Hatchery and Supplementation Program

North Fork Lewis River

FERC Hydroelectric Projects 935, 2071, 2111, 2213

2022 ANNUAL REPORT
FINAL

Prepared by

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A BERKSHIRE HATHAWAY ENERGY COMPANY

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EXECUTIVE SUMMARY

The intent of this report is to summarize results from monitoring activities associated with the Hatchery and Supplementation (H&S) program in 2022. A considerable amount of the reportable data reside in the many appendices attached to this report. These appendices represent most of the reporting requirements and obligations of the H&S Plan. Where appropriate, this report provides figures and tables to summarize and illustrate relationships and annual trends (including 2022) over several years for specific key questions and objectives.

It is important to note that several key questions are not addressed in 2022 and Appendix A identifies the status of those specific key questions or metrics . The primary reason a specific key question was not evaluated in 2022 is that a methodology or monitoring strategy has not yet been developed or agreed to by the ATS. Completing these strategies and methodologies will be a priority for the ATS in 2023 (e.g., genetic monitoring strategy, SAR's, etc.).

Reporting Format

The 2022 Annual H&S Report has been revised to conform to the structure and format of the most recent version of the H&S plan (PacifiCorp and Cowlitz County PUD 2020). This structure and format are also reflected in the 2022 Annual Operating Plan (AOP) – specifically the monitoring and evaluation section of the plan.

Appendix A of this report provides a useful "road map" of the revised structure and format for all monitoring and evaluation (M&E) objectives, key questions and associated metrics including those that are still being developed by the ATS to meet obligations of the H&S plan. This report is formatted to conform to the structure provided in Appendix A.

There are potential near-term developments that may continue to alter the reporting format of this report. These developments include HGMP submittals, related biological opinion(s), ongoing fish program transition planning and expansion of the existing fish passage program into Yale and Merwin reservoirs. To be consistent with any changes from these developments, the H&S plan, AOP and annual reporting may require revisions to remain consistent with these new developments as they occur and as prescribed by Section 8 of the Lewis River Settlement Agreement (Agreement).

1.0 INTRODUCTION

This report documents results from monitoring and evaluation activities associated with implementing the H&S program in 2022. This report is required by Section 8.2.4 of the Lewis River Settlement Agreement (PacifiCorp and Cowlitz County PUD 2004) that states:

"On an annual basis, the Licensees shall provide to the ACC for review and comment a report compiling all information gathered pursuant to implementation of the Hatchery and Supplementation Plan. The report also will include recommendations for ongoing management of the Hatchery and Supplementation Program. The ACC shall have 60 days to comment on the annual report. Within 60 days of the close of the comment period, the Licensees shall finalize the report after consideration of all comments. The Licensees shall also provide the comprehensive periodic review undertaken pursuant to Section 8.2.6 below to the ACC. The Licensees shall provide final annual reports and the comprehensive periodic review to the Services during the development of any required ESA permit or authorization for hatchery operations, including NOAA Fisheries' HGMP process. The report may be included as part of the detailed annual reports of the ACC activities required by Section 14.2.6."

2.0 MONITORING AND EVALUATION RESULTS

Please refer to Appendix A for a summary of all objectives contained in this section. Where available, this section provides summaries of data collected in 2022 and in many instances provides multi-year estimates of associated metrics to summarize and illustrate multi-year trends for specific key questions. For more detailed information including analysis on specific objectives, please refer to various attachments to this report. For information on study designs, methodology and analytical methods please refer to the 2022 AOP, and specifically, the several monitoring strategies attached to the AOP.

Objective 1.0: NOAA acceptance of a Hatchery and Genetic Management Plan (HGMP) for each hatchery program on the North Fork Lewis River

As of March 28, 2023, no HGMP's have been consulted on by NOAA. However, this is a priority task of the WDFW and PacifiCorp as co-submitters and it is anticipated that early and late coho, spring Chinook and steelhead HGMP's will be submitted for consultation in the summer of 2023

Objective 1.1: Receive Biological Opinion for all submitted HGMPs

This objective will be completed after the HGMP's are submitted and NOAA Fisheries completes their HGMP consultation and finalizes their Biological Opinion.

Objective 2.0: Finalize a Hatchery and Supplementation Plan every 5 years

The Utilities submitted the final Hatchery and Supplementation Plan to the FERC on December 31, 2020. This plan was approved by the FERC on March 11, 2022 and represents the second rewrite (Version 3) of the original H&S plan approved in 2009. The next revision of the plan will be due on March 11, 2027, which is five years after the FERC approval date of the existing plan,

Objective 2.1: Finalize an annual operating plan (AOP)

The final 2022 AOP is attached to this report as Appendix B

Objective 2.2: Finalize and Annual Operations Report (AOR)

The final 2022 Annual Operations Report will be submitted to the FERC in June 2023. No delays are anticipated.

Objective 2.3: Finalize an annual hatchery operations report

The final 2022 hatchery operations report is attached as Appendix G to this report.

Objective 3.0: Determine whether hatchery production protocols incorporate best available management practices to support program targets and goals.

Key Questions

3A: Do hatchery broodstock collection protocols support program goals?

3A.1 Trap entry timing (Merwin Fish Collection Facility)

Trap entry timing for each of the transport species is provided below. For all species, only females were used to define trap timing between HOR and NOR adults. The use of females tends to be a more reliable indicator of spawn timing. Specific timing data for adults entering the Lewis River trap were not available at the time of this reporting and therefore this section only includes trap timing related to the Merwin Fish Collection Facility (MFCF).

Coho salmon

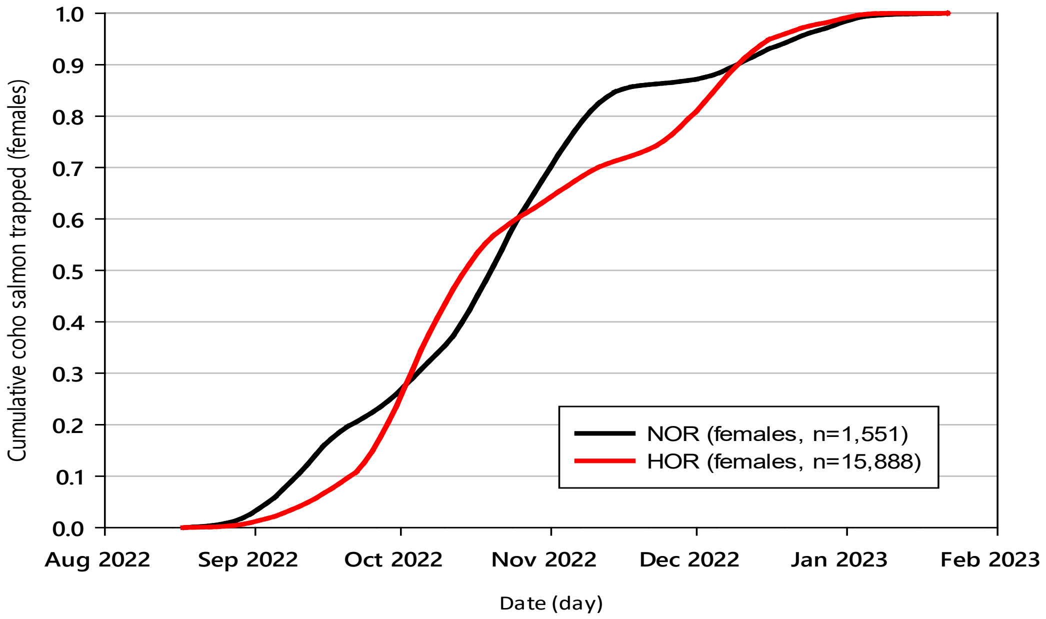


Figure 1. Percent cumulative trap returns of adult female NOR and HOR coho salmon at the MFCF - 2022

Spring Chinook salmon

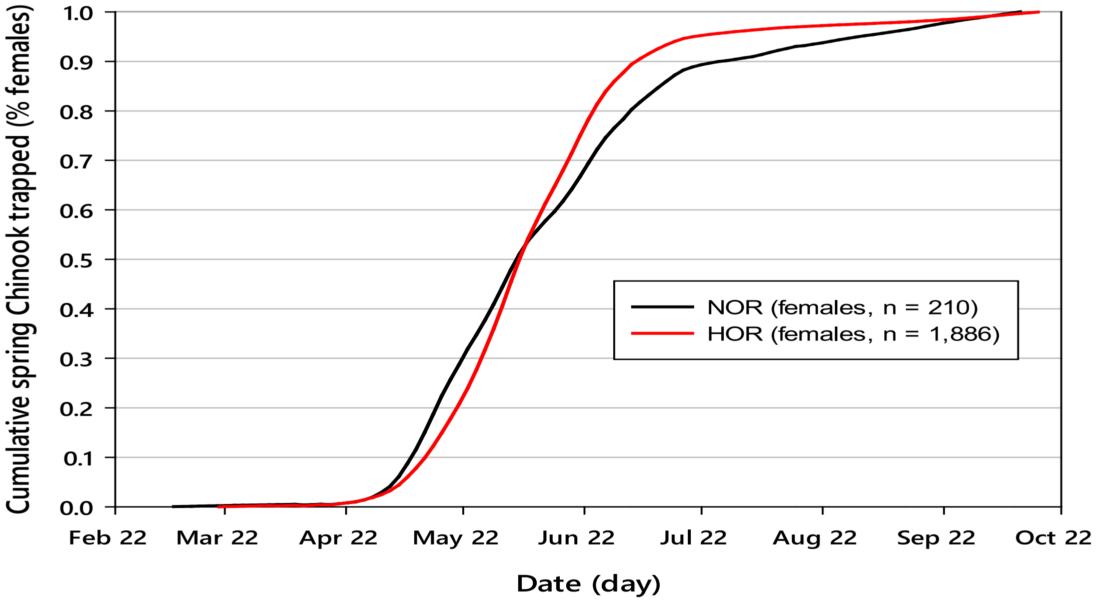


Figure 2. Percent cumulative trap returns of adult female NOR and HOR spring Chinook at the MFCF - 2022

Late Winter Steelhead

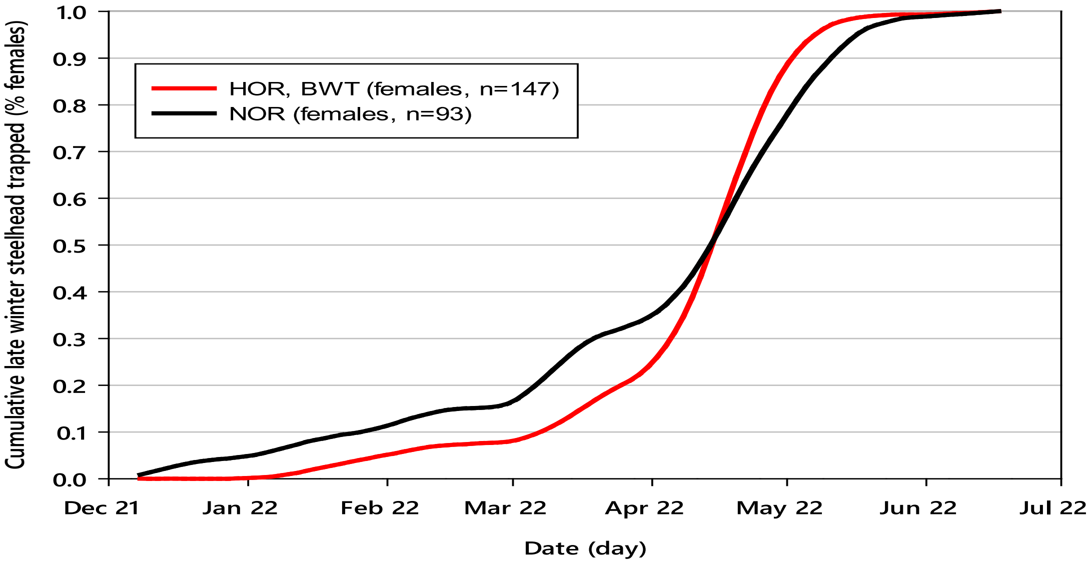


Figure 3. Percent cumulative trap returns of adult female NOR and HOR winter steelhead at the MFCF - 2022

3A.2 Broodstock retention rate (actual vs. planned)

Late Winter Steelhead

Steelhead broodstock are captured over a collection period that extends from January through May. The purpose of this protocol is to collect steelhead over the course of the run so that a representative sample of the natural-origin total run is spawned to limit selection bias in spawn time or other variables. However, collection timing is not always a reliable predictor of spawn timing as most NOR winter steelhead, regardless of collection time, typically spawn between mid-April and mid-May. No late winter steelhead were captured at the Lewis River trap and Figure 4 represents only captures from the MFCF.

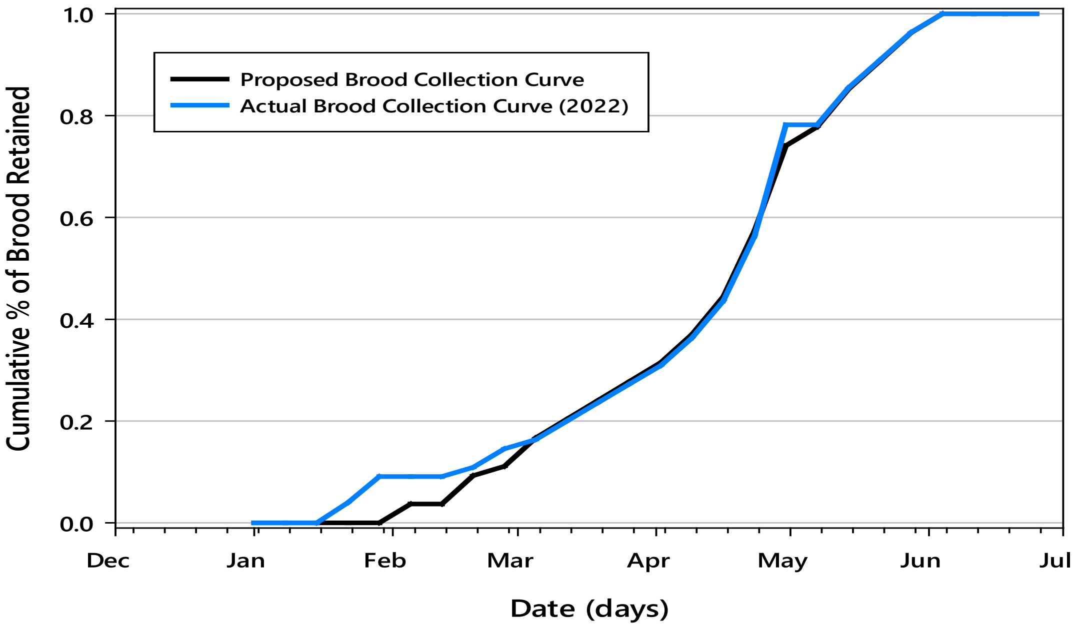


Figure 4. Actual percent cumulative late winter steelhead broodstock retained (blue line) vs. proposed broodstock retention curve provided in the 2022 AOP (black line).

Coho Salmon

Specific data related to broodstock retention timing for coho salmon were not available at the time of this reporting. Nearly all coho broodstock originate from the Lewis River ladder as most coho entering the MFCF are transported upstream to meet supplementation goals upstream of Swift Dam and to meet HPP needs upstream of Yale Dam in 2022.

Until those data are available from WDFW, a summary of broodstock retention from the Lewis River ladder is provided in Table 1. The first early coho retained for brood occurred on August 25, 2022 and on October 25, 2022 for late coho.

Table 1. Actual coho salmon broodstock retention rate at the Lewis River ladder - 2022.

STOCK	Trapping Totals (Lewis River only)		Brood Retained		Brood Retention Rate	
	HOR	NOR	HOR	NOR	HOR	NOR
Early Coho Salmon	24,007	329	1,427	*NA*	5.9%	*NA*
Late Coho Salmon	16,631	116*	1,802	79	10.8%	68.1%

** includes 31 late NOR coho transferred from MFCF to Lewis River hatchery*

Spring Chinook

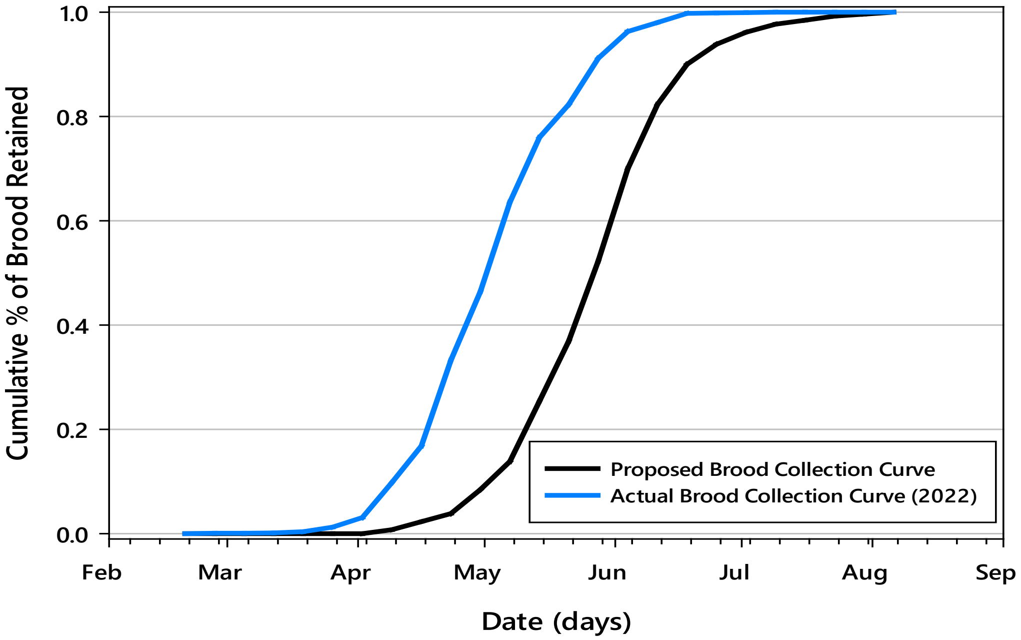


Figure 5. Actual percent cumulative late winter steelhead broodstock retained (blue line) vs. proposed broodstock retention curve provided in the 2022 AOP (black line).

3B: Do spawning, rearing and release strategies support program goals?

3B.1 Spawning Matrices and timing

Late winter steelhead

Table 2. Number of late winter steelhead spawning crosses, potential families, and duration of spawning period: 2009 - 2022

Brood Year	Crosses	Females	Males	Potential Families	Spawn Period	Days
2009	10	12	19		Mar 2 - May 21	81
2010	22	22	24		Mar 17 - May 14	56
2011	9	16	19		Mar 30 - May 18	49
2012	12	19	23		Apr 10 - May 29	49
2013	8	8	11		Apr 10 - May 6	26
2014	26	26	25		Apr 7 - May 16	39
2015	25	25	25		Mar 26 - May 22	58
2016	10	17	20		Apr 8 - May 27	49
2017	10	25	24		Apr 7 - May 19	43
2018	22	22	23	54	Mar 23 - May 25	63
2019	14	14	14	28	Apr 16 - May 17	32
2020	25	25	25	65	Apr 10 - May 15	35
2021	25	25	27	55	Apr 12 - May 21	39
2022	24	24	28	54	Apr 1 – Jun 2	62

Chinook and Coho Salmon

Table 3. Number of coho and Chinook spawned at Lewis River hatcheries by origin and sex

STOCK	HOR			NOR			HOR total	NOR total
	Male	Female	Jacks	Male	Female	Jacks		
Late Coho Salmon	857	929	21	61	16	2	1,807	79
Early Coho Salmon	509	524	15	▨	▨	▨	1,048	▨
Spring Chinook	585	632	13	▨	▨	▨	1,230	▨

3B.2 Broodstock Fecundity

Table 4. Average fecundity of hatchery spring Chinook, coho salmon and late winter steelhead: 2013 - 2022

Species	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Spring Chinook	3,352	3,495	3,410	3,278	3,017	3,152	3,429	3,278	3,095	3,227
Early Coho	3,089	2,842	2,079	3,235	2,479	2,607	2,445	3,075	2,670	2,980
Late Coho	3,465	3,046	2,387	3,506	3,205	3,374	3,158	3,686	3,053	3,097
Late Winter Steelhead	4,569	4,260	3,891	4,273	3,456	3,487	3,999	3,460	4,381	3,253

Table 5. Total green egg take of hatchery spring Chinook, early coho, late coho and late winter steelhead: 2013 - 2022

Brood Year	Spring Chinook	Early Coho	Late Coho	Late Winter Steelhead
2013	2,099,865	1,948,980	3,333,388	36,555
2014	1,488,540	1,932,442	3,305,396	106,038
2015	877,960	1,182,472	4,772,532	97,265
2016	538,365	1,652,894	3,217,383	72,649
2017	1,459,300	1,512,300	4,762,524	86,406
2018	2,527,850	1,556,439	1,849,024	76,724
2019	1,649,400	1,603,903	2,763,787	63,985
2020	1,923,900	1,844,956	2,815,754	91,103
2021	1,851,100	1,685,270	2,854,957	123,391
2022	2,036,000	1,577,598	2,800,856	78,078

3B.3 Feeding rations and delivery methods

This metric was not monitored or evaluated in 2022

3B.4 Avian predation rate

This metric was not monitored or evaluated in 2022

3B.5 Volitional releases

See key question 4A

3B.6 Total Dissolved Gas evaluation at Lewis River hatchery

A follow up evaluation was completed in 2022 to assess whether the upwelling inflow configuration at Lewis River hatchery is contributing to elevated TDG levels observed in previous evaluations. Please see Appendix C for a complete reporting of 2022 results, the 2022 plan and results from earlier evaluations.

3C. Are adult collection, handling and disposition (as defined in the AOP) protocols consistent with HSRG recommendations?

3C.1 Size of returning HOR and NOR adults (Merwin Trap)

Fork length data between returning HOR and NOR adults was not available at the time of this reporting. Lengths of returning fish relies on several data sources including collection at MFCF and Lewis River ladder, and from adults being held at the hatcheries. A comprehensive data management protocol must be developed between the Utilities and WDFW that includes a mechanism to share data freely between both organizations. Developing this protocol is a priority of the ATS in 2023 and it is anticipated that these data will be made available for the 2023 annual report for both the current and past years.

The only data available for 2022 includes NOR spring Chinook captures at the MFCF and are summarized below.

Spring Chinook:

Average fork length of NOR spring Chinook collected at the MFCF:

Female – 734 mm (n=23)
Male – 730 mm (n=67)

Late Winter Steelhead: Not Available for 2022

Coho Salmon: Not Available for 2022

3C.2 Age of returning HOR and NOR adults

Chinook

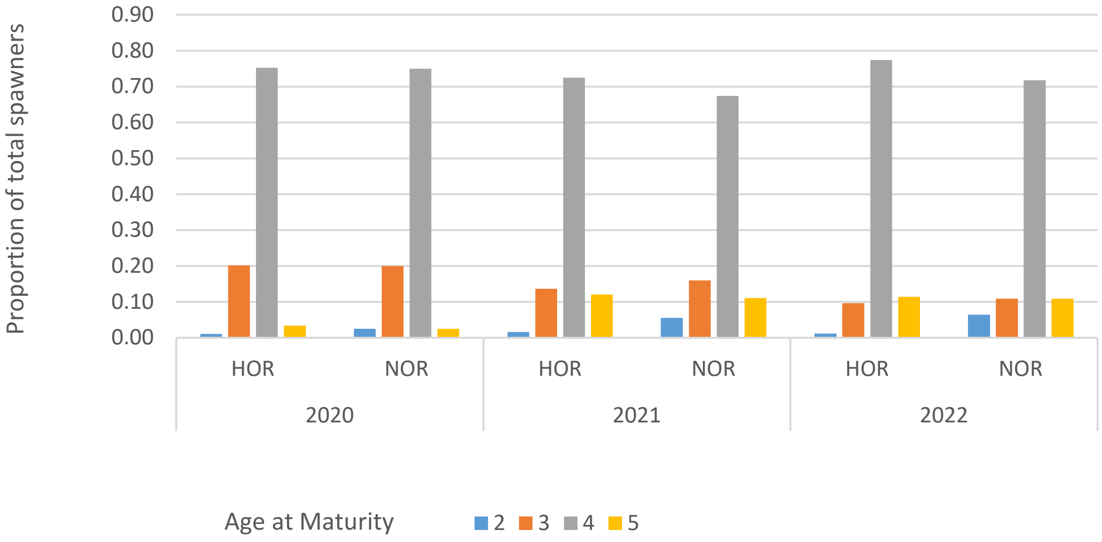


Figure 6. Age composition of returning spring Chinook sampled on the spawning grounds, North Fork Lewis River - 2020 – 2022

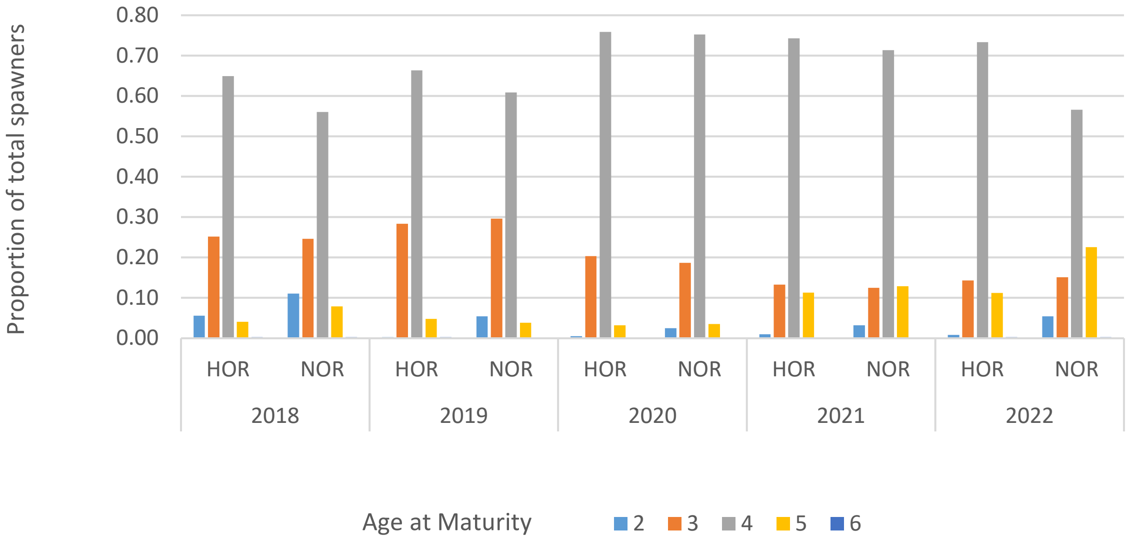


Figure 7. Age composition of returning fall Chinook (tules) sampled on the spawning grounds, North Fork Lewis River: 2018 – 2022

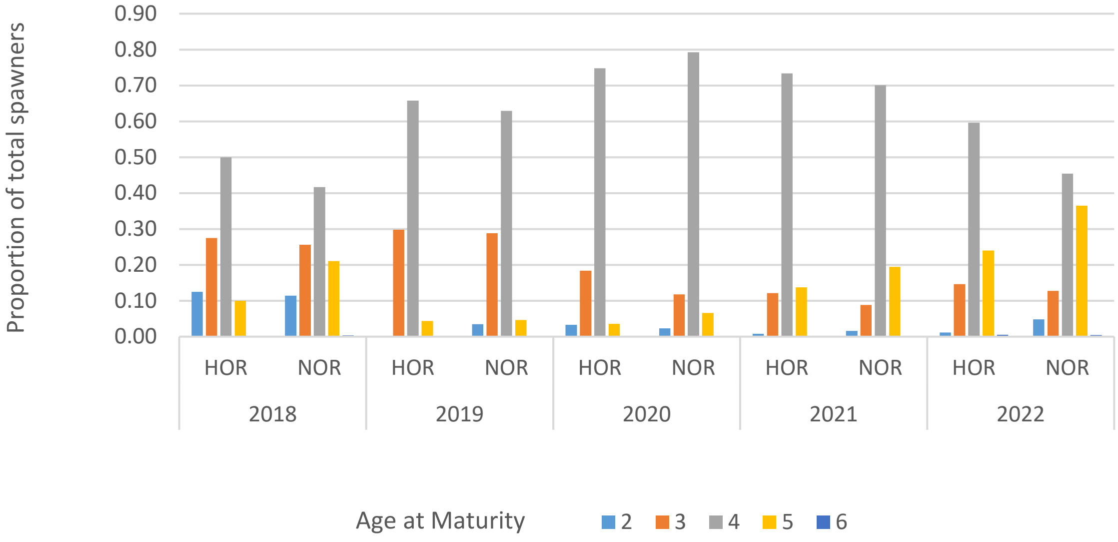


Figure 8. Age composition of returning fall Chinook (brights) sampled on the spawning grounds, North Fork Lewis River: 2018 – 2022

Coho Salmon and Late Winter Steelhead: Age data from scales collected from adult returns to the lower river traps was not available at the time of this reporting

3C.3 Distribution of adult trap captures

Adult Trap Captures (MFCF and Lewis Hatchery)

Table 6. Adult and jack trap captures by origin for coho salmon, spring Chinook and late winter steelhead at the Lewis River ladder and MFCF - 2022

STOCK	MFCF		Lewis Hatchery		Total Trapped (incl. jacks)
	HOR	*NOR*	*HOR*	*NOR*	
Coho Salmon	27,209	3,491	40,638	440	71,778
Spring Chinook	4,415	542	98	11	5,066
Late Winter Steelhead	460	179	0	0	639
Fall Chinook	145	291	74	0	510

Adult Upstream Transport Distribution Targets

Table 7. Total upstream transport of coho salmon, spring Chinook and late winter steelhead relative to H&S program transport targets - 2022

STOCK	Upstream Transport			Total Transported*	Transport Target*	Difference
	Upstream of Swift Dam		Yale Lake (HPP)			
	HOR	*NOR*	*HOR*			
Coho Salmon	5,816	3,780	1,801	11,397	11,300	+ 97
Spring Chinook	3,054	553	0	3,607	3,000	+ 607
Late Winter Steelhead	452	132	0	584	1700	(1,116)

** Total transported and target includes Swift target of 9,500 early and late coho and Yale HPP target of 1,801 HOR early coho*

Brood Distribution Targets

Table 8. Total broodstock retained of coho salmon, spring Chinook and late winter steelhead relative to H&S program brood targets - 2022

STOCK	Brood Retained		Total Brood Retained	Brood Target	Difference
	HOR	NOR			
Coho Salmon*	3,242	120	3,362	2,500	+ 862
Spring Chinook	1,297	0	1,297	1300	(3)
Late Winter Steelhead	8	46	54	60	(6)

** Coho brood retention includes egg needs for tribal (US v. Oregon) and regional educational programs. These additional egg programs are not part of the H&S program or the responsibility of the Utilities. Brood retention is not currently separated by program and is therefore reported as the total broodstock retained.*

Spawner Distribution Targets

Table 9. Total number of coho salmon, spring Chinook and late winter steelhead spawned at Lewis River hatcheries relative to H&S program spawner targets - 2022

STOCK	Spawned		Total Spawned	Spawner Target	Difference
	HOR	NOR			
Coho Salmon	2,855	79	2,934	2,400	+ 534
Spring Chinook	1,230	0	1,230	1,300	(70)
Late Winter Steelhead	8	46	54	55	(1)

Adult Mortalities and Carcass Distribution

Table 10. Total mortalities and carcass distribution by species and origin - 2022

STOCK	Mortalities		Total	Carcass Distribution**		Total
	HOR	NOR		HOR	NOR	
Coho Salmon	1,804	16	**1,820**	55,627	0	**55,627**
Spring Chinook	47	0	**47**	57	0	**57**
Late Winter Steelhead*	0	1	**1**	0	0	**0**

** All late winter steelhead are live spawned and released back to river.*
*** carcass distribution includes distribution to nutrient enhancement, food banks, tribal, landfill and commercial buyer*

3D. What are the estimated SAR's for each hatchery stock or rearing treatment group?

This key question was not evaluated in 2022, however the ATS is currently developing methods to estimate SAR's for all hatchery released smolts and it is anticipated that SAR values will be calculated for all stocks including smolts produced under the spring Chinook rearing and release evaluation in 2023.

Rearing and Release Evaluation

In 2017, the ATS initiated a rearing and release evaluation for spring Chinook (Strategy A). This evaluation consists of rearing a number of treatment groups that differ in the size at release (80, 12 and 8 fish per pound) and release timing (June, October and February). A key performance metric in evaluating the various treatment groups is estimating survival or the smolt to adult ratio (SAR) for each group. The specific methods to evaluate specific SAR's for each treatment group is currently in development. It is anticipated that initial SAR estimates will be provided once a complete release (5-year) cohort is available, and all CWT recoveries have been entered into RMIS – likely in late 2023. Therefore, we anticipate providing SAR metrics beginning with the 2023 annual report and on an annual basis until all full cohorts from the rearing evaluation have returned to the North Fork Lewis River.

Other indicators to evaluate rearing and migration performance of hatchery released smolts include migration, precocity sampling and age at maturity.

Table 11. Actual juvenile releases and trap returns by species and year: 2013 - 2022

		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
COHO SALMON	Juvenile Release	1,864,208	2,055,206	2,148,984	2,177,701	1,666,442	2,016,371	2,193,389	1,916,165	1,957,690	2,155,007
	Adult HOR Trap Return	28,752	72,847	21,453	33,331	23,064	21,226	14,035	38,310	59,052	67,847
	Adult NOR Trap Return	218	2,098	202	2,009	2,613	1,011	1,725	5,548	3,551	3,905
	Total Return (inc. jacks)	**28,970**	**74,945**	**21,655**	**35,340**	**25,677**	**22,237**	**15,760**	**43,858**	**62,603**	**71,752**
SPRING CHINOOK	Juvenile Release	1,286,171	1,086,637	1,244,910	600,967	402,224	802,048	1,278,855	1,314,441	1,321,373	1,600,844
	Adult HOR Trap Return	1,907	997	945	547	2,871	2,668	1,065	2,259	2,778	4,513
	Adult NOR Trap Return	41	22	42	16	40	26	36	175	288	553
	Total Return (inc. jacks)	**1,948**	**1,019**	**987**	**563**	**2,911**	**2,694**	**1,101**	**2,434**	**3,066**	**5,066**
LATE WINTER STEELHEAD	Juvenile Release	49,650	22,295	70,805	67,922	51,816	52,119	44,861	45,153	57,498	63,453
	Adult BWT Trap Return	714	1,048	1,252	851	634	1,217	992	726	208	460
	Adult NOR Trap Return	19	29	72	54	95	120	76	455	169	179
	Total Return (inc. jacks)	**733**	**1,077**	**1,324**	**905**	**729**	**1,337**	**1,068**	**1,181**	**377**	**639**

3E. Is the fish health strategy effective at reducing infections and mortalities?

3E.1 Infection rate and prevention

See Strategy D of the Annual Operating Plan.

3E.2 Mortality Rate

See Strategy D of the Annual Operating Plan.

3F. Do hatcheries incorporate new scientific advances to improve fish culture effectiveness and efficiency?

Periodic review of hatchery operations relative to current literature

The ATS has not conducted this review at the time of this reporting.

Objective 4.0: Adopt strategies that limit potential post-release ecological interactions between hatchery and NOR listed species

Key Questions

4A. Do current hatchery releases result in spatial and temporal overlap between HOR and NOR juveniles?

4A.1 Release locations of hatchery reared smolts relative to in-river spawning locations.

All hatchery releases include voluntary release period whereby rearing ponds are lowered and screens are pulled to provide a means for smolts to voluntarily migrate from the rearing ponds. After a specified volitional release period (up to 14 days), all smolts are forced out of the rearing ponds and either released directly to river or transported downstream and released to river. Table 12 provides the volitional release periods for each species including the release location.

Table 12. Volitional release schedule and location for steelhead, coho salmon and spring Chinook

Species	**Volitional Release Periods**	**Release Location**
Late Winter Steelhead	May 1 - May 30	Merwin boat Ramp (RM 19.6), Island Boat Ramp (RM 11.8), Martin Access Site (RM 6.8), Pekins Ferry (RM 3.4)
Winter Steelhead (chambers stock)	April 1 - April 15	Martin Access Site (RM 6.8), Pekin's Ferry (RM 3.4)
Coho Salmon	April 1 - April 15	Lewis River Hatchery
Spring Chinook	Oct 1 - 15, Feb1-15	Lewis River Hatchery

4A.2 Release timing of hatchery reared smolts relative to presence of NOR juveniles or adults.

See key question 4B below

4B. Does the migration rate of HOR juveniles result in overlap with NOR juveniles or spawning adults?

Migration timing and rates of HOR and NOR smolts

Migration timing is assessed using capture timing of smolts at the Lewis River screw traps. Using the screw traps to assess migration timing is limited in that the traps do not operate over the entire period of outmigration and the proportion captured is a measure of relative abundance and should not be inferred as an estimate of total abundance. Figures 9 and 10 illustrate temporal overlap between hatchery released smolts and naturally produced smolts during the period screw traps were in operation. See Objective 6 for estimates of juvenile abundance passing the screw traps.

Coho Salmon

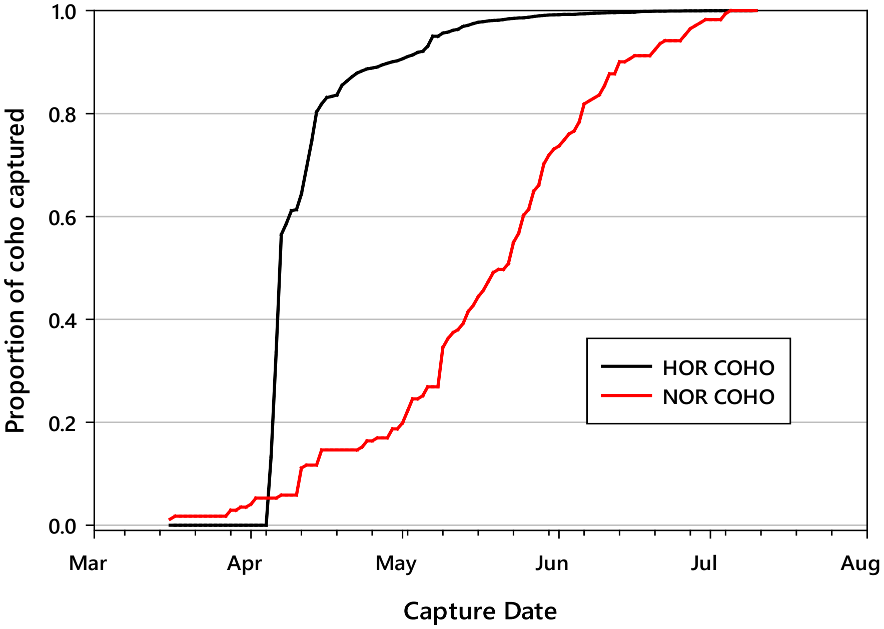


Figure 9. Cumulative proportion of HOR (n = 23,100) and NOR (n = 3,029) juvenile coho salmon unexpanded captures (capture timing) at the lower Lewis River screw trap – 2022. Hatchery release of coho began on April 2, 2022 and force out ended on April 16, 2022. All HOR coho released at Lewis River hatchery.

Late Winter Steelhead

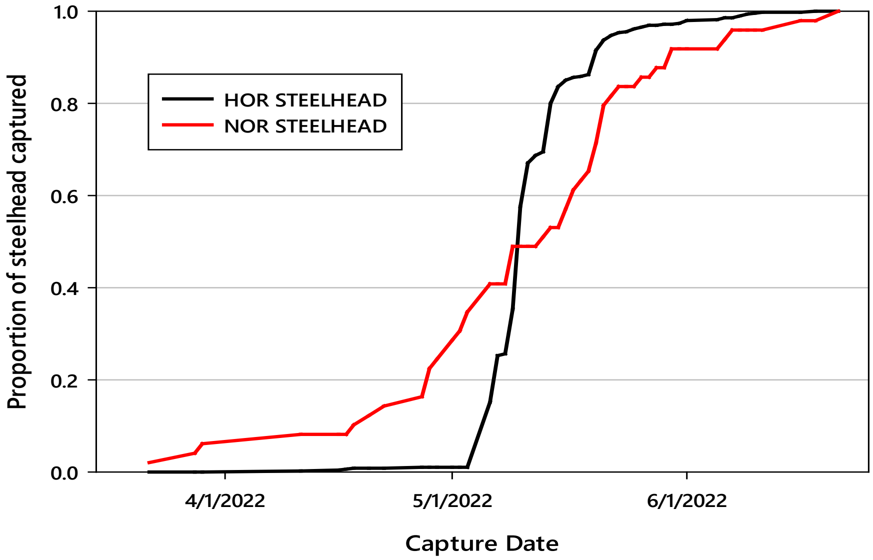


Figure 10. Cumulative proportion of HOR (n=900) and NOR (n=53) late winter steelhead smolt unexpanded captures at the lower Lewis River screw trap - 2022

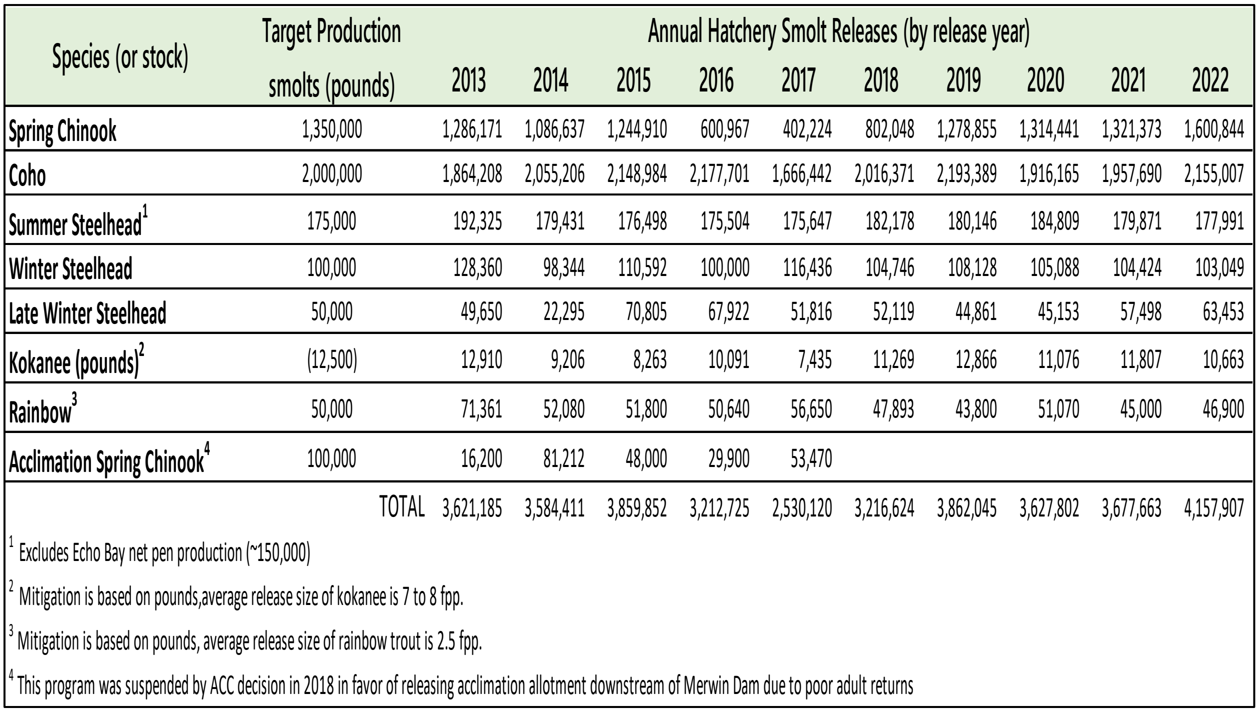
Chinook

No hatchery origin Chinook were captured in the trap to evaluate migration timing of hatchery released spring Chinook from Lewis River hatchery.

4C. Are the number of hatchery released juveniles equal to or less than production targets?

Number of smolts released by species

Table 13. Actual hatchery smolt releases vs. H&S program targets by species and year: 2013 – 2022



Species (or stock)	Target Production	Annual Hatchery Smolt Releases (by release year)									
	smolts (pounds)	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Spring Chinook	1,350,000	1,286,171	1,086,637	1,244,910	600,967	402,224	802,048	1,278,855	1,314,441	1,321,373	1,600,844
Coho	2,000,000	1,864,208	2,055,206	2,148,984	2,177,701	1,666,442	2,016,371	2,193,389	1,916,165	1,957,690	2,155,007
Summer Steelhead[1]	175,000	192,325	179,431	176,498	175,504	175,647	182,178	180,146	184,809	179,871	177,991
Winter Steelhead	100,000	128,360	98,344	110,592	100,000	116,436	104,746	108,128	105,088	104,424	103,049
Late Winter Steelhead	50,000	49,650	22,295	70,805	67,922	51,816	52,119	44,861	45,153	57,498	63,453
Kokanee (pounds)[2]	(12,500)	12,910	9,206	8,263	10,091	7,435	11,269	12,866	11,076	11,807	10,663
Rainbow[3]	50,000	71,361	52,080	51,800	50,640	56,650	47,893	43,800	51,070	45,000	46,900
Acclimation Spring Chinook[4]	100,000	16,200	81,212	48,000	29,900	53,470					
	TOTAL	3,621,185	3,584,411	3,859,852	3,212,725	2,530,120	3,216,624	3,862,045	3,627,802	3,677,663	4,157,907

[1] Excludes Echo Bay net pen production (~150,000)

[2] Mitigation is based on pounds,average release size of kokanee is 7 to 8 fpp.

[3] Mitigation is based on pounds, average release size of rainbow trout is 2.5 fpp.

[4] This program was suspended by ACC decision in 2018 in favor of releasing acclimation allotment downstream of Merwin Dam due to poor adult returns

4D. Are the sizes (length and weight) of released hatchery juveniles equal to or less than program targets?

Mean length and weight of smolts released by species and period

Table 14. Release size compared to H&S plan target for brood years 2016 - 2022, including corresponding coefficient of variation.

Stock	Target (fpp)	Release Year									
		2022		2021		2020		2019		2018	
		fpp	*CV**	*fpp*	*CV**	*fpp*	*CV**	*fpp*	*CV**	*fpp*	*CV**
Late Winter Steelhead	5 to 8	8.8	7.8%	9.2	NA	8.1	8.0%	8.7	18.8%	9.4	13.5%
Early Winter Steelhead	5 to 8	6.1	6.1%	4.9	7.2%	5.1	8.7%	4.6	NA	5.4	7.1%
Early Coho Salmon	16	16.3	7.0%	NA	NA	15.3	6.9%	15.3	6.8%	15.6	7.5%
Late Coho Salmon	16	16.2	7.9%	NA	NA	16	7.5%	16	7.7%	16.4	8.8%
Spring Chinook	8 to 12	12.9	8.2%	NA	NA	12.2	7.7%	12	6.0%	12	10.3%

* Note, there is no target for CV, however, this metric is routinely reported by hatchery staff

4E. What is the precocity rate for hatchery juveniles by release group prior to scheduled releases?

Precocity Rate

Spring Chinook (pre-release) precocity rate

Table 15. Observed precocity rate of pre-release spring Chinook sampled at Lewis River hatchery in October for the years 2019-2022

Year	Sample (n)	Raceway					Average
		13-1	13-2	13-3	13-4	14-4	
2019	1,031	5%	10%	9%	3%		7%
2020	830	3%	5%	4%	1%		3%
2021	559	1%	4%	3%	2%		2%
2022	1,764	2%	4%	4%	5%	11%	5%

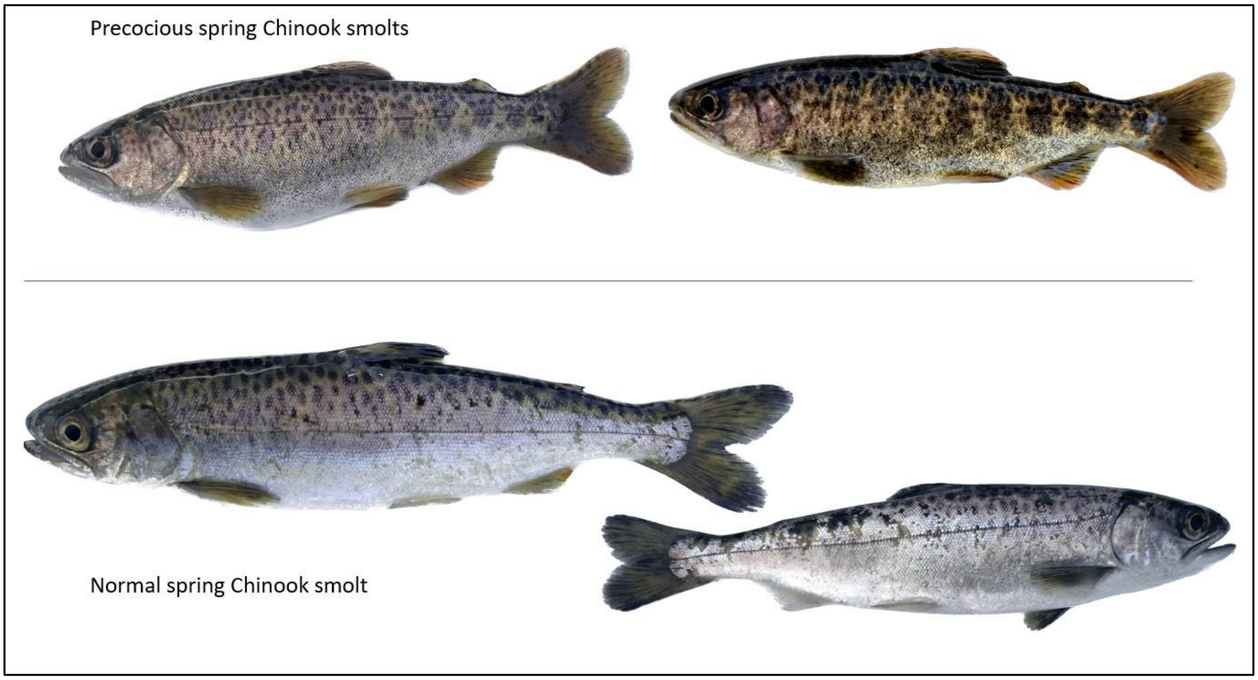


Figure 11. Images of precocious and normal spring Chinook smolts sampled at Lewis River hatchery, October 2022

Late Winter Steelhead

Table 16. Average length, weight and calculated condition factors for late winter steelhead pre-release and forced release groups sampled at Merwin hatchery, May 2022

Sample Date	Sample (n)	Release type	Avg. Length (mm)	Avg. Weight (g)	Mean K-factor (Fulton)
5/6/2022	70	Pre-release	181.0	61.0	0.99
5/31/2022	41	Forced release	175.0	55.0	0.99

K factor is a morphometric index estimate of body condition, which is determined by measuring the weight and length of individual fish.

Coho Salmon

No sampling in 2022

Objective 5.0: Estimate spawner abundance of late winter steelhead, Coho, chum and Chinook downstream of Merwin Dam

Key Questions

5A: Are estimates of spawner abundance unbiased and meeting precision targets?

Assumptions related to estimating spawner abundance have not been tested or evaluated for bias for coho or steelhead.   For Chinook however, WDFW has conducted assumption testing of various methods and have adapted the program to minimize bias (see Strategy G of the AOP). Coefficient of Variation (CV) estimates generally fall within targets for both Chinook and coho. CV estimates are not calculated for redd surveys which are used to estimate spawner abundance for steelhead.

5B: Are annual estimates of natural origin spawner abundance increasing, decreasing or stable?

Spawning abundance estimates the number of spawners in the North Fork Lewis River mainstem downstream of Merwin Dam. Natural spawner abundance estimates do not account for fish trapped and either used as broodstock or transported upstream as part of the supplementation program.

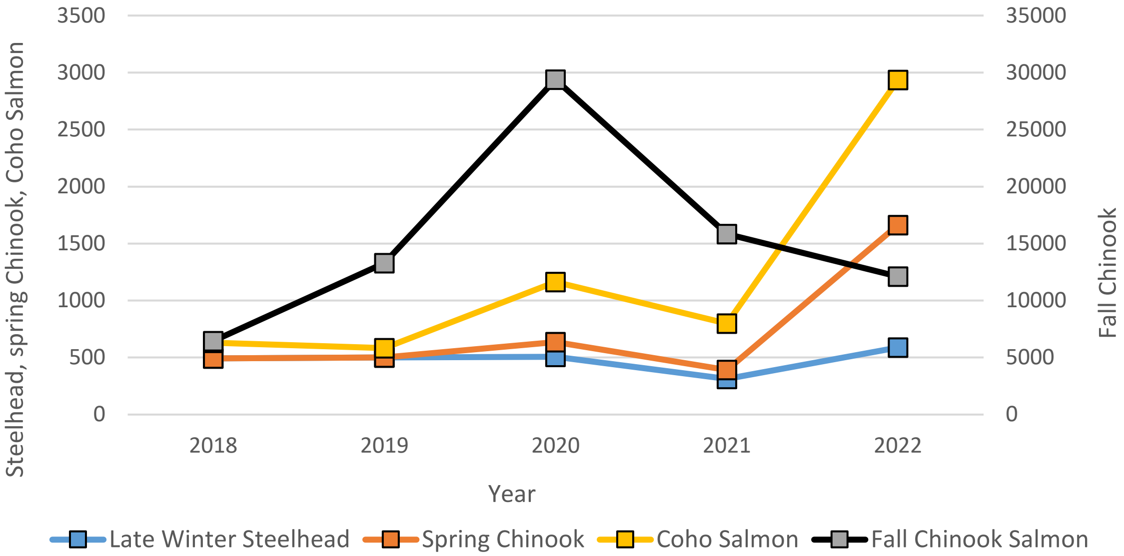


Figure 12. Estimated spawner abundance of naturally spawning fall Chinook, late winter steelhead, spring Chinook and coho salmon, North Fork Lewis River: 2018-2022. Note: estimates include both HOR and NOR spawners.

Table 17. Visual observation of 5-year trend of natural spawner abundance (HOR and NOR) for fall Chinook, late winter steelhead, spring Chinook (only 3 years available) and coho salmon, North Fork Lewis River: 2018-2022

Species	Observed Trend
Fall Chinook Salmon	Stable
Late Winter Steelhead	Stable
Spring Chinook Salmon	Increasing
Coho Salmon	Increasing

Late Winter Steelhead

Spawning abundance estimates rely on new redd census data, assumed sex ratio and females per redd to calculate total spawner abundance (Freymond and Foley 1986). Females per redd follow WDFW generalized guidelines of 0.81 females per redd and sex ratio is assumed to be equal. Beginning in 2013, we also calculate the spawner abundance using the observed sex ratio of late winter steelhead entering the Merwin Trap. This may be a more accurate estimate of female to male ratio in the river because of the large numbers captured in the trap and is unbiased in terms of capture efficiency for males or females.

Redd surveys (using jet sled) are used to estimate spawning abundance and distribution of winter steelhead in the mainstem North Fork Lewis River. Surveys are conducted weekly throughout the spawning period, which starts on March 1 and extends into mid-June.

A total of 273 individual redds were counted during redd surveys in 2022 (Table 18). Surveys began on March 17 and continued on a weekly basis until June 22. The survey area begins at Merwin Dam (RM 19) and continues to the downstream end of Eagle Island (RM 9.8). Based on redd counts, the estimated spawning population in 2022 is 588 total spawners (Table 18). Since 2018, this estimate is considered stable (Figure 13).

Using Merwin Trap capture data between December 8, 2021 through and June 21, 2022, a total of 639 late winter steelhead were trapped. This total includes 460 BWT and 179 NOR late winter steelhead. Of this total, 399 were male and 240 were female, or 1.6 males to every female.

Table 18. Late winter steelhead natural spawner abundance (HOR and NOR) estimates in the mainstem North Fork Lewis River downstream of Merwin Dam to lower end of Eagle Island: 2008 - 2022

Year	Number of Redds observed	Spawner Estimate	Observed sex ratio (females : males)	Spawner Estimate (corrected)[3]
2008	131	212		
2009	176	286		
2010	248	402		
2011	108	174		
2012	343	556		
2013	456	739	1 : 1.4	898
2014	364	590	1 : 0.8	531
2015	384	622	1 : 1.5	765
2016[2]	NA	357 (± 82)[1]	1 : 1.0	NA
2017[2]	NA	NA	1 : 1.2	NA
2018	317	492 (± 57)[1]	1 : 0.9	493
2019	292	473	1 : 1.1	500
2020	301	488	1 : 1.1	508
2021	226	366	1 : 0.7	313
2022	273	442	1 : 1.6	588

[1] Estimate is derived through H&S pHOS model using mark-recapture of tangle netted fish (See 2019 H&S AOP)

[2] Redd surveys were cancelled due to extreme river turbidity during spawning period

[3] Estimate uses the observed sex ratio provided by the total MFCF adult steelhead returns.

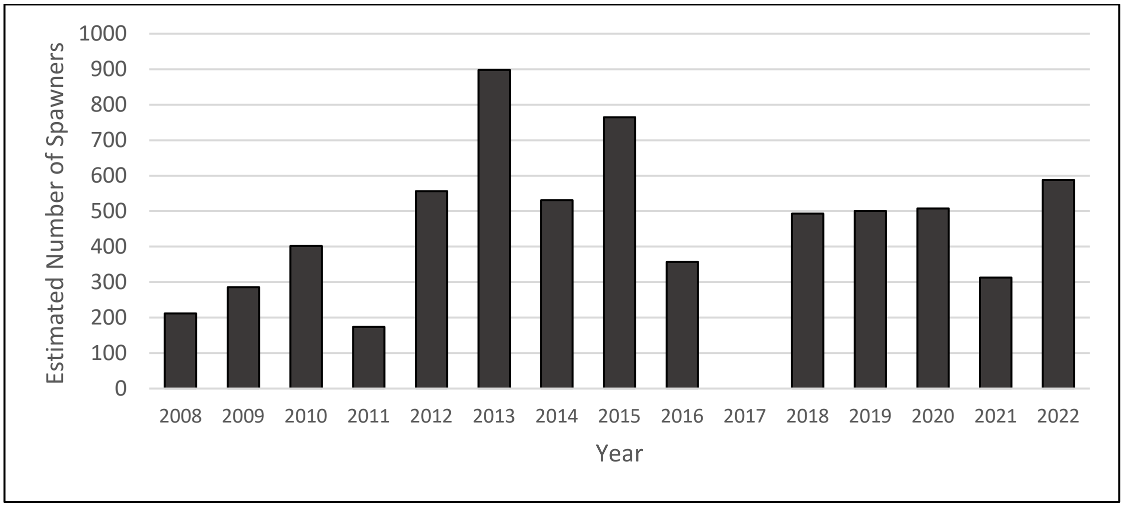


Figure 13. Estimated spawner abundance of late winter steelhead in the mainstem North Fork Lewis River from Merwin Dam to the downstream end of Eagle Island by year: 2008 – 2022

Chinook Salmon

Table 19. Annual natural spawner abundance (HOR and NOR) estimates for North Fork Lewis River Chinook salmon: 2013 - 2022

Year	Stock	Mean	SD	L.95%	Median	U.95%	CV
2013	Fall Chinook	**20,862**	**496**	**19,990**	**20,830**	**21,940**	**2%**
	Tule	*3,511*	*462*	*2,642*	*3,495*	*4,533*	*13%*
	Bright	*17,351*	*450*	*16,500*	*17,340*	*18,300*	*3%*
2014	Fall Chinook	**24,859**	**588**	**23,790**	**24,830**	**26,100**	**2%**
	Tule	*4,055*	*409*	*3,326*	*4,027*	*4,902*	*10%*
	Bright	*20,803*	*620*	*19,670*	*20,780*	*22,050*	*3%*
2015	Fall Chinook	**24,364**	**981**	**22,550**	**24,310**	**26,431**	**4%**
	Tule	*5,449*	*381*	*4,759*	*5,440*	*6,265*	*7%*
	Bright	*18,915*	*992*	*17,120*	*18,850*	*21,080*	*5%*
2016	Fall Chinook	**13,487**	**496**	**12,660**	**13,440**	**14,600**	**4%**
	Tule	4,127	482	3,329	4,073	5,225	12%
	Bright	9,360	243	8,912	9,357	9,863	3%
2017	Fall Chinook	**9,523**	**536**	**8,632**	**9,470**	**10,720**	**6%**
	Tule	*2,255*	*450*	*1,560*	*2,203*	*3,258*	*20%*
	Bright	*7,268*	*355*	*6,664*	*7,240*	*8,084*	*5%*
2018	Fall Chinook	**6,455**					
	Tule	*1,744*	*248*	*1,281*	*1,727*	*2,290*	*14%*
	Bright	*4,711*	*206*	*4,281*	*4,706*	*5,147*	*4%*
2019	Fall Chinook	**13,281**					
	Tule	*1,302*	*38*	*706*	*7,251*	*2,194*	*29%*
	Bright	*11,979*	*470*	*10,988*	*12,001*	*12,838*	*4%*
2020	Fall Chinook	**29,384**					
	Tule	*3,104*	*542*	*2,172*	*3,055*	*4,315*	*17%*
	Bright	*26,280*	*819*	*24,697*	*26,266*	*27,927*	*3%*
	Spring Chinook	*129*	*96*	*35*	*101*	*401*	*74%*
2021	Fall Chinook	**15,848**					
	Tule	*2,968*	*467*	*2,133*	*2,946*	*3,989*	*16%*
	Bright	*12,880*	*607*	*11,730*	*12,866*	*14,108*	*5%*
	Spring Chinook	*708*	*382*	*278*	*611*	*1,688*	*54%*
2022	Fall Chinook	**12,118**					
	Tule	*4,941*	*603*	*3,835*	*4912*	*6,193*	*12%*
	Bright	*7,177*	*564*	*6,042*	*7,182*	*8,264*	*8%*
	Spring Chinook	*1,075*	*550*	*411*	*939*	*2,508*	*51%*

Coho Salmon

Table 20. Annual natural spawner estimates (HOR and NOR) for coho salmon in the mainstem North Fork Lewis River: 2013 - 2022

Year	Number of marked carcasses	Number (%) of recaptured carcasses	Est. Gross Population Size	Bootstrap SE	95%-Confidence Interval	CV	Total Weeks Surveyable	Average Daily Flow during Surveys (cfs)	Average Daily Flow Oct 16-Jan-31
2013	328	41 (13%)	**1,970**	297	1,523 - 2,679	0.17	15	4,700	4,804
2014	431	18 (4%)	**7,805**	2,106	5,172 - 13,186	0.27	15	7,765	7,876
2015	12	2 (17%)	▨	▨	▨	▨	12	5,632	8,429
2016	65	20 (31%)	**124**	17	103 - 169	0.14	16	4,587	6,721
2017	24	8 (33.3%)	**44**	5	33 - 55	0.11	16	8,817	8,587
2018	61	22 (36%)	**137**	20	98 - 176	0.15	16	5,009	5,044
2019	40	7 (17.5%)	**83**	10	64 - 102	0.12	15	6,181	6,761
2020	223	65 (29%)	**527**	54	421 - 632	0.1	15	4,968	7,182
2021	94	14 (15%)	**407**	93	225 - 590	0.23	14	6,683	8,403
2022	338	53 (16%)	**1,273**	136	1,107-1,540	0.11	16	5,826	5,564

Note: In 2015, the number of marked carcasses was inadequate to provide a useful estimate of natural spawner abundance.

Objective 5.1: Determine the spatial and temporal distribution of spawning late winter steelhead, coho, chum and Chinook downstream of Merwin Dam

Key Questions

5.1A: Are annual trends in temporal and spatial spawning distribution increasing, decreasing or stable?

This key question relies on using a 5-year average to visualize distribution trends. Not all species have 5 years of data. Thus, available data from the past 5 years is used to denote trends. As annual evaluations continue to be implemented, it is anticipated that trend data will become more robust which will add confidence to annual determinations made through visual observations.

Table 21. Visual observation of available trend data for temporal and spatial distribution of late winter steelhead, coho salmon and Chinook salmon on the North Fork Lewis River

Species	Temporal Distribution	Spatial Distribution
Late winter Steelhead	Stable	Stable
Coho Salmon	Stable	Stable
Chinook	Stable	Not reported

Late Winter Steelhead

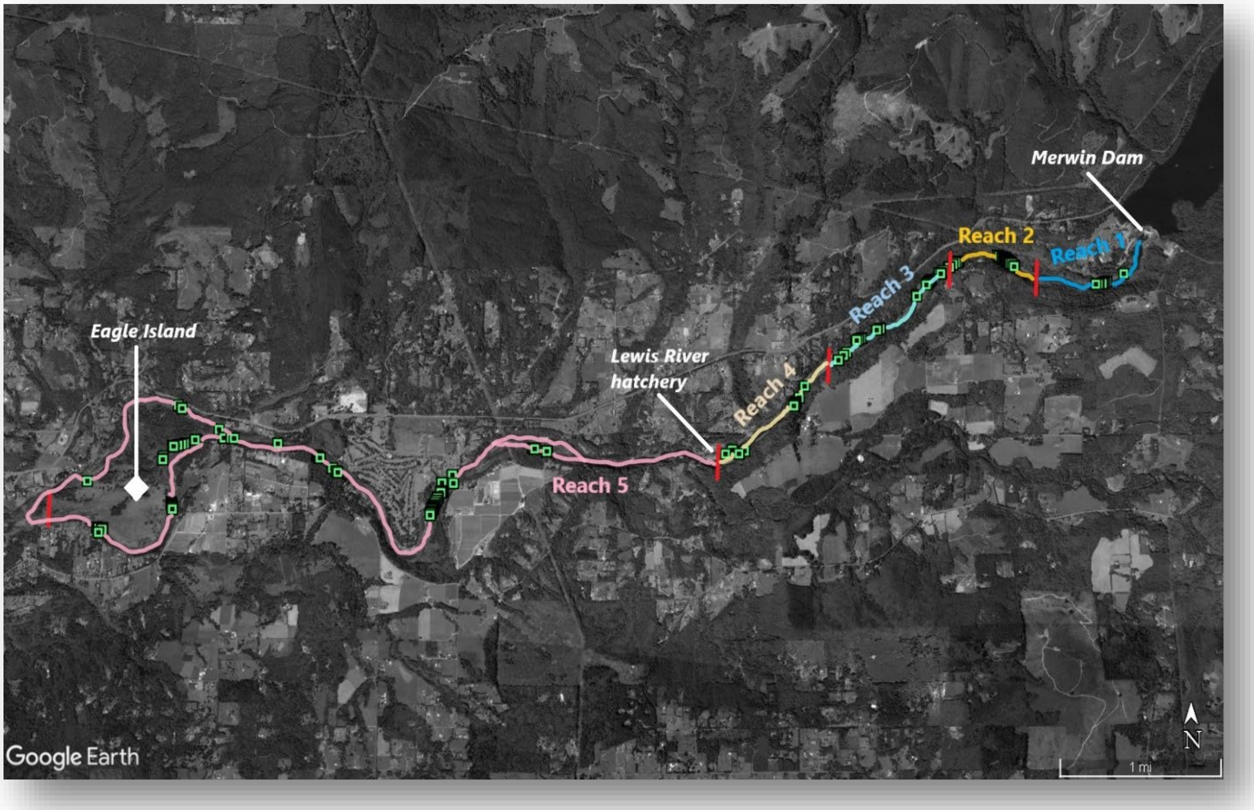


Figure 14. Distribution of late winter steelhead redds from Merwin Dam to the downstream end of Eagle Island (n=273) – 2022

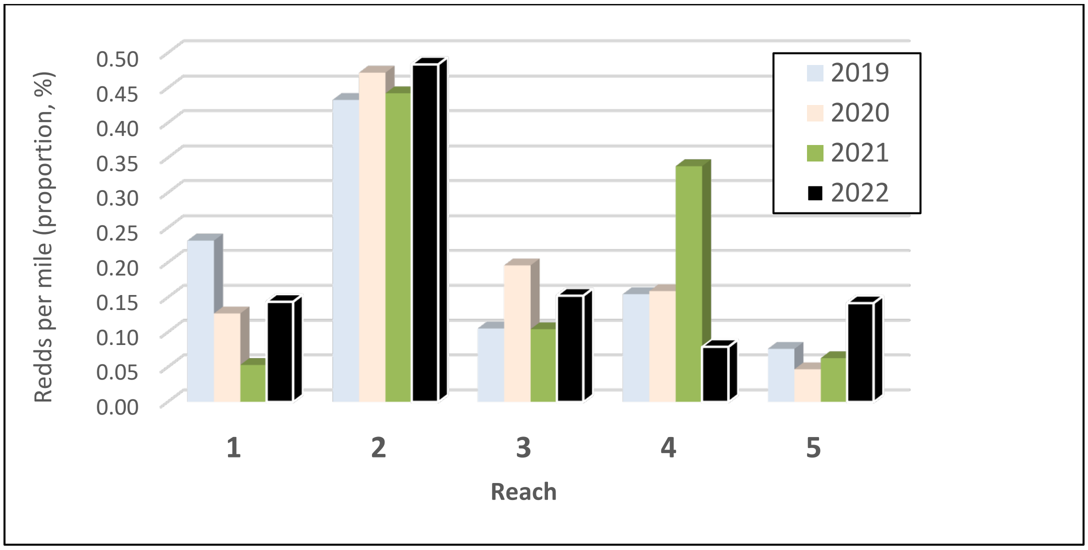


Figure 15. Spatial distribution and density of late winter steelhead redds by reach for the years 2019-2022

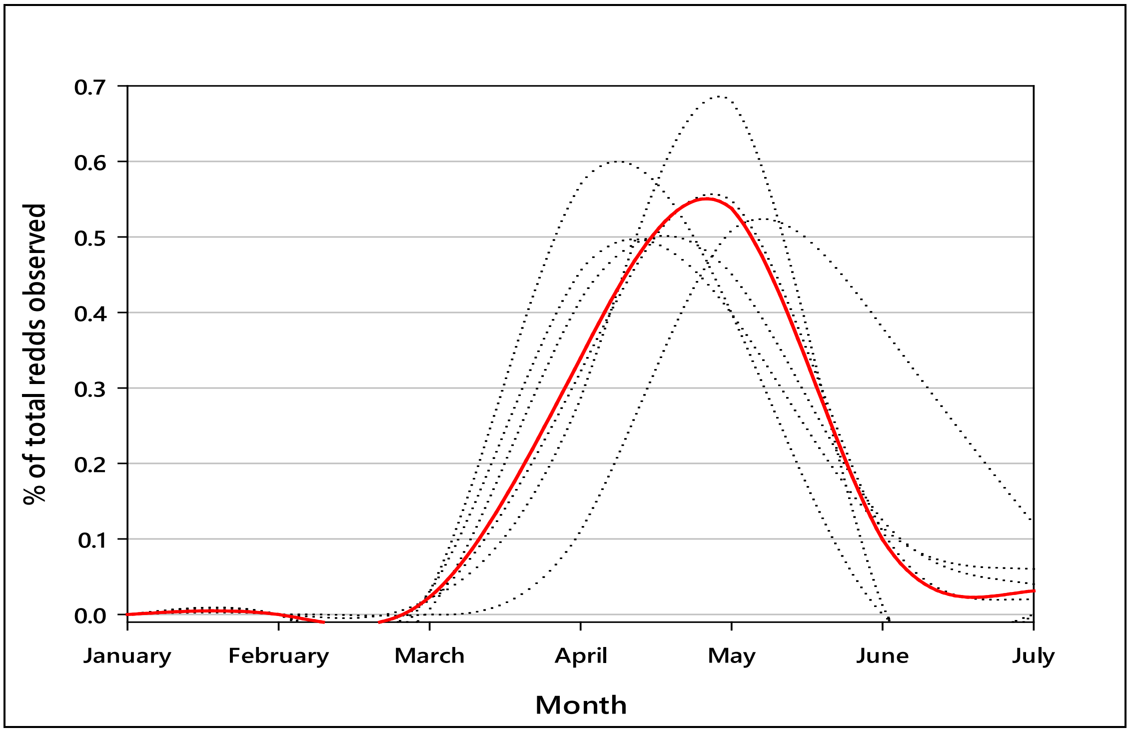


Figure 16. Proportion of observed new redds every 10 days for late winter steelhead redds; red line represents average of all years available 2015 - 2022

Coho Salmon

Table 22. Mainstem coho spawner distribution downstream of Merwin Dam by reach: 2017 - 2022

	NF Lewis River	Reach Length (miles)	Total Weeks (mid-Oct to Jan 31	Total Weeks Surveyable	Total Live Holders	Total Live Spawners	Total Carcass Unable to Sample	Hatchery Male Carcass	Hatchery Female Carcass	Unmarked Male Carcass	Unmarked Female Carcass	Total Carcass	Total Carcass Tagged	Total Carcass Recoveries	% Pre-spawn Mortality (Females	Carcass Wanded for CWT	CWT Positive Carcass
2017																	
	Reach 1	0.57	16	16	6	4	NA	0	0	0	0	0	0	0	NA	0	0
	Reach 2	0.68	16	16	4	14	NA	0	1	1	0	2	2	1	0%	2	0
	Reach 3	0.97	16	16	0	8	NA	0	0	0	0	0	0	0	NA	0	0
	Reach 4	1.32	16	16	20	25	NA	1	3	1	3	8	8	3	0%	8	0
	Reach 5	7.3	16	15	20	12	NA	7	2	3	2	14	14	4	25%	14	0
	Total	10.84	16	16	50	63	NA	8	6	5	5	24	24	8	9%	24	0
2018																	
	Reach 1	0.57	16	16	30	15	3	4	4	0	0	11	8	4	0%	8	0
	Reach 2	0.68	16	16	50	20	0	3	3	1	0	7	7	2	33%	7	0
	Reach 3	0.97	16	16	25	5	0	0	1	1	2	4	4	0	33%	4	0
	Reach 4	1.32	16	16	100	30	1	4	4	1	2	12	11	3	50%	11	5
	Reach 5	7.3	16	15	50	20	4	13	15	2	2	36	31	13	53%	32	3
	Total	10.84	16	16	255	90	8	24	27	5	6	70	61	22	42%	62	8
2019																	
	Reach 1	0.57	16	15	16	0	1	1	2	2	1	7	6	2	33%	6	0
	Reach 2	0.68	16	15	23	0	0	0	1	2	0	3	3	0	0%	3	0
	Reach 3	0.97	16	15	13	0	1	1	0	1	0	3	2	0	0%	2	0
	Reach 4	1.32	16	15	25	0	0	2	1	4	1	8	8	0	0%	8	0
	Reach 5	7.3	16	15	45	0	2	7	6	6	2	23	21	5	63%	21	0
	Total	10.84	16	15	122	0	4	11	10	15	4	44	40	7	43%	40	0
2020																	
	Reach 1	0.57	16	15	NA	NA	4	6	10	4	1	25	21	7	45%	21	0
	Reach 2	0.68	16	15	NA	NA	3	7	12	2	2	26	23	8	57%	23	0
	Reach 3	0.97	16	15	NA	NA	4	16	20	0	0	40	36	16	70%	36	0
	Reach 4	1.32	16	15	NA	NA	58	30	34	10	5	137	79	23	38%	79	1
	Reach 5	7.3	16	15	NA	NA	22	24	25	8	7	86	64	11	47%	64	0
	Total	10.84	16	15	NA	NA	91	83	101	24	15	314	223	65	49%	223	1
2021																	
	Reach 1	0.57	16	14	NA	NA	2	1	7	2	0	12	10	2	57%	10	0
	Reach 2	0.68	16	14	NA	NA	1	4	3	4	1	13	12	2	0%	12	0
	Reach 3	0.97	16	14	NA	NA	0	6	5	0	1	12	12	0	33%	12	1
	Reach 4	1.32	16	14	NA	NA	0	9	19	2	2	32	32	7	67%	32	0
	Reach 5	7.3	16	14	NA	NA	0	10	12	2	4	28	28	3	56%	28	0
	Total	10.84	16	14	NA	NA	3	30	46	10	8	97	94	14	54%	94	1
2022																	
	Reach 1	0.57	17	17	NA	NA	2	13	11	3	4	33	31	7	33%	31	1
	Reach 2	0.68	17	16	NA	NA	2	14	24	3	1	44	42	11	56%	42	0
	Reach 3	0.97	17	16	NA	NA	0	10	12	5	3	30	30	2	27%	30	1
	Reach 4	1.32	17	16	NA	NA	13	36	46	10	8	113	98	19	48%	100	1
	Reach 5	7.3	17	16	NA	NA	14	57	58	12	13	154	137	14	42%	140	1
	Total	10.84					31	130	151	33	29	374	338	53	44%	343	4

Coho Salmon (tributary surveys)

Table 23. Spawner distribution of coho salmon in selected tributaries of the North Fork Lewis River: 2017 - 2022

	Stream	Reach Length (miles)	Total Weeks (mid Oct through Jan)	Total Weeks Surveyable	Total New Redds	Total Live Holders	Total Live Spawners	Total Carcass Unable to Sample	Hatchery Male Carcass	Hatchery Female Carcass	Unmarked Male Carcass	Unmarked Femal Carcass	Total Carcass	% Pre-spawn Mortality (Females)	Carcass Wanded for CWT	CWT Positive Carcass
2017																
	Hayes Trib 1	1	16	16	2	0	0		0	0	0	0	0	NA	0	0
	Hayes Trib 2	0.5	16	16	0	0	0		0	0	0	0	0	NA	0	0
	Robinson Creek	1	16	16	15	0	16		0	0	1	1	2	0%	2	0
	Ross Creek	1	16	16	30	0	20		0	3	5	3	11	0%	11	0
2018																
	Ross Creek	1	16	15	12	1	10	0	1	2	0	0	3	0%	3	0
	Johnson Creek	0.95	16	16	17	2	8	1	1	0	0	1	3	0%	2	0
	Hayes Creek	1	16	13	1	0	1	0	0	0	0	0	0	0%	0	0
	Hayes Trib. 2	1	16	13	0	0	0	0	0	0	0	0	0	NA	0	0
	Bratton Creek	1	16	16	0	0	0	0	0	0	0	0	0	NA	0	0
2019																
	Ross Creek	1	15	12	13	2	29	2	0	2	2	4	10	0%	8	0
	Houghton Creek R1	1	15	14	16	0	5	0	0	1	0	1	2	0%	2	0
	Houghton Creek R2	1	15	11	0	0	0	0	0	0	0	0	0	NA	0	0
	Hayes Creek Trib 2	1	15	11	0	0	0	0	0	0	0	0	0	NA	0	0
2020																
	Robinson Creek	1	16	12	24	0	6	0	1	0	0	0	1	NA	1	0
	Hayes Creek	1	16	10	0	0	0	0	0	0	0	0	0	NA	NA	NA
	Hayes Trib 1	1	16	10	0	0	0	0	0	0	0	0	0	NA	NA	NA
	Hayes Trib 2	1	16	10	0	0	0	0	0	0	0	0	0	NA	NA	NA
2021																
	Johnson Creek R1		16	14	41	8	72	2	0	0	2	0	4	NA	2	0
	Bratton Creek R1		16	13	2	0	2	0	1	1	0	0	2	0%	2	0
	Hayes Creek Trib 1		16	11	0	0	0	0	0	0	0	0	0	NA	NA	NA
	Hayes Creek Trib 2		16	11	0	0	0	0	0	0	0	0	0	NA	NA	NA
2022																
	Houghton Creek	1	17	16	46	4	49	4	2	4	0	2	12	17%	8	0
	Ross Creek	1	17	15	53	0	68	0	1	9	1	0	11	11%	11	0
	Hayes Creek Trib 1	1	17	12	0	0	0	0	0	0	0	0	0	NA	NA	NA
	Hayes Creek Trib 2	1	17	12	0	0	0	0	0	0	0	0	0	NA	NA	NA

Chinook Salmon (mainstem)

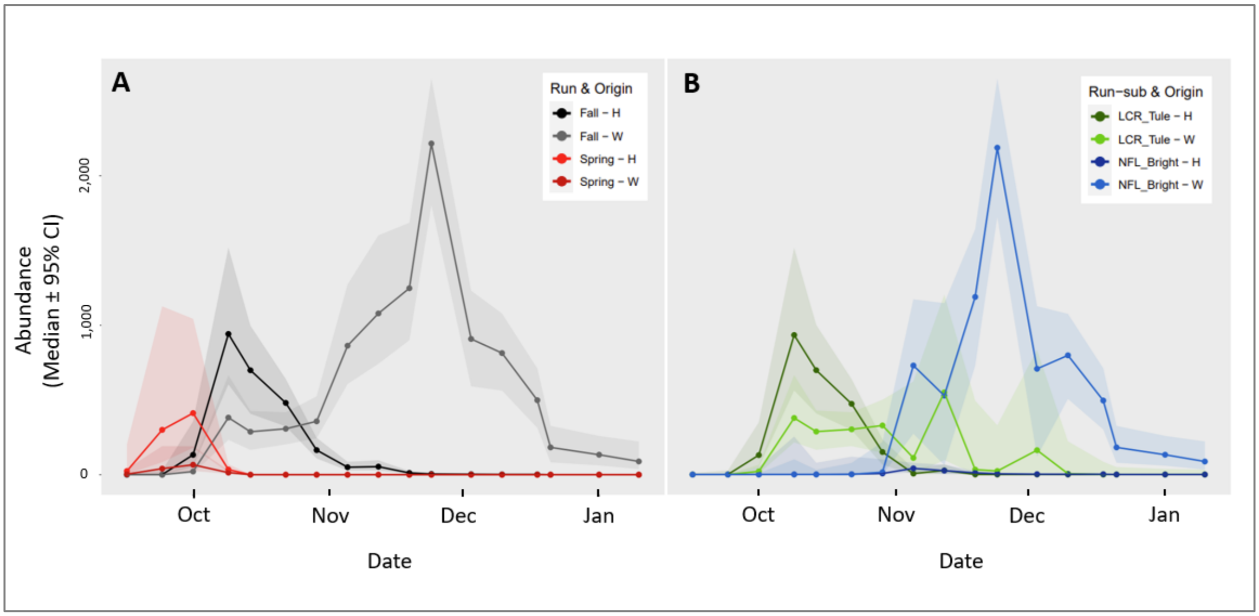


Figure 17. Weekly estimated abundance of A) spring-(red), and fall-(black) run Chinook inthe NFK Lewis River, 2022 by origin and tule (green) and bright (blue) runs. (source WDFW, appendix F)

Objective 6.0: Estimate juvenile outmigrant abundance for late winter steelhead, coho, and Chinook downstream of Merwin Dam

Key Questions

6A: Are estimates of NOR juvenile outmigrant abundance unbiased and meeting precision targets?

Monitoring assumptions have not been specifically tested for bias. Coefficient of Variation (CV) calculations were between 8 and 12 percent for coho and Chinook, and between 18 and 32 percent for 2+ and 1+ steelhead, respectively.

6B: Is the abundance of NOR juvenile outmigrants by species and outmigration year increasing, decreasing, or stable?

Abundance estimates of total NOR migrants by species and cohort

In 2022, two 8-foot rotary screw traps operated in tandem (side by side) at the Lewis River golf course site (RKM 21.6) between March 15 and July 10, 2022. For detailed results please see Appendix D. The estimated number of fish passing the trap site is provided in Table 24 and available trend of juvenile abundance is provided in Figure 18.

Table 24. Mean bootstrap abundance estimates of migratory coho (by origin), NOR Chinook and NOR winter steelhead juveniles passing the screw trap, NFL Lewis River by year: 2016 - 2022

Year	HOR Coho	NOR Coho	NOR Chinook	NOR Steelhead
2016	1,309,518	74,065	*NA*	20,404
2017	811,302	62,075	*NA*	6,866
2018	1,852,836	16,488	1,250,158	2,212
2019	No trapping			
2020	1,820,357	29,161	*NA*	*NA*
2021	*NA*	63,781	4,595,197	52,193
2022	*NA*	271,441	2,694,572	59,971

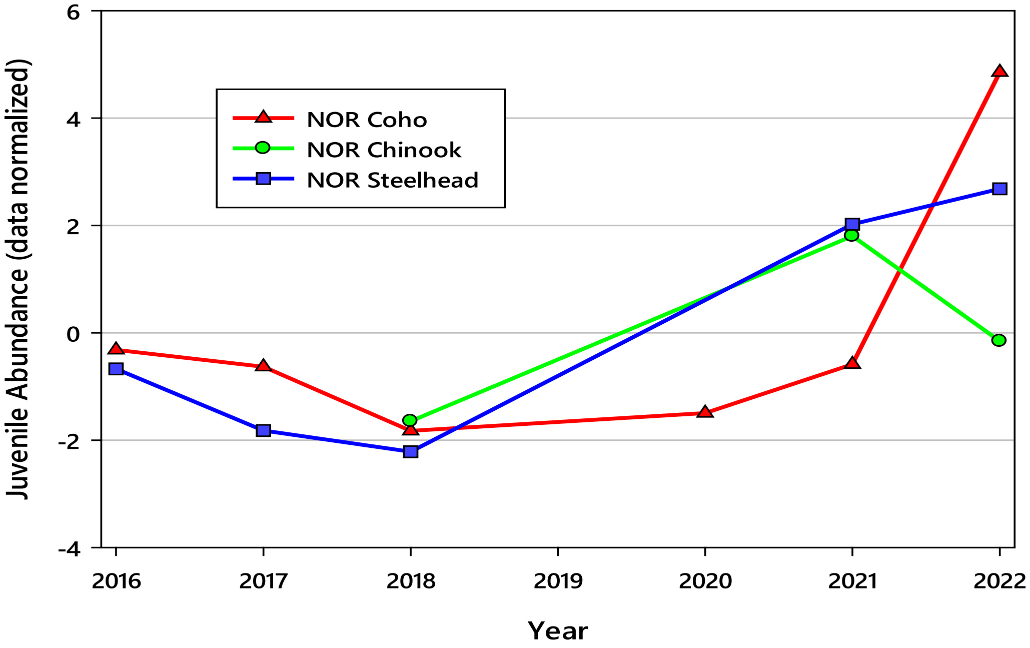


Figure 18. Trend analysis of bootstrap abundance estimates using a normalized y-scale for NOR coho, Chinook and winter steelhead passing the screw traps for years 2016 - 2022

2022 Observed Juvenile Abundance Trend (7-year)

Table 25. Observed 7-year juvenile abundance trend based on screw trapping data: 2016-2022

Species	Observed Trend
NOR Coho	Increasing
NOR Chinook	Stable
NOR Steelhead	Stable

6C: What are the morphological characteristics of out-migrating NOR juveniles relative to their conspecific HOR juveniles?

