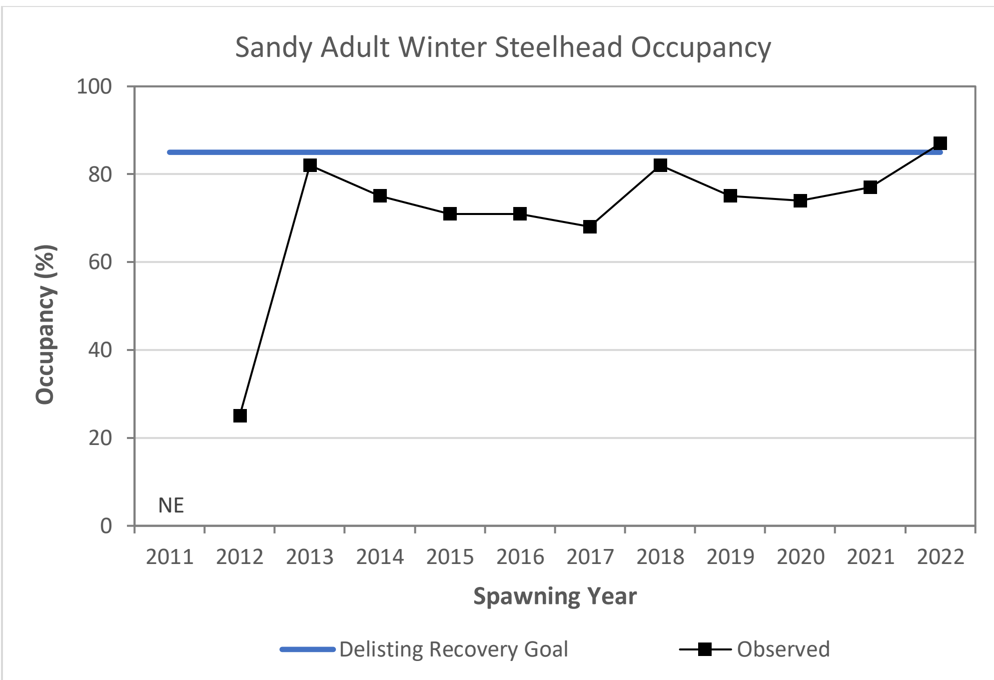

Figure A-III: 52. Percentage of sites occupied by spawning winter steelhead in the Sandy population, 2011–2022. NE = No Estimate.

Diversity Metric #1: Effective Population Size

Criterion: Annual estimates of abundance of naturally produced spawners in the Sandy winter steelhead population.

Objective: The observed spawner abundance is ≥ the abundance modeled for delisting at least six times in any 12-year period *and* the average observed spawner abundance is ≥ the average modeled abundance for delisting over that same period.

12-Year Assessment: Attained (see *Abundance and Productivity* metric).

Diversity Metric #2: Interbreeding with Hatchery Fish

Criterion: Annual assessments of the proportion of spawning fish that are of hatchery origin in the Sandy winter steelhead population.

Objective: Over a nine-year period, the average percentage of the total number of spawners that are of hatchery origin is on average less than or equal to 10 percent.

12-Year Assessment: Attained.
The nine-year average for pHOS in the Sandy winter steelhead population has consistently been below the delisting goal threshold of 10 percent (Figure A-III: 53).

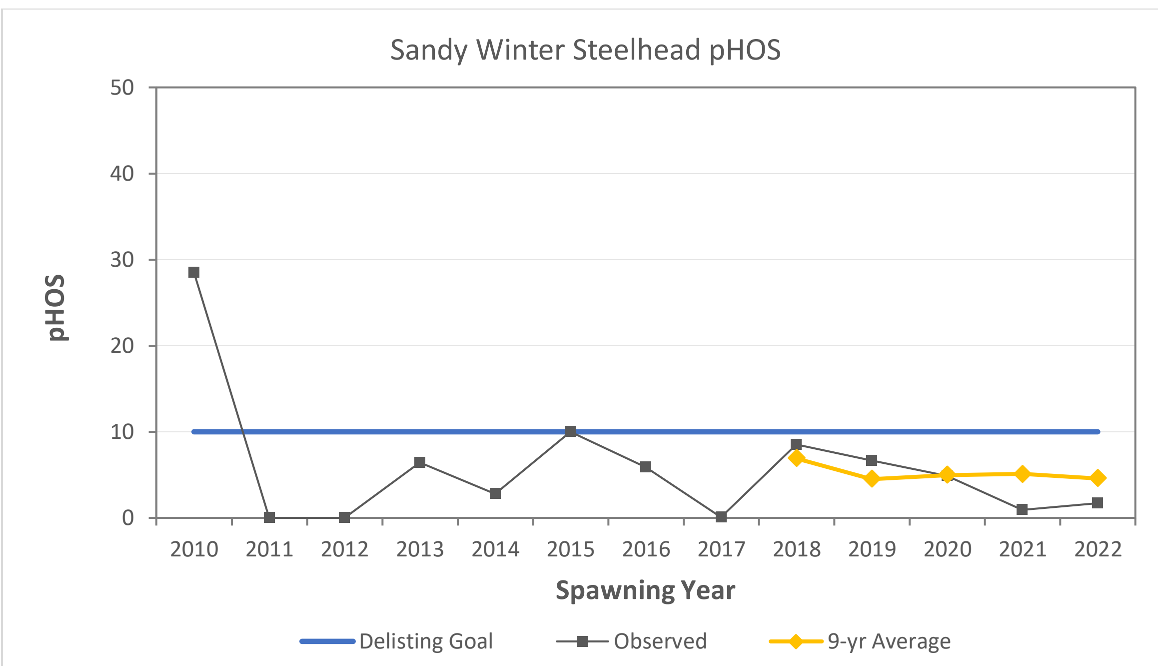

Figure A-III: 53. Percentage of hatchery origin fish on the spawning grounds in the Sandy winter steelhead population, 2010–2022. The running nine-year average (yellow line) and delisting goal (blue line) are shown for the period following Plan adoption in 2010.

DPS: Lower Columbia River Steelhead

Stratum: Gorge

Population: Hood River Winter Steelhead

Abundance and Productivity

Criterion: Annual estimates of abundance of naturally produced spawners in the Hood River winter steelhead population.

Objective: The observed spawner abundance is ≥ the abundance modeled for delisting at least six times in any 12-year period *and* the average observed spawner abundance is ≥ the average modeled abundance for delisting over that same period.

12-Year Assessment: *Attained.*
Winter steelhead spawner abundance in the Hood population met the A/P objective (Figure A-III: 54). Observed spawner abundance exceeding the modeled abundance in 6 of 11 years from 2011-2021 and average spawner abundance (458) was greater than the average modeled abundance (385) over that period. Although the objective was attained, spawner abundance has consistently been far below the delisting scenario goal since 2000.

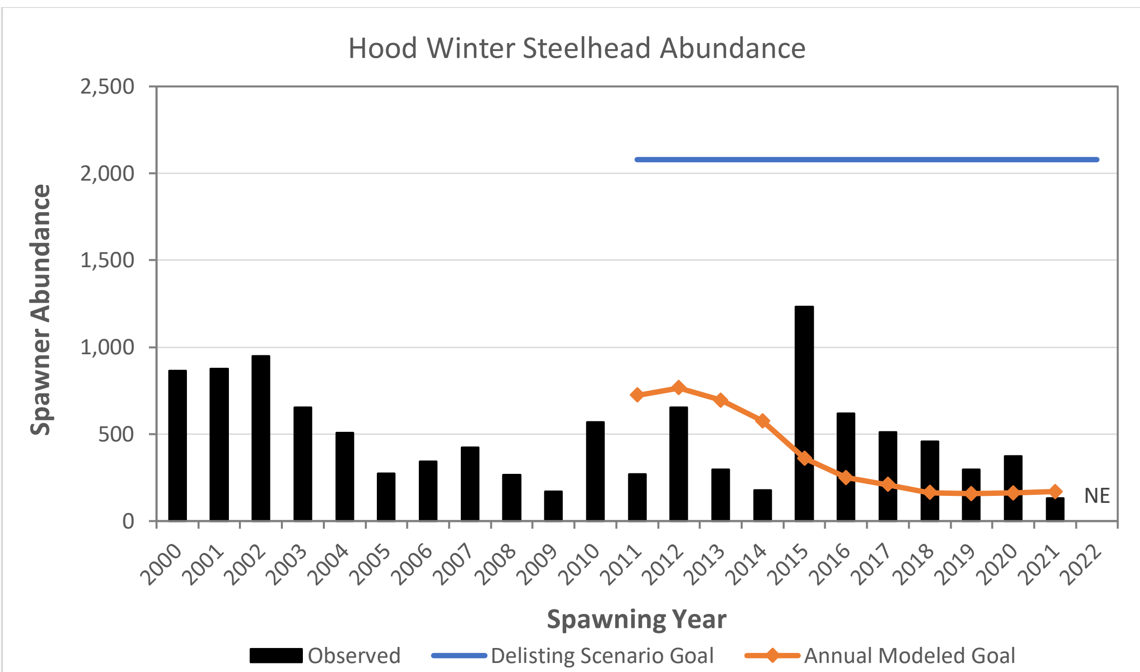

Figure A-III: 54. Natural origin winter steelhead spawner abundance in the Hood population, 2000–2022. The delisting scenario goal and annual modeled goals scaled to climate conditions are shown for the period following Plan adoption in 2010. NE = No Estimate.

Spatial Structure

Criterion: The occupancy of spawning adults or juveniles at spatially balanced, random survey sites in the Hood winter steelhead population.

Objective: The percentage of sites occupied by spawning adults or rearing juvenile steelhead is ≥ than the delisting threshold (80 percent) at least six times during a 12-year period *and* the overall average percentage of sites occupied during that same period is ≥ than the thresholds of 80 percent.

12-Year Assessment: Not Available.
ODFW does not conduct spatially balanced, random winter steelhead surveys in the Hood population. Adult abundance is currently assessed using model estimation methods that do not provide the data needed to assess this criterion. Juvenile steelhead surveys have been conducted annually in the LCR DPS since 2006, but these surveys do not provide population-scale occupancy estimates.

Diversity

Diversity Metric #1: Effective Population Size

Criterion: Annual estimates of abundance of naturally produced spawners in the Hood River winter steelhead population.

Objective: The observed spawner abundance is ≥ the abundance modeled for delisting at least six times in any 12-year period *and* the average observed spawner abundance is ≥ the average modeled abundance for delisting over that same period.

12-Year Assessment: Attained (see *Abundance and Productivity* metric).

Diversity Metric #2: Interbreeding with Hatchery Fish

Criterion: Annual assessments of the proportion of spawning fish that are of hatchery origin in the Hood River winter steelhead population.

Objective: Over a nine-year period, the average percentage of the total number of spawners that are of hatchery origin is on average less than or equal to 10 percent.

12-Year Assessment: In Progress.
The nine-year average for pHOS in the Hood winter steelhead population has consistently been above the delisting goal threshold of 10 percent (Figure A-III: 55). The Hood River hatchery steelhead program has been eliminated and the final smolt release occurred in 2021.

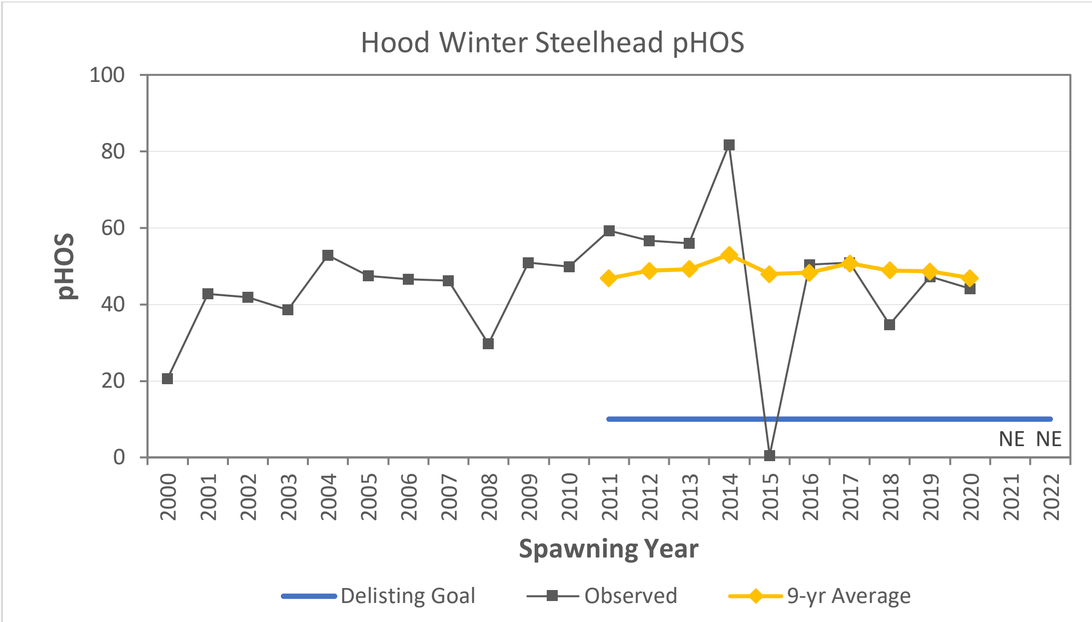

Figure A-III: 55. Percentage of hatchery origin fish on the spawning grounds in the Hood winter steelhead population, 2000–2022. The running nine-year average (yellow line) and delisting goal (blue line) are shown for the period following Plan adoption in 2010. NE = No Estimate.

DPS: Lower Columbia River Steelhead

Stratum: Gorge

Population: Hood River Summer Steelhead

Abundance and Productivity

Criterion: Annual estimates of abundance of naturally produced spawners in the Hood River summer steelhead population.

Objective: The observed spawner abundance is ≥ the abundance modeled for delisting at least six times in any 12-year period *and* the average observed spawner abundance is ≥ the average modeled abundance for delisting over that same period.

12-Year Assessment: *Not available.*
Available monitoring data was not sufficient to assess the A/P criterion due to a lack of estimates for several years and additional years where only partial estimates are available. In years when estimates are available, observed spawner abundance was consistently below the annual modeled abundance goal and far below the delisting scenario goal (Figure A-III: 68).

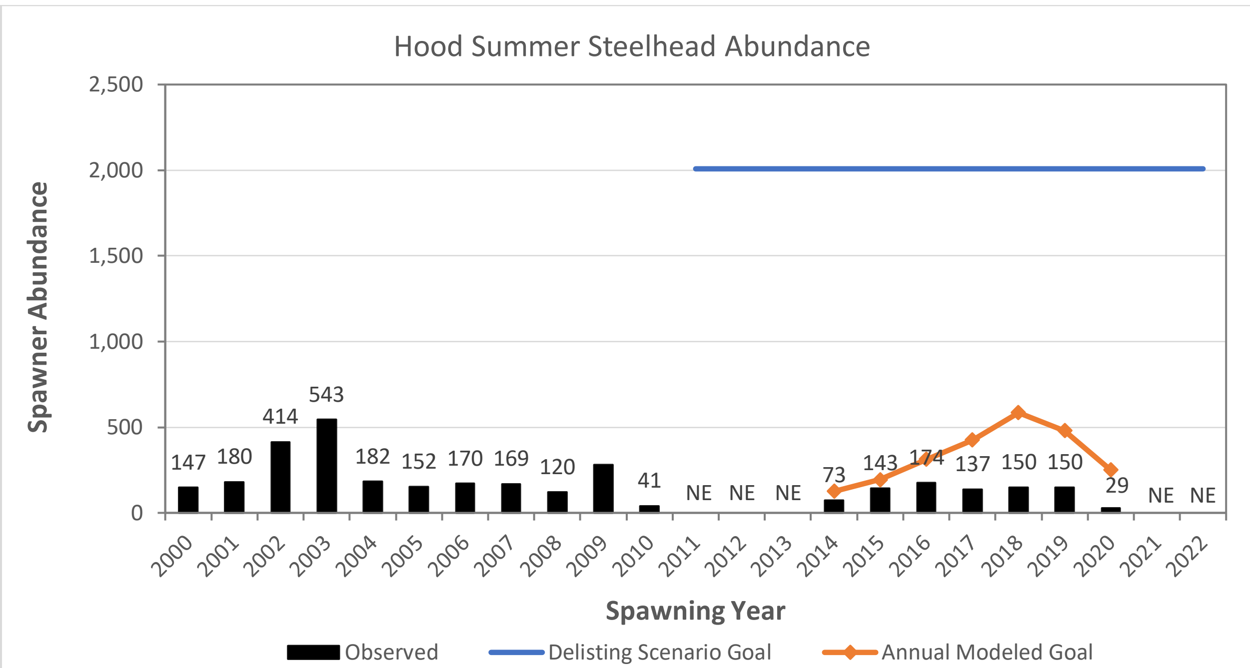

Figure A-III: 68. Natural origin summer steelhead spawner abundance in the Hood population, 2000–2022 (estimates are not available for 2011–2013 and 2021-2022; mark-recapture estimates could not be made in 2014–2015 and values shown are counts from adult capture facilities). The delisting scenario goal and annual modeled goals scaled to climate conditions are shown for the period following Plan adoption in 2010. NE = No Estimate.

Spatial Structure

Criterion: The occupancy of spawning adults or juveniles at spatially balanced, random survey sites in the Hood River summer steelhead population.

Objective: The percentage of sites occupied by spawning adults or rearing juvenile steelhead is ≥ than the delisting threshold (80 percent) at least six times during a 12-year period *and* the overall average percentage of sites occupied during that same period is ≥ than the thresholds of 80 percent.

12-Year Assessment: Not Available.
ODFW does not conduct spatially balanced, random summer steelhead surveys in the Hood population. Adult abundance is currently assessed using model estimation methods that do not provide the data needed to assess this criterion.

Diversity Metric #1: Effective Population Size

Criterion: Annual estimates of abundance of naturally produced spawners in the Hood River summer steelhead population.

Objective: The observed spawner abundance is ≥ the abundance modeled for delisting at least six times in any 12-year period *and* the average observed spawner abundance is ≥ the average modeled abundance for delisting over that same period.

12-Year Assessment: Not Available (see *Abundance and Productivity* metric).

Diversity Metric #2: Interbreeding with Hatchery Fish

Criterion: Annual assessments of the proportion of spawning fish that are of hatchery origin in the Hood River summer steelhead population.

Objective: Over a nine-year period, the average percentage of the total number of spawners that are of hatchery origin is on average less than or equal to 10 percent.

12-Year Assessment: In Progress.
The nine-year average for pHOS in the Hood summer steelhead population has consistently been above the delisting goal threshold of 0 percent (Figure A-III: 69). However, since the Hood River hatchery program was eliminated annual pHOS has been at or near zero and the nine-year average has been steadily declining since 2014.

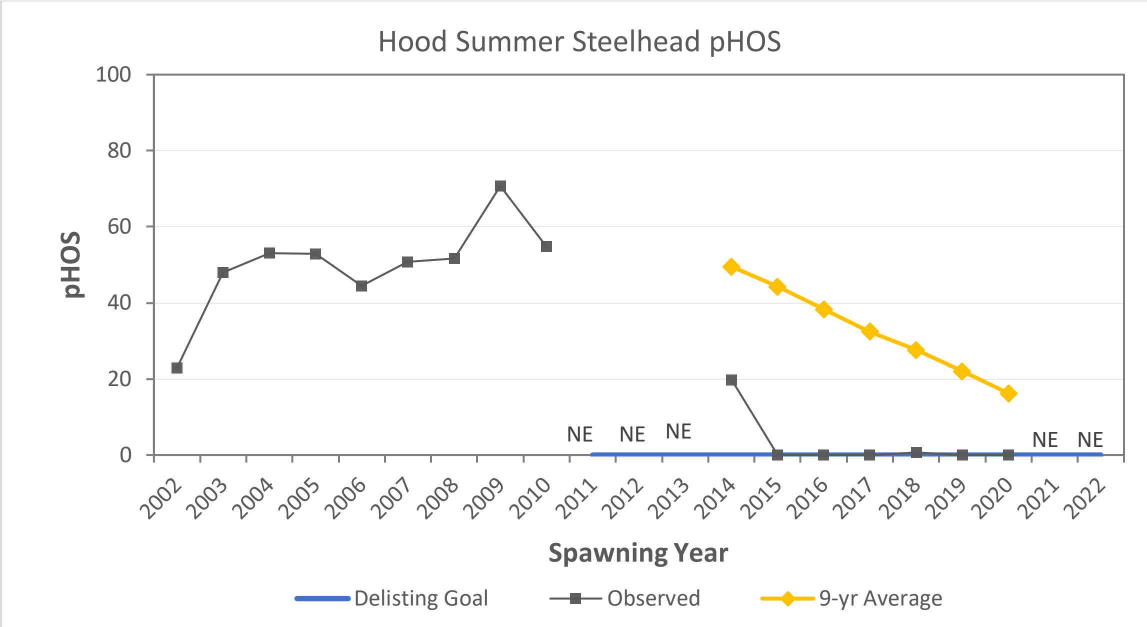

Figure A-III: 69. Percentage of hatchery origin fish on the spawning grounds in the Hood summer steelhead population, 2002–2022. The running nine-year average (yellow line) and delisting goal (blue line) are shown for the period following Plan adoption in 2010. NE = No Estimate.

DPS: SW Washington Steelhead

Stratum: Coast

Population: Youngs Bay Winter Steelhead

Abundance and Productivity

Criterion: Annual estimates of abundance of naturally produced spawners in the Youngs Bay winter steelhead population.

Objective: The observed spawner abundance is ≥ the broad sense goal at least six times in any 12-year period.

12-Year Assessment: *Not available*
The Youngs Bay population is part of the SWW DPS, which is not listed under the federal ESA. Spawner abundance in the Youngs Bay winter steelhead population did not exceed the broad sense recovery goal during the 2012-2013 period when monitoring occurred (Figure A-III: 56). After 2013, limited monitoring resources were directed toward higher priority populations and so progress toward the broad sense recovery goal could not be assessed.

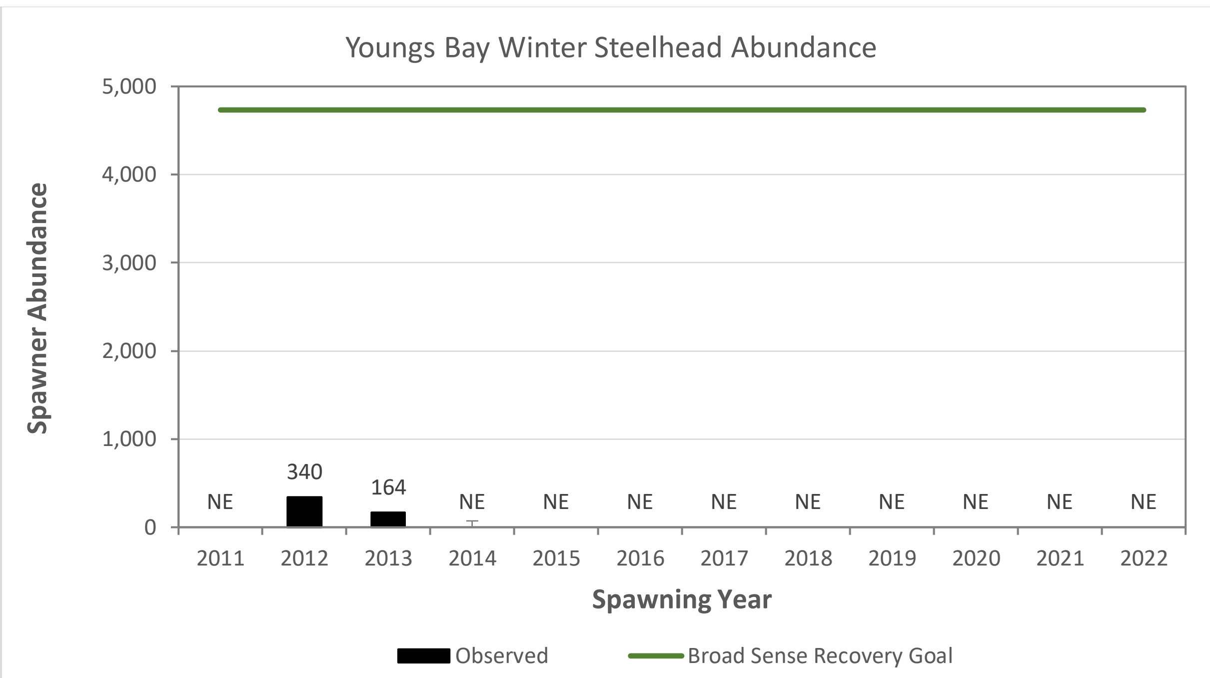

Figure A-III: 56. Natural origin winter steelhead spawner abundance in the Youngs Bay population, 2011–2022. The broad sense recovery goal is shown for the period following Plan adoption in 2010. NE = No Estimate.

Spatial Structure

Criterion: The occupancy of spawning adults or juveniles at spatially balanced, random survey sites in the Youngs Bay winter steelhead population.

Objective: The percentage of sites occupied by spawning adults or rearing juvenile steelhead is ≥ than the broad sense threshold (95 percent) at least six times during a 12-year period *and* the overall average percentage of sites occupied during that same period is ≥ than the thresholds of 95 percent.

12-Year Assessment: Not available.
Occupancy by spawning adults in the Youngs Bay winter steelhead population did not exceed the broad sense recovery goal during the 2012-2013 period when monitoring occurred (Figure A-III: 57). After 2013, limited monitoring resources were directed toward higher priority populations and so progress toward the broad sense recovery goal could not be assessed. Juvenile steelhead surveys have been conducted annually in the SWW DPS since 2006, but these surveys do not provide population-scale occupancy estimates.

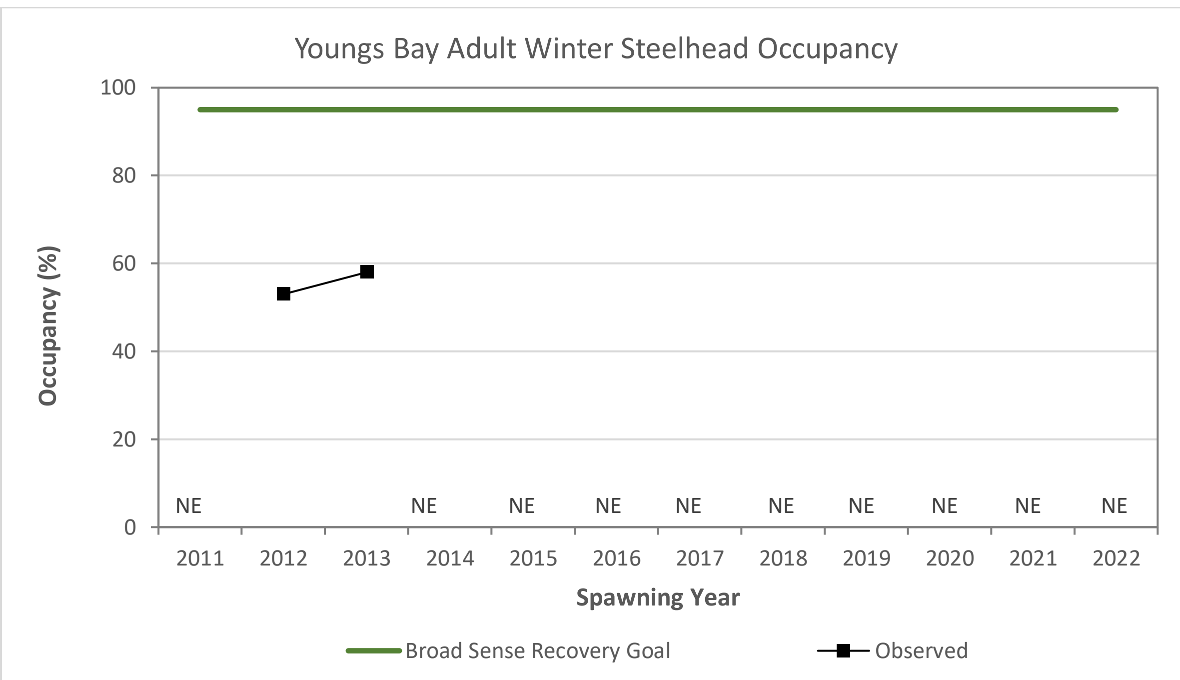

Figure A-III: 57. Percentage of sites occupied by spawning winter steelhead in the Youngs Bay population, 2011–2022. NE = No Estimate.

Diversity Metric #1: Effective Population Size

Criterion: Annual estimates of abundance of naturally produced spawners in the Youngs Bay winter steelhead population.

Objective: The observed spawner abundance is ≥ the abundance modeled for delisting at least six times in any 12-year period *and* the average observed spawner abundance is ≥ the average modeled abundance for delisting over that same period.

*12-Year Assessment: Not Available (*see *Abundance and Productivity* metric).

Diversity Metric #2: Interbreeding with Hatchery Fish

Criterion: Annual assessments of the proportion of spawning fish that are of hatchery origin in the Youngs Bay winter steelhead population.

Objective: Over a nine-year period, the average percentage of the total number of spawners that are of hatchery origin is on average less than or equal to 10 percent.

12-Year Assessment: Not Available.
During the 2012–2013 period when monitoring occurred, pHOS in the Youngs Bay winter steelhead population exceeded the broad sense recovery goal of ten percent (Figure A-III: 58). After 2013, limited monitoring resources were directed toward higher priority populations and so progress toward the broad sense recovery goal could not be assessed.

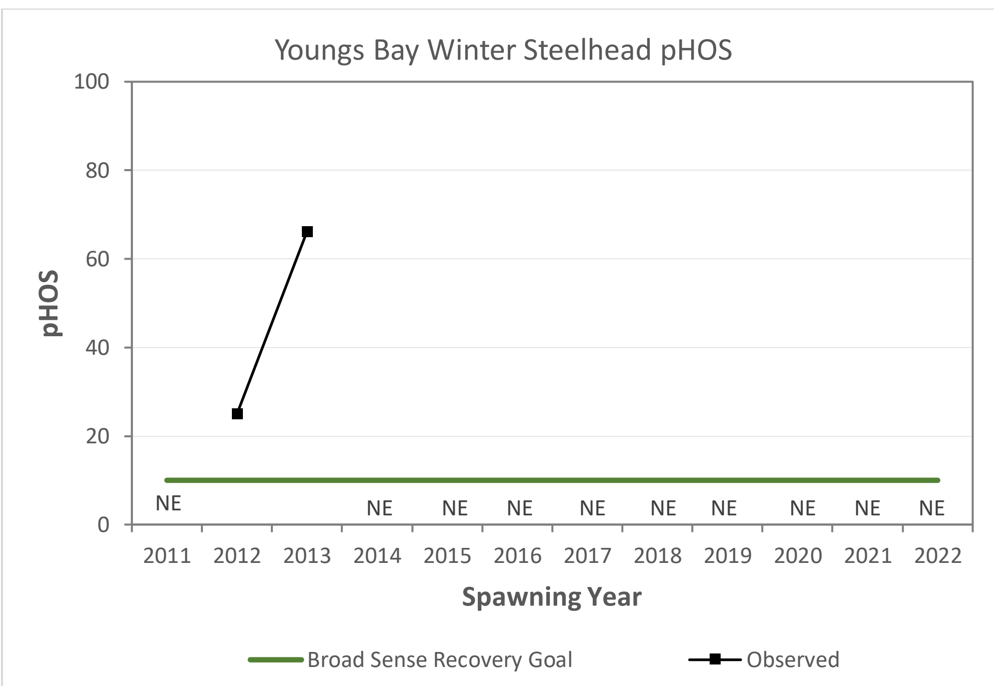

Figure A-III: 58. Percentage of hatchery origin fish on the spawning grounds in the Youngs Bay winter steelhead population, 2011–2022. The broad sense recovery goal is shown for the period following Plan adoption in 2010. NE = No Estimate.

DPS: SW Washington Steelhead

Stratum: Coast

Population: Big Creek Winter Steelhead

Abundance and Productivity

Criterion: Annual estimates of abundance of naturally produced spawners in the Big Creek winter steelhead population.

Objective: The observed spawner abundance is ≥ the broad sense goal at least six times in any 12-year period.

12-Year Assessment: *Not available*
The Big Creek population is part of the SWW DPS, which is not listed under the federal ESA. Spawner abundance in the Big Creek winter steelhead population did not exceed the broad sense recovery goal during 2012-2013 period when monitoring occurred (Figure A-III: 59). After 2013, limited monitoring resources were directed toward higher priority populations and so progress toward the broad sense recovery goal could not be assessed.

Figure A-III: 59. Natural origin winter steelhead spawner abundance in the Big Creek population, 2011–2022. The broad sense recovery goal is shown for the period following Plan adoption in 2010. NE = No Estimate.

Spatial Structure

Criterion: The occupancy of spawning adults or juveniles at spatially balanced, random survey sites in the Big Creek winter steelhead population.

Objective: The percentage of sites occupied by spawning adults or rearing juvenile steelhead is ≥ than the broad sense threshold (95 percent) at least six times during a 12-year period *and* the overall average percentage of sites occupied during that same period is ≥ than the thresholds of 95 percent.

12-Year Assessment: Not available.
Occupancy by spawning adults in the Big Creek winter steelhead population did not exceed the broad sense recovery goal during the 2012-2013 period when monitoring occurred (Figure A-III: 60). After 2013, limited monitoring resources were directed toward higher priority populations and so progress toward the broad sense recovery goal could not be assessed. Juvenile steelhead surveys have been conducted annually in the SWW DPS since 2006, but these surveys do not provide population-scale occupancy estimates.

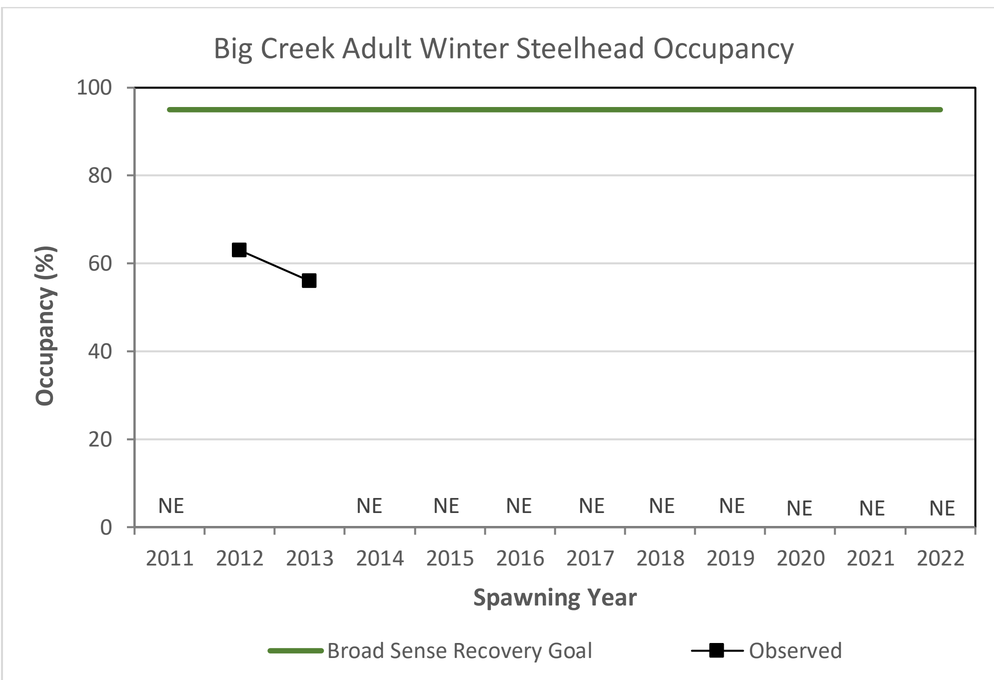

Figure A-III: 60. Percentage of sites occupied by spawning winter steelhead in the Big Creek population, 2011–2022. NE = No Estimate.

Diversity Metric #1: Effective Population Size

Criterion: Annual estimates of abundance of naturally produced spawners in the Big Creek winter steelhead population.

Objective: The observed spawner abundance is ≥ the abundance modeled for delisting at least six times in any 12-year period *and* the average observed spawner abundance is ≥ the average modeled abundance for delisting over that same period.

12-Year Assessment: Attainment Unknown (see *Abundance and Productivity* metric).

Diversity Metric #2: Interbreeding with Hatchery Fish

Criterion: Annual assessments of the proportion of spawning fish that are of hatchery origin in the Big Creek winter steelhead population.

Objective: Over a nine-year period, the average percentage of the total number of spawners that are of hatchery origin is on average less than or equal to 10 percent.

12-Year Assessment: Not Available.
During the 2012–2013 period when monitoring occurred, pHOS in the Big Creek winter steelhead population far exceeded the broad sense recovery goal of ten percent (Figure A-III: 61). After 2013, limited monitoring resources were directed toward higher priority populations and so progress toward the broad sense recovery goal could not be assessed.

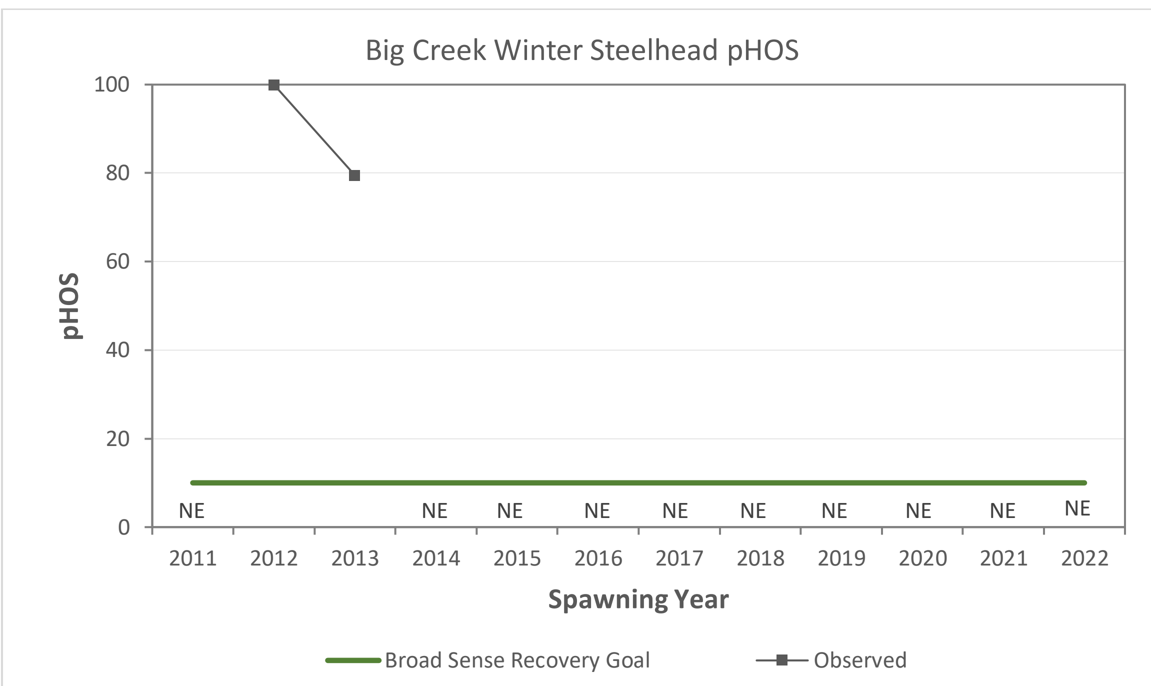

Figure A-III: 61. Percentage of hatchery origin fish on the spawning grounds in the Big Creek winter steelhead population, 2011–2022. The broad sense recovery goal is shown for the period following Plan adoption in 2010. NE = No Estimate.

DPS: SW Washington Steelhead

Stratum: Coast

Population: Clatskanie Winter Steelhead

Abundance and Productivity

Criterion: Annual estimates of abundance of naturally produced spawners in the Clatskanie winter steelhead population.

Objective: The observed spawner abundance is ≥ the broad sense goal at least six times in any 12-year period.

12-Year Assessment: *In Progress.*
The Clatskanie population is part of the SWW DPS, which is not listed under the federal ESA. Spawner abundance in the Clatskanie winter steelhead population met the A/P objective (Figure A-III: 62) in two of the three years for which an annual modeled goal could be calculated. Average spawner abundance (849) was greater than the average modeled abundance (596) over that period but was far below the broad sense recovery goal.

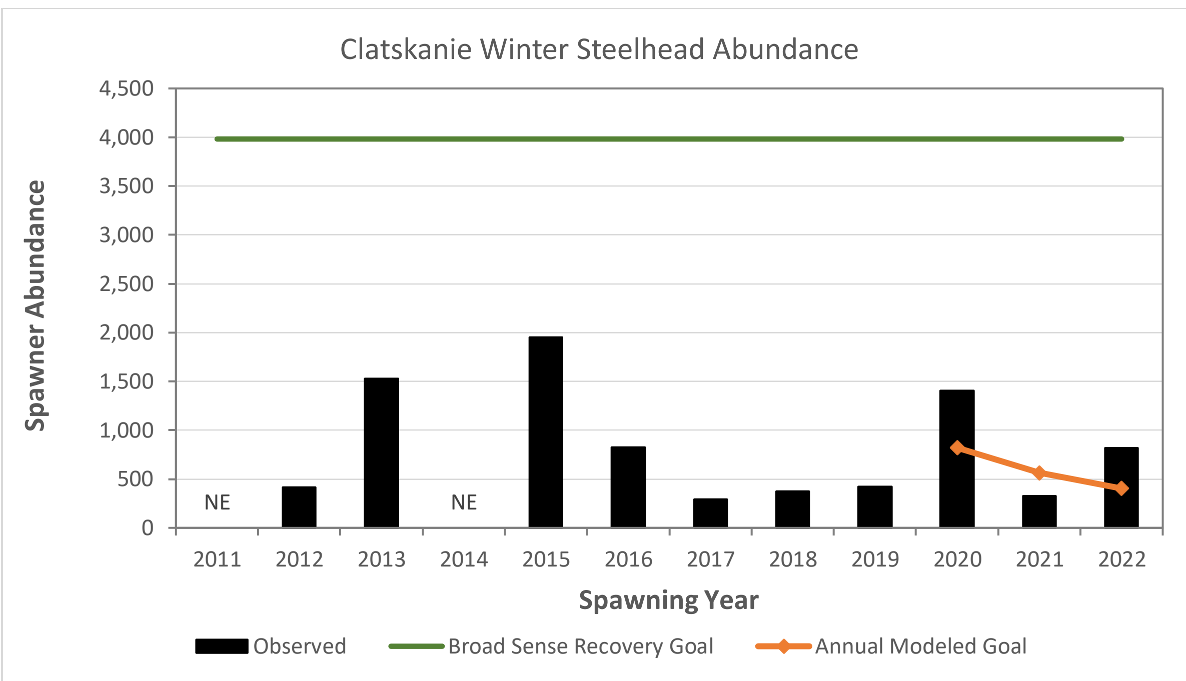

Figure A-III: 62. Natural origin winter steelhead spawner abundance in the Clatskanie population, 2011–2022. The broad sense recovery goal and annual modeled goals scaled to climate conditions are shown for the period following Plan adoption in 2010. NE = No Estimate.

Spatial Structure

Criterion: The occupancy of spawning adults or juveniles at spatially balanced, random survey sites in the Clatskanie winter steelhead population.

Objective: The percentage of sites occupied by spawning adults or rearing juvenile steelhead is ≥ than the delisting threshold (90 percent) at least six times during a 12-year period *and* the overall average percentage of sites occupied during that same period is ≥ than the thresholds of 90 percent.