Phenotypic differences between NOR and HOR juveniles (smolts, transitional)

All screw trap captures were measured for fork length. Differences between sizes (FL, mm) of smolts and transitional life stages upon capture by origin for coho and steelhead are summarized in tables 26 and 27. Comparisons between spring Chinook are not available as no HOR Chinook were captured at the screw traps.

Coho Length

Table 26. Summary statistics for fork lengths (mm) of HOR and NOR coho smolts captured at the NFK Lewis River screw trap - 2022

Metric	HOR	NOR
Mean	135.46	119.46
Standard Error	0.17	1.01
Median	135	118
Standard Deviation	12.14	13.17
Minimum	72	90
Maximum	185	176
Count	5030	171

Steelhead Length

Table 27. Summary statistics for fork length (mm) of HOR and NOR winter steelhead captured at the NFK Lewis River screw trap - 2022

Metric	HOR	NOR
Mean	183.04	178.18
Standard Error	0.76	4.88
Median	184	170
Standard Deviation	16.83	34.19
Minimum	108	116
Maximum	230	276
Count	495	49

Chinook

No hatchery origin Chinook captured

Objective 7.0: Monitor the extent of genetic risks associated with integrated and segregated hatchery programs on naturally spawning listed populations in the North Fork Lewis River

Key Questions

7A. Have the Lewis River hatchery programs impacted the among-population diversity of naturally spawning populations?

See 7B below

7B. Have the Lewis River hatchery programs impacted the within-population diversity of naturally spawning populations?

A defined strategy to establish methods to monitor and evaluate among (7A) and within (7B) population diversity is currently in development by the ATS. In 2022, the ATS agreed that implementation of this monitoring is contingent upon understanding what information is available prior to initiating additional collection efforts of tissue samples. However, tissue collection activities at trapping sites were collected as described in the 2022 AOP. Analysis of these samples will be part of this evaluation and will assist in developing a sampling strategy to implement to monitor both among and within population risks upstream of Swift Dam and downstream of Merwin Dam.

7C. Have the Lewis River hatchery programs increased the risk of domestication for naturally spawning populations?

Estimates of pHOS are used to infer whether potential risk of domestication are present on integrated hatchery programs (i.e., late winter steelhead and late coho salmon) or for naturally occurring populations of fall Chinook. Please refer to key question 8A of this report for estimated pHOS on coho and Chinook. Methods to estimate pHOS for steelhead is currently being developed by the ATS in 2023.

7D. Have the Lewis River hatchery programs impacted the phenotypic diversity of naturally spawning populations?

Specific metrics are still being developed for this key question. However, there are a number of metrics used for other key questions that relate to this specific key question. These include:

- *Migration and trap timing(see 3.A.1),*
- *Spawn timing (see 3.B.3),*
- *Size and age at maturity (see 3.C.1),*
- *Size and age of juvenile NOR/HOR outmigrants (see 6.C),*
- *Fecundity (see 3.B.3),*
- *Precocity (see 4.E)*

Ongoing Genetic Analysis of Late Winter Steelhead Broodstock

As part of ongoing late winter steelhead broodstock management, data related to the origin of broodstock has been collected and analyzed since 2009. Results from 2022 are included here to compare the stock origin of unmarked late winter steelhead collected in the MFCF and transferred to Merwin hatchery as potential broodstock for the integrated program. Since the inception of the integrated program, the ATS agreed to use a primary genetic assignment target level of 50 percent or greater to the NF Lewis River or Cedar Creek stock(s) to be considered acceptable broodstock. After April 1, steelhead may be considered broodstock if assignment probability is 50 percent or greater to Cascade Strata. The only exception to these requirements is any steelhead indicating assignment probabilities to any hatchery stock (e.g., Chambers Creek) of more than 5 percent will never be incorporated in the broodstock.

A total of 52 samples were taken from steelhead broodstock transferred to Merwin hatchery from the MFCF. All sampled steelhead were assigned a probability percentage as to likelihood of assignment to known baselines established for Lower Columbia River tributaries including the North Fork Lewis River. Probabilities are classified as primary, secondary and tertiary to account for introgression from other basins and provide a more complete picture of diversity present within the samples. Figure 19 illustrates the results of the **primary** assignment for all samples between 2009 and 2022.

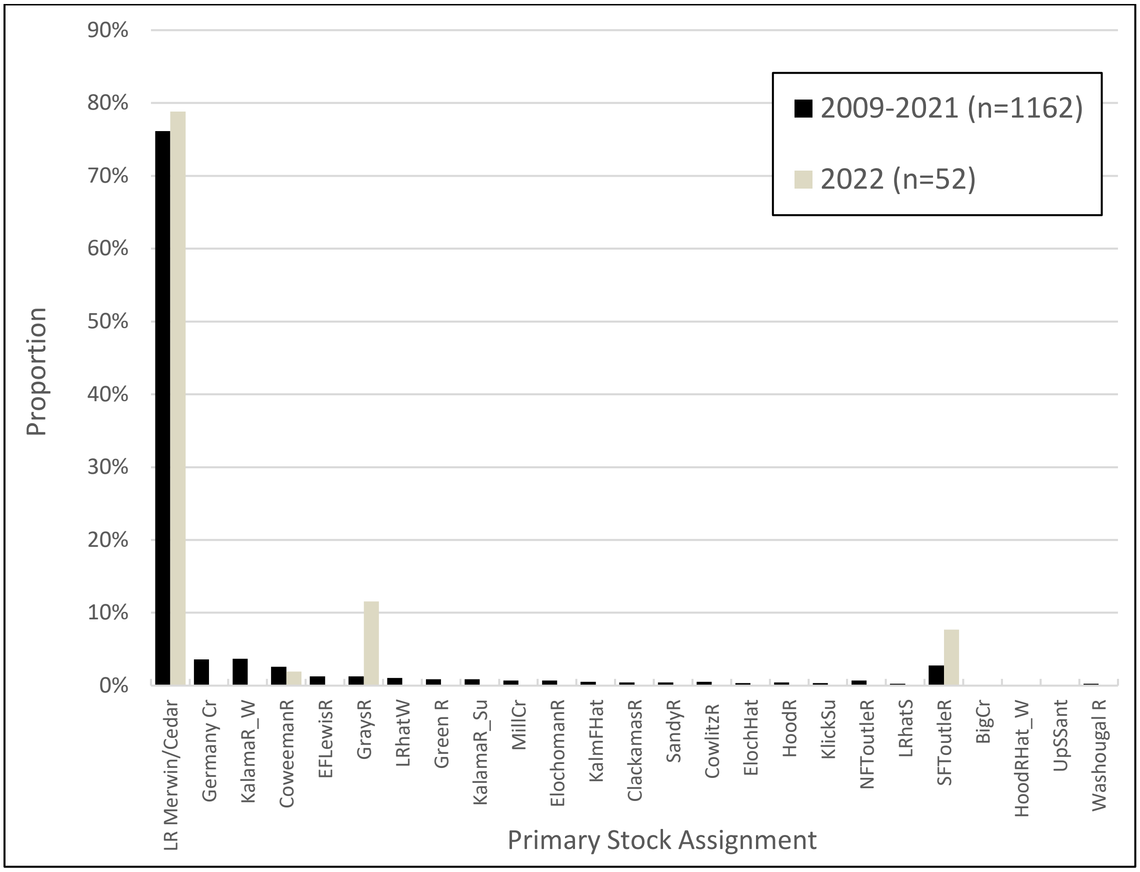


Figure 19. Proportion of primary genetic assignment of NOR late winter steelhead collected at the MFCF and tangle netting (until 2019) for the years 2009 - 2022

Objective 8.0: Determine the percent hatchery-origin spawners (pHOS), proportionate natural influence (PNI) and pNOB (for integrated programs)?

Key Questions

8A: What are the trends in pHOS, PNI, pNOB and PEHC and do they meet HSRG recommendations by program (when applicable)?

8A.1 pHOS - late winter steelhead

This metric was not evaluated in 2022 because a method to estimate pHOS on spawning grounds has not been established.

8A.2 pHOS – coho

Carcass surveys are used to estimate abundance of Coho salmon spawning in the mainstem North Fork Lewis River. The origin (hatchery or natural) of each carcass sampled is determined by the presence or absence of an adipose fin. To assign proper origin, all fish are wanded for the presence of a CWT as a portion of the return includes double index tagging (DIT). That is, adipose fin intact, but presence of CWT. An estimate of pHOS is generated by pooling the total number of carcasses sampled (including surveyed tributaries) over the sampling period. Table 28 provides the origin of trapped coho salmon in addition to carcasses sampled on the spawning grounds in 2022 for a more accurate estimate of actual pHOS for all returns. Appendix E provides data and analysis related to coho sampling in the mainstem and tributaries of the North Fork Lewis River during the 2022-2023 season.

Table 28. Origin of sampled coho carcasses from pooled mainstem and tributary surveys downstream of Merwin Dam with implied pHOS: 2016 - 2022

Year	Carcasses Sampled			
	HOR	NOR	TOTAL	pHOS %
2016	42	39	81	52%
2017	17	20	37	46%
2018	51	11	62	82%
2019	24	26	50	48%
2020	184	39	223	83%
2021	78	20	98	80%
2022	297	65	362	82%

Table 29. Origin of coho salmon returns sampled at the NFK Lewis River trapping facilities and from spawner surveys - 2022

STOCK	Trapping		Carcass Surveys		Total		Total pHOS (%)
	HOR	*NOR*	*HOR*	*NOR*	*HOR*	*NOR*	
Coho Salmon	67,847	3,905	297	65	68,144	3,970	94%

8A.3 pHOS – Chinook

Table 30. pHOS estimates for tule, bright and spring Chinook downstream of Merwin Dam on the North Fork Lewis River mainstem: 2013-2022

Year	Stock	Type	pHOS
2013	*Fall Chinook*		**7.7%**
		Tule	33.0%
		Bright	2.0%
2014	*Fall Chinook*		**10.5%**
		Tule	51.0%
		Bright	1.0%
2015	*Fall Chinook*		**18.0%**
		Tule	63.0%
		Bright	1.0%
2016	*Fall Chinook*		**22.9%**
		Tule	60.0%
		Bright	1.0%
2017	*Fall Chinook*		**17.6%**
		Tule	58.0%
		Bright	2.0%
2018	*Fall Chinook*		**12.0%**
		Tule	42.1%
		Bright	0.8%
2019	*Fall Chinook*		**3.8%**
		Tule	30.3%
		Bright	1.0%
2020	*Fall Chinook*		**5.4%**
		Tule	39.6%
		Bright	1.4%
	Spring Chinook		**68.2%**
2021	*Fall Chinook*		**11.8%**
		Tule	54.2%
		Bright	2.0%
	Spring Chinook		**79.0%**
2022	*Fall Chinook*		**22.0%**
		Tule	50.0%
		Bright	2.0%
	Spring Chinook		**85.0%**

8A.4 PNI

Late winter steelhead

Because current pHOS estimates are not available, a calculation of PNI is not possible for 2022. We anticipate that methods to evaluate pHOS will be developed by the ATS and provided to calculate PNI estimates in future years.

Late Coho Salmon

Estimates of pNOB for late coho salmon are not currently available from WDFW. As these data are provided to PacifiCorp, calculations of PNI will be provided as part of future annual reports.

8A.5 pNOB

Late Winter Steelhead

A total of 54 steelhead were spawned at Merwin hatchery. Of these, 8 were tagged with a blank wire tag (HOR) and the remaining 46 were unmarked (NOR). Calculated pNOB for the late winter program is 85%.

Late Coho Salmon

The total number of late coho spawned at Lewis River hatchery in 2022 was 1,807 HOR and 79 NOR. However, a portion of the HOR brood were spawned (HOR x HOR crosses) to meet tribal egg needs for the Washougal hatchery to support coho smolt releases into the Klickitat River. At this time, PacifiCorp has not been provided the portion of broodstock spawners used for the NFK Lewis River late coho program and therefore a calculation of pNOB is not available at this time.

3.0 UPSTREAM TRANSPORT OF STEELHEAD, COHO AND SPRING CHINOOK

Table 31. Number of male and female winter steelhead, coho salmon and spring Chinook transported upstream of Swift Dam: 2012 - 2022 (excludes HPP coho transported to Yale Lake)

Year	STEELHEAD			COHO				SPRING CHINOOK				Total
	Male	Female	Total	Male	Female	Jack	Total	Male	Female	Jack	Total	
2012	141	48	189	NA	NA	NA	206	0	0	0	0	**395**
2013	440	301	741	3,858	3,104	73	7,035	270	243	66	579	**8,355**
2014	452	581	1,033	4,788	4,217	174	9,179	0	0	0	0	**10,212**
2015	746	477	1,223	2,030	1,694	30	3,754	0	0	0	0	**4,977**
2016	382	390	772	3,430	3,377	539	7,346	0	0	0	0	**8,118**
2017	331	261	592	3,254	3,494	65	6,813	370	430	310	1,110	**8,515**
2018	682	535	1,217	3,999	2,659	402	7,060	491	177	32	700	**8,977**
2019	527	486	1,013	2,898	2,367	266	5,531	12	12	85	109	**6,653**
2020	517	535	1,052	4,319	4,911	256	9,486	193	56	385	634	**11,172**
2021	127	195	322	4,063	4,993	357	9,413	663	230	289	1,182	**10,917**
2022	374	220	594	4,302	4,851	392	9,545	1,886	1,428	286	3,600	**13,739**
Total	4,719	4,029	8,748	36,941	35,667	2,554	75,368	3,885	2,576	1,453	7,914	92,030

4.0 RECOMMENDATIONS FOR ONGOING MANAGEMENT

The annual operating plan (AOP) for the Hatchery and Supplementation program continues to be updated and used as an adaptive management tool to address both ongoing and new priorities as they relate to hatchery operations, supplementation activities and development of effective monitoring designs.

In 2020, the ATS finalized a revised H&S Plan which was submitted to the FERC in December 2020 and approved by the FERC in April 2022. This revised plan includes substantial revisions to the monitoring objectives incorporating HSRG recommendations and NMFS guidance in the form of VSP guidance.

Several challenges remain for implementing the AOP. Namely development of a genetics monitoring strategy, development of a strategy to evaluate SAR's of hatchery smolt release groups and a standardized sampling protocol for biological sampling (i.e., handling and sampling protocols). These challenges need to be resolved to fully implement the M&E program. Additionally, a data management system needs to be standardized to ensure accountability and storage of various data streams for each of the monitoring objectives. These challenges will be the priority of the ATS in 2023.

It is anticipated that HGMP's for all hatchery programs along with their associated transition plans will be submitted to NOAA in 2023. Once NOAA issues their biological opinion, some revisions to the existing set of monitoring objectives and key questions may need modification. However, we expect the biological opinion to refer to the H&S plan as the basis for M&E obligations of the biological opinion once issued.

In 2025, the Services are required to determine whether the program is achieving the stated goals in the Agreement. It is therefore the responsibility of the ATS and ACC to ensure that the data collected and analyzed under the H&S plan, AOP and AMEP provides the necessary detail, accuracy and precision for the Services to make this determination as required by the Agreement.

5.0 REFERENCES

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APPENDIX A –

Summary of monitoring objectives, key questions, metrics and status for 2022

	OBJECTIVE	KEY QUESTIONS		METRICS	Status in 2022
1.0	NOAA accepts final HGMP for each hatchery program				🔴
1.1	Biological Opinion is issued for each hatchery program				🔴
2.0	H&S Plan is submitted and accepted by the FERC				🟢
2.1	Finalize an annual operating plan (AOP)				🟢
2.2	Final annual operations report is submitted and accepted by the FERC				🟢
2.3	Final annual hatchery report is submitted by WDFW to the utilities				🟢
3.0	Determine whether hatchery production protocols incorporate best available management practices to support program targets and goals.	A. Do hatchery broodstock collection protocols support program goals?	3A.1	Trap entry timing (Merwin trap)	🟢
			3A.2	Broodstock retention rate	🟡
		B. Do spawning, rearing and release strategies support program goals?	3B.1	Spawning Matrices and timing	🟢
			3B.2	Broodstock Fecundity	🟢
			3B.3	Feeding rations and delivery methods	🔴
			3B.4	Avian predation rate	🔴
			3B.5	Volitional releases (see 4A)	🟢
			3B.6	Total Dissolved Gas at Lewis River hatchery	🟢
		C. Are adult collection, handling and disposition (as defined in the AOP) protocols consistent with HSRG recommendations?	3C.1	Size of returning HOR and NOR adults (Merwin Trap)	🔴
			3C.2	Age of returning HOR and NOR adults (Merwin Trap)	🟡
			3C.3	Distribution of adult trap captures	🟢
			3D	Smolt to Adult Ratio (SAR) of all hatchery releases	🔴
		E. Is the fish health strategy effective at reducing infections and mortalities?	3E.1	Infection rate and prevention	🔴
			3E.2	Mortality Rate	🔴
		F. Do hatcheries incorporate new scientific advances to improve fish culture effectiveness and efficiency?	3F	Periodic review of hatchery operations relative to current literature	🔴
4.0	Adopt strategies that limit potential post-release ecological interactions between hatchery and NOR listed species	A. Do current hatchery releases result in spatial and temporal overlap between HOR and NOR juveniles?	4A.1	Release locations of hatchery reared smolts relative to in-river spawning locations.	🟢
			4A.2	Release timing of hatchery reared smolts relative to presence of NOR juveniles or adults. (see 4B)	🟢
		B. Does the migration rate of HOR juveniles result in overlap with NOR juveniles or spawning adults?	4B	Migration timing and rates of HOR and NOR smolts	🟢
		C. Are the number of hatchery released juveniles equal to or less than production targets?	4C	Number of smolts released by species	🟢
		D. Are the sizes (length and weight) of released hatchery juveniles equal to or less than program targets?	4D	Mean length and weight of smolts released by species and period	🟢
		E. What is the precocity rate for hatchery juveniles by release group prior to scheduled releases?	4E	Precocity Rate	🟢
5.0	Estimate spawner abundance of late winter steelhead, Coho, chum and Chinook downstream of Merwin Dam	A. Are estimates of spawner abundance unbiased and meeting precision targets?	5A	Monitoring assumptions are met	🟡
		B. Are annual estimates of natural origin spawner abundance increasing, decreasing or stable?	5B	Estimate of total spawners (5 year trend)	🟢
5.1	Determine the spatial and temporal distribution of spawning late winter steelhead, coho, chum and Chinook downstream of Merwin Dam	A. Are annual trends in temporal and spatial spawning distribution increasing, decreasing or stable?	5.1A	Redds per mile and reach, redd, carcass and live timing (observed)	🟢
6.0	Estimate juvenile outmigrant abundance for late winter steelhead, coho, and Chinook downstream of Merwin Dam	A. Are estimates of NOR juvenile outmigrant abundance unbiased and meeting precision targets?	6A	Monitoring assumptions are met	🔴
		B. Is the abundance of NOR juvenile outmigrants by species and outmigration year increasing, decreasing, or stable?	6B	Abundance estimate of total NOR and HOR migrants by species and cohort	🟢
		C. What are the morphological characteristics of outmigrating NOR juveniles relative to their conspecific HOR juveniles?	6C	Phenotypic differences between NOR and HOR juveniles (length, smolt index)	🟢
7.0	Monitor the extent of genetic risks associated with integrated and segregated hatchery programs on naturally spawning listed populations in the North Fork Lewis River	A. Have the Lewis River hatchery programs impacted the among-population diversity of naturally spawning populations?	7A	F_{ST}, genetic distance combined with dendrograms, multi-variate clustering analyses	🔴
		B. Have the Lewis River hatchery programs impacted the within-population diversity of naturally spawning populations?	7B	Effective Population Size (N_e), Average F_{IS}, heterozygosity, allele frequency and number	🔴
		C. Have the Lewis River hatchery programs increased the risk of domestication for naturally spawning populations?	7C	See 8(a)	🟡
		D. Have the Lewis River hatchery programs impacted the phenotypic diversity of naturally spawning populations?	7D	Migration and trap timing(3.A.1), spawn timing (3.B.3), size and age at maturity (3.C.1), size and age of juvenile NOR/HOR outmigrants (6.C), fecundity (3.B.3),	🟡
8.0	Determine the percent hatchery-origin spawners (pHOS), proportionate natural influence (PNI) and pNOB (for integrated programs)	What are the trends in pHOS, PNI, pNOB and PEHC and do they meet HSRG recommendations by program (when applicable)?	8A.1	pHOS - late winter steelhead	🔴
			8A.2	pHOS - coho	🟢
			8A.3	pHOS - Chinook	🟢
			8A.4	PNI - late winter steelhead, late coho	🟡
			8A.5	pNOB - late winter steelhead, late coho	🟡

🔴	**Not Addressed in 2022**
🟡	**Incomplete**
🟢	**Complete**

APPENDIX B –

2022 Annual Operating Plan, H&S Program

2022

Annual Operating Plan

HATCHERY AND SUPPLEMENTATION PROGRAM
NORTH FORK LEWIS RIVER

Prepared by
the
North Fork Lewis River
Aquatic Technical Subgroup

December 28, 2022

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STRATEGIES AND APPENDICES

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DEFINITION OF TERMS AND ACRONYMS

Area Under the Curve (AUC): a method for estimating salmon escapement by dividing the integral of the escapement curve by the average residence time in the survey area.

Annual Operating Plan (AOP): An annual planning document that describes the methods and protocols needed to implement the North Fork Lewis River Hatchery and Supplementation Plan and Program.

Aquatic Coordination Committee (ACC): Committee formed after signing of the North Fork Lewis River Settlement Agreement (Settlement Agreement) and composed of its signatories. Many of the measures contained in the Settlement Agreement require review and consultation with the ACC prior to implementation. Thus, the committee acts as the governing body for implementing aquatic measures contained within the Settlement Agreement. The committee also approves aquatic habitat funds on an annual basis.

Aquatic Monitoring and Evaluation Plan (AMEP): A comprehensive planning document required by the North Fork Lewis River Settlement Agreement (Section 9). The purpose of the AMEP is to develop methods to evaluate aquatic monitoring and evaluation objectives contained within the North Fork Lewis River Settlement Agreement. These objectives relate to fish passage, reintroduction outcome goals, anadromous and resident species monitoring, and development of the North Fork Lewis River Hatchery and Supplementation Plan.

Aquatic Technical Subgroup (ATS): A subgroup of the Aquatic Coordination Committee intended provide technical recommendations to the ACC. The ATS is focused primarily on developing and reviewing technical aspects of plans, reports and monitoring strategies or objectives related to the Hatchery and Supplementation and Aquatic, Monitoring and Evaluation programs.

Bacterial Coldwater Disease (BCD): Bacterial disease of salmonid fish caused by *Flavobacterium psychrophilum*.

Bacterial Kidney Disease (BKD): Bacterial disease of salmonid fish caused by *Renibacterium salmoninarum.*

Bayesian Goodness of Fit (GOF): a test used to determine whether sample data are consistent with a hypothesized distribution.

Blank wire tag (BWT): A small wire that is uncoded (blank), inserted in the snout of fish, and detectible with handheld wire detection wands or devices. BWT are specific to the integrated late winter steelhead supplementation program and all BWT positive fish are of hatchery origin (HOR).

Brood year (BY): year in which spawning occurs, used to track a single cohort over time.

Coded wire tag (CWT): A small wire with unique codes etched onto the wire, inserted in the snout of fish, and detectible with handheld wire detection wands or devices.

Coefficient of Variation (CV): The ratio of the population standard deviation (σ) to the population mean (μ) *or* in instances when only a sample of data from the population is available CV is estimated by using the sample standard deviation (S) to the sample mean ($\bar{x}$) which shows the extent of variability in relation to the mean of the population. The absolute value of the CV, sometimes known as relative standard deviation, is expressed as a percentage.

- Population CV = σ/μ
- Sample CV = $s/\bar{x}$

Columbia Basin PIT Tag Information System (PTAGIS): A regional database that stores and tracks data from fish with passive integrated transponder (PIT) tags.

Condition factor (K): Fulton's condition factor, K, is a measure of individual fish health that assumes the standard weight of a fish is proportional to the cube of its length:

$$K = 100\left(\frac{W}{L^3}\right)$$

where *W* is the whole body wet weight in grams and *L* is the length in centimeters; the factor 100 is used to bring K close to a value of one (Fulton, 1904).

Distinct Population Segment (DPS): A population or group of populations that is discrete from other populations of the species and significant in relation to the entire species. This along with Evolutionarily Significant Unit (ESU) are used to define Endangered Species Act-listed species (DPS for steelhead and ESU for salmon species).

Effective Population Size (N_e): The average size of a population in terms of the number of individuals that can contribute genes equally to the next generation. Therefore, the effective population size is typically smaller than the actual census size of the population.

Enzyme-Linked Immunosorbent Assay (ELISA): This test uses antibodies and color change to identify viral antigens present in sampled fish tissues.

Ecosystem Diagnostic and Treatment (EDT) model: An analytical habitat-based model that evaluates environmental constraints on a fish population(s) and used to predict the carrying capacity or production potential of specific areas of the North Fork Lewis River such as upstream of Swift Dam.

Endangered Species Act (ESA): Passed in 1973, this piece of United States legislation was designed to protect species from extinction as well as the ecosystems upon which they depend. Listed species are classified as "threatened" or "endangered." The ESA is administered by the U.S. Fish and Wildlife Service and the National Marine Fisheries Service.

Evolutionarily Significant Unit (ESU): A distinct population unit that is reproductively isolated and an important component for the legacy of a species, considered a separate "species" for the purposes of conservation.

F1 generation: First generation offspring, in this case, typically referring to offspring of fish spawned in the hatchery and therefore of hatchery-origin.

F2 generation: Offspring of F1 parents that have spawned naturally and therefore of natural-origin.

Feed conversion ratio (FCR): The amount of feed an animal must consume to gain one kilogram of body weight.

Fish per pound (fpp): Number of juvenile salmon per pound batch weight

Floy tag: Visible tags with unique codes and colors applied to the dorsal side of fish to identify individual fish upon capture or through visual surveys. Floy tags are inserted near the posterior side of the dorsal fin and are intended to lock within the dorsal skeletal bones by means of a T-anchor.

Generalized Random Tessellation Stratified (GRTS) design: provides a probability sample with design-based variance estimators by establishing a spatially balanced, random sample allowing for unequal probability sampling to accommodate field implementation issues.

Hatchery and Genetic Management Plan (HGMP): a technical document that describes artificial propagation management strategies that ensure conservation and recovery of ESA-listed salmon and steelhead populations.

Hatchery and Supplementation Plan (H&S Plan): A 5-year planning document intended to provide the plan and process for implementing the goals of Section 8 (Hatchery and Supplementation Program) of the North Fork Lewis River Settlement Agreement.

Hatchery and Supplementation Program (Program): Defined in Section 8 of the Lewis River Settlement Agreement. The goals of the program are to support (i) self-sustaining, naturally producing, harvestable native anadromous salmonid species throughout their historical range in the North Fork Lewis River Basin, and (ii) the continued harvest of resident and native anadromous fish species.

Hatchery and Supplementation Subgroup (H&S Subgroup): Name of ATS prior to December 2018.

HOB: Hatchery Origin Broodstock**.**

HOR: Hatchery Origin Recruit.

HOS: Hatchery Origin Spawners.

Hatchery Production: Describes the artificial propagation of fish that occurs in a hatchery as opposed to propagation resulting from natural reproduction. In the North Fork Lewis River, the hatchery production program is designed to maintain harvest opportunities downstream of Merwin Dam and in project reservoirs (residents) and to provide both adult and juvenile anadromous fish for early supplementation efforts in the basin.

Hatchery Scientific Review Group (HSRG): An independent scientific review group established by the United States Congress to initiate hatchery reform that balances both conservation and harvest goals.

Infectious hematopoietic necrosis virus (IHNV): Severe viral disease in the *Novirhabdovirus* genus affecting salmonid fish, particularly smolts and younger life stages.

Infectious pancreatic necrosis virus (IPNV): Severe viral disease in the *Birnaviridae* family affecting salmonid fish, particularly smolts and younger life stages.

Jolly-Seber (JS) mark-recapture model: Provides estimates of abundance, survival, and capture rates from capture-recapture experiments. A fully open-population model (allows for births, deaths, immigration and emigration from a population) estimating both recruitment to the population and survival.

Juvenile life stages (parr, transitional, smolt, precocious male):

- Parr – Juvenile salmonid in a non-migratory stage adapted for freshwater residence. Exhibits distinct parr marks, yellow to brown body and fin coloration, or no signs of smoltification.
- Transitional – Juvenile salmonid exhibiting initial signs of smoltification (i.e., a silvery sheen with visible parr marks). Black pigment may be present on dorsal and caudal fins.
- Smolt – Juvenile salmonid that is entering a stage of seaward migration and adapted for survival in sea water. Exhibits a silvery sheen, mostly or completely absent of parr marks, deciduous scales, white or transparent abdominal fins, and black pigment on dorsal and caudal fins.
- Precocious male – Juvenile male fish that mature in their first or second year, prior to going to sea. Fully mature males have soft abdomens and milt may be expressed. Deeper body morphology compared to smolts. Dark body color. Parr marks may be visible. Dark body and abdomen coloration compared to parr and smolt life stages.
- Post smolt – A salmonid that has previously undergone smoltification and has reverted to a freshwater-adapted stage, typically due to being held in captivity in freshwater. Visual indicators of this phenotype are not well described in the literature. Some fading of silver coloration. Parr marks are not expected to re-emerge. Some yellow or brown-orange coloration of the fins. Fading of intense black pigmentation in the fins.

Kelt: A post-spawn iteroparous fish such as a steelhead or cutthroat.

Lewis River Hatchery Complex: Hatchery fish production in the Lewis River Basin originates from the Lewis River, Speelyai, and Merwin hatcheries, collectively known as the Lewis River Hatchery Complex. The three hatcheries share adult return, rearing, and release functions. A detailed description of each of these facilities is presented in Appendix A of the H&S Plan.

Lower Columbia River (LCR): for the purposes of salmon recovery, referring to the Sub-domain of the Columbia River Basin that includes the estuary and all sub-basins upstream to the towns of While Salmon, Washington and Hood River, Oregon.

Major Population Group (MPG): Group of populations, or strata, sharing similar genetic, life-history, and spatial distribution that make up a subgroup of an Endangered Species Act-listed species (e.g., Coastal MPG, Cascade MPG). Viability of all MPGs are necessary for viability of Endangered Species Act-listed species.

Merwin Fish Collection Facility (Merwin FCF): A trapping, collection, and sorting facility located at the base of Merwin Dam. The Merwin FCF processes fish for transport upstream as well as broodstock for hatchery operations.

Native (or indigenous): Fish species that have become established in the North Fork Lewis River Basin without human intervention or being substantially affected by genetic interactions through non-native stocks. Native North Fork Lewis River stocks may be present in areas outside the North Fork Lewis River Basin.

NOB: Natural Origin Broodstock

NOR: Natural Origin Recruit

NOS: Natural Origin Spawners

Natural Production: Fish that are produced in the natural environment without human intervention as opposed to artificial propagation in a hatchery.

North Fork Lewis River (Lewis River): Includes the mainstem Lewis River from its confluence with the Columbia River to its origin (RM 94.2) on the northwestern slope of Mt. Adams, including free flowing sections between hydroelectric dams. Excludes the East Fork Lewis which enters the North Fork Lewis River at RM 3.5.

North Fork Lewis River Settlement Agreement (Settlement Agreement): A binding agreement between the utilities; federal, state, and regional regulatory entities; tribal entities; and non-governmental organizations. The Settlement Agreement establishes the collective agreement of all signatories with respect to the utilities' obligations in mitigating effects of hydropower operation on fisheries, wildlife, recreation, and cultural and aesthetic resources. The Settlement Agreement forms the basis for issuing hydroelectric operating licenses by the Federal Energy Regulatory Commission for the four hydroelectric projects on the North Fork Lewis River.

Ocean Recruits: Total escapement of hatchery- and natural-origin fish including those harvested in the ocean, Columbia River, and terminal fisheries.

Proportion of Hatchery Origin Spawners (pHOS): Proportion of natural origin spawners composed of hatchery origin spawners. Equals HOS/(NOS + HOS).

Proportion of Natural Origin Brood (pNOB): Mean proportion of natural origin spawners contributing to broodstock in a hatchery program. Equals NOB/(HOB + NOB).

Passive Integrated Transponder (PIT) tags: Electronic tags inserted into the dorsal sinus or body cavity of fish that transmit data indefinitely when activated by a specialized antenna or reader. All PIT tags have a unique code allowing on-site identification of individual tagged fish.

Proportionate Natural Influence (PNI): Proportionate natural influence on a population composed of hatchery- and natural-origin fish. Equals pNOB/(pNOB + pHOS).

Regional Mark Information System (RMIS): a collection of online databases that maintain records of coded wire tag release, recoveries and locations.

Residual or Residualism: Salmonids that fail to migrate from their natal streams or stream basin after the majority of their cohort have emigrated in a given year. Depending on the species, residuals may take on several different life-histories including precocious sexual maturation, freshwater residence for a season (e.g., to overwinter) or for an additional year followed by anadromy, or in steelhead, permanent freshwater residence and spawning in multiple years. Salmonids with the potential to express anadromy are considered residuals as long as they reside in freshwater and do not become anadromous.

Returns: Adult steelhead or salmon that have spent at least 1 year at sea and have become sexually mature and have returned to the North Fork Lewis River to spawn.

Smolt Index: A number assigned to juvenile salmon that describes the stage of smolt development based on a visual assessment of skin and fin pigmentation (silvering) and body shape. 1 = parr, 2 = transitional, 3 = smolt, 4 = precocious male, 5 = post-smolt or residual (modified from Gorbman et al., 1982).

Smolt to Adult Ratio (SAR): Survival from the beginning point as a smolt (release) to an ending point as an adult.

Supplementation: The use of artificial propagation to develop, maintain, or increase natural production while maintaining the long-term fitness of the target population, and keeping the ecological and genetic impacts to non-target populations within specified biological limits. In the North Fork Lewis River, the supplementation program is designed to reintroduce spring Chinook, late winter steelhead, and early coho to habitat upstream of Merwin Dam.

Single Nucleotide Polymorphism (SNP): SNP genotyping is the measurement of genetic variations of between members of a species. A SNP is a single base pair mutation at a specific locus, usually consisting of two alleles. SNP arrays can be used to analyze large numbers of samples such as outmigrating smolts or transported steelhead upstream of Swift Dam for less cost than microsatellite genotyping.

Steelhead broodstock: Steelhead captured either through traps or in-river netting that meet predetermined genetic assignment probabilities.

Stubby dorsal fin: A dorsal fin in which the rays have become crooked especially along the leading edge and depressed as compared to naturally produced fish. Stubby dorsal fins are indicative of fish reared in a hatchery environment.

Swift Floating Surface Collector (FSC): A trap and haul facility used to collect, sort, sample, and tag outmigrating smolts from adult and juvenile supplementation programs upstream of Swift Dam. The FSC is located on the forebay of Swift Reservoir and has the ability to operate year-round and through fluctuating reservoir levels. All fish are sorted in the FSC and trucked either downstream of Merwin Dam or returned to the reservoir.

Tangle net: A net designed to entangle the snout (not the gills) of target species through use of smaller mesh sizes. This method is considered a safer alternative to traditional gill netting in which the net material may become wedged under the fish operculum, potentially causing lacerations of the gill lamellae.

Viral hemorrhagic septicemia virus (VHSV): Virus in the genus *Novirhabdovirus,* exclusive to fish and related to IHNV.

EXECUTIVE SUMMARY

The Annual Operating Plan (AOP) focuses on developing methods and protocols for monitoring and evaluating objectives and key questions described in the Hatchery and Supplementation Plan (H&S Plan, 2020).
https://www.pacificorp.com/content/dam/pcorp/documents/en/pacificorp/energy/hydro/lewis-river/license-implementation/ats/A%20-%20HS%20PLAN%20FINAL%202020.pdf

A summary of major changes between the 2021 AOP and the 2022 AOP is included in Table ES1.

This AOP is required under Section 8.2.3 of the North Fork Lewis River Settlement Agreement (Settlement Agreement). Section 8.2.3 states that, at a minimum, the AOP must contain the following information:

1. A production section specifying the species and broodstock sources
2. Current hatchery target and juvenile production targets
3. A release section identifying, by species, the rearing schedule and planned distribution of fish and the schedules and location for release
4. A list of facility upgrades to be undertaken in the current year
5. A description of relevant monitoring and evaluation to be undertaken

Sections A, B, and C of this plan are dedicated to the hatchery production components of each of the transport species:

- Section A - Late winter steelhead
- Section B - Spring Chinook
- Section C - Coho salmon

Each section is organized and formatted similarly to maintain consistency within this document to assist in locating specific information for each species. Other sections in this plan include Monitoring and Evaluation (Section D), Adaptive Management (Section E), and Reporting Requirements (Section F).

The monitoring and evaluation section of this AOP (Section D) has been completely updated to be consistent with revised monitoring objectives of the 2020 H&S Plan. Objectives provided in Section D represent the minimum monitoring benchmarks necessary to meet the requirements of the Settlement Agreement as well as recommendations from the Hatchery and Scientific Review Group (HSRG).

ADAPTIVE MANAGEMENT

Based on recommendations from the ATS, the Adaptive Management section (Section E) of this plan has received significant updates from previous versions. These updates were necessary to address the new decision making framework described in the most recent version of the H&S plan.

While the H&S plan outlines a general framework for adaptively managing the H&S program, it does not provide the details needed to adaptively manage the program. Rather, the H&S plan directs the AOP to develop a strategy using decision rules, triggers and targets for each of the monitoring objectives. However, the AOP is limited in both its scope and ability to establish specific decision rules or triggers to adaptively manage each of the monitoring objectives. Adaptive management decisions or actions are more appropriately made by committees or regulatory agencies with the authority to make and implement these decisions or actions. Therefore, Section E of this plan focuses on defining a scheduled review process that includes elements of the Settlement Agreement to identify adaptive management milestones (e.g., comprehensive periodic reviews, H&S plan updates, etc.). These milestones represent scheduled review opportunities for the ATS and ACC to recommend and implement adaptive management changes to the program. Section E has also been updated to define the roles (and limitations) of the ATS and ACC in the adaptive management process.

AREA OF FOCUS

Generally, the AOP is focused on monitoring hatchery production operations and assessing the risks of these operations on naturally occurring salmonid populations present in the North Fork Lewis River downstream of Merwin Dam (RM 19.5). For purposes of this plan, the North Fork Lewis River is defined as the mainstem Lewis River between Merwin Dam and the confluence of the East Fork Lewis River (RM 3.5).

Hatchery fish production in the Lewis River Basin originates from three separate hatcheries: Lewis River, Speelyai, and Merwin. These facilities are collectively referred to as the Lewis River Hatchery Complex. The facilities share and coordinate hatchery functions such as adult holding, spawning, juvenile rearing and release. A description of each of these facilities and the general hatchery production program is provided on the PacifiCorp website.

https://www.pacificorp.com/content/dam/pcorp/documents/en/pacificorp/energy/hydro/lewis-river/relicensing-documents/AQU_8_Report.pdf

Table ES - 1. Summary of Significant Changes to AOP, 2021 to 2022

Section(s)	Change	Rationale
Sections A, B, C	Modified broodstock collection protocols for late winter steelhead; added data collection and fish distribution procedures.	The late winter steelhead program began accepting program returns as part of the broodstock collection effort which required a collection protocol to be added.
Section D, Monitoring and Evaluation	New content summarizes how ongoing data collection meets new monitoring and evaluation needs of the H&S Plan (2020).	Approval of the H&S Plan updates by FERC in March 2022 provided the foundation for summarizing data collection activities to answer Key Questions that address the Monitoring and Evaluation Objectives.
Section E, Adaptive Management	Formalized the Adaptive Management approach to be consistent with decision-making roles, review milestones and cycles for considering program adjustments.	Provides a framework and process for the ATS or ACC to make recommendations and decisions to adaptively manage the program
Strategies	Monitoring and evaluation activities are described at a high level of detail in Strategies which are attached to the AOP and referenced in Section D of the AOP. Strategies included in the 2022 AOP include: • Strategy A: Adult Abundance and Composition • Strategy B: Adult Spatial and Temporal Distribution • Strategy C: Juvenile Abundance and Migration • Strategy D: Fish Health Monitoring and Disease Prevention • Strategy E: Spring Chinook Rearing and Release Evaluation • Strategy F: Precocity and Morphology Sampling • Strategy G: Genetic Risk Monitoring (DRAFT) • Strategy H: Volitional Release • Strategy I: Smolt-to-Adult Return Rate Estimation (IN PROGRESS) • Strategy J: Sampling and Data Collection Checklist • Strategy K: Total Dissolved Gas Saturation	Summarize M&E activities to be easily referenced in the main body of the AOP and ensure consistency of the level of detail provided for addressing each Key Question.
Appendix A	Updates to ATS Work Plan for 2022	The ATS uses a spreadsheet-based calendar to review action items and track and upcoming discussions and actions; for the sake of organization, it is included in the AOP as a working file.

SECTION A LATE WINTER STEELHEAD

1.0 INTRODUCTION

The Lewis River late-winter steelhead integrated-hatchery program (hereafter the “integrated hatchery steelhead program”) has three main components, described in Sections 2, 3, and 4 below: Section 2) broodstock collection and processing for adult program implementation; Section 3) juvenile rearing and release; and Section 4) adult supplementation upstream of Swift Dam. The following sections describe the protocols for implementing the Lewis River late winter steelhead portion of the Hatchery and Supplementation Plan (H&S Plan; PacifiCorp and Cowlitz County PUD, 2020).

2.0 ADULT PROGRAM IMPLEMENTATION

Broodstock collection for the integrated steelhead program is based on three factors: the relative abundance of natural- and hatchery-origin returning adults (Section 2.1), the total collection goal (Section 2.2), and adult return timing (Section 2.3). Adult steelhead are primarily collected at Merwin FCF (Section 2.4) and sampled following a standardized protocol (Section 2.5). Individual adults are sorted and transported either to Merwin Hatchery for broodstock or to the upper watershed to be released above Swift Reservoir (Section 2.6). Adults collected for broodstock are held and monitored (Section 2.7). As the broodstock reach maturation, individuals are live spawned following standardized protocols (Section 2.8). Upon completion of spawning, spawners are returned to river and genetic analysis is completed on all broodstock to evaluate their biological population of origin (Section 2.9).

2.1 Broodstock Collection Strategy

Since the inception of the integrated steelhead program in return year 2009-10 thru 2020-21, the broodstock collection strategy has had two main components. First, broodstock was collected using a “100% pNOB” strategy, which meant the broodstock could only be derived from natural-origin adults (i.e., pNOB = 100%). Second, broodstock had to be collected from adults that returned to the NF Lewis River Basin (i.e., no out-of-basin transfers) and preference was given to in-basin recruits that were determined via genetic screening. Subsequently, no hatchery-origin adults were permitted to be used for broodstock.

The primary justification for the original “100% pNOB” strategy was because there was no other existing within-ESU winter steelhead hatchery program to use as a source for broodstock for the NF Lewis program. Over the next decade, the 100% pNOB strategy remained in place even as BWT’s from the Lewis River integrated steelhead program began to return in relatively high numbers. This decision to keep the 100% pNOB strategy was based on the general goal of trying to minimize genetic risks associated with the hatchery program on the natural-origin population (e.g., loss of diversity, domestication). However, the performance of the 100% pNOB collection strategy was never assessed relative to alternative approaches to achieve the goal(s) of the supplementation program.

During the re-write of the Hatchery & Supplementation (H&S) Plan in 2020, the ATS identified the need to develop “transition plans” for all Lewis River hatchery programs. These proposed transitions plans will formally outline the goals of each hatchery program during each recovery phase, identify hatchery performance metrics and priorities associated with each recovery phase, outline current and alternative hatchery program operations, and provide guidance for future hatchery operations. The ATS has not begun developing transition plans for any program. However, over the past year, there have been ongoing discussions within the Lewis ATS to re-assess the integrated steelhead program and potentially update aspects of the current implementation strategy before the completion of the transition plans. These recent discussions were largely initiated by issues with the steelhead broodstock collection in 2021 and in-season discussions that transpired. In short, the ATS began debating whether the existing broodstock collection should be updated to allow for use of hatchery-origin adults.

In January 2022, the ATS met and discussed potential updates to the broodstock collection strategy for the integrated steelhead program. In summary, the ATS decided to change the broodstock collection strategy from 100% pNOB to a “mining rate” strategy that also ensures demographic replacement. Specifically, the mining rate strategy specifies the maximum proportion of natural-origin adults that can be removed for broodstock. However, NORs can only be collected for broodstock once an equivalent number of BWTs have been transported to the upper basin. Unlike the 100% pNOB strategy, which prioritizes returning NOR adults for broodstock, the mining strategy prioritizes NORs spawning in the wild while also allowing for a fixed proportion to be used for broodstock so long as it does not result in an overall net loss. The decision by the ATS to change the broodstock collection strategy was based on several factors, including recent guidance from HSRG (2020), the group discussing hatchery performance metrics and prioritization, and an evaluation of various broodstock collection strategies by WDFW that demonstrated the mining rate strategy outperforms the 100% pNOB strategy for priority metrics during the recolonization phase of recovery (Bentley and Buehrens, *unpublished*).

Beginning in return year 2021-22, a 30% fixed mining rate will be used to collect broodstock for the integrated steelhead program. Here, for every 10 NOR adults that return to the NF Lewis River and are collected at the Merwin FCF or Lewis Hatchery ladder, the first 7 will be transported above Swift Reservoir to spawn in the upper NF Lewis River basin and the next 3 can be collected for broodstock based on collection needs. However, for NOR adults to be collected for broodstock, each individual NOR must be demographically replaced by two integrated steelhead program adults (i.e., BWTs) that are transported to the upper basin. This 2:1 ratio of BWTs transported to NORs collected for broodstock assumes BWTs have a relative reproductive success of 50 percent (e.g., Araki et al. 2007). The number of adults collected for broodstock is based on the overall collection goal (Section 2.3) and the pre-determined collection schedule (Section 2.4). Any broodstock collection needs that cannot be met with NOR adults will be backfilled with BWTs.

2.2 Broodstock Collection Goal

The current goal is to collect and spawn 25 adult females and 25-35 adult males for a total of 50-65 adults. The total collection and spawn goal of 25 females is primarily based on the total egg take target of 90,000 +/- 20%, which is needed to meet the total smolt release target of 50,000 smolts +/- 20% based on the average fecundity of females and the anticipated in-hatchery survival from egg-take to smolt release. The 25-female target is also based on trying to minimize adverse genetic impacts. In short, hatchery supplementation programs can affect the effective population size of the natural-origin population due to alteration of reproductive success for a subset of a population and subsequent contribution rate (stocking proportion) of the artificially propagated parents (Ryman and Laikre, 1991). The smaller the supplementation program, the larger the risks of reducing genetic diversity and the relationship is likely non-linear (Ryman and Laikre 1991). Therefore, depending on the observed fecundity of collected broodstock, females may be partially spawned to assist in meeting the 25-female target without exceeding the egg take goal. However, this decision must be coordinated with WDFW and NMFS before implementation.

In previous years, the total broodstock collection goal was larger than the spawn goal based on expected in-season genetic assignment rates being <1 (i.e., some adults collected for brood would not be used based on their genetic assignment). Now that in-season genetic screening has been discontinued (see Section 2.9), the collection and spawn goal are the same.

2.3 Broodstock Collection Timing

Broodstock collection should occur proportional to the run timing of natural-origin Lewis River winter steelhead (Figure A-1). In January 2022, the ATS assessed the existing brood collection schedule relative to the return timing of NORs at Merwin FCF from (2015-2021) and found that it only captured ~65-70% of the entire NOR run-timing (Figure A-2). Therefore, the ATS agreed that the broodstock collection schedule should be updated to match the return timing of NORs with one small exception in that collection should end by May 31st (as opposed to the third week of June). This modification results in a 7% reduction in average run-timing relative to NORs which may reduce some genetic diversity but balances the risks associated with spawning late-arriving fish. Specifically, progeny from broodstock spawned after May 31st may be difficult to rear to appropriate release size by the scheduled release time in May of the following year. Risks of releasing under-sized fish include decreased survival and a potential increase in residualism (Hausch and Melnychuk 2012), which may increase ecological interaction with other Endangered Species Act (ESA) listed salmonid populations (i.e., competition and predation).

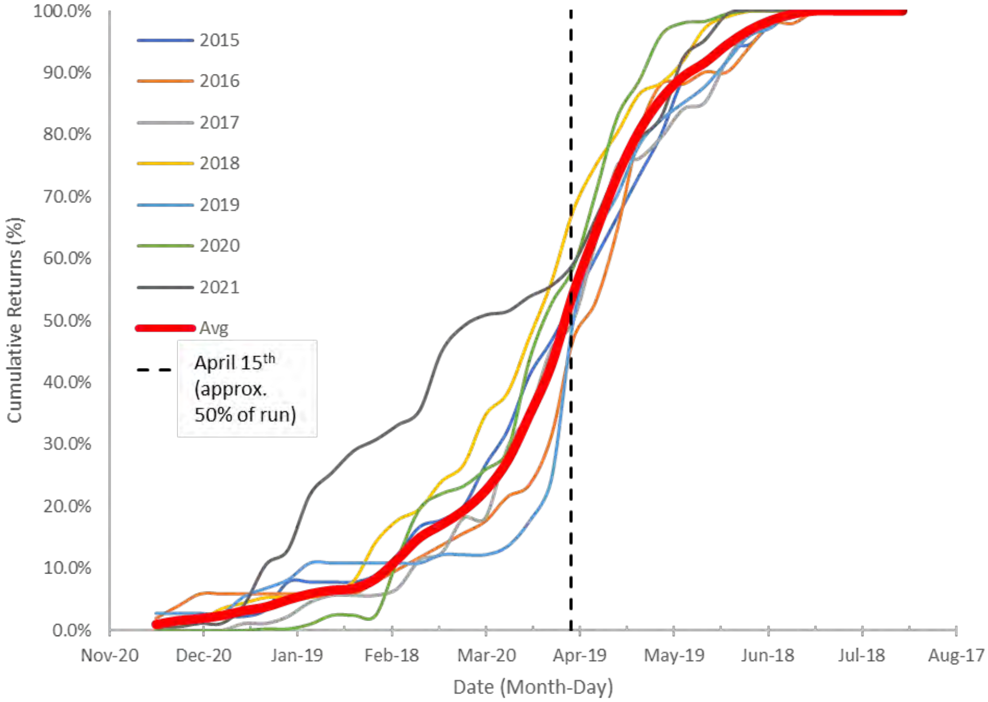

Figure A - 1. Percent cumulative returns of adult NOR winter steelhead at Merwin FCF by year (2015-2021) and the non-weighted average (solid red).

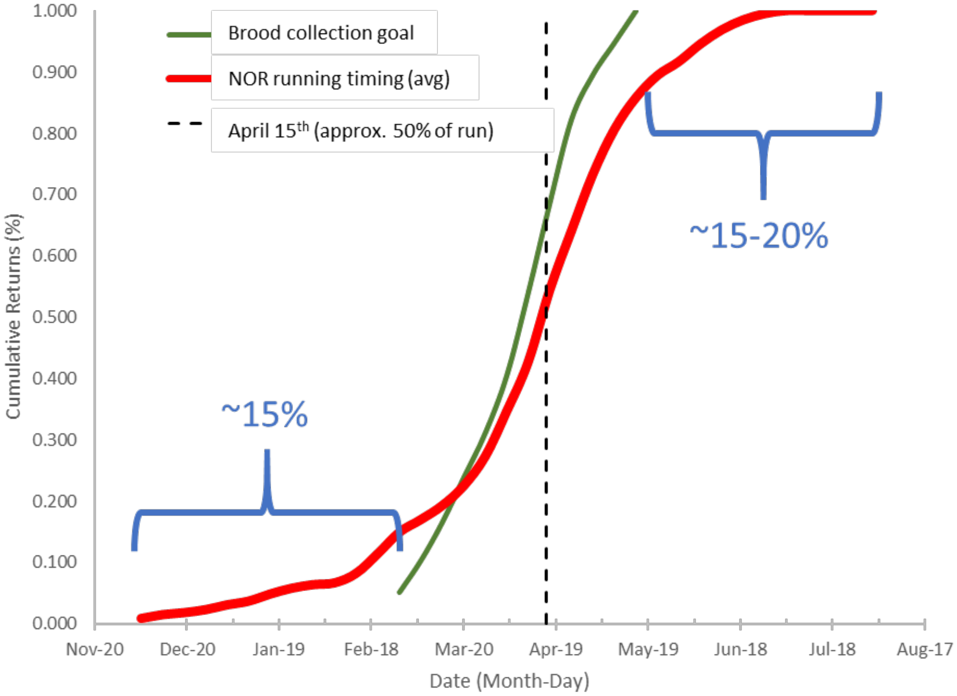

Figure A -2. Average percent cumulative returns of adult NOR winter steelhead at the Merwin FCF, 2015-2021 (solid red) and the cumulative brood collection goal prior to return year 2021-22 (green).

NOTE - The percentages and brackets in blue denote the approximate proportion of the return timing that was excluded prior to the collection timing being updated in 2021-22.

For return year 2021-22, the updated broodstock collection schedule was amended slightly given the timing run-timing assessment (late January 2022) relative to the average timing of NOR returns (mid-December). Specifically, broodstock collection began the week of January 31st and had a collection goal of five adults (2 females, 3 males). In future years, these five adults would be collected on average across seven weeks. The broodstock schedule for return year 2021-22 is detailed in Table A-1 and Figure A-1. The origin of the broodstock (NOR, BWT) will be derived by the criteria outlined in Section 2.2. Any broodstock collection targets that are not met for a given week will be added to the following week(s) targets.

Table A - 1. Broodstock collection goals for winter steelhead in return year 2021-22.

Date (Start of Week)	Females (Weekly)	Males (Weekly)	Total (Weekly)	Females (Cumulative)	Males (Cumulative)	Total (Cumulative)	% Total (Cumulative)
1/31/2022	2	3	5	2	3	5	9%
2/7/2022	-	-	-	2	3	5	9%
2/14/2022	1	-	1	3	3	6	11%
2/21/2022	1	1	2	4	4	8	15%
2/28/2022	-	1	1	4	5	9	16%
3/7/2022	1	1	2	5	6	11	20%
3/14/2022	1	1	2	6	7	13	24%
3/21/2022	1	1	2	7	8	15	27%
3/28/2022	1	1	2	8	9	17	31%
4/4/2022	1	2	3	9	11	20	36%
4/11/2022	2	2	4	11	13	24	44%
4/18/2022	3	4	7	14	17	31	56%
4/25/2022	3	3	6	17	20	37	67%
5/2/2022	3	3	6	20	23	43	78%
5/9/2022	2	2	4	22	25	47	85%
5/16/2022	1	2	3	23	27	50	91%
5/23/2022	1	2	3	24	29	53	96%
5/30/2022	1	1	2	25	30	55	100%

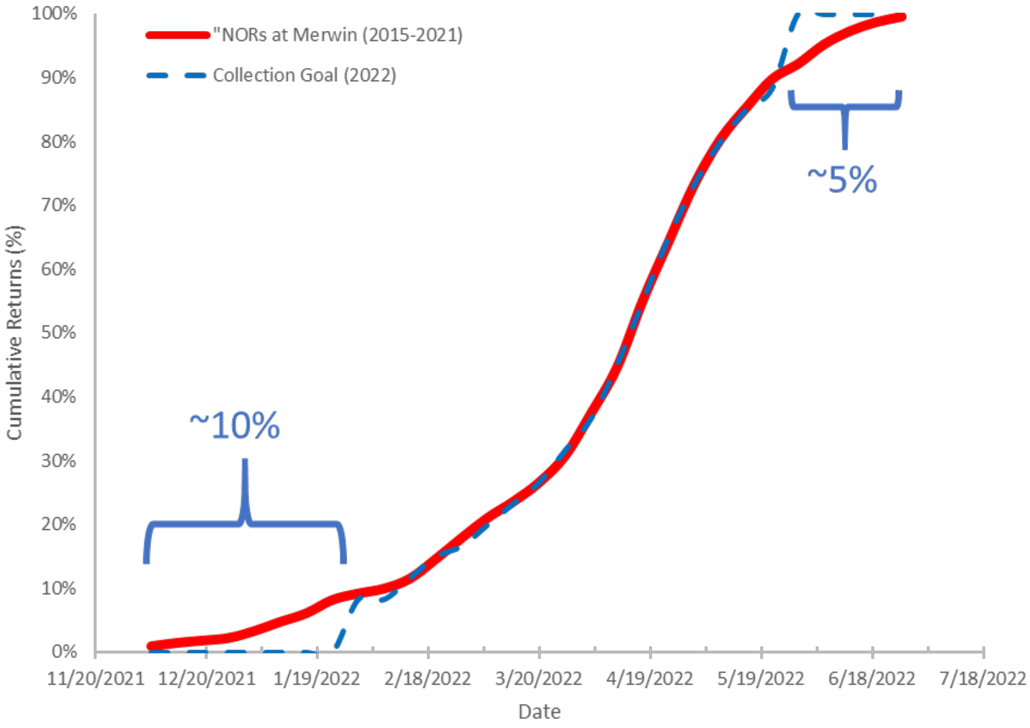

Figure A - 3. Average percent cumulative returns of adult NOR winter steelhead at Merwin FCF, 2015 - 2021 (red solid) and the cumulative brood collection goal for return year 2021-22 (blue dashed).

NOTE: The percentages and brackets in blue denote the approximate proportion of the return timing that was excluded in 2021-22 due to the timing of AOP updates.

2.4 Adult Collection Methods

To initiate the late winter steelhead supplementation program, natural-origin winter steelhead were collected from spawning grounds in the lower Lewis River Basin and used as broodstock. For approximately the first decade of the program, adults continued to be primarily collected in the lower mainstem Lewis River via tangle netting, and sometimes hook-and-line, on the spawning grounds. Over the years, more natural-origin adults have returned to the Merwin FCF and preliminary data suggest that a high proportion of the adults collected at Merwin FCF originated in the upper basin. Since return year 2018-2019, broodstock has been exclusively collected from Merwin FCF. The Lewis River Hatchery ladder collects a few NOR and BWT steelhead each year (Kevin Young, *WDFW*, personal communication) but these adults have not been used for broodstock and are transported to the upper basin.

2.5 Adult Disposition

Adults captured at the Merwin FCF are distributed based on presence of marks, PIT tags and subject to the broodstock collection strategy outlined in Section 2.1. The disposition of adults is illustrated in Figure A-4.

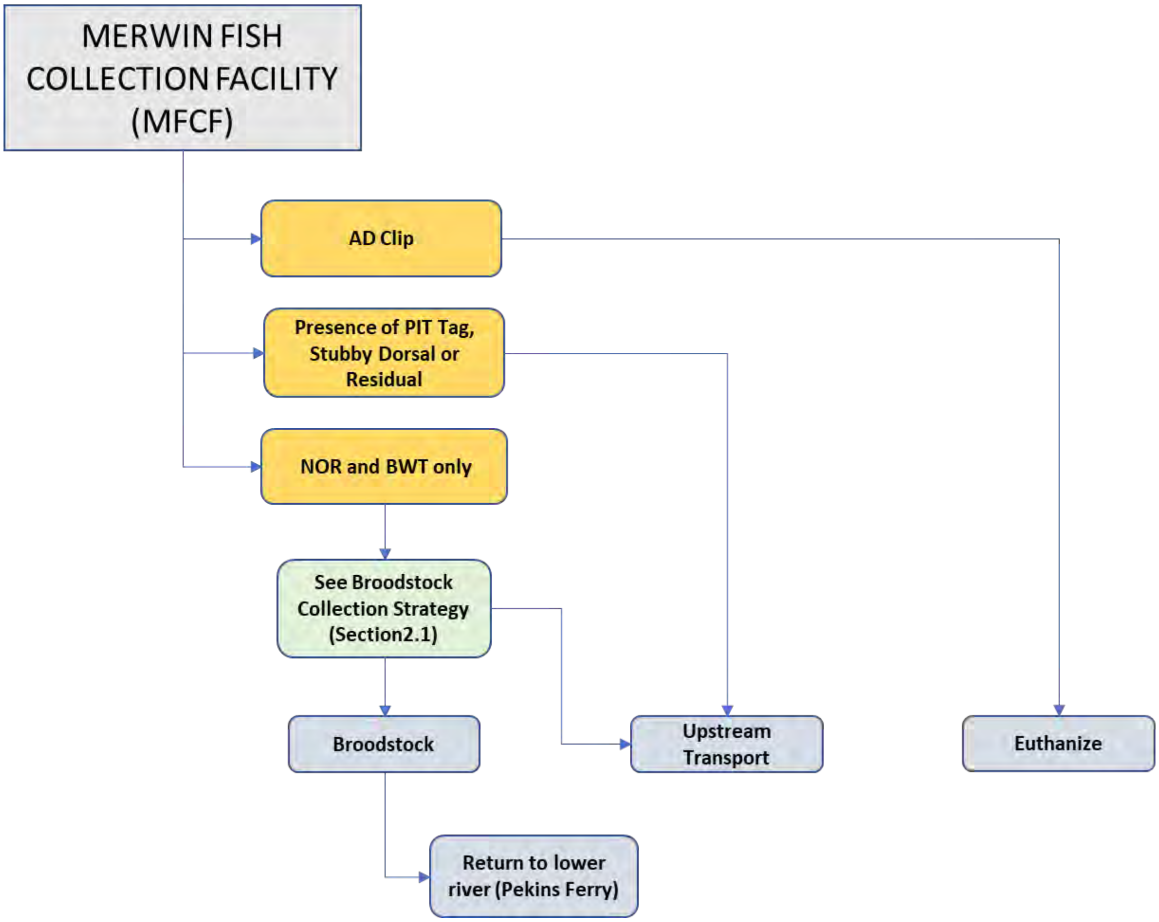

Figure A - 4. Distribution of adult late winter steelhead captured at the Merwin FCF

2.6 Data Collection Protocols

The majority of returning winter steelhead adults are collected and subsequently sampled at the Merwin FCF. The specific data and the group responsible for collection (WDFW, PacifiCorp) will depend on the transport location of each adult (hatchery broodstock or upstream transport) and the total number of adults handled in a given week (i.e., a subset of data are collected based on a sample rate).

For adults that will be transported upstream, staff at Merwin FCF will be responsible for collecting all necessary data fields prior to transport. Every data field will be recorded for each collected adult with the exception of three categories (fork length, scale sample, and tissue sample) that will be sub-sampled on a weekly basis.

For fish designated as broodstock, staff at the Merwin hatchery will be responsible for collecting all necessary data fields with the exception of PIT tagging (Table A-2). All data collected shall be provided to PacifiCorp for annual reporting purposes.

Any adult that does not possess a PIT tag will receive one from the Merwin FCF crew. All PIT tags (new and recaptures) will be uploaded to PTAGIS daily. All other sampling of broodstock will occur during the processing of brood at the hatchery by WDFW staff.

Below is a summary of the data types collected and a brief description of the collection procedure and sample rates (where applicable).

1. **Date of capture** (mm-dd-yyyy)
2. **Capture location** (Merwin FCF, Lewis River Hatchery, Lower Lewis River)
3. **Capture method** (trap/ladder, tangle net, hook-and-line)
4. **Disposition location** (upstream transport, broodstock, return to river (downstream of Merwin Dam)
5. **Sex** (Male/Female)

   The sex of a fish can be determined by assessing its relative size, shape and secondary characteristics such as maxillary length relative to eye position.
6. **Mark status** (e.g., AD, UM, BWT, unknown)

   The mark status of a fish describes any external fin clip(s) an individual fish has received. In general, the mark status is used to designate the presence (mark status = UM) or absence (mark status = AD) of an adipose fin.

   Each fish returning to the Merwin FCF will be automatically scanned for the presence of a BWT (mark status = BWT).

   A small proportion of hatchery fish can be "misclipped" where the intention was to remove the adipose fin but was either unsuccessful or only a partial clip of the adipose fin occurred. Partial clips of the adipose fin will be recorded as AD, and any fish possessing a BWT with adipose removed or partially clipped will be designated as "BWT -unknown".
7. **PIT tag status** (Positive or Negative)

   Scan each fish to determine the presence or absence of a PIT tag regardless of their mark status. Any fish that does not possess a PIT tag will be tagged by the Merwin FCF crew in the dorsal sinus regardless of where it is transported.
8. **Dorsal fin status** (Positive or Negative)

   A small number of steelhead captured display a stubby dorsal fin (Figure A-5), with no adipose clip or BWT. Based on several years of late winter steelhead genetic analysis, these fish originated from the integrated hatchery supplementation program that either lost their BWT or did not receive a BWT.

   To avoid the use of segregated early winter steelhead in the broodstock, all unmarked stubby dorsal positive fish will be transported upstream. Adipose marked stubby dorsal positive fish will be treated as segregated early winter steelhead and transported Merwin hatchery to be euthanized.

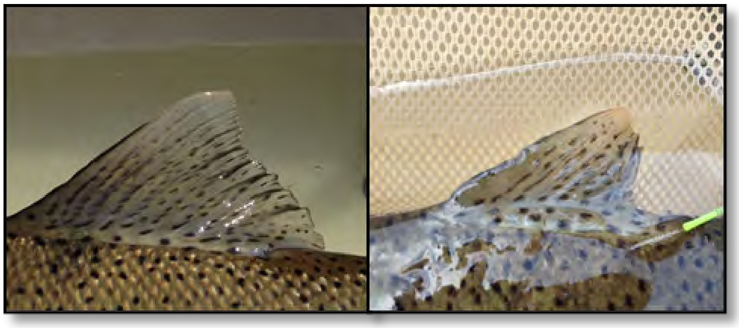

Figure A - 5. Example illustrating the shape of a normal (left) and stubby (right) dorsal fin.

9. **Life History (residual or anadromous)**

   Residuals are identified by color, body shape, and size (Figure A-6). Residuals exhibit deep (and often vibrant) coloration and spotting as opposed to anadromous fish that possess silvery sheens and subdued spotting. Residuals also possess a distinct red or pink lateral stripe. Body shape of residuals is more rotund and are always smaller in size than their anadromous cohorts - typically less than 500 mm in length. Residuals entering the Merwin FCF shall be transported upstream and not used for broodstock.

Figure A - 6. Residual steelhead encountered during annual tangle netting (note stubby dorsal fin)

10. **Fork length**

A fork length measurement should be taken from the first 10 fish captured per week by origin (i.e., up to 10 NOR and 10 BWT per week). Measure the fork length (FL) of each fish in millimeters from the tip of the jaw or tip of the snout, whichever is greater, to the center of the fork in the tail.

11. **Scale sampled** (Yes/No)

Scales should be collected from the first 10 fish captured per week by origin (i.e., a maximum of 20 scales per week). Similar to fork lengths, crews should use the combination of Mark Status and CWT/BWT presence to determine the origin. Do not collect scales from stubby dorsal fish as their origin cannot be verified or from PIT tag positive steelhead as age determination is obtained from the initial PIT tagging event from the Swift FSC as smolts.

Scales should be removed and placed on a scale card including date and location of capture and fork length. A new scale card should be used for each capture date. Collect three scales from each fish just above the lateral line and below the posterior insertion of the dorsal fin

12. Tissue Sample

Tissue samples shall be collected from all broodstock transported to Merwin hatchery. Similar to fork lengths, crews should use the combination of Mark Status and CWT/BWT presence to determine the origin.

Tissue samples should be collected from the upper lobe of the caudal fin. Collect as much tissue as possible up to approximately 1/4” X 1/4” in size (hole-punch sized). Samples should be stored at room temperature on either a sheet of blotter (i.e., chromatography) paper or in individual coin envelopes. If tissue samples are stored in coin envelopes, it is advised to place the sample inside a folded piece of blotter paper to help dry the sample.

13. Data Collection Responsibility

The sampling of returning late winter steelhead is a shared responsibility between the Merwin FCF and hatchery crews. Generally, sampling of fish transported upstream will be conducted by Merwin FCF crews and sampling of broodstock will be conducted by hatchery crews. As part of initial capture, Merwin FCF will PIT tag all captures that do not already have a PIT tag including those transported as broodstock.

Table A - 2. Data collection for late winter steelhead.

Data Type	HOR	NOR
Genetic Tissues	All broodstock sampled	
Fork Length	Merwin Trap (PIT -): 10 BWT per week (PIT +): Sample All (stubby dorsal only): no sample Merwin Hatchery All broodstock sampled	Merwin Trap (PIT -): 10 per week (PIT +): Sample All Merwin Hatchery All broodstock sampled
Scales	Merwin Trap (PIT -) 10 BWT per week (PIT +) none Merwin Hatchery All broodstock sampled	Merwin Trap (PIT -) 10 BWT per week (PIT +) none Merwin Hatchery All broodstock sampled
Fecundity	Individual estimate per female	Individual estimate per female

2.7 Broodstock Holding Protocols

All NOR winter steelhead broodstock will be held at the Merwin Hatchery. Upon arrival, each NOR fish will be Floy tagged and placed into adult holding pond(s). Hatchery staff will check broodstock as needed for maturity starting in the last week of March.

If a female becomes ripe to spawn and no male broodstock are available or the fish is being held as excess and has not yet been incorporated into broodstock that fish will be returned to the river; however, all possible precautions will be made to prevent this situation from occurring. The Hatchery and Supplementation steelhead program coordinator in consultation with hatchery management staff will make decisions regarding the release of fish. Collection goals should be reviewed to evaluate the risk to project goals of releasing the fish (i.e., will more females likely be available through future collections).

The following list represents recommendations from WDFW hatchery staff used to reduce handling related stress, injury, or mortality of steelhead held at the Merwin Hatchery.

1. The use of only rubberized nets to hold or move steelhead: Rubberized nets are known to reduce descaling and abrasion.
2. Eliminating the use of cotton gloves to handle steelhead in favor of bare hands: Cotton gloves are abrasive on fish and remove the protective mucous on the skin of fish.
3. Aqui-S is used for the safety of the employee and to prevent injury and stress to fish during air spawning from the females and live spawning of the males.
4. Floy tags of several colors are used for quick visual identification of individual fish to limit the number of fish handled when checking for ripeness.
5. Salt and Formalin are used in holding raceways or circular tanks for steelhead. Salt reduces stress and improves oxygen uptake. Formalin is used to control fungi and parasites.

2.8 Genetic Assignment and Analysis

Since the inception of the hatchery steelhead supplementation program, genetic stock identification (GSI) has been used in-season to genetically categorize returning adults and help information broodstock collection. Originally, the GSI work was completed by National Marine Fisheries Service (NMFS) under a contract with PacifiCorp. NMFS used a microsatellite (13 mSAT loci) based on a reference baseline almost exclusively composed of Lower Columbia steelhead used in Blankenship et al. (2011). In 2020, NMFS declined to renew the contract. In 2020 and 2021, WDFW's Molecular Genetics Laboratory (MGL) was awarded the contract to perform this in-season analysis using a single nucleotide polymorphism (SNP) based baseline that was specifically assembled for Lower Columbia steelhead populations and segregated hatchery programs (HW354). For more information on the WDFW MGL assembled Lower Columbia steelhead baseline, see memo written by Todd Seamons to the ATS on April 20th, 2020 (Subject: Assessing the performance of the WDFW Lower Columbia River steelhead SNP reference baseline for genetic stock identification (GSI)).

In January 2022, the ATS agreed to discontinue in-season genetic screening moving forward. This decision was based on three factors (see below). However, the ATS agreed that a post-season analysis was still warranted to continue monitoring the genetic composition of the broodstock and inform future monitoring decisions:

(1) **Past genetic screening results -** In-season results from 2020 & 2021 estimated that 95-100% of fish collected for broodstock were from Cascade MPG, which meant no adults were excluded based on their genetics results and the outlined broodstock collection criteria. Overall, these results suggest that the risk of collecting an out-of-MPG adult is probably pretty low.

(2) **Performance of SNP-based baseline** – Based on a power analysis of the current SNP-based steelhead baseline (HW354), it is great at correctly assigning Lewis River origin adults to the Cascade MPG (~90% accurate) and identifying segregated hatchery fish (i.e., Chambers winters and Skamania summers; >>99% accurate). However, the baseline is currently not so great at correctly assigning Lewis River origin adults to Lewis River versus other Cascade MPG populations (~50% accurate). Further details can be found in Seamons (2020). Therefore, past efforts to prioritize Lewis Basin origin adults over out-of-basin but within MPG adults were purely in guise.

(3) **Relative benefit of in-season screening** – Based on recent genetic results and the relative performance of the SNP-based baseline, the biggest benefit of continuing the in-season genetic screening is that it can accurately help exclude Chambers early winter steelhead from the broodstock. However, genetic screening adds little benefit given that there is little overlap between Chambers and NORs/BWTs, >99% of Chambers can be identified via AD clip (assuming an average mis-clip rate of 1%), and the remaining 1% can likely be identified via their "stubby dorsal" and excluded by invoking the rule that no adipose intact fish with a stubby dorsal can be collected for broodstock.

2.9 Spawning Protocols

The total collection and spawn goal of 25-35 males is based on the spawning strategy (see Section 3.8). Briefly, a randomized factorial spawning strategy is implemented for hatchery winter steelhead, which is simply the process of spawning individual fish with more than one mate. There are numerous ways to hypothetically implement factorial spawning, but the specific factorial cross is largely dependent on the number of ripe spawners for a given day. In general, the most common cross is 2x2. However, due to the small program size and variable spawn timing, there can be instances when there is a single ripe female on a given day. When this occurs, two males are spawned with one female. The possibility of this occurring necessitates the need for additional males to be collected.

All collected fully mature broodstock will be spawned according to the following protocols, without regard to age, size, or other physical characteristics:

1. No fish shall be excluded except for those with overt disease symptoms or physical injuries that may compromise gamete fertility or viability.
2. All spawned fish will be returned to the lower river.
3. Females will be air spawned.
4. Fully randomized factorial mating protocols are preferred to avoid or reduce selection biases and maintain diversity.
5. If pairwise mating is warranted (e.g., only one ripe female is available) the use of a backup male is preferred to reduce the potential for egg loss from infertile males.
6. If two females and only one male are ripe, a 2x1 cross can occur. However, this is not preferred and efforts should be made to collect additional males from the Merwin FCF if in Phase II collection.
7. Holding males for additional spawning crosses is not permissible.
8. If a ripe spawning female has no mate, that fish will be returned to the river downstream of Merwin Dam in hopes of spawning naturally (see Section 2.10 Release Protocols). All precautions will be taken to prevent this situation from occurring. Whenever possible the decision to release females should occur before the female becomes ripe.
9. During spawning, a fish health specialist will take the necessary viral samples according to standard protocols (see Strategy C).
10. Ovarian fluid will not be drained before fertilization.
11. Eliminate green egg samples: Total egg mass weight will be used to estimate fecundity.

3.0 JUVENILE PROGRAM IMPLEMENTATION

3.1 Egg Take Goals

The egg take goal for this program is 90,000 +/- 20%. This egg take target is based on the smolt release target paired with the average fecundity of females and the anticipated in-hatchery survival. Fecundity is highly variable among native females and this goal is intended to be flexible; however, total egg take should never exceed the maximum level of 108,000. In-season adaptive management will be used to meet egg collection goals through broodstock management.

3.2 Egg Incubation

Eggs from each female are placed into an individual tray to incubate. To reduce the risk of Bacterial Coldwater Disease (BCWD), each egg tray is partitioned in half, which subsequently increases egg density and reduces the flow and mobility of the eggs. Each spawned fish will have its own ozonated water supply. Eggs or fish will not be combined until viral results are known.

3.3 Rearing and Release Schedule

Fish will be transferred to the intermediate raceways located within the incubation building after incubation and hatching. Fish will remain in the intermediate raceways for a period of 6 to 8 months. All source water passes through the hatchery ozone plant for sterilization before entering the incubation building. After 6 to 8 months, or once fish outgrow the intermediate raceways, fish are transferred to outside raceways and ponds where they are subject to untreated water. Table A-4 presents a timeline for the movement of fish by life stage at the Merwin Hatchery.

In addition to monitoring rearing densities and feeding, hatchery staff assesses performance and growth by implementing sampling methods to calculate condition factor (K), estimated variation in length (CV), and feed conversion factor (FCR) for each raceway. For this stock, these assessments are typically completed prior to first feeding (July) and prior to release (May). This is done by sampling 100 fish from each raceway from three locations (upper, middle and lower) for a total of 300 fish per raceway.

Table A - 3. Generalized hatchery production and collection timeline for late winter steelhead

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult Collection	🟦	🟦	🟦	🟦	🟦							
Spawning			🟦	🟦	🟦							
Incubation			🟦	🟦	🟦	🟦	🟦					
Ponding	🟦	🟦	🟦			🟦	🟦	🟦	🟦	🟦	🟦	🟦
Tagging (BWT)												🟦
Volitional Release				🟦	🟦							

3.4 Feeding Type and Requirements

All fish that are ponded for rearing at Merwin Hatchery will be fed the best quality feed available through WDFW vendors. These formulations provide high protein and fat percentages and have proven to provide optimal growth from start to finish (Roberts, 2013).

There is a combination of feeding methods used. Hand feeding is typically done for early rearing troughs and raceways. Hand feeding occurs 2 to 8 times per day depending on life stage. Once fish are transferred to the large rearing ponds, demand feeders are used along with hand feedings 2 to 3 times per week if needed. The incorporation of belt feeders, or other options (underwater feeders) may be employed to provide for extended feeding schedules, or provide more natural methods for fish feeding.

3.5 Marking and Tagging

Once these fish reach a size of 20 to 25 fish per pound (fpp) in December, all are tagged with BWTs in their snout and placed into the rearing ponds until their scheduled release the following May. No other marks or clips are used for the late winter steelhead supplementation program.

3.6 Release Size and Number

Late Winter Steelhead: 50,000 smolts (± 20%) at 5 to 8 fish per pound.

Volumetric methods and individual length measurements are used to estimate the number and size of fish released (see Strategy F). If the rearing goal is exceeded, surplus fish will continue to be reared and released with the program fish. However, this will require notification to NMFS prior to release. The intention of the spawning program is to not exceed the egg take or release targets and precautions should be employed (e.g., partial spawning) if targets are in jeopardy of exceeding the production limits set in this plan.

3.7 Release Timing and Locations

Steelhead smolts are volitionally released over a six-week period, which is scheduled to begin by May 1 of each year.

Fish that actively migrate during the volitional release window are transported to the Merwin boat ramp (RM 19) for planting. Once the volitional window has ended, any remaining fish are transported and planted at Pekins Ferry Boat Ramp (RM 3.1). Alternate lower river release locations may be used if significant bird or pinniped predation is observed at the Pekins Ferry site (e.g., Woodland release ponds, county bridge, island boat ramp, etc.)

4.0 ADULT SUPPLEMENTATION UPSTREAM OF SWIFT DAM

The current transport goal of late winter steelhead is 1,700 adults (H&S Plan 2020). Transport of adult steelhead to the upper Lewis River Basin began in 2012 and has relied primarily on the production of hatchery-origin recruits (BWT) to provide a demographic boost. Over the past decade, there has also been an increase in the abundance of returning adults that are offspring from supplementation efforts upstream of Swift Dam. Because only about 10 percent of steelhead smolts are PIT tagged at the Swift FSC (and thus confirmed as upstream recruits), there remains an unknown portion of natural origin returns that cannot be classified as originating upstream of Swift Dam or downstream of Merwin Dam. However, based on the portion of PIT tagged adults returning from a known number of marks, inferences can be made on the estimated number of returning steelhead that originated upstream of Swift Dam. Therefore, steelhead transported upstream of Swift Dam will include all BWT returns and a portion of NOR returns to the trap. The portion of NOR returns transported upstream will be predicted by the ATS using PIT tag return rates and other factors deemed appropriate by the ATS (e.g., total number of smolts released from the FSC and hatchery production program by year).

Steelhead that are transported above Swift Dam are typically released at the Eagle Cliff Bridge Site. If the Eagle Cliff Bridge site is unavailable or inaccessible, steelhead may also be released at the Swift Camp boat ramp or Swift Dam. In some instances, fish may be released at alternate locations to enhance their distribution into tributaries of upper North Fork Lewis River. These alternate release locations include but are not limited to: Muddy River Bridge, Clear Creek Bridge, and Curly Creek Bridge. If alternate distribution sites are selected, planting trucks will work on a rotating basis for each haul. For example, the first load may be released at Curly Creek Bridge, the second at Muddy River Bridge, and so on. This may not equate to equal portions for each site but should be reasonably close.

SECTION B SPRING CHINOOK

1.0 INTRODUCTION

The Lewis River spring Chinook salmon program is composed of two parts: adult supplementation upstream of Swift Dam and juvenile hatchery production for release downstream of Merwin Dam. Adult supplementation will provide up to 3,000 adults for release upstream of Swift Dam each year to spawn naturally. Juvenile supplementation will rear up to 1,350,000 spring Chinook for release downstream of Merwin Dam.[1] Release timing of juvenile supplementation fish will vary depending on planned evaluations described in Strategy E. Returns from both the adult and juvenile supplementation programs comprise the foundation to meet the primary goals of providing harvest opportunity and creating a self-sustaining population that does not rely on hatchery support (see Settlement Agreement Section 8.4). This section describes the implementation of both the supplementation and hatchery production programs for 2022.

2.0 ADULT PROGRAM IMPLEMENTATION

The following sections describe the detailed protocols for implementation of the spring Chinook portion of the H&S Plan.

Prioritized goals for management of returning hatchery origin spring Chinook:

1. Lewis River hatchery broodstock goal
2. Upstream transport to support target of 3,000 adults
3. A fishery managed to allow for #1 and #2 to be achieved.
4. Out-of-basin programs (e.g., other Southern Resident Killer Whale programs, Deep River Net Pen project)

Prioritized goal for management of returning natural origin spring Chinook:

1. Upstream transport to support target of 3,000 adults

2.1 Broodstock Source and Selection

The Lewis River spring Chinook hatchery program is operated as a segregated program. Therefore, all broodstock transported to hatcheries will be of hatchery origin. Adult returns identified as NOR will be transported to the Lewis River above Swift Dam to help meet the transport target of 3,000 fish. No NOR Chinook will be used to meet juvenile production needs at the hatchery. Adult HOR (adipose fin missing, or adipose fin intact AND CWT snout tag) spring Chinook returns will be used to meet juvenile production (mitigation) targets. Broodstock will be selected over the course of the run, and any surplus spring Chinook will be

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[1] Beginning in 2018, the spring Chinook upper river acclimation program (up to 100,000 juveniles) was suspended by the ACC in favor of releasing these juveniles downstream of Merwin Dam for a period of at least 5 years. This decision was made in an effort to improve adult returns. Annual review of this modification will occur annually between the ACC and the ATS.

transported upstream to achieve adult supplementation targets. In years when hatchery returns are weak, it may be necessary to hold surplus Chinook at Lewis River Hatchery in the early portion of the run until it becomes clear the annual broodstock goal will be met. After 50% of the run has been realized, a decision will be made on whether to transport all (or a portion of) surplus Chinook being held at Lewis River Hatchery upstream of Swift Reservoir. Planning should be coordinated with hatchery staff to ensure that broodstock are collected proportionately over the run curve.

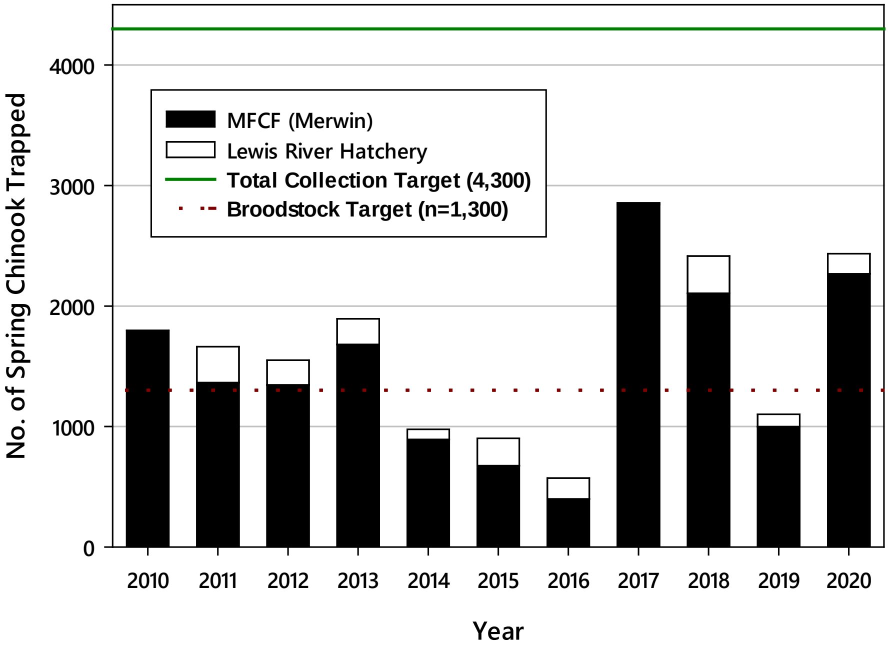


Figure B - 1. Actual number of spring Chinook trapped annually between 2010 and 2020 at both the Merwin FCF and Lewis hatchery ladder.

*Note: *Total collection target includes broodstock (1,300) and adult supplementation target (3,000) upstream of Swift Dam.*

2.2 Broodstock Collection Goal

Spring Chinook broodstock collection goals for the Lewis River programs are as follows:

- Hatchery Broodstock: Approximately 1,300 over the full range of the run with an approximate sex ratio of 2 males for each female.

Collection for hatchery broodstock will be given priority each week. All fish allocated for hatchery broodstock will be transported and held at Speelyai or Lewis River Hatchery. If the weekly quota for hatchery broodstock is not met, then all fish collected during subsequent weeks will be allocated for broodstock until the quota meets the predetermined broodstock collection curve.

All HOR fish collected prior to the week ending May 24, 2022, designated as adult supplementation (upstream) fish will be transported and temporarily held at Lewis River Hatchery. All fish containing CWTs will be allocated to hatchery broodstock and transported to Speelyai Hatchery. A meeting will be held between PacifiCorp Aquatics Team and WDFW Fish Managers during that week to discuss current run numbers and whether fish being held at Lewis River Hatchery can be taken upstream. If adult spring Chinook are returning at a rate at or above the projected running curve for that period, then all fish being held at Lewis River Hatchery will be taken upstream as well as any subsequent fish allocated for adult supplementation. If it appears that adult spring Chinook are returning at a rate exceeding the projected run curve, then it is possible that adults being held at Lewis River Hatchery could be taken upstream earlier. If it is decided that fish being held at Lewis River Hatchery will not be transported upstream by May 24, 2022, they will continue to be held until hatchery broodstock goals have been met. Fish allocated for adult supplementation may be reallocated for hatchery broodstock if the adult return rate remains below the projected number.

All spring Chinook less than 24 inches will be considered jacks. Jacks will not comprise more than 5% of the broodstock collection or adult supplementation. Variations to this guidance will be decided in-season through ATS agreement.

2.3 Broodstock Collection Timing

Broodstock collection for the juvenile supplementation program should occur proportionately over the entire run timing. NOR Chinook should be transported upstream at the time of capture if at Merwin FCF or as soon as possible if at Lewis Hatchery trap. Figure B2 illustrates the trap timing of spring Chinook entering the Merwin FCF. Table B1 illustrates the 2022 spring Chinook generalized collection curve for each part of the program described in the previous section.

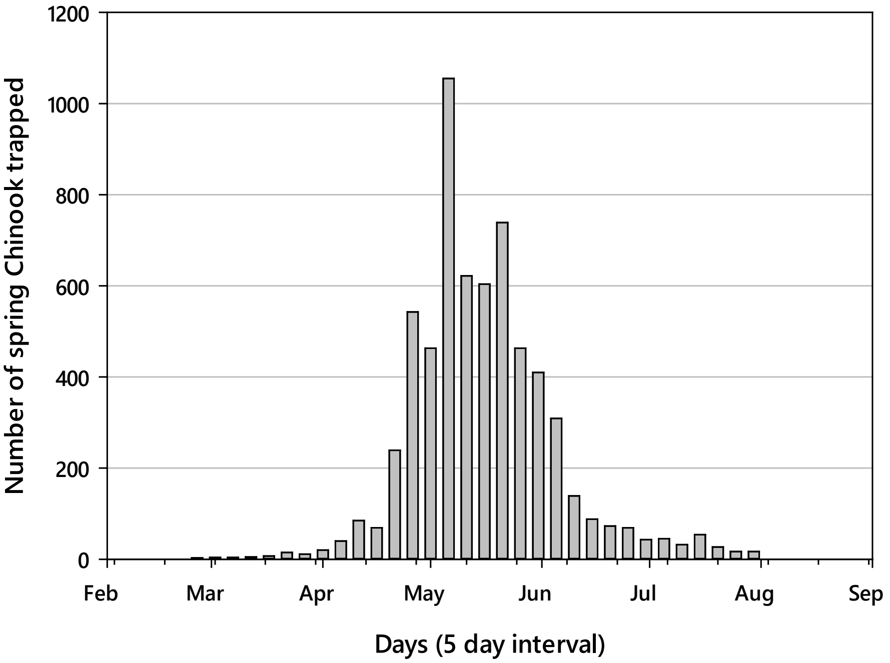


Figure B - 2. Actual number and timing of spring Chinook trapped at the Merwin FCF from 2016 to 2019.

Table B - 1. Spring Chinook generalized allocation schedule for broodstock and adult supplementation in 2022

Week Ending	Hatchery Brood Stock	Adult Supplementation (Upstream)	TOTAL
6-Apr	21	48	69
13-Apr	6	15	21
20-Apr	13	28	41
27-Apr	61	141	202
4-May	69	159	228
11-May	153	351	504
18-May	169	388	557
25-May	226	516	742
1-Jun	243	558	801
8-Jun	155	354	509
15-Jun	92	211	303
22-Jun	29	68	97
29-Jun	26	58	84

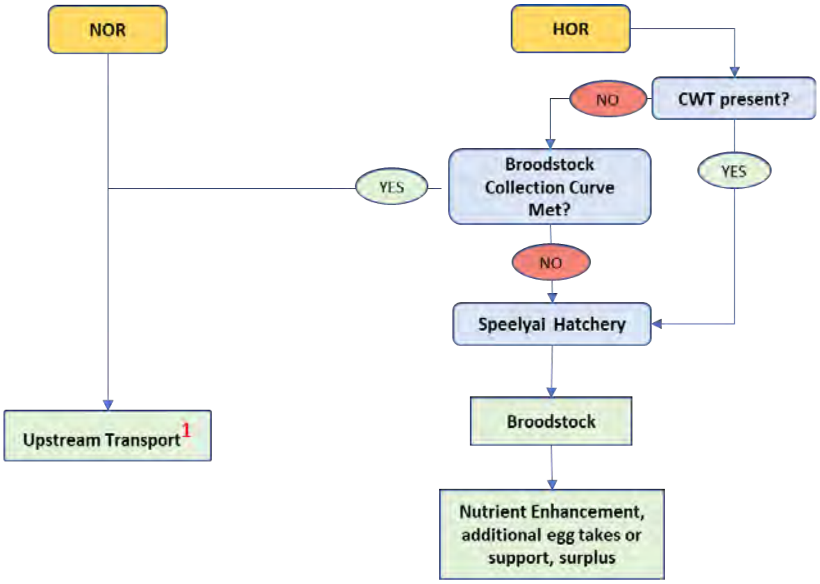
6-Jul	16	38	54
13-Jul	6	15	21
20-Jul	11	26	37
27-Jul	7	17	24
3-Aug	4	9	13
TOTAL	1,307	3,000	4,307

2.4 Adult Collection Methods

All broodstock are collected at either the Merwin FCF or Lewis River ladder.

2.5 Adult Disposition

Spring Chinook are either transported upstream or held for broodstock at Speelyai (or temporarily at Lewis River) hatchery depending on broodstock needs, origin and the presence of a CWT. Figure A2 illustrates the distribution protocol to be used for captured spring Chinook salmon.



[1] *ACC may approve increased upstream transport numbers of NOR's based on run size. If not approved, all NOR's in excess of approved transport goal would be returned to lower river (i.e., never surplused)*

Figure B - 3. Sorting and distribution protocol for Lewis River spring Chinook collected at the Merwin FCF and Lewis River ladder

2.6 Data Collection Protocols

The following data will be recorded for all individuals and for all capture methods.

1. Capture Date (mm-dd-yyyy)
2. Capture Location (Merwin Trap, Lewis River hatchery, in-river)
3. Origin (NOR or HOR)
4. Sex (M/F)
5. Mark Status (PIT, CWT, AD)
6. Life Stage (adult, jack)

The following data will be recorded as a subsample of the total captures.

Data Type	HOR	NOR
Genetic Tissues	No sampling in 2022	
Fork Length	(CWT +): up to 100 (CWT -): none	(PIT -): up to 10 per week (PIT +): sample all
Scales	(CWT +): up to 100 (CWT -): none	(PIT -): up to 10 per week (PIT +): none[2]
Fecundity	Average Fecundity by spawn date (batch)	NA

2.5 Broodstock Holding Protocols

Broodstock are typically collected daily from April 1 through as late as August at the Merwin FCF or Lewis River ladder. All broodstock are transported to Speelyai Hatchery and held until spawning begins in mid-August (Table B2). The exception to this protocol is if the run size

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[2] Age of PIT tag positive captures will be determined through PTAGIS records

forecast is relatively low, fish collection may begin early and fish exceeding weekly broodstock goals may be held at Lewis Hatchery until the approximate half-way (50%) point in the run. At this point, the ATS will determine whether to transport all or a portion of the spring Chinook being held at Lewis hatchery. This determination will be made based on the number of broodstock currently held at Speelyai and predicted trap returns for the remaining run. That is, the likelihood that broodstock goals will be met. Spring Chinook held at Lewis River are treated as if they are to be transported and released upstream of Swift Dam. Broodstock that receive antibiotic injections are not transported, released, used for nutrient enhancement, or donated to any food banks or tribes due to mandated injection withdrawal periods.

2.8 Genetic Assignment and Analysis

See Section D, Objective 7 and Strategy G.

2.9 Spawning Protocols

All collected fully mature broodstock will be spawned using a pairwise (1x1) mating cross with a backup male. No fish shall be excluded except for those with overt disease symptoms or physical injuries that may compromise gamete fertility or viability. All fish are kill spawned, and disposition of carcasses is directed by the WDFW. Note that spawning protocols may change during the transition planning process.

3.0 JUVENILE PROGRAM IMPLEMENTATION

3.1 Egg Take Goals

Egg take required to meet hatchery production goals as set forth in the Lewis River Settlement Agreement (Settlement Agreement) include the following:

Spring Chinook target: 1,755,000 eggs

3.2 Egg Incubation

Eggs are incubated in vertical stack incubators. Each female is assigned a number and only one female per tray, unless there are not enough trays towards the last egg take, then two or three fish will be pooled together until results are in from the enzyme-linked immunosorbent assay (ELISA) testing, if testing is performed (see Attachment A - Fish Health and Disease Strategy Plan).

3.3 Rearing and Release Schedule

All spring Chinook from fry to smolt are fed the highest quality feed available from WDFW contracted vendors. Fry will start out being fed 7 days per week. As they grow, the number of days fed per week will be reduced but will not be less than 3 days per week.

Hatchery staff will implement monthly performance sampling and a QA/QC sampling prior to release.

Immediately before the start of the volitional release period (pre-release group), additional sampling is conducted to assess precocity and assign a smolt index for a minimum of 100 smolts per release pond as part of ongoing morphology sampling (See Strategy F for Within-Hatchery Monitoring associated for the Spring Chinook Rearing and Release Study). This sampling is repeated at the end of the volitional release period, immediately before remaining fish are forced out (post-release group), to compare precocity between the pre and post release groups. These methods are described in detail in Strategy E.

Table B - 2. Hatchery production and collection timeline for North Fork Lewis River spring Chinook

	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F
Adult Collection				■	■	■	■																			
Spawning								■	■																	
Incubation								■	■	■	■	■														
Rearing													■	■	■	■	■	■	■	■	■	■	■	■	■	■
Tagging															■	■										
Volitional Release																		■				■				■
Direct Release																		■				■				■

3.4 Feeding Type and Requirements

PLACEHOLDER – HATCHERY STAFF TO DRAFT FOR 2023

3.5 Juvenile Marking and Tagging

Juvenile tagging type and location for hatchery-produced spring Chinook are presented in Table 6-1 of the H&S Plan (PacifiCorp and Cowlitz County PUD 2014). The number of tags and tagging groups may be modified annually as part of ongoing evaluations of rearing and release strategies (Strategy E).

A subset of juvenile spring Chinook that are collected at the FSC will be PIT tagged to provide additional information on juvenile transport survival at the release ponds and preliminary information on smolt out-migration timing (based on lower Columbia River detections) and out-of-basin avian predation (based on detections at bird colonies such as East Sand Island). The target is to tag approximately 10-15% of the parr or smolts (> 90mm) that are passed downstream from the Swift FSC. Juveniles captured at the FSC may be fish that were hatchery-reared and released from the juvenile supplementation program in previous years and overwintered upstream of Swift Dam or may be offspring of supplementation program adults.

The hatchery production goal is 1,350,000 smolts with the following three tagging groups:

Adipose fin clip:	1,050,000
Adipose fin clip and CWT:	150,000
CWT only (DIT group):	150,000

3.6 Release Size and Number

Spring Chinook: 1,350,000 smolts at 8, 12, or 80 fish per pound depending on release group (see Table B3)

Volumetric methods and individual length measurements are used to estimate the number and size of fish released (see Strategy F). If the rearing goal is exceeded, surplus fish will continue to be reared and released with the program fish. However, this will require notification to NMFS prior to release. The intention of the spawning program is to not exceed the egg take or release targets and precautions should be employed (e.g., partial spawning) if targets are in jeopardy of exceeding the production limits set in this plan.

3.7 Release Timing and Locations

As described in Strategy E of this plan, most Lewis program spring Chinook (1,350,000) are volitionally released as yearlings in October or February from Lewis River Hatchery directly into the Lewis River. The volitional release includes pulling the screens, lowering the water level slowly over a 2-week period or until 90% or more of the smolts have left on their own. The remaining fish left are then flushed out.

2021 is the fourth year of a study designed to test release strategies and survival between up to five release groups. The study began with BY 2017 and is described in detail in Strategy A. Table B3 shows a summary of the different release groups planned as part of this study, which were designed to test the following variables: release month, date transferred to Lewis River Hatchery, rearing environment, ration level and size at release. This study will continue for at least 3 BYs and strategies will be evaluated each year and changes made if substantial problems are discovered. After 3 years of implementation, in-hatchery survival rates, size-at-release, condition factor at release, fish health (frequency or rates of disease), and physiological status at the time of release will be compared between treatment groups as described in Strategy E. All juveniles are released from the Lewis River Hatchery. Planned releases for 2022 (BY2020 and BY2021) are summarized in Table B-3. Deviations from this plan will be described during reporting.

Table B - 3. Summary of planned annual release groups as part of the spring Chinook rearing and release evaluation (Strategy D)

Release Group	Transfer Month to Lewis River Hatchery	Release Month	Size at Release (fpp)	Planned Tagging^2		Planned Release (smolts)	Group Description
				AD + CWT	CWT ONLY		
1	May	February	8	37,500	37,500	150,000	Control group

2	December	February	12	37,500	37,500	175,000	Low ration, reared at Speelyai 6 months
3	December	February	8	37,500	37,500	150,000	Normal ration, reared at Speelyai 6 months
4	May	October	12	37,500	37,500	825,000	Released in October
5[1]	NA	June	80	0	50,000	50,000	Released in June
		TOTAL		**150,000**	**200,000**	**1,350,000**	

[1] *A minimum of 50,000 fish will be planted, but if surplus juveniles are available due to better than expected survival etc., they would be released in this group. All fish from this release group will be adipose fin-clipped; up to 50,000 fish will be marked with CWT.*

[2] *The number and type of tags distributed for each release group may be modified as recommended by the ATS based on projected surplus or deficit to planned release numbers.*

4.0 ADULT SUPPLEMENTATION UPSTREAM OF SWIFT DAM

Up to 3,000 spring Chinook (when available) will be transported from the Merwin FCF and Lewis River traps (or acceptable alternative stock) to Eagle Cliff or designated areas upstream of Swift Dam. Ideally, the transport goal would be entirely of natural origin spring Chinook. At present, all NOR returns are transported upstream, however, there are insufficient NOR returns to reach the transport goal. Therefore, HOR spring Chinook (when available) are also transported upstream in an effort to reach the transport goal of 3,000 spring Chinook.

The transport goal of 3,000 spring Chinook is based on EDT analysis completed in 2019. This goal is likely to change as more information becomes available (e.g., IPM's) and should be reviewed as part of the adaptive management component of this plan. If exceedences of the transport target is recommended by the ATS in any given year (i.e, returns exceed broodstock and upstream transport target), the ATS would seek approval by the ACC prior to exceeding the transport target in this plan.

A minimum of two tanker fish trucks will be used weekly to move captured spring Chinook upstream. Each tanker truck can transport about 100 adult Chinook salmon. Table B - 4 provides a proposed transportation schedule, indicating weekly numbers to achieve the transport goal of 3,000 over the run period; however, this schedule will not be possible to achieve if run sizes are low relative to the broodstock goal. In years with low pre-season run forecasts, fish will be held at Lewis Hatchery until broodstock goals are met, as described in AOP sections 2.1 and 2.2.

Prior to 2017, transported spring Chinook were released at different locations upstream of Swift Dam to enhance their distribution into streams (seed planting). Eagle Cliff, Muddy River Bridge, Clear Creek Bridge, and Curly Creek Bridge were used to release an approximately equal portion of the transported spring Chinook. To simplify the logistics, fish trucks rotated the release location of each haul. For example, the first load was released at Eagle Cliff, the second at Muddy River Bridge, and so on, resulting in nearly equal portions released at each site. Eagle Cliff was chosen as a preferred site for release as it is not affected by reservoir fluctuations and provides the opportunity for released fish to migrate upstream immediately without having to migrate through reservoir waters that can exceed optimal water temperatures. Distribution of spawning will be monitored annually to determine if spawning distribution is adequate and protocols are adapted as needed.

Table B - 4. Recommended transportation timing of adult spring Chinook for supplementation upstream of Swift Dam

Time Period	Target number of spring Chinook transported upstream of Swift Dam
Apr 15-30	300
May 1- 15	600
May 15-31	1,125
Jun 1-15	750
Jun 15-30	225
TOTAL	**3,000**

SECTION C COHO SALMON

1.0 INTRODUCTION

The Lewis River coho salmon program has two components, upstream adult supplementation and downstream hatchery production. The goal of the adult supplementation program is to transport up to 6,800 early and late adult coho (both NOR and HOR) to the upstream end of Swift Reservoir. This target number of adults was determined through the Ecosystem Diagnostic and Treatment (EDT) process which defines habitat capacity upstream of Swift Dam. The intent of the adult supplementation program is to increase the number of NOR coho salmon returning to the North Fork Lewis River with a long-term goal of passing only NOR coho salmon. The hatchery production goal is to release 1,100,000 segregated early coho smolts and 900,000 integrated late coho smolts annually. The minimum target for NOR integration into late coho hatchery production is 30% per HSRG guidance (HSRG 2014).

2.0 ADULT PROGRAM IMPLEMENTATION

The following section describes the protocols for implementing the coho program of the H&S Plan.

Prioritized Goals for management of returning Lewis River Early Coho:

1. Lewis River broodstock goal
2. Minimum upstream supplementation goal (1,000 Pairs may include NORs and some HORs as needed – early/late Coho)
3. A fishery managed to allow for #1 and #2 to be achieved
4. Additional upstream supplementation (target is 6,800 early and/or lates) and other in-basin programs (none currently planned)
5. Out of basin programs (none currently planned)

Prioritized Goals for management of returning Lewis River Late Coho:

1. Lewis River broodstock goal
2. U.S. v. OR[3] (in combination with other Cascade stratum sources, i.e., Washougal/Kalama)
3. Minimum upstream supplementation goal (1,000 Pairs may include NORs and some HORs as needed – early/late Coho)
4. A fishery managed to allow for #1 -#3 to be achieved
5. Additional upstream supplementation (target is 6,800 early and/or lates) and other in-basin programs (e.g., Educational Remote Site Incubators)
6. Other out of basin programs (none currently planned)

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[3] See 2008-2017 *United States v. Oregon* Management Agreement, May 2008

2.1 Broodstock Source and Selection

Broodstock source for the supplementation program shall be composed of both early (Type S) and late coho (Type N) returning to either the Merwin FCF or Lewis River Hatchery ladder.[4] For adult supplementation, the Merwin FCF is preferred because these fish are assumed to be upstream migrants attempting to reach areas above Merwin Dam. The Lewis River Hatchery ladder will be used primarily for hatchery broodstock collection. All early coho NORs should be passed upstream. A portion of late coho NORs are used for the late coho integrated hatchery program (integration rate minimum goal of 30%).

2.2 Broodstock Collection Goal

In most years, the number of coho salmon returning to traps has been sufficient to achieve both hatchery and upstream supplementation targets of about 10,000 adults (Figure C1). Broodstock comprise both returning adult and precocious males (jacks). The proportion of jacks integrated into the hatchery broodstock may include up to 10% of male spawners (HSRG recommendations). WDFW guidance is for at least 2% of male spawners to be jacks (WDFW HEAT Summer Meetings Handout – Jack Utilization Guidelines and Spawning Citations).

<u>Hatchery Broodstock:</u> Up to 1,400 HOR early adults, depending on fecundity, will be used as broodstock to support the segregated hatchery production goal of 1,100,000 smolts (released annually). An additional 1,000 late returning HOR and NOR adults will be used to support integrated hatchery production of about 900,000 smolts (released annually). The minimum target for NOR integration is 30% for late coho per HSRG guidance. Note that the ATS may discuss changing the broodstock target for 2022 in order to meet requirements of the transition plan.

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[4] On July 21, 2015, the H&S Subgroup agreed to incorporate late coho as a supplementation stock. This decision was affirmed by the ACC on August 13, 2015.

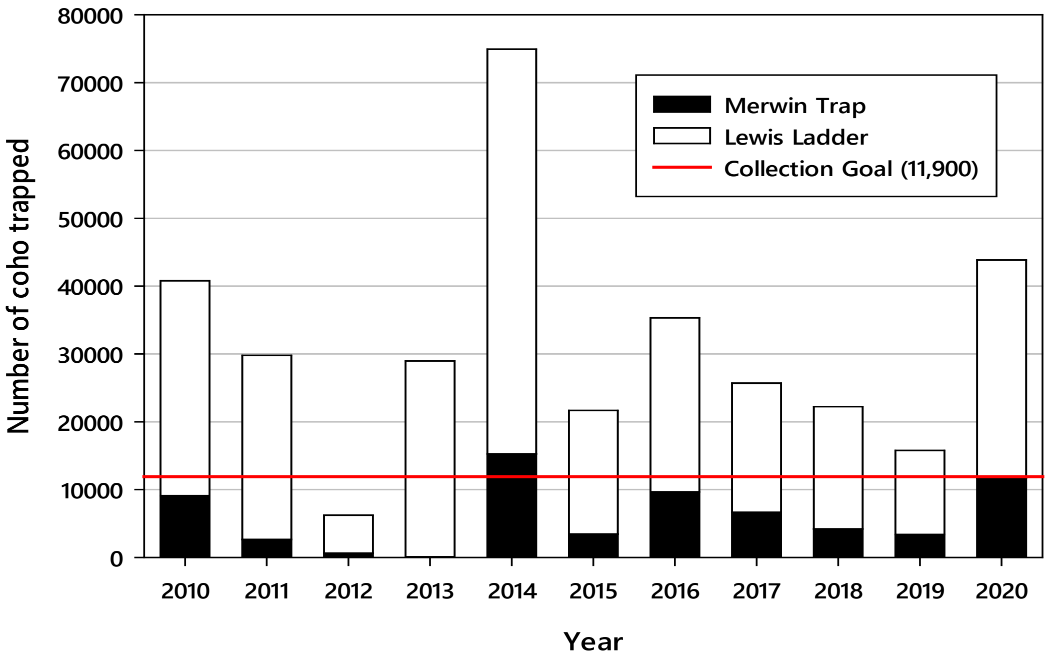

Figure C - 1. Total number of coho trapped annually between 2010 and 2020 at the Merwin Fish Collection Facility and Lewis Hatchery ladder

Note: Collection target line (11,900) represents number of early and late coho needed to meet hatchery broodstock (2,400) and adult supplementation goals (9,500).

2.3 Broodstock Collection Timing

Because the coho program relies on trapping, broodstock collection should occur proportionately over the trap collection curve. Early coho begin entering trapping facilities in early September and peak capture rates are observed in mid to late October. Late coho begin entering trapping facilities in late October and continue through December (Figure C2). Table C-1 provides a proposed collection curve for both early and late coho that is consistent with HSRG recommendations to collect broodstock over the entire collection window.

During the last 2 weeks of October when both early and late stocks are arriving at the traps, staff will visually assign fish to a stock based on coloration and maturation. Fish that cannot be clearly identified by stock are passed upstream unless they are in poor condition, in that case they would be used for nutrient enhancement or allocated to surplus.

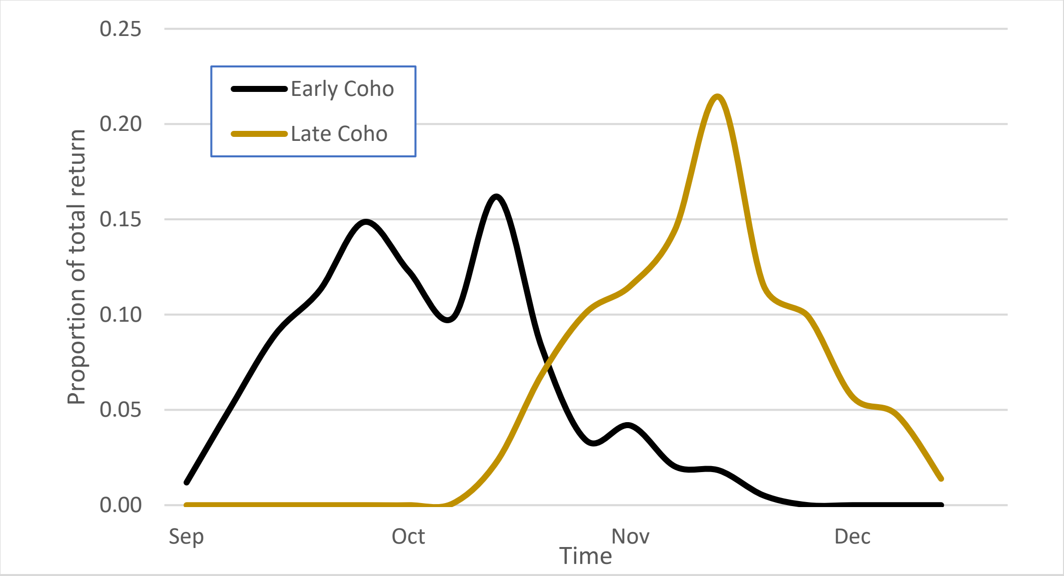

Figure C - 2. Trap entry timing for early and late coho at the Merwin Trap 2017 - 2021.

Table C - 1. Hatchery broodstock collection curve for early and late coho

Period	Number of Coho	Relative Proportion	Cumulative Proportion
Sep 1-15	50	0.02	
Sep 16-30	400	0.17	0.19
Oct 1-15	450	0.19	0.37
Oct 16-31	550	0.23	0.63
Nov 1-15	300	0.13	0.72
Nov 16-30	300	0.13	0.84
Dec 1-15	200	0.08	0.93
Dec 16-31	150	0.06	1.00
Total	2400		

2.4 Adult Collection Methods

Coho salmon are collected from both the Merwin FCF and Lewis River Ladder. Coho designated as broodstock are held at either Speelyai (earlies) or Lewis River (lates).

2.7 Adult Disposition

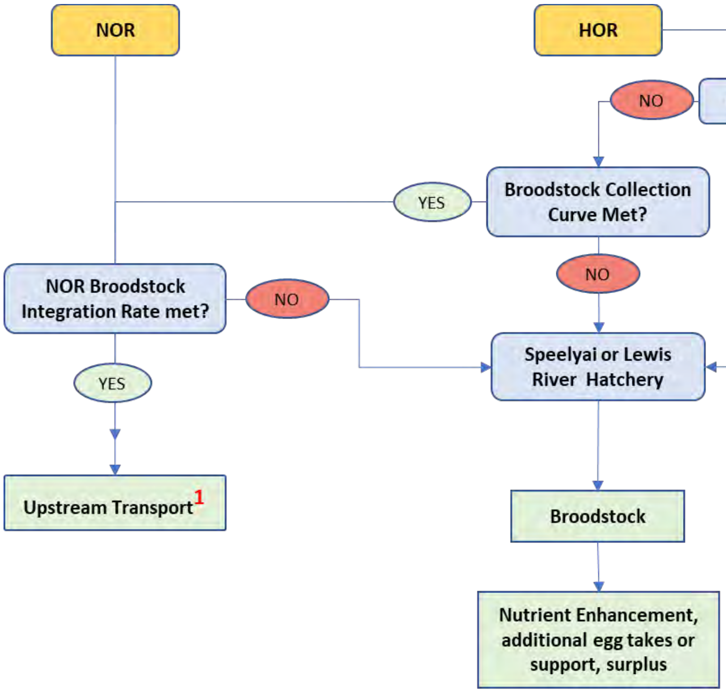

Figure C - 3. Sorting and distribution protocol for Lewis River coho salmon collected at the Merwin trap or Lewis River Ladder

[1] ACC may approve increased upstream transport numbers of NOR's based on run size. If not approved, all NOR's in excess of approved transport number would either be returned to lower river or integrated into the hatchery broodstock (i.e, never surplused)

2.7 Data Collection Protocols

The following data will be recorded for all individuals and for all capture methods.

1. Capture Date (mm-dd-yyyy)
2. Capture Location (Merwin Trap, Lewis River hatchery, in-river)
3. Origin (NOR or HOR)
4. Sex (M/F)
5. Mark Status (PIT, CWT, AD)
6. Life Stage (adult, jack)

The following data will be recorded as a subsample of the total captures.

Data Type	**HOR**	**NOR**
Genetic Tissues	Coho: up to 200 samples[5]	
Fork Length	(CWT +): up to 100 (CWT -): none	(PIT -): up to 10 per week (PIT +): sample all

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[5] Three year sampling effot to establish baseline using hatchery broodstock split among early, lates, sex and origin

Scales	(CWT +): up to 100 (CWT -): none	(PIT -): up to 10 per week (PIT +): none
Fecundity	Average Fecundity by spawn date (batch)	Average Fecundity by spawn date (batch)[6]

2.5 Broodstock Holding Protocols

Coho broodstock collected at Lewis River Hatchery trap or Merwin FCF are either transported to Speelyai Hatchery for spawning (early coho) or held and spawned at Lewis River Hatchery (late coho).

2.8 Genetic Assignment and Analysis

See Section D, Objective 7 and Strategy G.

2.9 Spawning Protocols

PLACEHOLDER – HATCHERY STAFF TO DRAFT FOR 2023

3.0 JUVENILE PROGRAM IMPLEMENTATION

3.1 Egg Take Goals

Egg take required to meet hatchery production goals as set forth in the Lewis River Settlement Agreement (Settlement Agreement) include the following:

- Early Coho: 1,800,500
- Late Coho: 1,400,000

3.2 Egg Incubation and Juvenile Rearing

Early Lewis River coho are spawned at Speelyai Hatchery and the resulting eyed eggs are shipped to the Lewis River Hatchery in November for incubation in vertical stack incubators. Late Lewis River coho are spawned and reared at Lewis River Hatchery.

According to WDFW, incubation conditions are consistent with loading densities recommended by Piper et al. (1982). Water quality and temperatures are generally very good. Stack flows during incubation are 3.6 gallons per minute and all eggs are treated with formalin to keep them free of fungus (WDFW and PacifiCorp 2014).

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[6] Late coho fecundity is averaged among HOR and NOR broodstock (i.e., separate average estimates for HOR and NOR broodstock)

Hatchery staff will implement performance sampling prior to first feeding and a QA/QC sampling prior to release. These methods are the same as described above in late winter steelhead Section 2.16.

3.3 Rearing and Release Program Schedule

Table C - 2. Hatchery production and collection timeline for North Fork Lewis River coho salmon

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult Collection									■	■	■	■
Spawning									■	■	■	■
Incubation	■	■	■						■	■	■	■
Rearing	■	■	■	■	■	■	■	■	■	■	■	■
Tagging						■	■					
Volitional Release				■	■							

3.4 Feeding Type and Requirement

PLACEHOLDER – HATCHERY STAFF TO DRAFT FOR 2023

3.5 Juvenile Marking and Tagging

Juvenile tagging type and location for coho salmon are presented in Table 5-1 of the H&S Plan (PacifiCorp and Cowlitz County PUD, 2014) and summarized below. Coho are mass-marked in June when they are about 120 fpp, as follows:

- 1,700,000 AD only
- 150,000 CWT only (double-index tag group)
- 150,000 CWT + AD

A subset of juvenile coho that are collected at the FSC will be PIT tagged to provide additional information on juvenile transport survival at the release ponds and preliminary information on smolt out-migration timing (based on lower Columbia River detections) and out-of-basin avian predation (based on detections at bird colonies such as East Sand Island). The target is to tag approximately 10-15% of the parr or smolts (> 90mm) that are passed downstream from the Swift FSC. Juveniles captured at the Swift FSC are most likely offspring from adult supplementation, or alternatively from residualized coho that eventually become mature and spawn. This scenario, however, has not been observed during fall spawning ground surveys in the upper basin or reservoir tributaries.

3.6 Release Size and Number

- Early Coho – 1,100,000 smolts at 14-16 fish per pound
- Late Coho – 900,000 smolts at 16 fish per pound

Volumetric methods and individual length measurements are used to estimate the number and size of fish released (see Strategy F). If the rearing goal is exceeded, surplus fish will continue to be reared and released with the program fish. However, this will require notification to NMFS prior to release. The intention of the spawning program is to not exceed the egg take or release targets and precautions should be employed (e.g., partial spawning) if targets are in jeopardy of exceeding the production limits set in this plan.

3.7 Release Timing and Location

Coho are volitionally released at Lewis River Hatchery beginning in April by pulling the screens, lowering the water level slowly over an approximately 2-week period (up to 6 weeks) or until approximately 90% or more of the smolts have left on their own. Remaining fish are flushed directly to the river prior to May 20. Prior to beginning the volitional release, an area Fish Health Specialist will evaluate the coho release group's health and condition.

4.0 ADULT SUPPLEMENTATION UPSTREAM OF SWIFT DAM

The supplementation program relies exclusively on transporting adults upstream of Swift Dam, which began in 2012. Supplementation adults are able to spawn naturally using all available habitats upstream of Swift Dam. Progeny from these transported adults will be collected at the FSC and transported downstream of Merwin Dam to begin their migration to the sea. The program targets up to 6,800 early or late adult coho to be transported over the duration of the run timing. This target was selected through the EDT process to define the spawning capacity upstream of Merwin Dam. The number of NOR coho available for upstream supplementation depends on return rates to the traps and needs of the integrated late coho hatchery program.

Previous trapping data for natural origin coho[7] (Figure C2) are used to create a potential collection schedule to meet the target goal of 6,800 coho (Table C2) for transport in 2022. Ideally, all transported coho would be NORs. However, there are not enough NOR coho to meet the supplementation goal. In addition, Lewis River Hatchery is currently implementing an integrated late coho program on the Lewis River that will use a portion of NOR late coho as broodstock. The supplementation program will use all NORs available that are not used for the integrated late coho hatchery production program.

Transported coho may be released at different locations upstream of Swift Dam to enhance distribution into streams and tributaries. Eagle Cliff, Muddy River Bridge, Clear Creek Bridge, and Curly Creek Bridge will be used to release an equal portion of the transported coho. To simplify the logistics, fish trucks will work on a rotating basis for each haul. For example, the first load will be released at Eagle Cliff, the second at Muddy River Bridge, and so on. This may not equate to equal portions for each site but should be reasonably close.

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[7] NOR coho returns may be progeny from upper river (supplementation program) or lower river spawners. There is no way to differentiate the two groups; However, this is not required because both groups are treated as the same population in this plan.

Table C - 3. Proposed collection rate of coho for broodstock and upstream transport indicting relative and cumulative proportion by two-week period over the collection window

Period	Coho for upstream Transport*	Relative Proportion	Cumulative Proportion
Sep 1-15	200	0.02	
Sep 16-30	1600	0.17	0.19
Oct 1-15	1800	0.19	0.38
Oct 16-31	2100	0.22	0.60
Nov 1-15	1200	0.13	0.73
Nov 16-30	1200	0.13	0.85
Dec 1-15	800	0.08	0.94
Dec 16-31	600	0.06	1.00
Total	9500		

** Values based on supplementation goal of 9,500 adults*

The actual number of adult coho transported may be modified (in-season) by the ATS based on actual returns to the hatchery and traps. The ATS may raise the total number of coho transported upstream to 9,500 adults without prior approval of the ACC. This value was agreed to by the ACC in previous years when returns to the traps exceeded broodstock and transport targets.

SECTION D MONITORING AND EVALUATION

1.0 INTRODUCTION

Monitoring activities described in this section are intended to meet monitoring objectives contained in the H&S Plan. Objectives are established to monitor population metrics related to abundance, distribution, composition, and potential ecological interactions of hatchery released smolts. Evaluation of the data collected to address these objectives and reporting on how the data trends change over time is critical for assessing population viability (extinction risk) of target populations.

The H&S Plan also lays out "key questions" that are nested within each objective. The key questions direct the research needed to support each objective and are answered by monitoring indicators. The H&S Plan also describes narratively the purpose, population recovery monitoring recommendations, proposed strategies, monitoring indicators, sampling frequency, and limitations or concerns for each objective.

This AOP is intended to provide the necessary level of detail to implement the monitoring component of the H&S plan as described in this section and through the various strategies attached to this plan.

Generally, study methods proposed in this AOP follow established protocols used in the Pacific Northwest. This allows methods to be standardized or improved based on data collection or results from other regional locations. An important component of some objectives is the accuracy and precision with which specific objectives are measured or quantified. NOAA Fisheries has provided guidance with respect to variation (Crawford and Rumsey, 2011), and the intent of this plan is to strive to meet these precision guidelines when practical.

Objectives

The M&E objectives are classified into four main categories:

- *Administrative:* Includes the reporting and planning documents required by the Settlement Agreement, HGMPs and Biological Opinion(s)
- *Hatchery Monitoring:* The purpose of hatchery evaluation objectives is to operate hatchery programs in a way that maximizes survival and health of program fish to meet production targets and reduces adverse effects on naturally produced ESA listed species.
- *Abundance Monitoring:* Includes objectives related to monitoring trends in juvenile and adult abundance to evaluate the status, trend, and viability of North Fork Lewis River populations of salmon and steelhead.
- *Risk Assessment:* These objectives are directed at monitoring potential risks of hatchery and supplementation programs to ESA listed species.

The hatchery, abundance, and risk assessment monitoring objectives are presented in a standardized format with key questions nested within each objective. For each key question, the general monitoring approach and methods are described (when appropriate) to develop an estimate for each of the metrics associated with each key question. Decision points for adaptive management and limitations or concerns are also described for each monitoring approach (when appropriate).

Key Questions

Each of the objectives (excluding administrative objectives) have a number of related key questions, presented in the H&S plan. The key questions are specific to each objective and are intended to ensure that specific metrics or benchmarks are addressed in annual reporting. The list of key questions provided in the H&S plan is not intended to be a list of obligations. Rather, the key questions provide monitoring guidance and focus for each of the H&S plan objectives to ensure metrics related to recovery are addressed (e.g., abundance, productivity, diversity and spatial structure). The ATS will determine which key questions are to be addressed annually or periodically (e.g., every 3 years) in the AOP.

Strategies

Some objectives have complex monitoring designs that often have a higher potential for frequent modifications. To adapt, the ATS reorganized the format used to address different monitoring objectives of the H&S Plan by adding ‘strategies’ to the AOP in 2021. Strategies are standalone planning documents attached to the AOP that follow the same general framework as described below. However, strategies generally provide a more detailed study design as is often required by more complex evaluations. Strategies are essentially ‘living’ plans and components to the AOP that can be updated independently throughout the season, or in future years, without requiring global reformatting of the AOP.

Strategies included in the 2022 AOP include:

Strategy A: Adult Abundance and Composition

Strategy B: Adult Spatial and Temporal Distribution

Strategy C: Juvenile Abundance and Migration

Strategy D: Fish Health Monitoring and Disease Prevention

Strategy E: Spring Chinook Rearing and Release Evaluation

Strategy F: Precocity and Morphology Sampling

Strategy G: Genetic Risk Monitoring

Strategy H: Volitional Release

Strategy I: Smolt-to-Adult Return Rate Estimation

Strategy J: Sampling and Data Collection Checklist

Strategy K: Total Dissolved Gas Evaluation

Framework

Following the framework set forth in the H&S Plan, this section of the AOP expands upon the monitoring strategies, monitoring indicators, sampling frequency and limitations or concerns for addressing each key question. The description of these elements follow a standardized template as follows:

Approach: Briefly, the approach used to quantify and estimate monitoring indicators with an acceptable level of precision and accuracy to address the objective or key questions. Includes references to other sections of the AOP or attached Strategies, where relevant.

Metric or Monitoring Indicator Name and Description: The desired numerical measurement or observation by which the objective is measured.

Targets: The program element endpoint or numeric value that the hatchery and supplementation program seeks to achieve (including precision for numeric targets)

Field Methods: Description of the specific methodology, sampling designs and protocols to collect and store field data in a format required by the analytical methodology adopted.

Analytical Methods and Reporting: Description of the application of the data or specific analysis applied to derive an estimate for each metric assigned to the objective or key question. Includes the description of any formulas, estimators or software used to analyze data sets.

Frequency and Duration: The sampling or data collection frequency and duration for each objective or key question that is being monitored. For example, steelhead redd surveys are conducted once every seven to ten days between March 1 and June 30.

Data Collection and Storage: Parties responsible for the data collection, storage, and location of data files.

Limitations or Concerns: General description noting specific challenges especially those related to field data collection and deployment.

2.0 OBJECTIVES

Administrative Objectives

The purpose of objectives 1.0 and 1.1 is to obtain ESA coverage for hatchery production and associated program activities. The HGMP represents the proposed operation of each hatchery program and is submitted to NOAA Fisheries for approval. Once approved, NOAA Fisheries will draft and finalize a Biological Opinion regarding the HGMP action and include specific terms and conditions, and reasonable and prudent measures to avoid jeopardizing ESA listed species from continued operation of the hatchery programs.

The purpose of objectives 2.0 through 2.3 is to ensure that reporting and planning requirements of the Settlement Agreement, HGMPs, and Biological Opinion (once issued) are met. The annual hatchery operations and H&S Program reports shall demonstrate whether the HGMP protocols are implemented as proposed. Reporting will include assessing the effectiveness of actions taken to limit the threat of hatchery operations to natural-origin fish as well as documenting whether each hatchery production program is meeting target production levels.

Objective 1.0: NOAA acceptance of a Hatchery and Genetic Management Plan (HGMP) for each hatchery program on the North Fork Lewis River

The following HGMPs are anticipated:

- Summer Steelhead
- Late Winter Steelhead
- Early Winter Steelhead (Chambers Creek stock)
- Spring Chinook
- Early Coho Salmon
- Late Coho Salmon

The ATS will receive updates on this process from WDFW throughout 2022. It is anticipated that draft versions of the HGMPs will be provided to ATS members for review; however, the ATS (with the exception of PacifiCorp) will not formally review or comment on the HGMPs. The ATS anticipates discussing issues related to the HGMP’s that may influence or modify the goals and objectives of the H&S program. Examples include transition planning from segregated to integrated hatchery programs, harvest management and hatchery production program sizing

Objective 1.1: Receive Biological Opinion for all submitted HGMPs

Continued operation of the hatcheries is critical as the supplementation program relies on hatchery returns for reintroduction efforts upstream of Swift Dam.

Biological Opinions (BiOps) for the Lewis River Hatchery programs will be issued after HGMPs are submitted and accepted by NOAA Fisheries. The ATS will receive updates on this process from WDFW and NOAA Fisheries throughout 2022. Once issued, the ATS will need to determine whether the the current H&S Plan and AOP are consistent with BiOp and make necessary revisions to the H&S Plan and AOP to ensure consistency with the BiOp.

Objective 2.0: Finalize a Hatchery and Supplementation Plan every 5 years

The current H&S plan was submitted to the FERC in December 2020. At present, the FERC has not formally accepted the revised H&S plan. The next rewrite of this plan is scheduled for completion 5 years from FERC acceptance of the H&S plan, or as extended by the FERC. The H&S Plan will be revised earlier if required by the HGMPs in Consultation with the ACC and NOAA Fisheries to adaptively manage the programs.

Objective 2.1: Finalize an Annual Operating Plan (AOP)

The AOP is the primary mechanism for adaptively managing the H&S Program. The AOP is developed collaboratively by the ATS on an annual basis and requires approval by the ACC and Services.

The ATS strives to finalize the AOP by December 31 of each year. This is not always possible and the ATS has developed a prioritization protocol for when the AOP is not completed by December 31. This protocol prioritizes the development of the AOP into two distinct phases:. Phase 1 focuses on field data collection and monitoring that is initiated during the first half of the year, while Phase 2 focuses on the second half of the year. This allows the ATS to complete monitoring and reporting requirements for those programs that are initiated earlier in the year such as late winter steelhead monitoring and juvenile trapping. Necessary AOP revisions for Phase 1 activities are scheduled for completion by February 1. Phase 2 includes primarily fall monitoring activities such as adult salmon abundance monitoring and is scheduled for completion by July 1.

Objective 2.2: Finalize an Annual Operations Report

PacifiCorp drafts the Annual Operations Report (AOR) in accordance with section 8.2.4 of the Settlement Agreement, outlining reporting requirements pursuant to the AOP. The AOR is provided to the ACC as part of the annual TCC and ACC reporting (Section 14.2.6 of the Settlement Agreement). The AOR reports on all monitoring activities described by the AOP. Section F of the AOP provides the minimum reporting requirements for the AOR as stipulated in the Settlement Agreement. The final AOR is submitted as part of the annual TCC and ACC annual report to the FERC by June 30 of every year.

Objective 2.3: Finalize an Annual Hatchery Report

WDFW drafts the Annual Hatchery Report which summarizes on site hatchery activities including spawning, rearing, feeding, pathogen testing, permit compliance, fish marking, and trapping counts. Because many of the hatchery activities are related to monitoring objectives in the H&S Plan and in Section 8.2.4 of the Settlement Agreement, PacifiCorp attaches the Hatchery Report in their submittal of the Annual Operations Report to FERC. At a minimum, the Hatchery Report includes the following metrics:

- Broodstock received from adult trapping operations, including disposition of adults received.
- Mortality of adults, juveniles and eggs
- Spawning, incubation and rearing summary
- Disease presence, prevention (treatments), and loss by life stage
- Growth rate by month from fry ponding to release as smolts
- Number of fish tagged, tag type, and purpose (experimental, production)
- All fish transfers in or out of the basin including species, number, marks, and life stage
- Production summary providing the total number of smolts released including the timing and locations of released and average smolt size at release.
- Volitional release data including volitional release timing and duration for all species.
- Monthly water temperatures and average rainfall
- Summary of maintenance and capital projects completed

Hatchery Monitoring Objectives

Objective 3.0: Determine whether hatchery production protocols incorporate best available management practices to support program targets and goals.

The purpose of objective 3.0 is to implement hatchery programs and practices that support the goals of the H&S program, are consistent with best management practices, and incorporate recommendations by the HSRG when possible. This objective also encourages hatchery programs to incorporate new scientific advances when available to continually improve overall hatchery performance in supporting the H&S program.

KEY QUESTION 3A. DO HATCHERY BROODSTOCK COLLECTION PROTOCOLS SUPPORT PROGRAM GOALS?

APPROACH

H&S Program goals are to 1) collect broodstock throughout the entire run timing for each species and 2) ensure the portion of broodstock retained from the total number of fish collected (trapped) follows the composition and retention rates established in collection curves for each species. Details on broodstock collection goals and timing are provided for individual species in Sections A2, B2, and C2.

- Trap entry timing is the number of adults trapped by species, stock and origin, and date (Merwin trap) or week (Lewis River Hatchery Ladder).
- Broodstock collection and selection timing is the number of adults retained for broodstock by species, stock and origin, and date (Merwin trap) or week (Lewis River Hatchery Ladder).
- Broodstock retention rate is the number of adults transferred to hatcheries for broodstock out of the total number of adults trapped by time period, species, stock, origin, and sex.

LIMITATIONS OR CONCERNS

In the early part of the year, if the broodstock collection targets are not projected to be met due to poor predicted returns, the ATS may decide to modify the broodstock collection curve by adjusting the collection timing or number of broodstock to be held at the hatchery. During the collection season, if the trap entry timing or broodstock retention rate deviates significantly from the planned collection curve without justification (e.g., due to poor realized returns), an in-season decision by the ATS may be needed to ensure that broodstock are collected throughout the duration of the run.

Trap entrance timing may not be a precise or accurate indicator of migration or spawn timing. Returning adults may choose to reside in the river for several weeks or months before volunteering into one of the traps. However, because traps are the primary source of hatchery broodstock, trap entry timing is used to determine whether broodstock collection protocols are consistent with targets.

DATA COLLECTION METHODS

Metric or Monitoring Indicator	Targets	Field Methods	Analytical Methods	Frequency and Duration
3A.1.Trap entry timing	Broodstock collection follows collection curves over the course of the trapping period.	See broodstock collection goals and timing for individual species in Sections A2, B2 and C2 of the AOP.	Sum of adults trapped by day or week. Identify first, last, and peak run dates from distribution of daily trap counts.	Data are collected when traps are sorted; daily at Merwin Trap, weekly at Lewis River Hatchery Ladder. Broodstock collection periods: • Steelhead: late January to end of May • Spring Chinook: April 1 to late August • Coho: early September through December
3A.2.Broodstock retention rate	Total broodstock target numbers are met. Broodstock collection rates that are consistent with planned broodstock collection curves for each species. For integrated programs, match collection timing to average NOR return timing.		Broodstock retention rate reported by week as the number of fish held for broodstock out of the total number of fish trapped and sorted (daily/weekly counts, cumulative total, and % cumulative total of annual total). Make comparisons of annual HOR and NOR return timing to 5-year average return time, and to planned and observed broodstock collection curves.	

KEY QUESTION 3B. DO SPAWNING, REARING AND RELEASE STRATEGIES SUPPORT PROGRAM GOALS?

APPROACH

The following metrics are assigned to this key question to ensure hatchery practices are consist with HSRG recommendations and best practices. In general, data on these metrics are collected as part of typical hatchery program operations and will be reported on in the Annual Operating Report, and trends will be evaluated as part of the Adaptive Management process described in Section E.

Not all metrics assigned to this key question are evaluated annually, for instance metrics related to water quality (e.g., temperature, TDG, etc.), avian predation or feeding strategies are evaluated periodically as determined by the ATS.

Integration Rates: For the integrated programs, late winter steelhead and Type N (late) Coho, integration rate targets are described in the Broodstock Collection Strategies (sections A 2.1 and C 2.1 of this document). For steelhead, a "mining rate" strategy is currently in use until the program can transition to use of 100% natural-origin spawners. A 30% fixed mining rate will be used to collect broodstock for the integrated steelhead program. For Coho, the minimum integration rate is 30%.

Spawning matrices and timing: Spawning designs are developed to be aligned with HSRG guidance for conservation of genetic diversity to ensure genetic diversity and relatedness targets are being met (when appropriate). Spawning designs ensure equal contribution from all spawners to the progeny and reduce the effects of artificial selection. Adults selected for broodstock should be similar in size and arrival timing to their natural counterparts whenever possible. Spawning crosses may follow pairwise, factorial or nested designs depending on the program goals (whether the program is integrated or segregated), to mitigate unequal genetic contributions among males, and ensure integration rates of NOR broodstock meet HSRG recommendations (when applicable). Target spawning matrices and timing are described in Sections A 2.8, B 2.8, and C 2.8.

Fecundity: Fecundity is monitored during hatchery spawning to ensure the number of broodstock collected will meet juvenile production targets. If fecundity declines over years, the targeted number of adults needed to achieve hatchery production or natural productivity upstream of Swift Dam may need to be adjusted. The relationship between fish length and fecundity may be evaluated to understand whether trends in fecundity are related to trends in body size. For steelhead, fecundity is measured for individual fish by volumetrically measuring the number of eggs for each female spawned and fork length of each female spawned. For Coho and Chinook, fecundity is estimated from the average number of eggs per female for a given spawn group of females. Fork lengths may be obtained from HOR female spawners processed for CWTs.

Feeding Rations and Delivery Rate: Not applicable in 2022

Avian Predation: Not applicable in 2022

Volitional Release: Refer to Sections A3.7, B3.7, and C3.7 for hatchery release timing for each species. For all species, fish are allowed to leave volitionally for at least a period of 2 weeks. Fish that remain after 2 to 6 weeks, depending on species, are moved into the river by a forced release. See Strategy H for practices at Lewis River Hatcheries and a review of the rationale for various approaches on the timing and duration of volitional release periods.

Water Quality: A TDG mitigation and evaluation plan will specifically evaluate altering the flow characteristics of the inflow into rearing bank 13 at Lewis River hatchery in 2022 (described in Strategy K). Modifications to the inflow piping will be evaluated with comparisons to unmodified inflow to determine whether modifications to the existing inflow configuration would benefit fish health by mitigating summer TDG levels at the hatchery. In addition, direct examination of a sample of spring Chinook smolts will be evaluated by WDFW pathologists during periods of high TDG (described in Strategy D).

LIMITATIONS OR CONCERNS

Specific limitations and concerns for the spring Chinook rearing and release study and precocity monitoring are described in Strategy E and F, respectively.

DATA COLLECTION METHODS

Metric or Monitoring Indicator	Targets	Field Methods	Analytical Methods	Frequency and Duration
3B.1. Integration Rates (pNOB; Integrated programs only)	Steelhead: 30% fixed mining rate. Coho: 30% integration rate.	Outlined in Sections A2.1, B2.1, C2.1 of this AOP as part of the broodstock collection process.	NA	In general, data on these metrics are collected as part of typical hatchery program operations and will be reported

3B.2. Spawning matrices and timing	Steelhead: Depends on spawners available on a given day; typically 2x2. Spring Chinook and coho: pairwise (1x1) mating cross with a backup male.	Outlined in Sections A2.9, B2.9, C2.9 of this AOP as part of the spawning protocols. The number, timing and composition of spawners used, and type of spawning matrix used for each stock will be recorded (e.g., pairwise, pairwise with backup male, factorial, etc.).	NA	on in the Annual Operating Report, and trends will be evaluated as part of the Adaptive Management process described in Section E. For spring Chinook salmon, after 3 years of implementation of the Spring Chinook Rearing and Release Plan (Strategy A), in-hatchery survival rates, size-at-release, condition factor at release, fish health (frequency or rates of disease), and physiological status at the time of release will be compared between treatment groups.
3B.3. Broodstock Fecundity	NA	Late winter steelhead: Record the estimated number of eggs per female. Early coho and spring Chinook: Average fecundity will be estimated from a subsample of females spawned.	For integrated programs (late winter steelhead and late coho), fecundity will be compared between HOR and NOR. Fecundity and spawn timing data are also used to examine risk to phenotypic diversity described in Objective 7.	
3B.4. Feeding rations and delivery methods	Not Applicable in 2022			
3B.5. Avian predation rate	Not Applicable in 2022			
3B.6. Volitional releases	Steelhead: May 1; 6-week volitional period. Spring Chinook: February 1, October 15, or June 1; 2-week volitional period. Coho: April for 2 to 6-week volitional period.	The start date and time of volitional release (i.e., when screens are pulled) and the start and end date and time of the forced release period will be recorded for each species and pond.	Report on	

3B.7. Water Quality	NA	2022 TDG Evaluation and Mitigation Plan (Strategy K)	See TDG Evaluation and Mitigation Plan (Strategy K)	The evaluation will occur during the summer of 2022 and capture periods of higher water temperatures, specifically between July and October. Water quality measurements will be recorded continuously using a 1-hour interval.

KEY QUESTION 3C. ARE ADULT COLLECTION, HANDLING AND DISPOSITION PROTOCOLS CONSISTENT WITH HSRG RECOMMENDATIONS?

APPROACH

This key question relates to sampling and disposition protocols applied to adult fish handled at either the Merwin Trap or Lewis River ladder. Specifically, a sample of HOR and NOR adults for each stock will be used to collect size (fork length) and age (scale samples) data using a representative sample of HOR and NOR returns over the entire run. Size and age data will also be collected at traps and during spawning ground surveys, summarized in Strategy A.

Additionally, the disposition for all salmon and late winter steelhead captures at the traps will be documented to ensure that broodstock and upstream transport collection goals consistent with HSRG guidelines are achieved.

Captures at the Merwin and Lewis River ladder will be grouped into one of the following five disposition categories, with the disposition protocols described in Sections A2.7, B2.7, and C2.7:

1. Retained for broodstock
2. Transported upstream
3. Returned to river downstream
4. Euthanized
5. Mortalities

LIMITATIONS OR CONCERNS

Several generations of adult returns may be necessary to provide adequate size and age data and analysis to support and justify implementation of specific HSRG recommendations.

DATA COLLECTION METHODS

Metric or Monitoring Indicator	Targets	Field Methods	Analytical Methods	Frequency and Duration
3C.1. Size and age of returning HOR and NOR adults	Use of size and age at maturity as indicator of phenotypic diversity among HOR, NOR and integrated programs. See Objective 7.	Subsample of fork lengths and scales from trap returns and in-stream carcass surveys for coho and Chinook. Refer to Strategy A for data collection on spawning grounds.	Size and age data should be visualized and compared between HOR and NOR with distribution plots and point estimates with 95% confidence intervals.	Sampling occurs throughout the duration of the run. Daily (Merwin Trap); weekly (Lewis hatchery ladder and stream surveys).
3C.2. Disposition of adult trap captures assigned to surplus	Meet goals for proportion and timing of adult disposition that are consistent with the H&S Plan and AOP.	Refer to Sections A2.7, B2.7, and C2.7.	Disposition of each captured adult will be recorded throughout the complete return period for each of the transport species.	Daily at Merwin Trap Weekly at Lewis hatchery ladder

KEY QUESTION 3D. WHAT ARE THE ESTIMATED SMOLT-TO-ADULT RETURNS (SAR'S) FOR EACH HATCHERY STOCK OR REARING TREATMENT GROUP?

APPROACH

Smolt-to-adult Return ratio (SAR) is the number of adults produced out of the number of smolts released. SAR is a key metric to estimate the effects of both freshwater and ocean productivity on the survival of hatchery-produced fish from release to their return to Lewis River traps or to spawn naturally. Harvest estimates from ocean fisheries and terminal (in-river) fisheries should also be incorporated into the SAR calculation to account for adults removed prior. The protocols for calculating SAR for Lewis River Hatchery fish will be described in Strategy I.

SAR is also one of the metrics used to evaluate different rearing strategies at the hatchery facilities, including the spring Chinook rearing and release evaluation (summarized in Strategy E).

LIMITATIONS OR CONCERNS

- Tag loss in juveniles.
- Incomplete tag recovery from adult cohorts.
- Time lag in reporting in RMIS.

DATA COLLECTION METHODS

Metric or Monitoring Indicator	Targets	Field Methods	Analytical Methods	Frequency and Duration
3D. Smolt-to-adult Return ratio (SAR) of all hatchery release groups	Adult returns are adequate to meet adult ocean recruit targets given in section 8.3 of the Settlement Agreement.	Collection of CWTs from fish encountered in 1) Lewis River traps 2) Lewis River subbasin spawning grounds, 3) strays to other basins and 4) harvest by stock	CWT data obtained from RMIS based on release codes. Returns include recaptures from: • Adult harvest in all fisheries • Adult spawners • Adult traps Releases are estimated number of CWT smolts released by release group, corrected for estimated tag loss and post-tagging in-hatchery mortality.	Annual SAR estimate for each brood year and release group

KEY QUESTION 3E. IS THE FISH HEALTH MONITORING AND DISEASE PREVENTION STRATEGY EFFECTIVE AT REDUCING INFECTIONS AND LIMITING MORTALITIES?

APPROACH

WDFW's Fish Health Unit is tasked with monitoring population health of all H&S Plan species and operates following standards and objectives outlined in the Salmon Disease Control Policy of the Fisheries Co-Managers of Washington State (WDFW 2006) and State of Washington Fish Health Manual (WDFW 2010). Services include monitoring reported and regulated pathogens in all broodstocks, baseline monitoring throughout the rearing cycle, and direct monitoring for specific disease progression and severity in targeted groups. Common species-specific diagnoses, disease prevention and treatments are described further in Strategy D, *Fish Health Monitoring and Disease Prevention Strategy for Lewis River Hatchery Programs.*

Mortality rates are monitored by life stage by hatchery staff to determine if mortality rates are preventing achieving the production goals.

Fish health monitoring at Lewis River Hatchery Facilities includes

- Routine baseline monitoring
- Directed monitoring (and treatment) in response to any significant loss of fish (>~0.05% loss for consecutive days or exponentially increasing loss pattern) that is suspected to be due to an infectious agent.
- Special monitoring of juveniles for gas bubble trauma, bacterial kidney disease

LIMITATIONS OR CONCERNS

The *Fish Health Monitoring and Disease Prevention Strategy for Lewis River Hatchery Programs* is not intended to be comprehensive protocols, but provide the common approaches for managing perennial disease issues.

BKD is endemic in the Lewis River Spring Chinook Salmon population. BKD prevalence and severity is highly variable year-to-year, confounding the ability to draw linkages to spawning and rearing practices. WDFW Hatchery staff and Fish Health staff will continue to discuss tracking BKD expression and prevalence in all life stages to link prevalence of BKD in progeny to results of females contributing to a rearing unit. Evaluation of current BKD screening protocols will be made on a yearly basis in response to patterns in BKD prevalence, disease severity, and rearing mortality among untested groups.

DATA COLLECTION METHODS

Metric or Monitoring Indicator	Targets	Field Methods	Analytical Methods	Frequency and Duration
3E.1. Infection rates by species and life stage	Ensure the health and productivity of H&S Plan fish	60 adult females of each species are inspected and sampled during spawning All spring Chinook females whose eggs are allocated for February release will be tested for BKD prevalence Rearing juveniles are monitored and examined routinely	Fish health monitoring results are reported and maintained by WDFW and pathogen histories are available at any time upon request. The subsample of juvenile spring Chinook evaluated for BKD at transfer and release will be analyzed to report prevalence (% positive), DNA load, prevalence of severe infections, and prevalence of gross pathology.	Baseline monitoring occurs throughout broodstock collection, spawning, and incubation as described in Strategy D. Directed monitoring occurs as needed.
3E.2. Mortality rates by species and life-stage	Ensure mortality rates are not adversely affecting production targets	If needed, medication will be provided by the veterinarian of record	Results are generally reported as presence/absence, mortality range (normal, increased, epizootic) and % loss (mortality) per day for a given rearing unit. In-hatchery survival reported as survival (S = total count – mortalities) from egg to release for each species and release group.	Special monitoring of juvenile spring Chinook for GBT will occur with an initial baseline examination in June, followed by weekly examinations in August Special monitoring of juvenile spring Chinook for BKD will occur at the times of transfer and release.

KEY QUESTION 3F. DO HATCHERIES INCORPORATE NEW SCIENTIFIC ADVANCES TO IMPROVE FISH CULTURE EFFECTIVENESS AND EFFICIENCY?

APPROACH

Periodic evaluations or reviews of the existing hatchery programs should occur to incorporate advances in the best available science that improve operational efficiency and benefit fish health at each of the three facilities. The focus of these periodic reviews will be the implementation of actions that help the hatchery programs achieve the goals of the H&S Plan (i.e., reintroduction outcome goal). The role of hatcheries is a critical component in meeting H&S goals and operation of the facilities should remain adaptable to the needs of the H&S program, development and transitioning into integrated hatchery programs and the needs of harvest management. Finally, operations should be reviewed of potential risks posed by hatchery management on the long-term viability of naturally producing stocks.

The ATS will conduct periodic reviews and report any recommendations to the ACC or hatchery managers for for modifying the hatchery program's activities to align with the best available science on fish health, behavior, and operational efficiency.

LIMITATIONS OR CONCERNS

Direct comparisons between Lewis River Hatcheries operations and those described from other hatcheries or literature may not be possible. Inferences and assumptions should be identified clearly at the time of review.

DATA COLLECTION METHODS

Metric or Monitoring Indicator	Targets	Field Methods	Analytical Methods	Frequency and Duration
3F. Periodic review of hatchery operations relative to current literature	Implementation of hatchery activities that are based on best available science on maintaining fish health, sustaining harvest, and minimizing genetic or ecological risks.	N/A	The AOR and current hatchery methods will be reviewed and compared to published literature and methods from other hatcheries. The ATS will identify known areas of concern for hatchery operations efficiency or topics of recent advances in hatchery science. Potential outcomes include identification of a data gap, next steps toward making changes in implementation, or recommending an immediate implementation change if evidence supports it.	Hatchery operations will be reviewed every three years. The discussion of the approach to the review will occur in June of the review year, and recommendations will be completed by October of the review year for incorporation into the following AOP for the following year.

Objective 4.0: Adopt strategies that limit potential post-release ecological interactions between hatchery and NOR listed species

The purpose of Objective 4.0 is to limit ecological interactions (predation, competition, residualism and pathogen transmission) between hatchery released juveniles on natural origin listed species. Interactions between hatchery released juveniles and ESA listed species cannot be observed directly. Therefore, this objective relies on "take surrogates" as described by NOAA Fisheries (NMFS 2017) to reduce the potential of adverse interactions between hatchery and natural-origin salmon and steelhead. Each key question provided under this objective relates directly to each take surrogate described by NOAA Fisheries.

KEY QUESTION 4A: DO CURRENT HATCHERY RELEASES RESULT IN SPATIAL AND TEMPORAL OVERLAP BETWEEN HOR AND NOR JUVENILES?

APPROACH

This question will be answered by comparing hatchery release timing and location to the spatial and temporal distribution of natural origin stocks in the NF Lewis River. Potential overlaps will be identified for all hatchery releases and all life stages of natural origin stocks (presence of juveniles in an area can be inferred from known spawning distributions).

Hatchery data on timing and locations for all hatchery releases will be compared to empirical information derived from field activities where natural-origin juveniles and spawners are encountered. Activities that help to characterize the spatial and temporal distribution natural-origin fish in the North Fork Lewis River and its tributaries include adult fish trapping, spawner surveys, juvenile screw trapping, and potentially other presence/absence surveys such as juvenile seining activities downstream of Merwin Dam. Potential or observed overlaps between hatchery releases and NOR stocks will be identified.

LIMITATIONS OR CONCERNS

Overlap in space or time is used as a "take surrogate" for ESA-listed natural-origin fish; it is not a direct measure of take and therefore cannot quantify or estimate actual take related to large hatchery releases in the North Fork Lewis River.

DATA COLLECTION METHODS

Metric or Monitoring Indicator	Targets	Field Methods	Analytical Methods	Frequency and Duration
4A.1. Release locations of hatchery smolts relative in-river spawning locations.	Mitigate potential spatial overlap between hatchery-released juveniles and NOR stocks	Release location(s) of each hatchery pond; multiple locations to include relative portion of total release (e.g., forced release group transferred to Pekins Ferry) Spawner distribution monitored by redd and carcass (spawner) surveys, as described in Strategy B.	compare hatchery release locations to distribution of natural-origin fish inferred from spawning surveys and screw trap captures.	Annually
4A.2. Release timing of hatchery reared smolts relative to presence of NOR	Mitigate potential temporal overlap between hatchery-released juveniles and NOR stocks		Compare hatchery juvenile release dates and encounters of hatchery origin fish with timing of natural-origin fish in the datasets for adult trap entry, spawner surveys, and screw trap encounters.	Annually

KEY QUESTION 4B: DOES THE MIGRATION RATE OF HOR JUVENILES RESULT IN OVERLAP WITH NOR JUVENILES OR SPAWNING ADULTS?

APPROACH

Monitoring migration rate is an indirect method for monitoring post-release behavior of hatchery smolts to infer their potential impacts on NOR species. The timing of hatchery-origin juvenile outmigration after release will be derived from screw trapping in the lower North Fork Lewis River as described in Strategy C. The beginning, peak and end of the volitional release period from the hatchery will be compared to the beginning, peak and end of encounters in the screw traps. The range of migration rates observed and average or median migration rate of hatchery-released smolts will be reported.

LIMITATIONS OR CONCERNS

The migration window of hatchery fish is typically very short (i.e., a few days) and if the traps are not in operation due to mechanical failure, an entire migration window may be missed.

Volitional release periods can last for just a few days if >90% of a group leave quickly, or up to 6 weeks if many fish do not volitionally leave the ponds. The specific timing of when hatchery fish enter the river during a volitional release period may not be precisely known, so travel time to screw traps may be reported as a range based on a range of potential river entry dates. PIT tagging of hatchery fish and use of a fixed PIT tag antenna at the hatchery could be used to determine river entrance timing and inform assumptions about average migration rate.

Screw trapping is planned to occur from March 1 through June 30 (but may be adjusted in season depending on flows); migration rates will not be available for fish emigrating outside of that period, which likely includes spring Chinook salmon that are released in June (as fry), October (as fall yearlings) or February (as spring yearlings).

DATA COLLECTION METHODS

Metric or Monitoring Indicator	Targets	Field Methods	Analytical Methods	Frequency and Duration
4B. Average migration rate and range of migration rates of hatchery released smolts	Rapid outmigration to minimize the period of time that hatchery-origin juveniles may encounter natural-origin fish.	Refer to Sections A3.7, B3.7, and C3.7 for hatchery release timing. Refer to Strategy C for screw trapping methods.	Derive minimum, maximum, and mean or median migration rates from the difference between release date and screw trap capture dates.	Average migration rates will be reported annually for species (or release groups) in context of trends across years, as described in Section E of this document, Adaptive Management.

KEY QUESTION 4C: ARE THE NUMBER OF HATCHERY-RELEASED JUVENILES EQUAL TO OR LESS THAN PRODUCTION TARGETS?

APPROACH

This question will be answered by reviewing hatchery release records documenting the total number of smolts released for each species. The number of fish planted into hatchery rearing vessels is determined by volumetric measurement. The number of fish released is derived from the number planted less any mortalities observed over the rearing period. This information will be compared to hatchery production targets contained in the H&S Plan and Settlement Agreement to ensure that total release number should not exceed 105 percent of production targets. Release targets are shown in Table X-X.

Table D-1. Total juvenile hatchery production targets for the North Fork Lewis River hatchery complex

Species	Number of fish	Maximum release number
Spring Chinook	1,350,000	1,417,500
Early Winter Steelhead	100,000	105,000
Late Winter Steelhead*	50,000	60,000
Summer Steelhead	175,000	183,500
Coho Salmon	2,000,000	2,100,000

* As specified in Section A3.6 late winter steelhead releases are 50,000 ± 20%

Hatchery release numbers are reviewed annually and any exceedances of target release numbers shall be noted in the Annual Operations Report. Any exceedances will be discussed within the ATS to determine the reason(s) for exceeding the target release number for any species and if necessary, adaptive management actions shall be incorporated into the Annual Operating Plan.

LIMITATIONS OR CONCERNS

Number at the time of release is an estimate based on original stocked number less observed mortalities, but may not account for unobserved mortalities (i.e. due to predation).

DATA COLLECTION METHODS

Metric or Monitoring Indicator	Targets	Field Methods	Analytical Methods	Frequency and Duration
4C. Number of total smolts released by species and period	≤ 105% of target release number.	Rearing ponds stocked with number determined volumetrically. Mortalities subtracted over rearing period.	Compare number released to target.	Report annually for each release group.

KEY QUESTION 4D: ARE THE SIZES (LENGTH AND WEIGHT) OF RELEASED HATCHERY JUVENILES EQUAL TO OR LESS THAN PROGRAM TARGETS?

APPROACH

Batch weights are collected monthly to compare actual fish size to programmed size targets by month. Length and weight are measured on a representative subsample of fish from each rearing pond at the time of release.

LIMITATIONS AND CONCERNS

Collecting a representative subsample from large rearing ponds is challenging, especially for groups with more variability in size (e.g. spring Chinook and late winter steelhead).

DATA COLLECTION METHODS

Metric or Monitoring Indicator	Targets	Field Methods	Analytical Methods	Frequency and Duration
4D. Mean and coefficient of variation (CV) in fork length and weight of smolts released by species and release group.	Steelhead: > 180 and < 220 mm. Spring Chinook: 8-12 fpp for October or February releases, 80 fpp for June release (see Strategy E). Coho: 16 fpp.	Batch weights collected monthly. Length measured from a representative subsample (e.g. 100 fish per release group) at the time of release.	Calculate fish per pound (fpp) from weights to compare to targets. Calculate mean and CV of fork length, weight.	Monthly batch weights. Average fork length at the time of release.

KEY QUESTION 4E: WHAT IS THE PRECOCITY RATE FOR HATCHERY JUVENILES BY RELEASE GROUP PRIOR TO SCHEDULED RELEASES?

APPROACH

The Aquatic Technical Subcommittee has discussed potential ways to quantify residualism and determined that measuring precocity in hatchery-reared spring Chinook salmon should be a priority. Precocious maturation refers to male fish that mature toward the end of either their first year (microjacks) or second year (minijacks), as measured from the date of fertilization.

Age 1 Precocity:

At the time of spawning (late-August through October for spring Chinook), fully mature males can be easily identified by their darkened body color and rounded belly and can be identified with a non-lethal screening. Their testes grow to fill most of their abdominal cavity, and milt can be expressed by gently squeezing the fish's abdomen in an anterior to posterior motion. Non-lethal screening may be used to evaluate whether specific rearing or feeding strategies contribute to overall precocity in spring Chinook

Age 2 Precocity:

The two most thoroughly validated indexes of maturity for spring Chinook maturing at 2 years of age require lethal sampling: 11-ketotestosterone (11-kt) levels in the blood plasma and testis weight compared to total body size (Refer to Strategy F for detailed methods). With either method, the distribution of the data tends to be bi-modal and precocious males are identified as individuals with 11-kt or GSI levels above a derived threshold level that separates the two modes.

LIMITATIONS OR CONCERNS

Non-lethal visual screening for precocious males a metric that can be objective, and for spring Chinook salmon in particular, inaccurate for fish released in February, 6 to 7 months prior to typical spawning times. The physiological processes that lead to maturity in spring Chinook may not have progressed enough in February to show detectable differences in physiological indicators; differences between immature and mature groups are more easily discerned later in March and April.

DATA COLLECTION METHODS

Metric or Monitoring Indicator	Targets	Field Methods	Analytical Methods	Frequency and Duration
4E. Precocity Rate	Minimize precocity rates to reduce residualism and interactions between mature juveniles released at the same time as natural spawning in the river. Precocity rate in wild spring Chinook likely to be less than 5% of males.	Non-lethal visual screening for October spring Chinook release group. Lethal 11kt or GSI sampling for February spring Chinook release groups. Refer to Strategy F for details.	Calculate precocity rate as number of precocious males out of total number of males. Refer to Strategy F for details.	Non-lethal visual screening for October spring Chinook release group carried out annually as part of routine morphology monitoring at the time of release. Lethal 11kt or GSI sampling for February spring Chinook release group carried out periodically.

Abundance Monitoring Objectives

Objective 5.0: Estimate spawner abundance of late winter steelhead, Coho, chum and Chinook downstream of Merwin Dam

The purpose of Objective 5.0 is to collect unbiased, long-term, abundance, distribution and cohort trend data for natural origin adult spawners (Chinook, Coho, chum salmon and late winter steelhead) downstream of Merwin Dam. This includes recovery of CWT tags from salmon carcasses to inform harvest management, and collection of mark and tag status information (i.e., adipose clips and CWT presence) to inform calculation of pHOS and PNI.

A secondary purpose of this objective is to provide data for Objective 22 of the AMEP which describes combining estimates from downstream of Merwin Dam with transport and monitoring data for areas upstream of Swift Dam to evaluate spawning distribution and develop population-level estimates of spawner abundance and productivity for Chinook, Coho and late winter steelhead.

KEY QUESTION 5A: ARE ESTIMATES OF SPAWNER ABUNDANCE UNBIASED AND MEETING PRECISION TARGETS?

APPROACH

For spring Chinook and fall Chinook, which are present in large numbers, spawner abundance is estimated using carcass mark-recapture data in an open-population Jolly-Seber “super population” model, described in Strategy A. When the assumptions of the JS model are met, it produces unbiased estimates of escapement with known levels of precision. Those assumptions are that carcasses have equal catchability, equal survival, no tag loss and readability upon recovery, and instantaneous sampling. The assumptions will be evaluated annually following methods described in Strategy A.

For steelhead, abundance is estimated using redd surveys in the mainstem. If river conditions prevent surveys, area-under-the-curve methods will be used and however this method relies on a number of untested assumptions, and bias in the estimates can not be evaluated.

For coho, abundance in the mainstem North Fork Lewis River is estimated using carcass mark-recapture data in a Jolly-Seber mark-recapture analysis, as described in Strategy A. Uncertainty in mainstem spawner abundance will be reported as the range in potential abundance within associated confidence intervals. Abundance in the tributaries to the North Fork Lewis River are estimated from carcass and redd data collected using a Generalized Random Tessellation Stratified (GRTS) method to predetermine a spatially-balanced set of survey reaches, and data are entered in to a Bayesian multivariate state-space model used for coho throughout the Lower Columbia ESU. Parameters are reported as posterior medians with associated 95% credible intervals.

Chum abundance is too low to evaluate bias in estimates at this time.

LIMITATIONS OR CONCERNS

The estimators may quantify all possible sources of variation better for some species but not others. See Key Question 5B for limitations and concerns for estimating abundance with spawner surveys.

DATA COLLECTION METHODS

Metric or Monitoring Indicator	Targets	Field Methods	Analytical Methods	Frequency and Duration
5A. Mark-recapture modeling assumptions are evaluated to determine if they are met	Generate an unbiased estimate of abundance and composition downstream of Merwin Dam with a CV of 15% or less, on average	Chinook: Carcass mark-recapture. Steelhead: redd survey. Coho: Carcass mark-recapture in mainstem, GRTS and Bayesian multivariate state-space model in tributaries. Refer to Strategy A.	Annual evaluation of assumptions made for modeled estimates of abundance. Refer to Strategy A. Chinook: Open-population Jolly-Seber "super population" analysis to generate abundance estimates by stock, origin, sex and age. Steelhead: redd counts multiplied by fish per redd; AUC if necessary. Coho: Jolly-Seber mark recapture model for mainstem, and Bayesian multivariate state-space model for tributaries, to generate abundance estimates by origin.	Surveys and analyses completed annually.

KEY QUESTION 5B: ARE ANNUAL ESTIMATES OF NATURAL-ORIGIN SPAWNER ABUNDANCE INCREASING, DECREASING OR STABLE?

APPROACH

For spring Chinook and fall Chinook, which are present in large numbers, spawner abundance is estimated using carcass mark-recapture data in an open-population Jolly-Seber “super population” model, described in Strategy A.

For steelhead, abundance is estimated using redd surveys. If river conditions prevent surveys, area-under-the-curve methods may be used.

For coho, abundance in the mainstem North Fork Lewis River is estimated using carcass mark-recapture data in a Jolly-Seber mark-recapture analysis, as described in Strategy A. Abundance in the tributaries to the North Fork Lewis River are estimated from carcass and redd data collected using a Generalized Random Tessellation Stratified (GRTS) method to predetermine a spatially-balanced set of survey reaches, and data are entered in to a Bayesian multivariate state-space model used for coho throughout the Lower Columbia ESU.

Chum abundance is currently low; carcasses that are encountered in Chinook and Coho surveys are enumerated.

LIMITATIONS OR CONCERNS

- For Chinook and Coho, violation of model assumptions may create unknown levels of bias in estimates.
- Assignment of redds to species is complicated by overlapping distributions of relatively large number of fall Chinook with Coho and spring Chinook.
-
- Steelhead abundance estimates are often limited by river conditions in the spring that cause high turbidity or flows and limit surveyors’ ability to identify redds.
- Steelhead are not currently surveyed across their entire spatial distribution in tributaries, thus generated estimates of abundance are likely biased low.

DATA COLLECTION METHODS

Metric or Monitoring Indicator	Targets	Field Methods	Analytical Methods	Frequency and Duration
5B. Total spawner abundance estimates by species, sex and origin, and age.	Annual trends are stable or increasing.	Carcass and redd surveys. Refer to Strategy A.	Chinook: Open-population Jolly-Seber “super population” analysis. Coho: Jolly-Seber mark recapture model for mainstem, and Bayesian multivariate state-space model for tributaries. Steelhead: redd surveys	Surveys and analyses completed annually. Results reported annually by species in context of trends across years, as described in Section E of this document, Adaptive Management.

Objective 5.1: Determine the spatial and temporal distribution of spawning late winter steelhead, coho, chum and Chinook downstream of Merwin Dam

KEY QUESTION 5C: ARE ANNUAL TRENDS IN SPATIAL AND TEMPORAL SPAWNING DISTRIBUTION INCREASING, DECREASING OR STABLE?

APPROACH

For steelhead, spatial and temporal distribution of spawners is estimated using redd surveys.

For Coho salmon in the mainstem North Fork Lewis River, spatial and temporal distribution is determined from live counts and carcasses. Redd surveys are not a reliable estimator in the mainstem due to superimposition with Chinook redds. In tributaries, redd counts and live counts will used to determine Coho distribution.

For Chinook, redd counts and live fish will be enumerated in the mainstem North Fork Lewis River. Standard metrics (e.g. median and standard deviation) will be used to describe abundance. Temporal distribution will be described by calculating median spawn date using weekly derived estimates of abundance using the Jolly-Seber model, and a cumulative distribution plot of abundance will be generated.

Chum salmon are present in low numbers; changes in spatial or temporal distribution will not be evaluated.

Spawner survey methods are described in Strategy A. Redd locations are recorded using GPS and data are time stamped. The number of redds or spawners per mile and per period will be calculated and compared across years to identify shifts in spatial or temporal distribution.

LIMITATIONS OR CONCERNS

Steelhead redd surveys are not performed if visibility is low or spill from Merwin Dam has been initiated. Poor visibility can also prevent identification of coho redds or live fish. Discerning Chinook and coho redds is challenging and substantial redd superimposition occurs between the species.

DATA COLLECTION METHODS

Metric or Monitoring Indicator	Targets	Field Methods	Analytical Methods	Frequency and Duration
5C. Estimate of redds, carcasses or live spawners by reach and time period	Proportion of redds per reach is stable or increasing	Spawner surveys described in Strategy A with spatial and temporal data recorded using GPS as described in Strategy B.	Median spawner number per reach and median spawn date per week to be calculated.	Surveys and analyses completed annually. Results reported annually by species in context of trends across years, as described in Section E of this document, Adaptive Management.

Objective 6.0: Estimate juvenile outmigrant abundance for late winter steelhead, coho, and Chinook downstream of Merwin Dam

The purpose of Objective 6.0 is to estimate the abundance of juvenile outmigrants by species and origin for the North Fork Lewis River downstream of Merwin Dam. Capture and sample juvenile fish to note morphological differences between HOR and NOR smolts, as well as other juvenile non-migrants (i.e., fry and parr).

KEY QUESTION 6A: ARE ESTIMATES OF NOR JUVENILE OUTMIGRANT ABUNDANCE UNBIASED AND MEETING PRECISION TARGETS?

APPROACH

Outmigration abundance is estimated through the use of rotary screw traps in the lower North Fork Lewis River. Trap operation and analysis protocols are described in Strategy C.

These traps capture a portion of the total number of juveniles passing the trap location. Trap efficiency is estimated using a mark-recapture approach in which trapped fish are marked, released upstream of the trap, and some percentage are recaptured. The estimated capture efficiency of the trap is used to derive estimates of abundance for juveniles passing the trap. Approaches for estimating trap efficiency and abundance by species, life-stage, and by week are an ongoing topic of ATS discussion.

Estimates of abundance are only useful if they are unbiased (i.e., accurate) and relatively precise. A recovery monitoring goal for juvenile salmon migrants is to have data with a CV on average of 15 percent or less, and steelhead migrant data with a CV on average of 30 percent or less. Assumptions of the estimator must be met, and variance must be estimated in an unbiased manner. Because it is not possible to estimate the level of bias, study designs should strive to meet all the assumptions of the estimator(s) to the extent practical. These assumptions are summarized in Strategy C, briefly:

1. The population is closed to immigration, emigration, births, and deaths.
2. No mark or tag loss (from fish marked for estimating trap efficiency).
3. No mark-related mortality.
4. All fish have equal probability of being caught and marked in the first event.
5. Marked fish mix completely with unmarked fish between sampling events.