12-Year Assessment: In Progress.
The Clatskanie winter steelhead population did not meet the spatial structure objective. Occupancy by spawning adults did not meet or exceed the broad sense recovery threshold of 90 percent in any year from 2011-2022 (Figure A-III: 63). Juvenile steelhead surveys have been conducted annually in the SWW DPS since 2006, but these surveys do not provide population-scale occupancy estimates.

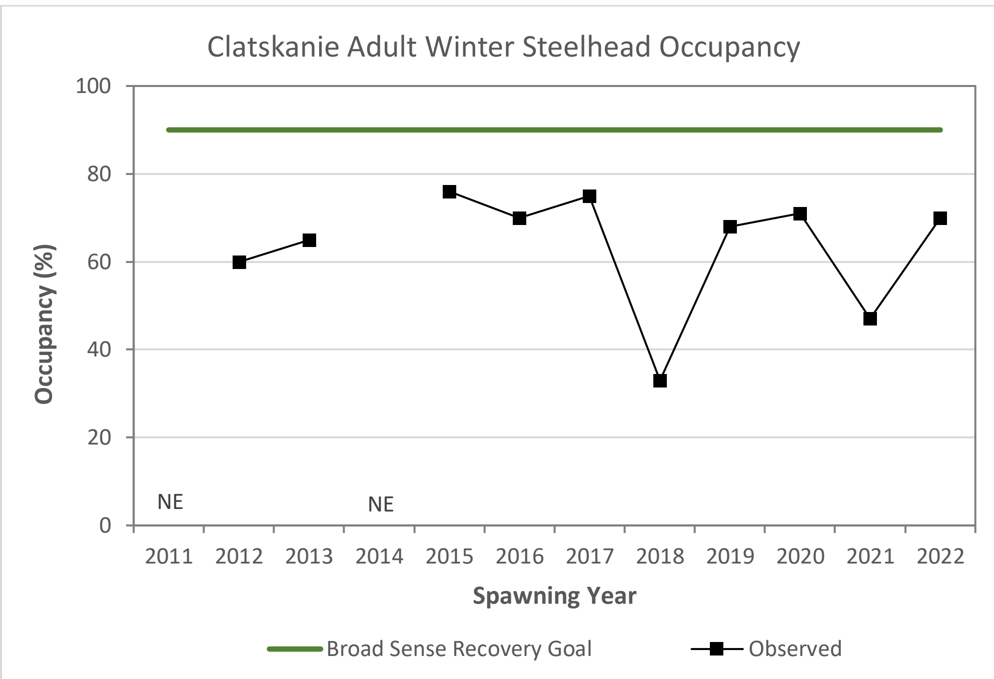

Figure A-III: 63. Percentage of sites occupied by spawning winter steelhead in the Clatskanie population, 2011–2022. NE = No Estimate.

Diversity Metric #1: Effective Population Size

Criterion: Annual estimates of abundance of naturally produced spawners in the Clatskanie winter steelhead population.

Objective: The observed spawner abundance is ≥ the broad sense goal at least six times in any 12-year period.

12-Year Assessment: In Progress (see *Abundance and Productivity* metric.)

Diversity Metric #2: Interbreeding with Hatchery Fish

Criterion: Annual assessments of the proportion of spawning fish that are of hatchery origin in the Clatskanie winter steelhead population.

Objective: Over a nine-year period, the average percentage of the total number of spawners that are of hatchery origin is on average less than or equal to five percent.

12-Year Assessment: Attained.
The nine-year average for pHOS in the Clatskanie winter steelhead population (4.1 percent) was below the broad sense recovery goal of five percent (Figure A-III: 64).

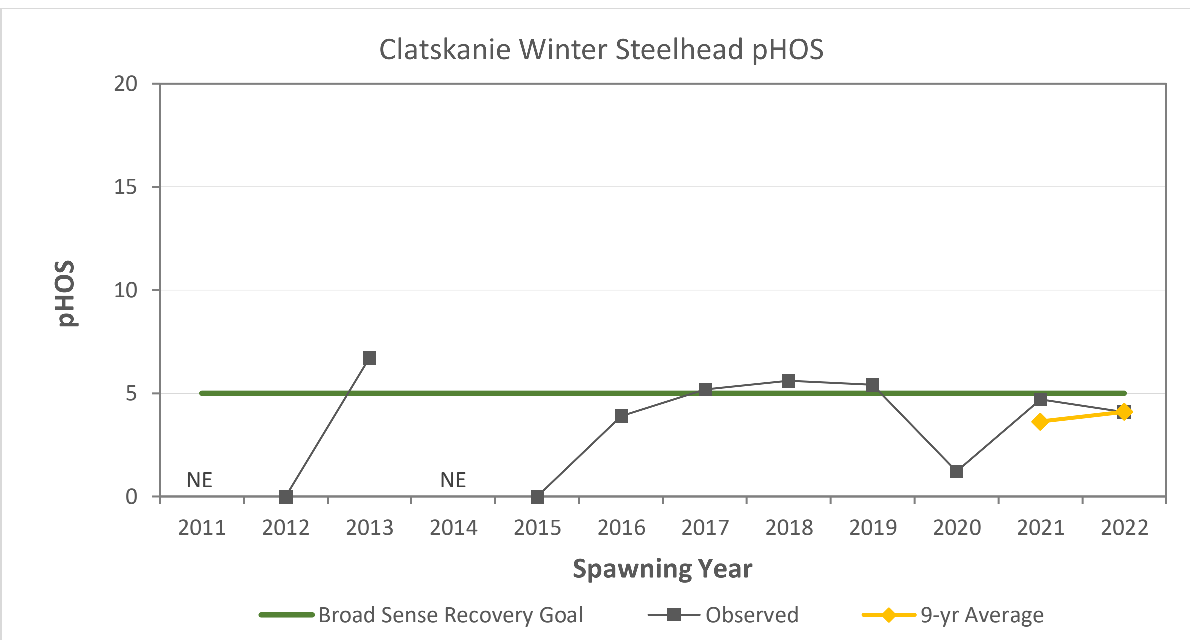

Figure A-III: 64. Percentage of hatchery origin fish on the spawning grounds in the Clatskanie winter steelhead population, 2011–2022. The running nine-year average (yellow dot) and broad sense recovery goal (green line) are shown for the period following Plan adoption in 2010. NE = No Estimate.

DPS: SW Washington Steelhead

Stratum: Coast

Population: Scappoose Winter Steelhead

Abundance and Productivity

Criterion: Annual estimates of abundance of naturally produced spawners in the Scappoose winter steelhead population.

Objective: The observed spawner abundance is ≥ the broad sense goal at least six times in any 12-year period.

12-Year Assessment: *In Progress.*
The Scappoose population is part of the SWW DPS, which is not listed under the federal ESA. Spawner abundance in the Scappoose winter steelhead population did not meet the A/P objective (Figure A-III: 65) in the four years for which an annual modeled goal could be calculated. Average spawner abundance (49) was less than the average modeled abundance (183) and far below the broad sense recovery goal over that period. Spawner abundance has declined since 2013.

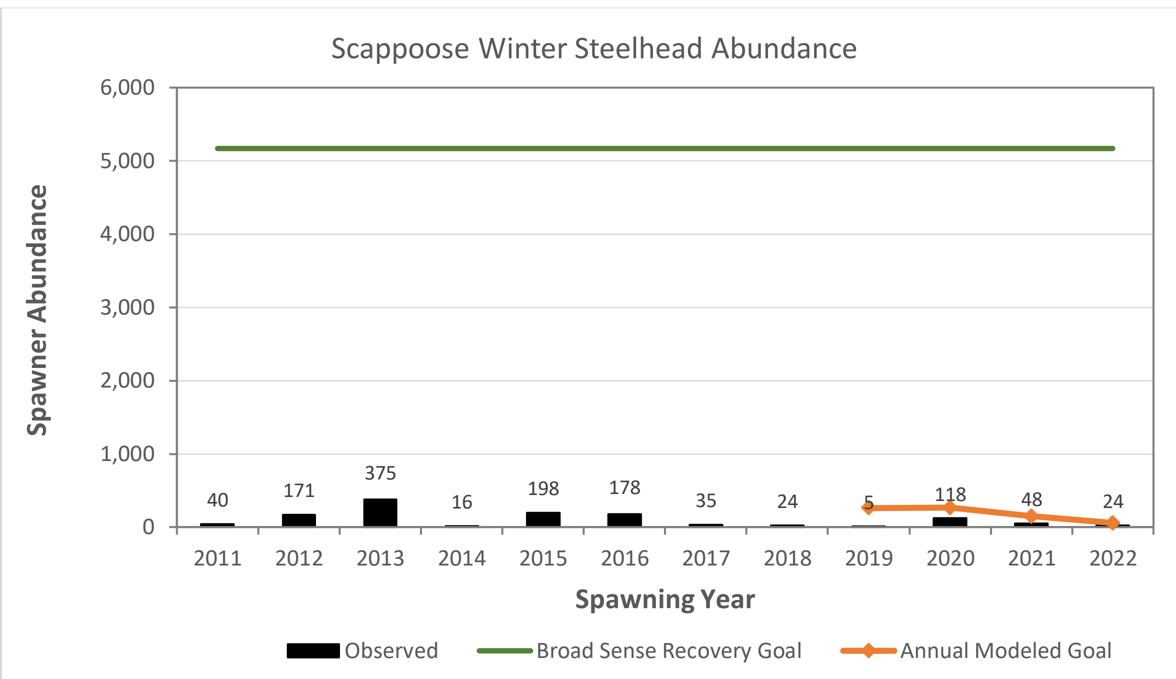

Figure A-III: 65. Natural origin winter steelhead spawner abundance in the Scappoose population, 2011–2022. The broad sense recovery goal and annual modeled goals scaled to climate conditions are shown for the period following Plan adoption in 2010.

Spatial Structure

Criterion: The occupancy of spawning adults or juveniles at spatially balanced, random survey sites in the Scappoose winter steelhead population.

Objective: The percentage of sites occupied by spawning adults or rearing juvenile steelhead is ≥ than the delisting threshold (90 percent) at least six times during a 12-year period *and* the overall average percentage of sites occupied during that same period is ≥ than the thresholds of 90 percent.

12-Year Assessment: In Progress:
The Scappoose winter steelhead population did not meet the spatial structure objective. Occupancy by spawning adults did not meet or exceed the broad sense recovery threshold of 90 percent in any year from 2011-2022 (Figure A-III: 66). Juvenile steelhead surveys have been conducted annually in the SWW DPS since 2006, but these surveys do not provide population-scale occupancy estimates.

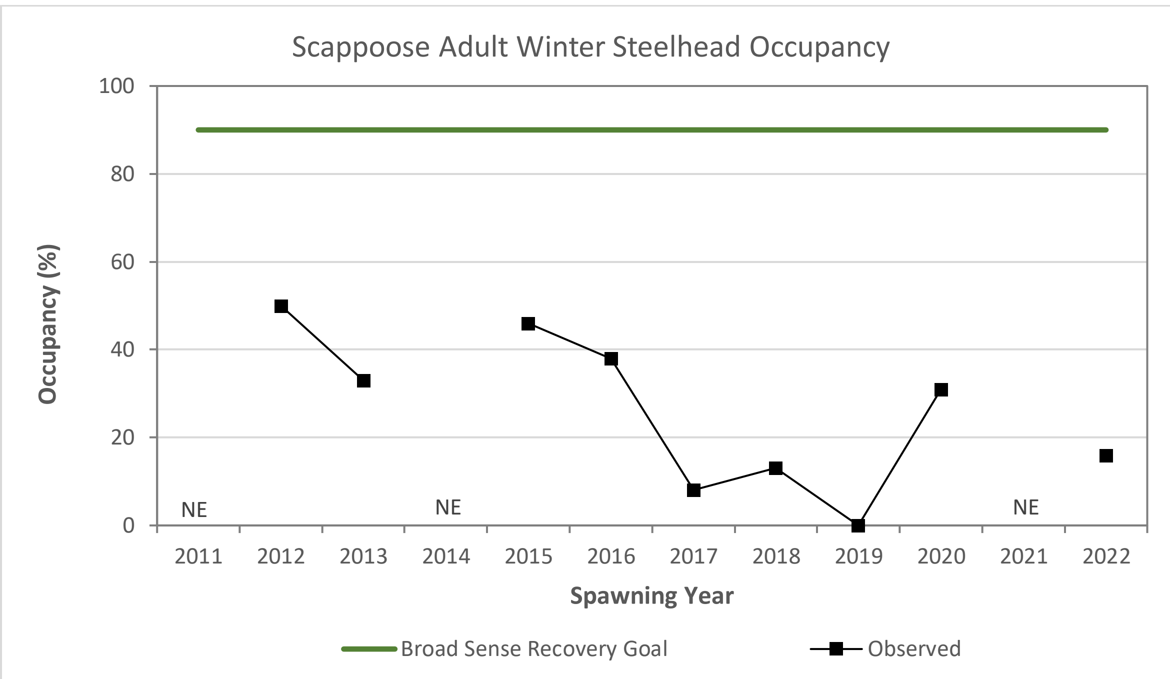

Figure A-III: 66. Percentage of sites occupied by spawning winter steelhead in the Scappoose population, 2011–2022. NE = No Estimate.

Diversity Metric #1: Effective Population Size

Criterion: Annual estimates of abundance of naturally produced spawners in the Scappoose winter steelhead population.

Objective: The observed spawner abundance is ≥ the broad sense goal at least six times in any 12-year period.

12-Year Assessment: In Progress (see *Abundance and Productivity* metric).

Diversity Metric #2: Interbreeding with Hatchery Fish

Criterion: Annual assessments of the proportion of spawning fish that are of hatchery origin in the Scappoose winter steelhead population.

Objective: Over a nine-year period, the average percentage of the total number of spawners that are of hatchery origin is on average less than or equal to five percent.

12-Year Assessment: Attained.
The nine-year average for pHOS in the Scappoose winter steelhead population (0 percent) was below the broad sense recovery goal of five percent (Figure A-III: 67).

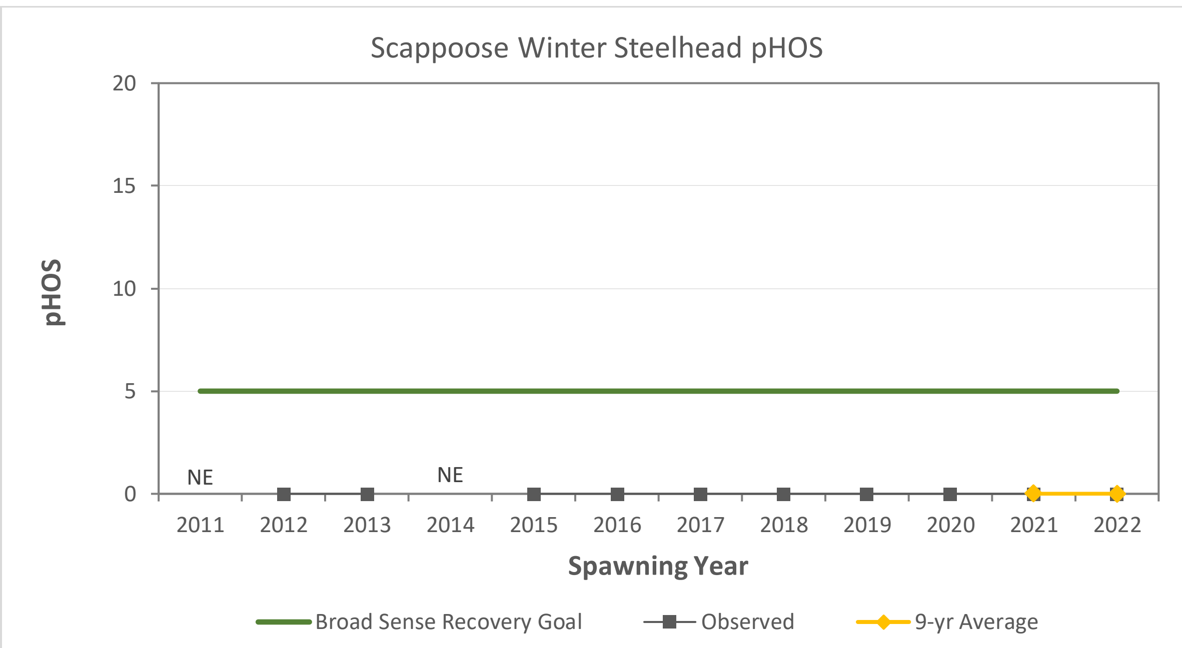

Figure A-III: 67. Percentage of hatchery origin fish on the spawning grounds in the Scappoose winter steelhead population, 2011–2022. The running nine-year average (yellow dot) and broad sense recovery goal (green line) are shown for the period following Plan adoption in 2010. NE = No Estimate.

Listing Factor Criteria Assessment

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

Habitat Related Metrics #1 – All Species

Objective: Positive trend in the status of the habitat degradation metrics.

12-Year Assessment: *Attainment Uncertain.*
Currently, there is not sufficient information to assess trends in individual habitat metrics at the population scale. LCR habitat conditions were analyzed in 2005 based on surveys conducted within the ESU from 1990-2004 (Anlauf et al. 2006), which informed development of the plan. Those data were collected from census surveys, making it difficult to compare them with subsequent surveys by ODFW's Aquatic Inventories Project (AQI), which began conducting surveys throughout the ESU in 2006 using a different sampling design and methods. Data collection by AQI is ongoing and provides adequate information for trend analysis at the stratum level. ODFW recently completed an evaluation of stratum-level changes in channel structure and complexity, as well as floodplain connectivity and function, from 2007-2016 (Strickland and Constable 2022). Sites surveyed two or more times during this ten-year period were analyzed using a linear mixed model to detect trends of selected habitat metrics within a monitoring stratum. Given the limited number of sites in the Cascade and Gorge strata, the two strata were combined for this analysis.

The results showed a decrease in percent gravel in the Coastal stratum and combined Cascade/Gorge strata, as well as an increase in winter parr capacity (an indicator of habitat complexity) in the combined Cascade/Gorge strata. No other significant trends across habitat variables were detected (Table A-III: 4).

It is important to note that results in Table A-III: 4 are based only on wadeable streams, and do not reflect habitat changes in larger streams. As a result, we do not know how much floodplain habitat was lost or gained across the ESU since plan adoption. We do know that restoration practitioners have added over 175,000 square meters of off-channel habitat, the equivalent of 140 Olympic sized pools. Additionally, flow has been improved or restored into 22 miles of side channel habitat. Most of this work has occurred in the Cascade stratum where strong partnerships with many representatives are available to assist with the needed capacity to get the restoration work completed (see Table A-III: 7).

Fish passage, while not a primary limiting factor, continues to be improved at a strong pace within the Oregon portion of the LCR ESU. One hundred and seven fish passage projects have been recorded since plan adoption, representing approximately 8-9 fish passage projects per year (Table A-III: 5). Projects vary in size from 0.13 miles to 144 miles (Powerdale Dam) of fish passage restored per project.

Table A-III: 4. Results of trend analysis on select habitat metrics. Analyses were run on sites surveyed two or more times between 2007 and 2016 (Strickland and Constable 2022).

Metric	Strata	Estimate	MSE	F value	P-value
Winter Parr/km	Coast	0.008	0.058	0.248	0.632
	Cascade/Gorge	0.034	1.417	7.699	0.034
% Secondary Channel	Coast	-0.001	0.001	0.003	0.961
	Cascade/Gorge	-0.027	0.952	3.247	0.074
% Pool Habitat	Coast	-0.006	0.031	0.155	0.703
	Cascade/Gorge	0.074	1.490	4.361	0.074
% Slackwater Pool Habitat	Coast	0.046	1.712	2.562	0.140
	Cascade/Gorge	0.041	1.546	3.957	0.079
Residual Pool Depth	Coast	-0.002	0.001	0.248	0.635
	Cascade/Gorge	-0.009	0.052	3.474	0.101
Wood Pieces/100m	Coast	0.042	0.291	2.607	0.144
	Cascade/Gorge	0.017	0.149	1.045	0.334
Wood Volume	Coast	0.011	0.024	0.179	0.684
	Cascade/Gorge	-0.030	0.426	2.842	0.134
Key Pieces of Wood	Coast	0.003	0.002	0.064	0.806
	Cascade/Gorge	-0.012	0.079	1.600	0.240
% Gravel	Coast	-0.798	418.15	6.671	0.025
	Cascade/Gorge	-0.790	683.06	13.782	0.004

Table A-III: 5. Number of fish passage projects recorded in LCR populations from 2010-2022 (note: other fish passage projects not included here may have occurred).

Population	Number of Fish Passage Projects
Youngs Bay	8
Big Creek	8
Clatskanie	11
Scappoose	20
Clackamas	30
Sandy	12
Lower Gorge	3
Upper Gorge	0
Hood	15
Total	107

Habitat Related Metrics #2 – All Species

Objective: Restoration action quantities equal or exceed "x"/15 of those shown in Table A-III: 6, where "x" is the number of years after adoption of this Plan and 15 is the number of years this Plan allows for tributary habitat restoration.

12-Year Assessment: Attainment Varies by Population and Restoration Action
Following adoption of the Plan, habitat restoration goals were revised from those needed to reach the broad sense goals to a delisting or maximum feasible scenario defined in the Plan (Table A-III: 6). Since plan approval occurred in 2010, thirteen years of the 15-year time span for tributary habitat restoration have passed. Therefore, to attain the objective approximately 87 percent of a restoration action quantity in Table A-III: 6 would need to be completed by 2022.

Assessment results vary widely across the ESU by strata and population as well as by restoration action type (Table A-III: 7). The Sandy population exceeded 87 percent of the goal for all four restoration actions, and far exceeding goals for riparian planting and off-channel wetland complexes. The Youngs Bay, Scappoose, and Clackamas populations exceeded 87 percent of the goal for two of the four restoration actions (Figure A-III: 70). Significant restoration work occurred in other populations, but they did not attain 87 percent of the goal for any of the four restoration actions.