LIMITATIONS OR CONCERNS

Juvenile outmigrant trapping can be complicated and requires development of clear study designs or protocols, project review and adaptive management to be successful. Estimates of abundance can be biased if the assumptions of the mark-recapture estimator are not met (e.g., equal survival and capture probability among marked and unmarked groups). Testing assumptions and describing how mark-recapture assumptions are being met is critical for developing unbiased estimates. The ability to specifically test all assumptions for the North Fork Lewis River smolt trapping project may be limited and should utilize results and recommendations from other juvenile migrant studies when applicable (e.g., tag retention studies).

In past years, it has been difficult to mark, and subsequently recapture enough juveniles to generate unbiased estimates of abundance. To reduce bias in the estimates, the ATS may evaluate whether the following methods are practical for implementation:

- Pooling of data to increase the sample size and power to improve the precision of estimates, however, this method can produce biased estimates and is not favored by WDFW.
- The use of marked hatchery releases as a surrogate for mark-recapture in smolt traps. However, capture probability may not be the same between HOR and NOR smolts due to differences in size or behavior, violating assumption number 4 of the estimator.
- Increasing the mark rate at the screw trap to increase the number of total marks available for recapture.
- Use of Cedar Creek screw trap captures to increase the number of NOR marks available for recapture.
- In theory, the use of juveniles captures from other sources (e.g., the Swift FSC, Cedar Creek, additional upstream trap) may provide the ability to increase the number of marked smolts available for capture to estimate capture efficiency. However, there are a number of considerations to assess when determining whether these sources are feasible:
    - Can marked fish can be released safely for both staff and marked fish?
    - What is the number of marked fish needed to make meaningful inferences regarding capture efficiency?
    - Are marked release groups representative of their NOR counterparts (e.g., size, behavior and migration timing)?
    - Does the use of alternative sources impact other required monitoring needs?
    - Are there any ESA regulatory restrictions on trapping or releasing additional marks into the NF Lewis River?
    - Is the use of juveniles from alternative sources practical from an operations, safety and regulatory obligations in the Settlement Agreement?

Behavior or migration rates between the traps and the mouth of the Lewis River cannot be described by the screw trap catches alone. More work is needed to quantify the number of fish residing (e.g., nonmigrants) upstream of the trap post-release to estimate residualism rates.

Trapping is inherently difficult in larger rivers due to debris load, variable flows (including spill) and mechanical failures – most of which are unavoidable consequences of operating floating traps in large rivers. Trap operation in the North Fork Lewis River may be limited by high streamflow conditions in late winter and spring as well as lower flow periods in the summer.

DATA COLLECTION METHODS

Metric or Monitoring Indicator	Targets	Field Methods	Analytical Methods	Frequency and Duration
6A. Precision and accuracy of abundance estimates.	VSP precision and accuracy targets are met: CV < 15% (salmon) and < 30% (steelhead)	Rotary screw traps will be used to capture a portion of the total number of juveniles passing the trap location. Mark-recapture of those fish will be used to test trap efficiency. Refer to Strategy C	Quantify whether assumptions of the estimator are met. See Strategy C for details.	See Strategy C. Annual juvenile outmigrant sampling. Traps checked every morning, 7 days per week, from March 1 through June 30. Trapping dates may be adjusted depending on river flows. Additional daily trap checks may be warranted during peak migration.

KEY QUESTION 6B: IS THE ABUNDANCE OF NOR JUVENILE OUTMIGRANTS BY SPECIES AND OUTMIGRATION YEAR INCREASING, DECREASING, OR STABLE?

APPROACH

Outmigration abundance is estimated through the use of rotary screw traps in the lower North Fork Lewis River. Abundance estimates are derived from trap efficiencies. Trap operation and analysis protocols are described in Strategy C. Trapped salmonids will be identified by species, life-stage (based on size), and origin (based on hatchery marking). The assignment of fish to these groups will follow a decision tree developed and used by WDFW in other trapping operations, included in Strategy C.

In addition to reporting abundance estimates, a power analysis will be conducted for each juvenile migrant population being monitored to determine the power of the data to detect a significant change in abundance and recommended sample sizes to be able to detect change over time.

Annual estimates of NOR juvenile outmigrant abundance will be reported in the Annual Operating Report for a given cohort, in some cases to include numbers of fish from the same cohort that out-migrate at different lift-stages. Data will be reported in context with previous years of data to make a determination if numbers are increasing, decreasing, or stable. The approach for annual reporting of trends and ACC review of the data are described in Section E of this document, Adaptive Management.

LIMITATIONS OR CONCERNS

Generating unbiased estimates of juvenile NOR outmigrant abundance is limited by low numbers of NOR captures in rotary screw traps. Trapping is limited to the major spring outmigration period for Chinook, coho, and steelhead (March 1 through June 30, trapping dates may be adjusted depending on river flows); fish migrating outside of this window will not be sampled.

DATA COLLECTION METHODS

Metric or Monitoring Indicator	Targets	Field Methods	Analytical Methods	Frequency and Duration
6B.1. Trend in total NOR outmigrants by species and cohort.	Annual trends are stable or increasing.	Screw trapping to capture outmigrants. Refer to Strategy C.	Derive estimates of abundance based on trap efficiency. Refer to Strategy C.	Juvenile outmigrant abundance and morphology sampling carried out annually. Traps checked every morning, 7 days per week, from March 1 through June 30. Trapping dates may be adjusted depending on river flows.

KEY QUESTION 6C: WHAT ARE THE MORPHOLOGICAL CHARACTERISTICS OF OUTMIGRATING NOR JUVENILES RELATIVE TO THEIR CONSPECIFIC HOR JUVENILES?

APPROACH

Outmigration of NOR juveniles is monitored through the use of rotary screw traps in the lower North Fork Lewis River. Trap operation and analysis protocols are described in Strategy C. Morphological information is collected from fish captured in rotary screw traps. Fish are identified as natural origin by lack of hatchery marks, and categorized as fry, parr, transitional, subyearling smolt, yearling smolt based on size and external coloration following the decision tree included in Strategy C. Size and smolt development are similarly collected at the time of release for hatchery-reared fish as described in sections A 3.7, B 3.7, and C 3.7 of this AOP.

LIMITATIONS OR CONCERNS

Hatchery-origin juveniles for this program to optimize high rates of smoltification, post-release survival and faster outmigration compared to natural-origin fish. No changes have been proposed for changing hatchery-origin size or release targets relative to natural-origin fish.

Similar to estimates of abundance, unbiased estimates of natural-origin outmigrant size and smoltification will be limited by low numbers captured in the screw traps and the timing of trapping operations between March 1 and June 30.

DATA COLLECTION METHODS

Metric or Monitoring Indicator	Targets	Field Methods	Analytical Methods	Frequency and Duration
6C. Comparison of fish size, life-stage and age-class between NOR and HOR juveniles.	No relevant target for natural-origin outmigrants; hatchery-origin outmigrant size based on optimizing post-release performance.	Refer to Sections A 3.7, B 3.7 and C 3.7 of this document for data collection at the time of release. Up to 10 fry per day and 50 subyearling/ transitional/ parr per day per category to be sampled for fork length during screw trapping. Refer to Strategy C.	Average size to be calculated from representative subsample at hatchery release and in screw trapping. The component of those subsampled made up by different life-stages and age classes should also be reported.	Juvenile outmigrant abundance and morphology sampling carried out annually. Traps checked every morning, 7 days per week, from March 1 through June 30. Additional daily trap checks may be warranted during peak migration. Refer to Strategy C.

Risk Assessment Objectives

Objective 7.0: Monitor the extent of genetic risks associated with integrated and segregated hatchery programs on naturally spawning listed populations in the North Fork Lewis River

The purpose of Objective 7 is to develop and implement a comprehensive genetic monitoring plan to assess the potential threats that hatchery programs may pose to naturally-spawning anadromous salmon and steelhead in the Lewis River. The monitoring of genetic risks and minimization of adverse effects is a requirement of the Settlement Agreement. This objective provides guidance on assessing (1) the genetic risks posed by the hatchery production programs and (2) whether the H&S Program is achieving or capable of achieving 'genetic viability' of reintroduced stocks.

The initial goal of this section of the AOP is to identify the baseline levels of genetic diversity and domestication as the starting point for observing changes and trends in the future. Focus species would include winter steelhead, coho salmon, spring Chinook, fall (tule) Chinook, and late-fall (bright) Chinook salmon. Five biologically-relevant populations existing within the designated boundaries of NF Lewis recovery populations (LCFRB 2010) including 1) the segregated hatchery programs and natural spawners in 2) the lower mainstem NF Lewis River below Merwin Dam, 3) tributaries to the lower NF Lewis River, 4) the upper mainstem NF Lewis River above Swift Dam, and 5) tributaries to the upper NF Lewis River.

The detailed approach and methods for monitoring genetic risk (Key Questions 7A and 7B) are described in Strategy G. Genetic baselines would be developed for the segregated hatchery populations and naturally-spawning/integrated hatchery programs. Tissue samples for genetic analysis will be collected from all adults used for broodstock, adults encountered in spawning surveys, and juveniles encountered in smolt traps or Swift Reservoir Floating Surface Collector.

The metrics used for assessing domestication (Key Question 7C) are described in Objective 8.

The metrics used for assessing phenotypic diversity (Key Question 7D) are components of Objectives 3, 4, and 6.

The information addressing each key question under this objective are summarized in the following sections.

LIMITATIONS OR CONCERNS

- Given the long history of hatchery production in the Lewis River basin along with the biological and environmental complexities that govern the impacts of hatchery programs and their progeny on wild populations, it is unlikely that the metrics generated from this plan can definitively answer the four key questions identified in Objective 7 (i.e., have hatchery programs affected the diversity of natural-origin populations?). However, in combination, these metrics will assess the genetic status of Lewis River populations, qualitatively assess the impacts of current hatchery programs on natural-origin populations, and help guide future hatchery operations that promote long-term genetic viability.

- The correct interpretation of results of genetic tests relies heavily on tissue collections that are representative of the intended populations or groups. Uncertainty of the genetic tests is dependent on the number of samples collected and successfully processed.
- Among- and within-population genetic variation may change due to factors other than hatchery production, including gene flow (straying) from other populations and natural selection. The SNP markers intended to be used here may, with adequate baseline data, allow detection of gene flow from outside into the NF Lewis River.
- Many of the SNP markers are assumed to be neutral (i.e., are not linked to traits under selection). Violation of this assumption would lead to incorrect interpretation of the data. Genomic methods are available and can be used to look for regions of the genome that may be under selection and associated with environmental variables. However, these methods are prohibitively expensive and are not currently part of routine hatchery monitoring.
- Genetic methods, technology, and markers continue to evolve and thus may substantially change between timesteps. In order to make valid comparisons among timesteps, the same marker panels must be used for all samples. Any substantial changes in method, technology, or markers may necessitate the re-processing of samples from earlier timesteps.
- The monitoring plan lacks monitoring of adaptive genetic diversity that uses genetic techniques. Some markers linked to adaptive diversity are known (e.g., Chinook/steelhead GREB markers, Chinook Y haplotype markers [age at maturity in males], Prince et al. 2017, Hess et al. 2016, McKinney et al. 2020) and could be used in monitoring efforts.
- Biological-based metrics of phenotypic diversity likely vary due to a combination of genetic and environmental factors and it may not be possible to determine whether such changes are good or bad for the population in terms of survival and persistence.
- Evaluating genetic- and biological-based metrics together provides the most comprehensive means of evaluating hatchery programs and the risks to natural spawning populations they affect. However, there is no consensus on how these metrics should influence adaptive management decisions.
- It is expected that Lewis River populations of salmon and steelhead will remain in the re-colonization phase well past the next rewrite of the H&S plan (scheduled in 2025) and hatchery supplementation will likely continue. However, Lewis River hatchery programs are scheduled for re-evaluation in the coming years through the development of “transition plans”. Changes to broodstock management may subsequently impact genetic risks to natural-origin populations. Thus, this plan may need to be updated accordingly.

KEY QUESTION 7A: HAVE THE LEWIS RIVER HATCHERY PROGRAMS IMPACTED THE AMONG-POPULATION DIVERSITY OF NATURALLY SPAWNING POPULATIONS?

APPROACH

Among-population diversity is measured as relative genetic differences among biological populations. Hatchery production can reduce among-population diversity when hatchery fish successfully spawn with natural-origin adults from biological populations other than those used as broodstock. Reductions of among-population diversity may reduce the long-term viability of the metapopulation through genetic homogenization and outbreeding depression.

DATA COLLECTION METHODS

Metric or Monitoring Indicator	Targets	Field Methods	Analytical Methods	Frequency and Duration
7A. Pariwise genetic distance (F_{st}), combined with dendograms, multi-variate clustering analyses.	See Strategy G.	See Strategy G.	See Strategy G.	Collect tissue samples annually. Analyses of genetic distance at least every third generation.

KEY QUESTION 7B: HAVE THE LEWIS RIVER HATCHERY PROGRAMS IMPACTED THE WITHIN-POPULATION DIVERSITY OF NATURALLY SPAWNING POPULATIONS?

APPROACH

Within-population diversity describes the amount of genetic diversity within a biological population and is important for the long-term resilience of the population. Reduced within-population diversity is an indication of inbreeding (i.e., increased allelic identity by descent), which may lead to inbreeding depression and reduced long-term viability. Hatchery production increases the risks of reducing within-population diversity of natural-origin populations because hatcheries spawn only a subset (sometimes a very small subset) of the entire population which is then amplified via the increased survival afforded by hatchery rearing. Segregated programs that use only hatchery-produced fish for broodstock are especially susceptible to reductions in within-population diversity.

DATA COLLECTION METHODS

Metric or Monitoring Indicator	Targets	Field Methods	Analytical Methods	Frequency and Duration
7B.1. Effect population size (Ne) 7B.2. Effective number of breeders (Nb) 7B.3. Inbreeding coefficient (FIS) 7B.4. Average heterozygosity 7B.6. Allele frequencies 7B.7. Linkage Disequilibrium (LD)	See Strategy G.	See Strategy G.	See Strategy G.	See Strategy G.

KEY QUESTION 7C: HAVE THE LEWIS RIVER HATCHERY PROGRAMS INCREASED THE RISK OF DOMESTICATION FOR NATURALLY SPAWNING POPULATIONS?

APPROACH

Domestication reduces the long-term fitness of populations through the proliferation of alleles which improve performance in domestic settings (i.e., hatcheries) while reducing performance in natural settings (domestication selection). However, there are currently no genetic techniques (e.g., domestication genes or markers) to assess the level of domestication within populations. Therefore, the following metrics based on biological data will be used to assess the potential for domestication of populations that spawn naturally.

- pHOS is the proportion of naturally-spawning adults that are of hatchery origin for a given population and year. An index of gene flow between a hatchery population and its companion natural population.
- pNOB is the proportion of hatchery broodstock composed of natural-origin adults each year. An index of gene flow between hatchery and natural-origin fish within the hatchery.
- PNI describes the collective effects of pHOS and pNOB; describes potential for interbreeding in both hatchery and natural components of the population.
- PEHC estimates interbreeding between hatchery and natural-origin spawners based on genetic parentage analysis of offspring.

DATA COLLECTION METHODS

Metric or Monitoring Indicator	Targets	Field Methods	Analytical Methods	Frequency and Duration
7C.1. Proportion hatchery-origin spawners (pHOS)	Specific HSRG-recommended targets apply, see Objective 8	See Objective 8	See Objective 8	Calculated annually
7C.2. Proportion natural-origin brood (pNOB)	A component of PNI target. Does not apply to segregated programs.	See Objective 8	See Objective 8	Calculated annually
7C.3. Proportion natural influence (PNI)	Specific HSRG-recommended targets apply, see Objective 8	See Objective 8	See Objective 8	Calculated annually

7C.4 Proportion Effective Hatchery Contribution (PEHC)	No specific targets recommended. Program should avoid increase in PEHC over time. Not relevant for integrated programs.	See Objective 8	See Objective 8	Calculated annually

KEY QUESTION 7D: HAVE THE LEWIS RIVER HATCHERY PROGRAMS IMPACTED THE PHENOTYPIC DIVERSITY OF NATURALLY SPAWNING POPULATIONS?

APPROACH

A potential result of declining genetic diversity and increasing domestication may include observable changes in phenotypic traits of naturally spawning populations. These traits may have some genetic component; however, there are currently few genetic markers with known allelic associations with phenotype. Therefore, the following metrics based on fitness traits will be used to assess phenotypic diversity.

DATA COLLECTION METHODS

Metric or Monitoring Indicator	Targets	Field Methods	Analytical Methods	Frequency and Duration
7D.1 Timing of adult return, spawning and juvenile outmigration.	See Key Questions 3A and 3B for adults. See Key Question 4B for juveniles.	See Key Questions 3A and 3B for adults. See Key Question 4B for juveniles.	See Key Questions 3A and 3B for adults. See Key Question 4B for juveniles.	See Key Questions 3A and 3B for adults. See Key Question 4B for juveniles.
7D.2 Size and age of returning adults and juvenile outmigrants.	See Key Question 3C for adults. See Key Question 4D and 6C for juveniles.	See Key Question 3C for adults. See Key Question 4D and 6C for juveniles.	See Key Question 3C for adults. See Key Question 4D and 6C for juveniles.	See Key Question 3C for adults. See Key Question 4D and 6C for juveniles.
7D.3 Broodstock Fecundity	See Key Question 3B	See Key Question 3B	See Key Question 3B	See Key Question 3B

Objective 8.0: Determine the percent hatchery-origin spawners (pHOS), proportionate natural influence (PNI) and pNOB (for integrated programs)

The purpose of Objective 8.0 is to monitor the genetic influence of hatchery programs on natural populations using HSRG-recommended metrics and targets (Table X-X).

Table D-2. Current population designations (LCFRB 2010), hatchery program types, and HSRG-recommended targets for pHOS and PNI for the North Fork Lewis River salmonid populations.

Population	Current Hatchery Program Type	Current Population Designation	HSRG pHOS Target	HSRG PNI Target
Spring Chinook	Segregated	Primary	< 5%	NA
Fall Chinook	None	Primary	< 5%	NA
Coho	Integrated (Late)	Contributing	< 30%	≥ 0.50
Coho	Segregated (Early)	Contributing	< 5%	NA
Winter Steelhead	Integrated (Late)	Contributing	< 30%	≥ 0.50
Winter Steelhead	Segregated (Early)	Contributing	< 5%	NA
Summer Steelhead	Segregated	Stabilizing	< 5%	NA
Chum	None	Primary	< 5%	NA

KEY QUESTION 8A: WHAT ARE THE TRENDS IN PHOS, PNI, PNOB AND PEHC AND DO THEY MEET HSRG RECOMMENDATIONS BY PROGRAM (WHEN APPLICABLE)?

APPROACH

Hatchery-origin and natural-origin spawners will be differentiated based on hatchery marks or tags; marking strategies vary by species and are described in sections A3.5, B3.5, C3.5. The calculation of pHOS, pNOB, and PNI rely on accurate spawner abundance estimates for each group based on assignments made in the field as described in Strategy A. PEHC is similar to pHOS in that it measures gene flow between hatchery and natural-origin fish based on spawner composition, however PEHC is calculated using genetic data of offspring to estimate parentage, described in greater detail in Strategy G.

- pHOS is the proportion of adults spawning naturally that are hatchery-origin spawners (HOS) for a given population and year.
- pNOB is the proportion of a hatchery broodstock composed of natural-origin adults each year.

- PNI is the proportion of natural influence on a population composed of hatchery and natural origin fish (i.e., integrated program).
- PEHC estimates interbreeding between hatchery and natural-origin spawners based on genetic parentage analysis of offspring.

Steelhead

Because steelhead are iteroparous, the number of fish of each origin must be made based on observations of live steelhead. A draft multi state mark-recapture model was developed by the U.S. Geological Survey to estimate pHOS in the population of late winter steelhead that spawn in the North Fork Lewis River downstream of Merwin Dam. The model uses data collected during ongoing field efforts to collect broodstock by tangle-netting, and the capture of all fish that migrate upstream to the Merwin Trap and Lewis Hatchery Ladder.

Chinook and Coho Salmon

Seasonal surveys of Chinook and Coho salmon carcasses are performed weekly throughout the spawning periods for Chinook and Coho salmon, outlined in Objective 5.1 and Strategy A. The origin (NOR, HOR, or Unknown) is recorded for sampled carcasses. The number and composition of carcass recoveries is a direct result of the recovery probability for each individual carcass, which are influenced by many factors (e.g., spawning timing, spatial distribution, sex and size of carcass), therefore, total estimates of pHOS will be derived by weighting of raw recovery data by relative abundance as described in Strategy A.

LIMITATIONS OR CONCERNS

Steelhead

The current steelhead model assumes that capture efficiency at the Merwin Trap is 100 percent and that all fish are correctly identified and recorded (e.g. noting residuals that migrate to the Merwin Trap). Additionally, while this model does not address all possible contingencies (e.g. capture efficiency varying among groups, or different rates of residualism among hatchery and natural populations), the posterior predictive check demonstrates that the model is adequate for the main goal of estimating the proportion of hatchery-origin spawners. However, the possibility for extensions or variations of the model to be evaluated in the future with more formal model comparison techniques remains.

Chinook Salmon

There is substantial temporal and spatial overlap between spring and fall runs of Chinook in the North Fork Lewis River, reducing the ability to reliably differentiate between fall and spring run Chinook in the field. Misidentification of carcasses as either spring or fall run will affect pHOS estimates because the vast majority of fall run Chinook are of natural origin whereas the spring run is predominantly of hatchery-origin from the segregated hatchery program.

Coho Salmon
A substantial portion of returning Coho either are trapped or spawn in tributaries of the mainstem North Fork Lewis River. Because most of the carcass recovery effort is focused on the mainstem, sampling may not be representative of the total returns to the basin. pHOS will not be reported separately for early and late Coho.

DATA COLLECTION METHODS

Metric or Monitoring Indicator	Targets	Field Methods	Analytical Methods	Frequency and Duration
8A.1. Proportion hatchery-origin spawners (pHOS)	See Table X-X above for population-specific targets.	For Chinook and Coho spawner origin is derived from spawner surveys. Refer to Strategy A. Methods for determining pHOS in steelhead are to be determined in coordination with the ATS.	pHOS = Number of HOS/(HOS + NOS)	Calculated annually
8A.2. Proportion natural-origin brood (pNOB)	A component of PNI target. Applies only to integrated programs. Late winter steelhead uses a pNOB target of 1 to achieve a PNI ≥ 0.50. Late coho follows a recommended integration rate (e.g., 30 percent) based on the designation for each stock or population (e.g., primary, contributing, or stabilizing.)	For each integrated program (late winter steelhead and late coho), the origin and sex of each fish spawned will be recorded.	pNOB = NOB / (HOB + NOB). pNOB will be calculated within each spawning matrix, and for the total number of spawners.	Calculated annually

8A.3.Proportion natural influence (PNI)	See Table X-X above for population-specific targets. This metric is influenced substantially by the pNOB. For example, if the broodstock incorporates 100 percent natural origin fish, PNI estimates cannot be less than 50 percent.	N/A	PNI = pNOB/(pNOB+pHOS)	Calculated annually
8A.4.Proportion Effective Hatchery Contribution (PEHC)	No specific targets recommended. Program should avoid increase in PEHC over time. Not relevant for integrated programs.	N/A	Refer to Strategy G.	Calculated annually

Objective 9.0: Monitor the post-release behavior of hatchery smolts and their potential impacts on native and ESA-listed species present downstream of Merwin Dam.

The purpose of Objective 9.0 is to provide a means for direct monitoring of ecological interactions between HOR and NOR juveniles if in-hatchery monitoring metrics described under Objective 4 are not achieved. This objective shall remain inactive for as long as the metrics described in Objective 4 remain measurable and within the targets provided each year in the AOP.

SECTION E ADAPTIVE MANAGEMENT

The ATS is tasked with reviewing technical aspects of program implementation within a given calendar year. The ATS Work Plan (Appendix A) is a calendar of ATS activities, program production tasks, and monitoring and evaluation strategies. The work plan also identifies specific decision points that the ATS tracks throughout the year. Adaptive management will be used to periodically evaluate and adjust activities covered by the AOP, including H&S Program implementation and the monitoring and evaluation (M&E) activities described in Section D.

Review Milestones

As envisioned in section 8.2 of the Settlement Agreement, program components will be evaluated in the following processes and documents:

- The H&S Annual Operating Report (AOR) compiles all information gathered pursuant to implementation of the H&S Plan, including recommendations for the ongoing management of the H&S Program, and is provided to the ACC for review and comment. The AOR is intended to provide estimates or results for each of the key questions and related objectives (Section D) evaluated each year. The AOR will include key highlights, accomplishments and technical recommendations to focus the ACC review as part of the Executive Summary. It is important to note that while the AOR provides estimates and results from annual monitoring activities and may recommend technical changes to program or M&E implementation, it does not provide decisions on the continuation of specific monitoring actions, management decisions, nor would the results reported trigger changes to management without further review. This decision-making process is the role and adaptive management function of the ATS and ACC as described in the following section.
- The H&S Plan will be updated every five years at a minimum, in coordination with the ACC and with the approval of the Services. (More frequent updates may be triggered by changes to the regulatory or management landscape, such as the approval of new HGMPs.) The update will consider recommendations from members of the ACC and the 10-year Comprehensive Review (described below), and identify those recommendations that have not been incorporated into the H&S Plan with a brief statement as to why the changes were not made. It is expected that information brought forward in the AORs will provide the basis for ACC recommendations for updating the H&S Plan.
- A Comprehensive Review will be undertaken every 10 years. In consultation with the ACC, an independent consultant will be hired to assess the H&S Program for the factors described in section 8.2.6 of the Settlement Agreement. The Comprehensive Review will consider all available data collected and reported as part of the AORs to evaluate the program’s effectiveness and impacts in light of recent scientific advancements in hatchery science.

Roles in Program Review and Decision-Making

Aquatic Coordination Committee (ACC)

The ACC is responsible for implementing the Settlement Agreement with the ability to implement changes to the Settlement Agreement through a Consultation process as defined in Section 14 of the Settlement Agreement. Therefore, modifications to the H&S Program implementation that may influence the Settlement Agreement or the Outcome Goal of the Agreement, require review and approval by the ACC prior to implementation. The ATS must request approval by the ACC of decisions that go beyond technical modifications, include programmatic recommendations, or decisions that modify interpretation of the intent of the H&S Program as described in Section 8 of the Settlement Agreement,. Prior to approval, the ACC may require use of the Decision-Making Template (see ACC ground rules document) to document and record decisions relating to implementation of the Lewis River Settlement Agreement or overall Outcome Goal of the Agreement.

Aquatic Technical Subgroup (ATS)

The ATS functions as a technical advisory group to the ACC. The ATS reviews and revises the AOP annually with a focus on technical approaches and protocols, with consideration for how changes in methods may affect the continuity of datasets and program implementation. The ATS may also make in-season decisions to ensure continuity of program implementation, such as adjusting broodstock collection curves in response to actual size and timing of an annual return. Reviewing and revising the AOP with flexibility for in-season adjustments ensures program implementation and M&E activities are achieved each year.

Adaptive Management Decision Making Process

Adaptive management of the H&S Program is done through a cycle of annual and periodic steps (as defined in the Settlement Agreement) that provide the means to modify the H&S Program through formal decision making.

The first step in the adaptive management process is the annual reporting of program performance trends. This step is achieved upon distribution of the AOR. Where available, the AOR provides annual results in the context of multi-year trends. The report includes a brief Executive Summary identifying notable trends and key concerns from the past year, and recommendations for adjustments to monitoring and evaluation activities.

The second step is an annual 30-day ACC review process which includes the following:

- Coinciding with the distribution of the review draft of the AOR to the ACC, PacifiCorp will summarize key findings during the ACC meeting in May to highlight accomplishments and identify any notable concerns to assist the ACC in their review.
- Upon completion of the 30-day review, the ACC, in coordination with the ATS, may recommend revisions to the AOP for the subsequent year in the form of informal consultations or request for decision using the ACC Decision Template.

The third step is to update the H&S Plan every 5-years, either in response to ACC recommendations based on data trends that are tracked by the ATS and reported in the AOR, or in response to recommendations given in the Comprehensive Periodic Review (described next).

The fourth and final step is a Comprehensive Periodic Review of longer-term data trends in the H&S Program every 10-years. This review will be undertaken by an independent third party to identify data gaps and modifications to the program implementation to ensure the H&S Program is achieving the stated goals, stipulated in Section 8 of the Settlement Agreement. The ATS shall review conclusions and results from the Comprehensive Periodic Review to determine whether formal program decisions or trigger points are warranted and, if so, develop recommendations for ACC review and approval using the ACC Decision Template.

The elements of the adaptive management cycle are shown in Figure X-X and schedule in Table X-X, below.

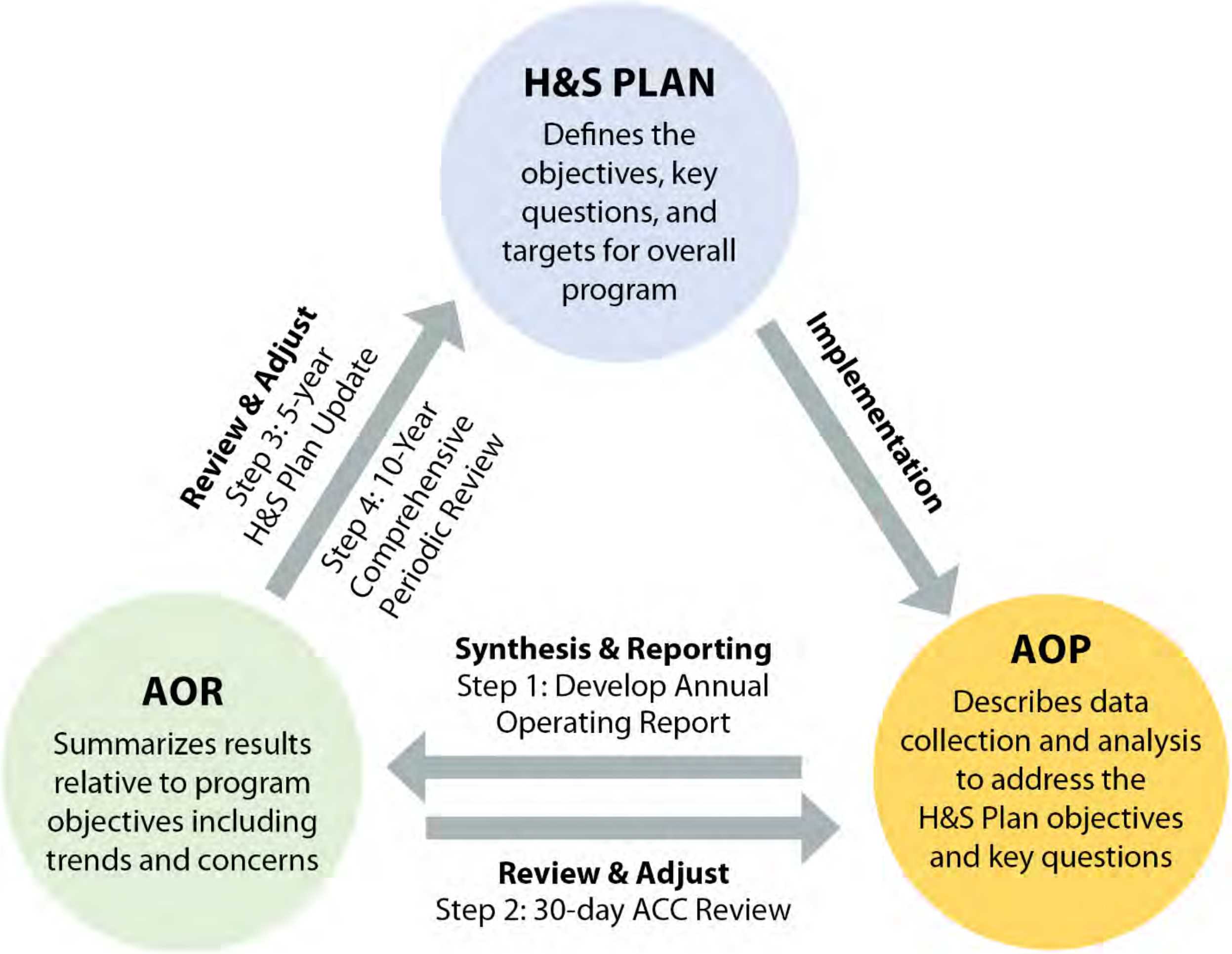

Figure X-X Graphical depiction of the H&S Program adaptative management approach and cycle through its corresponding plans (H&S Plan, AOP), reports (AORs), and review processes

Table E-1. Adaptive Management Milestones

		2023				2024					2025				2026				2027				2028				2029				2030				2031			
Annual Operating Report Development	PacifiCorp	■	■			■	■			■	■	■			■	■			■	■			■	■			■	■			■	■			■	■		
Annual Operating Report Review	ACC, ATS		■				■					■				■				■				■				■				■				■		
Annual Operating Plan Revisions	ATS			■	■			■	■				■	■			■	■			■	■			■	■			■	■			■	■			■	■
Comprehensive Periodic Review	Independent Reviewer																														■	■	■	■				
H&S Plan Update	ATS														■	■	■	■																	■	■	■	■

SECTION F REPORTING REQUIREMENTS

Annual reporting of AOP implementation and monitoring of objectives is provided as part of the Lewis River Annual Operations Report, distributed for review in late April of each year. According to the Settlement Agreement, the annual report will include, at a minimum, the following:

1.0 ADULT COLLECTION AND SPAWNING

- Collection numbers by location and method
- Collection numbers compared to targets
- Genetic assignment results for steelhead
- Spawning protocols and numbers
- Transportation numbers by date, species, and sex ratios (actual versus goals)
- Distribution of all collected species
- Disposition of any species

2.0 EGG INCUBATION AND JUVENILE REARING/RELEASE

- Egg take – actual versus goals
- Egg to fry survival – numbers of fish ponded
- Pathogen screening results
- Rearing strategies that differ from routine operations (e.g., use of circular rearing strategies)
- Smolt releases, length, and location (actual versus goals)
- Tagging and marking summary (PIT tags and BWTs)

3.0 MONITORING AND EVALUATION

Results of activities undertaken for each monitoring and evaluation objective. Reporting will be completed in accordance with the 2020 H&S Plan Objectives; however, these objectives are not described in this 2021 version of the AOP because it has yet to be approved by FERC. At a minimum, these monitoring and evaluation results reported will include the following along with associated confidence intervals and coefficient of variance, where applicable:

- Adult escapement estimates (abundance) downstream of Merwin Dam
- Adult composition (hatchery versus natural origin) on spawning grounds downstream of Merwin Dam
- Spatial and temporal distribution of spawning downstream of Merwin Dam
- Juvenile migration and residualism estimates of hatchery releases downstream of Merwin Dam
- Hatchery juvenile monitoring for ecological interactions with NOR smolts
- Summaries of screw trapping results including locations fished, time periods fished, catch rates (relative abundance) by species (composition), trapping efficiency, and estimates of juvenile abundance by species

- Distribution maps of redd locations and counts for each species

4.0 CONSISTENCY AND ADHERENCE WITH HSRG GUIDELINES

Annual reporting may include recommendations to ensure that Lewis River hatchery operations are consistent with recommendations of the HSRG.

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APPENDIX C –

Lewis River hatchery TDG Evaluation Report, Summer of 2022

Phase II assessment on the effects of total dissolved gas (TDG) saturation on fish health at Lewis River Hatchery, North Fork Lewis River

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FINAL REPORT

PACIFICORP
A BERKSHIRE HATHAWAY ENERGY COMPANY

April 20, 2023

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I. Introduction

This report presents results from total dissolved gas (TDG) monitoring at the Lewis River Hatchery during the summer of 2022. Monitoring objectives were developed to determine whether existing infrastructure components contribute to elevated TDG in the rearing ponds, specifically in rearing banks 13 and 14 (Figure 1, Appendix A). Results from this report supplement previous TDG monitoring results at the Lewis River hatchery in 2017 (Appendix B).

Specific monitoring objectives of this evaluation include the following and are further described in Appendix A (2022 monitoring plan) of this report.

<u>Objective 1</u>: Determine whether flow boxes installed on raceway 13-4 are effective in reducing inflow dissolved gas saturation

<u>Objective 2</u>: Determine the cause and potential effects of short-term fluctuations and longitudinal variation of TDG along raceways 13-4 and 14-4.

<u>Objective 3</u>: Quantify the influence of the bank 14-1 overflow wall on dissolved gas saturation

<u>Objective 4</u>: Determine if juveniles present with external indicators of gas bubble trauma (GBT)

Figure 1. Site location of rearing banks 13 and 14 at Lewis River Hatchery, NFK Lewis River

II. Results and Analysis

Results include monitoring of total dissolved gas saturation levels at specified locations and periods in rearing banks 13 and 14. Specific sampling locations were selected to answer specific objectives in the plan (Appendix A).

Summary of monitoring results

Tables 1 and 2 provide summary data for each objective including the sampling location, monitoring duration and summary statistics for each deployment of TDG monitors (Hydrolab MS-5).

Table 1. Sampling location and duration of monitoring for each objective

Objective	Sampling Location (raceway)	Monitoring Duration
1	13-1 (us) and 13-4 (us)	July 16 – Aug 12, 2022
2	13-4 (us, ds) and 14-4 (us, ds)	August 12 – September 23, 2022
3	13-1 (ds) and 14-1 (us)	September 23 – October 10, 2022

Note: us = upstream end of raceway; ds = downstream end of raceway

Table 2. Summary statistics of each data set collected for objectives 1 through 3

Objective	Data Set	*n =*	$\bar{x}$	Min	Max	*SD*	*SE*
1	13-1 (us)	644	108.2	104.5	114.8	3.07	0.12
	13-4 (us)	644	107.4	104.1	113.1	2.67	0.11
2	13-4 (us)	1004	106.3	100.6	112.1	2.29	0.07
	13-4 (ds)	1004	103.8	96.2	109.5	2.17	0.07
	14-4 (us)	1004	103.7	98.7	108.3	1.81	0.06
	14-4 (ds)	1004	102	96.8	106.7	1.82	0.06
3	13-1 (ds)	394	102.7	98.7	107.3	1.70	0.09
	14-1 (us)	394	102.2	98.9	105.5	1.28	0.06

Note: us = upstream end of raceway; ds = downstream end of raceway

Results and Analysis for each objective

Results are presented as time-series graphs and box plots to compare and illustrate differences in TDG (% saturation) between monitoring sites for each objective. The significance of any differences (e.g., statistical vs. biological significance) are discussed in the following conclusions section.

Objective 1: Determine whether flow boxes installed on raceway 13-4 are effective in reducing inflow dissolved gas saturation

Prior to this evaluation, modifications were made to the inflow piping in raceway 13-4. Modifications included the installation of flow boxes for each of the inflow pipes into raceway 13-4. Flow boxes were installed to direct the entire inflow water volume to flow over the (open) top of the boxes and into the raceway. The flow boxes modify the flow pattern into the raceways from an upwelling inflow to a surface inflow (Figure 2).

Figure 2. Illustration of flow changes with installation of flow boxes in raceway 13-4. Left picture illustrates upwelling inflow in raceway 13-1 (control); Right picture illustrates flow pattern with flow boxes installed in raceway 13-4.

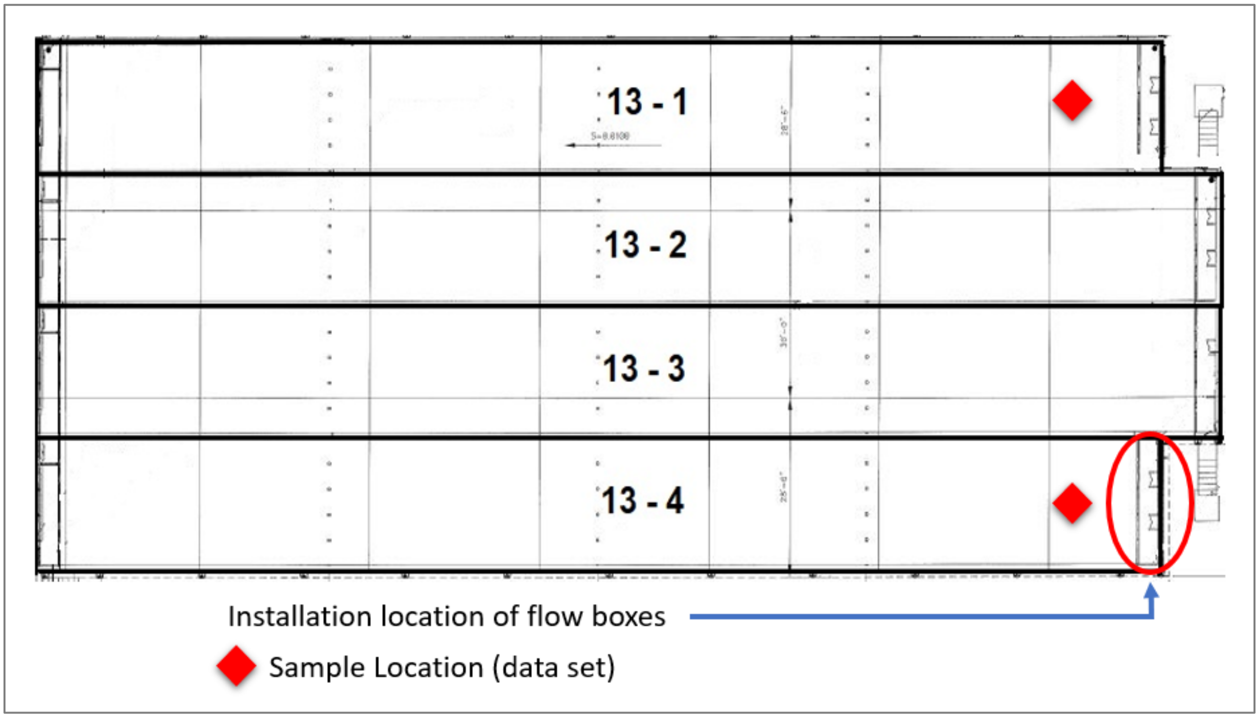

Figure 3. Sampling locations to evaluate objective 1 including the location of modifications to the upwelling inflow in raceway 13-4.

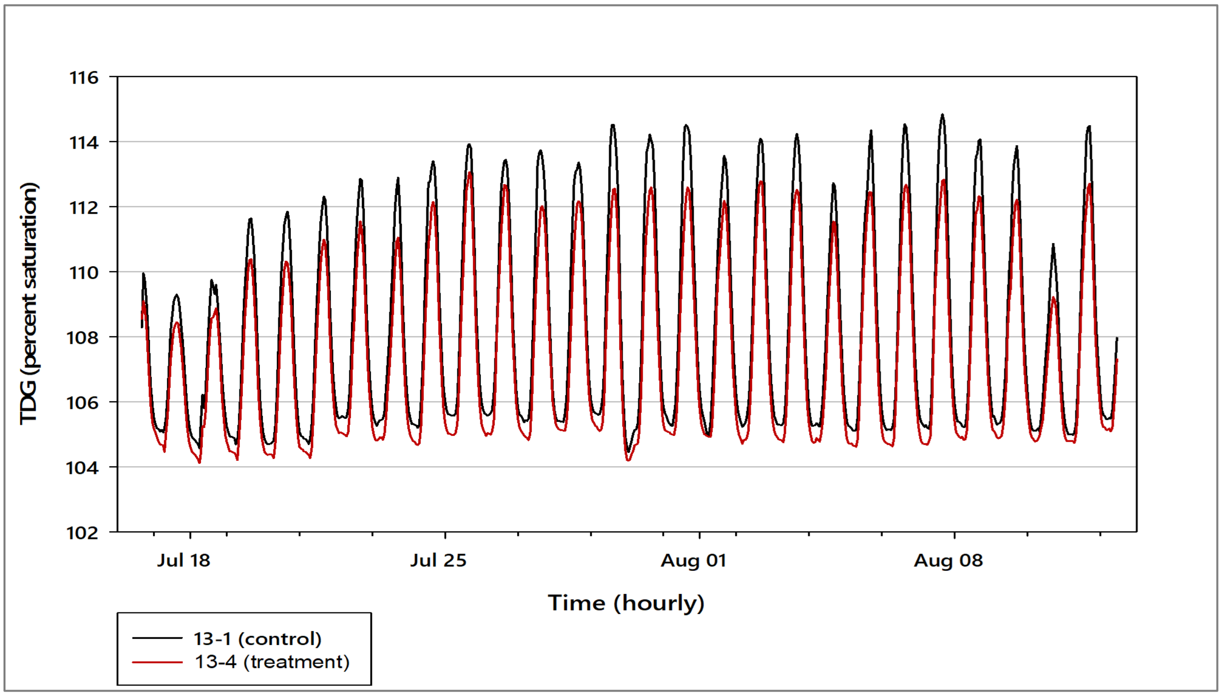

Figure 4. Time series data for total dissolved gas monitoring at raceway 13-1 and 13-4.

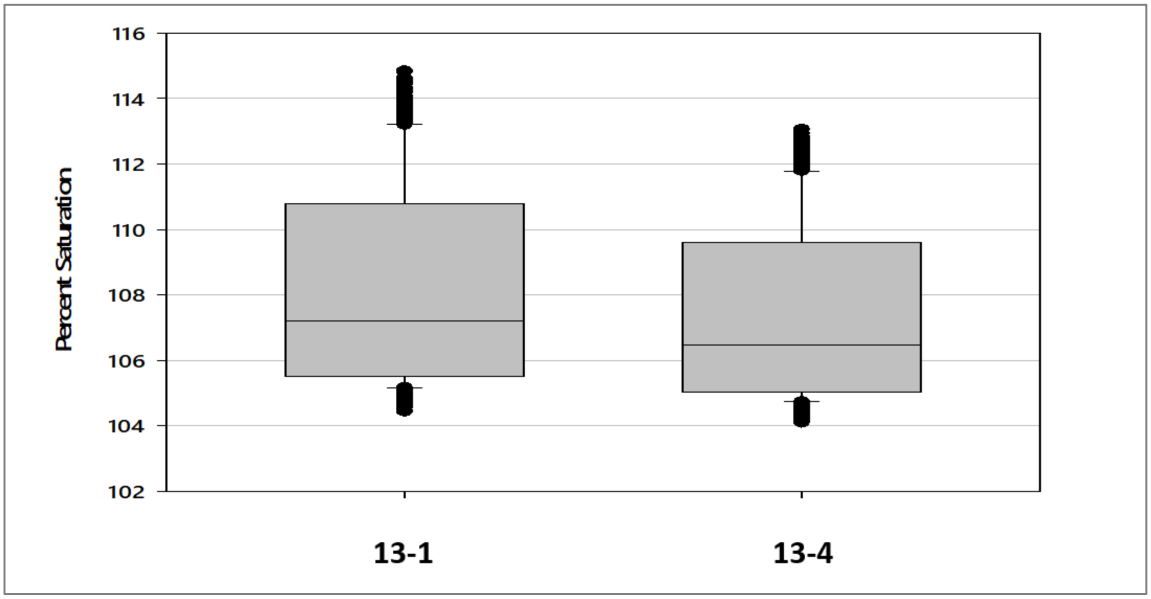

Figure 5. Box plot comparison of percent saturation measured at raceway 13-1 (control) and 13-4.

To focus on the mitigating effect of the flow boxes on oversaturation, Figure 6 compares the differences between raceway 13-1 and 13-4 using only data that is one standard deviation above the mean value for each site. That is, Figure 6 represents the differences of each site during relatively high oversaturation conditions.

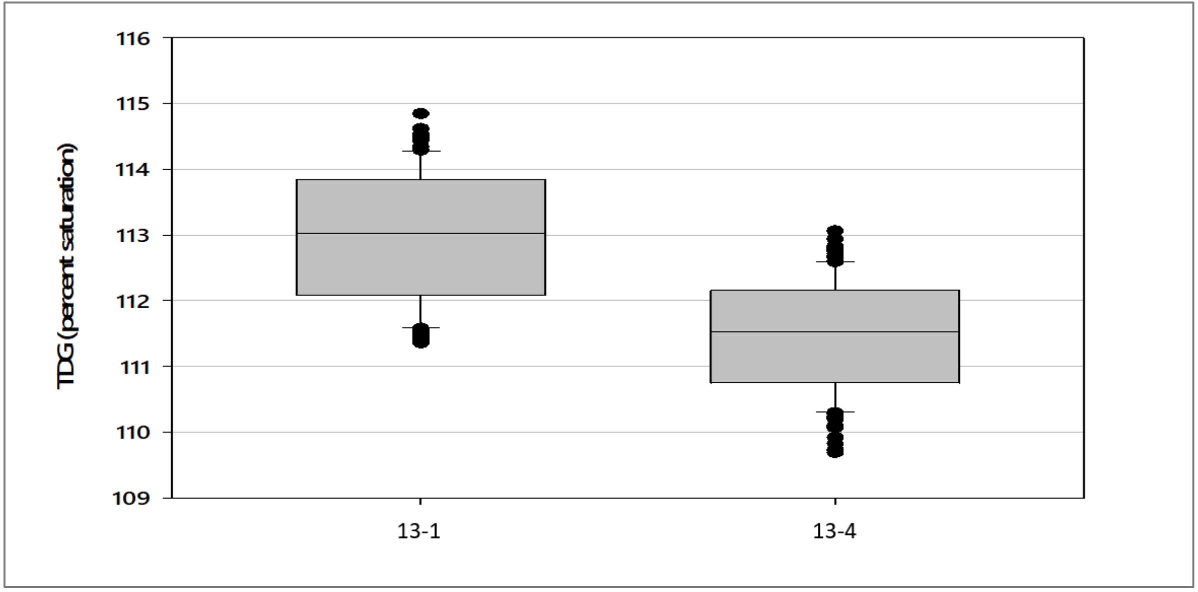

Figure 6. Comparison of percent saturation at raceways 13-1 (control) and 13-4 using data one standard deviation above the respective mean for each site.

Objective 2: To determine the cause and potential effects of short-term fluctuations and longitudinal variation of TDG along raceways 13-4 and 14-4.

The purpose of this objective is to determine the longitudinal variation of TDG along two connected raceways. In this case, using raceways 13-4 and 14-4. It is important to note that raceway 13-4 receives first pass source water and raceway 14-4 receives a combination of first pass and second pass (from 13-4) water (Figure 7).

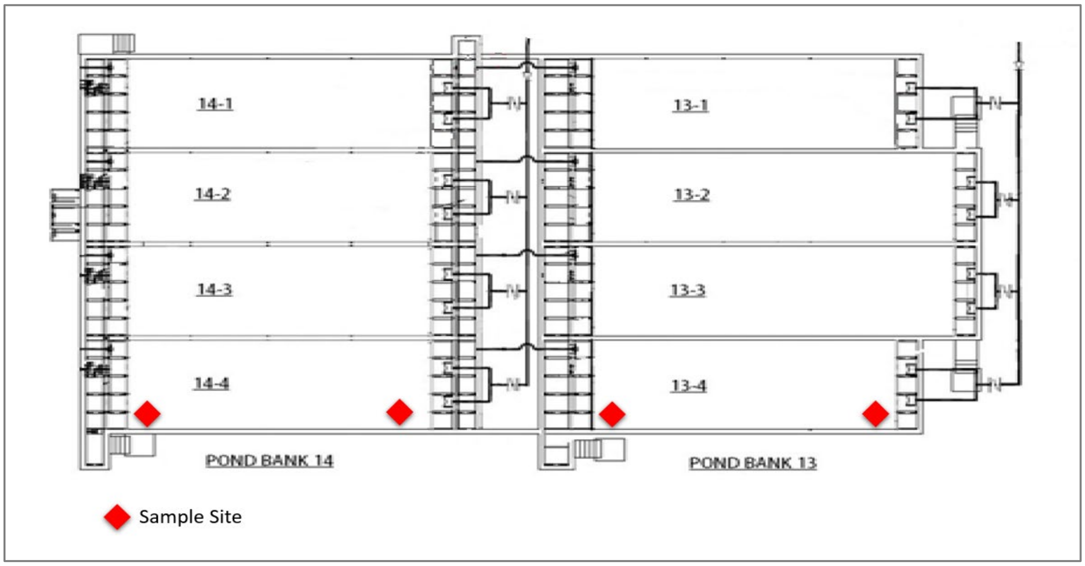

Figure 7. Sampling locations to monitor objective 2

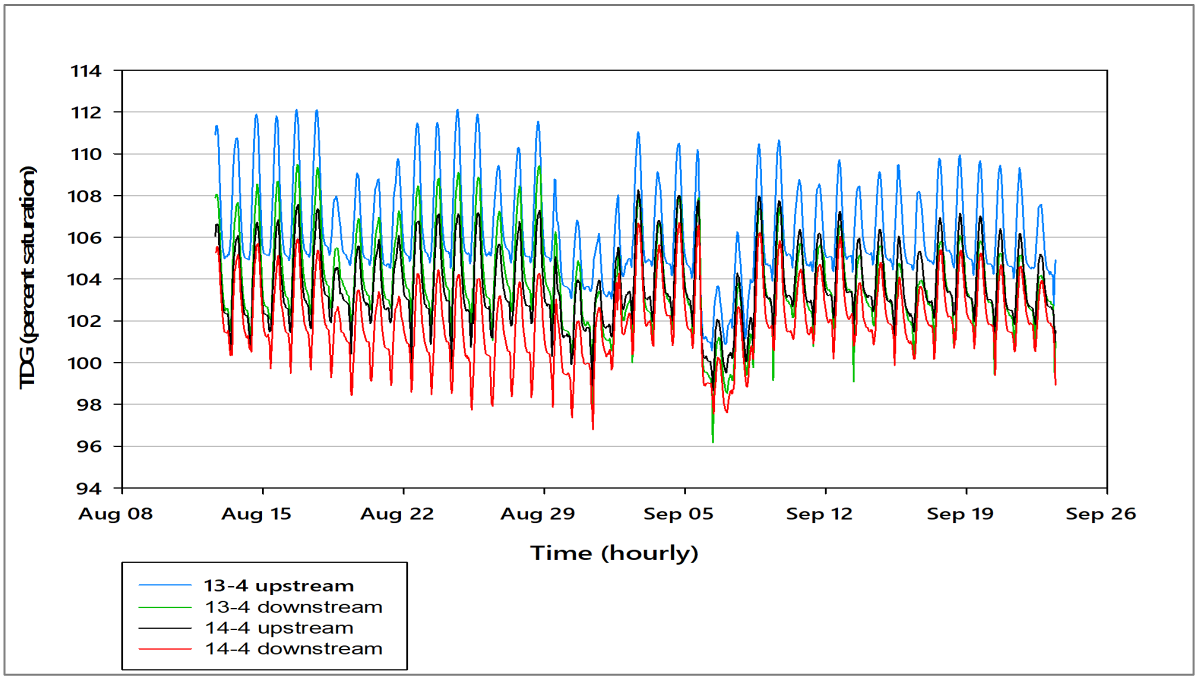

Figure 8. Time series data from monitoring objective 2 in raceways 13-4 and 14-4.

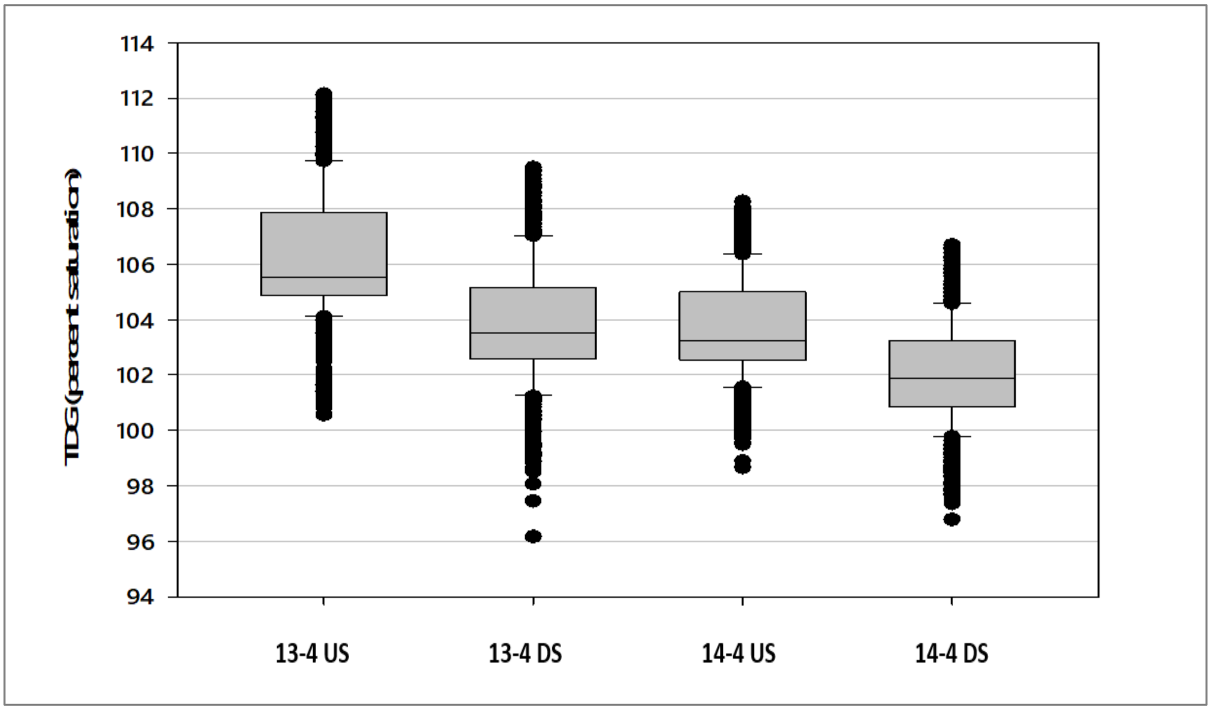

Figure 9. Box plots comparing the differences between the four sampling locations selected to evaluate objective 2.

To supplement TDG data monitored for objective 2, hatchery staff provided dissolved oxygen spot measurements taken during the monitoring period in raceway 14-4. All dissolved oxygen measurements were sampled from the downstream end of raceway 14-4 (Figures 10 and 11).

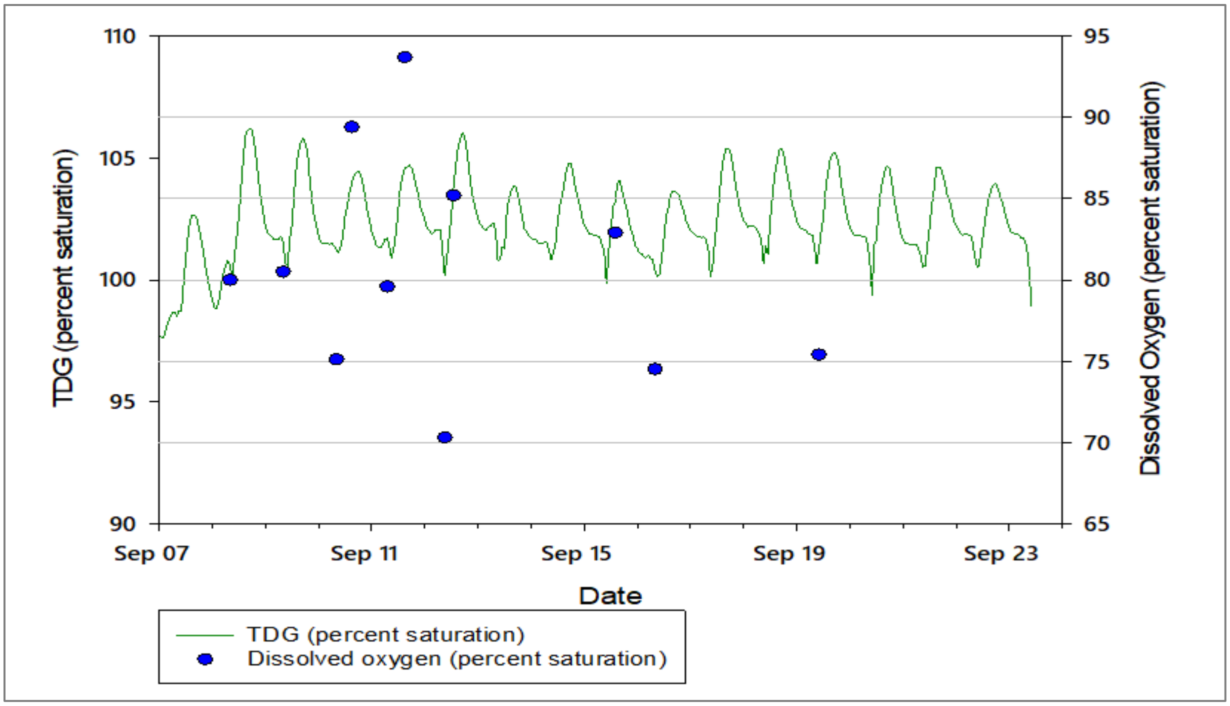

Figure 10. Percent saturation and supplemental dissolved oxygen measurements obtained at the downstream end of raceway 14-4

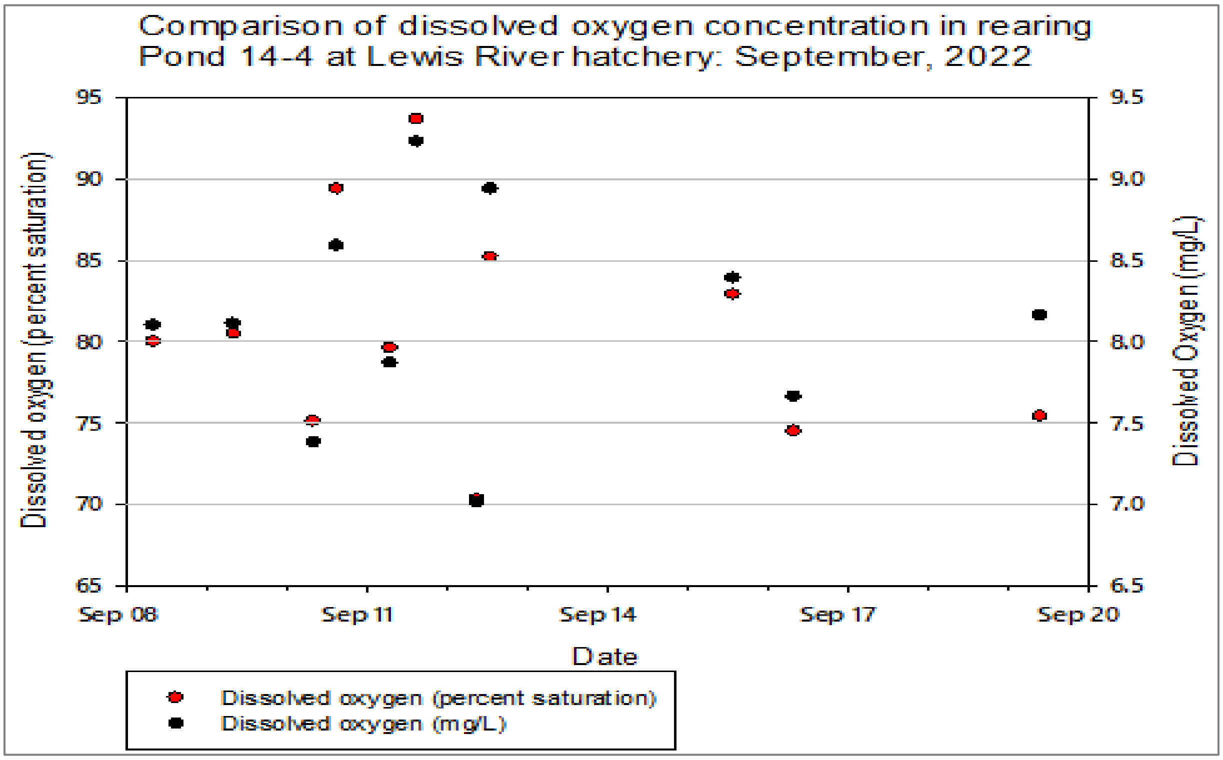

Figure 11. Comparison of dissolved oxygen concentration (mg/L) and dissolved oxygen saturation (% saturation) at the downstream end of raceway 14-4.

Objective 3: To quantify the mitigative benefit of the bank 14-1 overflow wall on oversaturation

The purpose of this monitoring is to determine whether the existing overflow wall (Figure 12) provides any benefit in equilibrating TDG that may be under or oversaturated prior to entering raceway 14-1. These data supplement similar monitoring conducted in 2017 (Appendix B).

Figure 12. Photograph illustrating the overflow wall and first pass inflow pipes at raceway 14-1.

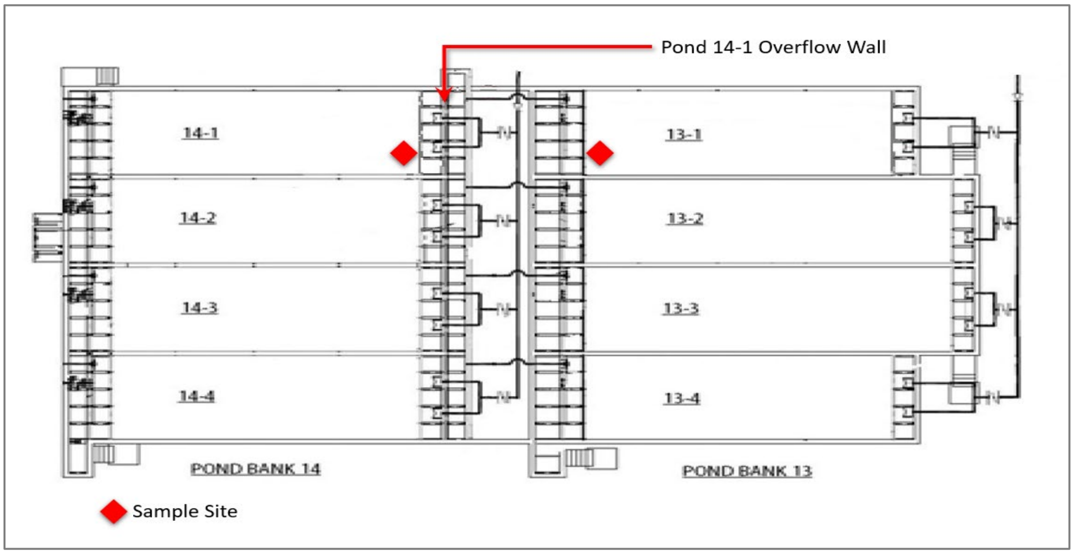

Figure 13. Sampling locations used to evaluate objective 3.

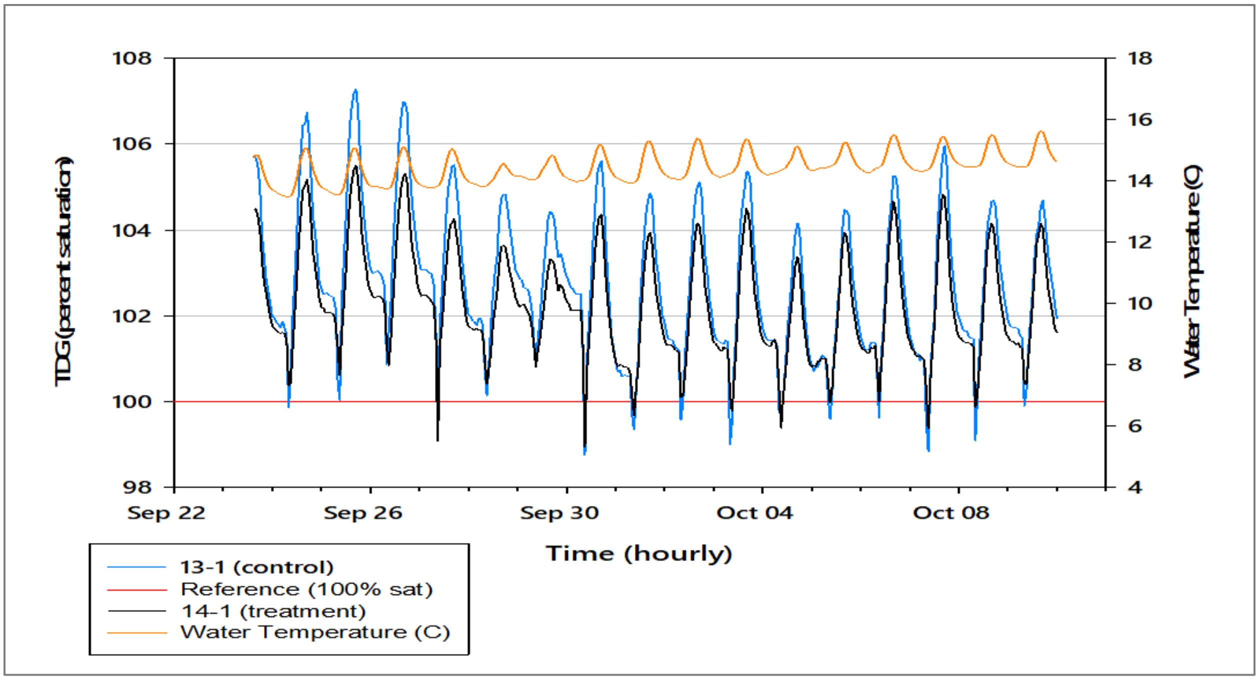

Figure 14. Time series data comparing TDG and water temperature at the downstream end of raceway 13-1 (control) and upstream end of raceway 14-1 (after passing over the overflow wall).

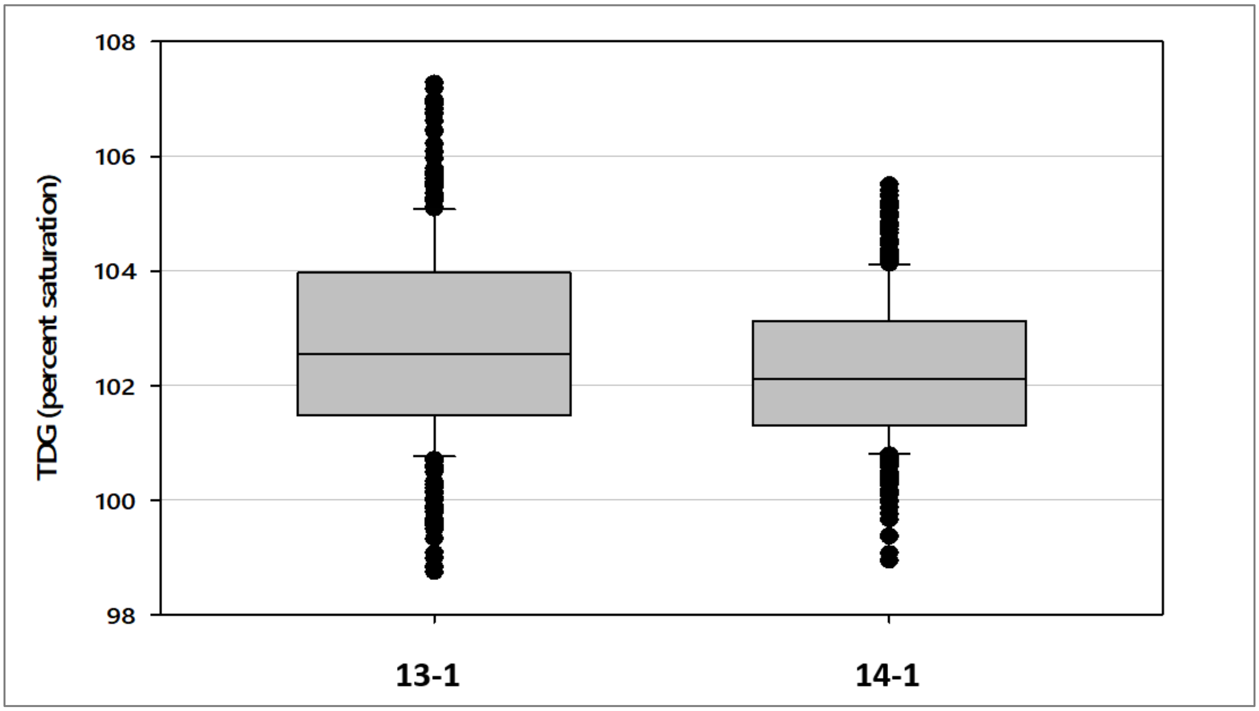

Figure 15. Box plots comparing the differences in TDG at the downstream end of raceway 13-1 (control) and raceway 14-1 (treatment).

Objective 4: To determine if juveniles present with external indicators of gas bubble trauma (GBT)

At the time of this reporting, this analysis has not been completed by WDFW. When available, this analysis will be reported by WDFW as part of routine pathology reporting.

III. Discussion and Conclusions

Objective 1

The intention of this evaluation was to show whether the use of flow boxes would mitigate elevated gas saturation of source water entering bank 13. In theory, exposing the surface area of water entering the raceways should act to equilibrate water to atmosphere. That is, saturation approaches 100 percent.

Observing the time series data presented in Figure 4 illustrates this effect, especially when observing diurnal peaks in gas saturation. The peaks observed in the treatment (raceway 13-4) are consistently less than those observed at the control site (raceway 13-1). However, the overall effect of the flow boxes is relatively small. While these differences represent a statistical difference between the control and treatment site, it is difficult to infer that short term difference of 1 to 2 percent saturation (during peak TDG observations) is biologically significant. A box plot comparison between both sites shows a mean difference of less than one percent (Figure 5). Figure 6 provides a box plot comparison of percent saturation at both locations using only data representing greater than one standard deviation above the respective means for each location. While Figure 6 shows a stronger effect of the flow boxes on elevated gas saturation levels, the mean difference is only about 1.5 percent lower for the treatment raceway 13-4.

It is important to note that at no time during this monitoring did percent saturation at either site drop below 104 percent saturation. This suggests that source water entering bank 13 remains in an oversaturated condition. This condition was also observed in 2017 at upstream sites in bank 13. Based on monitoring in 2017, it was shown that this elevated condition results from oversaturation conditions in the North Fork Lewis River during the summer months. That is, the hatchery design components do not appear to be a contributing factor to elevated gas saturation levels observed in bank 13.

Conclusions:

1. While the installation of flow boxes does produce a statistically significant decrease in gas saturation, it is unlikely that this difference has any biological significance in reducing stress and associated mortality or disease on smolts rearing in bank 13.
2. Ambient or background levels observed at the hatchery are related to ambient conditions present in the source water for the hatchery and not the result of any specific design components of the hatchery water conveyance infrastructure.

Objective 2

The intent of objective 2 is to describe the profile of gas saturation as water flows through raceway 13-4 and 14-4. Water entering raceway 14-4 is a mixture of first pass water and second pass water from raceway 13-4. This evaluation was specifically designed to focus on the extent of saturation 'troughs' observed in 2017. These troughs were most pronounced at the downstream end of raceways. Saturation troughs represent undersaturation of dissolved gases, which includes dissolved oxygen. To better understand whether dissolved oxygen deficits are occurring during saturation troughs, hatchery staff provided a limited number of spot measurements for dissolved oxygen during the monitoring period at the downstream end of raceway 14-4.

Figure 8 provides time series observations for all four stations. In general, gas saturation is highest at the upstream end of each raceway and tends to decline at each station downstream of the upper most station (13-4 upstream). Figure 9 illustrates this general trend of lower and lower measurements of total dissolved gas saturation.

The interpretation of this declining trend is limited because it is not known the specific composition of gasses contributing to the undersaturated condition. Limited insight into the representation of dissolved oxygen is provided by Figure 10 which compares levels of total dissolved gas saturation and dissolved oxygen saturation over time. Figure 10 shows that total dissolved gas saturation remains above 100 percent saturation over the period. However, dissolved oxygen remains undersaturated over the same period (between 70 and 95 percent saturation). This suggests that other dissolved gases (e.g., CO2) may be contributing to oversaturation of gases which may displace dissolved oxygen.

It is important to note that dissolved oxygen concentrations remain above 7 mg/L for all spot measurements provided by hatchery staff (Figure 11). This suggests that despite undersaturation (and under representation) of dissolved oxygen in the total gas saturation readings, dissolved oxygen concentration does not appear to be a chronic limiting factor in the raceways. However, it is possible that short term troughs observed both in 2022 and 2017 may result in short term oxygen deficits at the downstream end of raceways that were not observed with the limited dissolved oxygen data provided.

Conclusion:

1) Total dissolved gases generally decline as water flows through loaded raceways.
2) Short term dissolved gas deficits (troughs) are most pronounced at downstream ends of raceways.
3) The trough observed at the downstream end of raceway 13-4 is represented at the upstream end of raceway 14-4.
4) This trough pattern is not observed at the upper most station (13-4) that receives first pass water.

Objective 3

The influence of the overflow wall is thought to have an equilibrating effect on total dissolved gas saturation. That is, water flowing over the wall is exposed to atmosphere and therefore any over or under saturation conditions should benefit by moving towards equilibrium (i.e., 100% saturation). Figure 14 illustrates this benefit by showing that station 14-1 (downstream of the overflow wall) mitigates TDG spikes and slightly increased saturation during saturation troughs. The influence of the overflow wall however is minimal and represents only about a 0.50 percent change in overall saturation. A similar effect was also observed in 2017.

Conclusion:

1) The overflow wall does not produce a statistical or biological difference on saturation levels observed during the monitoring period.

Objective 4

This analysis will be completed by WDFW under separate reporting.

IV. Recommendations

1) The use of flow boxes at the upstream end of raceways is not considered a viable option given the minimal influence of the flow boxes on overall dissolved gas levels. It was shown in 2017, that the effect of the degassing tower has the most significant effect on dissolved gas levels in bank 13. Therefore, any mitigation of TDG at Lewis River hatchery should include use of the degassing tower during specific periods in which TDG levels warrant mitigative action.

2) Evaluation of the longitudinal variation within and between raceway banks showed that saturation troughs occur daily. It is unclear whether these observed troughs are affecting biologically important dissolved oxygen levels. Similar longitudinal and continuous testing should be conducted to inform managers on the extend of dissolved oxygen deficits occurring at the downstream end of raceways. It is recommended that both total dissolved gas and dissolved oxygen measurements be sampled at the same time and locations during the summer months to determine whether low dissolved oxygen saturation levels represent a potential stressor or trigger to juveniles rearing in specific raceways.

3) The cause of saturation troughs should also be evaluated further to determine their cause and whether there is correlation between natural (e.g., sunrise and sunset), hatchery operations (e.g., feeding schedules) or both.

APPENDIX A – 2022 Total Dissolved Gas Assessment Plan. Lewis River Hatchery, North Fork Lewis River

Phase II assessment on the effects of total dissolved gas (TDG) saturation on fish health at Lewis River Hatchery

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Final Plan

June 23, 2022

PACIFICORP
A BERKSHIRE HATHAWAY ENERGY COMPANY

I. Background

In 2017, PacifiCorp monitored and evaluated both total dissolved gas (TDG) and water temperature in rearing ponds at Lewis River Hatchery (PacifiCorp 2018). The purpose of this evaluation was to determine whether the water conveyance infrastructure (e.g., pumps, upwelling, etc.) was contributing to elevated TDG levels in rearing ponds as compared to ambient or background levels recorded in the North Fork Lewis River – the source water for the hatchery. The evaluation focused on other potential sources of TDG including the upstream pump intake, compressed air intake screen blowoff and the upwelling flow configuration of the rearing pond inlets.

Results from the Phase I evaluation in 2017 suggested that while gas saturation levels at the hatchery were often higher by 1 to 3 percent when compared to the in-river control point (Figure 1), elevated TDG events were of very short duration and did not represent a source of mortality to juveniles reared at the facility. However, results also showed that elevated gas saturation levels occur periodically in the North Fork Lewis River in late summer and early fall months when air and water temperatures are warmest.

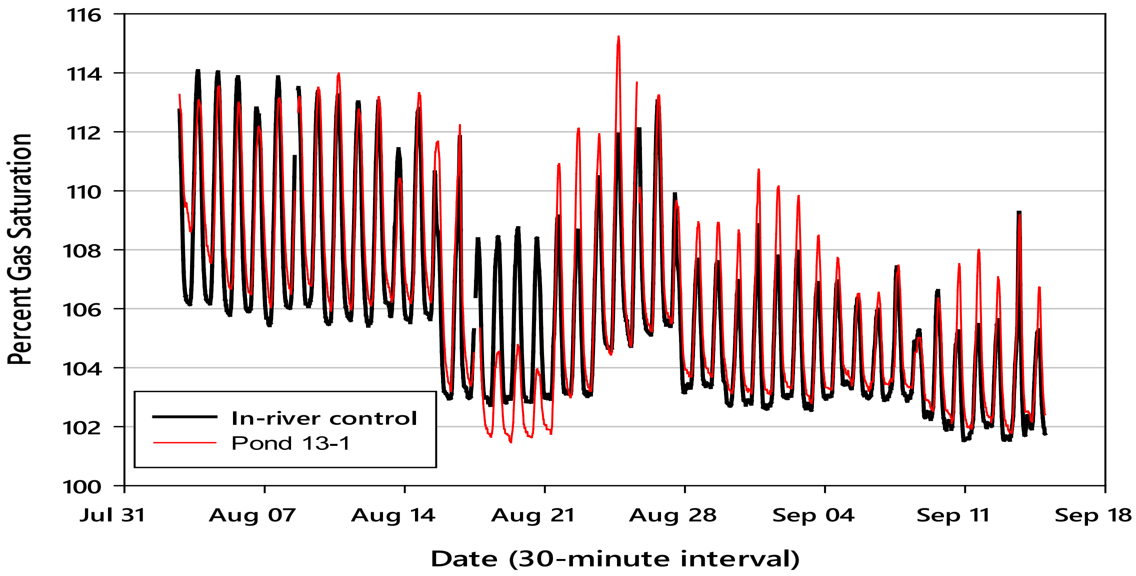


Figure 1. Comparison of percent gas saturation between in-river control and Lewis River hatchery pond 13-1: August 2 to September 14, 2017.

Gas saturation levels exceeding 110 percent in the North Fork Lewis River was most often observed in August as short-duration daily spikes. These spikes in TDG were also observed in the rearing ponds at Lewis River hatchery.

II. Introduction

This plan represents the second phase (Phase II) of monitoring for total dissolved gases at Lewis River hatchery. The first phase (2017) focused on potential sources of TDG at the hatchery; this second phase, focuses on determining or quantifying the effects of oversaturation (and undersaturation) observed in 2017 on fish health and evaluate opportunities to mitigate potential or observed biological effects from dissolved gases at the hatchery.

Available literature on the effects of oversaturation on salmonids has focused primarily on controlled experiments whereby juvenile salmonids are exposed to specific levels of dissolved gases (e.g., 120 percent) continuously for a specified duration (e.g., 48 hours) using fish in fixed depth tanks or cages (typically less than 1 meter deep). These studies were designed to correlate mortality rates (e.g., 50%) to specified chronic gas saturation levels over a defined period. While this information is useful to understand at what levels we can expect to observe direct mortality, it does not fully address conditions outside controlled environments. For example, gas saturation at the Lewis River hatchery varies daily with mid-day peaks and nighttime lows. That is, fish in Lewis River hatchery raceways are exposed to variable levels of dissolved gas concentrations. And despite observed daily peaks of TDG that approach levels considered as lethal (over longer periods of time and under controlled experiments) unexplained mass mortality events are not observed at any of the Lewis River hatcheries.

A more helpful question to ask for fish rearing at the Lewis River hatchery is whether the observed chronic condition of daily TDG peaks and troughs are having adverse health effects on fish. Specifically, whether TDG is a contributing factor or stressor leading to mortality from disease or otherwise reduces long-term survival (i.e., SAR’s). Relating high TDG to adverse health effects is challenging; however, it is well-documented that juvenile fish in hatchery environments are susceptible to oversaturation, and hatchery managers should strive to mitigate oversaturation (and undersaturation) conditions whenever possible.

III. Objectives

Evaluations proposed in 2022 will focus primarily on ways to reduce ambient dissolved gas saturation in rearing ponds and whether oversaturation is associated with external signs of gas bubble trauma (GBT) in the fish. Secondary considerations include determining the cause of TDG variations within ponds, characterization of potential short-term dissolved oxygen deficits in reuse pond bank 14, and an improved understanding of the effect of the overflow walls on gas saturation in bank 14 raceways.

Specific objectives of this evaluation include:

1) To determine whether flow boxes installed on raceway 13-4 are effective in reducing raceway gas saturation.

Installation of ‘flow boxes’ was completed in late April 2022. The boxes function by directing all inflow into a stainless-steel box that is open on the top. The top opening allows water to flow over the box where it is exposed to and can become equilibrated with atmospheric pressure prior to entering the raceway. This differs from the existing configuration that directs all inflow to the bottom of the raceway, which is subject to the hydrostatic pressure from the water column at the elevation present in the raceway, and prevents oversaturated inflow from equilibrating to atmospheric pressure (i.e., 100 percent gas saturation).

2) To determine the cause and potential effects of short-term fluctuations and longitudinal variation of TDG along raceways

In 2017, short-term drops in gas saturation were observed at the downstream end of raceways 13-1 and 14-1 (Figure 2). These drops were always observed at similar times each day. It was thought that these deficits may be caused either by 1) feeding schedules or methods that caused increased fish respiration or movement of pond sediments from feeding frenzies, or 2) the transitioning of algae and phytoplankton in the ponds from nighttime respiration to photosynthesis once sunlight reaches the pond. This phenomenon is concerning, because significant drops in total dissolved gasses may also affect dissolved oxygen levels. Of particular concern, is whether the oxygen levels at the downstream end of reuse pond bank 14 remain supportive and do not become a stressor that may impact fish health (e.g., increase susceptibility to disease).

3) To quantify the mitigative benefit of the bank 14 overflow wall on oversaturation

Monitoring in 2017, showed that the overflow wall at the upstream end of pond 14-1 provides some benefit (although limited) in reducing TDG (Figure 2). The overflow wall also appears to slightly improve the gas saturation deficit observed at the downstream end of pond 13-1. The evaluation of the overflow wall was very short (less than 2 weeks). Therefore, the 2018 report recommended that the role of the overflow wall should be evaluated further to 1) quantify the effect of the overflow wall and, if feasible, 2) suggest modifications that may improve the beneficial effects of the overflow wall on TDG.

4) To determine if juveniles present with external indicators of gas bubble trauma (GBT)

The presence of external GBT indicators provides a source of empirical information useful in determining whether gas saturation conditions are having direct effects on juvenile salmonids. GBT indicators include the observation of air bubbles (emboli) in the fin rays, along the lateral line or within the gill filaments and eyes and can be done through a visual examination from a subsample from each pond. Emboli may also be observed in the choroid rete, a complex of blood vessels behind the eye which is sampled lethally.

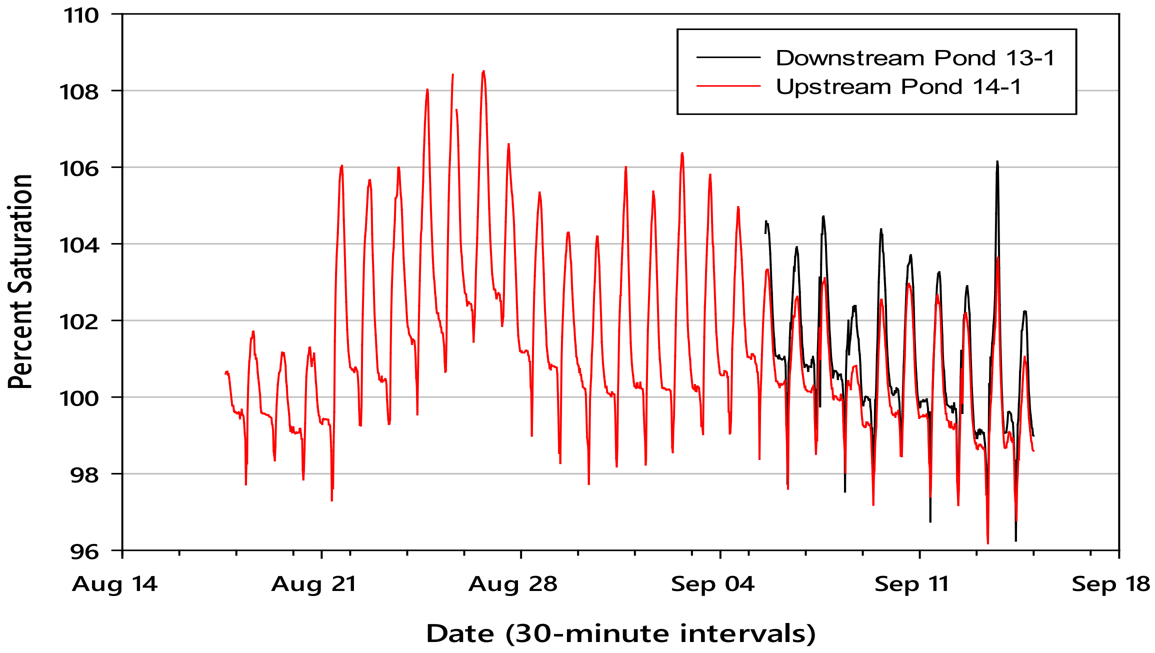


Figure 2. Comparison of percent saturation measured at the downstream end of raceway 13-1 and upstream end of raceway 14-1 downstream of the overflow wall – 2017

IV. Methods

A total of four (4) MS5 Hach Hydrolab meters will be deployed at Lewis River hatchery beginning on July 1 through August 31 (a total of two months). All meters will be field calibrated following protocols provided by Hach Hydrolab and fitted with new dissolved gas membranes and lithium batteries prior to deployment. Meters will be calibrated to ambient barometric pressure using a Monarch Instrument Track-it™ data logger. The data logger will also be deployed for the duration of the study to collect ambient barometric pressure and air temperature (1 hour interval). All sondes will be programmed to record water temperature (^{o}C), total dissolved gas pressure (mm Hg), depth (meters), and battery voltage at 30-minute intervals. Percent gas saturation (% sat) will be calculated by dividing total dissolved gas pressure by ambient barometric pressure and expressed as a percent. Deployment depth of sensors is limited by the depth of each raceway which is about 55 inches. Depth of each sensor will be fixed at 45 inches (suspended 10 inches from the raceway floor).

Deployment locations and duration for each sonde to evaluate each objective is provided in Table 1.

Table 1. Summary of all deployment locations for Hach Hydrolabs for each of the three TDG monitoring tests

SITE	DURATION	PURPOSE
A1	Aug 1 - Aug 30	Obj 1 (flow box effect)
A2	Aug 1 - Aug 30 Jul 16 - Jul 30	Obj 1 (flow box effect), Obj 2 (longitudinal variation)
A3	Jul 16 - Jul 31	Obj 2 (longitudinal variation)
B1	Aug 1 - Aug 30	Obj 1 (flow box effect)
B2	Aug 1 - Aug 30	Obj 1 (flow box effect)
C1	Jul 1 - Jul 15	Obj 3 (overflow wall effect)
C2	Jul 1 - Jul 15	Obj 3 (overflow wall effect)
D1	Jul 1 - Jul 15	Obj 3 (overflow wall effect)
D2	Jul 1 - Jul 15	Obj 3 (overflow wall effect)
E1	Jul 16 - Jul 31	Obj 2 (longitudinal variation)
E2	Jul 16 - Jul 31	Obj 2 (longitudinal variation)

Objective 1 - To determine whether flow boxes installed on raceway 13-4 are effective in reducing raceway gas saturation.

Evaluation of the modified inlet (flow boxes) will occur during August and include paired deployments of meters at the downstream end of the flow boxes in Pond 13-4 (Site A1 and A2) and a second paired deployment in Pond 13-1 representing the control site for this test (Figure 3). Paired meters will be used to ensure that calibration of the meters is correct and that a malfunction of one of the two meters can be diagnosed and corrected during the study period of Aug 1 to Aug 30.

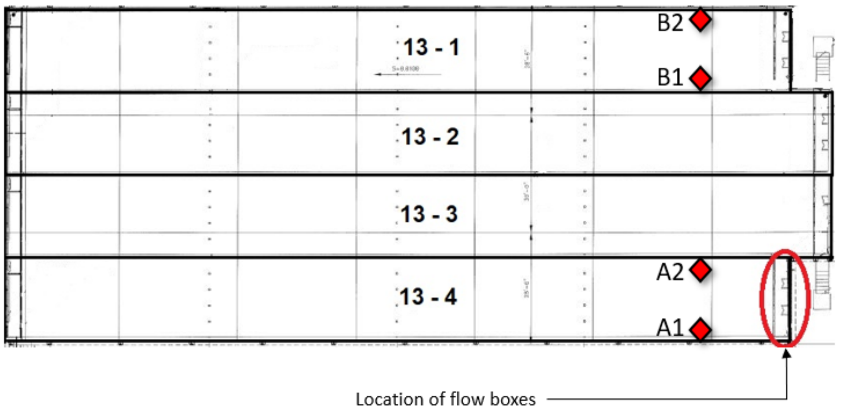


Figure 3. Location of individual meter placement to test the effectiveness of the modified flow inlet (location denoted by red circle) against a control point.

Objective 2 - To determine the cause and potential effects of short-term fluctuations and longitudinal variation of TDG along raceways

To understand the gas saturation deficits observed in 2017 and 2020, four TDG meters will be deployed; two in pond 13-4 and two in pond 14-4 (Figure 4). Analysis will include a comparison of upstream sites (control sites: A2, E1) and downstream sites (A3, E2). Differences will be reviewed and quantified. To determine the cause of differences additional information will be collected during this test including the specific feeding and cleaning times and dates for both ponds and the exact time when indirect and direct sunlight reaches each pond. This information may be obtained from hatchery staff or placement of a camera. Site E2 should be monitored by hatchery staff with a handheld dissolved oxygen on a periodically (e.g., weekly) basis. Monitoring should occur during the morning when total dissolved gas levels are expected to be lowest (based on 2017 data).

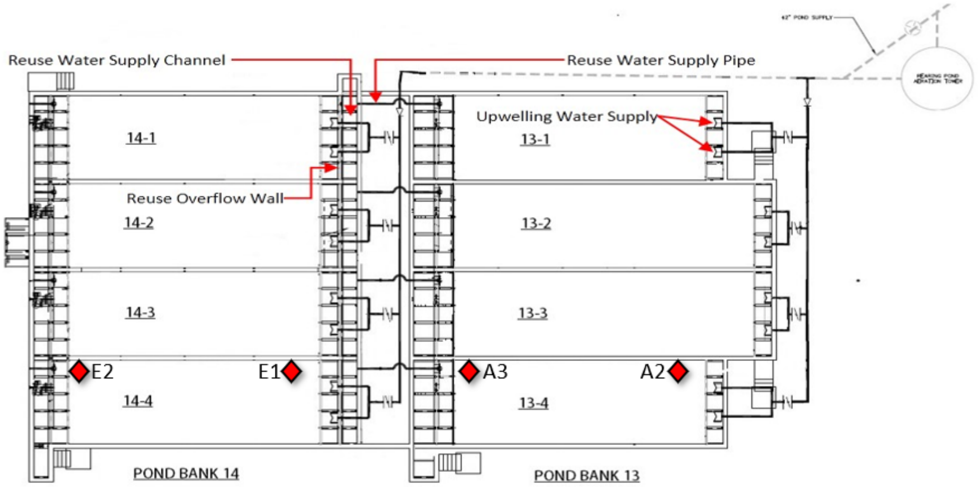


Figure 4. Placement of Hach Hydrolabs to test the longitudinal variation of gas saturation within ponds 13-4 and 14-4.

Objective 3. To quantify the mitigative benefit of the bank 14 overflow wall on oversaturation

Paired meters will be placed at the downstream end of Pond 13-1 (C1 and C2, control point) and immediately downstream of the overflow wall in Pond 14-1 (D1 and D2). The purpose of this placement is to evaluate whether the overflow wall (treatment) is effective at reducing total dissolved gas and, if possible, quantify this effect (i.e., difference in gas saturation recorded between sites D and C).

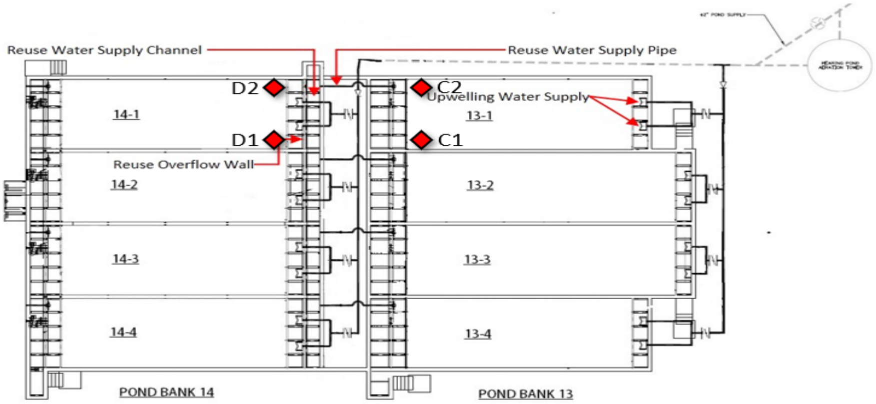


Figure 5. Placement of Hach Hydrolabs in ponds 13-1 and 14-1 to evaluate the effectiveness of the overflow wall into Pond 14-1.

Objective 4 - To determine if juveniles present with external indicators of gas bubble trauma (GBT)

Fish health will conduct a preliminary visit in June, after transfer from Speelyai Hatchery and prior to known periods of elevated TDG, to establish a baseline for these populations by comparing fish rearing in a control raceway (13-1) and a raceway outfitted with gas diffusion infrastructure (13-4). Following this initial baseline visit, weekly monitoring events will occur in August to inspect for pathology from both treatment groups (control and TDG diffusion structure groups). Each survey visit will be conducted as follows: gross clinical pathology directly associated with GBT (gas bubbles and embolic lesions present in gills, eyes, lateral line, or choroid rete; exophthalmos) and secondary conditions (external lesions, fin condition) will be surveyed in 10 general population and any present moribund fish (not to exceed 10) in both treatment groups. A subset of 3 general population and 3 moribund fish from each treatment condition will be preserved in 10% neutral buffered formalin for subsequent histopathology screening for cellular pathology associated with elevated TDG. Disease severity will be scored on a 0 – 3 scale, ranging from normal/none to severe as determined by a certified pathologist.

In addition to continuous monitoring of TDG by PacifiCorp meters, fish health will record TDG at the time of sampling (estimate afternoon based on 2017 TDG data recording highest numbers at this time of day) using a handheld TDG saturometer.

V. Analysis and Reporting

A report will be produced that summarizes all relevant data collected to answer each of the four objectives. All results will be presented the ATS for discussion and determination of whether modifications in hatchery practices or physical modifications to rearing ponds is warranted. Any recommendations of the ATS shall be provided to the ACC for approval consistent with the goals of the Hatchery and Supplementation Plan and Setion 8 of the Lewis River Settlement Agreement.

The report will include the following deliverables:

Objective 1 - To determine whether flow boxes installed on raceway 13-4 are effective in reducing raceway gas saturation.

- Comparison between sites in treatment raceway 13-4 and control pond 13-1.
- Quantify the differences in TDG between the control and treatment raceways
- Discussion and conclusion based on available literature on whether observed differences are statistically and biologically significant in terms of fish health.

Objective 2 - To determine the cause and potential effects of short-term fluctuations and longitudinal variation of TDG along raceways

- Comparison between upstream and downstream sites to assess the temporal TDG differences (if any)
- Illustration of dissolved oxygen weekly spot measurements at the downstream end of raceway 14-4 (obtained by hatchery staff) for the period August – October. Determination whether dissolved oxygen levels are below healthy levels.
- Determine whether a relationships exists between dissolved gas levels, feeding schedules and crepuscular periods at the downstream end of ponds 13-4 and 14-4

Objective 3. To quantify the mitigative benefit of the bank 14 overflow wall on oversaturation

- Comparison of results obtained in 2017 to new information obtained in 2022 to determine whether the overflow wall supports gas saturation equilibrium at the upstream end of raceway 14-1. This includes evaluating both over and under saturation conditions that may exist during the evaluation period.

Objective 4 - To determine if juveniles present with external indicators of gas bubble trauma (GBT)

- Results from subsampling fish for the presence of gas bubble trauma to establish the extent (e.g., portion of fish exhibiting GBT)) of observable gas bubble trauma.

VI. References

PacifiCorp and Cowlitz County PUD No 1. 2018. Total Dissolved Gas and Water Temperature Assessment: Lewis River Hatchery, North Fork Lewis River 2017. Hatchery and Supplementation Program, 2018 Annual Report, Attachment 1.

Appendix B – 2017 Lewis River Hatchery TDG Final Report

Total Dissolved Gas and Water Temperature Assessment

Lewis River Hatchery, North Fork Lewis River.

Erik Lesko
Senior Environmental Analyst

Table of Contents

Attachments

Attachment A1: Illustrated summary of total dissolved gas measurements for all sites
Attachment A2: Illustrated summary of water temperature measurements for all sites

Figures

Tables

I. Introduction

Elevated TDG levels at Lewis River Hatchery have been a concern since at least 1988. In a memo from Mr. Robin Nicolay (hatchery manager at the time) to Mr. Wayne Daley of Fish Pro dated June 29, 1988, chronically high total dissolved gas (TDG) levels and extreme temperature ranges were identified as potential contributors to disease outbreaks at the hatchery. More recently, concerns have been raised regarding the effect of elevated TDG levels on the fitness and survival (SAR's) of smolts released from the facility.

This assessment focuses on six questions related to how infrastructure or operations at the hatchery may influence natural TDG and temperature levels (i.e., in-river conditions).

1) Are TDG and temperature levels measured in the ponds (using upwelling) different than ambient in-river conditions?
2) Does the upstream intake air burst system or pumps elevate TDG above ambient in-river conditions?
3) Describe the TDG and temperature profile within a loaded rearing pond?
4) What affect do the aeration towers have on TDG?
5) What affect does the reuse wall have on TDG?
6) Are there TDG and temperature differences between pond banks?

II. Site Description

The Lewis River Hatchery is located on the north bank of the North Fork Lewis at river mile 15.8 in southwest Washington State (Figure 1). Source water for the hatchery is provided by two pumping stations (the "upstream" and "downstream" intakes) that pump water directly from the river. Source water is not filtered or treated prior to entering rearing ponds. The upstream intake directs water through an underground pipeline to rearing banks 13 and 14 as well as the sorting facility (Figure 1). Water enters Bank 13 through submerged header pipes using an upwelling configuration installed in 2011. Water entering Bank 14 can be first pass, reuse from Bank 13, or a combination of both (Figure 2). First pass water in Bank 14 uses the same upwelling configuration present for Bank 13. Reuse water from Bank 13 enters Bank 14 by flowing over a concrete wall (Figure 2). Because the wall exposes reuse water to atmosphere and removes hydrostatic pressure it allows dissolved gas pressure present in the reuse water to equilibrate to ambient atmosphere (i.e., 100 percent saturation).

During periods of spill at Merwin Dam (RM 19.8), source water can be routed through degassing towers prior to entering the rearing banks to reduce potentially elevated dissolved gas pressure.

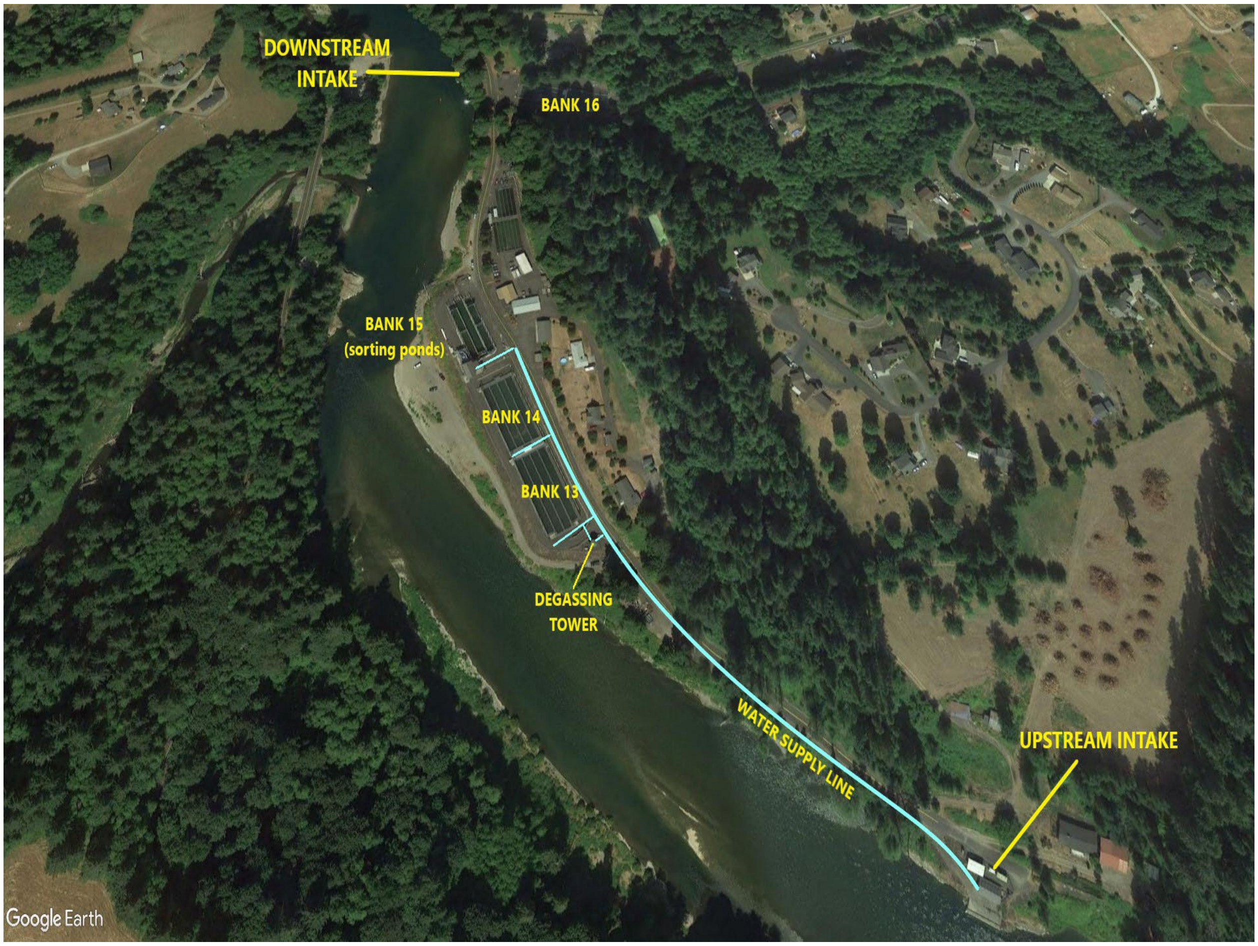


Figure 1. Aerial view of Lewis River Hatchery showing the location of rearing banks and water supply infrastructure

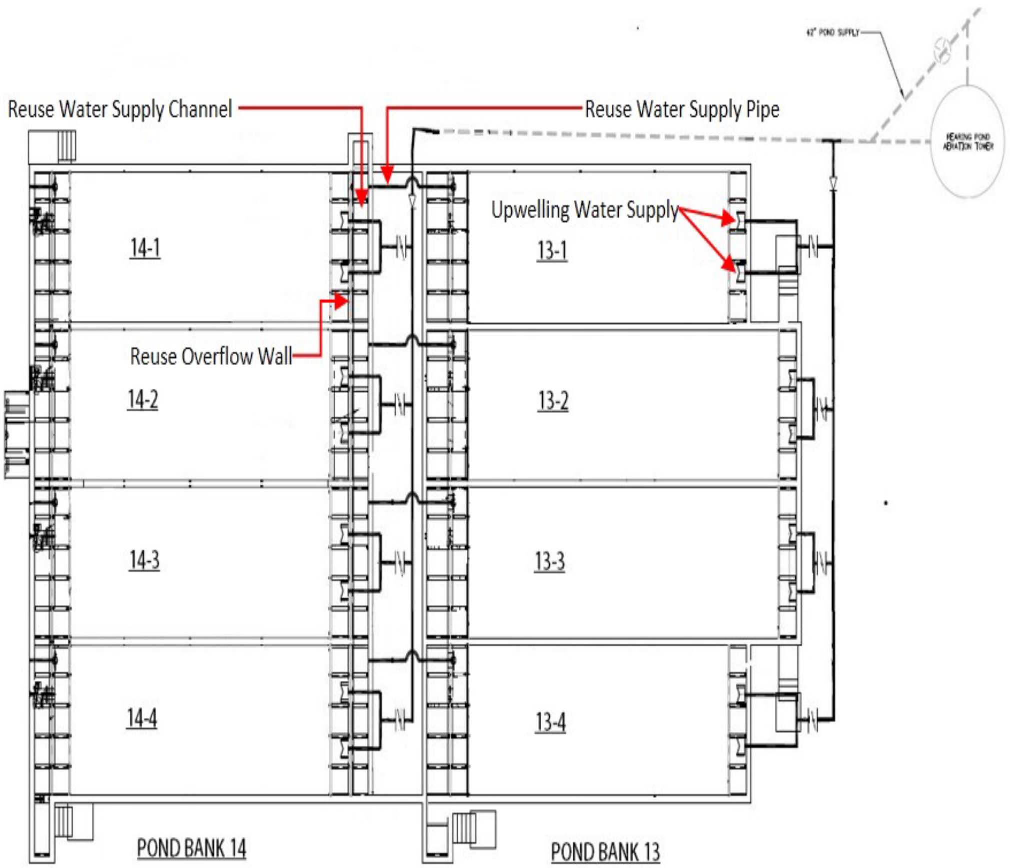


Figure 2. Piping diagram for rearing banks 13 and 14 indicating the location of the reuse water supply channel and wall.

Figure 3. Inflow configuration for Bank 14 showing the upwelling and reuse design

III. Methods

Hydrolab MS5 datasondes were deployed on August 2 until September 15, 2017. All sondes were set to continuously record temperature, TDG, depth, and battery voltage at 30-minute intervals. An external barometric pressure logger (Extech® SD700) was also placed near the upstream intake to log ambient atmospheric pressure during the assessment for calculation of percent gas saturation in the water. Deployment locations, duration and their intended purpose for each datasonde is provided in Table 1. Figure 3 illustrates these locations relative to the hatchery site.

Datasondes were suspended to a depth of 10 feet or within six inches of the bottom of each location (whichever is deepest). In rearing ponds, datasondes were suspended above the floor 6 to 8 inches to prevent erroneous readings from decaying fish waste and food.

Table 1. Site designation, location and purpose of each datasonde placement

SITE	LOCATION	PURPOSE
A (8/2 – 8/25)	Upstream of hatchery intake in the North Fork Lewis River	To measure ambient in-river TDG and water temperature without influence from the hatchery (primary control)
B (8/2 – 9/15)	Inside the screened pump intake well (upstream intake)	To measure TDG and water temperature at the pump source and near the air burst system (secondary control)
C (8/2 – 9/15)	Upstream end of Pond 13-1	To measure TDG and water temperature exiting the upwelling system
D (9/5 – 9/15)	In the water reuse channel from Pond Bank 13 to 14	To act as a control for Site E, and to provide a longitudinal TDG profile within Pond 13-1.
E (8/17 – 9/15)	Immediately downstream of the reuse inflow wall into Pond 14-1	To measure TDG after flowing over the reuse wall to determine if aeration (or degassing) benefits are observed
F (8/17 – 9/5)	Upstream end of Pond 16-3	To compare Bank 16 TDG and temperature with other rearing banks and determine if significant differences exists among individual banks or pumping stations.

***( ) denotes deployment duration**

Figure 4. Illustrated deployment location of each MS5 datasonde

IV. Results

Results here summarize various comparisons among available sites (A – F) to identify specific areas that may affect ambient TDG or temperature profiles. These comparisons are also selected to provide sufficient information to answer key questions stated in the introduction of the report. For time series comparison between sites, a summary of all measurements for all locations are represented in Attachment A1 (TDG) and A2 (water temperature).

1) Comparison between Pond 13-1 (Site C) and ambient river conditions (Site B)

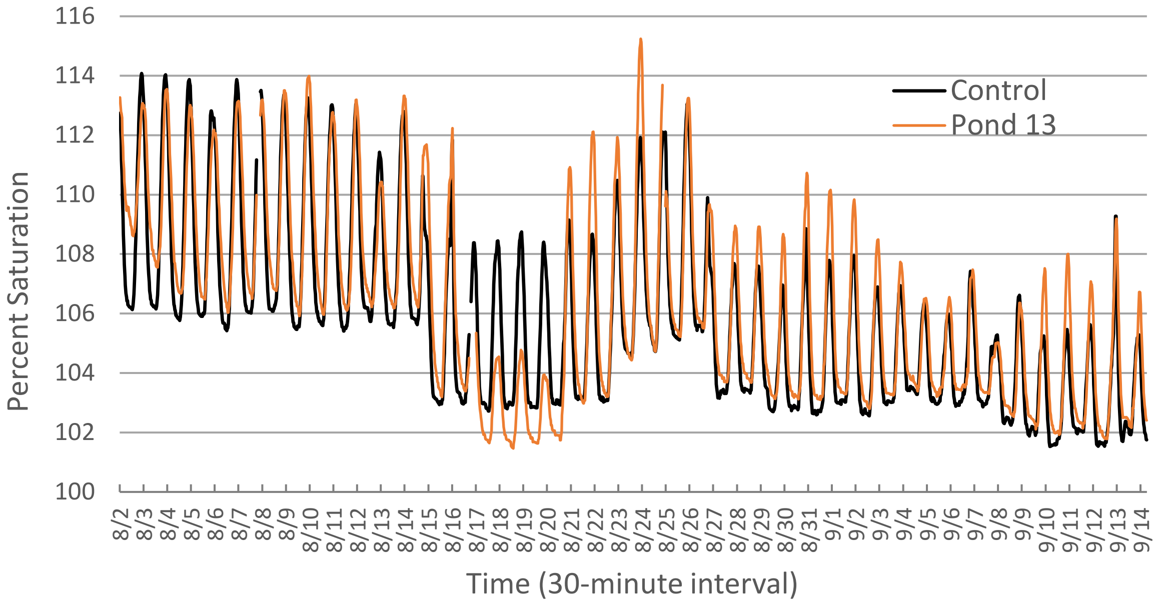


Figure 5. Time series comparison of percent saturation between the intake control (Site B) and Pond 13-1 (Site C).

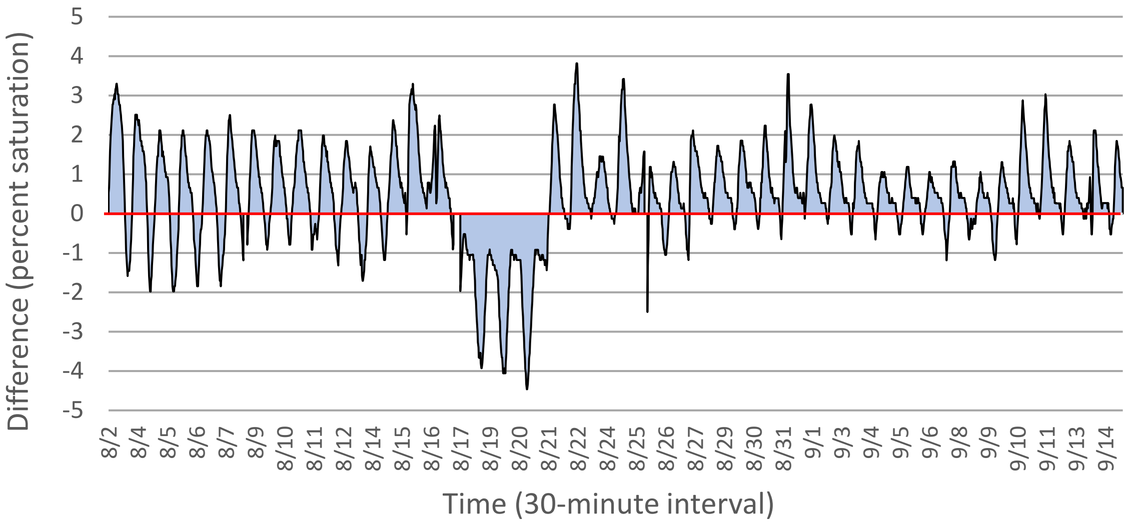


Figure 6. Difference in percent saturation measured between the intake control (Site B) and Pond 13-1 (Site C).

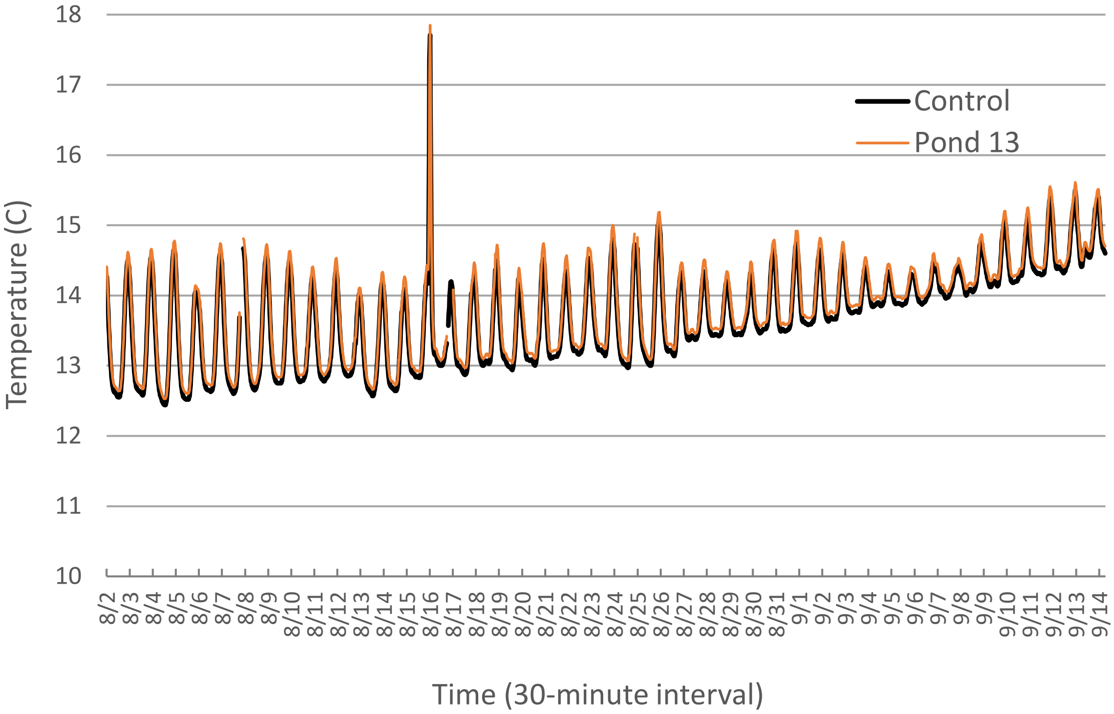


Figure 7. Time series comparison of water temperature between the intake control (Site B) and Pond 13-1 (Site C).

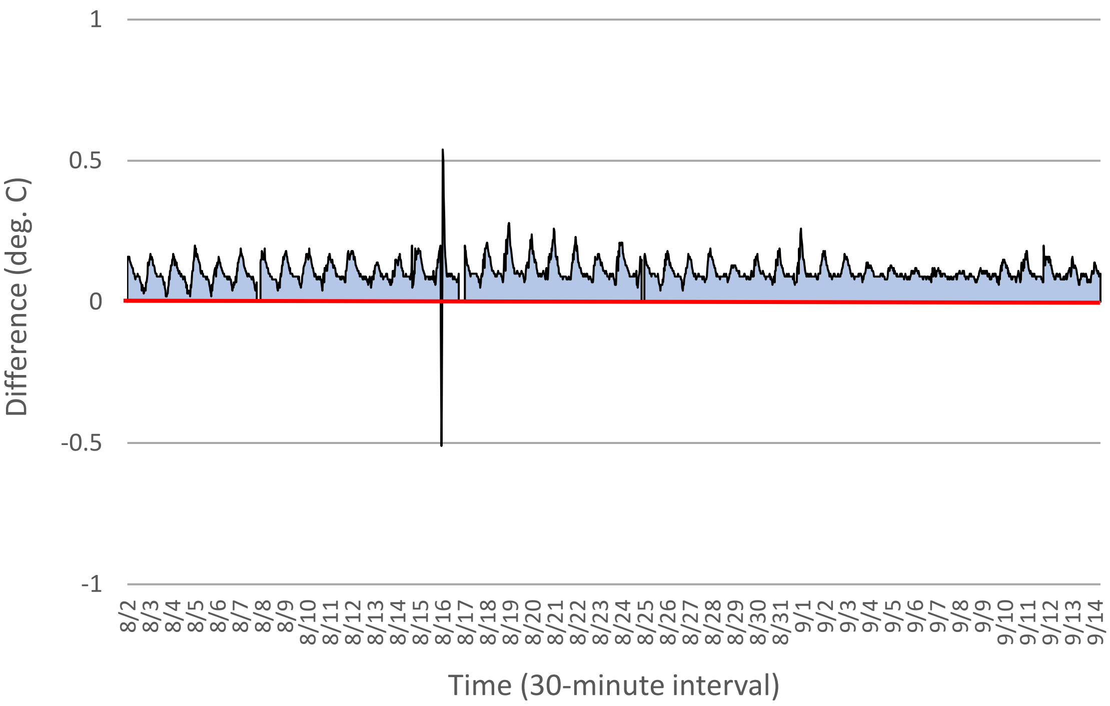


Figure 8. Difference in water temperature measured between the intake control (Site B) and Pond 13-1 (Site C).

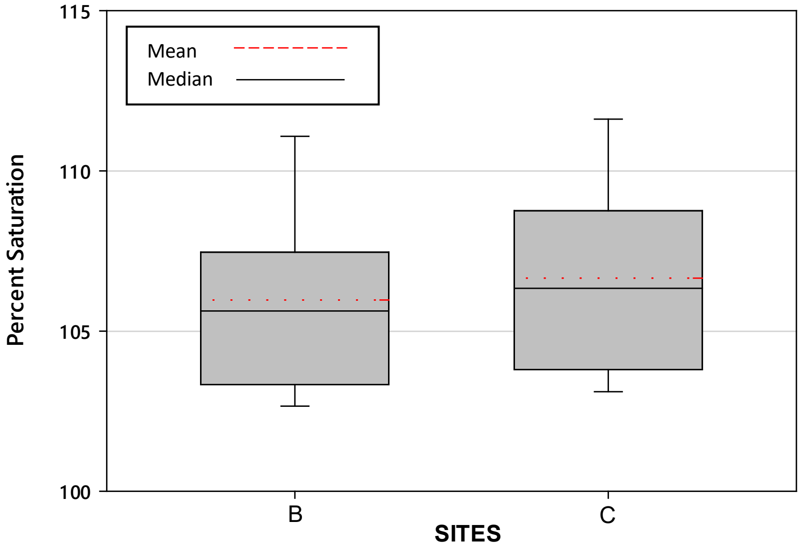


Figure 9. Box plot comparing percent saturation between sites B and C

Table 2. Summary statistics for TDG and Temperature between the intake control (Site B) and Pond 13-1 (Site C)

Metric	TDG Saturation		Temperature (C)	
	Site B	***Site C***	***Site B***	***Site C***
Mean	105.97	106.65	13.74	13.85
Standard Error	0.07	0.07	0.02	0.02
Median	105.63	106.34	13.79	13.91
Standard Deviation	3.07	3.14	0.69	0.70
Sample Variance	9.41	9.86	0.47	0.49
Range	12.55	13.46	5.27	5.32
Minimum	101.53	101.79	12.44	12.53
Maximum	114.08	115.24	17.71	17.85
Count	1825	1825	1825	1825
Significant Difference*	*Yes*		*Yes*	

* the differences in the median values among the sites are greater than would be expected by chance alone; a statistically significant difference exists (P = <0.001)

2) Comparison of TDG saturation between in-river control (Site A) and upstream intake control (Site B)

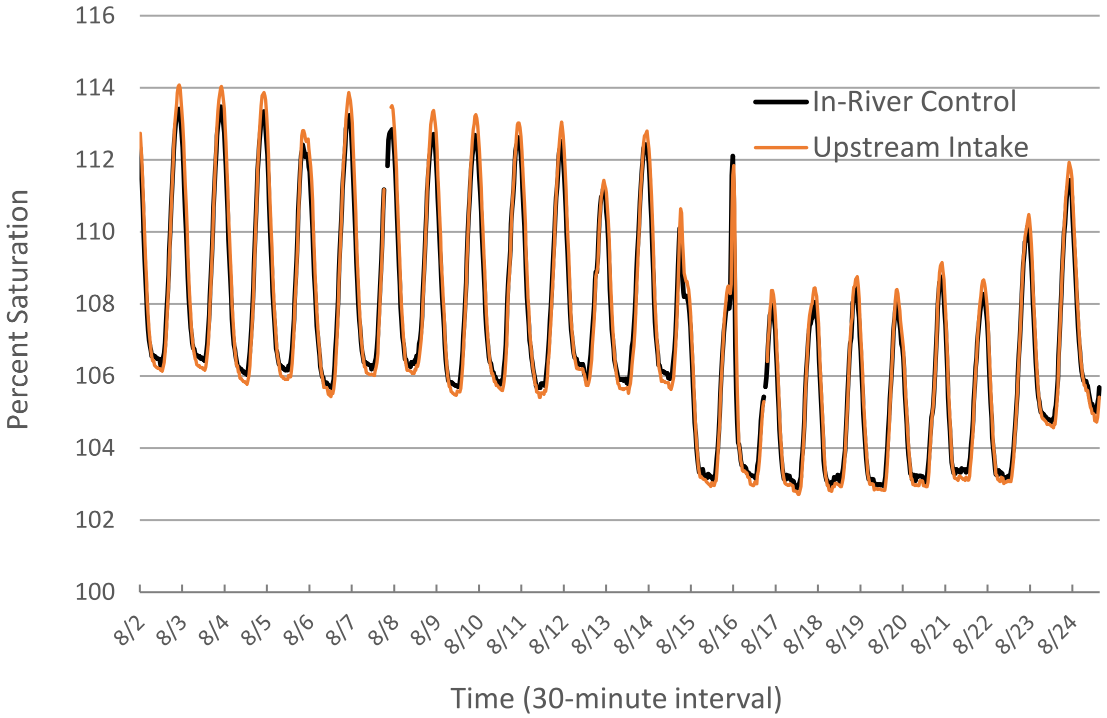


Figure 10. Time series comparison of percent saturation between the in-river control and upstream intake well (control sites)

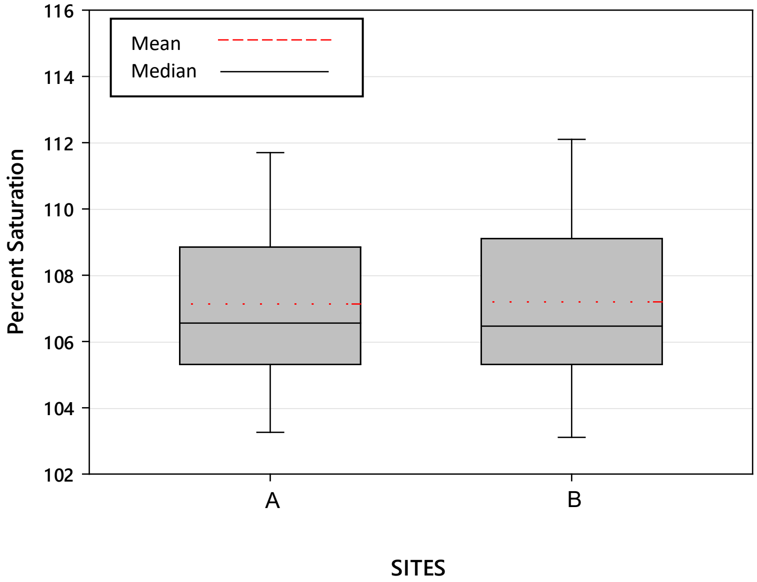


Figure 11. Box plot comparing percent saturation at sites A and B.

Table 3. Summary statistics between the in-river control (Site A) and upstream intake well (Site B)

Metric	TDG Saturation	
	Site A	*Site B*
Mean	107.14	107.20
Standard Error	0.09	0.09
Median	106.56	106.46
Standard Deviation	2.83	3.04
Sample Variance	8.02	9.25
Range	10.59	11.36
Minimum	102.89	102.72
Maximum	113.48	114.08
Count	1077	1077
Significant Difference*	*No*	

* the differences in the median values among the sites are NOT greater than would be expected by chance alone (P= 0.526)

3) Comparison of TDG and water temperature between the upstream (Site C) and downstream (Site D) areas within Pond 13-1.

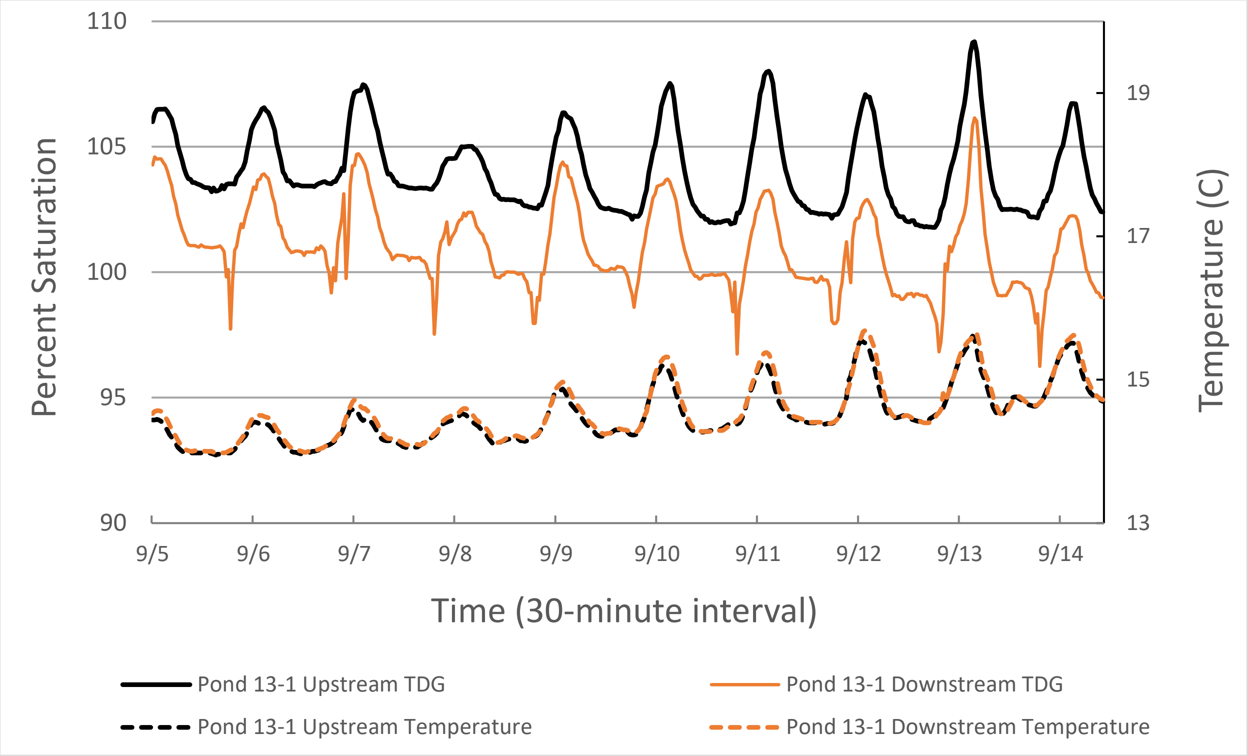


Figure 12. Time series comparison of percent saturation between the upstream (Site C) and downstream (Site D) ends in rearing pond 13-1

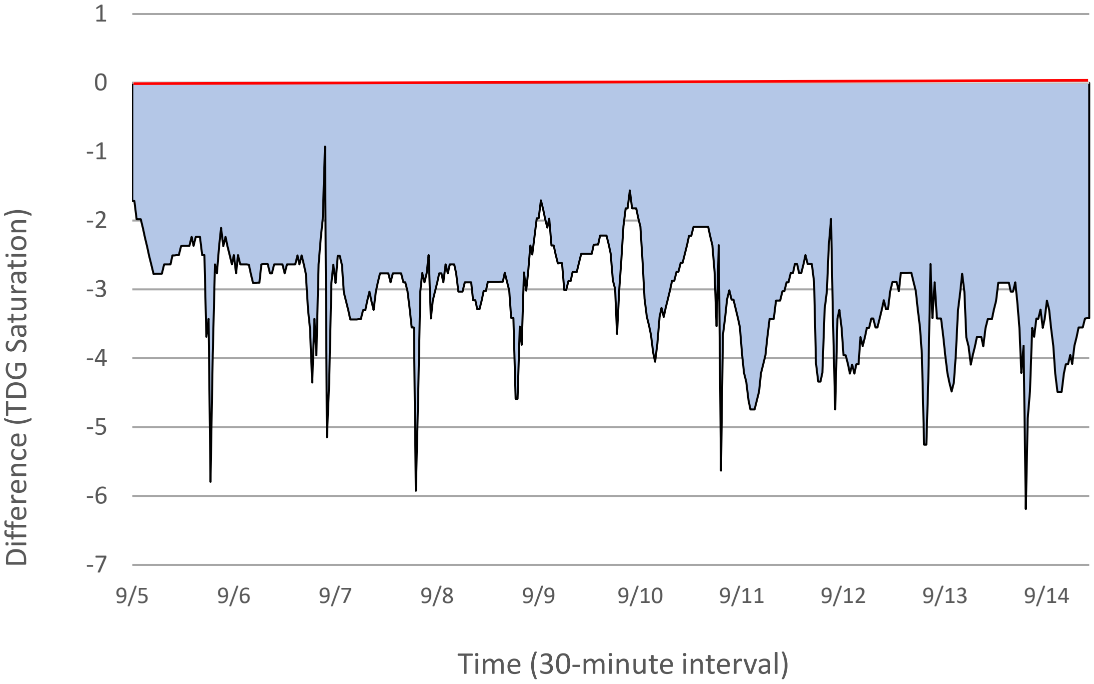


Figure 13. Differences in percent saturation between Site C and Site D in Pond 13-1

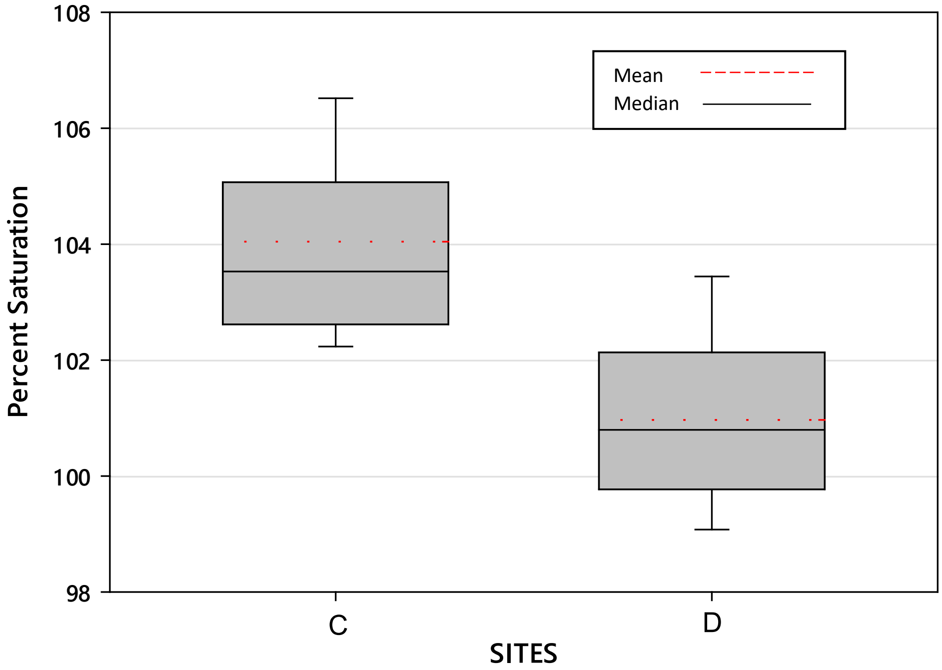


Figure 14. Box plot comparing percent saturation between sites C and D

Table 4. Summary statistics between the upstream (Site C) and downstream (Site D) locations within Pond 13-1

Metric	TDG Saturation		Temperature (C)	
	Site C	***Site D***	***Site C***	***Site D***
Mean	104.04	100.97	14.49	14.55
Standard Error	0.08	0.08	0.02	0.02
Median	103.53	100.79	14.41	14.47
Standard Deviation	1.66	1.69	0.39	0.42
Sample Variance	2.75	2.84	0.16	0.18
Range	7.40	9.91	1.66	1.71
Minimum	101.79	96.25	13.95	13.98
Maximum	109.19	106.15	15.61	15.69
Count	453	453	453	453
Significant Difference*	*Yes*		*Yes (p= <0.038)*	

* the differences in the median values among the sites are greater than would be expected by chance alone; a statistically significant difference exists (P = <0.001)

4) Comparison between in-river control (Site A), upstream intake control (Site B) and Pond 13-1 (Site C) during operation of the degassing (aeration) tower

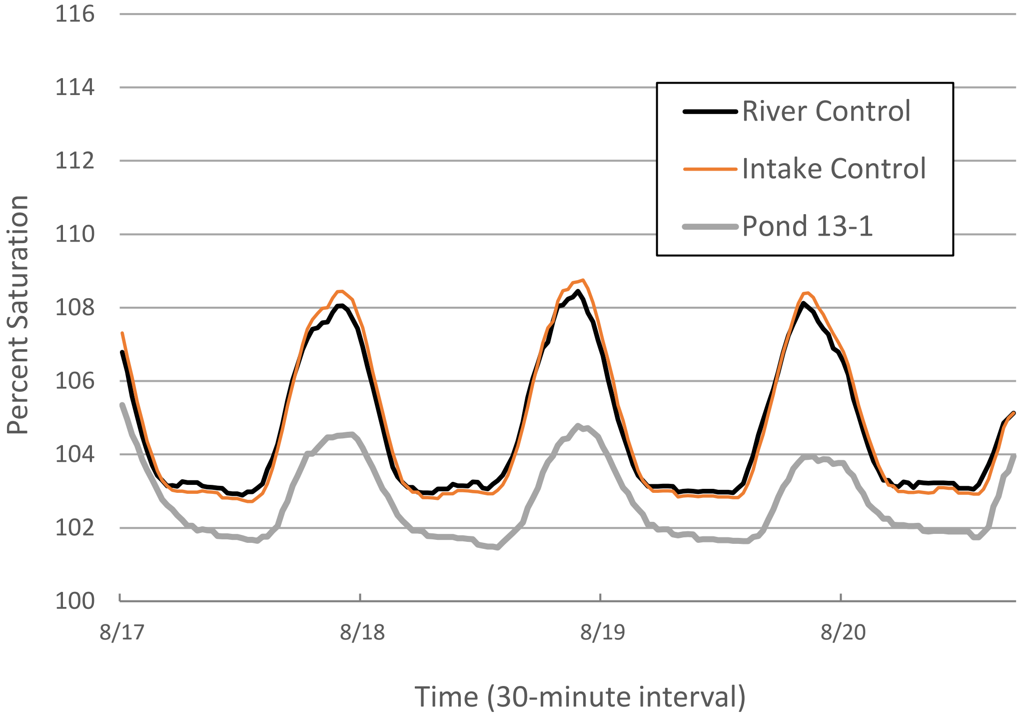


Figure 15. Time series comparison of percent saturation the in-river control (Site A), upstream intake (Site B) and pond 13-1 (Site C, downstream of degassing tower) while operating degassing tower.

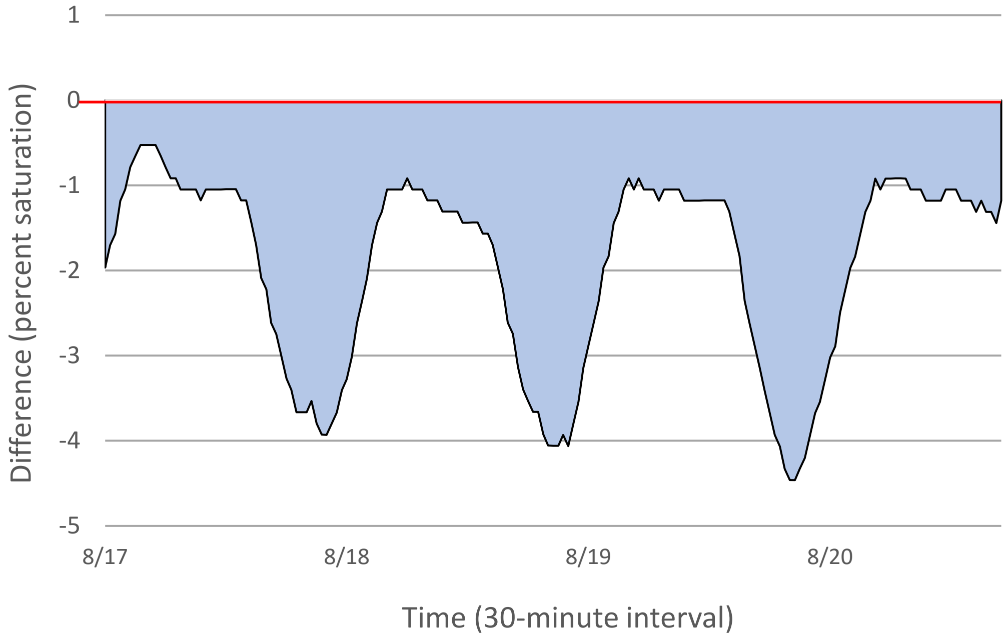


Figure 16. Difference in percent saturation between upstream intake (Site B) and pond 13-1 (Site C, downstream of degassing tower) while operating degassing tower

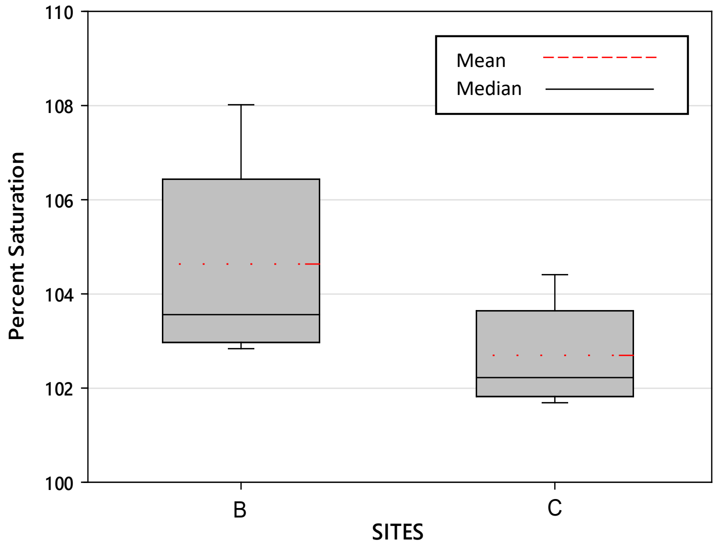


Figure 17. Box plot comparing percent saturation between sites B and C

Table 5. Summary statistics for Site B and Site C while operating the degassing tower.

Metric	TDG Saturation	
	Site B	***Site C***
Mean	104.64	102.69
Standard Error	0.15	0.08
Median	103.56	102.23
Standard Deviation	2.02	1.03
Sample Variance	4.07	1.06
Range	6.03	3.88
Minimum	102.72	101.46
Maximum	108.75	105.35
Count	179	179
Significant Difference*	*Yes*	

* the differences in the median values among the sites are greater than would be expected by chance alone; a statistically significant difference exists (P = <0.001)

5) Comparison between the downstream side of Pond 13-1 (Site D) and downstream of the water reuse wall of Pond 14-1 (Site E)

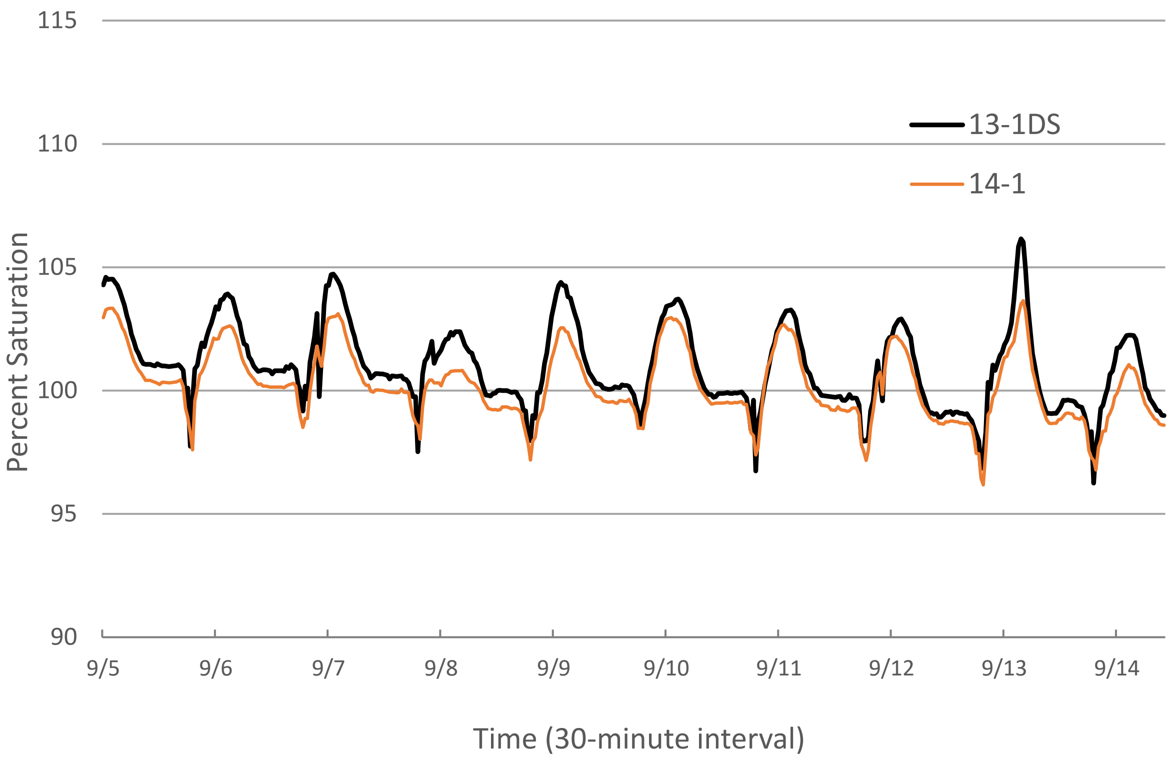


Figure 18. Time series comparison between percent gas saturation the downstream end of Pond 13-1 and upstream end of Pond 14-1

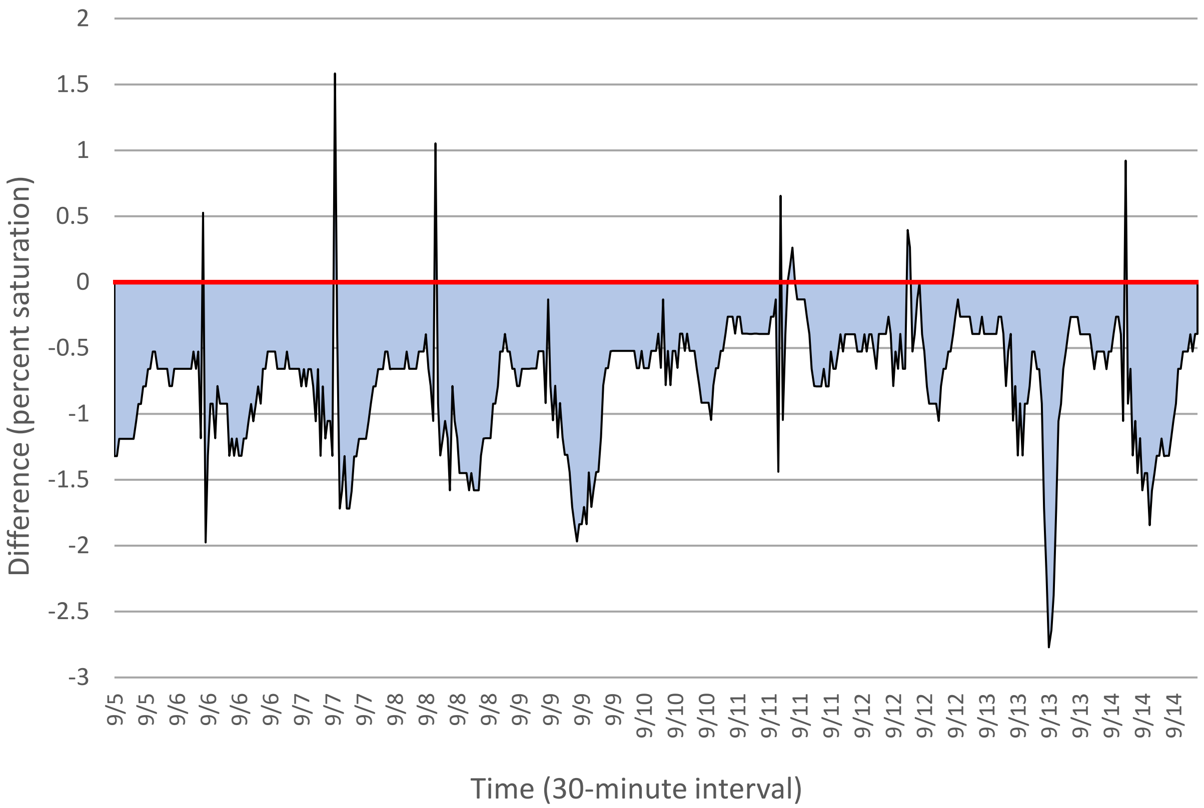


Figure 19. Difference in percent gas saturation between downstream end of Pond 13-1(D) and upstream end of Pond 14-1(E)

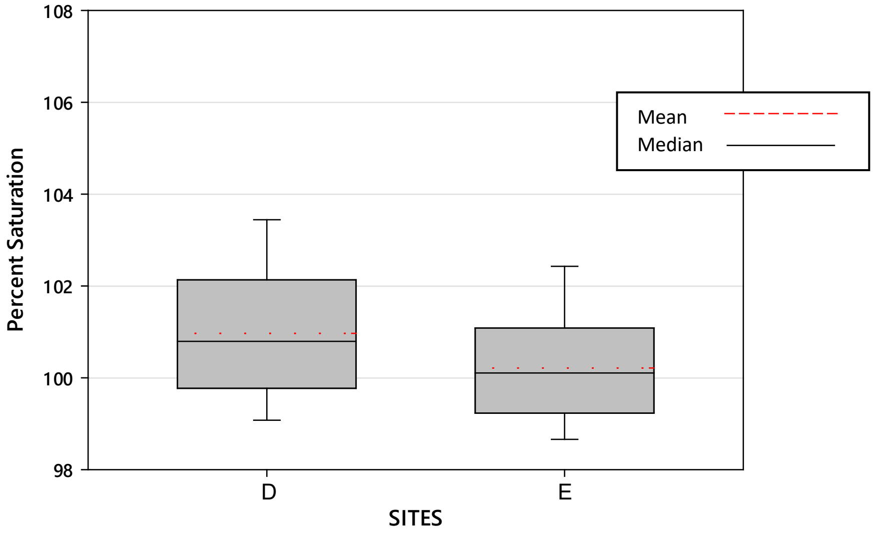


Figure 20. Box plot comparing percent saturation between sites D and E

Table 6. Summary statistics for the downstream end of Pond 13-1 (Site D) and upstream end of Pond 14-1 (Site E, post reuse wall measurement)

Metric	TDG Saturation	
	Site D	***Site E***
Mean	100.97	100.22
Standard Error	0.08	0.07
Median	100.79	100.10
Standard Deviation	1.69	1.43
Sample Variance	2.84	2.04
Range	9.91	7.47
Minimum	96.25	96.18
Maximum	106.15	103.64
Count	453	453
Significant Difference*	*Yes*	

* the differences in the median values among the sites are greater than would be expected by chance alone; a statistically significant difference exists (P = <0.001)

6) Comparison between upstream locations of Ponds 13-1 (Site C), 14-1 (Site E) and 16-3 (Site F)

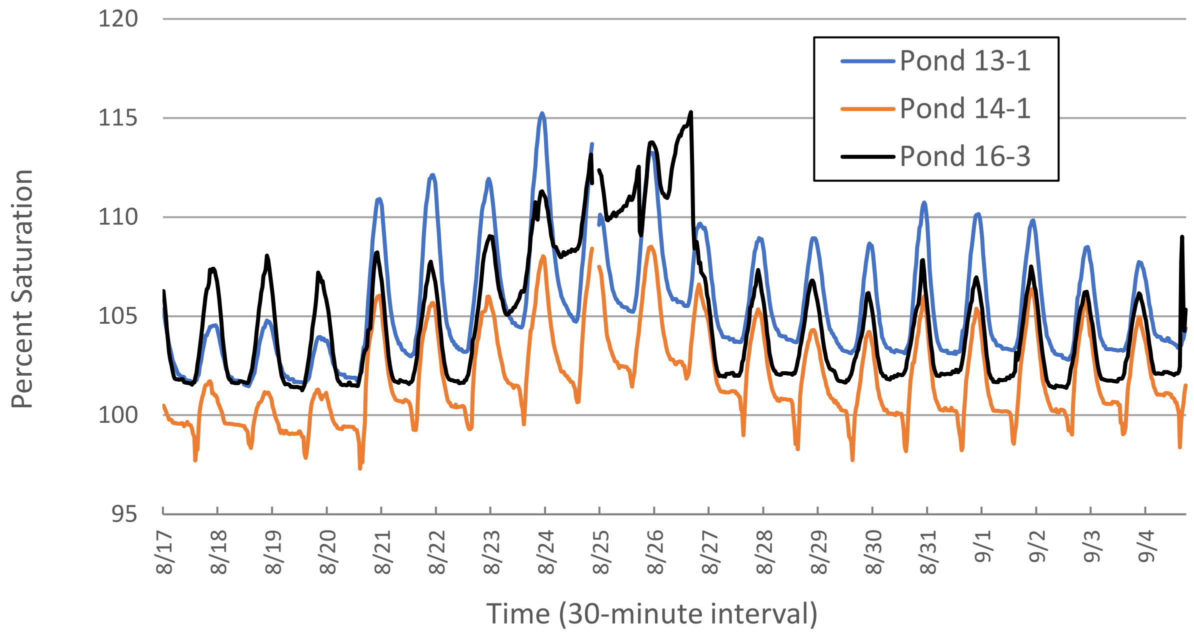


Figure 21. Time series comparison of percent gas saturation measured between ponds 13-1, 14-1 and 16-3

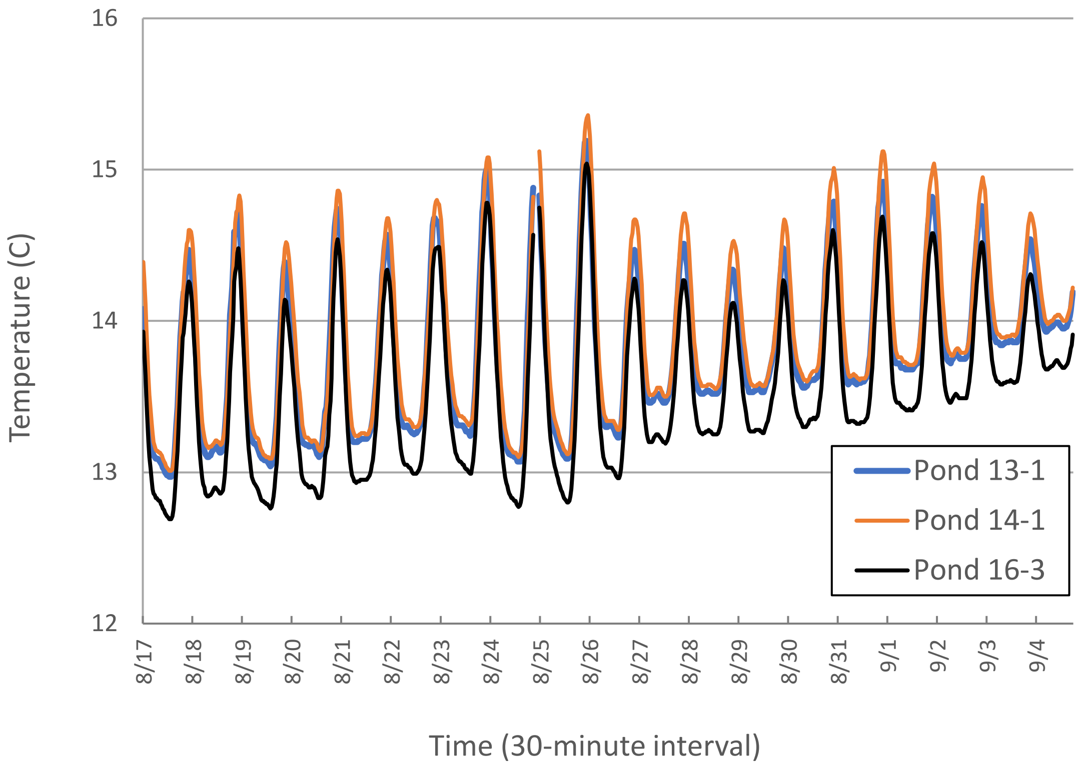


Figure 22. Time series comparison of water temperatures between ponds 13-1, 14-1 and 16-3

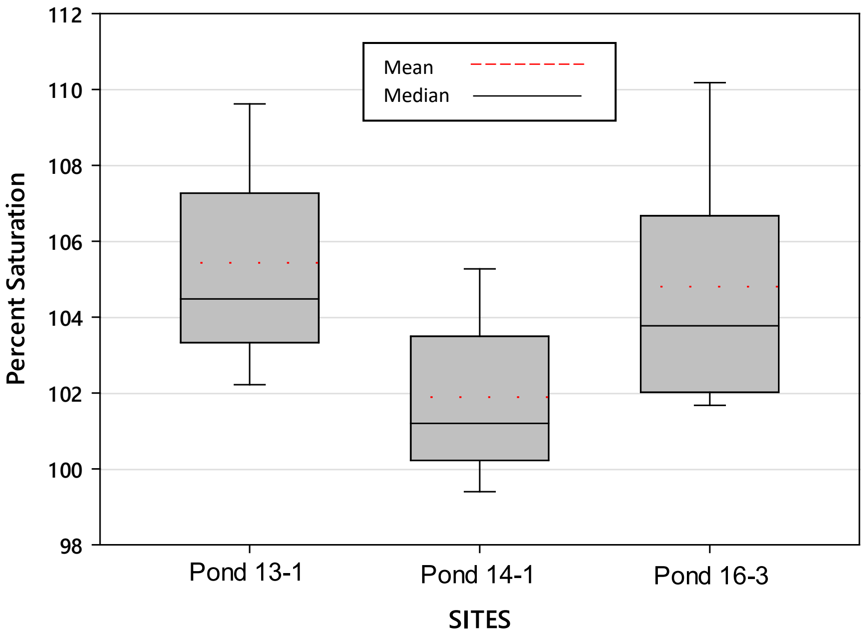


Figure 23. Box plot comparing percent saturation between sites C, E and F

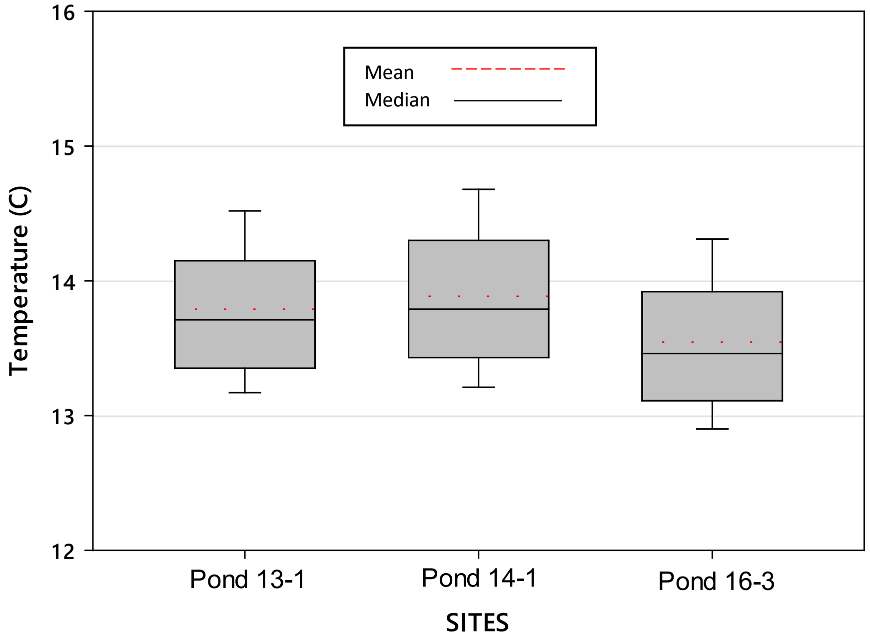


Figure 24. Box plot comparing water temperature between sites C, E and F

Table 7. Summary statistics for percent gas saturation and temperature for ponds 13-1 (Site C), 14-1 (Site E) and 16-3 (Site F)

Metric	Total Saturation			Temperature (deg. C)		
	Site C	***Site E***	***Site F***	***Site C***	***Site E***	***Site F***
Mean	105.43	101.89	104.81	13.79	13.89	13.54
Standard Error	0.10	0.08	0.11	0.02	0.02	0.02
Median	104.48	101.20	103.77	13.71	13.79	13.46
Standard Deviation	2.88	2.28	3.33	0.51	0.55	0.52
Sample Variance	8.28	5.19	11.11	0.26	0.30	0.27
Range	13.78	11.21	14.04	2.22	2.35	2.35
Minimum	101.46	97.30	101.26	12.97	13.01	12.69
Maximum	115.24	108.51	115.30	15.19	15.36	15.04
Count	895	895	895	895	895	895
Significant Difference*		*Yes*			*Yes*	

* the differences in the median values among the sites are greater than would be expected by chance alone; a statistically significant difference exists (P = <0.001)

V. Discussion

The stated purpose of this assessment is to identify and describe TDG and temperature profiles or characteristics at the hatchery that may be contributing to poor fish health, especially during times of stress (e.g., smolting, feeding, handling, warming water temperatures etc.). Any decisions to initiate structural or operational modifications will be developed through the Aquatic Technical Subgroup (ATS) in consultation with the Aquatic Coordination Committee (ACC). The goal of any modification should be to improve the overall health and fitness of juvenile fish rearing at the hatchery, with the intent of improving survival (and consequently adult return rates) after release from the hatchery.

Ambient conditions

Site A (in river control) and Site B (upstream intake well) provide measurements of percent gas saturation and temperature as they normally occur in the river prior to entering the hatchery intake pumps. When comparing both sites there is no statistical difference between the two (Table 3) with strong correlation (r^2 =0.99). Therefore, the in river probe was removed on August 25, 2018 to avoid theft and for use in other areas (e.g., site F). After August 25, Site B was used as the control site.

Ambient or natural in-river conditions were on average over saturated (~107%) during the study period. Whether this oversaturation is caused by oxygen, nitrogen or both is not known. Diel fluctuations were observed in both temperature and TDG which may have been exaggerated by relatively low flows (~1,200 cfs) and solar warming during the summer study period. That is, the average saturation and diel fluctuations observed during the study period may not be present during periods of higher flows and less solar warming. Nonetheless, it is a concern to observe ambient conditions that are consistently over saturated. Further study is needed to better understand the cause for over saturation in the river - at least during the summer months.

Are TDG and temperature levels measured in the ponds (using upwelling) different than ambient river conditions?

In 2011, an upwelling inflow design was put into service on pond banks 13 and 14. This design is different than inflow designs in use prior to 2011. Prior to 2011, inflow water poured into the pond via an above water header pipe. Prior to this study, there was concern that submerged upwelling designs may contribute to TDG levels as inflow water entering the pond would not be open to atmosphere and enter the ponds under hydrostatic pressure with no means to relieve the partial pressures of dissolved gases. In an open system, oversaturated water entering the ponds are exposed to atmosphere and would tend to equilibrate (although briefly) with atmospheric pressure.

Site C represents TDG and water temperature at the discharge upwelling pipe into Pond 13-1. Site B represents ambient water conditions prior to being pumped into the ponds. While statistically there is a difference in both TDG and temperature, the differences are relatively small. For TDG, the mean difference between the two sites was 0.68% with similar maximum and minimum values. Looking at only the average increase (i.e., taking only the measurements that show an increase), the data show a 1.06 percent increase from ambient levels. While there is some increase in TDG with the upwelling system, it is not likely to be a biological concern affecting fish health as natural diurnal fluctuations exceed effects of the upwelling system on TDG and that increase spike (of 2 or 3 percent) are of very short duration. However, as ambient conditions approach 110 percent saturation, this incremental increase may be a factor affecting fish health. With respect to temperature, the effects are (understandably) even less pronounced.

Recommendation: Discuss with fish health staff whether the incremental increase caused by the upwelling system presents a fish health concern. No changes to the current design are recommended.

Does the upstream intake air burst system or pumps elevate TDG above ambient river conditions?

The median differences observed between the in-river control site ‘A’ and the upstream intake site ‘B’ are not great enough to exclude the possibility that the difference is due to random sampling variability, therefore, the air burst system is not a contributing or significant factor relative to gas saturation.

Recommendation: None

Describe the TDG and temperature profile within a loaded rearing pond?

There is a significant difference in TDG measurements from at the upstream and downstream end of Pond 13-1. There is a notable dip in TDG observed at the downstream end every morning beginning around 0800 hours and lasting for approximately two hours. This ‘dip’ almost always creates a short-term under saturated condition whereas the upstream end appears to remain oversaturated (Figure 12). The cause for this dip is unknown, but may be related to morning feeding schedules that cause increased respiration (stress) by fish or possibly the timing of primary production through photosynthesis. During the afternoon, both temperature and TDG become elevated typically peaking in the late afternoon. The influence of temperature on TDG is well established and the relationship of increasing water temperatures causing higher saturation levels is well established and observed both in Pond 13 (Figure 12) and at the in-river control sites.

Recommendation: Determine the cause for under saturated dips observed in the early morning. Are these dips the result of feeding schedules, loss of photosynthetic activity or both? Explore delaying feeding until late morning to mitigate saturation dips at the downstream ends of the rearing ponds. Explore different feeding methods such as demand feeders or underwater timed feeders that reduce stressful and chaotic feeding activity observed from the current feeding regime.

What affect do the aeration towers have on TDG?

Using the degassing tower at Pond 13 produces a mean reduction in gas saturation of about 2 percent (Table 5). This reduction becomes even more pronounced during periods when in-river TDG levels are highest in the late afternoon (mean reduction of about 4 percent). Therefore, use of the degassing towers are effective in reducing over saturated waters entering the rearing ponds. Whether it is practical to use the towers on a continual basis would need to be balanced with head loss and consequently less water inflow rates while the towers are in use. However, it is important that these towers be used consistently whenever periods of spill are initiated from Merwin Dam. Another option may be to use the towers on a seasonal basis when in-river gas saturation levels are highest during the summer months if rearing pond saturation levels are a concern affecting fish health or fitness.

Recommendation: Continue to use degassing towers continuously during spill events at Merwin Dam. Explore the practicality of using the towers during the summer months when in-river TDG levels are highest – especially during periods of high water temperatures and solar radiation (e.g., afternoon).

What affect does the Pond 14 reuse have on TDG?

The reuse wall causes water exiting from Pond 13 to collect within a reuse water supply channel (Figure 2) before flowing over the reuse wall into Pond 14 (Figure 3). Reuse water flowing over the wall increases the surface area of water exposed to atmosphere. This configuration allows dissolved gases in the reuse water to come out of solution and acts to bring dissolved gas pressure to ambient levels (i.e., barometric pressure). Figure 19 shows that water flowing over the wall and into Pond 14 is consistently less saturated than water exiting Pond 13. The mean difference, however, is less than 1 percent. As observed with the degassing towers, the significance of this reduction is greater with higher levels of initial gas saturation present in the effluent water from Pond 13. That is, higher saturation levels exposed to atmosphere from flowing over the wall will naturally desaturate at a faster rate than water that is only slightly over saturated.

Figure 18 provides a time series comparison between these two sites. It is notable that the 'dip' observed at the downstream end of Pond 13 in the early morning hours persists into Pond 14 despite water flowing over the reuse wall. That is, under saturated water flowing over the wall should increase in saturation. Figure 19 shows only very short term spikes in saturation during these periods however. Perhaps of more significance are the saturation levels present at the downstream end of Pond 14 in the early morning as the inflow water is already at a saturation deficit compared to first pass water which is typically oversaturated (e.g., Pond 13 Site C). This should be evaluated as under saturation can result in low dissolved oxygen levels in the rearing pond.

Recommendation: All reuse water should continue to flow over the reuse wall. The benefits with respect to TDG are likely insignificant given the diel fluctuations observed. There may be opportunities to increase the surface area of the water exposed to atmosphere while flowing over the wall including a screened section that would increase the effectiveness and improve the water quality entering Pond 14.

An evaluation of the downstream end of Pond 14 should be done in 2019 to evaluate the significance of early morning TDG 'dips' especially when using reuse water that already is under saturated upon entering Pond 14. This evaluation should focus on dissolved oxygen levels present at the downstream ends of ponds using reuse water as their source.

Are there TDG and temperature differences between pond banks?

Figure 21 shows the time series TDG observation between first pass source water ponds 13, 16 and reuse source water pond 14. Pond 16 derives source water from the downstream intake pumps and Pond 13 from the upstream intake. Ponds 13 and 16 show similar TDG profiles and diurnal fluctuations. Ponds 13 and 16 exceeded the 110 percent standard during a portion of this two week assessment; however, these exceedences occurred when the river water also exceeded 110 percent of saturation (week of August 17). Pond 14 TDG levels are consistently less than either pond 13 or 16. This difference is attributed to reuse source water. Temperature differences were much less pronounced between the three ponds, although Pond 16 is always incrementally cooler than ponds 13 or 14.

Recommendation: None

VI. Conclusions

Generally, total dissolved gas levels at the hatchery remain below the state standard of 110 percent. When exceedances of this standard did occur, they were more closely related to ambient in river conditions rather than any design elements at the hatchery (Attachment A1). Elevated levels in the river are not as concerning as levels in the hatchery. Raceways are relatively shallow compared to in river conditions and fish are not able to sound or leave to escape the effects of over saturation.