Table A-III: 6. Summary of the quantity of specific restoration actions needed for listed species within population areas of lower Columbia River ESUs and associated restoration standards based on the maximum feasible and delisting scenarios (revision of Table 9-2 from the LCR Plan).

Population area	LWD Placement (miles)	Side channel increase (miles)	Riparian Planting (miles)	Off-channel Wetland Complex Increase (m^2)
Youngs Bay	2.3	0	0.9	263.7
Big Creek	23.7	1.8	7.5	8,445.0
Clatskanie	65.8	0	16.4	21,358.0
Scappoose	23.2	7.5	8.1	2,730.0
Clackamas	62.5	64.6	34.8	19,780.3
Sandy	34.9	17.5	18.5	5,446.6
Lower Gorge	15	8.8	8.4	6,783.6
Upper Gorge	4	1.8	1.8	1,422.0
Hood	33.6	20.1	19.2	15,501.3
Total	265	122.1	115.6	81,730.5
	20 m^3 of lwd/ 100 m of stream		30 m width on each side of stream	

Table A-III: 7. Summary of habitat restoration accomplishments in the LCR ESU from 2010-2022 (note: other restoration projects not included here may have occurred).

Population	Instream Habitat Restored (Miles)	Side Channel Habitat Restored (Miles)	Riparian Habitat Restored (Miles)	Off-Channel Habitat Restored (m^2)
Youngs Bay	4.20	0	14.29	0
Big Creek	2.94	0.42	4.63	0
Clatskanie	7.12	0.56	3.47	371
Scappoose	9.28	0.36	18.19	22,047
Clackamas	29.73	4.22	78.91	69,964
Sandy	39.47	18.09	58.11	83,205
Lower Gorge	1.77	0.40	3.42	0
Upper Gorge	0	0	0	0
Hood	11.89	1.31	6.89	836
Total	106.4	25.36	187.91	176,423

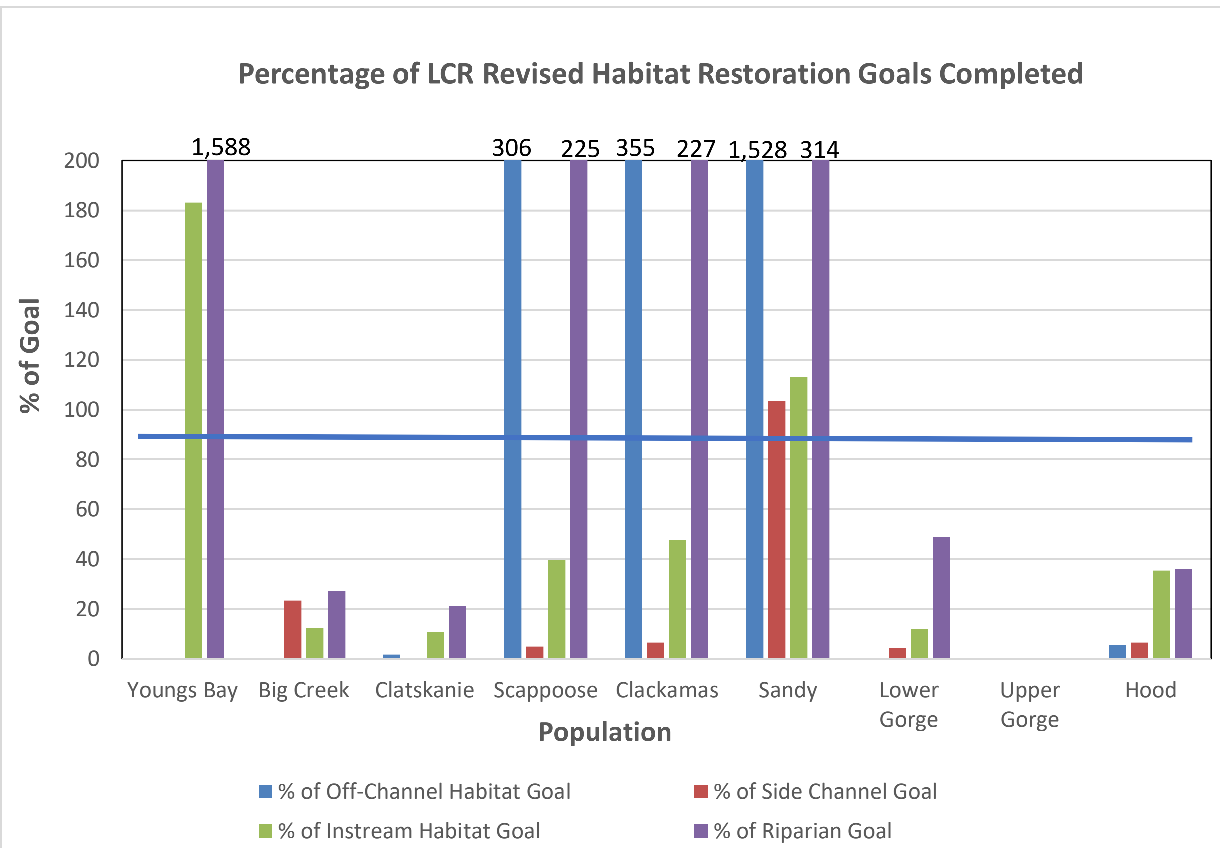

Figure A-III: 70. Percentage of LCR revised habitat restoration goals completed by population, 2010-2022.

Habitat Related Metrics #3 – Coho

Objective: The number of additional/new miles of high-quality habitat (as determined by ODFW's Habitat Limiting Factors Model) equals or exceeds that shown in Table A-III: 8.

12 Year Assessment: Attainment Varies by Population
The recovery plan used a 2006 estimate of miles of high quality coho habitat for every population then conducted modeling to determine the additional miles of high-quality habitat needed to meet the delisting scenario (Table A-III: 8). For this assessment, ODFW conducted an analysis in 2022 based on aquatic habitat surveys conducted from 2011-2021. ODFW used the Habitat Limiting Factors Model (HLFM; Nickelson 1998) to estimate the number of miles of high-quality habitat in each population. High quality habitat is defined as habitat with winter coho parr capacity greater than 1,850 parr/kilometer (> 2,977 parr/mile).

The Youngs Bay, Scappoose and Clackamas coho populations attained the goal of miles of high-quality habitat needed under the delisting scenario (Table A-III: 9). All other populations need additional miles of high-quality habitat to meet the goal under the delisting scenario. This criterion cannot be assessed for the Lower Gorge population due to a lack of monitoring data. All populations except Big Creek had higher quantities of high-quality habitat in the 2022 analysis compared to the 2006 analysis. However, comparisons between results in 2006 and 2022 must be made with some caution due to differences in the survey data used to generate the estimates. The 2006 analysis relied on existing data, most of which came from basin surveys that were selected in a non-random fashion. In contrast, the 2022 analysis was based on stream surveys selected using a random design (GRTS). Thus, the decline in high quality habitat miles in the Big Creek, as well as large increases in the Youngs Bay, Clatskanie, Scappoose, and Clackamas populations are likely due at least in part to the different data sources used in the two analyses.

Table A-III: 8. Additional miles of high-quality habitat needed to achieve delisting and broad sense recovery abundance goals for coho. See Anlauf et al. (2006) for an evaluation of the amount of high-quality habitat available for coho at the time of plan development.

	Additional Miles of High-Quality Coho Habitat Needed	
Population	Delisting	Broad Sense
Youngs Bay	0[a]	>135
Big Creek	0[a]	76
Clatskanie	19	19
Scappoose	10	24
Clackamas	0[a]	61
Sandy	37	37
Lower Gorge	10	31
Upper Gorge/Hood	53	>53

[a] Although the modeling approach indicates that no additional miles of high-quality habitat are needed for several populations to strictly reach the delisting desired status, Oregon fully supports efforts to protect and restore habitat in order to assure healthy populations into the future, meet broad sense recovery goals, and be precautionary against model and future uncertainty. The most probable scenario for Youngs Bay and Big Creek, between delisting and broad sense scenarios, where additional high-quality habitat is necessary; the most probable scenario for Clackamas is the same as the broad sense goal presented here.

Table A-III: 9. Estimated quantity of coho high quality habitat (HQH) in each population, total miles needed to meet the delisting scenario, and additional miles needed to meet the delisting scenario based on the 2022 analysis.

Population	HQH Miles (Anlauf et al. 2006)	HQH Miles 2022 Analysis[a]	Total HQH Miles Needed to Meet Delisting Scenario[b]	Additional HQH Miles Needed to Meet Delisting Scenario
Youngs Bay	1.4	**39.9**	1.4	0.0
Big Creek	11.4	3.1	11.4	8.3
Clatskanie	0.0	13.2	19.0	5.8
Scappoose	0.0	**20.1**	10.0	0.0
Clackamas	27.1	**88.7**	27.1	0.0
Sandy	4.5	9.8	41.5	31.7
Lower Gorge	NA	NA	10+	NA
Upper Gorge/Hood	0.0	0	53.0	53.0

[a] Estimated HQH miles based on winter parr/km estimates derived from the Habitat Limiting Factors Model (HLFM; Nickelson 1998) using stream habitat surveys conducted from 2011 through 2021.

[b] Sum of the population-specific estimate from Anlauf et al. (2006) and the additional miles needed for delisting from Table A-III:8.

Hydropower Related Metric #1 - Clackamas Fish Passage

Objective: Achievement of fish passage goals outlined in the Clackamas River Hydroelectric Project (FERC Project No. 2195) Fish Passage and Protection Plan.

12-Year Assessment: Attained
Portland General Electric Company (PGE) is the licensee for the Clackamas River Hydroelectric Project (Project No. 2195). On December 21, 2010, the Federal Energy Regulatory Commission (FERC) issued an Order Issuing New License, Portland General Electric Company, 133 FERC ¶ 62,281 (2010), order on reh'g, 134 FERC ¶ 61,206 (2011). The license duration is 40 years. The Clackamas River Hydroelectric Project's Fish Passage Plan contains measures for salmon and steelhead in addition to lamprey species and cutthroat trout. This evaluation only considers those measures directly related to Clackamas fish populations of salmon and steelhead. All one-time occurrence measures contained within the Fish Passage and Protection Plan are complete. All recurring measures have been implemented as prescribed in the Fish Passage and Protection Plan and continue as scheduled.

Hydropower Related Metric #2 – Habitat Conditions Above and Below Clackamas Hydropower Projects

Objective: Achievement of habitat goals outlined in the Clackamas River Hydroelectric Project (FERC Project No. 2195) Fish Passage and Protection Plan.

12-Year Assessment: Attained
PGE is the licensee for the Clackamas River Hydroelectric Project (Project No. 2195). On December 21, 2010, the Commission issued an Order Issuing New License, Portland General Electric Company, 133 FERC ¶ 62,281 (2010), order on reh'g, 134 FERC ¶ 61,206 (2011). The license duration is 40 years. The Clackamas River Hydroelectric Project's Fish Passage Plan contains habitat measures for salmon and steelhead in addition to lamprey species and cutthroat trout. This evaluation only considers those measures directly related to Clackamas fish populations of salmon and steelhead. All one-time occurrence habitat measures contained within the Fish Passage and Protection Plan are complete. All recurring habitat measures have been implemented as prescribed in the Fish Passage and Protection Plan and continue as scheduled.

Hydropower Related Metrics #3 – Hood Fish Passage

Objective: Provision of passage for adult and juvenile coho and winter steelhead at Laurance Lake Dam.

12-Year Assessment: Not Attained
The Middle Fork Irrigation District owns and operates Hydro Plants 1 and 2 which includes the intake structure at Clear Branch Dam at Laurence Lake. Both the dam and lake are located on United States Forest Service (USFS) property and require a special use permit and Oregon Department of Environmental Quality approval for operations. Discussions are occurring regarding fish passage, but to date fish passage at Clear Branch Dam on Laurence Lake has not been restored.

Listing Factor B: Over-utilization for commercial, recreation, scientific or educational purposes.

Harvest related metrics identified in the Plan are intended to serve as measurable criteria for Listing Factor B, as well as a diversity metric in the biological criteria assessment (*Diversity Metric #3: Anthropogenic mortality*).

Harvest Related Metrics for Clatskanie, Scappoose, Clackamas, Sandy, and Lower Gorge Coho

Objective: Harvest rates of wild coho do not exceed the seeding and ocean condition category specific harvest rates shown in Table A-III: 10 in any given year more than once in 10 years (> 90 percent compliance)

12-Year Assessment: Attained.
Exploitation rate limits for Lower Columbia River natural origin (LCN) Coho are set annually by National Marine Fisheries Service (NMFS) using a harvest matrix that considers parameters of ocean survival and parental escapement. The matrix was updated in 2015 to include additional reference populations. LCN exploitation rates in ocean and Columbia River fisheries were below the allowed limit for nine of 10 years between 2012-2021, with the lone exceedance in 2015 (Table A-III: 10).

Table A-III: 10. LCN Coho, ocean and in-river exploitation rates, 2010-2022 (ODFW and WDFW 2022).

Year	Exploitation Rates			
	Ocean	In-River[a]	Actual	Allowed
2010	7.6%	6.9%	14.5%	15%
2011	5.8%	7.7%	13.5%	15%
2012	9.9%	3.4%	13.3%	15%
2013	9.8%	3.3%	13.1%	15%
2014	12.0%	5.3%	17.2%	22.5%
2015	17.1%	7.2%	24.3%	23%
2016	8.0%	2.0%	9.0%	18%
2017	7.0%	4.0%	11.0%	18%
2018	9.4%	1.7%	11.1%	18%
2019	15.9%	3.6%	19.5%	23%
2020	4.9%	2.1%	7.0%	18%
2021	7.8%	2.8%	10.6%	30%
2022	10.2%	1.5%	11.7%	23%

[a] Includes non-treaty mainstem and Select Area commercial and sport fisheries.

Terminal fisheries within the Youngs Bay and Big Creek areas increase impacts on these two coho populations relative to the base rate indicated in Table A-III: 10. The Plan states that maximum allowable harvest impacts for these populations should be commensurate with those indicated in Table A-III: 10 plus the difference in long-term modeled harvest rate between these populations and those to which Table A-III: 10 applies directly (i.e., annually, the Table A-III: 10 rate plus 45 percent [Youngs Bay] and 25 percent [Big Creek]). Current ODFW monitoring does not provide population-specific estimates of Youngs Bay and Big Creek terminal fisheries impacts, and so attainment of the objective for these two populations is uncertain.

The Delisting Scenario for the Upper Gorge/Hood population indicates a long-term modeled harvest rate which is well below the base rate applied to other populations. The Plan states that efforts should be made to decrease harvest impacts on this population approximately 20 percent over the long-term relative to other populations to which the limits in Table A-III: 10 apply directly. However, given the mixed stock nature of harvest impacts, it is likely that the annual harvest rate of Upper Gorge/Hood coho will be similar to rates indicated in Table A-III: 10. Estimates in Table A-III:10 do not account for additional fishery impacts that occur between Bonneville Dam and Hood River, and current monitoring does not provide estimates of these impacts. Therefore, attainment of the objective for the Upper Gorge/Hood population is uncertain.

Harvest Related Metrics for all populations of fall and late fall Chinook

Objective: Harvest rates of wild fall and late fall Chinook do not exceed those contained in a sliding scale harvest matrix (to be developed as part of implementation of the Plan) in any given year more than once in 10 years (> 90 percent compliance).

12-Year Assessment: Attained.
Fall-season fisheries in the Columbia River and ocean that harvest LCR tule fall Chinook are managed according to an abundance-based exploitation rate (ER) schedule that fluctuates based on the combined Lower River Hatchery (LRH) Chinook return. The LRH Chinook are considered a valid indicator of the relative abundance of LCR (natural) tule Chinook. The total allowed ER is shared between ocean and in-river fisheries downstream of Bonneville Dam. LCR tule fall Chinook exploitation rates were below the allowed limit for 10 of 10 years between 2013-2022 (Table A-III: 11).

Given additional fisheries that affect Youngs Bay, Big Creek, and Upper Gorge (and Hood, though see below) fall Chinook populations, similar considerations as those applied to Youngs Bay and Big Creek coho metrics are needed for these populations. Hood fall Chinook likewise have similar considerations as Upper Gorge/Hood coho (i.e., threat reductions which are well below the baseline for the species, and which are unlikely to be met due to mixed stock harvest). The Sandy late fall Chinook population should have harvest impacts at least 5 percent below the long-term average for other populations to which the base rate applies, based on historical impacts on this population relative to the others and desired threat reductions. Current ODFW monitoring does not provide population-specific estimates of additional fisheries impacts, and so attainment of the objective for the Youngs Bay, Big Creek, and Upper Gorge populations is uncertain.

Table A-III: 11. Lower Columbia River tule fall Chinook exploitation rates, 2010-2022 (ODFW and WDFW 2022).

Year	Exploitation Rates			
	Ocean	Columbia [a]	Actual	Allowed
2010	28.8%	6.2%	34.9%	38%
2011	30.7%	10.1%	40.8%	37%
2012	32.8%	10.2%	43.1%	41%
2013	23.6%	9.3%	32.9%	41%
2014	33.0%	7.4%	40.4%	41%
2015	27.5%	7.5%	34.9%	41%
2016	25.6%	10.4%	36.0%	41%
2017	28.4%	7.7%	36.1%	41%
2018	25.7%	8.9%	34.5%	38%
2019	21.0%	10.3%	31.3%	38%
2020	14.4%	11.4%	25.7%	38%
2021	24.2%	13.5%	37.7%	38%
2022	22.7%	7.9%	30.6%	38%

[a] Fall season non-treaty fisheries.

Harvest Related Metrics for all populations of spring Chinook and Steelhead

Objective: The average harvest rate over a 12-year period does not exceed the impact shown in Table A-III: 12.

12-Year Assessment: Attained/ Likely Attained varies by population

Twelve years of data are needed to determine attainment for this objective. Due to monitoring constraints and time lags for harvest reporting, we do not have sufficient data to determine definitively whether the objective was achieved for all spring Chinook and steelhead populations. Sandy spring Chinook and Sandy and Scappoose winter steelhead populations have attained the goal and most other populations had sufficient information to assess whether the objective has likely been met. For spring Chinook, available information indicates that average fishery impact rates were well below the 25 percent threshold in the Sandy and Hood populations (Table A-III:13). However, there are additional impacts in the Hood population that are not accounted for with current monitoring. For steelhead, fishery impact rates were consistently below maximum allowable levels in all populations in years when monitoring information was available (Table A-III:14 and Table A-III:15). For other populations where data is available for most or all years since plan adoption (Clatskanie, Clackamas, Hood Winter, and Hood Summer populations), the harvest rate objective was almost certainly attained. Harvest impact data for the Youngs Bay, Big Creek, Lower Gorge and Upper Gorge populations is more limited, but available information suggest that fishery impacts are similarly low for these populations.

Table A-III: 12. Maximum allowable average harvest rates for Oregon populations of spring Chinook salmon and steelhead in the LCR.

Species	Population	Harvest Impact
Spring Chinook	Sandy, Hood	25%
Winter Steelhead	Youngs Bay, Big Creek, Clatskanie, Scappoose, Clackamas, Sandy, Lower Gorge	10%
	Upper Gorge, Hood	15%
Summer Steelhead	Hood	15%

Table A-III: 13. Estimated fishery impact rates (IR)[c] for Sandy and Hood Spring Chinook, 2010-2022.

Year	IR Ocean	IR Columbia River	IR Sandy	IR[a] Hood	IR Total	
					Sandy	Hood[b]
2010	6.9%	1.48%	1.2%	1.2%	9.6%	9.6%
2011	8.3%	1.48%	3.4%	3.7%	13.2%	13.5%
2012	13.8%	1.48%	5.0%	2.7%	20.3%	18.0%
2013	6.7%	1.48%	2.4%	2.8%	10.6%	11.0%
2014	9.5%	1.48%	3.0%	2.1%	14.0%	13.1%
2015	12.5%	1.48%	3.1%	1.6%	17.1%	15.6%
2016	22.6%	1.48%	4.6%	3.8%	28.7%	27.9%
2017	11.9%	1.48%	3.9%	2.2%	17.3%	15.6%
2018	6.8%	1.48%	2.0%	5.6%	10.3%	13.9%
2019	6.6%	1.48%	2.9%	6.0%	11.0%	14.1%
2020	6.4%	1.48%	3.2%	5.4%	11.1%	13.3%
2021	9.6%	1.48%	3.3%	NA	14.4%	NA
2022	14.4%	1.48%	3.4%	NA	19.3%	NA
Average					14.8%	15.1%

[a] Does not include tribal harvest impact rates.

[b] Not including Columbia River Zone 6 fishery impacts.

Ocean IR obtained from the Pacific Salmon Commissions Joint Chinook Technical Committee Reports used in annual exploitation rate analysis and model calibration. Willamette hatchery spring Chinook are a surrogate for impacts in AABM and ISBM ocean fisheries. Columbia River IR was calculated to produce a 5-year average based on harvest in LCR fisheries (recreational, Select Area commercial and mainstem commercial). Indirect mortality in Sandy and Hood recreational fisheries is estimated based on encounter rates made through run reconstruction from hatchery and natural origin returns and estimated hooking mortality rates.

Table A-III: 14. Estimated fishery IR for the Youngs Bay, Big Creek, Clatskanie, Scappoose, Clackamas, Sandy, and Lower Gorge winter steelhead populations, 2011-2022 (NA indicates no estimate available). The maximum allowable harvest rate is 10 pecent for these populations.