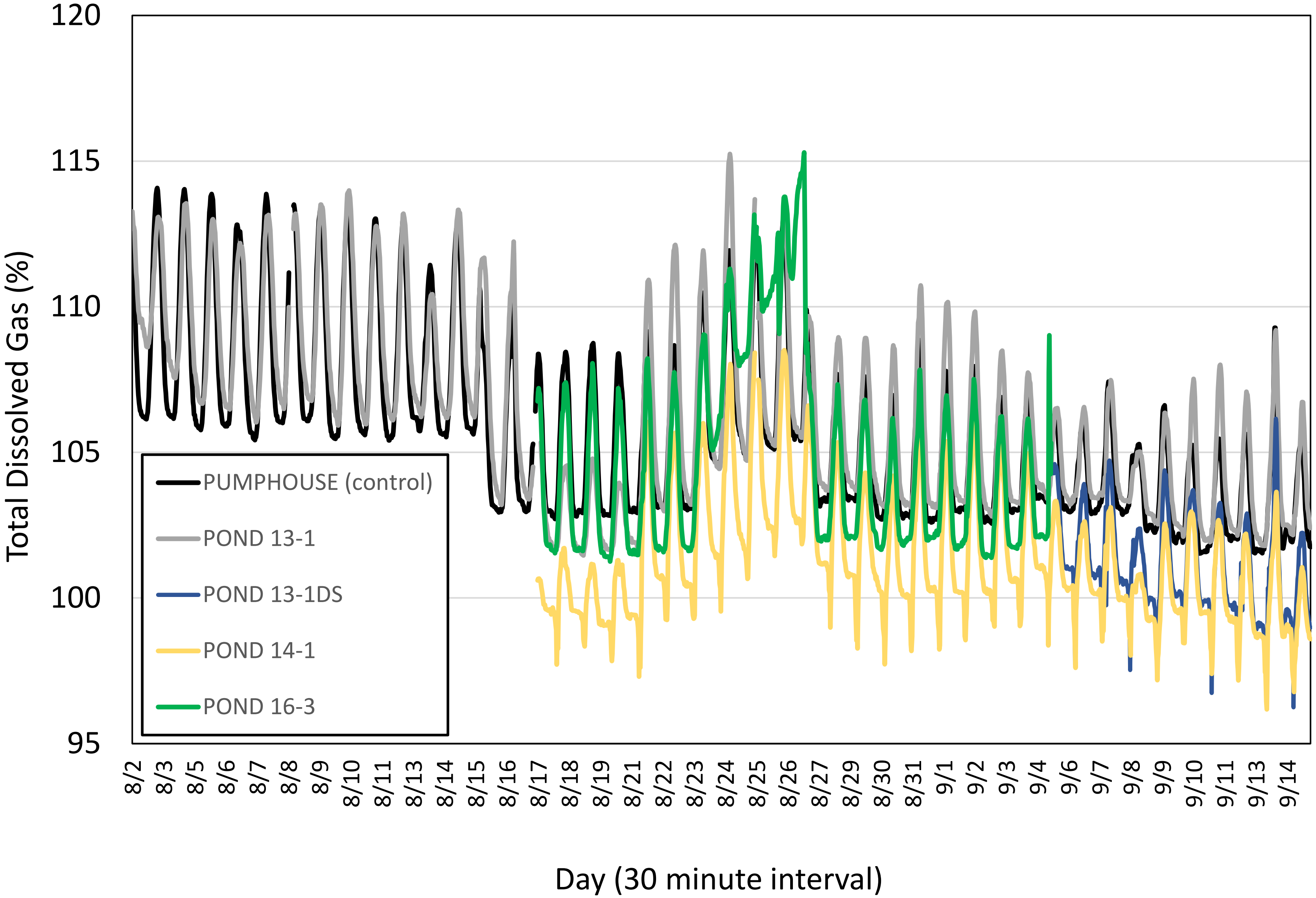
The use of degassing towers is shown to be an effective measure to reduce over saturation. Not just during spill events, but during the summer months when the potential of TDG to exceed healthy levels is greatest. The use of the degassing towers should be discussed further with fish health staff at WDFW to determine whether the towers should be selectively used.

An unexpected observation was made during this assessment regarding significant dips in TDG during the early morning hours. This dip is unique to loaded raceways and not observed in the river. This observation is most likely related to feeding or fish densities in the rearing raceways. More work should be done to determine the cause of these dips and whether they are causing any negative effects. A measure to improve aeration of water flowing over the reuse wall would have benefits to reuse water (e.g., a screened portion on top of reuse wall to increase the surface area of reused water). Dissolved oxygen levels should be monitored in raceways relying on reuse water to ensure that oxygen levels remain at healthy levels throughout the length of the rearing raceway.

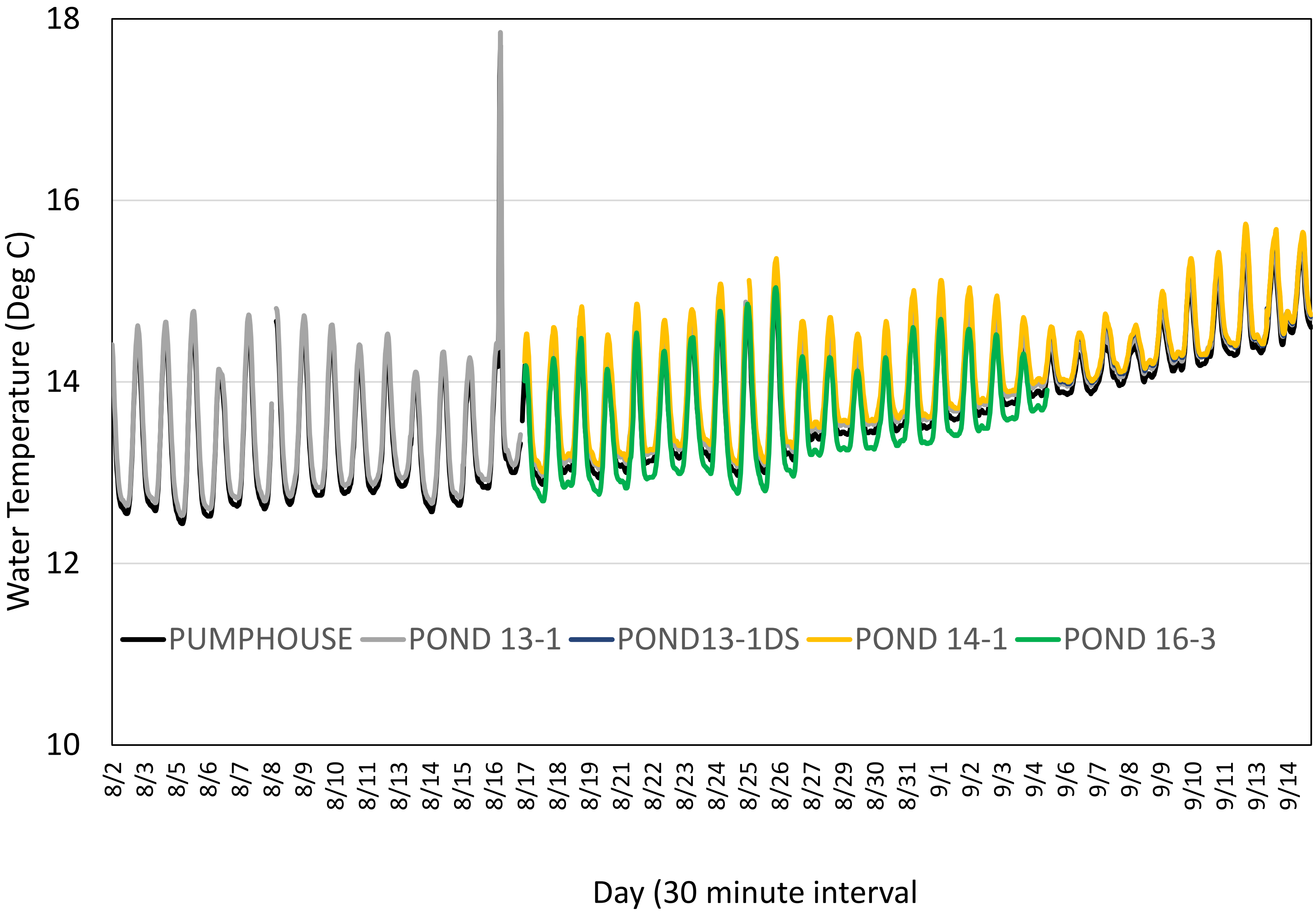
Feeding schedules and methods should be evaluated to determine if modifications should be initiated as a means to reduce potential stress from erratic and chaotic behavior exhibited with current methods. Feeding methods or timing may be contributing to saturation dips observed.

Temperature profiles for all raceways were very similar to in-river conditions. No significant warming was noted (from a biological perspective) in any of the raceways.

ATTACHMENT A1: Summary of total dissolved gas measurement of all sites



ATTACHMENT A2: Summary of water temperature measurement of all sites



APPENDIX D –

Screw trapping results from lower river sampling 2022, North Fork Lewis River

JMX Smolt Trap Protocols and Reporting
(2/14/2023)

This document includes three sections:

- **Part 1 – Data Collection is to be completed prior to the trapping season.**
- **Part 2 – Implementation Notes is to be completed once data are collected in preparation for analysis.**
- **Part 3 – Analysis and Results is to be completed as the last step.**

All protocols reported in this document reflect standardized Region 5 smolt trapping and analysis methods. The purpose of this document is to ensure consistency among projects and to document protocols for posterity.

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Part 1: DATA COLLECTION PROTOCOLS

Protocol Name: North Fork Lewis River (downstream of Merwin Dam) - 2022

Project Supervisor: Jason Shappart (Meridian Environmental, Inc. – PacifiCorp contractor)

Science Leader: Jason Shappart (Meridian Environmental, Inc. – PacifiCorp contractor)

ESA Take Permit No. (if applicable): ESA Section 7(a)(2) Consultation, Biological Opinion for PacifiCorp's operation of the Lewis River Hydroelectric Projects (NMFS Consultation No. 2005/05891). August 27, 2007.

Trap information:

Trap Name	Type of Trap	Trap Location RKM	Start Date (Planned)	End Date (Planned)
Lewis River Upper Golf Course Traps	Two 8-foot rotary screw traps fished in tandem strapped together side-by-side	21.6	03/15/2022	07/10/2022

1.1 Field Objectives:

Trap Name	Lewis River Upper Golf Course Traps							
Species	**Origin**	**Life Stage**	**Age Class**	**Catch**	**Efficiency Trials**	**Fork Length**	**Scales**	**Other**
Chinook	All	All	All	Y	Y	Y	N	Scan for CWT/BWT
Chum	All	F	Subyearling	Y	Y	Y	N	
Unidentified Trout Fry	All	F	Subyearling	Y	Y	Y	N	
Steelhead	All	P	Subyearling	Y	Y	Y	N	Scan for BWT
Steelhead	All	T/S	Yearling	Y	Y	Y	N	Scan for BWT
Coho	All	F	Subyearling	Y	Y	Y	N	
Coho	All	P	Subyearling	Y	Y	Y	N	Scan for CWT
Coho	All	T/S	Yearling	Y	Y	Y	N	Scan for CWT
Cutthroat	All	P/T/S/A	All	Y	Y	Y	N	
Additional Comments/Narrative: Fry (F), Parr (P), Transitional (T), Smolt (S), Adult (A), Blank Wire Tag (BWT), Coded Wire Tag (CWT)								

1.2 Site Selection:	
• *Why was this site selected for the smolt trap?*	Anchoring, permitting, laminar flow, ease of access and downstream of the majority of spawning
• *Are there spawner estimates above the trap site that can be used to estimate freshwater productivity, capacity, and smolt-to-adult return?*	Mainstem Chinook, Coho and Steelhead: Yes Chum: No
• *Describe the method used for adult escapement estimates (e.g., Carcass tagging, adult MR, AUC, redds, PCE, other).*	Chinook and Coho: Carcass tagging in mainstem NF Lewis River, WDFW GRTS redd surveys in tributaries Steelhead: Redd Surveys
• *Estimated % of the total basin-specific population that spawn above the trap. Include source for this information (% can be a range).*	Steelhead: > 90% (Annual Operations Report) Chinook: unknown Coho: unknown
• *Estimated % of yearling life stage juveniles that continuously rear) above the trap (summer and winter) prior to outmigrating. Include source for this information.*	Unknown
• *Additional Information*	Juvenile anadromous fish transported from upstream of the Lewis River Projects are released downstream of the trap locations (spring Chinook, Steelhead, Coho, Cutthroat).

1.3 Collection Event:	
• *Describe the planned frequency for enumerating and sampling fish caught in the trap.*	Traps to be checked daily (between 09:00 and 15:00 hours).
• *Describe and explain any planned trap outages.*	None
• *Describe process of handling and anaesthetizing fish.*	Dip nets used to transfer all fish to buckets or bins with battery aeration units. Salmonids to be anesthetized in solution of 1 ml Aqui-S to 2 gallons river water prior to sampling.
• *Describe method for measuring rotation per minute (RPM)*	Visually for 1 minute (daily)
• *List flow gauge associated with the trap.*	USGS Lewis River at Ariel Gage Station - 14220500
• *Describe method for measuring visibility and frequency of measurements.*	Not estimated
• *Describe method for measuring stream temperature and frequency of measurements.*	Not measured
• *Describe additional environmental variables measured, the method for the measurement, and the frequency of measurements.*	None

1.4 Fish Count by Group and Individual Measures:	
• *Life stage will be assigned according to the Region 5 Decision Tree (see appendix). Note any exceptions to the Decision Tree for species/life stage. Exceptions need to be approved by your Science Leader in advance!*	No exceptions to the Region 5 Decision Tree.
• *Describe how origin is assigned.*	Combination of presence and absence of adipose fin clips and CWT or BWT snout tags.

- *Describe the characteristics of individual fish (species/life stage, condition, and mark status) that are sorted and released downstream of the trap.*	All non-salmonids to be released downstream of trap regardless of life stage.
- *Describe that characteristics of individual fish (species/life stage, condition, and mark status) that are selected for efficiency trials.*	All salmonids. Fish with visual injury or other impairment shall not be used for trials regardless of species or life stage.

Table 1.4a. Date and length criteria used for field calls of Chinook age classes.

Life Stage	Age Class	Date Range	Length Range (mm FL)	Phenotype
Fry		3/1 to 6/30	<50 mm	
Parr/Trans/Smolt		3/1 to 6/30	≥50 mm	Determined by using Region 5 Decision Tree based on physical appearance
Individual Fish Measures:				
• *Sample rate for fork length*	F – 10 per day; P/T/S – up to 50 per day per each category			
• *Sample rate for scales*	NA			

Table 1.4b. Date and length criteria used for field calls of Coho age classes.

Life Stage	Age Class	Date Range	Length Range (mm FL)	Phenotype
Fry		3/1 to 6/30	<50 mm	
Parr/Trans/Smolt		3/1 to 6/30	≥50 mm	Determined by using Region 5 Decision Tree based on physical appearance
Individual Fish Measures:				
• *Sample rate for fork length*	F – 10 per day; P/T/S – up to 50 per day per each category			
• *Sample rate for scales*	NA			

Table 1.4c. Date and length criteria used for field calls of Steelhead age classes.

Life Stage	Age Class	Date Range	Length Range (mm FL)	Phenotype
Fry		3/1 to 6/30	<50 mm	
Parr/Trans/Smolt		3/1 to 6/30	≥50 mm	Determined by using Region 5 Decision Tree based on physical appearance
Individual Fish Measures:				
• *Sample rate for fork length*	F – 10 per day; P/T/S – up to 50 per day per each category			
• *Sample rate for scales*	NA			

Table 1.4d. Date and length criteria used for field calls of Cutthroat age classes.

Life Stage	Age Class	Date Range	Length Range (mm FL)	Phenotype
Fry		3/1 to 6/30	<50 mm	
Parr/Trans/Smolt		3/1 to 6/30	≥50 mm	Determined by using Region 5 Decision Tree based on physical appearance
Individual Fish Measures:				
• *Sample rate for fork length*	F – 10 per day; P/T/S – up to 50 per day per each category			
• *Sample rate for scales*	NA			

1.5 Marking and Release:	
- *Explain purpose of applying marks or tags to fish prior to release (if applicable).*	Marks are used to calibrate trap efficiency.
- *Describe the schedule for which fish will be released to determine trap efficiency.*	Daily (seven days per week)
- *Describe the target number of fish for each release group (species/life stage/age class).*	For all species in which outmigration estimates are planned (Chinook, Coho, Chum, Steelhead, and Cutthroat) all captured naturally produced fish ≥50 mm FL in good condition are marked and used in efficiency trials daily. Mark 1,000 fry (aggregate of all species) one day per week.
- *Describe marking or tagging method used for each species/origin/life stage/age class.*	**For salmonid fry**: Bismarck brown dye. Use 0.4 grams of dye per approximately 4 gallons of water. **For all maiden capture salmonids (≥50 mm FL):** Alcian Blue tattoo marks varied by week.
- *Describe release location for efficiency trials (rkm).*	In pool/run with bank habitat structures located at N45.937741, W-122.644367 about 0.85 miles upstream of trap site.
- *Describe where and how long marked or tagged fish are held prior to release for efficiency trials.*	Marked fish are held in aerated buckets for recovery after sampling and released immediately after each trap is sampled.
- *Describe what time of day marked or tagged fish are released for efficiency trials.*	Between 09:00 and 15:00 hours – depending on the number of fish sampled each day.
- *Describe plans to evaluate mark retention and mark-related mortality.*	None
- *Describe plans to evaluate mark-recapture assumption that the second sample is a random representative sample (i.e., marked and unmarked fish are completely mixed)*	None planned for 2022

Table 1.5. Marking Plan for Trap Efficiency Trials

Species	Origin	Life Stage	Age Class	Start Date (Planned)	Stop Date (Planned)	Mark Rotation (Frequency)	Mark Type
Chinook	all	F		3/1	6/30	Same all season	Bismark Brown dye
Chinook	all	P/T/S		3/1	6/30	Weekly	tattoo (dye)
Coho	all	F		3/1	6/30	Same all season	Bismark Brown dye
Chum	all	F		3/1	6/30	Same all season	Bismark Brown dye
Trout Fry	all	F		3/1	6/30	Same all season	Bismark Brown dye
Steelhead	all	P/T/S		3/1	6/30	Weekly	tattoo (dye)
Coho	all	P/T/S		3/1	6/30	Weekly	tattoo (dye)
Cutthroat	all	P/T/S		3/1	6/30	Weekly	tattoo (dye)

1.6 Recapture:	
- *Describe how fish are examined for all marks (visual, PIT scan, CWT wand).*	Visual inspection for Alcian Blue tattoo marks or Bismark Brown dye, and adipose fin clip. Where applicable, fish will be wanded for presence of CWT or BWT.
- *Describe how maiden/recapture status is assigned.*	Captured fish indicating the presence of Alcian Blue tattoo marks and Bismark Brown Dye are considered recaptures. All other fish are considered maiden captures.
- *Describe effort to accurately detect marked fish used in efficiency trial. Include methods used to evaluate detection rates.*	All fish captured are visually evaluated for a previous mark.

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Part 2: IMPLEMENTATION NOTES

The Lewis River Upper Golf Course screw traps were operated from March 15 to July 10, 2022. The Lewis River is developing a meander bend just upstream of the screw trap location by cutting into the bank on the north side of the river with a developing point-bar on the south side of the river. This meander bend development is forcing the thalweg to the south side of the river where the screw traps have been historically operated. In 2022, the traps were located along the south bank within the thalweg in the same location as fished in 2021 (Photo 2a). The Lewis River Upper Golf Course Traps were fished in the same location continuously the entire season with no alterations (Table 2.1). Missed trapping periods were brief and caused by logs stuck in a trap cone (Table 2.2).

Photo 2a. Lewis River Upper Golf Course traps fishing location (2021), same location in 2022.

2.1 Trap Alterations

Trap Name: Lewis River Upper Golf Course Traps

Date	Type of Alteration	Details
NA	none	NA

2.2 Missed Trapping Periods

Trap Name: Lewis River Upper Golf Course Traps

Last Time Observed Fishing	Time Stopped Fishing	Method to Determine Trap Not Fishing	Time Start Fishing again	Comments
4/20/2022 ~10:00am	unknown	NA	4/21/2022 ~9:36am	Left Trap cone stopper: logs/brush
4/21/2022 ~9:36pm	unknown	NA	4/22/2022 ~9:54am	Left Trap cone stopper: logs/brush
7/5/2022 ~11:53am	unknown	NA	7/6/2022 ~9:20am	Right Trap cone stopper: logs/brush

2.3 Raw Data for Mark-Recapture Analysis

For the purpose of this analysis, capture data from both traps was combined to treat the traps fished side-by-side as one functional unit. Total maiden naturally produced salmonids caught included 3,330 Coho, 33,122 Chinook, 2,849 Chum, 53 Steelhead, and 69 Cutthroat. In addition, 135 trout fry (likely either Rainbow/Steelhead or Cutthroat) were also caught. Most naturally produced Coho, Chinook, and Chum salmon were young-of-year (YOY). A total of three (3) naturally produced Sockeye fry were caught on March 18, 2022 and are not further discussed. Total maiden hatchery produced salmonids caught included 23,100 Coho and 900 Steelhead. In addition, the traps caught 445 three-Spine Stickleback, one (1) Chiselmouth, two (2) Dace, 21 Lamprey, 303 Northern Pikeminnow, one (1) Redside Shiner, and 365 Sculpin.

The total number of salmonids captured, released upstream, and recaptured during each weekly period by origin and species from March 15 to July 10, 2022 are summarized in Table 2.3a (Coho), Table 2.3b (Chinook and Chum), Table 2.3c (Steelhead), and Table 2.3d (Cutthroat). Fork length (FL) distributions of Coho, Chinook, and Chum are summarized in Table 2.3e, and in Table 2.3f for Steelhead and Cutthroat. Overall trap efficiency was significantly different for fish <50 mm in length compared to fish ≥50 mm. Therefore, weekly trap efficiency estimates were calculated separately for these two discrete size classes. Relatively few recaptured fish ≥50 mm were available to determine weekly trap efficiency. Therefore, trap efficiency by period (week) was calculated by pooling all hatchery and naturally produced Coho, Chinook and Steelhead. Cutthroat were not included in this pooling due to uncertainty of being actual downstream migrants. Similarly, all Coho, Chinook, Chum and trout fry <50 mm in length were pooled to estimate weekly trap efficiency for fry-sized fish.

Table 2.3a - Summary of Coho captured at the Lewis River Upper Golf Course Traps during 2022 by period.

Lewis River below Merwin Dam – Screw Traps 2022			Naturally Produced Coho								Hatchery Produced Coho				Ave. Weekly Flow (cfs)[a]	Ave. Weekly Cone RPMs Index[b]
			Maiden		Mark-Release Up		Recapture		Efficiency		Maiden	Mark-Release Up	Recapture	Efficiency		
Period	Start	End	<50mm	≥50mm	<50mm	≥50mm	<50mm	≥50mm	<50mm	≥50mm	≥50mm	≥50mm	≥50mm	≥50mm		
1	15-Mar	20-Mar	293	5	120	3	2		0.0167						7,278	9.6
2	21-Mar	27-Mar	742	2	249	2	2		0.0080						6,419	9.7
3	28-Mar	3-Apr	1113	8	335	8	2		0.0060						3,890	8.3
4	4-Apr	10-Apr	210[c]	2	22	2		2		1.0000	14,181	768	13	0.0169	4,239	8.1
5	11-Apr	17-Apr	2[c]	15		15					5,076	1,350	25	0.0185	4,226	8.3
6	18-Apr	24-Apr	216	3		3					1,227	864	10	0.0116	5,736	7.1
7	25-Apr	1-May	141	6	101	6					455	454	3	0.0066	6,353	8.8
8	2-May	8-May	54	12		12					1,010	468	3	0.0064	7,284	8.8
9	9-May	15-May	27	27		27					565	551	7	0.0127	7,083	8.2
10	16-May	22-May	110	14		14		1		0.0714	212	212	1	0.0047	7,436	8.1
11	23-May	29-May	63	43	11	41		1		0.0244	155	154	1	0.0065	6,066	7.8
12	30-May	5-Jun	46	18	25	18					66	65			5,650	7.6
13	6-Jun	12-Jun		17		17					62	59			8,553	9.0
14	13-Jun	19-Jun		12		12					55	53			7,190	7.3
15	20-Jun	26-Jun	3	50	2	50					22	22			4,201	6.9
16	27-Jun	3-Jul		54		54		1		0.0185	9	8			2,951	6.0
17	4-Jul	10-Jul	9	13		13					5	3			2,497	3.8
Total:			3,029	301	865	297	6	5	0.0069	0.0168	23100	5031	63	0.0125		

[a] Note: USGS Lewis River at Ariel, WA (Gage No. 14220500).

[b] Note: Weekly average left cone RPMs plus weekly average of right cone RPMs.

[c] Note: Predation of hatchery Coho smolts on Coho fry within the trap box and/or within the river likely resulted in lower Coho fry observed within the traps during weeks 4 and 5, which coincided with the peak of hatchery Coho smolt captures within the traps.

Table 2.3b - Summary of Chinook and Chum captured at the Lewis River Upper Golf Course Traps during 2022 by period.

Lewis River below Merwin Dam – Screw Traps 2022			Naturally Produced Chinook								Naturally Produced Chum				Ave. Weekly Flow (cfs)[a]	Ave. Weekly Cone RPMs Index[b]
			Maiden		Mark-Release Up		Recapture		Efficiency		Maiden	Mark-Release Up	Recapture	Efficiency		
Period	Start	End	<50mm	≥50mm	<50mm	≥50mm	<50mm	≥50mm	<50mm	≥50mm	<50mm	<50mm	<50mm	<50mm		
1	15-Mar	20-Mar	2,826		1,382		9		0.0065		555	177	3	0.0169	7,278	9.6
2	21-Mar	27-Mar	5,059		1,783		8		0.0045		816	359	8	0.0223	6,419	9.7
3	28-Mar	3-Apr	10,471		2,241		80		0.0357		1,193	344	15	0.0436	3,890	8.3
4	4-Apr	10-Apr	2,512[c]		461						239[c]	39			4,239	8.1
5	11-Apr	17-Apr	1,115[c]	1		1					1[c]				4,226	8.3
6	18-Apr	24-Apr	1,125								2				5,736	7.1
7	25-Apr	1-May	1,879	1	1,298		2		0.0015		1	1			6,353	8.8
8	2-May	8-May	615												7,284	8.8
9	9-May	15-May	916	14		14					1				7,083	8.2
10	16-May	22-May	510	6		5									7,436	8.1
11	23-May	29-May	1,165	119	170	16	1		0.0059		41	30			6,066	7.8
12	30-May	5-Jun	1,610	20	919	15	3	1	0.0033	0.0667					5,650	7.6
13	6-Jun	12-Jun	446	66	89	65									8,553	9.0
14	13-Jun	19-Jun	660	31	322	30									7,190	7.3
15	20-Jun	26-Jun	995	75	411	75		1		0.0133					4,201	6.9
16	27-Jun	3-Jul	579	136	217	121	1	6	0.0046	0.0496					2,951	6.0
17	4-Jul	10-Jul	136	34		20									2,497	3.8
Total:			32,619	503	9,293	362	104	8	0.0112	0.0221	2,849	950	26	0.0274		

[a] Note: USGS Lewis River at Ariel, WA (Gage No. 14220500).

[b] Note: Weekly average left cone RPMs plus weekly average of right cone RPMs.

[c] Note: Predation of hatchery Coho smolts on Chinook and Chum fry within the trap box and/or within the river likely resulted in lower Chinook and Chum fry observed within the traps during weeks 4 and 5, which coincided with the peak of hatchery Coho smolt captures within the traps.

Table 2.3c - Summary of Steelhead and Trout Fry at the Lewis River Upper Golf Course Traps during 2022 by period.

Lewis River below Merwin Dam – Screw Traps 2022			Naturally Produced Steelhead / Trout Fry								Hatchery Produced Steelhead				Ave. Weekly Flow (cfs)[a]	Ave. Weekly Cone RPMs Index[b]
			Maiden		Mark-Release Up		Recapture		Efficiency		Maiden	Mark-Release Up	Recapture	Efficiency		
Period	Start	End	<50mm[c]	≥50mm	<50mm	≥50mm	<50mm	≥50mm	<50mm	≥50mm	≥50mm	≥50mm	≥50mm	≥50mm		
1	15-Mar	20-Mar													7,278	9.6
2	21-Mar	27-Mar		1		1									6,419	9.7
3	28-Mar	3-Apr		2		2									3,890	8.3
4	4-Apr	10-Apr		1		1									4,239	8.1
5	11-Apr	17-Apr		2		1					3	3			4,226	8.3
6	18-Apr	24-Apr		3		3					1				5,736	7.1
7	25-Apr	1-May		7		7					1	1			6,353	8.8
8	2-May	8-May		7		7					519	116			7,284	8.8
9	9-May	15-May		6		5					295	287	3	0.0150	7,083	8.2
10	16-May	22-May		14		13		1		0.0769	55	55			7,436	8.1
11	23-May	29-May		4		4					12	12			6,066	7.8
12	30-May	5-Jun	3	2	2	2					5	5			5,650	7.6
13	6-Jun	12-Jun	3	2		2					8	8			8,553	9.0
14	13-Jun	19-Jun	3	1	3	1					1	1			7,190	7.3
15	20-Jun	26-Jun	17	1	7	1									4,201	6.9
16	27-Jun	3-Jul	56		33		2		0.0606						2,951	6.0
17	4-Jul	10-Jul	53												2,497	3.8
Total:			135	53	45	50	2	1	0.0444	0.0200	900	488	3	0.0061		

[a]Note: USGS Lewis River at Ariel, WA (Gage No. 14220500).

[b]Note: Weekly average left cone RPMs plus weekly average of right cone RPMs.

[c]Note: Fish <50 mm FL are unidentified trout fry (likely either Rainbow/Steelhead or Cutthroat).

Table 2.3d - Summary of Cutthroat at the Lewis River Upper Golf Course Traps during 2022 by period.

Lewis River below Merwin Dam – Screw Traps 2022			Naturally Produced Cutthroat				Ave. Weekly Flow (cfs)[a]	Ave. Weekly Cone RPMs Index[b]
			Maiden	Mark-Release Up	Recapture	Efficiency		
Period	Start	End	≥50mm	≥50mm	≥50mm	≥50mm		
1	15-Mar	20-Mar	1				7,278	9.6
2	21-Mar	27-Mar	1	1			6,419	9.7
3	28-Mar	3-Apr					3,890	8.3
4	4-Apr	10-Apr	4	3			4,239	8.1
5	11-Apr	17-Apr	1	1			4,226	8.3
6	18-Apr	24-Apr	3	3			5,736	7.1
7	25-Apr	1-May	8	8			6,353	8.8
8	2-May	8-May	10	9			7,284	8.8
9	9-May	15-May	12	12			7,083	8.2
10	16-May	22-May	12	12			7,436	8.1
11	23-May	29-May	7	7			6,066	7.8
12	30-May	5-Jun	9	9			5,650	7.6
13	6-Jun	12-Jun					8,553	9.0
14	13-Jun	19-Jun	1	1			7,190	7.3
15	20-Jun	26-Jun					4,201	6.9
16	27-Jun	3-Jul					2,951	6.0
17	4-Jul	10-Jul					2,497	3.8
Total:			69	66	0	Unknown		

[a] Note: USGS Lewis River at Ariel, WA (Gage No. 14220500).

[b] Note: Weekly average left cone RPMs plus weekly average of right cone RPMs.

Table 2.3e - Summary of Coho, Chinook, and Chum captured at the Lewis River Upper Golf Course Traps during 2022 by size class.

	Naturally Produced Coho				Hatchery Produced Coho				Naturally Produced Chinook				Naturally Produced Chum			
Fork Length Bin	Maiden	Mark/ Release Up	Recapture	Efficiency	Maiden	Mark/ Release Up	Recapture	Efficiency	Maiden	Mark/ Release Up	Recapture	Efficiency	Maiden	Mark/ Release Up	Recapture	Efficiency
20-29mm																
30-39mm	2,251	622	5	0.0080					5,719	1,233	60	0.0487	955	141	10	0.0709
40-49mm	778	243	1	0.0041					26,900	8,060	44	0.0055	1,894	809	16	0.0198
50-59mm	27	23							314	187	3	0.0160				
60-69mm	63	63			1	1			127	119	3	0.0252				
70-79mm	28	28	1	0.0357	4	4			45	41	2	0.0488				
80-89mm	7	7			13	13			14	12						
90-99mm	11	11			28	28			3	3						
100-109mm	25	25			68	68	2	0.0294								
110-119mm	58	58	1	0.0172	275	275	6	0.0218								
120-129mm	42	42	3	0.0714	935	853	9	0.0106								
130-139mm	26	26			10,197	1,748	22	0.0126								
140-149mm	13	13			11,000	1,466	22	0.0150								
150-159mm					475	472	2	0.0042								
160-169mm					88	87										
170-179mm	1	1			14	14										
180-189mm					2	2										
190-199mm																
200-249mm																
250-299mm																
300-349mm																
350-399mm																
Total	3,330	1,162	11		23,100	5,031	63		33,122	9,655	112		2,849	950	26	
<50mm	3,029	865	6	0.0069	NA				32,619	9,293	104	0.0112	2,849	950	26	0.0274
≥50mm	301	297	5	0.0168	23,100	5,031	63	0.0125	503	362	8	0.0221	NA			

Table 2.3f - Summary of Steelhead, Cutthroat, and Trout Fry captured at the Lewis River Upper Golf Course Traps during 2022 by size class.

	Naturally Produced Steelhead/Trout Fry				Hatchery Produced Steelhead				Naturally Produced Cutthroat			
Fork Length Bin	Maiden	Mark/ Release Up	Recapture	Maiden	Mark/ Release Up	Recapture	Efficiency	Efficiency	Maiden	Mark/ Release Up	Recapture	Efficiency
20-29mm[a]	5											
30-39mm[a]	130	45	2	0.0294								
40-49mm												
50-59mm												
60-69mm												
70-79mm												
80-89mm	1	1										
90-99mm					1	1						
100-109mm	3	3			1	1						
110-119mm	1	1										
120-129mm	2	2			2	2			1	1		
130-139mm					4	4						
140-149mm	3	3			7	7						
150-159mm	7	7	1	0.1429	16	16			1	1		
160-169mm	9	8			46	46	1	0.0217	6	6		
170-179mm	7	7			106	106			11	10		
180-189mm	6	6			120	120	2	0.0167	10	9		
190-199mm	4	3			272	104			12	12		
200-249mm	7	6			325	81			25	25		
250-299mm	3	3										
300-349mm									3	2		
350-399mm												
Total	188	95	3		900	488	3		69	66	0	
<50 mm	135	45	2	0.0444	NA				NA			
≥50 mm	53	50	1	0.0200	900	488	3	0.0061	69	66	0	

[a] Note: Fish <50 mm FL are unidentified trout fry (likely either Rainbow/Steelhead or Cutthroat).

2.4 Age Results from Scale Data

Scale and age data were not collected. Age at length data are not available for this site. However, age at length data based on scale analysis for the Kalama River was reviewed to aid in assessing potential age-length brackets (WDFW 2019).

2.5 Data Collected to Evaluate Mark-Recapture Assumption that Marking the Fish Does Not Affect Behavior (e.g., Mark-Related Mortality) and that Marks Are Not Lost

Mark-recapture assumptions were not tested.

2.6 Data Collected to Evaluate Mark-Recapture Assumption that the Second Sample is a Random Representative sample (i.e., Marked and Unmarked Fish are Completely Mixed)

Mark-recapture assumptions were not tested.

2.7 Smolt Trapping Assumption Testing Summary

Trap Name: Lewis River Upper Golf Course Traps			
Species: All Salmonids	**Origin(s): All**	**Life Stage(s): All**	**Age Class(es): All**

Place "X"	**Method to test/satisfy assumption**	**Comments**

Closure - Population is geographically closed to immigration, emigration, births, and deaths.

Unknown	Minimized by trapping over entire run	
	Minimized predation by checking trap box multiple times per day	
	Tested optimal release location to minimize predation on fry	
	Test predation by lavaging Coho, steelhead, and cutthroat and enumerating marked and unmarked fry [fry migrants only]	
	Adjusted for missed trapping days	

*Assumption Met? (**Unknown**) Comments: Trapping is conducted from early March to the end of June as specified by PacifiCorp Contract.*

Marks are not lost

X	Minimized by following standard marking/tagging protocols with known mortality	
	Minimized by double tagging experiment	
	Tested by holding fish for 1-3 days to test mark/tag retention and adjusted marks released	
	Tested by double tagging experiment, estimated tag loss, and adjusted marks released	

*Assumption Met? (**Yes**) Comments: Marking follows standard procedures.*

Marking does not affect behavior

X	Minimized by using standard procedures for marking and only releasing healthy marked fish	
	Tested by holding marked fish overnight to assess mark related mortality; adjust mark release numbers accordingly	

*Assumption Met? (**Yes**) Comments: Marking follows standard procedures.*

Capture probabilities are homogeneous by strata

X	Minimized heterogeneous capture probability by stratifying the trap efficiency data	
X	Tested for differences in capture probabilities among trap efficiency trials	
X	Tested for differences in initial capture probability (e.g., due to body size)	

*Assumption Met? (**Yes**) Comments:*

Second Sample is random representative sample (i.e., marked and unmarked fish are completely mixed)

X	Maximize mixing by releasing fish upstream of sinuous reaches above trap site	
	Maximize mixing by releasing fish during the time of migration (e.g., night releases)	
	Tested optimum release site for mixing (consider statistical power to detect differences)	

*Assumption Met? (**Unknown**) Comments: Typical recapture rates preclude statistical testing of release sites.*

Mark status is reported correctly

X	Minimized error through staff training and careful examination of all fish	
X	Minimize error associated with subsampling high catch numbers by obtaining a representative subsample for evaluating mark status	All fish are examined, no subsampling occurs
	Tested by having samplers counting known numbers of marked and unmarked fish mixed in a bin	
	Tested by having a second sampler check first samplers placement of fish into marked and unmarked bins	

*Assumption Met? (**Yes**) Comments:*

2.8 Graphical presentation of catch, trap efficiency, and flow

Age class/brood-year size class brackets were determined by assessing the seasonal length distribution patterns over time. Kalama River age at length data was also reviewed to aid in assessing potential age-length brackets (WDFW 2019); note the Kalama River is the adjacent river basin to the north of the Lewis River. Length frequency is presented in Figures 2.8a (Coho), 2.8b (Chum), 2.8c (Chinook) and 2.8d (Steelhead and Cutthroat). Scatter plots of the fork lengths of all fish caught each day and average daily flow are presented in Figures 2.8e (Coho), 2.8f (Chum), 2.8g (Chinook), 2.8h (Steelhead and trout fry) and 2.8i (Cutthroat). The size class demarcations used to infer age classes for naturally produced salmonids are depicted on each of the length scatter plots of each species.

As discussed previously, because relatively few fish were available to determine specific mark-recapture rates by individual combinations of species and size class, trap efficiency by period (week) was calculated by pooling all Coho, Chinook, Chum, and Steelhead separately for two size classes, <50 mm FL and ≥50 mm FL. As not all weekly periods had recaptured fish to estimate trap efficiency, efficiency estimates across weeks were pooled to increase mark-recapture sample size if the stream flow and/or cone RPMs were similar. These weekly trap efficiency estimates were applied to the total maiden catch to estimate the total number of fish passing the trap for each salmonid species by age class. The pooled weekly mark-recapture data and weekly trap efficiencies applied are summarized in Table 2.8a. The migration timing (estimated total number of fish passing the trap on a weekly basis for each salmonid species by inferred age class) is depicted in Figures 2.8j (salmon species) and 2.8k (trout species). Estimates of total fish passing the trap during the monitoring period for each naturally produced salmonid species are presented in Section 3.

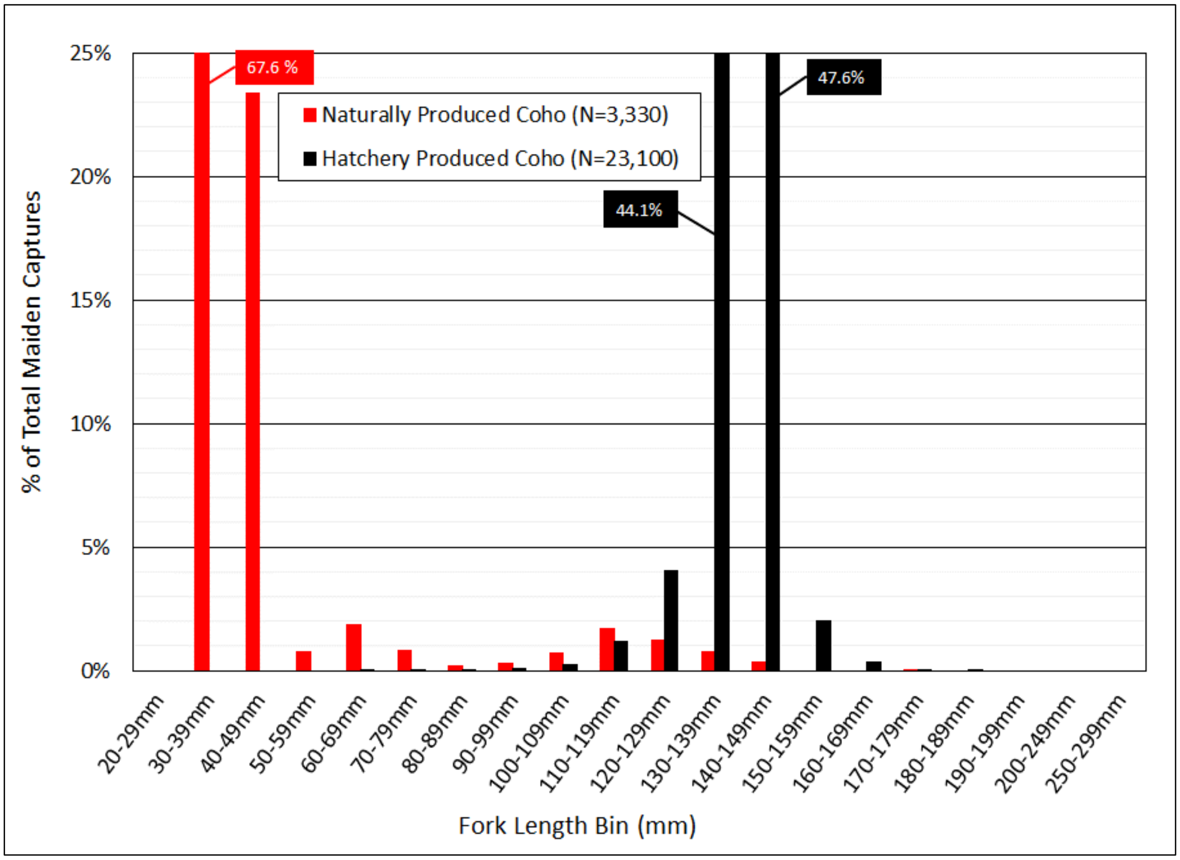


Figure 2.8a - Length frequency of all Coho maiden catch in 2022.

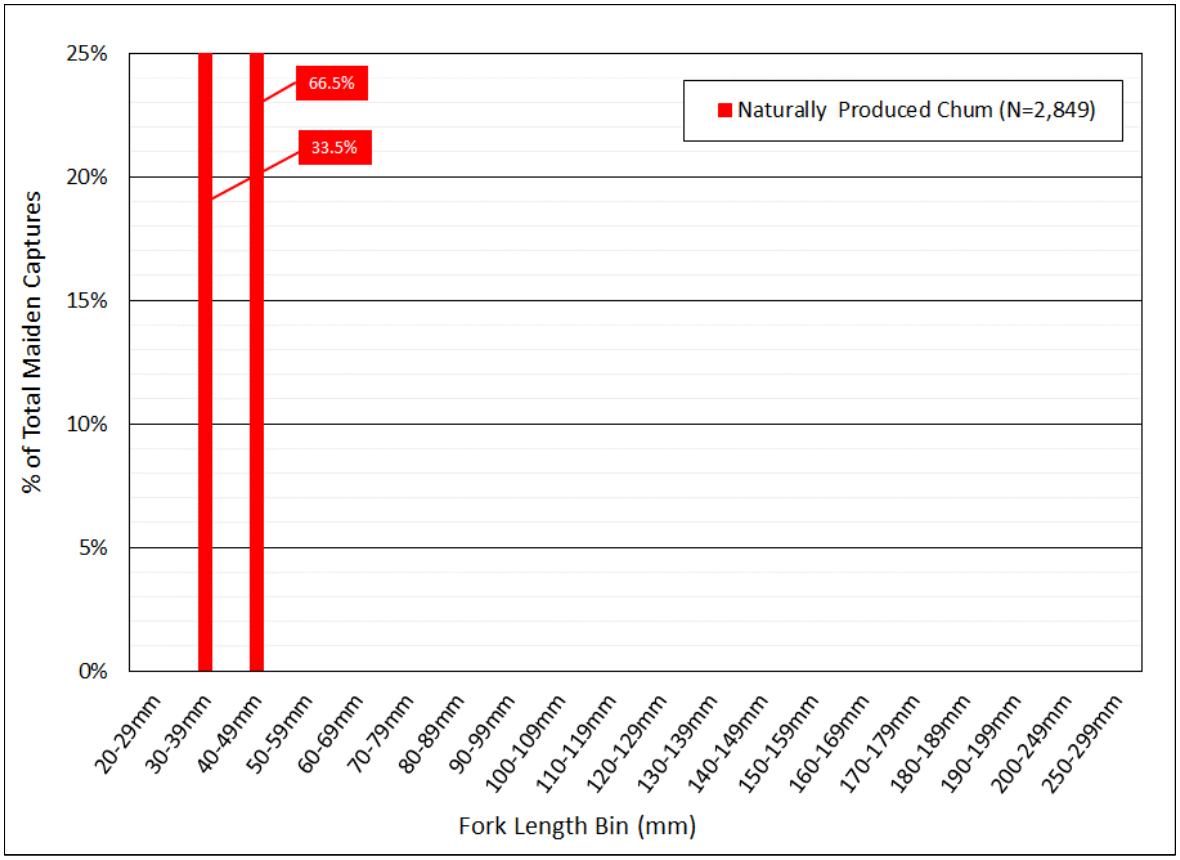


Figure 2.8b - Length frequency of all Chum maiden catch in 2022.

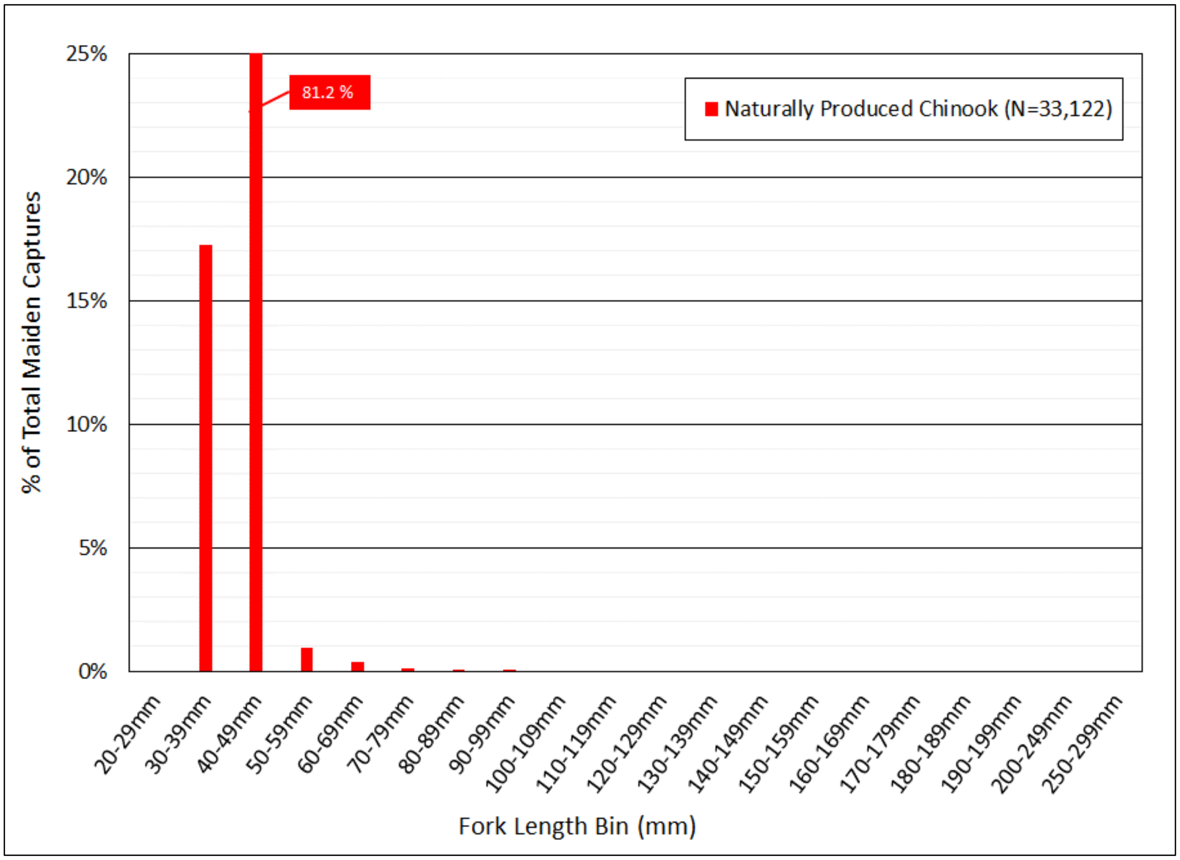
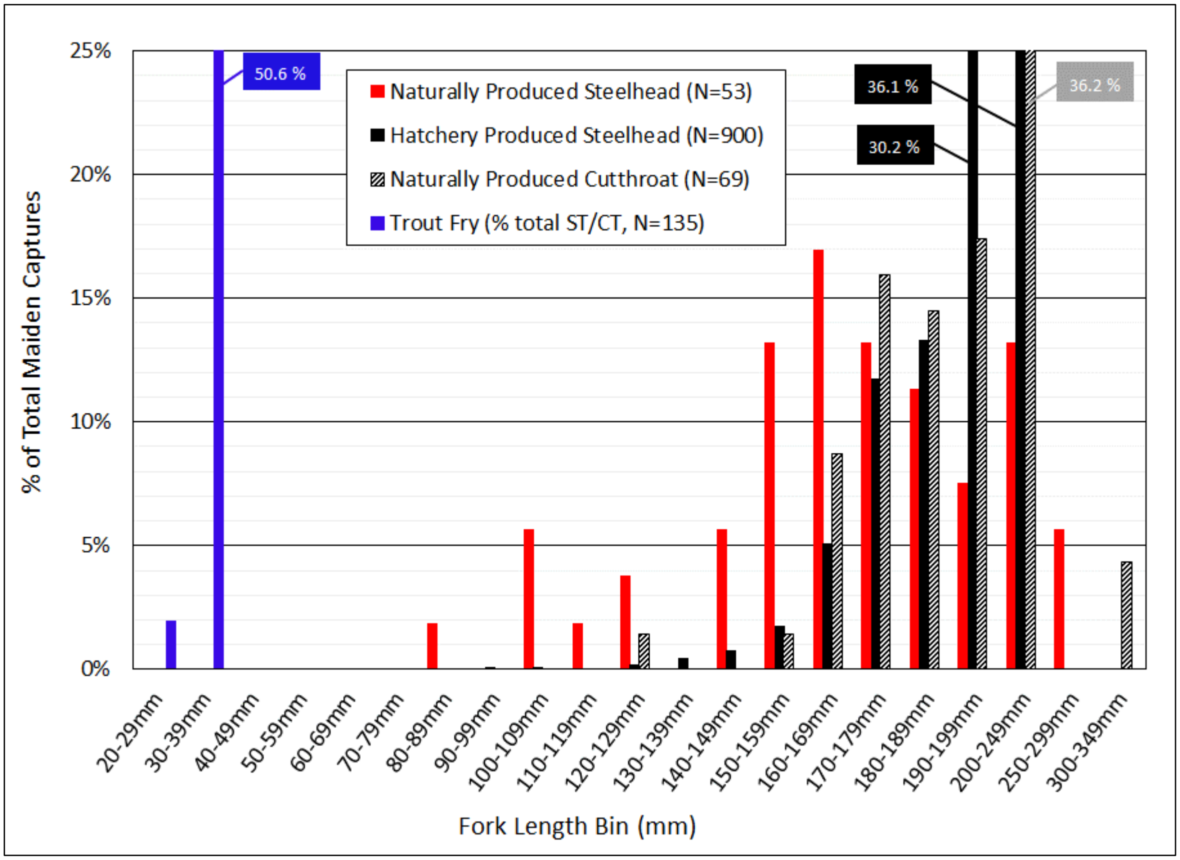
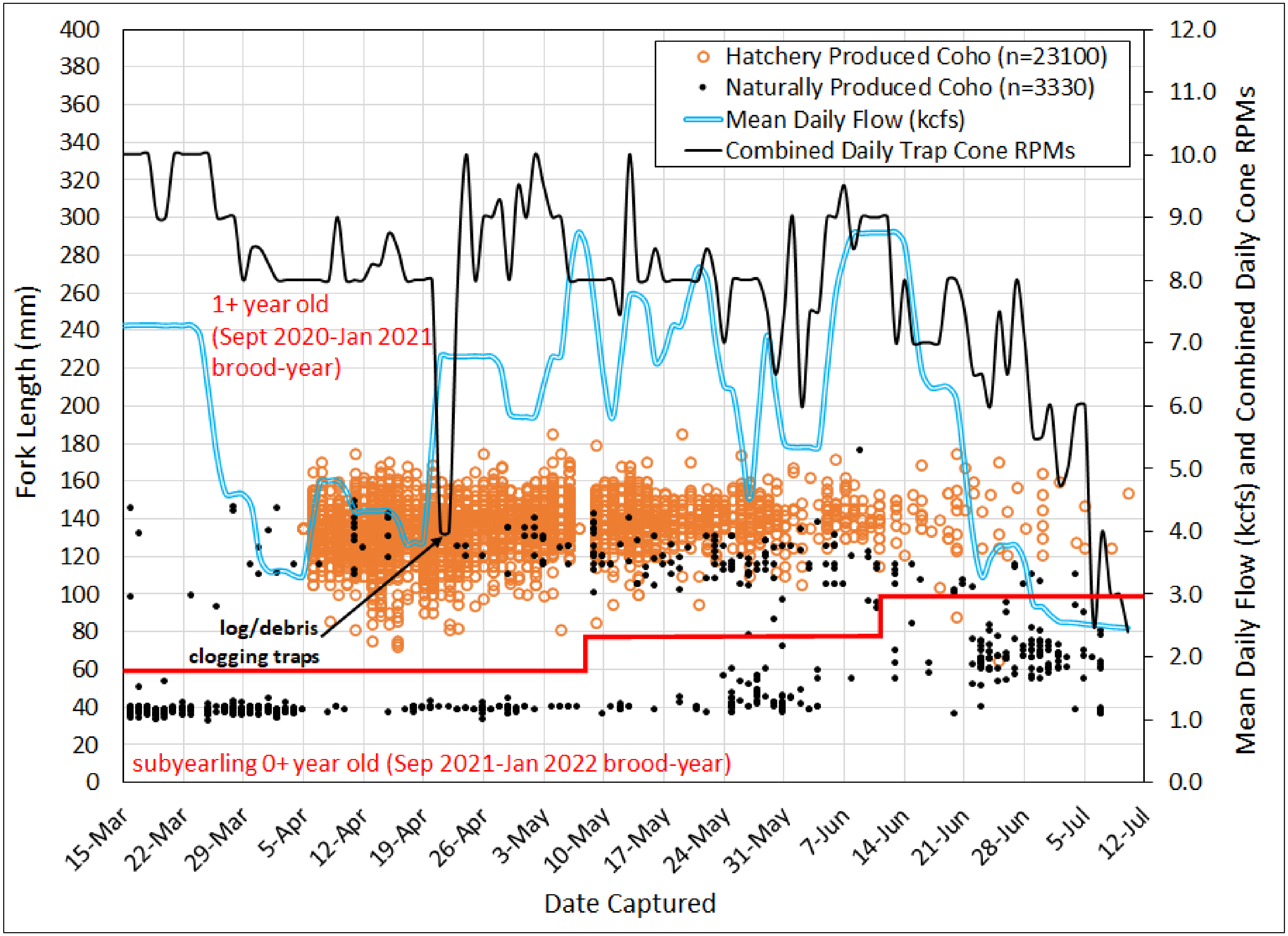


Figure 2.8c - Length frequency of all Chinook maiden catch in 2022.



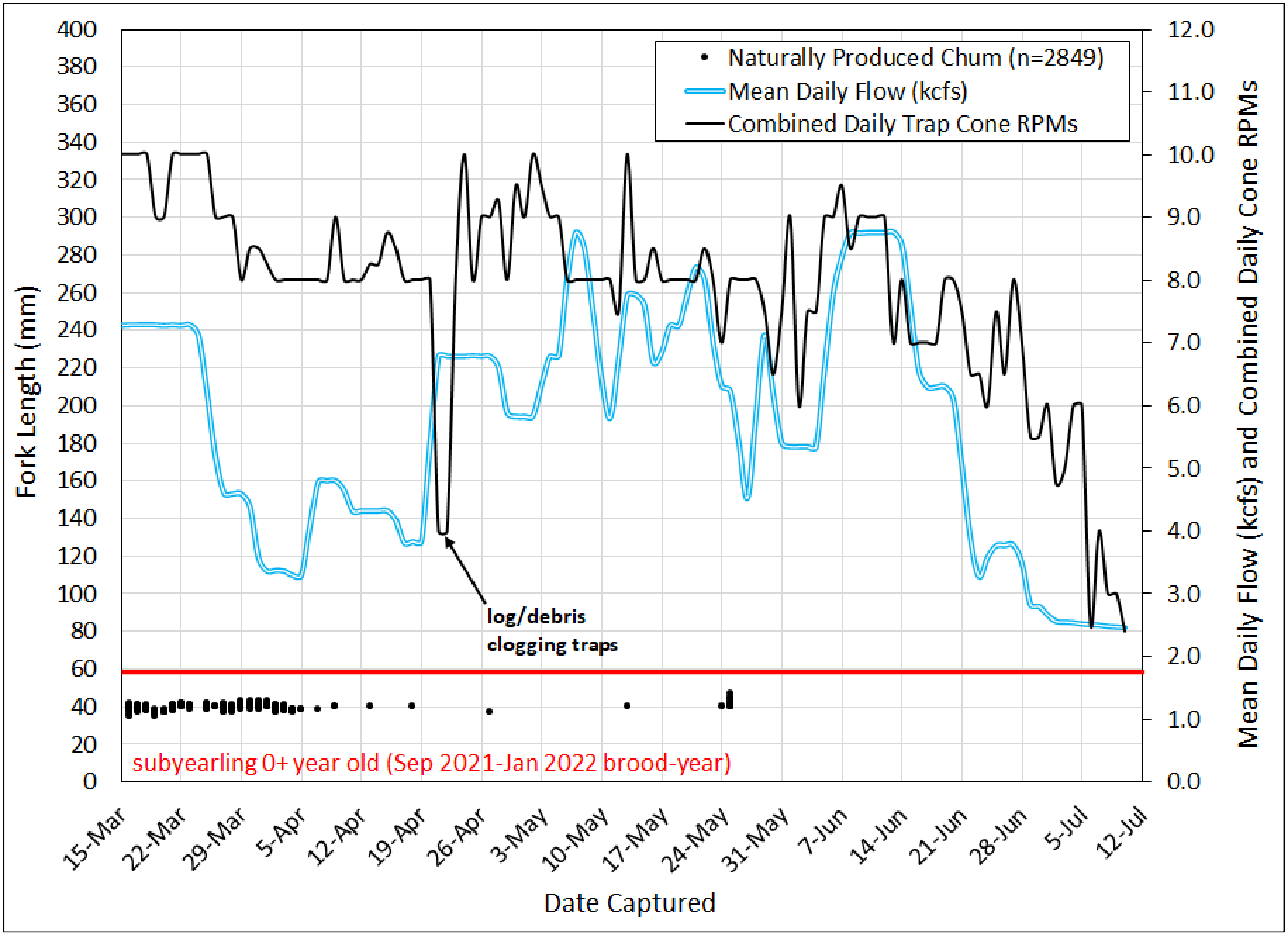
Note: Trout fry represents percentage of the total Steelhead, Cutthroat, and Trout Fry maiden catch combined.

Figure 2.8d - Length frequency of all Steelhead, Cutthroat, and trout fry maiden catch in 2022.



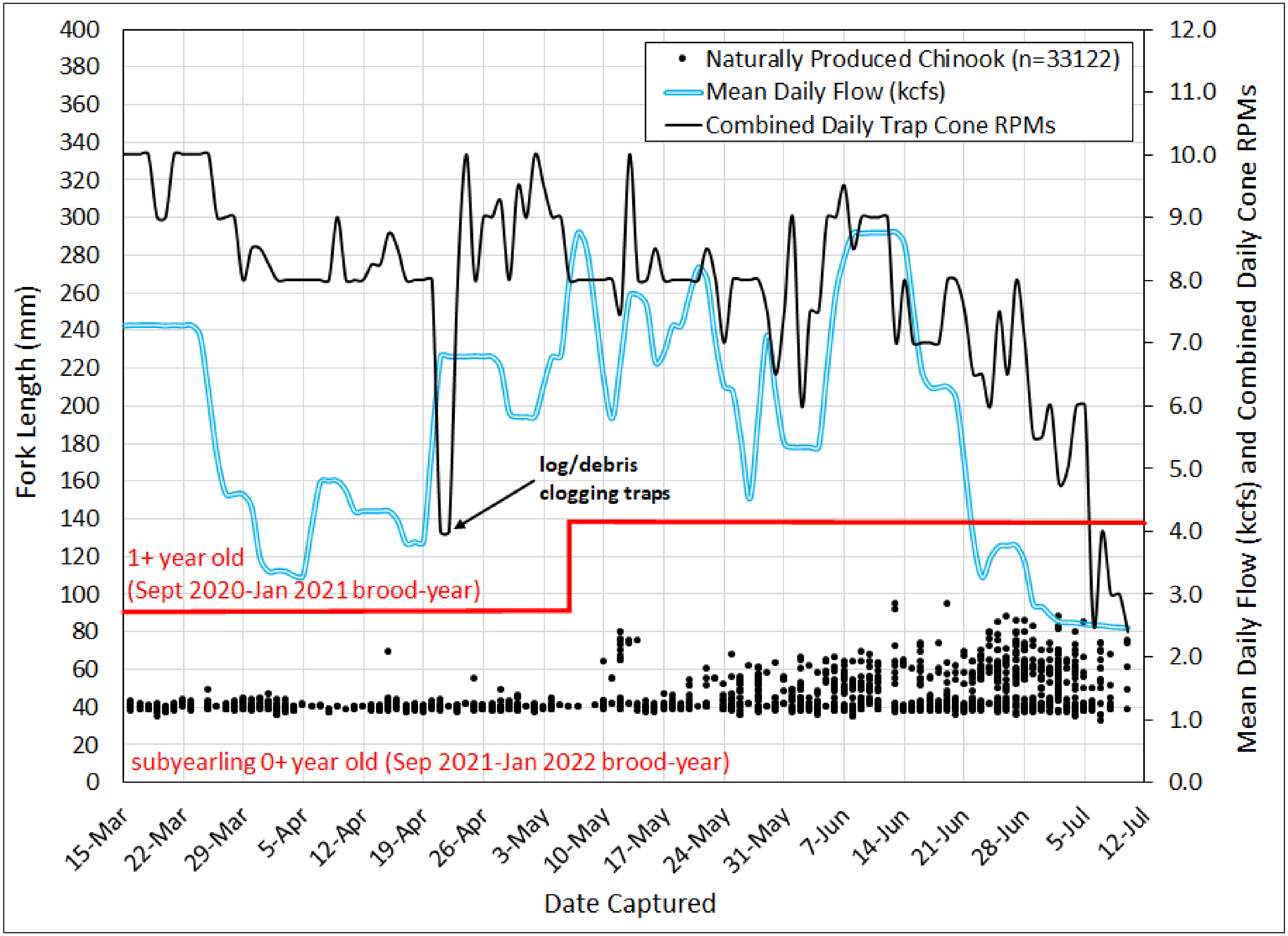
Note: Red line splits naturally produced Coho into two age classes/brood-years (subyearlings/0+ and yearlings/1+). Flow is USGS at Aerial Gage in 1000s cfs (kcfs).

Figure 2.8e - Fork lengths of all Coho maiden catch and flow by day in 2022.



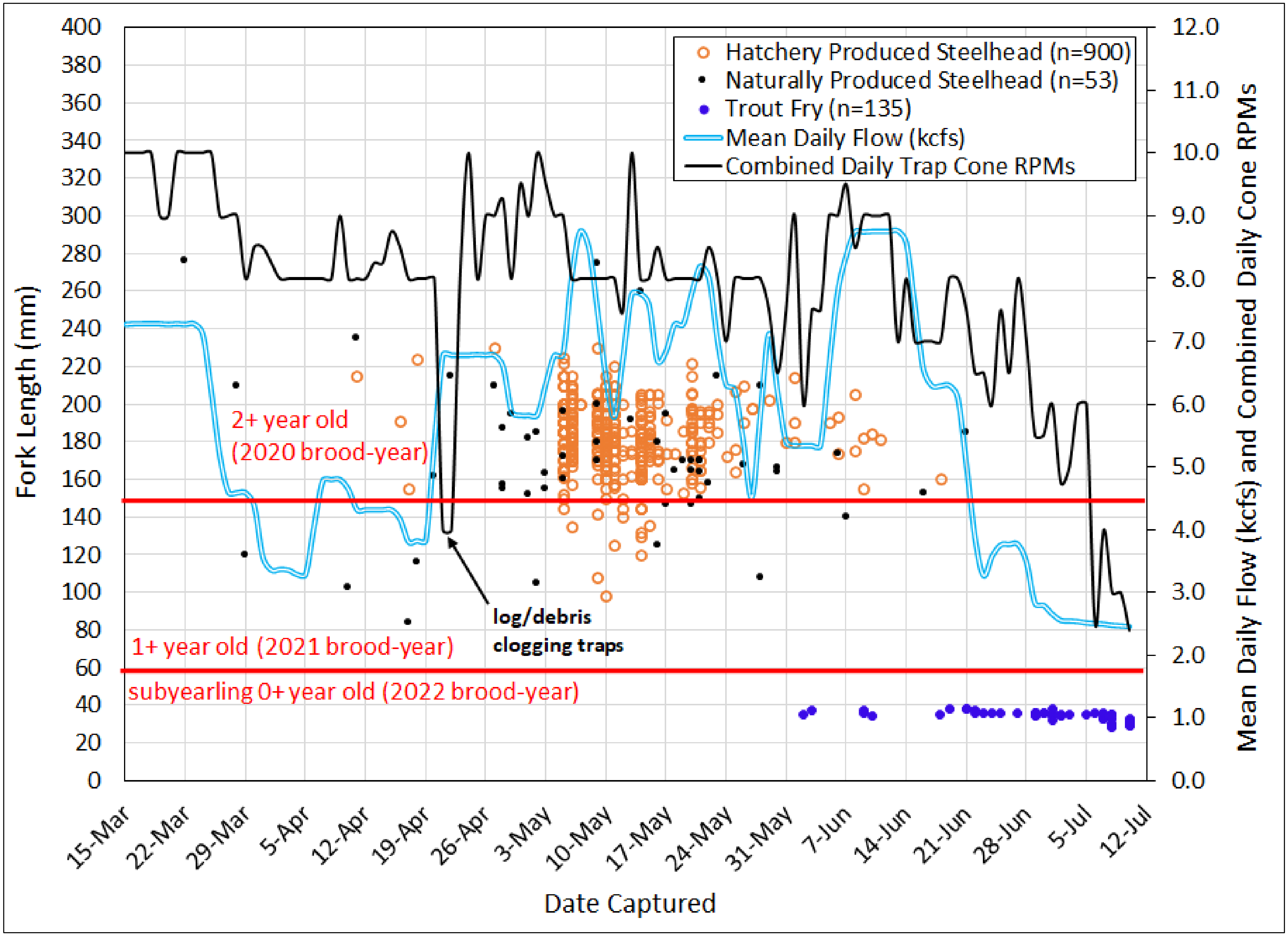
Note: The red line shows naturally produced Chum occupy only one age class/brood-year. Flow is USGS at Aerial Gage in 1000s cfs (kcfs).

Figure 2.8f - Fork lengths of all Chum maiden catch and flow by day in 2022.



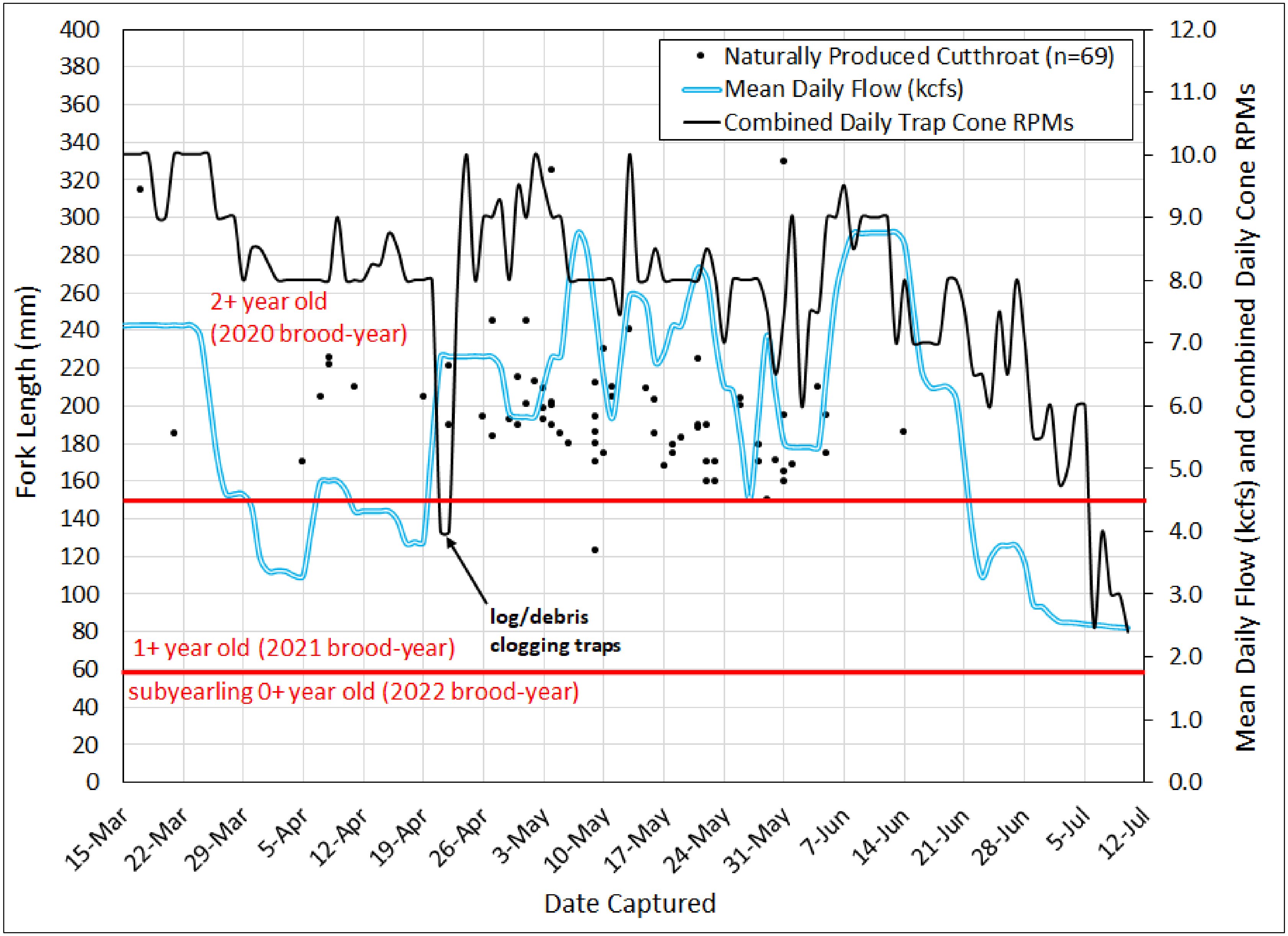
Note: The red line splits naturally produced Chinook into two age classes/brood-years. Flow is USGS at Aerial Gage in 1000s cfs (kcfs).

Figure 2.8g - Fork lengths of all Chinook maiden catch and flow by day in 2022.



Note: The red lines bracket the age classes/brood-years for naturally produced Steelhead and trout fry. Flow is USGS at Aerial Gage in 1000s cfs (kcfs).

Figure 2.8h - Fork lengths of all Steelhead and trout fry maiden catch and flow by day in 2022.



Note: The red lines bracket the age classes/brood-years for naturally produced Cutthroat. Flow is USGS at Aerial Gage in 1000s cfs (kcfs).

Figure 2.8i - Fork lengths of all Cutthroat maiden catch and flow by day in 2022.

Table 2.8a - Weekly pooled mark-recaptured and regression analysis estimates of trap efficiency.

Lewis River Upper Golf Course Screw Traps 2022			All Natural and Hatchery Coho, Chinook, Chum, and Steelhead Combined								Ave. Weekly Cone RPMs Index[b]	Ave. Weekly Flow (cfs)[a]	Adjusted Efficiency	
			Maiden		Mark-Release Up		Recapture		Efficiency					
Period	Start	End	<50mm	≥50mm	<50mm	≥50mm	<50mm	≥50mm	<50mm	≥50mm			<50mm	≥50mm
1	15-Mar	20-Mar	3,674	5	1,679	3	14		0.0083		9.6	7,278	0.0067[d]	0.0079[d]
2	21-Mar	27-Mar	6,617	3	2,391	3	18		0.0075		9.7	6,419	0.0052[e]	0.0072[e]
3	28-Mar	3-Apr	12,777	10	2,920	10	97		0.0332		8.3	3,890	0.0251[f]	0.0178[f]
4	4-Apr	10-Apr	2,961	14,184	522	771		15		0.0195	8.1	4,239	0.0251[f]	0.0195[c]
5	11-Apr	17-Apr	1,118	5,097	0	1,370		25		0.0182	8.3	4,226	0.0251[f]	0.0182[c]
6	18-Apr	24-Apr	1,343	1,234	0	870		10		0.0115	7.1	5,736	0.0032[g]	0.0115[c]
7	25-Apr	1-May	2,021	470	1,400	468	2	3	0.0014	0.0064	8.8	6,353	0.0052[e]	0.0064[c]
8	2-May	8-May	669	1,548	0	603		3		0.0050	8.8	7,284	0.0067[d]	0.0050[c]
9	9-May	15-May	944	907	0	884		10		0.0113	8.2	7,083	0.0067[d]	0.0113[c]
10	16-May	22-May	620	301	0	299		3		0.0100	8.1	7,436	0.0067[d]	0.0100[c]
11	23-May	29-May	1,269	333	211	227	1	2	0.0047	0.0088	7.8	6,066	0.0052[e]	0.0090[i]
12	30-May	5-Jun	1,659	111	946	105	3	1	0.0032	0.0095	7.6	5,650	0.0032[g]	0.0090[i]
13	6-Jun	12-Jun	449	155	89	151					9.0	8,553	0.0067[d]	0.0079[d]
14	13-Jun	19-Jun	663	100	325	97					7.3	7,190	0.0067[d]	0.0079[d]
15	20-Jun	26-Jun	1,015	148	420	148		1		0.0068	6.9	4,201	0.0251[f]	0.0068[c]
16	27-Jun	3-Jul	635	199	250	183	3	7	0.0120	0.0383	6.0	2,951	0.0120[h]	0.0383[c]
17	4-Jul	10-Jul	198	52	0	36					3.8	2,497	0.0120[h]	0.0320[j]
Total:			38,632	24,857	11,153	6,228	138	80	0.0124	0.0128				

[a] Note: USGS Lewis River at Ariel, WA (Gage No. 14220500).

[b] Note: Weekly average left cone RPMs plus weekly average of right cone RPMs.

[c] Note: No adjustment to weekly mark-recapture efficiency estimate.

[d] Note: Combined efficiency measured during weeks with similar stream flow (weeks 1, 1, 8, 9, 10, 13, 14).

[e] Note: Combined efficiency measured during weeks with similar stream flow (weeks 2, 7, 11).

[f] Note: Combined efficiency measured during weeks with similar stream flow (weeks 3, 4, 5, 15).

[g] Note: Combined efficiency measured during weeks with similar stream flow (weeks 6, 12).

[h] Note: Combined efficiency measured during weeks with similar stream flow (weeks 16, 17).

[i] Note: Combined efficiency measured during weeks with similar stream flow and RPMs (weeks 11, 12).

[j] Note: Combined efficiency measured during weeks with similar stream flow and RPMs (weeks 16, 17).

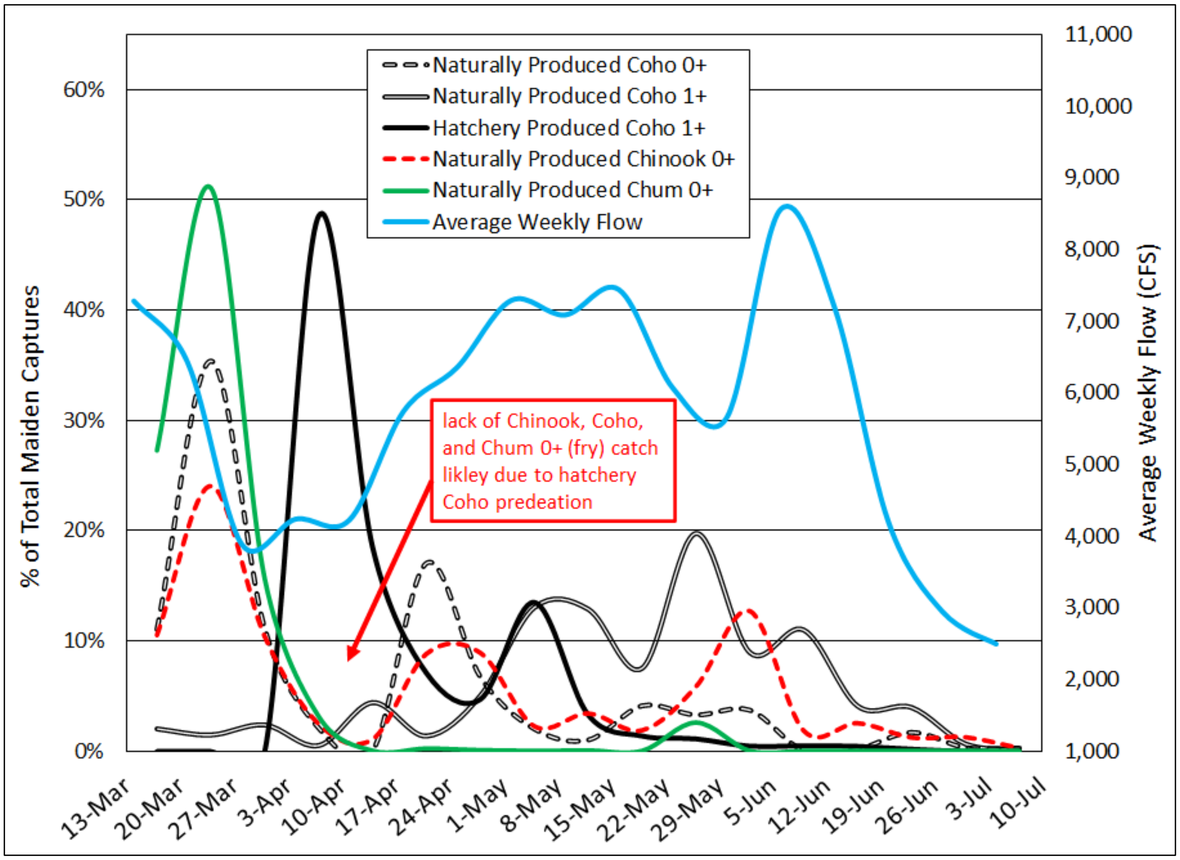


Figure 2.8j - Percent of estimated total salmon species passing the trap by age class in 2022.

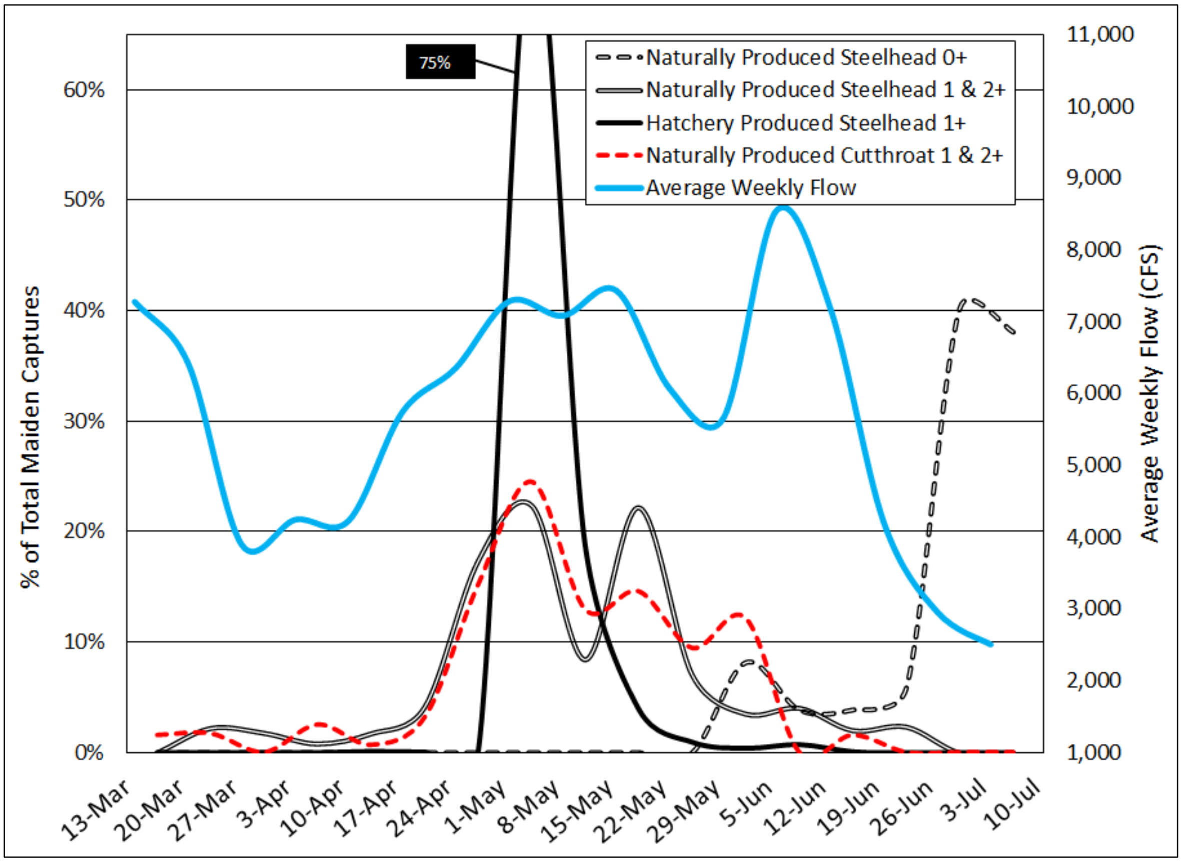


Figure 2.8k - Percent of estimated total trout species passing the trap by age class in 2022.

It is important to note that the timing of naturally produced Chinook, Coho, and Chum fry (0+ age class) captures, as depicted in Figure 2.8j, is likely affected by the timing of hatchery Coho smolt captures, which peaked during the week of April 4. During this week, thousands of hatchery Coho smolts were captured each day within the traps, with very few fry present. Limited examination of gut contents of hatchery Coho smolts in 2021 suggested substantial predation on fry during this week (16 Chinook fry in one stomach sample, see Photo 2.8.a). Stomach contents of hatchery Coho were not examined in 2022. It is unknown if predation was primarily occurring within the river at large or just within the trap boxes.

Photo 2.8a - Example of hatchery Coho smolt predation on Chinook fry (week of April 5, 2021).

****

Part 3: ANALYSIS AND RESULTS

3.1 Description of changes made to raw Capture-Mark-Recapture Data (Tables 2.3a and 2.3b) prior to generating the final Capture-Mark-Recapture Data (Tables under 3.2). Add additional bullets as needed.		
• *Were capture, mark, and/or recapture data from multiple trapping periods combined (i.e., pooled)?*	Yes	All hatchery and naturally produced Coho, Chinook, Chum, and Steelhead were pooled at two size classes (<50 mm and ≥50 mm FL)
• *Were capture, mark, and/or recapture data from an entire period omitted prior to or as part of the analysis?*	No	
• *Were capture, mark, and/or recapture data from a single day or multiple days with a period or periods omitted?*	No	
• *Describe any additional changes that were made to the raw data set prior to generating the final data set*	None	

3.2 Final Data Summary for Mark-Recapture Analysis

Total estimates of naturally produced juvenile Coho, Chinook, Chum, Steelhead, and Cutthroat passing the traps by inferred age class/brood-year (based on size) and the associated 95% confidence intervals (CI) were generated using the Bootstrap Method (Thedinga et al. 1994, Manly 2007, Efron and Tibshirani 1986). The trap efficiency used to make these estimates for each species/age class combination was based on the total pooled mark-recapture data corresponding to the total time when each species' age class was captured as listed in the tables in this section. Individual estimates of the total number of fish <50 mm FL and ≥50 mm FL were made then summed to estimate the total number of fish passing the traps for the age 0+ bracket where fish smaller and larger than 50 mm FL were captured over the trapping season. Relatively few fish ≥50 mm were recaptured; therefore, trap efficiency was calculated by pooling all hatchery and naturally produced Coho, Chinook and Steelhead. Cutthroat were not included in this pooling due to uncertainty of being actual downstream migrants. Similarly, all Coho, Chinook, Chum and trout fry <50 mm in length were pooled to estimate trap efficiency for fry-sized fish.