Year	IR						
	Youngs Bay	Big Creek	Clatskanie	Scappoose	Clackamas	Sandy	Lower Gorge
2011	NA	NA	NA	0.8%	NA	3.9%	NA
2012	1.5%	7.2%	1.5%	0.3%	8.5%	7.3%	NA
2013	2.2%	3.2%	1.0%	0.7%	8.0%	6.6%	NA
2014	NA	NA	NA	0.7%	7.6%	4.0%	NA
2015	NA	NA	1.4%	0.5%	7.9%	5.2%	NA
2016	NA	NA	1.2%	0.2%	7.2%	5.3%	NA
2017	NA	NA	0.2%	0.3%	8.2%	4.3%	NA
2018	NA	NA	0.3%	0.2%	7.2%	4.4%	NA
2019	NA	NA	2.7%	0.3%	6.9%	6.6%	NA
2020	NA	NA	3.5%	0.3%	7.7%	7.6%	NA
2021	NA	NA	7.2%	0.3%	7.7%	7.2%	NA
2022	NA	NA	5.7%	0.3%	7.3%	6.5%	NA
Average	1.8%	5.2%	2.5%	0.4%	7.2%	5.7%	NA

Table A-III: 15. Estimated fishery IR for the Upper Gorge winter steelhead, Hood River winter steelhead, and Hood River summer steelhead populations, 2011-2022 (NA indicates no estimate available). The maximum allowable harvest rate is 15 percent for these populations.

Year	IR		
	Upper Gorge Winter Steelhead	Hood River Winter Steelhead	Hood River Summer Steelhead
2011	NA	2.6%	NA
2012	NA	4.4%	NA
2013	NA	5.2%	NA
2014	NA	2.8%	1.3%
2015	NA	NA	7.4%
2016	NA	5.4%	5.5%
2017	NA	2.8%	4.2%
2018	NA	6.2%	6.6%
2019	NA	4.7%	0.9%
2020	NA	7.2%	0.9%
2021	NA	NA	0.9%
2022	NA	NA	NA
Average	NA	4.6%	3.5%

Listing Factor C: Disease and Predation

Caspian Tern and Double-crested Cormorant Predation Metric

Objective: The average cumulative mortality of Oregon populations of coho, Chinook, and steelhead due to predation by Caspian terns, double-crested cormorants, marine mammals, and northern pikeminnow over a 12-year period due to anthropogenic influences is equal to or less than that shown in Table A-III: 16.

Table A-III: 16. Cumulative mortality rate targets for Oregon populations of coho, fall Chinook (CHF), spring Chinook (CHS), winter steelhead (STW), and summer steelhead (STS).

Population and Species	Predation Mortality Rate				
	CHF	CHS	Coho	STW	STS
Youngs	4%		3%	6%	
Big Creek	4%		3%	6%	
Clatskanie	5%		4%	7%	
Scappoose	5%		4%	7%	
Clackamas	6%	7%	4%	7%	
Sandy	6%	7%	4%	7%	
Lower Gorge	6%		4%	7%	
Upper Gorge	7%			10%	
Hood	7%	7%	5%	10%	8%
Sandy late	6%				

The evaluation thresholds for predation are based on the reductions in predation related mortality described in recovery scenarios from the Plan. These mortality rates represent long term (100-year) average rates that recovery scenario modeling indicates will, when combined with reduction in mortality in other threat categories, will be sufficient to ensure long term viability of the ESU. To provide for more timely assessments of progress towards achieving recovery goals for predation, this measurable criterion is linked to a 12-year time frame (i.e., 3-4 salmon or steelhead generations).

The predation reduction goal used in the recovery scenarios is based on the mortality reductions expected from the Caspian Tern Management Plan (USFWS 2005) and the Pikeminnow Reward Program (Beamesderfer et al. 1996). Pinniped control is outlined in NMFS's draft *Environmental Assessment: Reducing the Impact on At-Risk Salmon and Steelhead by California Sea Lions in the Area Downstream of Bonneville Dam on the Columbia River, Oregon and Washington*, with actions primarily directed at reducing the impact of marine mammal predation on spring Chinook and summer steelhead as they pass over Bonneville Dam. The modeled predation reduction rates are slightly different for each population, based on migration timing of yearlings and sub-yearlings, and the relative distance from river of origin. For example, Coastal stratum populations have lower mortality rates due to pikeminnow predation than do populations in the Cascade or Gorge strata. For coho and steelhead, the total of the actions identified in the applicable plans equate to an approximate 35 percent and 45 percent reduction, respectively, in the current mortality due to predation that is human influenced. Rates for Chinook represent an approximate 18-55 percent reduction in the current mortality rate due to predation. As with estuary habitat, it was the consensus of the planning team that these reductions in mortality associated with predation are likely the maximum that can be accomplished to alleviate this impact. In addition, the relatively minor impact that predation represents among all the threats means that decreasing predation mortality further will have relatively little effect on the status of LCR populations.

12-Year Assessment: Attainment uncertain
Nearly all actions and sub-actions for the predation threat have been implemented or are ongoing. Implementation of these actions assumes the percent reductions hypothesized in the recovery scenarios are reducing mortality due to predation which is human influenced. The Plan also recommends monitoring predation associated with anthropogenic alterations, which has occurred at Bonneville Dam, Willamette Falls, man-made islands and structures, and reservoirs. Each of the predator management plans has evolved since Plan adoption and expanded in efforts to further understand mortality rates associated with each of the predator types: avian, pinniped, and piscine. With the current level of monitoring, in some circumstances we can estimate a mortality rate at the ESU level by predator type, but in no case are we able to detect mortality rates at the population level with confidence.

Due to the complexity of determining cumulative mortality rates as described in the Plan, this metric cannot be quantitatively assessed. Instead, ODFW has developed narratives for avian, pinniped, and piscine predation. Each narrative describes the current state of research, what has been learned over the last 12 years, and provides a recommendation to advance the state of knowledge of predator impacts on LCR salmon and steelhead.

Avian Predation

Overview
Our knowledge related to avian predation and the complexities associated with avian management in the Columbia River basin have advanced substantially since the Plan was finalized in 2010. We now have reasonably precise estimates for predation rates by Caspian terns and double-crested cormorants in the Columbia River estuary for most ESUs of ESA-listed salmonids, at least for some years. In general, estimates for avian predation rates for LCR ESUs are considerably higher than previously estimated. In addition, three major avian management plans have recently been implemented in the basin, although all have encountered problems, and anticipated benefits to fish are generally unlikely or uncertain to have been met for at least two of these plans. Additionally, our understanding of the influence of physical and biological factors (e.g. flow, turbidity, fish density) on avian predators has advanced; in some cases, this new information appears to contradict previously held assumptions. Finally, our understanding of ecological dynamics within the estuary and plume have improved, which may raise important questions related to the possible effects of predator management on ESA-listed fish. Overall, this section is intended to review the current state of knowledge regarding avian predation in the reach of river used by juveniles from LCR runs and relate this new information to elements of the Plan.

Predation rates

Improved estimates of predation rates by avian species on Passive Integrated Transponder (PIT)tagged individuals from various ESA-listed runs are now available relative to when the Plan was drafted, when only minimum estimates were available. In general, current estimates of avian predation rates are substantially higher than estimates provided in the Plan for all sources of predation combined (i.e. total predation by piscine, avian, and marine mammal predators), suggesting the overall impact by predators is higher than previously estimated. The vast majority of avian predation on LCR runs is presumed to occur in the Columbia River estuary, where the majority of Caspian terns and double-crested cormorants within the basin typically nest. For the purposes of avian predation research and management, we follow Simenstad et al. (2011) and consider the Columbia River estuary to extend from the mouth of the river to the uppermost extent of tidal influence at Bonneville Dam.

Average annual point estimates for combined predation by Caspian terns and double-crested cormorants associated with the East Sand Island colony during 2007–2014 were 30.4%, 16.8%, and 17.2% of available PIT-tagged fish for LCR Chinook, coho, and steelhead, respectively (Roby et al. 2021a; Table A-III:17). In comparison, average estimated predation rates in the Plan for all predators combined for populations within these ESUs were 5.6%–7.3%, 5.6%–15.6%, and 11.3%–14.7% for LCR Chinook, coho, and steelhead, respectively, compared to target predation rates of 4%–7%, 3%–5%, and 6%–10%, for these runs in the Plan, respectively (ODFW 2010). Overall, the most recent point estimates of avian predation rates on LCR Chinook, coho, and steelhead were 4.3–7.6 times higher, 3.4–5.6 times higher, and 1.7–2.9 times higher, respectively, than target predation rates for LCR populations under the plan for all predators combined. It is also worth noting that predation rates may be substantially higher today than during 2007–2014 because of a recent change in double-crested cormorant distribution in the Columbia River estuary. The findings of Lawonn (2023a, 2023b) suggest that current estuary-wide predation rates by double-crested cormorants on steelhead runs could be higher than during the pre-management period by about a factor of 1.7.

Besides estimates of avian predation at an ESU level, PIT tag recovery data for Caspian tern and double-crested cormorant colonies on East Sand Island is available for some LCR populations, though most of these data have not been completely analyzed. The only known complete analysis of avian predation on a population level for LCR species was for double-crested cormorant predation on hatchery releases of fall Chinook from the Big Creek Hatchery, operated by ODFW. During 2002–2012, the average of annual median predation rates by double-crested cormorants breeding on East Sand Island on this run was 42% (Table A-III: 18).

Additional information on LCR Chinook suggests tule stock fish may be considerably more vulnerable to avian predation than fish from the upriver bright stock (Sebring et al. 2013). In a recent study, recovery of PIT tags on East Sand Island bird colonies for tule stock fish averaged 22%, compared to 3% for upriver bright fish (Sebring et al. 2013). The reason for the difference may be because of a longer residency period for tule Chinook (Sebring et al. 2013). Therefore, populations of tule stock fish may be more likely to benefit from avian management than upriver bright stocks.

Table A-III: 17. Point estimates of annual predation rates by Caspian terns (CATE) and double-crested cormorants (DCCO) breeding on East Sand Island on ESA-listed Lower Columbia River (LCR) salmonids. Data obtained from Roby et al. (2021a).

	LCR Chinook			LCR coho			LCR steelhead		
Year	CATE	DCCO	Total	CATE	DCCO	Total	CATE	DCCO	Total
2007	4.1%	22.1%	26.2%	2.6%	8.1%	10.7%	15.2%	2.6%	17.8%
2008	5.3%	51.0%	56.3%	0.9%	17.8%	18.7%	11.9%	9.0%	20.9%
2009	4.4%	25.0%	29.4%	1.2%	12.5%	13.7%	15.5%	6.3%	21.8%
2010	4.5%	31.7%	36.2%	3.7%	18.1%	21.8%	14.5%	4.5%	19.0%
2011	2.2%	18.5%	20.7%	1.1%	17.8%	18.9%	7.1%	5.7%	12.8%
2012	2.5%	19.8%	22.3%	–	–		10.4%	4.0%	14.4%
2013	2.4%	26.8%	29.2%	–	–		11.3%	1.7%	13.0%
2014	1.1%	22.0%	23.1%	–	–		10.5%	7.7%	18.2%
Mean	3.3%	27.1%	30.4%	1.9%	14.9%	16.8%	12.1%	5.2%	17.2%

Table A-III: 18. Number of PIT tagged juvenile tule Chinook released at Big Creek Hatchery and subsequently recovered on the double-crested cormorant colony on East Sand Island, and associated annual predation estimates for the East Sand Island double-crested cormorant colony. Data provided by A. Evans, Real Time Research, Bend, Oregon.

Year	Number PIT tagged fish released	Number PIT tagged fish recovered	Median Predation Rate	Lower 95% credible boundary	Upper 95% credible boundary
2002	2,927	230	33.2%	23.4%	52.4%
2003	2,974	148	19.1%	13.3%	30.2%
2005	2,999	312	34.9%	24.8%	55.4%
2006	3,031	461	55.2%	39.2%	85.8%
2007	3,028	252	31.9%	22.2%	50.5%
2008	3,055	626	66.1%	48.0%	93.5%
2009	3,038	427	43.9%	31.9%	67.4%
2010	3,051	520	47.8%	34.6%	73.7%
2011	2,992	565	53.5%	38.9%	82.5%
2012	2,921	286	29.9%	21.1%	46.9%

Overall, recent information related to avian impacts on LCR Chinook, coho, and steelhead suggest the Plan may have underestimated the importance of avian predation on recovery objectives, especially for populations of LCR Chinook and coho. Although in most cases population-level impacts of avian predators on fish are unknown, it seems reasonable to assume that avian predation generally affects populations of the same ESU similarly, because juvenile individuals from most populations of LCR salmonids must pass the same mortality source (i.e., avian colonies) during outmigration, and because outmigration behavior across populations within an ESU are likely similar, with the possible exception of upriver bright vs. tule Chinook (Sebring et al. 2013). Therefore, recent estimates of ESU-level predation may be acceptable substitutes for population-specific rates. Based on recent ESU-level estimates, increased management emphasis may be warranted for avian predators in the Columbia River estuary.

Recent changes in avian abundance and distribution in the Columbia River estuary are discussed in the *Recent Management* section below. These changes have likely affected predation rates on LCR ESUs, but an absence of comprehensive predation monitoring data complicates inferences. Along with a recent substantial decline in Caspian tern abundance in the estuary following management (Figure A-III: 71), tern-specific predation on LCR steelhead has declined from 12.1% during 2007–2014 to 7.4% during 2015–2018 (Table A-III: 19). However, data on tern predation on LCR steelhead have not been collected since 2018, although presumably tern predation on LCR steelhead has continued to decline concomitant with declining Caspian tern abundance during 2019–2021 (Figure A-III: 71).

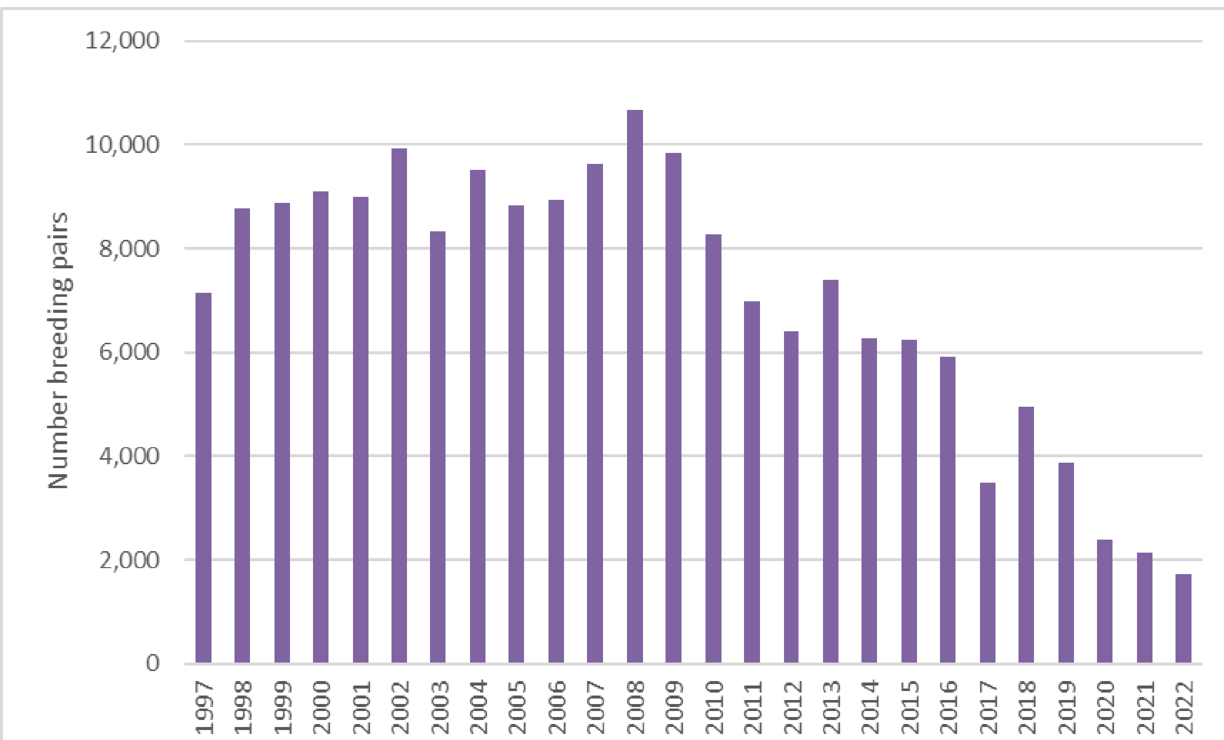

Figure A-III: 71. Abundance of Caspian terns breeding in the Columbia River estuary, 1997–2022. Data from Collis et al. (2021), Roby et al. (2021a), Brandtner and Tidwell (2022), and Strong and Tidwell (2023).

Table A-III: 19. Point estimates of annual predation rates by Caspian terns nesting on East Sand Island in the Columbia River estuary on estuary on PIT-tagged runs of ESA-listed salmonids from the Columbia River basin. Data from Roby et al. (2021a) and Evans et al. (2022). SR = Snake River; UCR = Upper Columbia River; UWR = Upper Willamette River; MCR = Mid-Columbia River.

Year	SR Spring/ Summer Chinook	SR Fall Chinook	UCR Spring Chinook	UWR Spring Chinook	SR Sockeye	MCR Steelhead	SR Steelhead	UCR Steelhead	LCR Chinook	LCR coho	LCR Steelhead
1999	0.4%	0.5%	0.2%	–	–	0.9%	1.1%	0.9%	–	–	–
2000	4.6%	3.3%	2.2%	–	–	–	10.5%	16.3%	–	–	–
2001	14.0%	6.4%	13.2%	–	–	15.0%	33.9%	–	–	–	–
2002	2.9%	1.7%	2.5%	–	–	–	21.9%	14.2%	–	–	–
2003	4.7%	2.7%	3.7%	–	–	–	26.0%	19.0%	–	–	–
2004	4.8%	1.3%	3.7%	–	–	–	25.8%	14.1%	–	–	–
2005	3.0%	1.3%	2.4%	–	–	–	28.3%	15.1%	–	–	–
2006	3.3%	2.5%	3.6%	–	–	–	27.5%	23.4%	–	–	–
2007	3.1%	3.4%	1.9%	1.4%	–	18.7%	22.6%	15.7%	4.1%	2.6%	15.2%
2008	2.5%	1.9%	1.7%	4.4%	–	13.5%	14.2%	16.7%	5.3%	0.9%	11.9%
2009	4.7%	2.0%	3.7%	1.7%	1.3%	14.1%	14.5%	20.0%	4.4%	1.2%	15.5%
2010	3.4%	0.7%	2.9%	1.8%	1.6%	11.9%	14.3%	13.7%	4.5%	3.7%	14.5%
2011	2.5%	0.7%	2.9%	0.9%	0.4%	9.6%	12.0%	9.1%	2.2%	1.1%	7.1%
2012	2.2%	0.7%	1.2%	0.7%	2.1%	9.4%	10.2%	7.5%	2.5%	–	10.4%
2013	1.2%	0.9%	0.7%	1.0%	0.8%	9.9%	12.7%	8.9%	2.4%	–	11.3%
2014	1.1%	1.0%	1.4%	1.2%	1.6%	9.5%	8.6%	11.4%	1.1%	–	10.5%
2015	2.0%	0.8%	1.9%	0.4%	1.6%	7.8%	10.2%	10.5%	0.6%	–	6.7%
2016	0.8%	0.7%	1.4%	1.2%	–	8.8%	6.1%	7.5%	0.8%	–	8.4%
2017	0.8%	0.2%	1.4%	–	–	8.4%	5.3%	6.5%	1.0%	2.5%	5.8%
2018	1.4%	1.3%	1.4%	–	4.2%	5.3%	6.9%	6.5%	1.8%	6.7%	8.7%
2019	–	–	–	–	–	–	–	–	–	–	–
2020	0.7%	0.3%	0.4%	–	1.1%	5.4%	5.9%	4.5%	–	–	–
2021	–	–	–	–	–	–	–	–	–	–	–

Although the recent reduction in tern predation may have decreased tern-specific mortality on LCR steelhead, the recent redistribution of double-crested cormorants to areas upriver of East Sand Island may have offset this effect. ODFW recently estimated that double-crested cormorant predation on steelhead in 2021 may have been 1.7 times higher than it was prior to management during 2004–2014 (Lawonn 2023b). Thus, it is unclear whether avian predation on LCR steelhead has lessened in recent years. For LCR Chinook and coho, the vast majority of historical avian predation in the estuary was associated with double-crested cormorants breeding at the East Sand Island colony. Because most double-crested cormorants in the estuary are now breeding in locations where salmonids are more vulnerable to cormorant predation, it appears likely that cormorant predation on LCR Chinook and coho has not lessened since the plan was finalized in 2010 and may even be substantially worse (Lawonn 2023a).

Recent management

Three major avian management plans have occurred in recent years within the Columbia River basin. Although only two of these plans were implemented in the estuary, this section will briefly describe all three because lessons from each may be important for future decision making. Overall, only the plan dealing with Caspian tern management in the Columbia River estuary unambiguously achieved its objective to improve fish survival, although at a substantial cost to the regional Caspian tern population. The results of the other two plans have been equivocal and adaptive management appears necessary to meet their objectives.

Caspian tern management in the Columbia River estuary

The management plan *Caspian Tern Management to Reduce Predation of Juvenile Salmonids in the Columbia River Estuar*y (Caspian tern management plan) was developed to alleviate predation by Caspian terns breeding on East Sand Island, particularly on steelhead (USFWS 2005). The intent of this plan was to reduce the size of the Caspian tern colony on East Sand Island, a semi-natural island located near the mouth of the Columbia River, by gradually reducing the amount of bare sand nesting habitat on the island, while simultaneously developing new breeding colonies elsewhere in the flyway for displaced terns to relocate to. The target size of the colony on East Sand Island was originally 2,500–3,125 breeding pairs, but was revised upward to 3,125–4,375 breeding pairs in the final Record of Decision (USFWS 2006).

Habitat reduction on East Sand Island began in 2008, and breeding habitat was gradually reduced from 5.4 acres in 2008 to 1.0 acre in 2015, the size it has remained since (Roby et al. 2021b). Along with the reduction in colony size, the abundance of Caspian terns breeding on East Sand Island has declined from an average 9,159 pairs during the pre-management period (2001–2007), to 3,371 pairs during the current period (2017–2021; Figure A-III: 71). Predation rates on ESA listed salmonids have declined substantially following management, with most ESUs during 2017–2021 experiencing declines in predation of 60% or more compared with the pre-management period, based on averages of annual point estimates of predation (Table A-III: 19). However, the response of LCR ESUs to reductions in tern abundance on East Sand Island is complicated by limited predation data during both the pre-management and current periods. Nevertheless, available data collected during 2014–2018, when tern abundance averaged 5,377 pairs on East Sand Island, indicate average tern predation rates for LCR Chinook and coho were 71% and 35% lower than predation rates during 2007–2013, when tern abundance averaged 8,457 pairs (Table A-III: 19).

Although the Caspian tern management plan was successful at reducing tern predation rates on salmonids, it remains unclear whether salmonid survival rates in the estuary and plume have improved as a result. This is because of data gaps related to salmonid survival in the estuary and plume during the pre-management and current periods, as well as the difficulty in determining the effects of predator management in complex, multi-predator systems (Sih et al. 1998, Yodzis 2001). For example, it is possible predation rates by other predators, such as double-crested cormorants, harbor seals, and sooty shearwaters have increased in response to higher abundance of salmonid prey resulting from tern management, compensating for lower predation by terns. Additionally, although the plan set out to relocate half of East Sand Island terns to new colony sites across the western United States, the most recent regional survey suggests the number of terns breeding at sites besides East Sand Island is nearly the same as in 2008, when management began (Lawes et al. 2021). Overall, it appears more work is needed to ensure that conservation goals for salmonids and terns expressed in the Caspian tern management plan are met.

Double-crested cormorant management in the Columbia River estuary

To address predation on ESA-listed salmonids associated with double-crested cormorants, the U.S. Army Corps of Engineers (Corps) implemented a management plan during 2015–2020 to reduce breeding abundance on East Sand Island (USACE 2015). East Sand Island is a human-modified island near the mouth of the Columbia River estuary that supported an average of 12,982 breeding pairs during 2004–2014, about 97% of all nesting pairs within the estuary (Figure A-III: 72). Predation by double-crested cormorants associated with the East Sand Island colony annually represented up to 17% of available salmonids for ESUs originating in the Upper and Middle Columbia River, and Snake River, and up to 51% of available salmonids for LCR ESUs (Table A-III: 20).

Following the active phase of management under the East Sand Island management plan, abundance of double-crested cormorants nesting on East Sand Island declined to an average 1,694 breeding pairs during 2018–2021, although the average during 2019–2021 was only 258 pairs (Lawonn 2023a, 2023b). Concurrent with management at East Sand Island, the colony located on the Astoria-Megler Bridge, located 12 km upstream of East Sand Island, grew from 333 breeding pairs in 2014, to a peak of 5,081 pairs in 2020, before declining slightly to 4,151 pairs in 2021 (Lawonn 2023a, 2023b). The aggregate total at other estuary colony sites grew from 414 pairs to 1,023 pairs during 2014–2021. Overall, the estimated abundance of double-crested cormorants across the Columbia River estuary in 2021 was 5,599 breeding pairs, compared to an average 13,337 breeding pairs during 2004–2014 (Lawonn 2023b), a decline of about 58%.

Along with the overall decline in abundance of double-crested cormorants within the estuary, the distribution of double-crested cormorants nesting within the estuary shifted dramatically from the marine zone in the lower estuary to areas farther upriver, where salmonids constitute a much larger proportion of the cormorant diet. Only about 3% of estuary-wide breeding abundance occurred upriver of the marine zone during 2004–2014, compared to 89% in 2021. Associated with this spatial shift, estimated estuary-wide double-crested cormorant predation increased relative to the pre-management period (Lawonn et al. 2023a). In 2021, estimated double-crested cormorant predation on steelhead across the estuary was equivalent to 26,479 pairs on East Sand Island, about 169% of average predation during 2004–2014 (Figure A-III: 73; Lawonn 2023b). Although the impact of this recent distributional shift on predation of LCR runs is unclear, it seems likely predation remains at least as high as prior to management on East Sand Island, despite the lower abundance of breeding double-crested cormorants.

Finally, it appears that management itself was a major cause of the undesired change in distribution of double-crested cormorants in the Columbia River estuary. Available evidence suggests implementation of the East Sand Island management plan was a pre-eminent causal factor in this redistribution, although management also coincided with other stressors that contributed to reduced double-crested cormorant fidelity to this colony (Lawonn 2023a). Management of the Astoria-Megler Bridge and, likely, other estuary colony sites will be necessary if managers wish to reduce estuary-wide double-crested cormorant predation to the equivalent of 5,380–5,939 breeding pairs on East Sand Island, a goal suggested in various federal documents related to hydrosystem management.

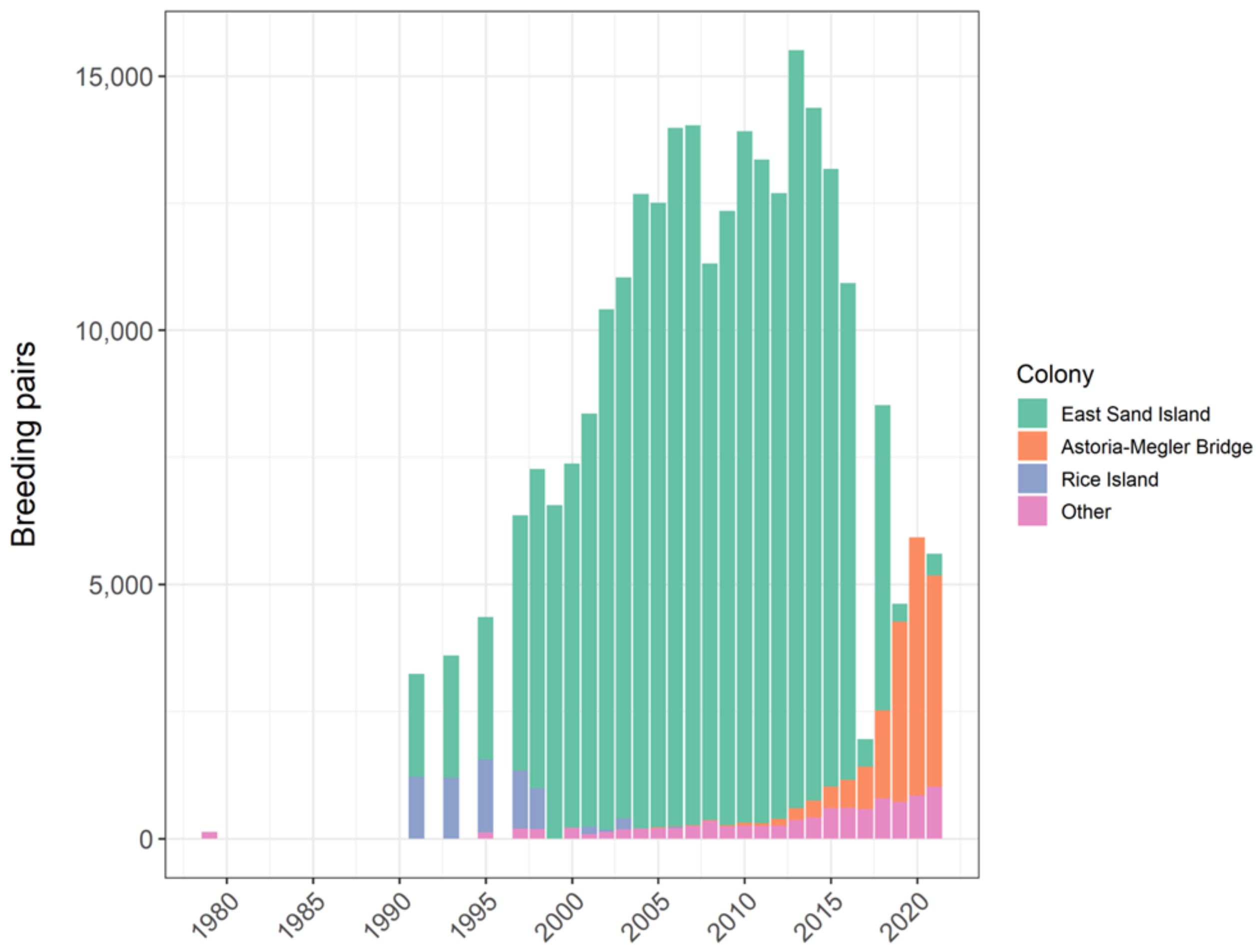

Figure A-III: 72. Number double-crested cormorant breeding pairs nesting within the Columbia River estuary, 1979–2021. Graph only includes years when survey effort was presumed to reflect estuary-wide double-crested cormorant abundance. Data summarized in Lawonn (2023a, 2023b).

Table A-III: 20. Point estimates of annual predation rates by double-crested cormorants nesting on East Sand Island in the Columbia River estuary on PIT-tagged runs of ESA-listed salmonids from the Columbia River basin. Data provided for years where an assumed majority of double-crested cormorant predation in the estuary was associated with East Sand Island. Data from Roby et al. (2021a). SR = Snake River; UCR = Upper Columbia River; UWR = Upper Willamette River; MCR = Mid-Columbia River.

Year	SR Spring/ Summer Chinook	SR Fall Chinook	UCR Spring Chinook	UWR Spring Chinook	SR Sockeye	MCR Steelhead	SR Steelhead	UCR Steelhead	LCR Chinook	LCR coho	LCR Steelhead
1999	0.8%	1.4%	0.7%	–	–	0.3%	2.4%	1.9%	–	–	–
2000	3.3%	5.1%	3.4%	–	–	NA	10.6%	6.0%	–	–	–
2001	2.2%	5.5%	3.3%	–	–	2.5%	2.8%	NA	–	–	–
2002	1.8%	1.4%	2.2%	–	–	NA	3.1%	3.7%	–	–	–
2003	1.7%	1.1%	1.4%	–	–	NA	1.9%	1.5%	–	–	–
2004	5.1%	1.9%	4.7%	–	–	NA	3.6%	7.4%	–	–	–
2005	4.8%	3.6%	4.5%	–	–	NA	4.3%	5.5%	–	–	–
2006	5.2%	2.7%	4.7%	–	–	NA	13.1%	4.7%	–	–	–
2007	1.7%	1.6%	2.7%	1.0%	–	2.8%	3.5%	3.4%	22.1%	8.1%	2.6%
2008	3.5%	2.6%	3.6%	3.3%	–	14.0%	14.7%	6.2%	51.0%	17.8%	9.0%
2009	6.8%	4.5%	2.7%	1.4%	5.7%	14.9%	16.6%	7.2%	25.0%	12.5%	6.3%
2010	5.3%	3.9%	3.3%	4.2%	2.6%	8.2%	7.5%	6.8%	31.7%	18.1%	4.5%
2011	4.3%	1.9%	5.6%	0.4%	4.8%	7.8%	5.3%	11.4%	18.5%	17.8%	5.7%
2012	3.7%	2.6%	2.1%	0.6%	3.7%	3.3%	4.9%	6.5%	19.8%	–	4.0%
2013	3.6%	2.2%	3.0%	1.0%	3.3%	2.1%	2.5%	3.4%	26.8%	–	1.7%
2014	8.5%	2.4%	6.1%	1.8%	4.5%	6.4%	7.8%	10.4%	22.0%	–	7.7%
2015	14.5%	8.7%	8.3%	2.4%	2.4%	12.4%	12.8%	10.5%	18.9%	–	11.2%

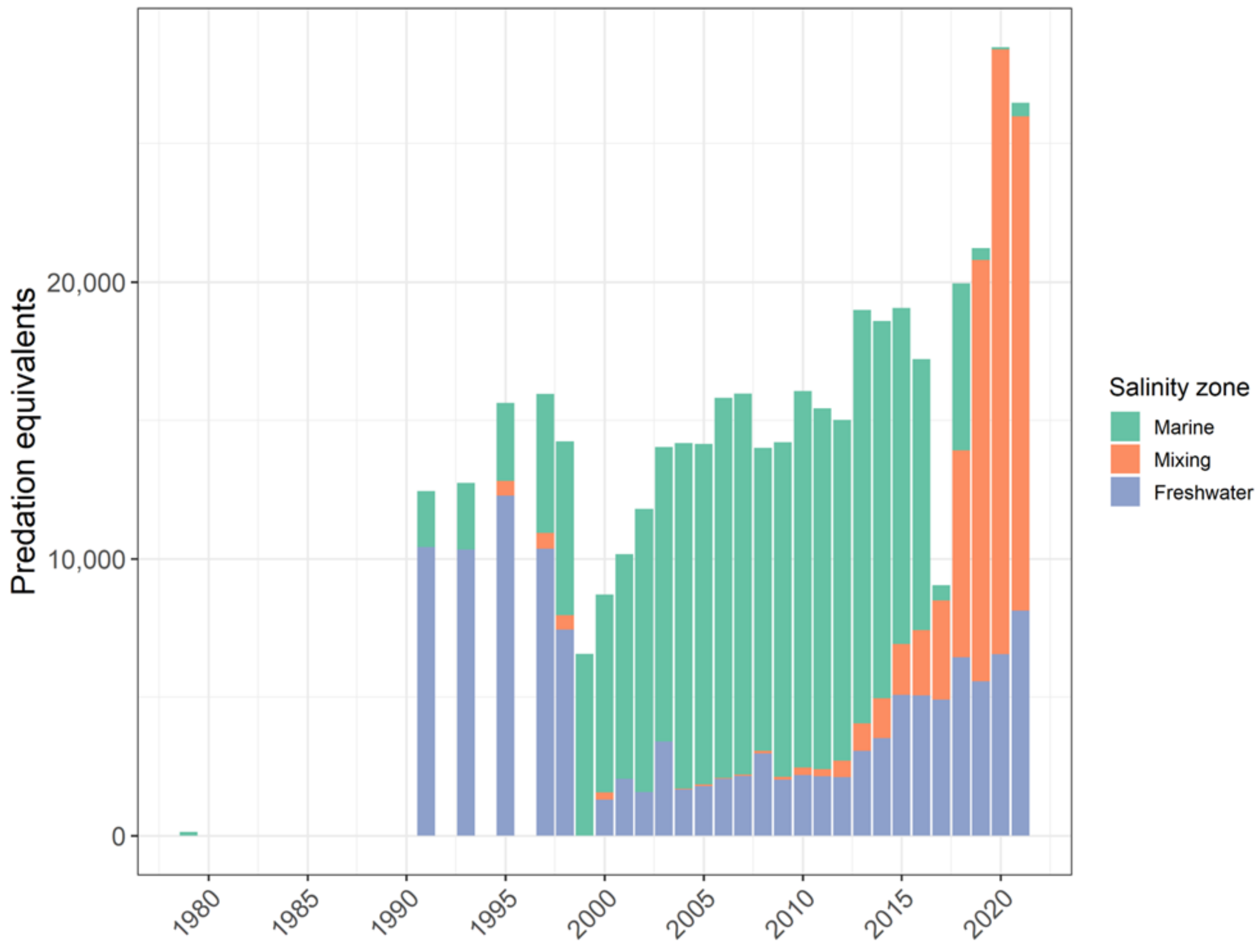

Figure A-III: 73. Estimated predation impact on juvenile steelhead for double-crested cormorants breeding in three salinity zones within the Columbia River estuary. Predation expressed as the number of breeding pairs on East Sand Island that would cause equivalent predation impacts (predation equivalents). Graph only includes years when survey effort was presumed to reflect estuary-wide double-crested cormorant abundance. Data summarized in Lawonn (2023a, 2023b).

Caspian tern management on the Columbia Plateau

The Inland Avian Predation Management Plan (USACE 2014) was developed to improve survival of ESA-listed salmonids by reducing the breeding abundance of Caspian terns across the Columbia Plateau. The plan initially sought to eliminate Caspian tern nesting at two major colonies in Washington, one at Crescent Island associated with the mainstem Columbia River, and one at Goose Island associated with Potholes Reservoir. The plan was first implemented in 2014 and is ongoing.

The plan was initially successful at reducing Caspian tern abundance at both Crescent and Goose islands. However, some terns subsequently relocated to nearby colony sites at other areas along the Columbia River, and recently have reestablished colonies on both Crescent Island and, to a lesser extent, on Goose Island (Evans et al. 2022). As part of a subsequent effort to reduce tern abundance at a colony site at the Blalock Islands, the Columbia River Systems Operations EIS (USACE et al. 2020) called for an elevation of the John Day pool to flood the tern breeding grounds on the Blalock Islands. This action was successful at deterring tern breeding on the Blalock Islands in 2021 and 2022, but concurrently tern abundance increased at nearby Badger and Crescent islands (Evans et al. 2022).

The overall abundance of terns across the Columbia Plateau declined substantially as a result of this plan, from a high of 1,003 pairs in 2012 to 400 pairs in 2021. Despite the decline, however, there is no evidence that survival of salmonids through the hydrosystem has improved, despite major anticipated gains derived from modelling efforts (Payton et al. 2020, Payton et al. 2021). Instead, it appears that predation by gulls and mortality from other factors has partially or completely compensated for reductions in tern predation (Evans et al. 2022).

Recent research and monitoring

Recent research has revealed new information about avian predation in the Columbia River basin that was unknown at the time the Plan was drafted. Recent findings of potential importance to avian predation management and recovery of LCR populations are discussed below.

Substantial predation by double-crested cormorants

Since the Plan was originally drafted, researchers have found that in addition to predation by Caspian terns, predation impacts by double-crested cormorants are substantial, and in many cases are far greater than for terns. For example, predation rates on LCR Chinook and coho by double-crested cormorants during 2007–2014 were about 8 times higher than for Caspian terns (Table A-III: 17), and double-crested cormorants also consumed a substantial proportion of available LCR steelhead (Table A-III: 17). Further, recent modelling suggests current predation rates by double-crested cormorants may substantially exceed estimates for outmigration years 2007–2014 (Lawonn 2023a). Overall, recent work indicates that predation of juvenile salmonids by double-crested cormorants is a much greater proximate source of mortality than indicated in the Plan.

Predation rates high for some ocean-type salmonid stocks

Recent estimates suggest that some ocean-type runs are highly vulnerable to avian predation. For example, recent monitoring has revealed that LCR Chinook experience the highest avian predation rates of any ESU in the basin, with Caspian terns and double-crested cormorants together consuming 22%–56% of available fish annually during 2007–2014 (Table A-III: 17; Roby et al. 2021a). Thus, although Caspian terns appear to have the largest impacts on stream-type fish, probably because these fish tend to be more energetically profitable because of their larger size, predation by double-crested cormorants appears to substantially impact both stream-type and at least some runs of ocean-type fish.

Relationships between turbidity, flow, and avian predation rates

The influence of environmental factors on avian predation has been found to be variable and sometimes contradictory depending on predator species and location (Hostetter et al. 2021, Hostetter et al. 2023). Caspian tern predation was found to be higher at an inland colony under increasingly turbid conditions. However, increasing turbidity was found to be associated with decreased predation susceptibility by double-crested cormorants at an inland colony (Hostetter et al. 2021). Further complicating the influence of turbidity on predation is the relationship between avian predation and river flow. Both double-crested cormorants and Caspian terns tend to consume more salmonids in the estuary as flow increases (Lyons 2010, Lyons et al. 2014). The mechanism for this relationship is thought to be the decreased availability of marine-associated forage fish species under lower salinity conditions present during high flow (Good et al. 2022). Since high flow is also often associated with increased turbidity, turbidity itself may not be a major influence on predation in the estuary. In support of this, decreased water clarity was found to be a predictor of avian predator presence in the Columbia River plume, with common murres and sooty shearwaters apparently preferentially foraging in the turbid waters of the plume rather than surrounding waters (Phillips et al. 2017). Overall, more research is necessary to clarify the role of turbidity on susceptibility of juvenile salmonids to predation by avian predators.

Presence of alternative prey mediates avian predation on salmonids

The collective abundance of alternative prey fishes (e.g. Pacific herring [*Clupea pallasi*], northern anchovy [*Engraulis mordax*]) is increasingly understood to be a major driver of avian predation rates on salmonids in the estuary (Lyons et al. 2014, Weitkamp et al. 2016, Good et al. 2022). In conditions where abundance of non-salmonid prey is low relative to salmonid prey, Caspian terns and double-crested cormorants tend to rely more heavily on juvenile salmonids as a prey source, and predation rates on various runs tend to increase. However, despite the importance of non-salmonid forage to predation on salmonids, much remains unknown about the dynamics of prey fishes in the estuary and plume, complicating efforts to predict potential future changes. Nevertheless, climate projections suggest higher Columbia River flows in winter and early spring and reduced saltwater intrusion in the estuary, both of which could reduce availability of alternative prey fishes for avian predators (Good et al. 2022). In addition, it is unclear how ongoing changes to oceanographic processes associated with changing climate (e.g. marine heat waves) will affect abundance of alternative prey in the estuary (Good et al. 2022). Overall, availability of alternative prey appears to be an important factor related to avian predation rates. A better understanding of the dynamics of the fish community in the estuary and plume would improve our ability to identify effective options to manage predation.

Functional responses of avian predators affect predation rates

The response of predators to varying densities of juvenile salmonid prey can have important conservation implications. Recent work suggests predation of steelhead by Caspian terns in the Columbia River basin is consistent with a Type II functional response (Hostetter et al. 2022). Essentially this means the probability that a steelhead is consumed by terns is inversely related to steelhead density, although this response is typically assumed to be non-linear. This means that at low steelhead abundance, tern predation can be destabilizing, causing higher mortality as populations decline, which can contribute to elevated extinction risk. Conversely, at high steelhead abundance, terns can be "swamped" by the abundance of food, and therefore low predation rates can result. In contrast to terns, double-crested cormorants appear to display a Type III functional response to abundance of steelhead, increasing predation rates as prey abundance increases (Hostetter et al. 2022). This response likely reflects "prey switching" in response to dynamic pulses in prey abundance (Hostetter et al. 2022). A potential consequence of Type III predation is that high local densities of salmonids, such as occur immediately following hatchery releases in the lower estuary, can result in higher predation rates than if these releases were made more gradually or in a manner than would allow juvenile salmonids to spread out prior to being exposed to cormorant predation. Overall, recent work related to the functional responses of Caspian terns and double-crested cormorants suggest management that affects density of juvenile salmonids in the estuary can have substantial effects on predation rates by avian predators.