The data used to generate the Bootstrap estimates for each species inferred age class are summarized in Tables 3.2a through 3.2j below. The data in these tables is presented in the Bayesian Time-Stratified Population Analysis (BTSPAS) model format for informational purposes. Note that all recaptured fish were recaptured within "Period 0", which is defined as the same week as initially marked and released upstream. Note that following the JMX Protocol, fish recaptured with the same mark-type one day after the last day of the release week period were assigned to being recaptured in Period 0. If a fish were to be recaptured more than one day after the last day of a release week, then it would be assigned to Period 1, Period 2, etc. based on actual recapture date compared to when that specific mark-type batch was released. As all recaptured fish were assigned to Period 0, the data in tables 3.2a through 3.2j are in the BTSPAS diagonal format. Note that non-diagonal format would be applied if some recaptured fish were encountered latter in time than Period 0 after initial release.

Table 3.2a - Final capture-mark-recapture data used to estimate total naturally produced Coho (age 0+).

Trap Name: Lewis River Upper Golf Course Traps | **Species:** Coho | **Origin:** Naturally Produced | **Age Class/Brood Year:** 0+ / Sep 2021-Jan 2022

Analysis: Bootstrap (listed below in BTSPAS diagonal format for informational purposes)

			[c]**Life Stage & Size Classes by Period:** Fry <50 mm (Periods 1 to 17)						[c]**Life Stage & Size Classes by Period:** Parr, Transitional, Smolt 50 to 59 mm (Periods 1 to 8) 50 to 79 mm (Periods 9 to 13) 50 to 99 mm (Periods 14 to 17)					
Period	**Period Start Date**	**Period End Date**	**Total Marked**	**Mark Group[a]**	**Period 0 Recaps**	**Total Recaps**	**Total Maiden Capture**	**Prop Fished**	**Total Marked**	**Mark Group[b]**	**Period 0 Recaps**	**Total Recaps**	**Total Maiden Captured**	**Prop Fished**
1	15-Mar	20-Mar	1,679	M, S	14	14	293	1	3	M, S			2	1
2	21-Mar	27-Mar	2,391	M, S	18	18	742	1	3	M, S				1
3	28-Mar	3-Apr	2,920	M, S	97	97	1,113	1	10	M, S				1
4	4-Apr	10-Apr	522	M, S			210	1	771	M, S	15	15		1
5	11-Apr	17-Apr		M, S			2	1	1,370	M, S	25	25		1
6	18-Apr	24-Apr		M, S			216	0.71[d]	870	M, S	10	10		0.71[d]
7	25-Apr	1-May	1,400	M, S	2	2	141	1	468	M, S	3	3		1
8	2-May	8-May		M, S			54	1	603	M, S	3	3		1
9	9-May	15-May		M, S			27	1	884	M, S	10	10		1
10	16-May	22-May		M, S			110	1	299	M, S	3	3		1
11	23-May	29-May	211	M, S	1	1	63	1	227	M, S	2	2	10	1
12	30-May	5-Jun	946	M, S	3	3	46	1	105	M, S	1	1	3	1
13	6-Jun	12-Jun	89	M, S				1	151	M, S			1	1
14	13-Jun	19-Jun	325	M, S				1	97	M, S			6	1
15	20-Jun	26-Jun	420	M, S			3	1	148	M, S	1	1	45	1
16	27-Jun	3-Jul	250	M, S	3	3		1	183	M, S	7	7	49	1
17	4-Jul	10-Jul		M, S			9	0.87[d]	36	M, S			12	0.87[d]
		Total:	11,153		138	138	3,029		6,228		80	80	128	

[a]Note: Mark Group for all periods = all marked Coho, Chinook, Chum and trout fry <50 mm FL combined.

[b]Note: Mark Group for all periods = all marked Coho, Chinook and Steelhead ≥50 mm FL combined.

[c]Note: Same as inferred age backets based on size class as depicted in Figure 2.8e for Coho.

[d]Note: Based on outages listed in Table 2.2.

Table 3.2b - Final capture-mark-recapture data used to estimate total naturally produced Coho (age 1+).

<table>
<tr><td colspan="4">Trap Name: Lewis River Upper Golf Course Traps</td><td colspan="2">Species: Coho</td><td colspan="3">Origin: Naturally Produced</td></tr>
<tr><td colspan="9">Age Class / Brood Year: 1+ / Sep 2020-Jan 2021</td></tr>
<tr><td colspan="9">Analysis: Bootstrap (listed below in BTSPAS diagonal format for informational purposes)</td></tr>
<tr><td></td><td></td><td></td><td colspan="6">[b]Life Stage & Size Classes by Period: Parr, Transitional, Smolt
60 to 179 mm (Periods 1 to 8)
80 to 179 mm (Periods 9 to 13)
100 to 179 mm (Periods 14 to 17)</td></tr>
<tr><th>Period</th><th>Period Start Date</th><th>Period End Date</th><th>Total Marked</th><th>Mark Group[a]</th><th>Period 0 Recaps</th><th>Total Recaps</th><th>Total Maiden Captured</th><th>Prop Fished</th></tr>
<tr><td>1</td><td>15-Mar</td><td>20-Mar</td><td>3</td><td>M, S</td><td></td><td></td><td>3</td><td>1</td></tr>
<tr><td>2</td><td>21-Mar</td><td>27-Mar</td><td>3</td><td>M, S</td><td></td><td></td><td>2</td><td>1</td></tr>
<tr><td>3</td><td>28-Mar</td><td>3-Apr</td><td>10</td><td>M, S</td><td></td><td></td><td>8</td><td>1</td></tr>
<tr><td>4</td><td>4-Apr</td><td>10-Apr</td><td>771</td><td>M, S</td><td>15</td><td>15</td><td>2</td><td>1</td></tr>
<tr><td>5</td><td>11-Apr</td><td>17-Apr</td><td>1,370</td><td>M, S</td><td>25</td><td>25</td><td>15</td><td>1</td></tr>
<tr><td>6</td><td>18-Apr</td><td>24-Apr</td><td>870</td><td>M, S</td><td>10</td><td>10</td><td>3</td><td>0.71[c]</td></tr>
<tr><td>7</td><td>25-Apr</td><td>1-May</td><td>468</td><td>M, S</td><td>3</td><td>3</td><td>6</td><td>1</td></tr>
<tr><td>8</td><td>2-May</td><td>8-May</td><td>603</td><td>M, S</td><td>3</td><td>3</td><td>12</td><td>1</td></tr>
<tr><td>9</td><td>9-May</td><td>15-May</td><td>884</td><td>M, S</td><td>10</td><td>10</td><td>27</td><td>1</td></tr>
<tr><td>10</td><td>16-May</td><td>22-May</td><td>299</td><td>M, S</td><td>3</td><td>3</td><td>14</td><td>1</td></tr>
<tr><td>11</td><td>23-May</td><td>29-May</td><td>227</td><td>M, S</td><td>2</td><td>2</td><td>33</td><td>1</td></tr>
<tr><td>12</td><td>30-May</td><td>5-Jun</td><td>105</td><td>M, S</td><td>1</td><td>1</td><td>15</td><td>1</td></tr>
<tr><td>13</td><td>6-Jun</td><td>12-Jun</td><td>151</td><td>M, S</td><td></td><td></td><td>16</td><td>1</td></tr>
<tr><td>14</td><td>13-Jun</td><td>19-Jun</td><td>97</td><td>M, S</td><td></td><td></td><td>6</td><td>1</td></tr>
<tr><td>15</td><td>20-Jun</td><td>26-Jun</td><td>148</td><td>M, S</td><td>1</td><td>1</td><td>5</td><td>1</td></tr>
<tr><td>16</td><td>27-Jun</td><td>3-Jul</td><td>183</td><td>M, S</td><td>7</td><td>7</td><td>5</td><td>1</td></tr>
<tr><td>17</td><td>4-Jul</td><td>10-Jul</td><td>36</td><td>M, S</td><td></td><td></td><td>1</td><td>0.87[c]</td></tr>
<tr><td colspan="3">Total:</td><td>6,228</td><td></td><td>80</td><td>80</td><td>173</td><td></td></tr>
</table>

[a] Note: Mark Group for all periods = all marked Coho, Chinook and Steelhead ≥50 mm FL combined.

[b] Note: Same as inferred age backets based on size class as depicted in Figure 2.8e for Coho.

[c] Note: Based on outages listed in Table 2.2.

Table 3.2C - Final capture-mark-recapture data used to estimate total naturally produced Chum (age 0+).

Trap Name: Lewis River Upper Golf Course Traps				**Species:** Chum		**Origin:** Naturally Produced		
Age Class / Brood Year: 0+ / Sep 2021-Jan 2022								
Analysis: Bootstrap (listed below in BTSPAS diagonal format for informational purposes)								
			[b]**Life Stage & Size Classes by Period:** Fry <50 mm (Periods 1 to 17)					
Period	**Period Start Date**	**Period End Date**	**Total Marked**	**Mark Group**[a]	**Period 0 Recaps**	**Total Recaps**	**Total Maiden Captured**	**Prop Fished**
1	15-Mar	20-Mar	1,679	M, S	14	14	555	1
2	21-Mar	27-Mar	2,391	M, S	18	18	816	1
3	28-Mar	3-Apr	2,920	M, S	97	97	1,193	1
4	4-Apr	10-Apr	522	M, S			239	1
5	11-Apr	17-Apr		M, S			1	1
6	18-Apr	24-Apr		M, S			2	0.71[c]
7	25-Apr	1-May	1,400	M, S	2	2	1	1
8	2-May	8-May		M, S				1
9	9-May	15-May		M, S			1	1
10	16-May	22-May		M, S				1
11	23-May	29-May	211	M, S	1	1	41	1
12	30-May	5-Jun						
13	6-Jun	12-Jun						
14	13-Jun	19-Jun						
15	20-Jun	26-Jun						
16	27-Jun	3-Jul						
17	4-Jul	10-Jul						
		Total:	9,123		132	132	2,849	

[a] Note: Mark Group for all periods = all marked Coho, Chinook, Chum and trout fry <50 mm FL combined.

[b] Note: Same as inferred age backets based on size class as depicted in Figure 2.8f for Chum.

[c] Note: Based on outages listed in Table 2.2.

Table 3.2d - Final capture-mark-recapture data used to estimate total naturally produced Chinook (age 0+).

Trap Name: Lewis River Upper Golf Course Traps						**Species:** Chinook		**Origin:** Naturally Produced			**Age Class/Brood Year:** 0+ / Sep 2021-Jan 2022			
Analysis: Bootstrap (listed below in BTSPAS diagonal format for informational purposes)														
			[c]**Life Stage & Size Classes by Period:** Fry <50 mm (Periods 1 to 17)						[c]**Life Stage & Size Classes by Period:** Parr, Transitional, Smolt 50 to 89 mm (Periods 1 to 8) 50 to 139 mm (Periods 9 to 17)					
Period	**Period Start Date**	**Period End Date**	**Total Marked**	**Mark Group[a]**	**Period 0 Recaps**	**Total Recaps**	**Total Maiden Capture**	**Prop Fished**	**Total Marked**	**Mark Group[b]**	**Period 0 Recaps**	**Total Recaps**	**Total Maiden Captured**	**Prop Fished**
1	15-Mar	20-Mar	1,679	M, S	14	14	2,826	1						
2	21-Mar	27-Mar	2,391	M, S	18	18	5,059	1						
3	28-Mar	3-Apr	2,920	M, S	97	97	10,471	1						
4	4-Apr	10-Apr	522	M, S			2,512	1						
5	11-Apr	17-Apr		M, S			1,115	1	1,370	M, S	25	25	1	1
6	18-Apr	24-Apr		M, S			1,125	0.71[d]	870	M, S	10	10	0	0.71[d]
7	25-Apr	1-May	1,400	M, S	2	2	1,879	1	468	M, S	3	3	1	1
8	2-May	8-May		M, S			615	1	603	M, S	3	3	0	1
9	9-May	15-May		M, S			916	1	884	M, S	10	10	14	1
10	16-May	22-May		M, S			510	1	299	M, S	3	3	6	1
11	23-May	29-May	211	M, S	1	1	1,165	1	227	M, S	2	2	119	1
12	30-May	5-Jun	946	M, S	3	3	1,610	1	105	M, S	1	1	20	1
13	6-Jun	12-Jun	89	M, S			446	1	151	M, S			66	1
14	13-Jun	19-Jun	325	M, S			660	1	97	M, S			31	1
15	20-Jun	26-Jun	420	M, S			995	1	148	M, S	1	1	75	1
16	27-Jun	3-Jul	250	M, S	3	3	579	1	183	M, S	7	7	136	1
17	4-Jul	10-Jul		M, S			136	0.87[d]	36	M, S			34	0.87[d]
		Total:	11,153		138	138	32,619		5,441		65	65	503	

[a]Note: Mark Group for all periods = all marked Coho, Chinook, Chum and Steelhead <50 mm FL combined.

[b]Note: Mark Group for all periods = all marked Coho, Chinook and Steelhead ≥50 mm FL combined.

[c]Note: Same as inferred age backets based on size class as depicted in Figure 2.8g for Chinook.

[d]Note: Based on outages listed in Table 2.2.

Table 3.2e - Final capture-mark-recapture data used to estimate total naturally produced trout fry (age 0+).

Trap Name: Lewis River Upper Golf Course Traps			**Species:** trout fry		**Origin:** Naturally Produced			
Age Class / Brood Year: 0+ / 2022								
Analysis: Bootstrap (listed below in BTSPAS diagonal format for informational purposes)								
			[b]**Life Stage & Size Classes by Period:** Fry <50 mm (Periods 1 to 17)					
Period	**Period Start Date**	**Period End Date**	**Total Marked**	**Mark Group**[a]	**Period 0 Recaps**	**Total Recaps**	**Total Maiden Captured**	**Prop Fished**
1	15-Mar	20-Mar						
2	21-Mar	27-Mar						
3	28-Mar	3-Apr						
4	4-Apr	10-Apr						
5	11-Apr	17-Apr						
6	18-Apr	24-Apr						
7	25-Apr	1-May						
8	2-May	8-May						
9	9-May	15-May						
10	16-May	22-May						
11	23-May	29-May						
12	30-May	5-Jun	946	M, S	3	3	3	1
13	6-Jun	12-Jun	89	M, S			3	1
14	13-Jun	19-Jun	325	M, S			3	1
15	20-Jun	26-Jun	420	M, S			17	1
16	27-Jun	3-Jul	250	M, S	3	3	56	1
17	4-Jul	10-Jul		M, S			53	0.87[c]
		Total:	2,030		6	6	135	

[a]Note: Mark Group for all periods = all marked Coho, Chinook, Chum and trout fry <50 mm FL combined.

[b]Note: Same as inferred age backets based on size class as depicted in Figure 2.8h for Steelhead / trout fry.

[c]Note: Based on outages listed in Table 2.2.

Table 3.2f - Final capture-mark-recapture data used to estimate total naturally produced Steelhead (age 1+).

Trap Name: Lewis River Upper Golf Course Traps | **Species:** Steelhead | **Origin:** Naturally Produced

Age Class / Brood Year: 1+ / 2021

Analysis: Bootstrap (listed below in BTSPAS diagonal format for informational purposes)

			[b]**Life Stage & Size Classes by Period:** Parr, Transitional, Smolt 60 to 149 mm (Periods 1 to 17)					
Period	**Period Start Date**	**Period End Date**	**Total Marked**	**Mark Group**[a]	**Period 0 Recaps**	**Total Recaps**	**Total Maiden Captured**	**Prop Fished**
1	15-Mar	20-Mar						
2	21-Mar	27-Mar						
3	28-Mar	3-Apr	10	M, S			1	1
4	4-Apr	10-Apr	771	M, S	15	15	1	1
5	11-Apr	17-Apr	1,370	M, S	25	25	1	1
6	18-Apr	24-Apr	870	M, S	10	10	1	0.71[c]
7	25-Apr	1-May	468	M, S	3	3		1
8	2-May	8-May	603	M, S	3	3	1	1
9	9-May	15-May	884	M, S	10	10		1
10	16-May	22-May	299	M, S	3	3	3	1
11	23-May	29-May	227	M, S	2	2	1	1
12	30-May	5-Jun	105	M, S	1	1		1
13	6-Jun	12-Jun	151	M, S			1	1
14	13-Jun	19-Jun						
15	20-Jun	26-Jun						
16	27-Jun	3-Jul						
17	4-Jul	10-Jul						
		Total:	5,758		72	72	10	

[a]Note: Mark Group for all periods = all marked Coho, Chinook and Steelhead ≥50 mm FL combined.

[b]Note: Same as inferred age backets based on size class as depicted in Figure 2.8h for Steelhead.

[c]Note: Based on outages listed in Table 2.2.

Table 3.2g - Final capture-mark-recapture data used to estimate total naturally produced Steelhead (age 2+).

Trap Name: Lewis River Upper Golf Course Traps | **Species:** Steelhead | **Origin:** Naturally Produced

Age Class / Brood Year: 2+ / 2020

Analysis: Bootstrap (listed below in BTSPAS diagonal format for informational purposes)

			[b]**Life Stage & Size Classes by Period:** Transitional, Smolt ≥150 mm (Periods 1 to 17)					
Period	**Period Start Date**	**Period End Date**	**Total Marked**	**Mark Group**[a]	**Period 0 Recaps**	**Total Recaps**	**Total Maiden Captured**	**Prop Fished**
1	15-Mar	20-Mar						
2	21-Mar	27-Mar	3	M, S			1	1
3	28-Mar	3-Apr	10	M, S			1	1
4	4-Apr	10-Apr	771	M, S	15	15		1
5	11-Apr	17-Apr	1,370	M, S	25	25	1	1
6	18-Apr	24-Apr	870	M, S	10	10	2	0.71[c]
7	25-Apr	1-May	468	M, S	3	3	7	1
8	2-May	8-May	603	M, S	3	3	6	1
9	9-May	15-May	884	M, S	10	10	6	1
10	16-May	22-May	299	M, S	3	3	11	1
11	23-May	29-May	227	M, S	2	2	3	1
12	30-May	5-Jun	105	M, S	1	1	2	1
13	6-Jun	12-Jun	151	M, S			1	1
14	13-Jun	19-Jun	97	M, S			1	1
15	20-Jun	26-Jun	148	M, S	1	1	1	1
16	27-Jun	3-Jul						
17	4-Jul	10-Jul						
		Total:	6,006		73	73	43	

[a]Note: Mark Group for all periods = all marked Coho, Chinook and Steelhead ≥50 mm FL combined.

[b]Note: Same as inferred age backets based on size class as depicted in Figure 2.8h for Steelhead.

[c]Note: Based on outages listed in Table 2.2.

Table 3.2i - Final capture-mark-recapture data used to estimate total naturally produced Cutthroat (age 1+).

Trap Name: Lewis River Upper Golf Course Traps | **Species:** Cutthroat | **Origin:** Naturally Produced

Age Class / Brood Year: 1+ / 2021

Analysis: Bootstrap (listed below in BTSPAS diagonal format for informational purposes)

			[b]**Life Stage & Size Classes by Period:** Parr, Transitional, Smolt 60 to 149 mm (Periods 1 to 17)					
Period	**Period Start Date**	**Period End Date**	**Total Marked**	**Mark Group[a]**	**Period 0 Recaps**	**Total Recaps**	**Total Maiden Captured**	**Prop Fished**
1	15-Mar	20-Mar						
2	21-Mar	27-Mar						
3	28-Mar	3-Apr						
4	4-Apr	10-Apr						
5	11-Apr	17-Apr						
6	18-Apr	24-Apr						
7	25-Apr	1-May						
8	2-May	8-May						
9	9-May	15-May	884	M, S	10	10	1	1
10	16-May	22-May						
11	23-May	29-May						
12	30-May	5-Jun						
13	6-Jun	12-Jun						
14	13-Jun	19-Jun						
15	20-Jun	26-Jun						
16	27-Jun	3-Jul						
17	4-Jul	10-Jul						
		Total:					1	

[a] Note: Mark Group for all periods = all marked Coho, Chinook and Steelhead ≥50 mm FL combined.

[b] Note: Same as inferred age backets based on size class as depicted in Figure 2.8i for Cutthroat.

[c] Note: Based on outages listed in Table 2.2.

Table 3.2j - Final capture-mark-recapture data used to estimate total naturally produced Cutthroat (age 2+).

Trap Name: Lewis River Upper Golf Course Traps			**Species:** Cutthroat		**Origin:** Naturally Produced			
Age Class / Brood Year: 2+ / 2020								
Analysis: Bootstrap (listed below in BTSPAS diagonal format for informational purposes)								
			[b]**Life Stage & Size Classes by Period:** Transitional, Smolt ≥150 mm (Periods 1 to 17)					
Period	**Period Start Date**	**Period End Date**	**Total Marked**	**Mark Group**[a]	**Period 0 Recaps**	**Total Recaps**	**Total Maiden Captured**	**Prop Fished**
1	15-Mar	20-Mar	3	M, S			1	1
2	21-Mar	27-Mar	3	M, S			1	1
3	28-Mar	3-Apr	10	M, S				1
4	4-Apr	10-Apr	771	M, S	15	15	4	1
5	11-Apr	17-Apr	1,370	M, S	25	25	1	1
6	18-Apr	24-Apr	870	M, S	10	10	3	0.71[c]
7	25-Apr	1-May	468	M, S	3	3	8	1
8	2-May	8-May	603	M, S	3	3	10	1
9	9-May	15-May	884	M, S	10	10	11	1
10	16-May	22-May	299	M, S	3	3	12	1
11	23-May	29-May	227	M, S	2	2	7	1
12	30-May	5-Jun	105	M, S	1	1	9	1
13	6-Jun	12-Jun	151	M, S				1
14	13-Jun	19-Jun	97	M, S			1	1
15	20-Jun	26-Jun						
16	27-Jun	3-Jul						
17	4-Jul	10-Jul						
		Total:	5,861		72	72	68	

[a]Note: Mark Group for all periods = all marked Coho, Chinook and Steelhead ≥50 mm FL combined.

[b]Note: Same as inferred age backets based on size class as depicted in Figure 2.8i for Cutthroat.

[c]Note: Based on outages listed in Table 2.2.

3.3 Equations or Software Used to Complete Analysis

A nonparametric Bootstrap Method (Thedinga et al. 1994, Manly 2007, Efron and Tibshirani 1986) was used to calculate the mean population estimate, variance, and 95% confidence interval for naturally produced salmonids by inferred age class passing the Lewis River Upper Golf Course Traps during the 2022 monitoring period. The Bootstrap was run with 1,000 iterations. The 95% confidence interval was calculated as the square root of the mean Bootstrap variance multiplied by 1.96. The coefficient of variation was calculated by dividing the standard deviation by the mean population estimate.

3.4 Final Outmigrant Abundance Estimates

The final data tables listed in section 3.3 were used to generate total estimates of naturally produced salmonids passing the trap during the monitoring period for each species/inferred age class using the Bootstrap Method (Table 3.1).

Table 3.1 - Bootstrap estimates of total naturally produced juvenile salmonids passing the Lewis River Upper Golf Course Traps for the period of March 15 to July 10, 2022.

Species	Brood- Year / Cohort	2022 Sample Weeks[a]	Age Class	Mean Bootstrap Abundance Estimate	Bootstrap Estimated Variance	95% CI	CV
Coho	Sep 2021-Jan 2022	1 to 17	<50mm / 0+	245,804	395,049,500	±38,957	8.1%
		11 to 17	≥50mm / 0+	12,086	18,403,830	±8,408	35.5%
		1 to 17	**Total 0+**	**257,890**	**413,453,330**	**±39,854**	**7.9%**
	Sep 2020-Jan 2021	1 to 16	**Total 1+**	**13,551**	**2,842,657**	**±3,305**	**12.4%**
Chinook	Sep 2021-Jan 2022	1 to 17	<50mm / 0+	2,651,986	46,413,970,000	±422,260	8.1%
		5 to 17	≥50mm / 0+	42,586	27,638,200	±10,304	12.3%
		1 to 17	**Total 0+**	**2,694,572**	**46,441,608,200**	**±422,386**	**8.0%**
Chum Fry[c]	Sep 2020-Jan 2021	1 to 11	Total 0+	198,109	263,222,300	±31,799	8.2%
Trout Fry[c]	2022	12 to 18	Total 0+	55,573	1,225,835,000	±68,623	63.0%
Steelhead	2021	2 to 15	**Total 1+**	**811**	**68,543**	**±513**	**32.3%**
	2020	2 to 15	**Total 2+**	**3,587**	**453,325**	**±1,320**	**18.8%**
Cutthroat	2021	9 only	**Total 1+**	**95[b]**	**13,210[b]**	**±225**	**121.0%**
	2020	2 to 14	**Total 2+**	**5,639**	**883,730**	**±1,843**	**16.7%**

[a] Note: Sample weeks (periods) bracketing the time when the specific species/origin/age/size class were captured in the screw traps.

[b] Note: Estimate based on only 1 Cutthroat captured in the screw traps estimated to be within the 1+ age class during week 9.

[c] Note: All Chum and trout fry were <50 mm FL.

3.5 Graphical Presentation of Results

Period (weekly) specific outmigrant abundance with confidence intervals was not estimated due to the limited number of periods with recaptures for each species/age class combination. Therefore, time series abundance estimates with confidence intervals are not provided. However, the migration timing depicted in Figures 2.8j (salmon species) and 2.8k (trout species) approximate total estimates of abundance by week.

3.6 Project Assessment

The relatively low number of recaptures limits the potential to make species/size/origin/period specific outmigration estimates based on mark-recapture data for the 2022 Lewis River trapping season. However, pooled data allows estimates to be made. The estimates of fish passing the Lewis River Upper Golf Course Traps (Section 3.4) rely on the following key assumptions:

- The pooled trap efficiency used in this analysis is representative of the true trap efficiency for each species/size/origin/period specific categories for which estimates were made.
- The inferred age classes based on length distribution over time for each species are representative of the true proportion of the total fish captured by age class.
- Marking does not affect catchability or survival.
- All fish (marked and unmarked) have an equal probability of being caught.
- Fish do not lose their marks and marks are recognizable.
- All hatchery fish are actually marked with an adipose fin clip and/or CWT so as to be distinguishable from naturally produced fish.
- All recovered marks are reported.

The efficiency of the Lewis River Golf Course Traps for hatchery Coho for weeks 4 through 17 combined (periods when hatchery Coho were recaptured) was 1.25% (63 recaptured / 5,031 marked and placed upstream). The Lewis River Hatchery estimated a total release of 2,155,007 hatchery Coho smolts during the screw trapping season. Using the Bootstrap method, 1,954,754 (standard deviation = 238,564; CV = 12.2%) hatchery Coho were estimated to have passed the traps during the monitoring period. The total number of hatchery coho released is within one standard deviation of the estimated number to have passed the traps. These results suggest that capture rates of marked and released hatchery Coho at the Lewis River Upper Golf Course Traps are likely representative of hatchery Coho moving past the trap during the 2022 monitoring period. The trap efficiency for naturally produced Coho ≥50 mm FL was not significantly different from that measured for hatchery Coho, though the confidence in the naturally produced Coho measured trap efficiency is reduced by low sample size.

3.7 Self-Assessment

In 2021, river flows were relatively stable during the sampling period and a relationship between cone revolutions and flow allowed for estimating trap efficiency for weeks with no recaptures. However, flows in 2022 were much more variable and no relationship was apparent between estimated weekly efficiency and flow or trap RPMs. Therefore, assessing trap efficiency relied solely on weekly mark-recapture testing. In 2022, species and life-stage/age specific efficiency estimates could not have been improved by marking additional fish as most naturally produced salmonids ≥50 mm FL captured were marked and placed upstream for efficiency trials (99% Coho, 72% Chinook, 94% Steelhead, 96% Cutthroat). However, additional fish <50 mm FL could have been marked for efficiency trials to improve species specific estimates for fry. In 2022, the target was to mark at least 1,000 fry (all species combined) one day per week. In the future, once fry capture rates drop, a target of tagging 500 fry total per week will be used which may take more than one day of tagging to meet this sample size.

References

Efron, B., and R. Tibshirani. 1986. Bootstrap methods for standard errors, confidence intervals, and other measures of statistical accuracy. Statistical Science, Vol. 1, No. 1, 54-77.

Manly, B. 2007. Randomization, Bootstrap, and Monte Carlo Methods in Biology, 3rd edition. Chapman and Hall, Boca Raton, Florida, USA.

Thedinga J.F., M.L. Murphy, S.W. Johnson, J.M. Lorenz, and K.V. Koski. 1994. Determination of salmonid smolt yield with rotary-screw traps in the Situk River, Alaska, to predict effects of glacial flooding. North American Journal of Fisheries Management 14:837 851.

Washington Department of Fish and Wildlife. 2019. JMX smolt trap protocols and reporting, Kalama River 2019. Project supervisor: Jeremy Wilson, Science Leader: Thomas Buehrens.

APPENDIX E –

North Fork Lewis River Downstream of Merwin Dam – 2022 Coho salmon spawning survey results (October 2022 through January 2023)

Memorandum

To: Erik Lesko and Chris Karchesky, PacifiCorp

From: Jason Shappart (Fisheries Scientist) and Brittany Winston (Fish and Wildlife Biologist)

Date: April 3, 2023

Re: North Fork Lewis River Downstream of Merwin Dam – 2022 Coho Salmon Spawning Survey Results (mid-October 2022 through January 2023)

Introduction

As a component of its existing FERC license, PacifiCorp conducts annual Coho Salmon spawning surveys from mid-October through January to facilitate estimating Coho Salmon spawning escapement in the North Fork (NF) Lewis River downstream of Merwin Dam (PacifiCorp and Cowlitz PUD 2020). Meridian Environmental, Inc. (Meridian) has performed these surveys under contract with PacifiCorp since 2013 using the same survey crew each year. This memorandum summarizes the results of the Coho Salmon spawning surveys from mid-October 2022 through January 2023.

Methods

The NF Lewis River tributary spawning survey reaches are defined annually by Washington Department of Fish and Wildlife (WDFW) using a Generalized Random Tessellation Stratified (GRTS) sample design. The tributary survey data summarized in this report is combined with spawning survey data throughout the region and used by WDFW to estimate Coho escapement within the lower Columbia River area. In 2022, WDFW designated two survey reaches within the Hayes Creek watershed, and one reach each in the Ross Creek and Houghton Creek watersheds (Figure 1). Each survey reach is approximately one mile in length.

All tributary surveys were conducted weekly by foot as environmental conditions allowed (flow, turbidity, etc.) following the methods described in Brown et al. (2021). During each tributary survey, the number of live Coho were enumerated. Coho carcasses were enumerated by species, sex, and origin. All carcasses were scanned for a coded wire tag (CWT) and all external marks were noted. Scale samples were taken from all unmarked carcasses (assumed natural origin return). The tail was removed from each carcass after counting so that it would not be counted as a new carcass on subsequent surveys. All new redds were counted and given a uniquely numbered flag by date. GPS coordinates were recorded for all redds. On subsequent surveys the visibility of each previously flagged redd was recorded. Once a redd was deemed no longer visible, the flag was removed.

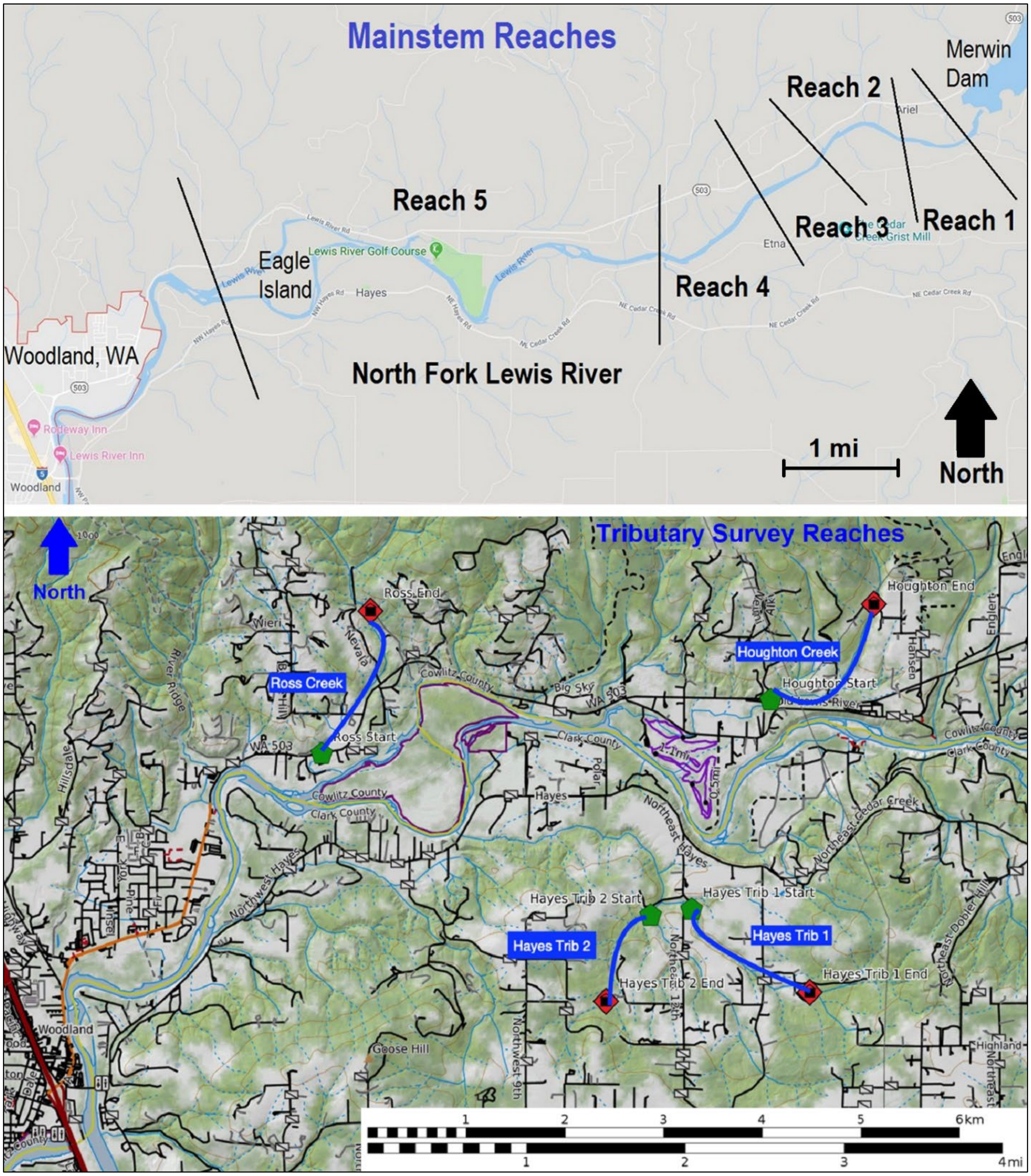


Figure 1. NF Lewis River mainstem and tributary Coho spawning survey reaches below Merwin Dam in 2022.

Mainstem NF Lewis River spawning surveys were conducted as stipulated in PacifiCorp and Cowlitz PUD (2020). The mainstem NF Lewis River spawning survey area is divided into five index reaches as defined previously by WDFW (Bentley et al. 2018), extending from the boat barrier downstream of Merwin Dam to the downstream end of Eagle Island (Figure 1) encompassing 10.84 river miles (mainstem channel and Eagle Island side channel). All five mainstem NF Lewis River reaches were surveyed weekly via jet boat during a single day. In prior years, PacifiCorp conducted river drawdowns once per week during the Coho and fall Chinook spawning survey seasons at the request of WDFW to facilitate WDFW's ability to recover fall Chinook carcasses. From 2013 to 2015, Meridian purposefully avoided conducting Coho surveys during the weekly drawdowns at the request of WDFW. However, additional data analyses suggested that Coho carcass recovery rates may be improved during lower flows. As a result, starting in 2016, Meridian conducted mainstem NF Lewis River Coho surveys during drawdown days to improve carcass detection probability and increase carcass resight probability. Drawdown days continued to be targeted for surveys during the 2022 season to the extent possible.

As in prior years, Meridian biologists conducting Coho spawning surveys in the mainstem NF Lewis River found it difficult to differentiate Coho redds from fall Chinook redds due to the relatively large number of fall Chinook spawning in the mainstem NF Lewis River compared to Coho. Therefore, only Coho carcass surveys were conducted in the mainstem NF Lewis River. During each mainstem NF Lewis River survey, all carcasses that could be recovered (not too deep) were counted and sampled as described previously for tributary surveys. In addition, all recovered carcasses were tagged and left where found (as recommended by WDFW after the 2015 spawning survey season). Prior to 2015, tagged carcasses were placed back into the thalweg per WDFW recommended methods. Tags consisted of uniquely numbered plastic strips, which were stapled to the inside of both opercula. The tails were not removed after counting. On subsequent surveys, previously tagged carcasses were recorded and were left in place for potential subsequent resights. Carcasses too deep to recover were also enumerated if identified as Coho.

As described in Starcevich (2022), the carcass mark-resight data was used to generate an estimate of total Coho carcasses over time with associated 95% confidence interval, and were analyzed assuming the super-population parameterization (Schwarz and Arnason 1996) of the Jolly-Seber model (POPAN model). Analysis was conducted in the R statistical consulting environment (2020) with the RMark package (Laake 2013). Intercept-only models were used for capture and survival probabilities.

Survey Conditions

In 2022, flows downstream of Merwin Dam on the NF Lewis River were variable. Flows were generally at or below median flow levels from mid-October to mid-December, but were above median flow levels for a large portion of time from late-December through January (Figure 2). NF Lewis River mainstem surveys from November to mid-December generally occurred on drawdown days (Figure 3). River conditions were surveyable every week during the survey period for the mainstem NF Lewis River except for the week of December 19; due to inclement weather (i.e., strong winds/freezing rain) only Reach 1 was surveyed. Tributary surveys were conducted every week during the survey period except for one week at the end of December, and two weeks in January due to high flows and high turbidity. As a result, Ross Creek was surveyable during 16 weeks and Houghton Creek was surveyable during 15 weeks of the 17 week survey season. In addition, Hayes Creek Tributary 1 and Hayes Creek Tributary 2 were generally not surveyable from late-December through January due to high turbidity and were only surveyable during 12 weeks total.

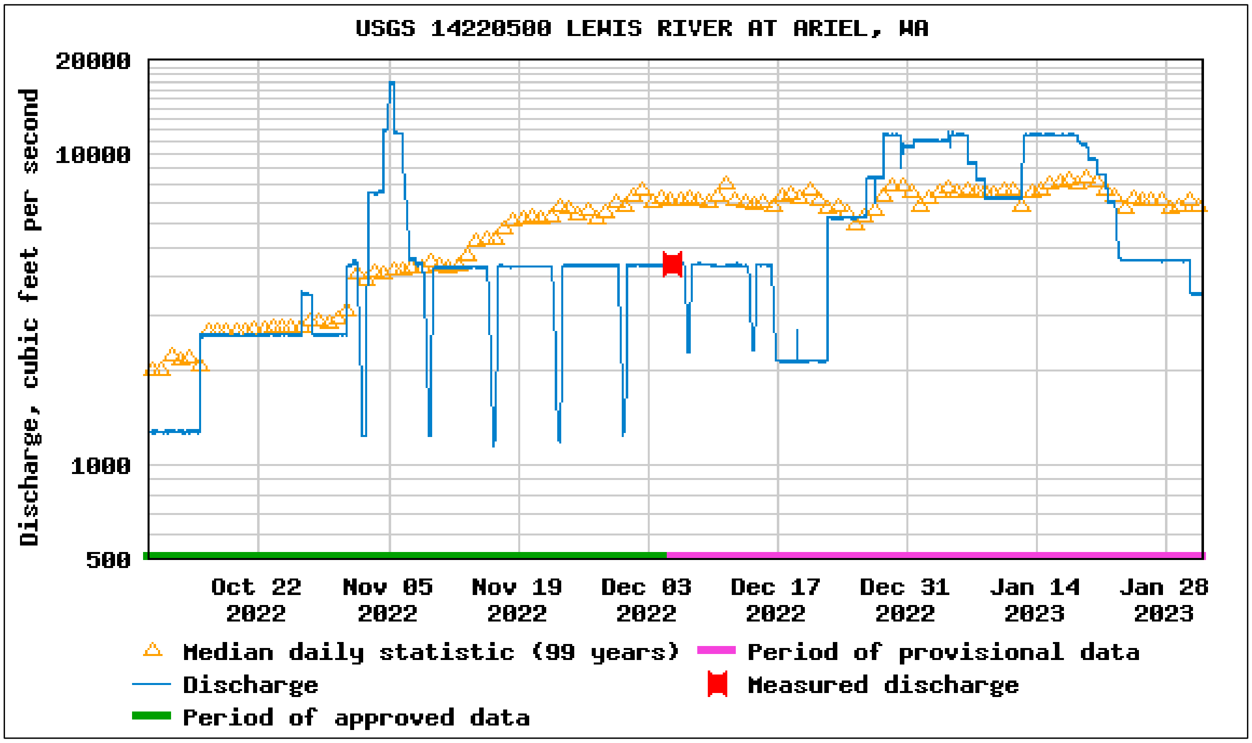


Figure 2. USGS Lewis River Ariel Gage – 15 minute interval reported discharge (cfs) during the 2022 survey season and period of record median daily statistic.

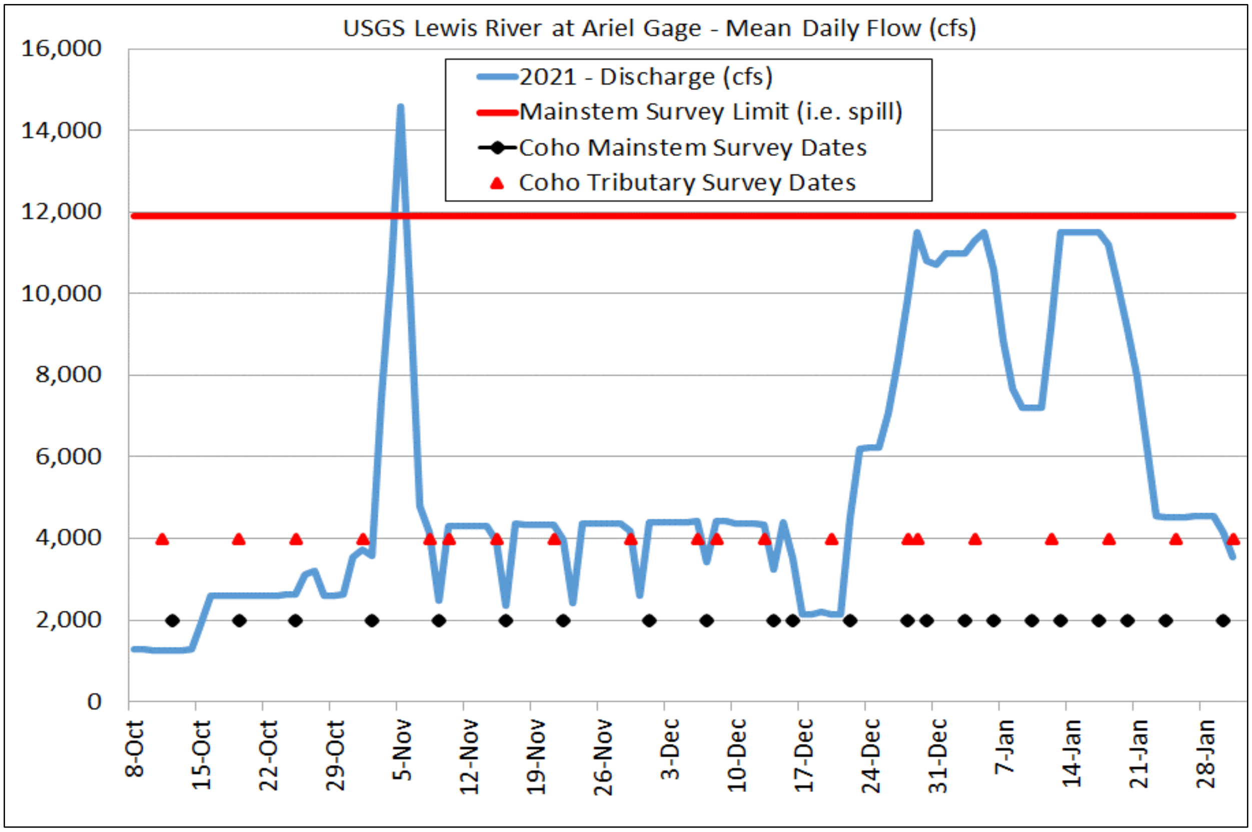


Figure 3. USGS Lewis River Ariel Gage – mean daily discharge (cfs) and survey timing (mid-October 2022 through Janaury 2023).

Results

NF Lewis River Tributary Surveys

Meridian biologists counted a total of 53 live Coho and 46 redds in Houghton Creek, and a total of 68 live Coho and 53 redds in Ross Creek (Table 1), which represented the highest redd count in both stream reaches since Meridian began surveys in 2013 (Table 2). Meridian biologists did not observe any live Coho, carcasses, or redds in Hayes Creek Tributary 1 or Hayes Creek Tributary 2 during the survey season. Coho spawning activity has not been observed in Hayes Creek Tributary 2 since Meridian began surveys in 2013 (Table 2). Only two suspected Coho redds have been observed in Hayes Creek Tributary 1 (2017), but no live Coho or carcasses have ever been observed in this reach by Meridian biologists since surveys began in 2013 (Table 2).

Table 1. Summary of tributary Coho Salmon spawning surveys downstream of Merwin Dam (mid-October 2022 through January 2023).

Stream	Reach Length (miles)	Total Weeks (mid-Oct to Jan 31)	Total Weeks Surveyable	Total New Redds	Total Live Holders	Total Live Spawners	Total Carcass Not Sampled[a]	Hatchery Male Carcass	Hatchery Female Carcass	Unmarked Male Carcass	Unmarked Female Carcass	Total Carcass	% Pre-spawn Mortality	Carcass Wanded for CWT	CWT Positive Carcass
Houghton Cr.	1.0	17	16	46	4	49	4[a]	2	4	0	2	12	17%	8	0
Ross Cr.	1.0	17	15	53	0	68	0	1	9	1	0	11	11%	11	0
Hayes Trib 1	1.0	17	12	0	0	0	0	0	0	0	0	0	NA	NA	NA
Hayes Trib 2	1.0	17	12	0	0	0	0	0	0	0	0	0	NA	NA	NA

NA = Not Applicable

[a] Note: Carcasses too deep or too decayed to sample.

Table 2. Summary of tributary survey data (2013-2022) for stream reaches selected for survey in 2022 (if a year is not shown under a specific stream reach, then it was not selected for survey during that year by WDFW).

Year	Weeks Surveyable	Total Live Spawners	Total Carcasses	Total Redds
Ross Creek				
2013	13	44	20	18
2014	14	14	68	33
2015	10	10	5	2
2016	15	49	10	33
2017	16	20	11	30
2018	15	10	3	12
2019	12	29	10	13
2022	16	49	12	46
Houghton Creek				
2013	15	52	2	8
2014	13	13	14	8
2015	10	0	0	0
2016 (2 reaches)*	16	10	2	10
2019 (2 reaches)*	14	5	2	16
2022	15	68	11	53
Hayes Tributary 1				
2013	13	0	0	0
2014	4	0	0	0
2017	16	0	0	2
2020	10	0	0	0

Year	Weeks Surveyable	Total Live Spawners	Total Carcasses	Total Redds
2022	12	0	0	0
Hayes Creek Tributary 2				
2013	14	0	0	0
2014	2	0	0	0
2016	9	0	0	0
2017	16	0	0	0
2018	13	0	0	0
2019	11	0	0	0
2020	10	0	0	0
2021	11	0	0	0
2022	12	0	0	0

[a] Note: A single one mile-long reach was surveyed in each year for each stream, except two reaches (one mile-long each) were surveyed in Hayes Creek in 2018.

NF Lewis River Mainstem Surveys

A total of 374 carcasses were observed in the entire mainstem NF Lewis River survey area over the 17-week survey period (Table 3). Of those, 338 carcasses were able to be recovered and in sufficient condition to sample and tag. Five carcasses were sampled, but not tagged, as they were observed on the last survey day of the season. A total of four carcasses had a CWT present. A total of 82% of sampled carcasses were of hatchery origin (identified as having an adipose fin clipped or CWT present). A total of 44% of female carcasses sampled were determined to be pre-spawn mortality by the presence of substantial egg retention.

Of the 338 tagged carcasses, 53 were resighted at least once for an observed resighting probability of 16%. Thirty-nine carcasses were resighted once; nine carcasses were resighted twice; four carcasses were resighted four times; and one carcass was resighted six times. Based on the mark-resight estimation methods, total Coho carcasses in the NF Lewis River mainstem between the downstream end of Eagle Island and the boat barrier downstream of Merwin Dam during the 2022 survey season was estimated to be 1,273 carcasses; bootstrap 95% confidence interval (CI): 1,007 to 1,540 (Starcevich 2023). The coefficient of variation for the total carcass estimate was 0.11. The carcass sighting probability was estimated as 0.17 (95% confidence interval of 0.13 to 0.24).

Table 3. Summary of NF Lewis River mainstem Coho Salmon spawning surveys downstream of Merwin Dam (mid-October 2022 through January 2023).

NF Lewis River	Reach Length (miles)	Total Weeks (mid-Oct to Jan 31)	Total Weeks Surveyable	Total Carcass Not Sample (too deep)	Hatchery Male Carcass	Hatchery Female Carcass	Unmarked Male Carcass	Unmarked Female Carcass	Total Carcass[a]	Total Carcass Tagged	Total Carcass Recoveries	% Pre-spawn Mortality (Females)	Carcass Wanded for CWT	CWT Positive Carcass
Reach 1	0.57	17	17	2	13	11	3	4	33	31	7	33%	31	1
Reach 2	0.68	17	16	2	14	24	3	1	44	42	11	56%	42	0
Reach 3	0.97	17	16	0	10	12	5	3	30	30	2	27%	30	1
Reach 4	1.32	17	16	13	36	46	10	8	113	98	19	48%	100	1
Reach 5	7.3	17	16	14	57	58	12	13	154	137	14	42%	140	1
Total	**10.84**	17	16	31	130	151	33	29	374	338	53	44%	343	4

[a] Note: Includes carcasses too deep to sample and carcasses sampled.

Discussion and Conclusions

Incorporating surveys on drawdown days in 2016 nearly doubled the proportion of tagged carcasses that were resighted compared to the highest resight proportion in previous years (2013 to 2015) when surveys were conducted on non-drawdown days (Table 4). However, the resight proportion has been variable since that time. It is important to note that the same crew conducted all surveys during all 10 years covering the same reaches and season. While the resighting proportion in 2021 and 2022 decreased, Starcevich (2023) determined that the sighting probability estimates from 2021 and 2022 are more precise than previous carcass sighting probabilities for years with adequate sample sizes.

Table 4. Total Coho redd estimates for 2013 to 2022.

Year	Total Carcasses Tagged	Total Carcasses Resighted	% Carcasses Resighted	Total Weeks Surveyable	Average Daily Flow during Survey Days (cfs)	Average Daily Flow All Days Mid-Oct to Jan-31	Total Carcass Estimate	Bootstrap SE	95% Confidence Interval	CV
2013 Season Total	328	41	13%	15	4,700	4,804	1,970	297	1,523 to 2,679	0.17
2014 Season Total	431	18	4%	15	7,765	7,876	7,805	2,106	5,172 to 13,186	0.27
2015 Season Total	12	2	17%	12	5,632	8,429	no estimate due to low sample size 52 (simple Chapman estimator)			
2016 Season Total	65	20	31%	16	4,587	6,721	124	17	103 to 169	0.14
2017 Season Total[a]	24	8	33%	16	8,817	8,587	44	5	33 to 56	0.11
2018 Season Total	61	22	36%	16	5,009	5,044	137	20	98 to 176	0.15
2019 Season Total[a]	40	7	18%	15	6,181	6,761	83	10	64 to 102	0.12
2020 Season Total	223	65	29%	15	4,968	7,182	527	54	421 to 632	0.10
2021 Season Total	94	14	15%	14	6,683	8,403	407	93	225 to 590	0.23
2022 Season Total	338	53	16%	16	5,826	5,564	1,273	136	1,107 to 1,540	0.11

[a] Drawdowns for spawning surveys generally did not occur during the Coho spawning survey season.

Coho returns for the 2022 run-year for both Lewis River Hatchery and the Merwin Adult Fish Collection Facility were the highest recorded since 2013, with 75,812 Coho captured in total. Spawning activity in the NF Lewis River tributaries also appears to be the highest recorded since 2013. The Houghton Creek reach had a total of 46 redds observed in 2022, with a previous maximum of 16 redds recorded in 2019. Ross Creek had a total of 53 redds observed in 2022, with previous maximums of 33 redds recorded in both 2016 and 2014.

Comparing the total number of adult Coho trapped annually at the Lewis River Hatchery and Merwin Adult Fish Collection Facility to the total carcass estimates since 2013 (Figure 4) suggests that as the trap-and-haul upstream passage program has been implemented to transport Coho upstream of the Lewis River Hydroelectric Projects (beginning in 2012 and refined over time), returning Coho are electing to travel further upstream to spawn or spawn in lower NF Lewis River tributaries, rather than spawn in the lower mainstem NF Lewis River. The primary evidence of this effect is that thousands of adult Coho have been captured at the fish passage facilities annually since 2013, while the number of Coho carcasses encountered in the lower NF

Lewis River mainstem downstream of the fish passage facilities appears to have declined greatly after 2014 (Figure 4). From 2013 to 2014, total carcass estimates as a percentage of total Coho trapped annually ranged from 7 to 11%; but dropped to 0.2 to 1.2% from 2015 through 2021 (Figure 4). The greatest number of Coho returned to the Hatchery and Merwin traps in 2022 (since 2013), yet the total carcass estimate as a percentage of total Coho trapped was only 1.7%. The total annual Coho carcass estimate within the mainstem NF Lewis River downstream of Merwin Dam appears to be highly correlated with the combined total yearly Coho trapped at the Lewis River Hatchery and Merwin Adult Fish Collection Facility after 2014 (Figure 8), which is indicated by $R^2 = 0.88$.

It is also important to note that Coho spawning surveys have started in mid-October through PacifiCorp contract since 2013, but a large portion of the adult return can be composed of early-run Coho in some years. For example, by the end of September in 2021, nearly 50% of Coho for the entire year had already been trapped at the Lewis River Hatchery and Merwin Fish Collection Facilities before spawning surveys started in mid-October. In 2022, over 25% of Coho had already been trapped by the end of September. This suggests that some portion of early-Coho carcasses could potentially be missed due to the contracted survey start time in mid-October in relation to the early-Coho run timing in August and September.

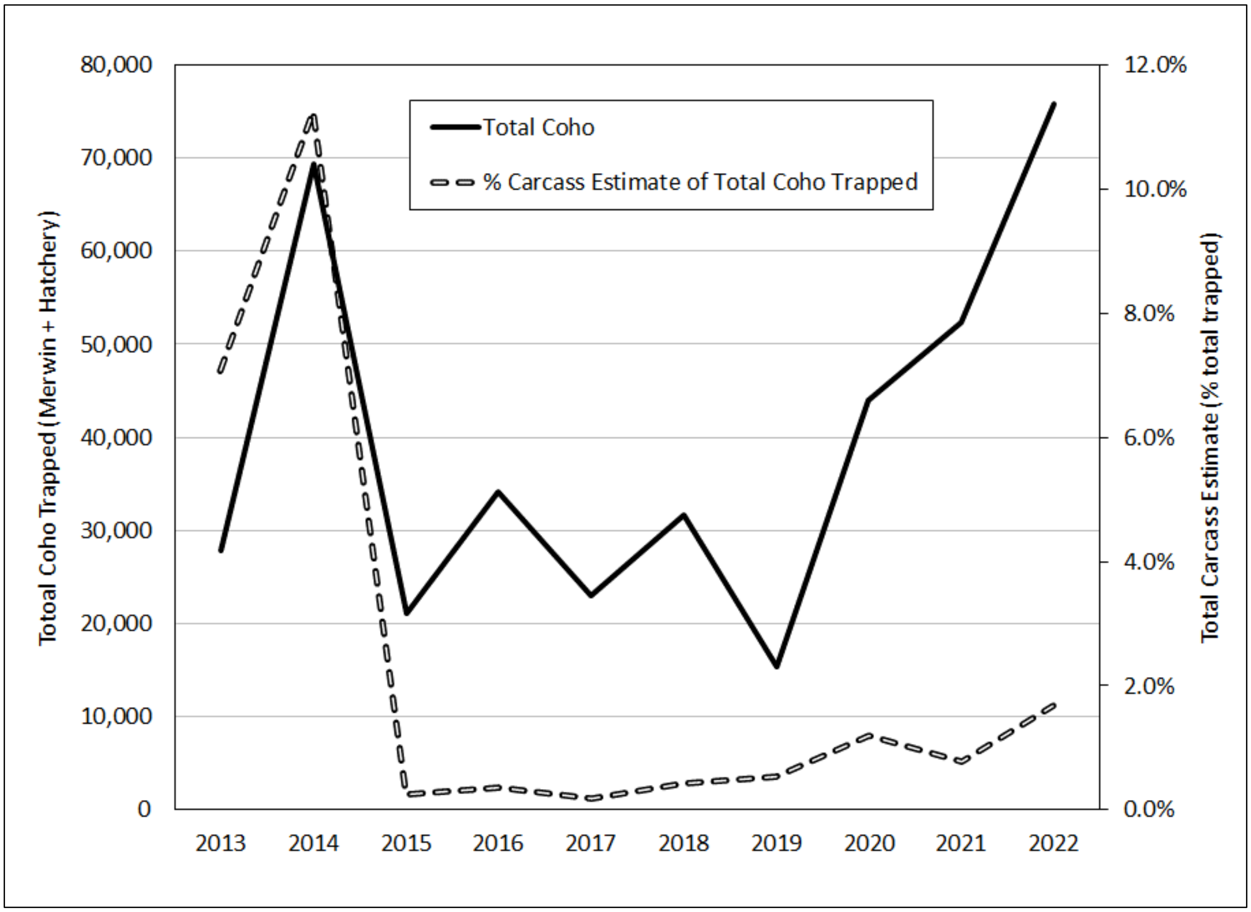


Figure 7. Total Coho captured vs. carcass estimates.

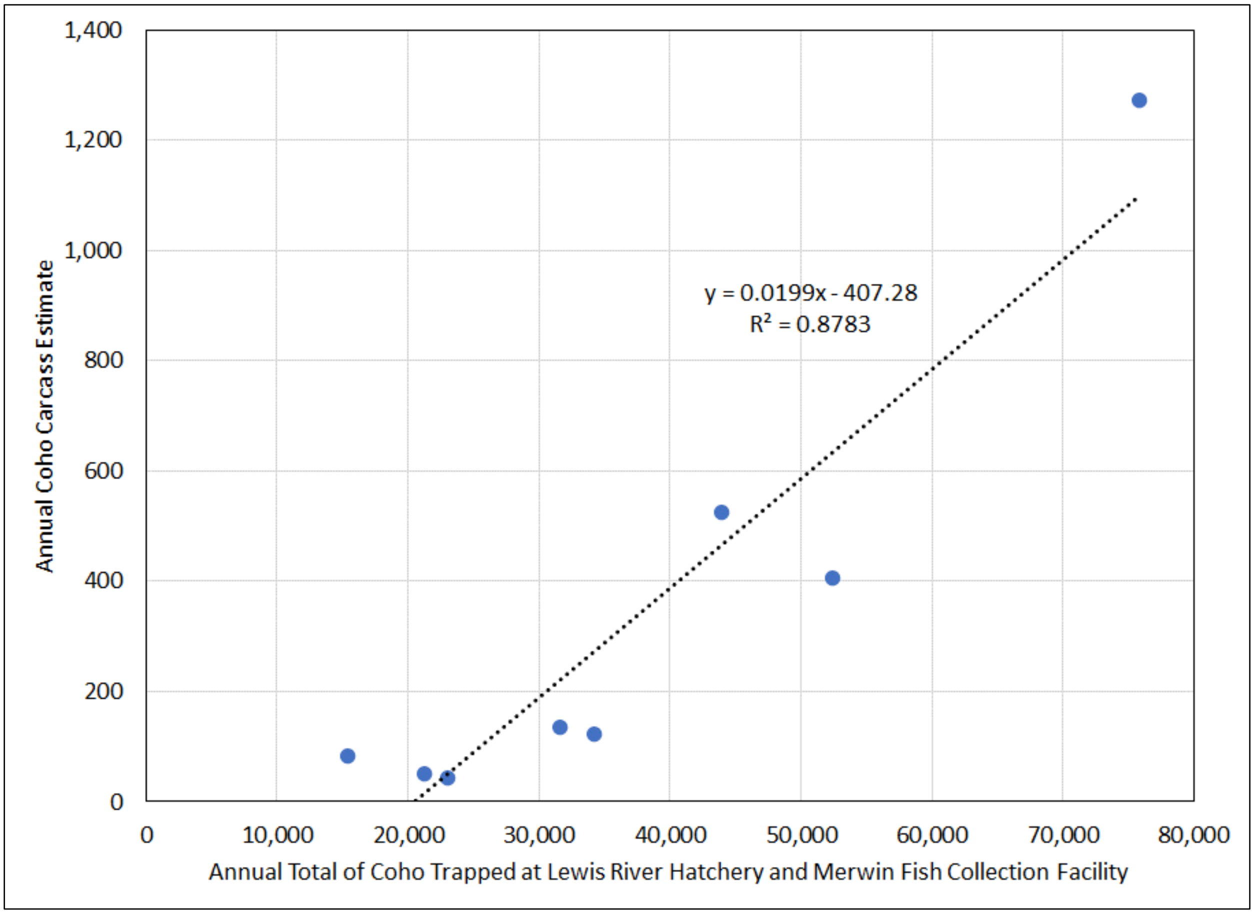


Figure 8. Total Coho captured vs. carcass estimate regression (2015 to 2022).

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WEST Inc.

ENVIRONMENTAL & STATISTICAL CONSULTANTS

2725 NW Walnut Blvd, Corvallis, OR 97330
Phone: 541-738-6198 www.west-inc.com

Date: March 29, 2023
To: Jason Shappart (Meridian Environmental, Inc.)
From: Leigh Ann Starcevich and Simon Weller (WEST, Inc.)
Re: Estimates of 2022 Coho Adult Escapement from Tagged Carcass Surveys in the Lower North Fork Lewis River downstream of Merwin Dam

Introduction

Meridian Environmental, Inc. (Meridian) conducts annual Coho salmon spawning surveys (including carcass tagging) for PacifiCorp to estimate escapement in the mainstem North Fork Lewis River downstream of Merwin Dam to the downstream end of Eagle Island. The area of interest, previously defined by Washington Department of Fish and Wildlife (WDFW), consists of five reaches ranging from 0.57 to 7.30 miles long.

Coho carcass surveys were conducted on 22 occasions between October 12, 2022 and January 30, 2023. All observed Coho carcasses in adequate condition were tagged with a uniquely-numbered plastic disk behind the gills (two tags per carcass) so that tagging would not impact resighting probabilities. As recommended by WDFW, carcasses were counted by reach during successive survey occasions, and observed tagged carcasses were recorded and returned to the river in the same location where initially observed.

Statistical Methods

The carcass data were analyzed assuming the super-population parameterization (Schwarz and Arnason 1996) of the Jolly-Seber model (POPAN model). Analysis was conducted in the R statistical consulting environment (2020) with the RMark package (Laake 2013). Intercept-only models were used for capture and survival probabilities. The resulting estimate of total escapement, defined by Schwarz and Arnason (1996) as the total number of gross "births" in the area of interest, accounts for Coho present at the beginning of the study, those that move into the study area during the monitoring period, and those that do not survive to the end of the monitoring period.

Results

The results of the 2022 carcass survey, as well as surveys extending back to 2013, are provided in Table 1. In the 2022 surveys, 374 carcasses were observed and 338 carcasses were able to be recovered and in sufficient condition to mark. Of the 338 marked carcasses, 53 were re-sighted at least once for an observed resighting probability of 0.16. Thirty-nine carcasses were re-sighted once; nine carcasses were re-sighted twice; four carcasses were re-sighted four times; and one carcass was re-sighted six times. The 2022 estimate of escapement was 1273 (95%-CI: 1007, 1540) individuals. The carcass sighting probability was estimated as 0.17 (95%-CI: 0.13, 0.24).

Table 1. Estimated 2013-2022 Coho spawner escapement to the mainstem North Fork Lewis River from Merwin Dam to the downstream end of Eagle Island, with 95%-confidence intervals.

Year	Number of marked carcasses	Number of resighted carcasses	Est. Gross Population Size	SE	95%-Confidence Interval	Coefficient of Variation (SE/Est. Size)
2013	328	41	1970	297	(1523, 2679)	0.15
2014	431	18	7805	2106	(5172, 13186)	0.27
2016	65	20	124	17	(103, 169)	0.14
2017	24	8	44	5	(35, 56)	0.11
2018	61	22	137	20	(98, 176)	0.15
2019	40	7	83	10	(64, 102)	0.12
2020	223	65	527	54	(421, 632)	0.10
2021	94	14	407	93	(225, 590)	0.23
2022	338	53	1273	136	(1107, 1540)	0.11

Table 2. Estimated 2016-2022 carcass sighting probabilities, with 95%-confidence intervals.

Year	Number of marked carcasses	Number of resighted carcasses	Observed proportion of captured carcasses	Est. Carcass Sighting Probability	SE	95%-Confidence Interval
2013*	328	41	0.13	-	-	-
2014*	431	18	0.04	-	-	-
2016	65	20	0.31	0.45	0.13	(0.23, 0.68)
2017†	24	8	0.33	1.00	0.00	(1.00, 1.00)
2018	61	22	0.36	0.46	0.09	(0.30, 0.63)
2019†	40	7	0.18	1.00	0.00	(1.00, 1.00)
2020	223	65	0.29	0.44	0.09	(0.27, 0.62)
2021	94	14	0.15	0.14	0.04	(0.07, 0.24)
2022	338	53	0.16	0.17	0.03	(0.13, 0.24)

* Estimates of carcass sighting probabilities were not generated these years.

† Standard errors for estimates of carcass sighting probabilities were impacted by lack of convergence due to small sample sizes.

Discussion

Estimates of escapement and precision of the estimates have varied across years (Table 1). The sighting probability observed in 2022 (estimate: 0.17; 95%-CI: 0.13, 0.24) resulted in an estimate similar in magnitude and precision to the 2021 sighting probability estimate of 0.14 (95%-CI: 0.07, 0.24). The sighting probability estimates from 2022 and 2021 are lower, but more precise than previous carcass sighting probabilities (for years with adequate sample sizes) of 0.45 (95%-CI: 0.23, 0.68) in 2016, 0.46 (95%-CI: 0.30, 0.63) in 2018, and 0.44 (95%-CI: 0.27, 0.62).

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APPENDIX F –

Estimates of abundance estimates for Adult Chinook downstream of Merwin Dam, 2022

memo

To: Erik Lesko and Chris Karchesky, PacifiCorp
From: Kale Bentley and Erin Peterson, WDFW
CC: Lewis ATS
Date: April 14, 2023
Subject: Estimates of abundance for adult Chinook downstream of Merwin Dam, 2022

Executive Summary

In 2022, the Washington Department of Fish and Wildlife (WDFW) conducted weekly mark-recapture surveys from September 12th, 2022, through January 6th, 2023. Across all surveys, 6,449 unique carcasses were recovered of which 2,109 were tagged and 878 were recaptured. Flows and visibility were generally favorable throughout the survey period, except during the survey that took place in early November (November 8-9) that occurred immediately after a high-water event that greatly increased turbidity. However, PacifiCorp was still able to provide all seven drawdowns requested in November and December. The crew worked through the first week of January, tagging as many carcasses as possible except for on the last survey day, when no carcasses were tagged. Using a Jolly-Seber (JS) open population model, the total estimates of abundance (mean; %CV) for spring-, fall- (tule), and late fall-run (bright) Chinook salmon were 1,075 (51%), 4,941 (12%), and 7,177 (8%), respectively. The proportion of estimated abundance that were hatchery-origin spawners (pHOS) for the three run-types was estimated to be 0.85, 0.50, and 0.02, respectively.

Project Overview

WDFW has been conducting spawning ground surveys for adult Chinook salmon in the mainstem North Fork (NF) Lewis River downstream of Merwin Dam for over five decades. Over this time, the methods used to assess the status of NF Lewis Chinook have varied. Since 2013, WDFW has been implementing weekly mark-recapture surveys using carcasses that are recovered from the river and adjacent streambanks to estimate the abundance and composition of Chinook salmon spawners throughout their entire spatial and temporal extent each year. The estimates of abundance and composition are used by WDFW, NOAA, and other entities to assess the status and trend of NF Lewis populations of Chinook, which represent three of the 32 historical independent populations with the Lower Columbia River (LCR) Chinook salmon Evolutionarily Significant Unit (ESU). The monitoring of wild fall Chinook spawner populations in the NF Lewis River is also a requirement of the Lewis River Hydroelectric Projects FERC Settlement Agreement of 2004 and details are outlined in PacifiCorp's most up-to-date Hatchery and Supplemental (H&S) Plan of 2020.

Project Goals

(1) Conduct spawning ground surveys for Chinook salmon in the NF Lewis River downstream of Merwin Dam throughout the entire spawning period. Spawning ground surveys include both weekly mark-recapture surveys for carcasses and peak-count visual surveys of live spawners, carcasses, and redds

(2) Generate an unbiased estimate of the total abundance for Chinook salmon spawners with uncertainty in the NF Lewis River downstream of Merwin Dam
(3) Estimate the composition of spawner abundance by management population (spring, tule, and bright), origin (hatchery, wild), and age (ages 2 – 6)
(4) Evaluate the spatial and temporal spawning distribution of Chinook salmon downstream of Merwin Dam

Methods

A brief description of the survey approach, data collection, and data analysis are outlined below. For a more in-depth description of each aspect of the project, see Bentley et al. (2018) and the annually updated Spawning Ground Survey Protocol for NF Lewis River adult Chinook salmon.

Survey Approach

Spawning ground surveys are conducted for Chinook salmon in the NF Lewis River from the bottom of Eagle Island upstream to just below Merwin Dam (Figure 1), which comprises the entire spawning distribution for Chinook salmon in the mainstem Lewis. Spawning ground surveys begin the third week of September (14th – 18th) and typically continue into January to encompass the entire spawning duration of all three populations (i.e., stocks, run types) of Chinook salmon. Surveys are typically conducted 1 – 2 days per week so long as river conditions are conducive to staff safety and fish visibility. One to four jet boats are used to navigate the river and complete spawning ground surveys, which are primarily focused on recovering carcasses to conduct mark-recapture.

Data Collection

During each carcass survey, Chinook salmon carcasses are located, recovered, accessed, sorted, and processed sequentially. All recovered carcasses are enumerated while a subset is sampled for biological data (e.g., fork length – FL –, sex, scales, CWTs) and carcass tagged. Visual surveys are also conducted to count the number of live spawners and redds during the presumed peak spawning periods for all three populations of Chinook salmon. Data are captured on scale cards and whiteboards in the field and entered into WDFW's Traps, Weirs, and Surveys (TWS) Access database. Further data collection and carcass handling protocols are detailed in Bentley et al. (2018).

Data Analysis

Carcass recoveries and associated biological data were queried, summarized, and analyzed to generate estimates of abundance of NF Lewis Chinook salmon using nearly the same methods outlined in Bentley et al. (2018). Briefly, estimates were generated using a multivariate, random-walk mark-recapture Jolly-Seber (J-S) model. Our model was a modified version of the "super-population" Jolly-Seber (J-S) estimator that was developed by Schwarz et al. (1993) and Schwarz and Arnason (1996) and previously implemented in a Bayesian framework by Rawding et al. (2014). A more detailed description of the data analysis and the J-S model can be found in Appendix A and Appendix B, respectively.

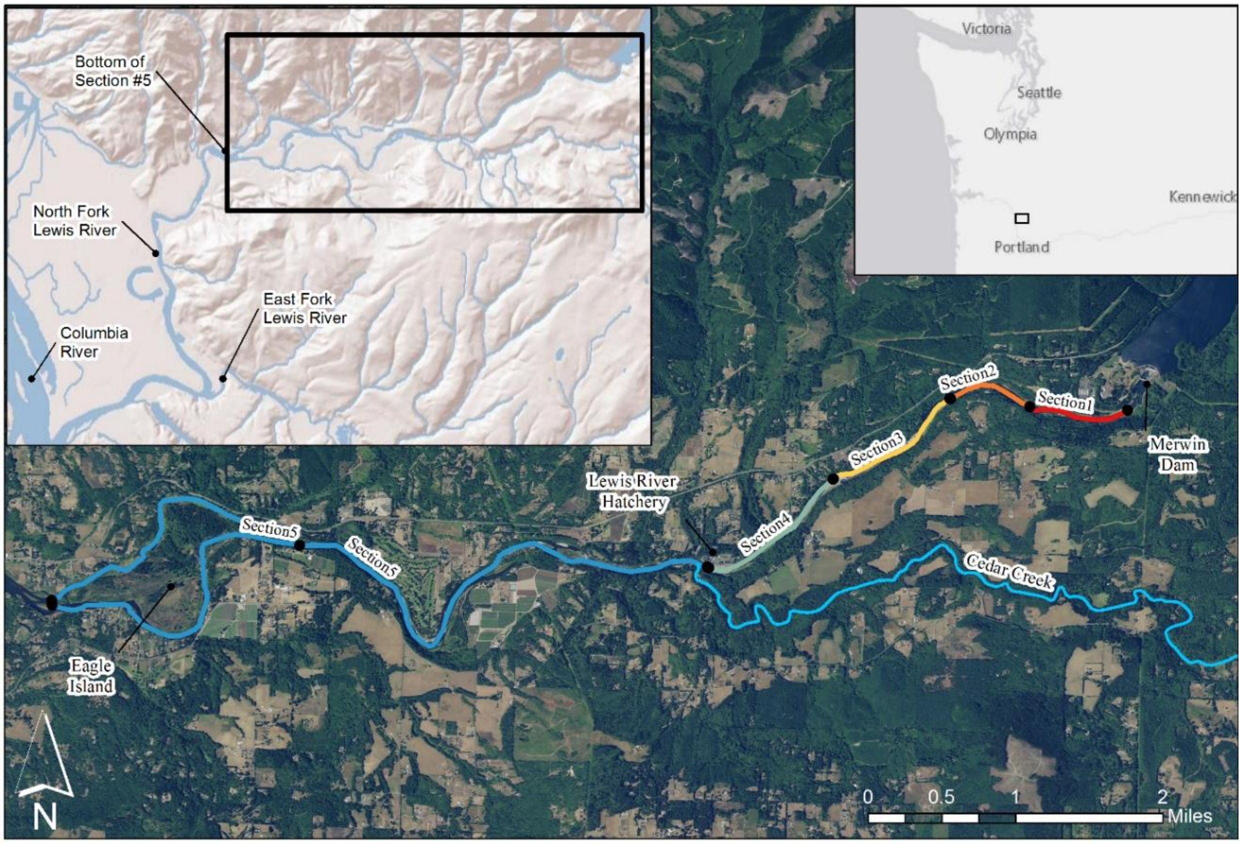

Figure 1. Map of spawning ground survey sections for Chinook salmon in the NF Lewis River.

Results

Data Collection

Mark-recapture carcass tagging surveys were conducted for Chinook salmon in the NF Lewis River downstream of Merwin Dam from September 12th, 2022, through January 6th, 2023. In total, 30 individual days were surveyed over 17 weeks and required 51 boat days to complete. No surveys were missed due to unsafe conditions.

Across all survey days, a total of 6,449 unique carcasses were recovered of which 2,109 were tagged and 878 were recaptured (Table 1). The total number of carcasses recovered, tagged, and recaptured varied among survey weeks and carcass groupings (Appendix C). Overall, the carcass recoveries were comprised of 59% females, 38% large males, and 3% small males (“jacks”).

Table 1. Summary of the total carcass recoveries by grouping, tag status, and recovery rate in 2022.

Carcass Grouping	Maiden	Tagged	Recaptured	Recovery Rate (%)
Jack	182	171	38	22.2
Female	3,827	1,170	533	45.6
Male	2,440	768	307	40.0
Total	6,449	2,109	878	41.6

Across the entire survey period, the recovery rate of females was slightly higher than the recovery rate for males, and over double the recovery rate for jacks (Table 1). However, as observed in previous years, the recovery probability of carcasses varied throughout the fall (**Figure 2**). In general, recovery probabilities for all sexes (female, large males, and jacks) were relatively low in September and then began to increase in mid-October. A high flow event that occurred in early November only appeared to negatively impact recovery probabilities for about one week. Although flows did increase again in late December and early January, there are also very few fish available to be recovered during this time because the majority of the fall run has ended, so flows may have a smaller effect on recovery probabilities late in the season.

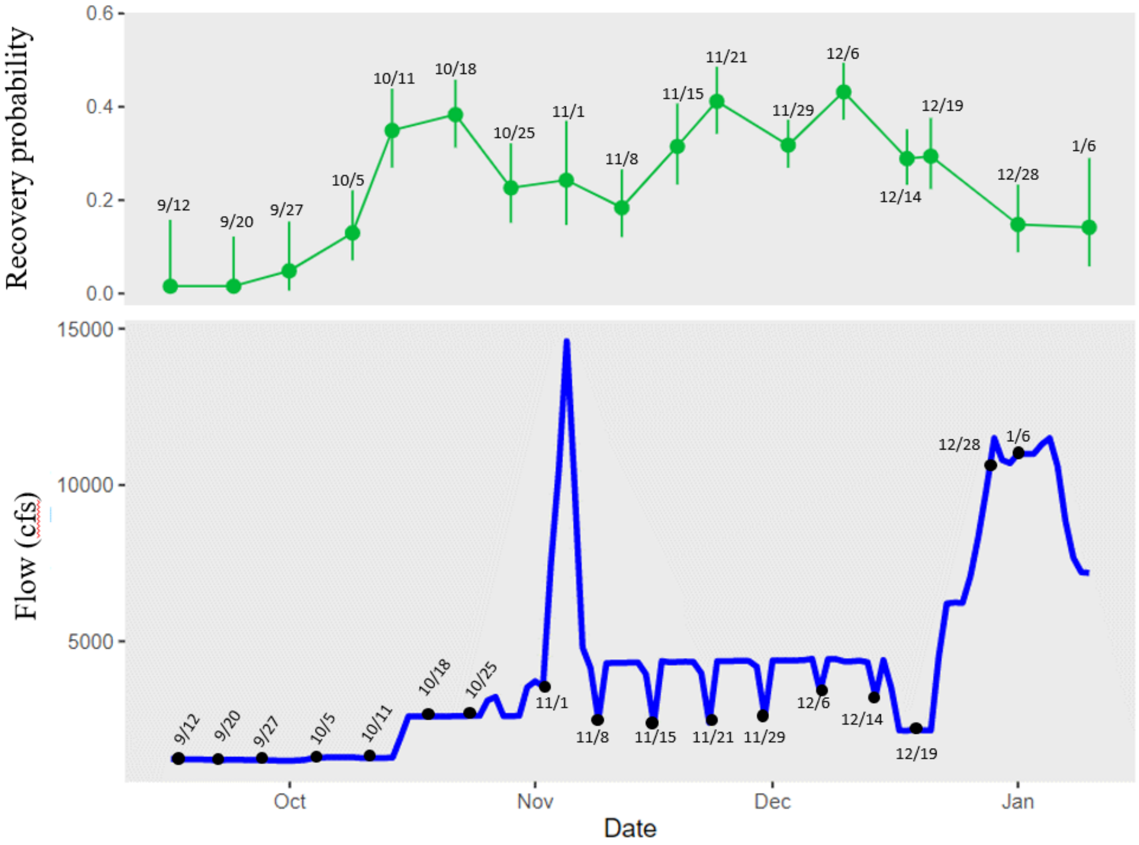

Figure 2. Recovery probability of female carcasses by period (top) and average daily flow below Merwin Dam (bottom) in the fall of 2022. Carcass survey dates are shown with black dots and dates (NOTE: one dot comprises 1-3 individual survey days).

Abundance and Composition

Estimates of abundance were generated for NF Lewis Chinook salmon for return year 2022 (**Table 3** – **Table 4**). Spring Chinook estimates have increased steadily over the last three years (Figure 3). The mean number of spring Chinook estimated to have returned to the NF Lewis River in 2022 made that run year one of the largest run years since the 1990's (mean=1,075; CV=51% [Table 2]). Tule fall Chinook estimates in 2022 (4,941; 12% [Table 3]) were also higher than in the previous two years (Figure 3). Bright abundance estimates were lower in 2022 compared to the two preceding years (Figure 3), with an estimated 7,177 (8%) bright fall Chinook returning to the NF Lewis River in 2022 (Table 4).

The proportion of each run that was comprised of hatchery-origin spawners (i.e., pHOS) was 0.85, 0.50, and 0.02, respectively (**Table 5**). As was previously explained in Bentley et al. (2018), there are no hatchery releases of bright-run Chinook salmon in the lower Columbia Basin. Specifically, the small, estimated proportion of bright-run Chinook that were assigned as hatchery-origin (0.02) is simply an artifact of how biological data are partitioned in the analyses. Thus, the 170 hatchery-origin Chinook that the model estimated as bright-run Chinook are likely hatchery-origin tule-run Chinook.

Table 2. Estimates of abundance (i.e., escapement) and composition for NF Lewis spring-run Chinook salmon in 2022.

Origin	Age	Mean	SD	L95%	Median	U95%	%CV
Hatchery	-	919	476	345	800	2,147	52
	2	11	18	1	6	54	166
	3	89	52	29	76	224	59
	4	711	372	264	617	1,678	52
	5	105	62	34	90	264	59
	6	3	3	-	2	10	100
Wild	-	156	90	56	134	382	58
	2	10	21	-	5	51	202
	3	17	11	5	14	43	67
	4	112	65	39	96	275	58
	5	17	10	5	14	43	63
	6	-	1	-	-	2	142
Total	**-**	**1,075**	**550**	**411**	**939**	**2,508**	**51**

Table 3. Estimates of abundance (i.e., escapement) and composition for NF Lewis fall-run Chinook salmon (i.e., tules) in 2022.

Origin	Age	Mean	SD	L95%	Median	U95%	%CV
Hatchery	-	2,444	238	1,990	2,437	2,936	10
	2	21	19	4	15	68	91
	3	350	53	255	347	465	15
	4	1,792	184	1,444	1,785	2,178	10
	5	275	43	196	273	365	16
	6	6	4	2	6	16	59
Wild	-	2,497	499	1,635	2,466	3,585	20
	2	135	67	51	121	303	49
	3	378	79	246	371	557	21
	4	1,413	239	991	1,397	1,925	17
	5	563	173	275	547	945	31
	6	8	4	2	7	18	51
Total	**-**	**4,941**	**603**	**3,835**	**4,912**	**6,193**	**12**

Table 4. Estimates of abundance (i.e., escapement) and composition for NF Lewis late fall-run Chinook salmon (i.e., brights) in 2022.

Origin	Age	Mean	SD	L95%	Median	U95%	%CV
Hatchery	-	170	116	65	133	496	68
	2	2	2	-	1	7	134
	3	25	17	9	20	72	66
	4	102	85	33	73	340	83
	5	41	16	20	37	82	39
	6	1	-	-	-	2	78
Wild	-	7,007	521	5,933	7,024	7,980	7
	2	339	71	231	329	511	21
	3	896	101	703	892	1,103	11
	4	3,183	261	2,656	3,187	3,685	8
	5	2,558	204	2,146	2,563	2,945	8
	6	31	12	12	29	59	40
Total	**-**	**7,177**	**564**	**6,042**	**7,182**	**8,264**	**8**

Table 5. Estimates of pHOS and pNOS for NF Lewis Chinook salmon by population in 2022.