Possible hatchery subsidization of predators

The abundance of juvenile salmonids migrating down the Columbia River may be substantially higher than before hydropower development because of hatchery inputs. Results of an exercise based on reconstruction of historical data suggest that smolt abundance has increased by a factor of 2–8 over historical levels, depending on salmonid species (ISAB 2011). Such a major increase could reflect a substantial prey subsidy to avian predators, especially considering that most of these fish are reared in hatcheries and released in large groups, which tend to attract avian predators, particularly in the estuary (ODFW unpubl. data). The release of large numbers of hatchery fish could therefore subsidize higher abundances of avian predators than may have been possible historically, which could have consequences for survival of both hatchery and wild-reared fish. Work to reduce the vulnerability of hatchery-reared fish to predation could therefore be an important step to reducing the overall impact of predators on juvenile salmonids (ISAB 2011).

Future needs

Address data gaps related to population and release-specific predation rates

Although predation rates by Caspian terns and double-crested cormorants have regularly been estimated for tagged portions of various ESA-listed ESUs, only scattered information is available for predation of LCR runs at finer spatial scales, and little information is available at the hatchery or population scale (Sebring et al. 2013, Zamon et al. 2013, Lyons et al. 2014). Further, cumulative avian predation rates on LCR runs remain poorly understood because of an apparent lack of proportional representation of PIT tagging effort among diverse population origins and life histories within these ESUs (Zamon et al. 2013). A carefully designed PIT-tagging program that reflects the diversity of salmonid populations across the LCRwould improve our understanding of the impact of avian predators on a population level. Such a study could also shed light on factors related to hatchery releases conditions that may reduce fish vulnerability to avian predation.

Estimates needed for double-crested cormorant predation rates at non-ESI colonies

During 2004–2014, 97% of double-crested cormorant abundance in the Columbia River estuary was associated with the colony on East Sand Island. Therefore, monitoring this colony alone was sufficient to provide reasonably accurate estimates of double-crested cormorant predation across the estuary. However, in 2021 the vast majority of predation was estimated to have been associated with colonies upriver of East Sand Island, most of which were not monitored for predation impacts (Lawonn 2023b). Monitoring predation associated with about 20 potentially active colony sites in the estuary will be necessary to estimate estuary-wide double-crested cormorant predation rates to a degree of accuracy comparable to monitoring conducted prior to management on East Sand Island.

Clarify critical uncertainties related to management of avian predation

There are several critical uncertainties related to management of avian predators to improve survival of LCR salmonids. First, it is unclear the extent to which predation by Caspian terns, double-crested cormorants, or other predators reduces life-cycle scale abundance of anadromous salmonids in the Columbia River basin (ISAB 2016). Losses to avian predators during the juvenile life stage might be ameliorated by improved survival later in life, especially if double-crested cormorants preferentially consume the least fit individuals (ISAB 2016).

Second, the role of predators in maintaining the structure of biological communities, even communities altered by humans, is often poorly understood (ISAB 2016). For example, depending on their colony sizes, double-crested cormorants can consume hundreds to even thousands of tons of forage fish in the Columbia River estuary annually, the vast majority of which are non-salmonids (Lawes et al. 2021). Reductions in double-crested cormorant abundance could therefore substantially alter the local food web and predator community, which could result in counterintuitive and unintended consequences for juvenile salmonids, as suggested by a wide body of research related to predator-prey dynamics across a variety of taxa (Holt and Lawton 1994, Sih et al. 1998, Yodzis 2001, Bruno and O'Connor 2005, Harvey and Karieva 2005, Wiese et al. 2008, Abrams 2009, Ellis-Felege et al. 2012).

Finally, the likelihood that management would substantially reduce avian predation is uncertain. The Independent Science Advisory Board (2016) suggests predator management is best suited to local scale and temporary conflicts (i.e. hotspots) rather than persistent conflicts that occur across a wide geographical area. This is because of the high cost and biological uncertainty related to predation management conducted at large scales. Nevertheless, management of double-crested cormorants in the estuary, for example, would likely need to occur across a wide area because isolated colony-specific management would likely cause at least some dispersal of displaced cormorants to new areas of the estuary, which would move the predation issue rather than resolve it.

Food web models

Although many predator species occur in the Columbia River estuary and plume, double-crested cormorants and Caspian terns are the only two predator species that are regularly monitored for predation impacts to juvenile salmonids. However, the combined abundance of other predators appears much higher in the estuary and plume than these two species. For example, the abundance of common murres (*Uria aalge*) and sooty shearwaters (*Ardenna grisea*) in the plume is more than an order of magnitude greater than the combined abundance of double-crested cormorants and Caspian terns in the estuary (Phillips et al. 2017). The abundance of non-avian predators in the estuary and plume is also high, with large numbers of Pacific harbor seals (*Phoca vitulina*; Jeffries et al. 2015) and various piscivorous fishes (Emmett and Krutzikowsky 2008) present during the spring smolt outmigration. To better understand the potential degree that avian management will benefit recovery of LCR salmonids, more research is needed to clarify potential interactions that may occur among predators and other constituents of the local food web as a result of predator management. The most practical way of achieving this goal may be to develop modelling approaches that investigate food web responses to predator management (Yodzis 2001).

Pinniped Predation

The state of knowledge on pinniped predation on Columbia River salmonids has improved in the last 12 years, driven by an increasing abundance of pinnipeds and subsequent salmonid predation. Most of the pinniped monitoring and management efforts occur at two locations where fish migration is delayed, and salmonids become more vulnerable to predation. The two sites are at Bonneville Dam and Willamette Falls. Sea lion management in the Columbia River Basin has been ongoing for over a decade, since fish and wildlife agencies were first given Section 120 authorization to remove California sea lions (CSL) observed preying on salmon and steelhead below Bonneville Dam in 2008 and years later at Willamette Falls. Before 2020, the States were only able to remove CSL at these two locations, and only then after spending years documenting predation, meeting multiple criteria for removal of individual sea lions, as well as expending considerable effort with non-lethal methods such as relocation and hazing that have largely proved futile. After 2020, changes to the existing law streamlined the process for the eligible states and tribes to remove Stelar sea lions (SSL) and CSL by changing the eligibility criteria from a rigorous, data-intensive process to geographic-based eligibility.

Bio-energetic modeling by Casey Clark with the Washington Department of Fish and Wildlife (WDFW) shows spring chinook predation in the ¼ mile below Bonneville Dam peaked in 2015 and 2016 and then began to decrease yearly to pre-Plan levels (Figure A-III: 74; Hatch and Clark 2022). Sea lion removals under the Marine Mammal Protection Act Section 120 Pinniped Removal Program have resulted in approximately 30-60 percent reduction of the animals.

ODFW produced a population viability study for Upper Willamette River (UWR) Steelhead, an assessment of effect of sea lions at Willamette Falls (Falcy 2017). This report described some UWR steelhead populations facing an 89 percent chance of extinction. Following one year of CSL removal at Willamette Falls, estimated CSL predation on salmonids in 2019 decreased by 67 percent and maximum single-day CSL abundance decreased by 57 percent (Steinglass et al 2019).

Recent studies have shown that predation is beginning to decrease at two specific locations totaling two miles of the 172 river miles of mainstem Columbia and Willamette rivers. However, the assessment of recent decreases in pinniped predation below Bonneville Dam and Willamette Falls effects mostly non-LCR ESU stocks.

ODFW, Washington Department of Fish and Wildlife (WDFW), NOAA and the Columbia River Intertribal Fish Commission (CRITFC) have conducted occasional efforts to estimate pinniped abundance and predation events by boat on the mainstem Willamette and Columbia Rivers. Yearly flights have also occurred in the Astoria area at select locations and are showing increasing abundance of pinnipeds. These efforts have not been able to produce an estimate of pinniped predation at the ESU or population level for LCR salmon and steelhead.

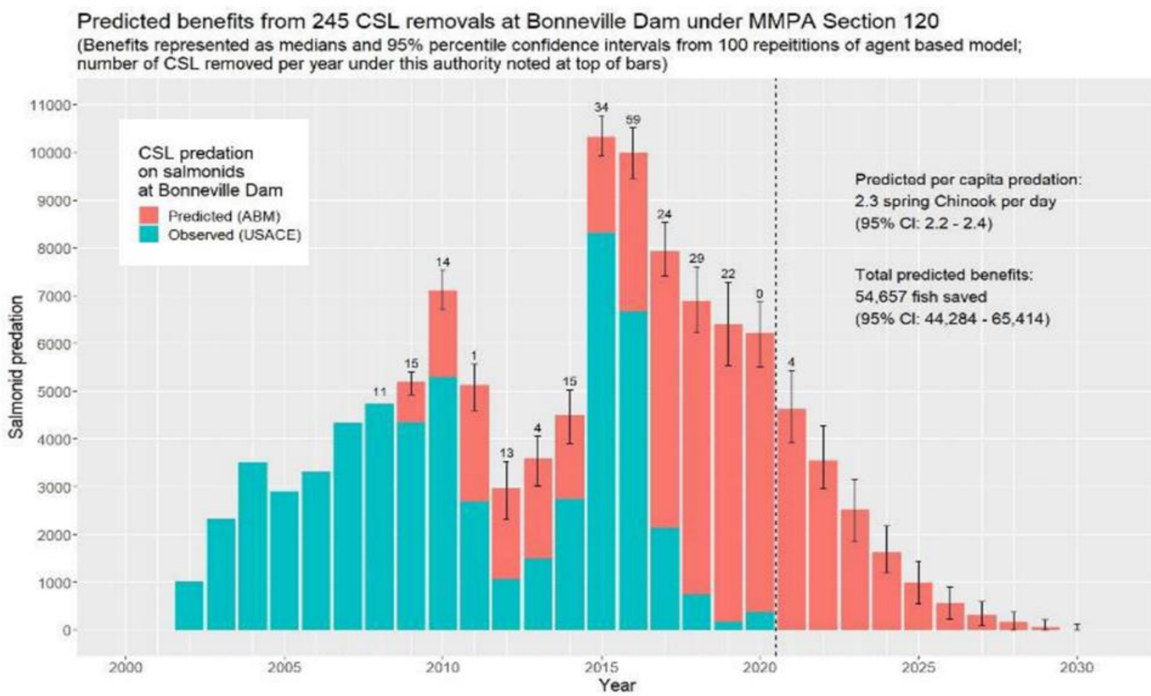

Figure A-III: 74. Bonneville Dam predation events on spring chinook and projected benefits because of California sea lion removal (Hatch and Clark 2022).

Monitoring and Management at Bonneville Dam

The Columbia River below Bonneville Dam has been an area of intensive pinniped predation RME and management since 2002 in response to salmonid predation concerns and to fulfill requirements established through ESA consultation with NMFS regarding the operation and maintenance of the Federal Columba River Power System

The US Army Corps of Engineers is responsible for monitoring the number of animals present and the number of fish those sea lions consume to fulfill requirements of operations of the Federal Columbia River Power System. Federal, state, and tribal managers use this data to adjust and adaptively manage the animals near Bonneville Dam. Management of sea lions under the Marine Mammal Protection Act at Bonneville Dam also contains monitoring and reporting requirements.

Sea lion monitoring at Bonneville Dam begins approximately mid-August when a 20-animal trigger is realized and continues through approximately the following May when less than 20 animals remain within a ¼ mile below Bonneville Dam (Tidwell et al. 2022). Pinniped abundance peaked in 2015 and decreased by two thirds during the 2019-2021 (Table A-III: 21) period because of increased management activities allowed under the passage of the Endangered Salmon Predation Prevention Act in December 2018.

Table A-III:21. Minimum estimated number of individuals pinnipeds observed at Bonneville Dam tailrace areas during the spring sampling period, 2010-2021 (Tidwell at al. 2022).

Year	Pinnipeds Observed
2010	166
2011	144
2012	115
2013	136
2014	137
2015	264
2016	203
2017	156
2018	134
2019	76
2020	81
2021	86

During the same time that pinniped abundance monitoring is occurring, surface observations of pinniped-fish interactions are collected to measure the number of fish and species consumed by pinnipeds in the quarter mile boundary below the dam. Data was collected over the last 19 years but estimates and timing of monitoring for the various runs has changed over time. Spring Chinook and steelhead monitoring has occurred throughout the time span. Coho and fall Chinook predation monitoring was added in 2017 and in 2022 the steelhead estimate is now separated by winter and summer run types. Predation rates are affected by pinniped abundance in addition to salmon and steelhead run size. Predation rates vary by year and by species with fall Chinook having the least impact and steelhead suffering the highest impact (Table A-III: 22).

Table A-III:22. Annual estimates of adult fish predation by pinnipeds at Bonneville Dam based on data reported by Tidwell et al. (2022).

Year	Spring Chinook		Steelhead		Coho		Fall Chinook	
	Predated	Percent of Run	Predated	Percent of Run	Predated	Percent of Run	Predated	Percent of Run
2021	2,079	3.3%	102	7.4%				
2020	1,180	2.5%	174	1.0%	292	0.3%	756	0.2%
2019	1,974	3.1%	208	8.7%	156	0.3%	1,365	0.7%
2018	2,813	2.9%	295	7.2%	269	1.4%	419	0.6%
2017	4,951	4.6%	322	9.0%	368	3.1%	401	0.7%
2016	9,222	5.9%	302	5.4%				
2015	10,622	4.3%	237	4.3%				
2014	4,576	2.1%	128	2.2%				
2013	2,710	2.3%	218	6.0%				
2012	1,959	1.2%	400	6.3%				
2011	3,634	1.6%	336	6.0%				
2010	5,909	2.2%	413	4.0%				
Average		3.0%		5.6%		1.3%		0.6%

One action listed within the Plan is "Expand federal and state activities at Bonneville Dam to test and implement non-lethal and potentially lethal methods of reducing pinniped populations. This includes efforts to manage pinnipeds through the Marine Mammal Protection Act". NOAA provided approval for this action in 2008. The action relied heavily on hazing sea lions away from Bonneville Dam which has since proved ineffective (see ODFW website for more information: https://www.dfw.state.or.us/fish/sealion/index.asp). Lethal removal was allowed under a strict set of conditions which required branding individual sea lions and documenting their predation over years for CSL. NOAA amended the approval and in 2020 approved management of CSL and SSL under an area management scenario, which lessened the burden and increased efficiency of federal, state, and tribal agencies to manage pinnipeds. Since lethal removal was approved in 2008, 376 habituated sea lions have been removed (Table A-III: 23). Modeled and observed predation rates are decreasing in the ¼ mile below Bonneville Dam. This management action should have a beneficial effect on Upper Gorge and Hood River salmon and steelhead populations.

Table A-III:23. Combined Columbia River and Willamette River sea lion removal, 2008-2022 (Hatch and Clark 2022).

Year	California Sea Lions Removed	Stellar Sea Lions Removed	Total
2008	11	2*	13
2009	15	N/A	15
2010	14	N/A	14
2011	1	N/A	1
2012	13	N/A	13
2013	4	N/A	4
2014	15	N/A	15
2015	35	1*	36
2016	59	N/A	59
2017	24	N/A	24
2018	33	N/A	33
2019	50	N/A	50
2020	0	6	6
2021	29	38	67
2022	17	9	26
Total	320	56	376

Monitoring and Management at Willamette Falls

ODFW began intermittently monitoring pinniped abundance at Willamette Falls in 1995 and shifted to a yearly rigorous monitoring effort in 2013. The efforts showed sea lion abundance increasing and predation had become particularly acute for Willamette River steelhead populations. After the viability assessment of Willamette River winter steelhead by Falcy (2017), Oregon applied for lethal removal authority under Section 120(f) of the Marine Mammal Protection Act (MMPA) to reduce extinction risk for Willamette River steelhead. As part of the approval process ODFW continues to monitor pinniped abundance and predation from Willamette Falls downstream to the mouth of the Clackamas River (1.5 miles).

ODFW uses a combination of direct observation as well as imagery from automated time-lapse cameras at the main haul out area below Willamette Falls at the Sportcraft Landing Marina to obtain a minimum abundance estimate per day (Wright et al. 2022). Peak abundance occurred in 2017 and as habituated sea lions have been removed the number of sea lions observed has gone down every year since ODFW received approval to remove sea lions near Willamette Falls (Figure A-III: 75).

During the same time that pinniped abundance monitoring is occurring, surface observations of pinniped-fish interactions are collected to measure the number of fish and species consumed by pinnipeds in the mile boundary below the falls. Spatial and temporal under coverage in the sampling frame likely result in the estimates of predation being biased low. Monitoring of management activities targeting removal of sea lions has shown a decrease in predation on Willamette River spring chinook and steelhead. Sea lion management occurs near the mouth of the Clackamas River and should have a beneficial effect on Clackamas River salmon and steelhead populations.

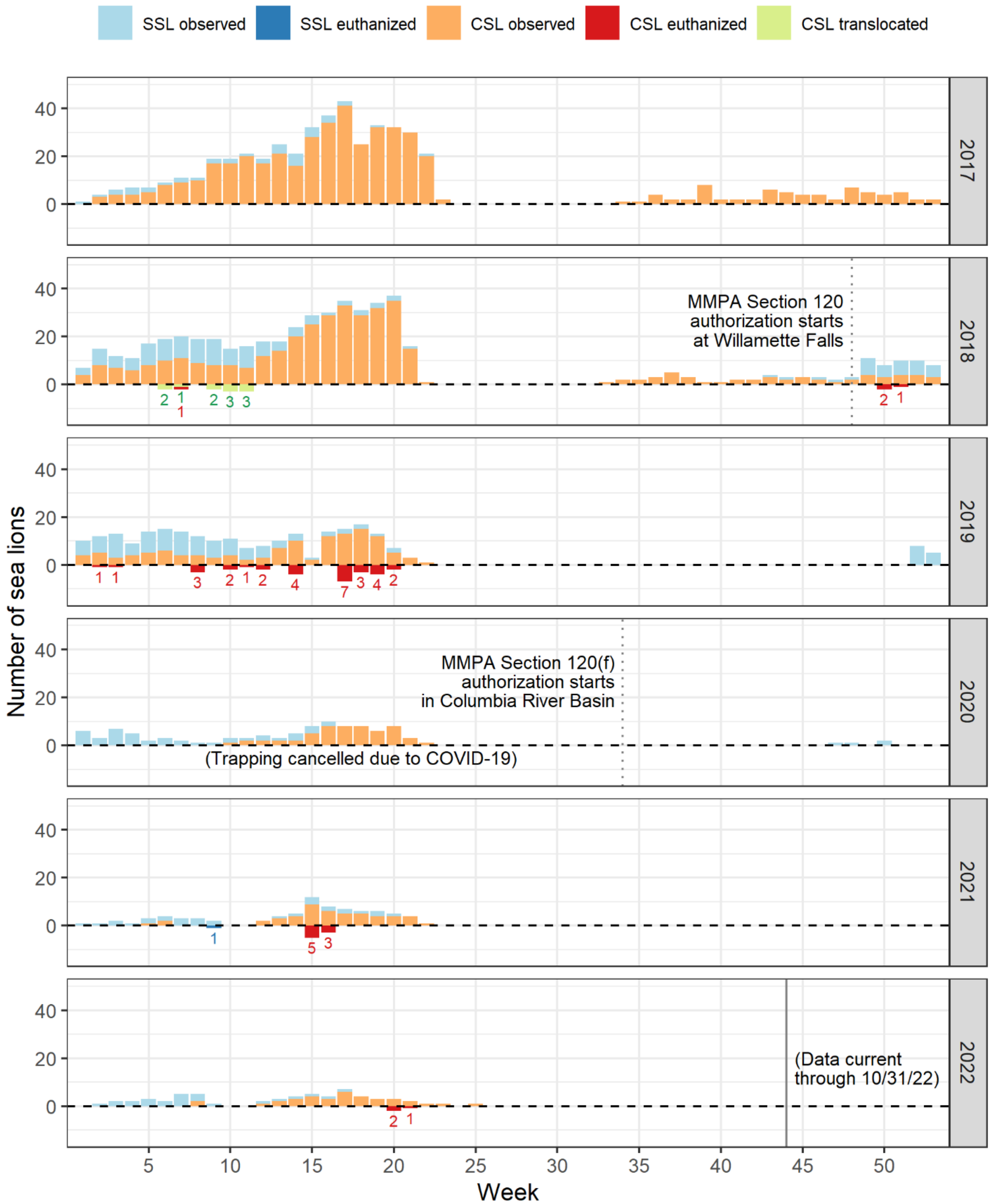

Figure A-III:75. Weekly counts of California sea lions (CSL) and Steller sea lions (SSL) at Willamette Falls, 2017-2022 (Wright et al. 2022). Numbers translocated or euthanized are summed over the week; numbers observed are the minimum number of unique individuals observed for that week and may include animals translocated or euthanized.

Lower Columbia River Monitoring and Research

Management activities are limited to the areas around Bonneville Dam, Willamette Falls and tributary streams. There is a strong desire and need to improve our understanding of pinniped abundance and predation impacts within the Columbia River estuary at the LCR ESU and population levels.

Since 1997, ODFW has conducted periodic haul-out counts at the South Jetty (river km 0) and East Mooring Basin (river km 25) to estimate seasonal and annual abundance of sea lions in the Columbia River estuary (Brown et al. 2020). This monitoring found that several thousand California sea lions regularly hauled out at the mouth of the river, but similar numbers did not occur inside the estuary until 2013. In 2020, ODFW also began conducting boat counts of sea lions in the Willamette River from the falls to the Columbia River (Wright et al. 2022).

State and federal research on predation in the 146 miles between the ocean and Bonneville Dam indicates that a significant portion of the annual spring Chinook salmon run is lost to marine mammal predation. Research conducted by Wargo Rub et al. (2019) from 2010-2015 found that non-harvest mortality between the estuary and Bonneville Dam for spring Chinook ranged from 20-44%, and that reductions in spring Chinook survival were associated with higher abundance of California sea lions. Predation estimates by Wargo Rub et al. (2019) are comparable to estimates developed separately using a bioenergetics approach (Chasco et al. 2017). Sorel et al. 2020 also found that higher sea lion abundance was associated with lower spring Chinook survival, and that survival varied among populations based on migration timing. Inferences from these studies could potentially be applied to LCR spring Chinook, particularly in the Hood River, but application to other LCR populations is complicated by variation in migration timing and other factors that affect exposure to predation.

Conclusion

Pinniped predation of salmonids has been a matter of concern for decades, particularly where salmonid abundance is low. Research has occurred in the ocean, bays, and river basins along the entire West Coast. Most research and monitoring in the Columbia Basin is focused on the areas immediately below Bonneville Dam and Willamette Falls, in addition to annual haul-out counts near Astoria. Recently, NOAA-Fisheries has conducted research to estimate pinniped predation impacts on spring Chinook populations above Bonneville Dam. Bonneville Dam provides a tag interrogation point that is not readily available in the lower Columbia River and tributaries below Bonneville Dam. Thus, none of the efforts to date provide estimates of pinniped predation at the ESU or population level for LCR salmon and steelhead, and obtaining these estimates would require substantial resources.

Recent research has demonstrated a correlation between the pinniped removal program and subsequent improved salmonid escapement at two major in-river obstructions. These results support continued efforts to implement targeted lethal removal under Section 120(f) of the MMPA. Implementation will require extension of the 120(f) permit, additional funding to replace outdated equipment, and increased capacity to remove and process animals.

Piscine Predation

Numerous studies occurring over the last 50 years have demonstrated negative effects from piscine predators to out-migrating juvenile salmonids in the Columbia River Basin (e.g., Poe and Vigg 1991, Rieman et al. 1991, Beamesderfer et al. 1996, Friesen and Ward 1999, Counihan 2012, Tiffan et al. 2020, Waltz et al. 2022). From concerns regarding these effects, the Northern Pikeminnow Management Program (NPMP) began. Creation of the NPMP came about using information generated from numerous studies in the 1970s–1990s and the program has since generated a long-term data set for some piscine predation metrics, including indices of abundance for northern pikeminnow *(Ptychocheilus oregonensis*), smallmouth bass (*Micropterus dolomieu*), and walleye (*Sander vitreus*). However, additional data is needed to provide information about ESU or population level impacts from piscine predation on juvenile salmonids in the Columbia River Basin, including the LCR.

Past work in the Columbia River Basin suggests predation by northern pikeminnow (NPM) on juvenile salmonids accounted for a high percentage of mortality that juvenile salmonids experienced from piscivorous fish in each of eight Columbia River and Snake River reservoirs. Modeling simulations based on work in John Day Reservoir from 1982 through 1988 indicated that if predator-size NPN were exploited at a 10-20 percent rate, the resulting re-structuring of their population could reduce their predation on juvenile salmonids by as much as 40 percent (Winther et al. 2022). Evaluation techniques have changed over the years, but the assumption of a continued yearly exploitation on NPM will provide up to a 40 percent reduction on juvenile salmonid mortality rates from piscine predators at the Columbia River basin level continues. Smallmouth bass (SMB) and walleye (WA) are also evaluated and studied as concern for compensatory effects may influence assumed juvenile salmonid survival increases.

The Plan recommended specific actions in which juvenile salmonid life cycle survival could be improved. This narrative reviews Plan action 76: "Manage pikeminnow and other piscivorous fish, including introduced species and hatchery fish, to reduce predation on salmonids. 1) Monitor the abundance levels of NPM, SMB, WA, and channel catfish. 2) Implement actions as necessary to prevent population growth (i.e., modify habitat); increase the NPM bounty program in the estuary."

RME and Management for Northern Pikeminnow Predation

Since 1990, the NPMP has applied targeted removal fisheries in the Columbia and Snake rivers to restructure populations of NPM to suppress predation on out-migrating juvenile Pacific salmon and steelhead. Ultimately, assessments of various management strategies identified targeted removal fisheries as a favorable option to address the issue of predation on juvenile salmonids and provided the foundation for the contemporary NPMP.

The NPMP was developed to help address NPM predation of juvenile salmonids and partially mitigate for the impacts of the Columbia River dams via removal of NPM. The program is a collaborative effort between ODFW, WDFW and the Pacific States Marine Fisheries

Commission (PSMFC), with funding from the Bonneville Power Administration (BPA). The goal of the program is to reduce predation on out migrating salmon and steelhead by suppressing the population of native NPM and removing the largest individuals while monitoring the population of this native predator and evaluating potential compensatory effects of predation by non-native SMB and WA.

The concept behind the program is that an annual 10-20 percent exploitation rate of NPM greater that 11 inches in length will shift the population structure toward smaller fish that tend to consume fewer juvenile salmonids, over time reducing predation by NPM by up to 40 percent. Early research showed that NPM consumed millions to tens of millions of out-migrating juvenile salmonids annually, with a substantial portion being consumed below Bonneville Dam (Beamesderfer et al. 1996). Success of the program depends on maintaining harvest rates within the 10 to 20 percent range each year, a target that has been achieved in 23 of the 27 years of the program's history (Table A-III: 24).

ODFW captures and tags NPM using boat electrofishing and estimates exploitation rates with tag recovery data from the Sport Reward Fishery. ODFW quantifies the proportion of the NPM population removed during the Sport Reward Fishery using mark-recapture data from Columbia River reservoirs below Priest Rapids Dan and Snake River reservoirs below Hells Canyon Dam. These estimates of exploitation are used to model the predation reduction to juvenile salmonids from NPM removals.

Annual basin-wide NPM exploitation is used as one parameter in suite of fixed model parameters used to estimate annual juvenile salmonid predation reduction from the Sport Reward Fishery. The NPMP can model and forecast predation reduction three years into the future. Since 1992, the median reduction in salmonid predation has been over 30 percent (Figure A-III: 76). These improvements are system wide and likely account for all salmon and steelhead populations within the Columbia River basin.

NPMP calculates several fisheries independent indices to further assess the predatory relationship among NPM, SMB, and WA. An index of abundance is estimated seasonally for NPM, SMB, and WA on a three-year rotating basis by groups of reservoirs. The index of abundance is estimated by calculating the mean catch per 900 s of boat electrofishing by season and area. This information is applied with gut content data in the models of Ward et al. (1995) and Ward and Zimmerman (1999) to calculate consumption index values for NPM and SMB. The abundance and consumption indices are further used to calculate an index of predation for NPM and SMB. These three indices were designed to complement the trends in exploitation and predation reduction found using the fisheries dependent mark/recapture modeling used with the Sport Reward Fishery tag return data. In this way, NPMP was better able to evaluate the effectiveness of the Sport Reward Fishery to reduce juvenile salmonid predation and monitor for signs of piscine predator compensation or population declines of NPM.

Table A-III: 24: Time series of annual exploitation rates (%) of Northern Pikeminnow (≥ 250 mm) in the Sport Reward Fishery by location (Winther et al. 2022). Mean and SE were calculated for each location across the time series.

Year	Below Bonneville	Bonneville
1991	7.6	10.9
1992	11.4	4.0
1993	6.0	2.1
1994	13.6	2.2
1995	16.1	3.5
1996	12.7	6.1
1997	7.8	8.0
1998	8.2	7.8
1999	9.6	13.9
2000	10.0	16.3
2001	16.2	8.5
2002	12.6	6.0
2003	13.6	16.7
2004	20.1	9.3
2005	23.1	8.2
2006	15.6	13.7
2007	19.4	11.1
2008	22.2	10.5
2009	11.3	15.9
2010	19.8	13.1
2011	14.5	10.4
2012	17.4	13.5
2013	9.6	11.2
2014	9.2	6.9
2015	16.7	14.3
2016	11.6	8.9
2017	16.3	14.8
2018	13.8	18.3
2019	14.7	7.8
2020	19.0	10.1
2021	11.8	5.6
mean (SE)	13.9 (0.8)	10 (0.8)

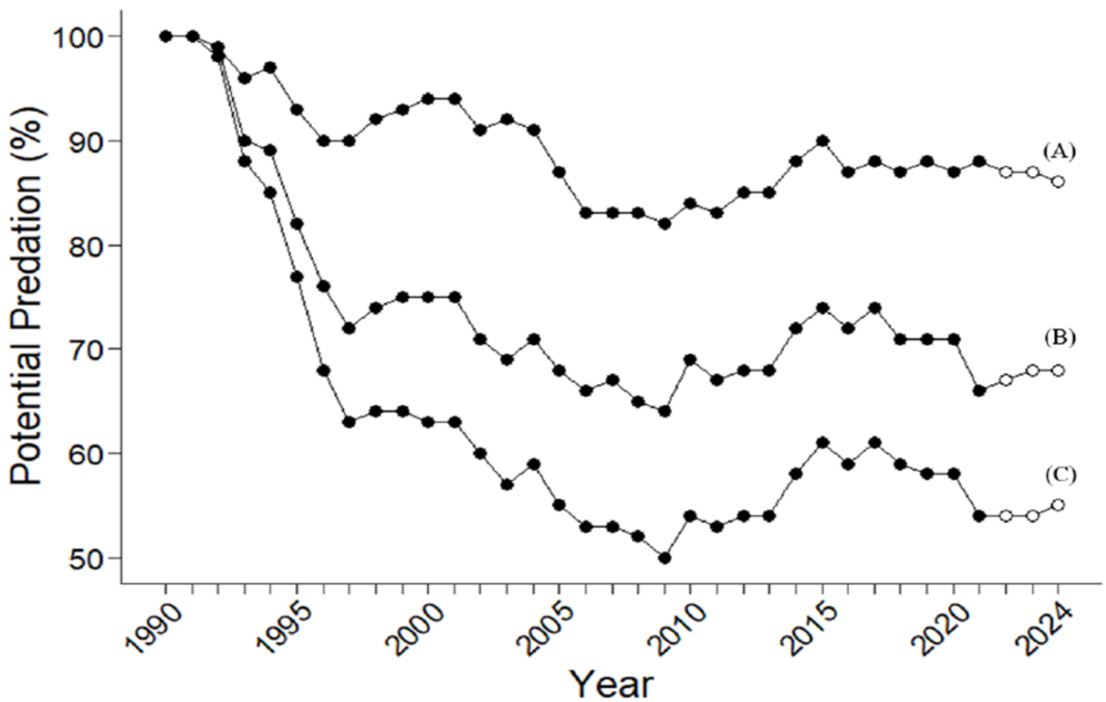

Figure A-III: 76. Estimates of (A) maximum, (B) median, and (C) minimum annual levels of potential predation by Northern Pikeminnow on juvenile salmon relative to predation levels before implementation of the Northern Pikeminnow Management Program (Winther et al. 2022). For the years 1991–2021, model estimates (filled circles) are based on exploitation rates from the previous year. Model forecast predictions after 2021 (open circles) are based on average exploitation estimates from years with similar fishery structure (2001, 2004–2020).

Additional Piscine Predators and NPMP

The NPMP has been a long-term tool to reduce piscine predation on juvenile salmonids in the mid and lower Columbia River (below Priest Rapids Dam) and lower Snake River (below Hells Canyon Dam). These efforts have focused on reducing predation through controlling a single, native piscine predator. The program has concurrently monitored indices from three piscine predators (NPM, SMB, and WA) to track predator/prey dynamics and explore the potential for compensatory responses associated with the removal of NPM. These efforts have broadly shown that juvenile salmonid predation has been consistently reduced through the removal of NPM. Trends in these indices are also starting to suggest signs of compensatory or other changes in predator/prey dynamics, particularly between NPM and SMB (Figure A-III:77).

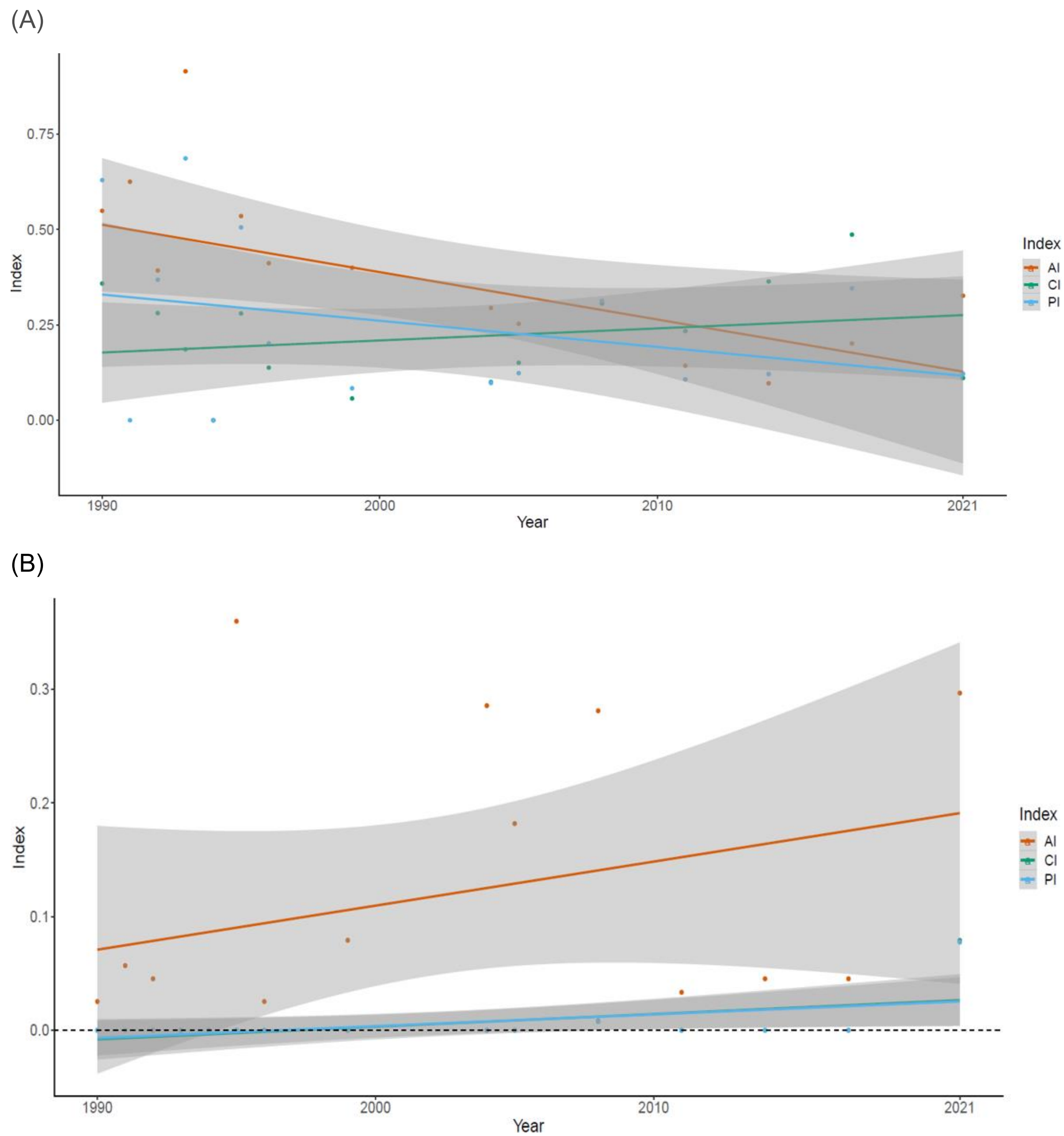

Figure A-III: 77. Indices of Abundance (AI), Consumption (CI), and Predation (PI) below Bonneville Dam Tailrace for (A) Northern Pikeminnow and (B) Smallmouth Bass, 1990-2021.

Therefore, NPMP can function as a foundational monitoring, evaluation, and mitigation tool upon which to explore the benefits of adding other piscine predators into the control program. Specifics are detailed below but NPMP has a long history of mark/recapture data, diet data, fisheries indices, and institutional knowledge that can be built upon or leveraged into new or updated tools. Specifically, there are numerous potential mechanisms to obtain finer scale juvenile salmonid taxonomic information, incorporate additional piscine predators into the mark/recapture and removal fishery, test new or updated analytical tools to estimate piscine predator populations and juvenile salmonid consumption, as well as provide a model for potential new monitoring, evaluation, and mitigation tools being developed elsewhere in the Columbia River Basin.

In conjunction with the information available through NPMP, there are other piscine predation studies from other areas of the Columbia Basin that can be used to inform potential piscine predation impacts in the LCR. These studies should not be ignored for their utility relative to the LCR, but their relevance also needs to be qualified by the fact that there are known and unknown ecological differences between study sites in the mid-Columbia and lower Snake Rivers with respect to the LCR. Specifically, work from the Grant and Chelan People's Utility District in collaboration with United States Geological Society (USGS) and private contractors have consistently demonstrated significant piscine predation on juvenile salmonids from SMB, WA, and NPM (Counihan et al. 2011, Grant PUD/Chelan PUD). Similarly, Erhardt et al. (2018) and Tiffan et al. (2020) showed substantial levels of predation on juvenile salmonids from SMB on the Snake River from Hells Canyon Dam to the confluence with the Columbia River. These studies concluded that hundreds of thousands of juvenile salmonids were consumed each year by SMB. These studies (Erhardt et al. 2018, Tiffan et al. 2020) did not include any additional piscine predators, which were present in the study area (Winther et al. 2022).

As mentioned previously, numerous studies were conducted throughout the 1980s and 1990s in various places in the mid and lower Columbia River, demonstrating predatory impacts from NPM, SMB, WA, and channel catfish to juvenile salmonids. In combination with additional piscine predation work in other sections of the Columbia River Basin, piscine predators consume juvenile salmonids in potentially large numbers. Despite this, there are numerous unknowns regarding absolute estimates of juvenile salmonid predation rates, as well as important details like finer scale taxonomic information of prey, multi-species predator dynamics, and emerging ecological dynamics from several additional processes (e.g., climate change, additional non-native predators). Therefore, applying our existing body of knowledge regarding piscine predation on juvenile salmonids at the ESU or population level may not result in effective management recommendations. Compounding the quality of the information available to guide management decisions is the difficulty of measuring the effect of implemented management actions across multiple piscine predator species. This problem is not exclusive to the LCR but is chronic for the entire Columbia River Basin.

Independent Scientific Advisory Board (ISAB)

The Independent Scientific Advisory Board (ISAB) serves NOAA Fisheries, Northwest Fisheries Science Center; Columbia River Indian Tribes (via the Columbia River Inter-Tribal Fish Commission); and the Northwest Power and Conservation Council (NPCC) by providing independent scientific advice and recommendations regarding scientific issues that relate to the respective agencies' fish and wildlife programs. The ISAB operates in conjunction with the NMFS and reviews programmatic and scientific issues in the Columbia River basin. ISAB members are experienced scientists with demonstrated achievement and high standing in their field, chosen to fill specific areas of needed expertise. ISAB members includes scientists with expertise in Columbia River anadromous and resident fish ecology, statistics, wildlife ecology, ocean and estuary ecology, fish husbandry, genetics, geomorphology, social and economic sciences, and other relevant disciplines, with a balance between scientists with specific knowledge of the Columbia River Basin and those with more broad and diverse experience. The NPCC requested the ISAB to provide a review of the biological and economic impacts of native and nonnative predators and the effectiveness of predator management control efforts currently implemented (Yost 2018). The ISAB responded with recommendations for assessing predation by piscivores based on a model of bioenergetics of the predator population (ISAB 2019), noting that the NPMP (Williams and Miller 2018) uses similar methods to estimate the consumption of salmonid juveniles by NPM. Applying this approach across multiple piscivorous species would require a major effort and there will still be considerable uncertainty in the final estimates (ISAB 2019).

Future Needs

Piscine predation studies in the Columbia River Basin have primarily focused on four major predators: NPM, SMB, WA, and channel catfish. These species have been shown to predate on juvenile out-migrating salmonids in study locations that include areas from the lower, mid, and upper Columbia River, as well as portions of the Snake River. A common theme from these studies is that absolute estimates of predator populations and metrics related to predation on juvenile salmonids, including finer scale taxonomic information, were difficult to obtain. In aggregate, these studies provide a broad foundation to guide next steps in fisheries management to improve our understanding of the scale and composition of piscine predation on specific salmonid ESUs or stocks. These studies also help to highlight several key data gaps around piscine predation that need to be addressed to improve the information used to recommend and measure potential piscine predation management actions, particularly as they relate to Action 76 from the Plan. These include:

1. Improved metrics of piscine predator abundance for NPW, SMB, WA, and channel catfish.
2. Improved diet composition data from piscine predator species.
3. Enhanced understanding of spatiotemporal patterns in piscine predation.
4. Mechanisms to evaluate the effects of Columbia Basin ecological dynamics on trends in piscine predation (e.g., climate change, emerging/expanding non-native species).

The region has a strong need for this information but has yet to fully support complete or updated studies required to obtain the critical information to better assess piscine predation. Until piscine predation is better understood, there will be difficulties recommending meaningful piscine predation management actions and few reliable and robust metrics by which to measure the effect of piscine predation management actions at the ESU or population level.

Listing Factor D: Adequacy of Existing Regulatory Mechanisms

No measurable criteria have been established for this listing factor.

Listing Factor E: Other Natural or Man-made Factors Affecting the Continued Existence of the ESU.

The hatchery related metrics identified in the Plan are intended to serve as measurable criteria for Listing Factor E, as well as a diversity metric in the biological criteria assessment (*Diversity Metric #2: Interbreeding with Hatchery Fish)*. Metric assessment results for each population can be found in the Biological Criteria Assessment section above.

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