Population	Variable	Mean	SD	L95%	Median	U95%
Spring	pHOS	0.85	0.04	0.78	0.86	0.91
	pNOS	0.15	0.04	0.09	0.14	0.22
Tule	pHOS	0.50	0.05	0.40	0.50	0.60
	pNOS	0.50	0.05	0.40	0.50	0.60
Bright	pHOS	0.02	0.05	0.01	0.02	0.06
	pNOS	0.98	0.01	0.94	0.98	0.99

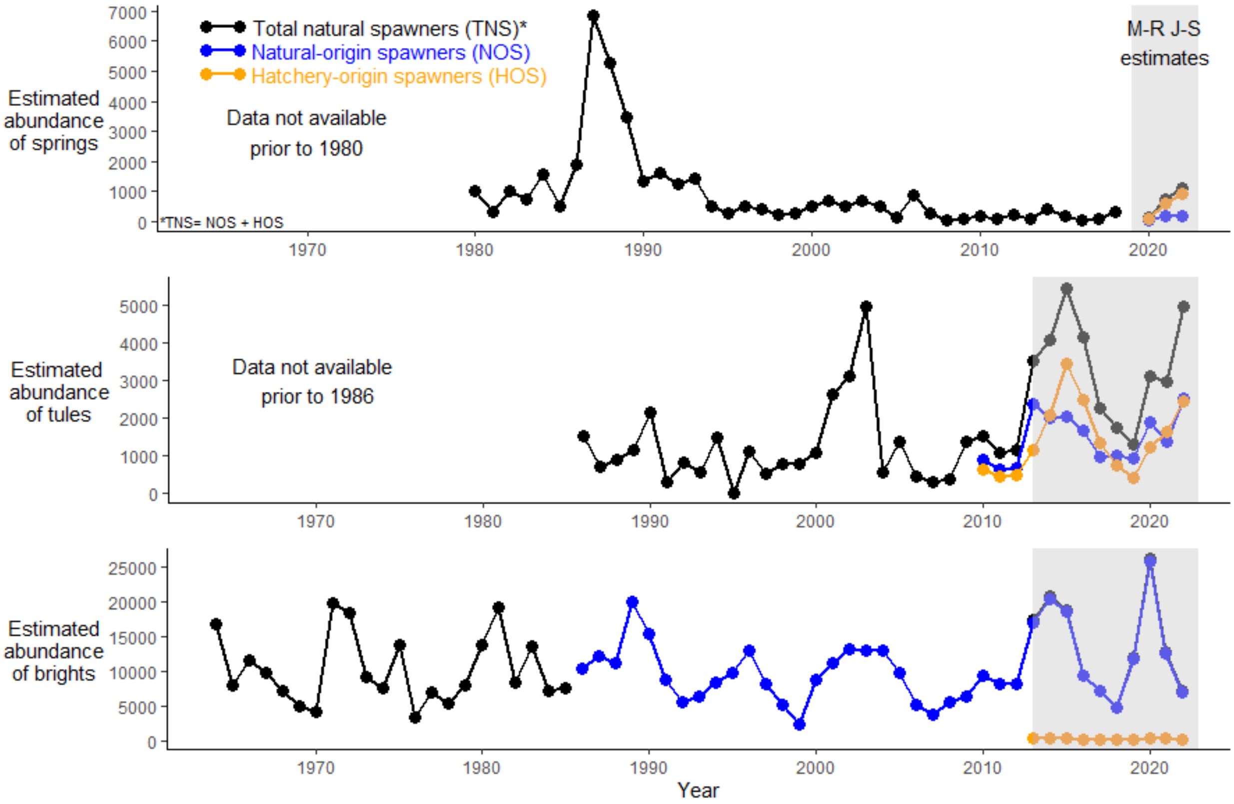

Figure 3. Estimated annual abundance of spring- (top), tule- (middle), and bright-run (bottom) Chinook salmon in the North Fork Lewis River. Total natural spawners (black) are the sum of natural-origin spawners (NOS) and hatchery-origin spawners (HOS). For years in which NOS and HOS abundances were estimated separately, abundances are shown with blue (NOS) and orange (HOS) lines. Mark-recapture Jolly-Seber (M-R J-S) abundance estimates have been used for tules and brights since 2013 (shaded area), and springs since 2020 (details in Bentley et al. 2018). Data were retrieved from WDFW's Salmon Conservation Reporting Engine. Mass marking of Chinook in the lower Columbia was fully implemented and had adults returning in 2010 thereby allowing for NOS and HOS to be differentiated.

Timing and Distribution

Estimates of abundance were generated via a time-stratified model and thus period-specific estimates can be visualized to assess run-timing (**Figure 4**). Because these data are carcass recoveries, as opposed to live spawners, the observed patterns are a function of relative spawner abundance and recovery probability, which is a function of survey conditions and survey effort. Overall, patterns of run-timing are similar to previous years where spring Chinook are present in the NF Lewis from mid-September through early October with peak carcass abundance in late September, tules are present from mid-September through early November with peak carcass abundance in mid-October, and brights are present from late October through January with peak carcass abundance in late November. However, 2022 also had a pulse of tule carcasses collected in early-mid November.

Surveys of live spawners, carcasses, and redds are typically conducted across several weeks corresponding to the peak abundance for each of the three runs. These data have been collected with the intent of monitoring spawning distribution within and among years. For these surveys to be successful, flows must be relatively low (<5,000 CFS) and clarity high. In 2022, there were a total of nine peak count surveys, but these data are not included here.

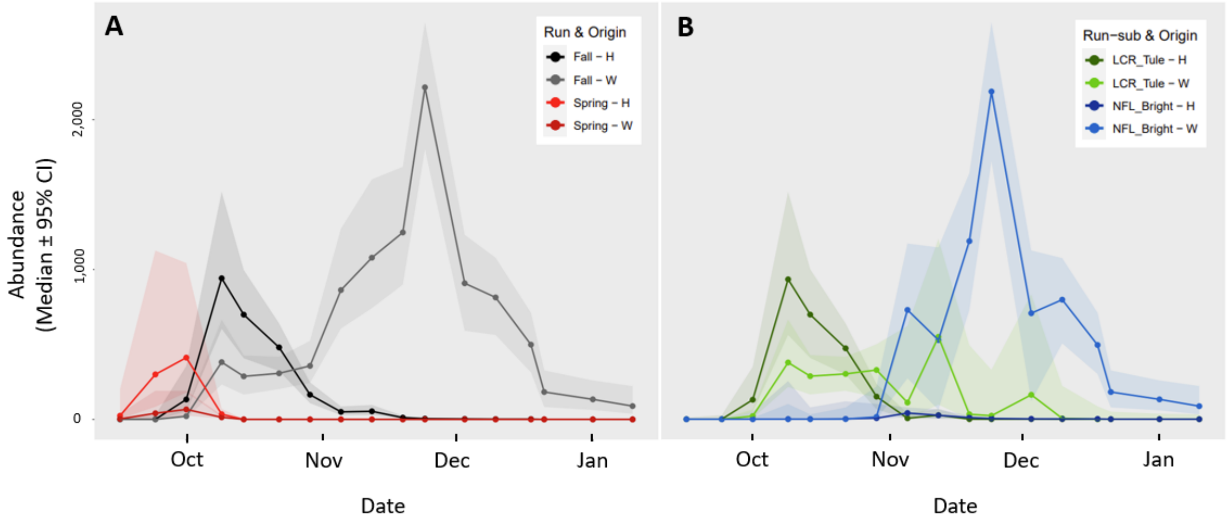

Figure 4. Weekly estimated abundance of A) spring- (red), and fall- (black) run Chinook in the NF Lewis River, 2022, separated by origin and B) the breakdown of tule (green) and bright (blue) runs during the fall-run Chinook season, separated by origin. The relative abundance shown here is based on carcass recoveries and represents the timing of when spawners died.

Assessment and Recommendations

Monitoring efforts in 2022 were carried out without any major setbacks. Estimates of abundance were generated for NF Lewis Chinook via mark-recapture carcass surveys and the composition of the total run was partitioned by population (spring, tule, fall), origin (hatchery, wild), and age using stratified biological data. As discussed in Bentley et al. (2018) and our Spawning Ground Protocol, partitioning the total estimate by population requires the use of visual stock identification (VSI) to differentiate spring- and fall-run Chinook and we use the ratio of CWT recoveries to split tules and brights. Until recently, the low absolute abundance of spring Chinook, and particularly wild-origin adults, and the limited temporal overlap of tules and brights, has caused us to have minimal concerns over the potential bias that may be induced due to violation of assumptions. However, spring Chinook forecasts indicate that the size of this run may continue to increase, due in part to reintroduction efforts above Swift Dam. Likewise, the differentiation of tules and brights relies on many untested assumptions about the structure of these two stocks. WDFW and its partners are currently working to update the genetic baseline for Lower Columbia River Chinook salmon, with the goal of potentially being able to differentiate these stocks using genetic markers. That work is ongoing and has the potential to greatly enhance our understanding of the structure of these populations.

In 2022, as in previous years, the survey crews worked diligently to recover and tag a large absolute number of carcasses in all weeks. However, we continually strive to increase the precision of our estimates by adapting our study design and data collection methods to better align with our understanding of Chinook salmon biology and our observations in the field. Currently, untagged carcasses are not sexed in the field, but are instead partitioned into sex categories (jack, female, male) based on the observed sex ratios of tagged carcasses. This method may have a tendency to mis-estimate the number of jack carcasses collected, as these small carcasses have a low recovery probability, and even more so once they have deteriorated (i.e., are no longer in a taggable condition). The impact of this data collection strategy on the overall accuracy is likely negligible because untagged jack-sized carcasses are rare. However, beginning in 2023, we will assign sex calls (jack or adult) to all carcasses collected in the field, including those that are too degraded to be tagged. This operational change has the double advantage of improving the accuracy of the estimates and also simplifying the data recording and entry process.

The success of the monitoring program for Chinook salmon in lower NF Lewis is a function of a sound study design, the ability to satisfy the assumptions of the estimator, and the high survey effort that routinely results in a large absolute number of carcass recoveries and resights. While in some years high survey effort may result in diminishing returns as it pertains to the precision of the abundance estimates, it also helps ensure model assumptions are met and unbiased estimates with high levels of precision can be reliably generated. Therefore, we recommend that the survey effort showcased in 2022 should be emulated in future years at least until past Bright-eye method (BEM) estimates of abundance are bias-corrected and an alternative estimator is developed that incorporates covariates which may allow the frequency and/or intensity of mark-capture surveys to be reduced (see *Recommendations* in Bentley et al. 2018).

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Appendices

Appendix A – Description of Data Analysis

Carcass survey data were queried from the TWS Access database and ran through a standardized set of summarizations in R (R Core Team 2022) via RStudio (RStudio Team 2022). Briefly, each tagged carcass was first designated as either a jack (i.e., males <60 cm), female, or male (males ≥60) based on field calls and/or associated biological data. Capture histories were then generated for each tagged carcass and mark-recapture (M-R) summary statistics were generated by carcass grouping (jack, female, male) and survey period/week using the R package *RMark* (Laake 2013). Biological data were summarized by carcass grouping and survey period/week where visual-stock identification was used to partition spring- and fall-run carcasses, coded-wire tag (CWT) recoveries were used to partition tule and bright run carcasses, adipose clip and CWT status were paired to identify and partition hatchery- and natural-origin carcasses, and scale-age readings were used to partition carcasses into total age 2 – 6.

Estimates of abundance were generated using the "super-population" Jolly-Seber (JS) estimator that was developed by Schwarz et al. (1993) and Schwarz and Arnason (1996) specifically for estimating salmon spawning escapement using mark-capture methods. The super-population JS model has been previously implemented in a Bayesian framework by WDFW and a comprehensive description of the model, including summary statistics, fundamental parameters, derived parameters, and likelihoods, is provided in Rawding et al. (2014). Previously model selection had compared four versions of this model, each with a time-dependent probability of entry, but with combinations of either time-dependent or constant probabilities of survival and capture. A limitation of this approach was that the model with both time-dependent capture and survival probabilities had a considerably larger parameter count, and therefore greater variance, and could not be implemented without first pooling capture periods (thereby inducing bias) if the raw data lacked sufficient statistics for identifiability without pooling.

To address these limitations, in 2020, we modified the fully time-dependent version of the model (a.k.a. the "*ttt*" model). Specifically, the period-specific probabilities of survival (*phi*) and capture (*p*) were estimated using logit-normal random walks while the probability of entry (*pent*) was estimated via a softmax construction and subject to a simplex constraint where the log-components followed a random walk except for the first period, which by convention is fixed to 0. Additionally, the model was modified so that it could generate separate capture, survival, and entry probabilities for distinct groups of fish (e.g., jack, female, and male salmon), but rather than estimate their parameters entirely independently, it was assumed that temporal evolution in their probabilities of entry, survival, and capture might be correlated. Therefore, the process errors of their random walks were estimated via a multivariate-normal distribution with an inverse Wishart prior, allowing the model to estimate the extent of covariance in parameter evolution among the groups of fish. In contrast to the previous model version, this improved super-population JS model enables estimation of the full-rank time-dependent model regardless of data sparsity by enforcing parsimony through random effects "shrinkage"; probabilities of survival, capture, and entry experience shrinkage by modeling the period-to-period differences in as a random effect (i.e., a random walk model is a random-effects model on first-order differences). Definitions of the data, stochastic parameters, and derived parameters that comprise the model are outlined in Table A-1, Table A-2, and Table A-3, respectively. Model code is shared in Appendix B.

Samples from the posterior distribution were obtained using Markov chain Monte Carlo (MCMC) simulations (Gilks 2005) in JAGS (Plummer 2007) using the R2jags package (Su and Yajima 2021). We ran four chains with 500,000 iterations, a burn-in period of 250,000, and a thinning rate of 250 so that the number of independent samples, as measured by effective sample size (ESS), was approximately 4,000 for each parameter of interest. Initial values for each chain were automatically generated within the JAGS package. Modeled convergence was assessed in the same manner as the JS models (i.e., assessment of ESS and BGR statistics).

Table A-1. Notation and definition of data used in the updated Jolly-Seber model.

Statistic	Definition
s	number of sample periods (note: each period denoted with an "i"; i = 1, …, s)
num_strata	number of carcass groupings (note: each grouping denoted with a "k"; k = 1, …, num_strata)
$time_i$	Amount of time (e.g., days) between subsequent periods (e.g., $time_i$ = time between $period_{i+1}$ and $period_i$); length of $time_i$ = s-1
$u_{i, k}$	number of carcasses that were handled per period that were unmarked (i.e., maiden captures)
$m_{i, k}$	number of carcasses that were handled per period that were previously marked (i.e., recaptures)
$n_{i, k}$	total number of carcasses that were handled per period (i.e., n = m + u)
$R_{i, k}$	number of carcasses that were marked and released back into the sample area per period (i.e., new marks deployed; subset of n)
$r_{i, k}$	Total number of marked carcasses from each specific period that were subsequently recaptured in any period after release (i.e., number of "R" that are recaptured)
$T_{i, k}$	number of previously marked carcasses that are recaptured during or after a given period (T = m + z; z = number of previously marked carcasses that are recaptured after
$uTot_k$	total number of unmarked carcasses handled across all sample periods (i.e., sum of "u")
ex_tule_i	number of examined carcasses that were tules by period (note: current parameterization does NOT split up race bio-data by "strata" - not enough data)
ex_race_i	number of carcasses examined for race by period (note: current parameterization does NOT split up race bio-data by "strata" - not enough data)
$ex\_clip_{i,k}$	number of examined carcasses that were adipose clipped by period
$ex\_adfin_{i,k}$	number of carcasses examined for adipose clip status by period
$age\_dat_{i,k,1:num\_ages}$	number of examined carcasses by age and period
$age\_tot_{i,k}$	number of carcasses with a specified (read) age by period
num_ages	Number of age groups

Table A-2. Notation and definition of stochastic (a.k.a. fundamental) parameters used in the updated Jolly-Seber model.

Parameter	Definition
inv_Sigma_p	prior on process error variance/covariance matrix for p
inv_Sigma_phi	prior on process error variance/covariance matrix for phi
inv_Sigma_pent	prior on process error variance/covariance matrix for pent
$logit\_p_{1,k}$	prior on p (probability of capture) in the first period
$logit\_phi_{1,k}$	prior on phi (probability of survival) in the first period
$log\_delta_{1,k}$	prior on delta (probability of entry) in the first period
$logit\_p_{i,k}$	prior on p for periods 2:s
$logit\_phi_{i,k}$	prior on phi for periods 2:s
$log\_delta_{i,k}$	prior on delta for periods 2:s
$sigma\_lambda_k$	prior on shape and rate parameters for gamma distribution prior on total abundance (note: shape = rate = sigma_lambda^-2)
$v_{i,k}$	probability that a carcass that was handled in a given period will be marked and re-released back into the sample area
$Ntot_k$	continuous total abundance
$Nsuper_k$	discrete total abundance
inv_Sigma_pclip	prior on process error variance/covariance matrix for pclip
$logit\_ptule_1$	prior on ptule (portion of carcasses that were tule) in the first period
$logit\_pclip_{1,k}$	prior on pclip (portion of carcasses that were clipped) in the first period
$log\_delta\_age_{1,k,a}$	prior on delta_age (age distribution of carcasses) in the first period
$logit\_ptule_i$	prior on ptule for periods 2:s
$logit\_pclip_{i,k}$	prior on pclip for periods 2:s
$log\_delta\_age_{i,k,a}$	prior on delta_age for periods 2:s
$sigma\_ptule_i$	process error standard deviation for ptule
$sigma\_p.age$	process error standard deviation for p.age

Table A-3. Notation and definition of derived parameters used in the updated Jolly-Seber model.

Parameter	Definition
$p_{i,k}$	probability that a carcass will be handled (i.e., captured) for a given period given that it is in the sample area
$phi_{i,k}$	probability that a carcass that is in the sample area for given period will remain (i.e., survive) in the sample area until the following sample period
$pent_{i,k}$	probability that a carcass enters the sample area between subsequent periods (i.e., the fraction of the total number of carcasses that enter the sample area between each period)
$psi_{i,k}$	probability that a carcass enters the sample area, is still available for capture, and is not seen before a specific period; $psi_{1,k}$ = $pent_{1,k}$
$lambda_{i,k}$	probability that a carcass that has been captured will be captured again (i.e., recaptured); $lambda_{s,k}$ = 0
$Bstar_{i,k}$	number of carcasses that enter the sample area between two subsequent sample periods (note: these include animals that enter and "leave" before the next sampling period)
$delta_{i,k}$	odds of entering in period
$temp_{i,k}$	probability of recovery = probability of survival ($phi_{i,k}$) X probability of capture ($p_{i,k}$)
$psiPtot_{k}$	overall probability of recovery a carcass in the sample area across all periods
$multP_{i,k}$	proportion of maiden captures in each period
$tau_{i,k}$	conditional probability that a carcass is recaptured during a specific period given that it was recaptured at or after that sampled period
$Sigma\_p_{k,k}$	Covariance matrix for p process errors; Inverse of "inv_sigma_p"
$Sigma\_phi_{k,k}$	Covariance matrix for phi process errors; Inverse of "inv_sigma_phi"
$Sigma\_pent_{k,k}$	Covariance matrix for pent process errors; Inverse of "inv_sigma_pent"
$sigma\_p\_process_{k}$	process error standard deviation for p
$sigma\_phi\_process_{k}$	process error standard deviation for phi
$sigma\_pent\_process_{k}$	process error standard deviation for pent
$rho\_p_{k,k}$	among strata process error correlation in p
$rho\_phi_{k,k}$	among strata process error correlation in phi
$rho\_pent_{k,k}$	among strata process error correlation in pent
$ptule_{i}$	proportion of total abundance that was of the run type tule (opposed to bright) by period
$pclip_{i,k}$	proportion of total abundance that was adipose clipped (opposed to UM - adipose intact) by period
$p.age_{i,k,a}$	proportion of total abundance that was of age "a" by period
$Sigma\_pclip_{k,k}$	Covariance matrix for the "pclip" process errors; Inverse of "inv_sigma_p"
$Sigma\_pclip\_process_{k}$	process error standard deviation for pclip
$rho\_pclip_{k,k}$	among strata process error correlation in pclip
$delta\_age_{i,k,a}$	odds of the age distribution in carcasses' by period

Appendix B – Code for the Multivariate, Random-Walk Mark-Recapture Jolly-Seber Model

```
model{
#-----------------------
#Derived parameters
#-----------------------
Sigma_p<-inverse(inv_Sigma_p)
Sigma_phi<-inverse(inv_Sigma_phi)
Sigma_pent<-inverse(inv_Sigma_pent)
for(k in 1:num_strata){
  pent[1,k]<-1/(1+sum(delta[1:(s-1),k]))
  psi[1,k]<-pent[1,k]
  lambda[s,k] <- 0
  psiPtot[k] <- sum(temp[1:s,k])
  Bstar[1:s,k] ~ dmulti(pent[1:s,k], Nsuper[k])
  for (i in 1:(s-1)){
    phi[i,k] <- ilogit(logit_phi[i,k]) ^ time[i]
    delta[i,k]<-exp(log_delta[i,k]) * time[i]
    psi[i+1,k] <- psi[i,k]*(1-p[i,k])*phi[i,k] + pent[i+1,k] *(phi[i,k]-1)/log(phi[i,k])
    lambda[i,k] <- phi[i,k]*(p[i+1,k]+(1-p[i+1,k])*lambda[i+1,k])
  }
  for(i in 2:s){
    pent[i,k]<-delta[i-1,k]/(1+sum(delta[1:(s-1),k]))
  }
  for (i in 1:s){
    p[i,k] <- ilogit(logit_p[i,k])
    temp[i,k] <- psi[i,k]*p[i,k]
    multP[i,k] <- temp[i,k]/sum(temp[1:s,k])
    tau[i,k] <-p[i,k]/(p[i,k]+(1-p[i,k])*lambda[i,k])
  }
  #calculate process error variance and correlation matrix
  sigma_phi_process[k] <- sqrt(Sigma_phi[k,k])
  sigma_p_process[k] <- sqrt(Sigma_p[k,k])
  sigma_pent_process[k] <- sqrt(Sigma_pent[k,k])
  for (j in 1:num_strata){
    rho_phi[k,j] <- (Sigma_phi[k,j]/(sigma_phi_process[k]*sigma_phi_process[j]))
    rho_p[k,j] <- (Sigma_p[k,j]/(sigma_p_process[k]*sigma_p_process[j]))
    rho_pent[k,j] <- (Sigma_pent[k,j]/(sigma_pent_process[k]*sigma_pent_process[j]))
  }
}
#------
#priors
#------
for(k in 1:num_strata){
  sigma_lambda[k] ~ dt(hyper_value_sigma_lambda_mu, hyper_value_sigma_lambda_sd^-2, 1) T(0,)
  #nuisance variable to detect if n>0
  for (i in 1:s){
    v[i,k] ~ dbeta(hyper_value_beta_v, hyper_value_beta_v)
  }
  #Priors for first states in process model of prob capture, survival, birth:
  logit_phi[1,k] ~ dnorm(hyper_value_logit_phi_1_mu, hyper_value_logit_phi_1_sd^-2)
  logit_p[1,k]   ~ dnorm(hyper_value_logit_p_1_mu,   hyper_value_logit_p_1_sd^-2)
  log_delta[1,k] ~ dnorm(hyper_value_log_delta_1_mu, hyper_value_log_delta_1_sd^-2)
  #priors on abundance
```

```
  Ntot[k] ~ dgamma(sigma_lambda[k]^-2, sigma_lambda[k]^-2)
  Nsuper[k] ~ dpois(Ntot[k])
}
#process model priors
for (i in 2:(s-1)){
  logit_phi[i,1:num_strata] ~ dmnorm(logit_phi[i-1,1:num_strata], inv_Sigma_phi)
  log_delta[i,1:num_strata] ~ dmnorm(log_delta[i-1,1:num_strata], inv_Sigma_pent)#similar to dirichlet
trick except used additive log ratios
}
for(i in 2:s){
  logit_p[i,1:num_strata] ~ dmnorm(logit_p[i-1,1:num_strata], inv_Sigma_p)
}
#priors for process error covariance matrices
inv_Sigma_p    ~ dwish(Rmat[1:num_strata,1:num_strata],num_strata + 1)
inv_Sigma_phi  ~ dwish(Rmat[1:num_strata,1:num_strata],num_strata + 1)
inv_Sigma_pent ~ dwish(Rmat[1:num_strata,1:num_strata],num_strata + 1)
#-----------
#Likelihoods
#-----------
for(k in 1:num_strata){
  uTot[k] ~ dbin(psiPtot[k],Nsuper[k])
  u[1:s, k] ~ dmulti(multP[1:s,k],uTot[k])
  for (i in 1:(s-1)){
    R[i,k] ~ dbin(v[i,k], n[i,k])
    r[i,k] ~ dbin(lambda[i,k],R[i,k])
  }
  for (i in 2:(s-1)){
    m[i,k] ~dbin(tau[i,k],T[i,k])
  }
}
#~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
#         Partition Bstar estimates by proportional data: race, clips, sex and age
#~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
#derived
Sigma_pclip<-inverse(inv_Sigma_pclip)
for(i in 1:s){
    ptule[i] <- ilogit(logit_ptule[i])
    pfall[i] <- ilogit(logit_pfall[i])
}
for(k in 1:num_strata){
sigma_pclip_process[k] <- sqrt(Sigma_pclip[k,k])
  for (j in 1:num_strata){
    rho_pclip[k,j] <- (Sigma_pclip[k,j]/(sigma_pclip_process[k]*sigma_pclip_process[j]))
  }
  for(i in 1:s){
    pclip[i,k] <-ilogit(logit_pclip[i,k])
    for(a in 1:num_ages){
      delta_age[i, k, a] <- exp(log_delta_age[i,k,a])
      p.age[i, k, a] <- delta_age[i,k,a]/sum(delta_age[i,k,1:num_ages])
    }
  }
}
#priors
inv_Sigma_pclip ~ dwish(Rmat[1:num_strata,1:num_strata],num_strata + 1)
```

```
sigma_ptule ~ dt(hyper_value_sigma_ptule_mu,hyper_value_sigma_ptule_sd^-2,1) T(0,)
sigma_pfall ~ dt(hyper_value_sigma_pfall_mu, hyper_value_sigma_pfall_sd^-2,1) T(0,)
sigma_p.age  ~ dt(hyper_value_sigma_p.age_mu,hyper_value_sigma_p.age_sd^-2,1) T(0,)
for(i in 2:s){
  logit_ptule[i] ~ dnorm(logit_ptule[i-1],sigma_ptule^-2)
  logit_pfall[i] ~ dnorm(logit_pfall[i-1],sigma_pfall^-2)
  logit_pclip[i,1:num_strata] ~ dmnorm(logit_pclip[i-1,1:num_strata],inv_Sigma_pclip)
}
logit_ptule[1] ~ dnorm(hyper_value_logit_ptule_1_mu, hyper_value_logit_ptule_1_sd^-2)
logit_pfall[1] ~ dnorm(hyper_value_logit_pfall_1_mu, hyper_value_logit_pfall_1_sd^-2)
for(k in 1:num_strata){
  logit_pclip[1,k] ~ dnorm(hyper_value_logit_pclip_1_mu, hyper_value_logit_pclip_1_sd^-2)
  for(a in 1:num_ages){
    log_delta_age[1, k, a] ~ dnorm(hyper_value_log_delta_age_1_mu,hyper_value_log_delta_age_1_sd^-2)
    for(i in 2:s){
      log_delta_age[i, k, a] ~ dnorm(log_delta_age[i-1, k, a],sigma_p.age^-2)
    }
  }
}
#Likelihoods
for(k in 1:num_strata){
  for(i in 1:s){
    ex_clip[i, k] ~ dbin(pclip[i, k],ex_adfin[i, k])
    age_dat[i, k, 1:num_ages] ~ dmulti(p.age[i, k, 1:num_ages], age_tot[i, k])
}
for(i in 1:s){
    ex_tule[i] ~ dbin(ptule[i], ex_race[i])
    ex_fall[i] ~ dbin(pfall[i], ex_run[i])
}
}
```

Appendix C – Summarized mark-recapture recovery data by carcass grouping

Table C-1. Summary of mark-recapture statistics by date/period for the **jack** carcass grouping in 2022.

Period	Date (mm-dd)	Handled (n_i)	Maidens (u_i)	Tagged (R_i)	Recaptures in a period (m_i)	Recaptures from a release (r_i)	Eventual recaps at large (z_i)	Percent recaptured (r_i/R_i)
1	09/12	0	0	0	0	0	0	-
2	09/20	0	0	0	0	0	0	-
3	09/27	2	2	1	0	0	0	0%
4	10/05	2	2	2	0	0	0	0%
5	10/11	3	3	3	0	1	0	33%
6	10/18	8	7	4	1	0	0	0%
7	10/25	3	3	3	0	1	0	33%
8	11/01	27	26	19	1	0	0	0%
9	11/08	16	16	16	0	3	0	19%
10	11/15	34	32	32	2	12	1	38%
11	11/21	73	65	65	8	14	5	22%
12	11/29	22	14	14	8	6	11	43%
13	12/06	24	10	10	14	1	3	10%
14	12/14	6	2	2	4	0	0	0%
15	12/19	0	0	0	0	0	0	-
16	12/28	0	0	0	0	0	0	-
17	01/06	0	0	0	0	0	0	-
Total	-	220	182	171	38	38	20	22%

Table C-2. Summary of mark-recapture statistics by date/period for the **female** carcass grouping in 2022.

Period	Date (mm-dd)	Handled (n_i)	Maidens (u_i)	Tagged (R_i)	Recaptures in a period (m_i)	Recaptures from a release (r_i)	Eventual recaps at large (z_i)	Percent recaptured (r_i/R_i)
1	09/12	3	3	1	0	0	0	0%
2	09/20	10	10	9	0	0	0	0%
3	09/27	44	44	32	0	8	0	25%
4	10/05	180	177	81	3	42	5	52%
5	10/11	404	370	123	34	49	13	40%
6	10/18	420	361	61	59	19	3	31%
7	10/25	154	137	24	17	6	5	25%
8	11/01	178	168	65	10	20	1	31%
9	11/08	180	168	65	12	27	9	42%
10	11/15	364	335	133	29	81	7	61%
11	11/21	676	616	215	60	135	28	63%
12	11/29	471	384	114	87	65	76	57%
13	12/06	641	543	100	98	44	43	44%
14	12/14	313	253	76	60	23	27	30%
15	12/19	217	173	49	44	9	6	18%
16	12/28	74	60	22	14	5	1	23%
17	01/06	31	25	0	6	0	0	-
Total	-	4,360	3,827	1,170	533	533	224	46%

Table C-3. Summary of mark-recapture statistics by date/period for the **male** carcass grouping in 2022.

Period	Date (mm-dd)	Handled (n_i)	Maidens (u_i)	Tagged (R_i)	Recaptures in a period (m_i)	Recaptures from a release (r_i)	Eventual recaps at large (z_i)	Percent recaptured (r_i/R_i)
1	09-12	2	2	1	0	0	0	0%
2	09-20	13	13	10	0	1	0	10%
3	09-27	36	35	16	1	4	0	25%
4	10-05	148	146	55	2	14	2	25%
5	10-11	197	188	69	9	32	7	46%
6	10-18	283	250	45	33	9	6	20%
7	10-25	122	108	26	14	10	1	38%
8	11-01	159	151	57	8	11	3	19%
9	11-08	131	126	55	5	22	9	40%
10	11-15	252	233	91	19	47	12	52%
11	11-21	528	495	168	33	78	26	46%
12	11-29	238	191	54	47	33	57	61%
13	12-06	392	313	65	79	34	11	52%
14	12-14	148	119	37	29	9	16	24%
15	12-19	76	54	16	22	2	3	13%
16	12-28	13	8	3	5	1	0	33%
17	01-06	9	8	0	1	0	0	-
Total	-	2,747	2,440	768	307	307	153	40%

APPENDIX G –

WDFW Lewis River Hatchery Complex, Operations program report - 2022

WASHINGTON STATE DEPARTMENT OF FISH AND WILDLIFE
FISH PROGRAM
HATCHERIES DIVISION

Washington
Department of
FISH and
WILDLIFE

LEWIS RIVER COMPLEX OPERATIONS
FOR
JANUARY 1, 2022 TO DECEMBER 31, 2022

Funded By
PACIFICORP ENERGY & COWLITZ PUD

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Merwin Hatchery Introduction

The Merwin Hatchery is a PacifiCorp owned and funded facility that is operated by the State of Washington Department of Fish and Wildlife. The facility has been in operation since 1993.

Merwin Hatchery is located 11 miles east of Woodland off state route 503 adjacent to PacifiCorp Merwin Dam and Merwin Reservoir.

Program Goals

- 175,000 summer Steelhead @ 5.5 f/lb planted into N.F. Lewis River
- 100,000 winter Steelhead @ 5.5 f/lb planted into N.F. Lewis River
- 50,000 wild winter Steelhead @ 6-8 f/lb planted into N.F. Lewis River
- 7,000 Rainbow Trout planted into Swift Power Canal
- 45,000 Rainbow Trout transferred to Speelyai Hatchery

Approximately 5000 gallons per minute can be delivered to the hatchery by three intake pumps located on Merwin Dam which draft water from Merwin Reservoir. Two screened intakes located at depths of fifteen and ninety feet below the surface of the reservoir enable some temperature manipulation for fish rearing.

Ozone water sterilization is part of the design criteria to meet fish health needs not only at the hatchery but also for fish stocks and the Lewis River Hatchery downstream of our effluent discharge. Two ozone generators fed by compressed air supply ozone gas to a water/ozone contact chamber. A maximum flow of 3800 gallons per minute can be sterilized and supplied to the hatchery.

There is approximately 216,470 cubic feet of rearing space. These areas consist of four one quarter acre rearing ponds, ten 9.5’ x 80’ x 2.5’ fingerling raceways, four 7.5’ x 33’ x 4’ adult holding ponds, six 4.5’ x 34’ x 2’ intermediate raceway and 15 double stack Mari Source incubation trays.

The hatchery has an operations building housing the office, feed room, shop, lab, day room, locker room and restrooms. Other buildings associated with this facility are hatchery building with attached covered adult holding ponds, water treatment facility including the ozone generator building, one three bay storage building, chemical storage building and three residences.

Brood Stock & Spawning – Merwin Hatchery

During this reporting period, trapping was conducted at the Merwin Dam Fish Collection Facility, Lewis River Hatchery, and the lower river, pending on the species. In the below stocks the carcass distribution line represents surplus fish not needed for program goals and may go to food bank/tribes, nutrient enhancement, or landfill.

2023 Brood Merwin Hatchery Origin Summer Steelhead

A total of 300 adults were received for spawning purposes. All fish were trapped at the Merwin Dam FCF and The Lewis River Ladder. Spawned carcasses, mortality, and surplus fish were disposed by landfill. Disposition is as follows:

Final Trapping & Disposition

Adults Received from FCF	300
Adults Received from Lewis Ladder	0
Adults Spawned	234
Non-viable Females	10
Adult Mortality (5.7%)	17
Adult Carcass Distribution	39

2023 Brood Merwin Hatchery Origin Winter Steelhead

A total of 126 adults were received for spawning purposes. All fish were trapped at the Merwin Dam FCF and Lewis River Hatchery. Spawned carcasses, mortality, and surplus fish were disposed by landfill. Disposition is as follows:

In-Season Trapping & Disposition

Adults Received from FCF	126
Adults Received from Lewis Ladder	0
Adults Spawned	50
Non-viable Females	2
Adult Mortality (0.8%)	1
Adult Carcass Distribution	2

2022 Brood Lewis River Wild Origin Late Winter Steelhead

A total of 46 adults were received for live spawning purposes. These fish were collected at various sites to include Merwin FCF, tangle net fishing in the lower river and Lewis River Hatchery. Mortality and culled fish are disposed by landfill, all live spawned fish were hauled downstream to North Fork Lewis River, at river mile five, Martin's access site. Disposition is as follows:

Final Trapping & Disposition

Adults Received from FCF	46
Adults Spawned	46
Non-viable Females	0
Adult Mortality (2.2%)	1
Males Culled (Hatchery Genetics)	0
Females Culled (Hatchery Genetics)	0
Adults Planted Downstream	45

2022 Brood Lewis River Hatchery Origin Late Winter Steelhead

A total of 8 adults were received for live spawning purposes. These fish were collected at various sites to include Merwin FCF, tangle net fishing in the lower river and Lewis River Hatchery. Mortality and culled fish are disposed by landfill, all live spawned fish were hauled downstream to North Fork Lewis River, at river mile five, Martin's access site. Disposition is as follows:

Final Trapping & Disposition

Adults Received from FCF	8
Adults Spawned	8
Non-viable Females	0
Adult Mortality (0.0%)	0
Males Culled (Hatchery Genetics)	0
Females Culled (Hatchery Genetics)	0
Adults Planted Downstream	8

Adult Trapping – Merwin Dam FCF

2022 Brood Lewis River Hatchery Origin Spring Chinook

The first spring chinook was trapped at the Merwin FCF on February 28, 2022. Spring chinook are planted in the upper watershed of North Fork Lewis River, hauled to Speelyai Hatchery for brood, and donated to food banks / tribes. Mortality is disposed by landfill.

Final Trapping & Disposition

Adults Trapped	3,990
Jacks Trapped	439
Adult Mortality (0.0%)	0
Jack Mortality (0.0%)	0
Adults Planted Upstream	2,451
Jacks Planted Upstream	251
Males Shipped	798
Females Shipped	722
Jacks Shipped	56
Adults Carcass Distribution	19
Jacks Carcass Distribution	132

2022 Brood Lewis River Wild Origin Spring Chinook

The first wild spring chinook returned to the FCF on February 13, 2022. This stock is planted in the upper watershed of North Fork Lewis River. All Mortality is disposed by landfill.

Final Trapping & Disposition

Adults Trapped	518
Jacks Trapped	10
Adult Mortality (0.0%)	0
Jack Mortality (0.0%)	0
Adults Planted Upstream	518
Jacks Planted Upstream	10

2022 Brood Hatchery Unknown Origin Fall Chinook

This first arrival of unknown hatchery origin fall chinook was August 25, 2022. This unknown origin hatchery stock is surplus to food banks and tribes. Mortality can be disposed by landfill or donated to American Canadian Fisheries.

Final Trapping & Disposition

Adults Trapped	222
Jacks Trapped	24
Adult Mortality (2.3%)	5
Jack Mortality (0.0%)	0
Adult Carcass Distribution	217
Jack Carcass Distribution	24

2022 Brood Lewis River Wild Origin Fall Chinook

Lewis River Wild Origin Fall Chinook first arrived at Merwin FCF on August 15, 2022. This stock is planted downstream to North Fork Lewis River, river mile 5 at Martin's access site. All mortality is disposed by landfill.

Final Trapping & Disposition

Adults Trapped	92
Jacks Trapped	47
Adult Mortality (0.0%)	0
Jack Mortality (0.0%)	0
Adults Planted Downstream	92
Jacks Planted Downstream	47

2022 Brood Lewis River Hatchery Origin (Type S) Early Coho

On August 11, 2022, the first hatchery origin early Coho showed up to Merwin FCF. This stock is planted upstream to North Fork Lewis River, shipped to Speelyai Hatchery for brood, and surplus to food banks / tribes. Low grade quality surplus carcasses and mortality are used for nutrient enhancement, donated to American Canadian Fisheries and or disposed by landfill.

Final Trapping & Disposition

Adults Trapped	18,501
Jacks Trapped	1,330
Adult Mortality (6.4%)	1,176
Jack Mortality (9.4%)	125
Adults Planted Upstream	4,483
Jacks Planted Upstream	0
Adults Shipped	0
Jacks Shipped	0
Adult Carcass Distribution	12,842
Jack Carcass Distribution	1,205

2022 Brood Lewis River Wild Origin (Type S) Early Coho

This stock first arrived at Merwin FCF on August 15, 2022. These fish are planted upstream to the North Fork Lewis River at Eagle Creek site. Mortality is disposed by landfill.

Final Trapping & Disposition

Adults Trapped	1,857
Jacks Trapped	234
Adult Mortality (0.9%)	11
Jacks Mortality (0.0%)	0
Adults Planted Upstream	1,846
Jacks Planted Upstream	234

2022 Brood Lewis River Hatchery Origin (Type N) Late Coho

The first hatchery origin late Coho was trapped at the Merwin FCF on October 18, 2022. These fish are planted upstream to the North Fork Lewis River at Eagle Creek site, shipped to Lewis River Hatchery for brood stock, and surplus to food banks / tribes. Low grade carcasses and mortality can be used for nutrient enhancement, donated to American Canadian Fisheries, or disposed by landfill.

In-Season Trapping & Disposition

Adults Trapped	10,860
Jacks Trapped	594
Adult Mortality (8.7%)	948
Jack Mortality (3.7%)	22
Adults Planted Upstream	3,065
Jacks Planted Upstream	0
Adults Shipped to Lewis River	0
Adult Carcass Distribution	6,847
Jacks Carcass Distribution	572

2022 Brood Lewis River Wild Origin (Type N) Late Coho

The first returning wild origin late Coho to Merwin FCF was on October 18, 2022. This stock is planted upstream to the North Fork Lewis River at Eagle Creek site and shipped to Lewis River Hatchery for an intergraded brood stock. Mortality is disposed by landfill.

In-Season Trapping & Disposition

Adults Trapped	1,190
Jacks Trapped	138
Adult Mortality (0.0%)	0
Jack Mortality (0.0%)	0
Adults Planted Upstream	1,150
Jacks Planted Upstream	137
Adults Shipped to Lewis River	40
Jacks Shipped to Lewis River	1

2021 Brood Lewis River Hatchery Origin (Type N) Late Coho

The first late hatchery origin Coho was trapped at the Merwin FCF on October 13, 2021. Adult late Coho are planted upstream to North Fork Lewis River at Eagle Creek sit, shipped to Lewis River Hatchery for brood, and surplus to food banks / tribes. Low grade carcasses and mortality can be used for nutrient enhancement, donated to American Canadian Fisheries, or disposed by landfill.

Final Trapping & Disposition

Adults Trapped	4,837
Jacks Trapped	1,161
Adult Mortality (8.3%)	402
Jack Mortality (3.4%)	39
Adults Planted Upstream	1,991
Jacks Planted Upstream	0
Adults Shipped to Lewis River	0
Jacks Shipped to Lewis River	0
Adult Carcass Distribution	2,444
Jacks Carcass Distribution	1,122

2021 Brood Lewis River Wild Origin Late Coho

The first wild origin late Coho was trapped at Merwin FCF on October 19, 2021. Wild late Coho are shipped to Lewis River Hatchery for an integrated brood stock and planted upstream to North Fork Lewis River at Eagle Creek Site. Mortality is disposed by landfill.

Final Trapping & Disposition

Adults Trapped	884
Jacks Trapped	85
Adults Mortality (0.13%)	0
Jack Mortality	0
Adults Planted Upstream	884
Jacks Planted Upstream	85
Adults Shipped to Lewis River	0
Jacks Shipped to Lewis River	1

2023 Brood Merwin Hatchery Origin Summer Steelhead

The first Merwin Hatchery origin summer steelhead was trapped at Merwin FCF on May 13, 2022. Summer steelhead are shipped for brood to Merwin Hatchery, hauled downstream to river mile 5 on the North Fork Lewis River at Martin's access site to enhance sport fisheries, and surplus to food banks / tribes. Mortality is disposed by landfill.

Final Trapping &Disposition

Adults Trapped	3,382
Adults Mortality (0.2%)	8
Adults Recycled Downstream	1,078
Adults Shipped to Merwin	300
Adult Carcass Distribution	1,996

2023 Brood Lewis River Wild Origin Summer Steelhead

The first Lewis River wild origin summer steelhead was collected at Merwin FCF on June 6, 2022. This stock is planted downstream to the North Fork Lewis River, river mile 5 at Martin's access site. Mortality is disposed by landfill.

Final Trapping and Disposition

Adults Trapped	10
Adult Mortality (0.0%)	0
Adults Planted Downstream	10

2022 Brood Merwin Hatchery Origin Winter Steelhead

This stock began returning last period and the first winter steelhead was trapped at Merwin FCF on November 30, 2021, and the last was trapped on April 28, 2022. Merwin Hatchery origin winter steelhead are shipped for brood to Merwin Hatchery, planted to Horseshoe Lake (Cowlitz County) to enhance sport fisheries, and surplus to food banks / tribes. Mortality is disposed by landfill.

Final Trapping & Disposition

Adults Trapped	1,524
Adult Mortality (7.7%)	118
Adults Planted to Horseshoe Lake	151
Adults Shipped to Merwin	262
Adult Carcass Distribution	993

2023 Brood Merwin Hatchery Origin Winter Steelhead

The first winter steelhead arrived at the Merwin FCF on November 16, 2022. Merwin Hatchery origin winter steelhead are shipped for brood to Merwin Hatchery, planted into Horseshoe Lake (Cowlitz County) to enhance sport fisheries, and surplus to food banks / tribes. Mortality is disposed by landfill.

In-season Trapping & Disposition

Adults Trapped	897
Adult Mortality (1.3%)	12
Adults Shipped to Merwin	126
Adult Carcass Distribution	759

2022 Brood Lewis River Late Winter Hatchery Origin Steelhead

This stock is a result of live spawning wild winter Steelhead brood stock at Merwin Hatchery. The adult wild steelhead were collected from the Merwin FCF, tangle netting in the lower river and Lewis River Hatchery. These fish are reared at Merwin Hatchery and blank wire tagged as juveniles. Upon return as adults, they are transported upstream by PacifiCorp staff as part of a supplementation project or shipped to Merwin Hatchery for broodstock. No fish were hauled downstream this season for trapping efficiency study. The first arrival at Merwin FCF was on December 9, 2021, and the last was trapped on June 10, 2022. All upstream fish are planted on the North Fork Lewis River at Eagle Creek site. Mortality is disposed by landfill.

Final Trapping & Disposition

Adults Trapped	464
Adult Mortality (0.0%)	0
Adults Planted Upstream	456
Adults Planted Downstream	0
Adults Shipped to Merwin	8

2023 Brood Lewis River Wild Origin Late Winter Steelhead

The first wild origin late-winter steelhead was trapped at Merwin FCF on November 1, 2022. Wild origin late winter steelhead are planted upstream, downstream, and shipped to Merwin Hatchery for brood stock. Upstream adults are planted on the North Fork Lewis River at Eagle Creek site. Mortality is disposed by landfill.

In-season Trapping & Disposition

Adults Trapped	12
Adult Mortality (0.0%)	0
Adults Planted Upstream	11
Adults Planted Downstream	3

2022 Brood Lewis River Wild Origin Late Winter Steelhead

This stock began returning last period and the first adult retuned to Merwin FCF on November 24, 2021. Wild late-winter steelhead can be trapped at the FCF or tangle netted on the Lewis River. Wild late-winter steelhead are planted upstream / downstream, shipped for brood to Merwin Hatchery. Returning downstream planted adults were planted upstream after trapped. Upstream fish are planted on the North Fork Lewis River at the Eagle Creek site. Mortality is disposed by landfill.

Final Trapping & Disposition

Adults trapped	172
Adult Mortality (0.0%)	0
Adults Planted Upstream	125
Adults Planted Downstream	1
Adults Recaptured & Planted Upstream	1
Total Adults Planted Upstream	126
Adults Shipped to Merwin	46

2023 Brood Lewis River Late Winter Hatchery Origin Steelhead

This stock is a result of live spawning wild winter Steelhead brood stock at Merwin Hatchery. The adult wild steelhead were collected from the Merwin FCF, tangle netting in the lower river and Lewis River Hatchery. These fish are reared at Merwin Hatchery and blank wire tagged as juveniles. Upon return as adults, they are transported upstream by PacifiCorp staff as part of a supplementation project or shipped to Merwin Hatchery for broodstock. No fish were hauled downstream this season for trapping efficiency study. The first arrival at Merwin FCF was on December 10, 2022. All upstream fish are planted on the North Fork Lewis River at Eagle Creek site. Mortality is disposed by landfill.

In-season Trapping & Disposition

Adults Trapped	4
Adult Mortality (0.0%)	0
Adults Planted Upstream	4
Adults Planted Downstream	0
Adults Shipped to Merwin	0

INCIDENTAL TRAPPING

2022 Brood Unknown Stock & Wild Origin Sockeye

The first unknown origin wild sockeye returned to the Merwin FCF on June 29, 2022. This stock is planted downstream on the North Fork Lewis River at Martin's access site. Mortality is disposed by landfill.

Final Trapping & Disposition

Adults Trapped	12
Mortality (0.0%)	0
Adults Planted Downstream	12

2022 Brood Lewis River Wild Origin Chum

The first Lewis River wild origin Chum salmon was trapped at the Merwin FCF on August 1, 2022. This stock is planted downstream on the North Fork Lewis River at Martin's access site. Mortality is disposed by landfill.

Final Trapping & Disposition

Adults Trapped	3
Mortality (0.0%)	0
Adults Planted Downstream	3

2022 Brood Lewis River Wild Origin Pink

No Lewis River wild origin Pink salmon were trapped this year at the Merwin FCF. This stock is planted downstream on the North Fork Lewis River at Martin's access site. Mortality is disposed by landfill.

Final Trapping & Disposition

Adults Trapped	0
Mortality (0.0%)	0
Adults Planted Downstream	0

2022 Brood Lewis River Wild Origin Anadromous Coastal Cutthroat

The first returning wild origin anadromous coastal cutthroat was collected at the Merwin FCF on March 6, 2021 and the last was on December 22, 2021. These fish are planted upstream on the North Fork Lewis River at Eagle Creek access site. Mortality is disposed by landfill.

Final Trapping & Disposition

Adults Trapped	147
Adult Mortality (0.0%)	0
Adults Planted Upstream	147

2023 Brood Lewis River Wild Origin Anadromous Coastal Cutthroat

The first trapped wild origin anadromous coastal cutthroat was collected at the Merwin FCF on March 4, 2022. These fish are planted upstream on the North Fork Lewis River at Eagle Creek access site. Mortality is disposed by landfill.

In-Season Trapping & Disposition

Adults Trapped	96
Adult Mortality (0.0%)	0
Adult Planted Upstream	96

	CK:SP:LEHA:22:H			CK:SP:LEWI:22:W			CK:FA:UNKN:22:H			CK:FA:LEWI:21:W		
	M	F	J	M	F	J	M	F	J	M	F	J
Planted Downstream										51	41	47
Recycled Fish Trapped												
Planted Upstream	1379	1072	251	315	203	10						
Shipped	798	722	56									
Mortalities							2	3				
Carcass Distribution	19		132				99	118	24			
Total	**2196**	**1794**	**439**	**315**	**203**	**10**	**101**	**121**	**24**	**51**	**41**	**47**

	CO:SO:LEHA:22:H			CO:SO:LEWI:22:W			CO:NO:LEWI:22:H			CO:NO:LEWI:22:W		
	M	F	J	M	F	J	M	F	J	M	F	J
Planted Downstream												
Recycled Fish Trapped												
Planted Upstream	2064	2419		912	934	234	1386	1679		581	569	137
Shipped										25	15	1
Mortalities	485	691	125				356	592	22			
Carcass Distribution	6540	6302	1205				3347	3500	572			
Total	**9089**	**9412**	**1330**	**912**	**934**	**234**	**5089**	**5771**	**594**	**606**	**584**	**138**

	CO:NO:LEWI:21:H			CO:NO:LEWI:21:W		
	M	F	J	M	F	J
Planted Downstream						
Recycled Fish Trapped						
Planted Upstream	762	1229		458	426	85
Shipped						
Mortalities	157	245	39			
Carcass Distribution	1433	1011	1122			
Total	**2352**	**2485**	**1161**	**458**	**426**	**85**

	SH:SU:MEHA:23:H			SH:SU:LEWI:23:W		
	M	F	J	M	F	J
Planted Downstream	320	758		2	8	
Recycled Fish Trapped						
Planted Upstream						
Shipped	141	159				
Mortalities	3	5				
Carcass Distribution	754	1242				
Total	**1218**	**2164**	**0**	**2**	**8**	**0**

	SH:WI:MEHA:22:H			SH:WI:MEHA:23:H		
	M	F	J	M	F	J
Planted Downstream						
Recycled Fish Trapped						
Planted Upstream						
Shipped	161	101		63	63	
Mortalities	56	62		2	10	
Carcass Distribution	665	328		363	396	
Planted Horseshoe Lake	91	60				
Total	**973**	**551**	**0**	**428**	**469**	**0**

	SH:WL:LEWI:22:H			SH:WL:LEWI:22:W			SH:WL:LEWI:23:W			SH:WL:LEWI:23:H		
	M	F	J	M	F	J	M	F	J	M	F	J
Planted Downstream				1								
Recycled Fish Trapped				1								
Planted Upstream	305	151		62	63		6	6		4		
Shipped	8			22	24							
Mortalities												
Carcass Distribution												
Total	**313**	**151**	**0**	**85**	**87**	**0**	**6**	**6**	**0**	**4**	**0**	**0**

	PK:OD:UNKN:22:W			CH:NA:LEWI:22:W			CT:AC:LEWI:22:W			CT:AC:LEWI:23:W		
	M	F	J	M	F	J	M	F	J	M	F	J
Planted Downstream				3								
Recycled Fish Trapped												
Planted Upstream							147			95	1	
Shipped												
Mortalities												
Carcass Distribution												
Total	**0**	**0**	**0**	**3**	**0**	**0**	**147**	**0**	**0**	**95**	**1**	**0**

	SO:NA:UNKN:22:W		
	M	F	J
Planted Downstream	11	1	
Recycled Fish Trapped			
Planted Upstream			
Shipped			
Mortalities			
Carcass Distribution			
Total	**11**	**1**	**0**

Incubation Summary

2022 Brood Goldendale Rainbow

Merwin Hatchery received 85,100 eyed eggs from Goldendale Hatchery on December 7, 2022.

2023 Brood Lewis River Summer Steelhead

The first eggs were taken on November 22, 2021. Disposition of this stock to date is as follows:

Estimated Green Egg take	479,700
Eyed Eggs After Inventory	515,782
Egg Loss (27.5%)	142,015
Eggs Culled	57,043
Fecundity	4,408
Eyed Eggs on Hand	373,767

2023 Brood Lewis River Winter Steelhead

The first eggs were taken on December 29, 2022. Disposition of this stock to date is as follows:

Estimated Total Egg Take	189,200
Estimated Fecundity	4,400

2022 Brood Lewis River Winter Steelhead

The first eggs were taken on December 27, 2021 and finalized on January 10, 2022. Disposition of this stock to date is as follows:

Estimated Green Egg Take	184,800
Eyed Eggs After Inventory	160,987
Egg Loss (6.7%)	10,859
Eggs Culled	29,654
Fecundity	3,833
Eyed Eggs on Hand	120,474

2022 Brood Lewis River Wild Winter Steelhead

These fish were spawned from April 1, 2022, to June 2, 2022. Disposition is as follows.

Estimated Green Egg Take	73,861
Eyed Eggs After Inventory	78,078
Egg Loss (16.9%)	13,188
Fecundity	3,253
Eyed Eggs on Hand	64,890

Rearing Summary

2021 Brood Lewis River Summer Steelhead

The overall rearing of this brood went a well and program goals were achieved for Merwin Hatchery. However, due to disease, 11,249 juveniles @ 13.7 f/lb totaling 821 lbs. were shipped from Skamania Hatchery on November 4, 2021, to achieve Echo Net Pen plant goals. During this rearing cycle, these fish were diagnosed with ichthyopthirius and gill disease. They were therapeutically treated accordingly with higher-than-average loss. Hatchery staff began releasing the fish on station in April 2022. All these fish were trucked and planted at river mile five on the North Fork Lewis River or released from Echo Net Pens.

Final Stock Inventory

Fry Ponded	271,121
Fry Pounds Ponded	108
Juveniles Shipped	61,300
Juvenile Pounds Shipped (7.1 f/lb)	8,634
Smolts Planted	179,991
Smolt Pounds Planted @ Release (5.5 f/lb)	32,726
Rearing Mortality (18.4%)	50,013
Feed Fed (lbs.)	39,789
Net Gain (lbs.)	41,252
Feed Conversion	0.96
Average CV @ Release	7.80

2021 Brood Lewis River Summer Steelhead @ Echo Net Pens

Final Stock Inventory

Juveniles Shipped	61,300
Juvenile Pounds Shipped (7.1f/lb)	8,634
Smolts Planted	61,300
Smolt Pounds Planted @ Release (5.6 f/lb)	10,946
Rearing Mortality (0.0%)	0
Feed Fed (lbs.)	1,760
Net Gain (lbs.)	2,312
Feed Conversion	0.76
Average CV @ Release	8.77

2021 Brood Lewis River Winter Steelhead

The overall rearing of this brood has gone exceptional, and program goals were achieved. During this rearing cycle, these fish were diagnosed with ichthyopthirius. They were therapeutically treated accordingly with average loss. Hatchery staff began releasing the fish on station in April 2022. All these fish were trucked and planted at river mile five on the North Fork Lewis River.

Final Stock Inventory

Fry Ponded	119,295
Fry Pounds Ponded	48
Juveniles Shipped	0
Juvenile Pounds Shipped	0
Smolts Planted	102,812
Smolt Pounds Planted @ Release (5.4f/lb)	19,037
Rearing Mortality (6.3%)	7,552
Feed Fed (lbs.)	19,812
Net Gain (lbs.)	18,989
Feed Conversion	1.04
Average CV @ Release	6.10

2021 Brood Lewis River Wild Winter Steelhead

The overall rearing of this brood has well, and programs goals were achieved. During this rearing cycle, these fish were diagnosed with ichthyopthirius. They were therapeutically treated accordingly with average loss. Hatchery staff began releasing these fish in May 2022. All volitional release fish were planted at the Merwin Boat Launch on NF Lewis River, the remaining forced out fish were planted at Martin Access downstream at river mile five on the NF Lewis River.

Final Stock Inventory

Fry Ponded	104,393
Fry Pounds Ponded	42
Juveniles Shipped	0
Juvenile Pounds Shipped	0
Smolts Planted	63,275
Smolt Pounds Planted @ Release (8.8f/lb)	7,190
Rearing Mortality (32.9%)	34,314
Unfed Fry Plant	0
Feed Fed (lbs.)	6,661
Net Gain (lbs.)	7,148
Feed Conversion	0.93
Average CV @ Release	7.75

2022 Brood Lewis River Summer Steelhead

The rearing of this brood has been okay this period. During this rearing cycle this stock was diagnosed with ichthyopthirius and minor gill disease. These fish were therapeutically treated accordingly with higher-than-average loss. Rearing vessel RP-11 and will be shipped to Echo Net Pen site in March 2022. Hatchery staff will begin planting the remaining fish on station to Martin Access downstream at river mile five on the North Fork Lewis River starting April 2023.

Stock Inventory This Period

Fry Ponded	295,132
Fry Pounds Ponded	118
Juveniles On-Hand	235,732
Juvenile Pounds (9.0f/lb)	26,192
Rearing Mortality (14.6%)	42,998
Feed Fed (lbs.)	22,101
Net Gain (lbs.)	26,074
Feed Conversion	0.85

2022 Brood Lewis River Winter Steelhead

The rearing cycle for this stock has been okay this period with higher-than-average rearing loss inside the incubation room due to pin head dropouts. These fish were diagnosed with ichthyopthirius and therapeutically treated with little to no mortality. Hatchery staff will begin planted this stock to Martin Access downstream at river mile five of the North Fork Lewis River on April 2023.

Stock Inventory This Period

Fry Ponded	119,074
Fry Pounds Ponded	48
Juveniles On-Hand	100,403
Juvenile Pounds (8.7f/lb)	11,541
Rearing Mortality (30.3%)	36,081
Feed Fed (lbs.)	7,384
Net Gain (lbs.)	11,493
Feed Conversion	0.64

2022 Brood Lewis River Wild Winter Steelhead

The overall rearing of this brood has gone well with some early rearing issues. We experienced higher than average loss at ponding. Some orifice plugging may have contributed to this issue. During this rearing cycle, these fish were also diagnosed with ichthyopthirius. They were therapeutically treated accordingly with average loss. Hatchery staff will began releasing these fish in May 2023.

Stock Inventory This Period

Fry Ponded	63,765
Fry Pounds Ponded	26
Juveniles On-Hand	53,825
Juvenile Pounds (17.4f/lb)	3,093
Rearing Mortality (13.0%)	8,297
Feed Fed (lbs.)	2,692
Net Gain (lbs.)	3,067
Feed Conversion	0.88

2021 Brood Goldendale Rainbow

The rearing cycle of this stock has been great. We received 85,245 eyed eggs from Goldendale Hatchery in December 2021. This year, these fish were diagnosed with ichthyopthirius and therapeutically treated accordingly with little to no mortality. 47,142 fish @ 14.3 f/lb and totaling 3,297 pounds were shipped to Speelyai Hatchery on November 1, 2022. They are to be planted as part of Speelyai' s program goal to Swift Reservoir / Power Canal in 2023. The stocking plan for this stock is as follows: Merwin Hatchery will plant to Swift Power Canal in 2022; 3,500 @ 2.5 f/lb in April; 2,100 @ 1.5 f/lb in May, and 1,400 @ 1.0 f/lb in June. This will total 4,200 pounds. Merwin Hatchery will also retain 1,500 fish for MSKD in July 2023, 1,500 fish for the Forest Service Derby held at Merwin Park in June 2023, and 2,000 fish for MSKD in July 2023.

Stock Inventory This Period

Fry Ponded	80,445
Fry Pounds Ponded	23
Fish Planted	0
Fish Transferred	47,142
Pounds Transferred (14.3f/lb)	3,297
Rearing Mortality (17.5%)	14,080
Fish On-Hand (Derby 2022/2023)	5,263
Fish On-Hand (Swift Power Canal Plant)	7,200
Pounds On-Hand (6.1/lb)	2,043
Feed Fed (lbs.)	4,687
Net Gain (lbs.)	5,317
Feed Conversion	0.88

2022 Merwin special Kids Derby and Forest Service Derby

The Merwin Special Kids Derby (MSKD) went great this year. It had been cancelled for the last two seasons and it was much celebrated and needed event. All remaining fish that were not caught in the derby were planted in Merwin Reservoir the following week. Disposition is as follows:

Final Stock Inventory 2019 Brood:

Beginning Balance	2,657
Rearing Mortality (13.8%)	304
Planted to Merwin Reservoir 2022	1,967
Pounds Planted (0.25 fpp)	7,868
Fish Caught at 2022 Derby	386

Stock Inventory This Period 2020 Brood:

Beginning Balance	12,495
Rearing Mortality (0.53%)	66
Fish Caught at 2022 Derby	133
On hand for 2023 MSKD	2,338

Temperature & Rainfall

	Jan	*Feb*	*Mar*	*Apr*	*May*	*June*	*July*	*Aug*	*Sept*	*Oct*	*Nov*	*Dec*
Avg High (F)	46.2	45.2	47.9	50.6	54.7	55.5	57.2	60.2	62.2	65.0	58.9	51.2
Avg Low (F)	44.9	43.6	45.9	48.1	52.4	53.4	55.5	57.0	60.5	63.7	57.4	50.0
****Rain (inches)***	11.30	7.21	7.33	9.29	7.60	4.83	0.25	0.00	1.07	4.20	13.70	12.63

** 2022 total rainfall accumulation 79.36 inches*

** Intake was drawing from upper intake only from February 23rd to July 2nd, 2022*

** Intake was drawing from lower intake only from January 1st to February 22nd and from July 3rd to December 31st, 2022.*

Treatments

Date	Brood Year / Species	Pond Numbers	Treatment Chemical	Disease
January – July	2022 Summer, Winter, & Late-Winter Steelhead eggs	Incubators	Formalin	Fungus
June – November	2023 Summer Steelhead adults (Brood)	Smolt Pond 1 & Smolt Pond 2	Formalin	Fungus
September – October	2020 Goldendale Rainbow derby fish	Raceways 9 & 10	Formalin	Ichthyopthirius
September – October	2021 Goldendale Rainbow Juveniles	Raceways 1, 2, 3, & 7	Formalin	Ichthyopthirius
September – October	2022 Winter Steelhead	Raceway 3, & Rearing Pond 12	Formalin	Ichthyopthirius
September – October	2022 Summer Steelhead	Raceway 7 & Rearing Ponds 11, 13, & 14	Formalin	Ichthyopthirius
June	2022 Late-Winter Steelhead	Intermediate Raceways 3, 4, & 5	Potassium Permanganate	Bacterial Gill Disease
September – October	2022 Late-Winter Steelhead	Raceways 7 & 8	Formalin	Ichthyopthirius
December	2022 Goldendale Rainbow eggs	Incubators	Formalin	Fungus
November – December	2023 Summer & Winter Steelhead eggs	Incubators	Formalin	Fungus
December	2023 Winter Steelhead Adults (Brood)	AP-2	Formalin	Fungus
February – June	2022 Late-Winter Steelhead Adults (Brood)	AP-1	Formalin	Fungus

Maintenance & Capital Projects

Maintenance

- Cleaned all dielectric tubes, inspected all fuses and rings, replaced any damaged or worn-out parts on Ozone Generator #1 & #2
- Replaced power cables on both Generators.
- Replaced all elements and filters on Kaeser Compressor supply lines and Pure Gas air dryers.
- Routine Maintenance on Kaeser Compressors
- Annual calibration for ambient ozone sensors and generators
- Replaced leaking fitting for Ozone Plant residual sampling line.
- Routine maintenance for Ford Cargo planting truck
- Replaced ignition, batteries, & cables for Ford Cargo planting truck
- Routine maintenance for International planting truck
- Aerator replaced on International planting truck.
- Routine maintenance for Ford F-350
- Routine maintenance for Ford F-250
- Replaced air compressor for fire suppression.
- Routine service for all on station equipment; gator, mowers, pumps, trimmers, blowers, saws, etc.
- Trimmed all deciduous trees, bushes, & hedges around facility
- Purchased new blinds, dish washer, oven, doorknobs, exhaust fan for residence.
- Routine service for hatchery building walk in freezer compressor & heat pump.
- Routine service for residence heat pumps
- Purchased two new winches for raceway sumps.
- Replaced exterior bulbs around facility, light poles, and Ozone Plant with led bulbs.
- Replaced all sprinkler heads for raceway sprinkler system.
- Repaired residence gate.

Capital

- Reconstruction, new flooring, and new interior paint for residence

Lewis River Hatchery Introduction

The Lewis River Salmon Hatchery is located approximately eight miles east of Woodland, WA on the North Fork Lewis River. Originally constructed in 1909 on Johnson Creek, the hatchery was moved to its present site in 1923.

Program Goals

- 1,300,000 yearling Spring Chinook @ 8-12 f/lb planted into N.F. Lewis River
- 1,100,000 yearling Early Coho @ 16 f/lb planted into N.F. Lewis River
- 900,000 yearling Late Coho @ 16 f/lb planted into N.F. Lewis River

Approximately 29,000 gallons of water per minute can be delivered to the hatchery by eight pumps that are located at two separate intakes. Four booster pumps permit further distribution of water to other areas of the facility as needed. Three gas stabilization towers and one packed column are available to remove supersaturated gases from the water supply when necessary.

There is approximately 312,000 cubic feet of available rearing space. This space consists of 14 super raceways and 12 standard raceways. Adult holding space consists of four large concrete ponds with a common center channel totaling 53,000 cubic feet.

The incubation facility houses fifty stacks (16 trays/stack) of vertical incubators and four shallow troughs.

The Lewis River Hatchery also includes three residence, hatchery/office building, freezer building, two three bay storage buildings, two small storage buildings, public restrooms, two intake structures, two generator/pump control buildings, two compressor buildings, domestic water pump house and a two-story adult handling facility.

Adult Trapping and Brood Stock

The Lewis River Ladder operates continuously year around. Once the fish are captured, staff identify, numerate and sort for hatchery brood stock and watershed escapement goals. In the below stocks the carcass distribution line represents surplus fish not needed for program goals and may go to food bank/tribes, nutrient enhancement, or landfill. The trapping and disposition of the stocks below only represent fish that were trapped at the Lewis River Hatchery Ladder.

2022 Lewis River Winter Steelhead

The last 2022 brood winter steelhead were trapped at the Lewis Ladder on March 3, 2022.

Final Trapping & Disposition

Total Trapped	315
Mortality (1.3%)	4
Carcass Distribution	311

2022 Brood Lewis River Late Winter Steelhead, Hatchery Origin

The were no Late Winter Steelhead trapped at Lewis River Hatchery in 2022.

2023 Brood Lewis River Summer Steelhead

The first summer steelhead trapped at the Lewis River Ladder was on June 23, 2022, and the final pair trapped on November 16, 2022

Final Trapping & Disposition

Total Trapped	352
Recycled	0
Mortality (0%)	0
Carcass Distribution	352

2023 Brood Lewis River Winter Steelhead

The first Winter Steelhead was trapped December 8, 2022, at the Lewis River Ladder.

In-season Trapping & Disposition

Total Trapped	11
Mortality (18.2%)	2
Brood Shipped	0
Carcass Distribution	9

2021 Brood Lewis River (Type N) Coho

The last Late Coho captured at the Lewis River Ladder was on February 8, 2022. All spawned fish were given to Lower Columbia Fish Enhancement for nutrient enhancement of the Lewis River Basin.

Final Trapping & Disposition

Adults Trapped	11,239
Jacks Trapped	4,324
Adult Mortality (3.3%)	373
Jack Mortality (1.2%)	52
Adults Spawned	1485
Jacks Spawned	2
Adult Carcass Distribution	9,381
Jack Carcass Distribution	4,270
Adults Planted Upstream	0
Jacks Planted Upstream	0
Adults Received from Merwin FCF	0
Jacks Received from Merwin FCF	0

2022 Brood Lewis River Spring Chinook

The first arrival at the Lewis Ladder was on June 23, 2022. Brood stock was collected and shipped to Speelyai Hatchery. Excess adults were shipped down from Merwin FCF until the midpoint of the run. At that point it was decided to ship the excess adults upstream to Swift reservoir.

Final Trapping & Disposition

Adults Trapped	80
Jacks Trapped	18
Adults Received From Merwin FCF	287
Jacks Received From Merwin FCF	18
Adult Mortality (0.5%)	2
Jack Mortality	0
Adult Carcass Distribution	23
Jacks Carcass Distribution	18
Adult Brood Shipped	1
Jack Brood Shipped	0
Adults Planted Upstream	341
Jacks Planted Upstream	18

2022 Brood Lewis River (Type S) Early Coho

The first early Coho trapped at the Lewis River Ladder was on August 25, 2022. Brood stock for hatchery production is collected and then shipped to Speelyai Hatchery.

Final Trapping & Disposition

Adults Trapped	21,446
Jacks Trapped	2,561
Adult Mortality (1.9%)	411
Jack Mortality (0.2%)	5
Adult Carcass Distribution	19,644
Jack Carcass Distribution	2,520
Adult Brood Shipped	1,391
Jack Brood Shipped	36
Adults Planted Upstream	0
Jacks Planted Upstream	0

2022 Brood Lewis River (Type N) Late Coho

The first Late Coho trapped at the Lewis River Ladder was on October 25, 2022. All brood stock is held and spawned at the Lewis River Hatchery.

In-season Trapping & Disposition

Adults Trapped	14,981
Jacks Trapped	1,650
Adult Mortality (7.6%)	1,142
Jack Mortality (4.1%)	68
Adults Spawned	1,781
Jacks Spawned	21
Adult Carcass Distribution	12,053
Jack Carcass Distribution	1,561

INCIDENTAL TRAPPING

2022 Brood Lewis River Wild Spring Chinook

The first wild Spring Chinook trapped at the Lewis River Ladder was on May 16, 2022. All wild spring chinook trapped were planted into the Lewis River at Swift Reservoir.

Final Trapping & Disposition

Adults Trapped	10
Jacks Trapped	1
Adults Planted Upstream	10
Jacks Planted Upstream	1

2021 Brood Lewis River Wild Fall Chinook

The last wild Fall Chinook trapped at the Lewis Ladder was on September 14, 2021. All fish were returned to the Lewis River, at the hatchery outfall.

Final Trapping & Disposition

Adults Trapped	9
Jacks Trapped	0
Adults Returned to Stream	9
Jacks Returned to Stream	0

2022 Brood Lewis River Wild Fall Chinook

There were no 2022 brood wild Fall Chinook were trapped at Lewis River.

2022 Brood Fall Chinook (Unknown Hatchery Origin)

There is no hatchery released Fall Chinook on the Lewis River, we identify any adipose clipped Fall Chinook as “unknown” origin. The first Fall Chinook of hatchery origin was trapped at the Lewis River Ladder on September 7, 2022.

Final Trapping & Disposition

Adults Trapped	74
Jacks Trapped	7
Adult Mortality (4.1%)	3
Jack Mortality (0%)	0
Adult Carcass Distribution	71
Jack Carcass Distribution	7

2022 Brood Lewis River Wild Early Coho

The first natural origin Early Coho was trapped at the Lewis River Ladder was on September 1, 2022. All wild Early Coho were planted into the Swift Reservoir.

Final Trapping & Disposition

Adults Trapped	326
Jacks Trapped	3
Adults Planted Upstream	326
Jacks Planted Upstream	3

2022 Brood Lewis River Wild Late Coho

The first wild Late Coho was trapped at the Lewis River Ladder on October 25, 2022. Lewis River Hatchery received some wild Late Coho from the Merwin FCF that were used for brood stock as part of the integrated portion of the Late Coho hatchery program. Fish not used for brood stock were planted into the Lewis River, at the Swift Reservoir.

In-season Trapping & Disposition

Adults Trapped	82
Jacks Trapped	3
Adult Mortality (14.3%)	16
Jack Mortality (0 %)	0
Adults Spawned	77
Jacks Spawned	2
Adults Planted Upstream	16
Jacks Planted Upstream	0
Adults Received from Merwin FCF	30
Jacks Received from Merwin FCF	1

2022 Brood Chum (Unknown Wild Origin)

The lone chum trapped at the Lewis River Ladder, was trapped on September 1, 2022. The fish was returned to the Lewis River, at the hatchery outfall.

Final Trapping & Disposition

Adults Trapped	1
Adult Mortality	0
Adults Returned to Stream	1

2022 Brood Sockeye (Unknown Wild Origin)

The lone sockeye trapped at the Lewis River Ladder, was trapped on July 21, 2022. The fish was returned to the Lewis River, at the hatchery outfall.

Final Trapping & Disposition

Adults Trapped	1
Adult Mortality	0
Adults Returned to Stream	1

Adult Trapping – Lewis Hatchery Ladder

	CK:SP:LEHA:22:H			CK:SP:LEWI:22:W			CK:FA:UNKN:22:H			CK:FA:LEWI:22:W		
	M	F	J	M	F	J	M	F	J	M	F	J
Return to Stream												
Planted Upstream	186	155	18	8	2	1						
Shipped		1										
Mortalities	1	1					2	1	0			
Carcass Distribution	20	3	18				51	20	7			
Total	**207**	**160**	**36**	**8**	**2**	**1**	**53**	**21**	**7**	**0**	**0**	**0**

	CO:SO:LEHA:22:H			CO:SO:LEWI:22:W			CO:NO:LEWI:22:H			CO:NO:LEWI:22:W		
	M	F	J	M	F	J	M	F	J	M	F	J
Return to Stream												
Planted Upstream				208	118	3						
Shipped	676	715	36							6	10	
Mortalities	181	230	5				515	627	68	7	9	
Carcass Distribution	11000	8644	2520				7049	5004	1561			
Spawned							857	929	21	61	16	2
Total	**11857**	**9589**	**2561**	**208**	**118**	**3**	**8421**	**6560**	**1650**	**74**	**35**	**2**

	CO:NO:LEWI:21:H			CO:NO:LEWI:21:W			CH:NA:LEWI:22:U		SO:NA:UNKN:2022:U	
	M	F	J	M	F	J	M	F	M	F
Return to Stream							1		1	
Planted Upstream										
Shipped										
Mortalities	9	5								
Carcass Distribution	10	8	6							
Spawned										
Total	**19**	**13**	**6**	**0**	**0**	**0**	**1**	**0**	**1**	**0**

	SH:SU:MEHA:23:H		SH:WI:MEHA:22:H		SH:WI:MEHA:23:H		SH:WL:LEWIS:22:H	
	M	F	M	F	M	F	M	F
Return Downstream								
Planted Upstream								
Shipped to Merwin Hatchery								
Mortalities				2	1	1		
Carcass Distribution	157	195	172	115	6	3		
Total								

Incubation Summary

2021 Brood Lewis River Late Coho (Integrated and Segregated)

Once a strong eye developed, the eggs were shocked and picked to remove dead eggs. After the morbid eggs were removed, the eyed eggs were inventoried and laid down to hatch or ship. Total egg loss (roughly 12.6%) was 363,501. The integrated on-station program of 1,090,480 eyed eggs for the Lewis River program were kept on station for the entirety.

A combined total of 1,540,017 segregated eyed and green eggs were shipped out of Lewis River Hatchery. Washougal Hatchery received 1,465,917 green eggs. The 74,100 eyed eggs were distributed as follows: The Steve Syverson Project 5,000; Ridgefield High School 10,000; Clark PUD 46,000; Columbia Springs 13,000; Captain Strong Primary School 100. Egg inventory and distribution was as follows:

Total Egg Take (green)	2,854,957
Egg Loss	363,501
Short/Over	40,854
Adjusted Egg Take	2,895,811
Total Eyed Eggs	2,532,310
Shipped (Green)	1,457,239
Adjusted Shipped (Green)	1,465,917
Shipped (Eyed)	74,100
Viable Females Spawned	935
Fecundity	3,097

2022 Brood Lewis River Early Coho

Most of the Early Coho brood stock were shipped to Speelyai and spawned there. Speelyai spawned the brood and incubated the resulting eggs to the eyed stage. From October through December, the 1,407,298 eyed eggs were shipped to Lewis River Hatchery to finish their incubation.

2022 Brood Lewis River Late Coho (Integrated and Segregated)

Just over 2.8 million eggs were taken in 2022. The first spawn of late Coho took place on November 21, 2022, and the last was on December 13, 2022. The Washougal Hatchery received about 1.41 million (segregated) green eggs. The remaining eggs were laid down for incubation at Lewis River Hatchery. Of the remaining eggs, 62,400 are being incubated to the eyed stage and will be distributed to the following schools and coops in January: 36,000 to Clark County PUD, 5,000 to the Steve Syverson Project, 150 to Captain Strong Primary School, 10,000 to Union Ridge; and 11,250 to Columbia Springs. The eggs that are not shipped out, approximately 1.3 million, are the integrated portion of the egg take. These will be kept at Lewis River Hatchery to be reared until their release into the Lewis River in April of 2024. At the time of this report eggs are still green and have not been inventoried.

Total Egg Take (green)	2,800,856
Egg Loss	0
Short/Over	0
Shipped (green)	1,409,577
Adult Females Spawned	940
Fecundity	2,980

Rearing Summary

2020 Brood Lewis River Late Coho

Lewis River Hatchery volitionally released 800,470 Late Coho averaging 16.2 f/lb, between April 1 and 30, 2022. Approximately 75K were adipose clipped and coded wire tagged; while 75K were coded wire tagged only. The remaining fish were only adipose fin clipped.

Final Stock Inventory

Beginning Balance	823,049
Pounds Ponded	653
Rearing Mortality (3.9%)	32,175
Adjustment	9,596
Fish Planted	800,470
Pounds Planted	49,471
Feed Fed (lbs.)	42,860
Net Gain (lbs.)	48,818
Conversion	.88:1
CV	7.92

2020 Brood Spring Chinook

The last of the 2020 brood Spring Chinook were volitionally released from February 2 through February 16, of 2021. This group totaled 473,135 and was a mix of fish that were at 8 and 12 f/lb. The prior October release consisted of 870,201 smolts released, making a total of 1,343,336 fish planted from the 2020 brood year. Of the 2020 brood Spring Chinook, approximately 32-38k out of each of the four unique release groups (October 12 f/lb early transfer, February 8fpp early transfer, February 12 f/lb late transfer, and February 8 f/lb late transfer) were adipose clipped with a coded wire tag, and another 32-38k out of each group were coded wire tagged with adipose fin present. The remaining fish in each group were adipose marked.

Final Stock Inventory

Fish Received	1,382,660
Pounds Received	27,764
Rearing Mortality (2.8%)	39,324
Fish Planted	1,343,336
Pounds Planted	117,560
Feed Fed (lbs.)	70,054
Net Gain (lbs.)	89,796
Conversion	.78:1
Average CV of Groups Planted	7.70

2020 Brood Lewis River Early Coho

Lewis River Hatchery volitionally released 1,354,537 Early Coho, averaging 16.3 f/lb, between April 1st and 30th of 2022. Approximately 75K were coded wire tagged and adipose clipped and another 75K were only coded wire tagged. All other fish in the release group were adipose fin clipped.

Final Stock Inventory

Beginning Balance	1,498,956
Pounds Ponded	1,238
Rearing Mortality (4.0%)	59,811
Adjustment	(84,608)
Fish Planted	1,354,537
Pounds Planted	83,151
Feed Fed (lbs.)	70,161
Net Gain (lbs.)	81,913
Conversion	.86:1
Average CV	7.03

2021 Brood Lewis River Spring Chinook

On May 2nd and May 10th of 2022, the Lewis River Hatchery received 1,064,747 Spring Chinook from Speelyai Hatchery. In addition, 315,160 were shipped from Speelyai to Lewis River Hatchery on November 28th and 2nd of 2022. Out of each size and release group of 2021 brood springers (May transfer 12 f/lb, May transfer 8 f/lb, December transfer 12fpp, December transfer 8 f/lb), approximately 37k were coded wire tagged and adipose fin clipped, 37k were only coded wire tagged, and the remaining were only adipose fin clipped. From October 12th through 27th of 2022, a total of 808,759 of the 2021 brood year Spring Chinook were released into the Lewis River. The remaining group from May, approximately 151k, will be released with the December transfer groups in February of 2022.

Stock Inventory This Period

Fish Received	1,379,907
Pounds Received	32,629
Rearing Mortality (3.4%)	120,773
Planted as of December 31st	808,759
On Hand as of December 31st	450,375
Pounds Planted	66,093
Pounds on Hand	43,705
Feed Fed (lbs.)	63,486
Net Gain (lbs.)	77,169
Conversion	.82:1
CV of Fish Planted	8.23

2021 Brood Lewis River Early Coho

The last take of Early Coho was ponded on January 31, 2022. Approximately 75k were snout tagged with an adipose mark, and 75k were snout tagged without an adipose mark. The remaining were only adipose fin marked. The 2022 brood Early Coho are scheduled for release in April of 2023.

Stock Inventory This Period

Balance Prior To Ponding	1,414,271
Fry Loss	16,500
Beginning Rearing Balance	1,397,693
Pounds Ponded	1,038
Rearing Mortality (3.8%)	64,851
Adjustment	(115,974)
Fish on Hand	1,216,868
Pounds on Hand	63,340
Feed Fed (lbs.)	49,904
Net Gain (lbs.)	62,302
Conversion	.80:1

2021 Brood Lewis River Late Coho

The 2021 brood Late Coho were moved from the incubation room to the standard raceways between February 22nd and April 8th of 2022. Approximately 75k were coded wire tagged and adipose fin clipped, 75k were only coded wire tagged, and the remaining fish were only adipose fin clipped. The 2021 brood Late Coho are scheduled for release in April of 2023.

Stock Inventory This Period

Balance Prior to Ponding	1,090,480
Fry Loss	12,000
Beginning Balance	1,078,480
Pounds Ponded	829
Rearing Mortality (3.1%)	34,118
Rearing Adjustment	(55,115)
Fish on Hand	989,247
Pounds on Hand	46,445
Feed Fed (lbs.)	38,650
Net Gain (lbs.)	45,616
Conversion	.85:1

Temperature and Rainfall

	Jan.	***Feb.***	***Mar.***	***Apr.***	***May***	***June***	***July***	***Aug.***	***Sept.***	***Oct.***	***Nov.***	***Dec.***
Average High (F)	43.9	42.9	43.6	45.8	48.4	52.2	56.1	58.0	59.0	61.2	56.2	48.0
Avg. Low (F)	43.4	42.1	42.7	44.4	46.9	50.4	52.7	54.7	56.3	59.9	55.4	47.6
****Rain (inches)***	9.50	5.00	5.75	7.65	6.05	4.00	0.30	0.00	1.10	4.60	11.60	12.80

** 2022 total rainfall accumulation 68.4 inches*

Treatments

Date	**Brood Year / Species**	**Pond Numbers**	**Treatment Chemicals**	**Disease**
January	2021 CONO	Incubators	Formalin	Fungus
February	2021 COSO	Raceways 2-7	Formalin	Costia
March	2021 COSO 2021 COSO	Raceways 2-7 Raceways 2-7	Formalin KMn04	Costia Gill Fungus
April	2021 CONO	Raceways 8-12	KMn04	Gill Fungus
April-May	2022 Spring Chinook Adults (Brood)	Raceway 15-4	Formalin	Fungus
November-Dec	2022 CONO	Incubators	Formalin	Fungus

Maintenance and Capital Projects

Maintenance:

- Replaced stolen catalytic converter on F-450 flatbed.
- Installed more security motion sensor lights on back of hatchery building.
- Replaced sprinkler heads on raceway sprinkler system.
- Repaired and strengthened metal rack at the fish ladder entrance.
- Replaced photo eye for lights in the sorting facility.
- Replaced canopies on 13-14 and 16 pond series.
- Replaced hot water heater in Res #3.
- Routine service of walk-in freezer and compressor.
- Routine service of residences heat pumps.
- Routine of all hatchery compressors.
- Routine maintenance and service on Gators.
- Routine service of Domestic Water Plant.
- Routine service preformed on F-250 and F-450 Flat bed.
- Routine service preformed on all on station small equipment i.e.: mowers, pumps, trimmers, blowers, saws etc.
- Replaced thermostat in Res #3.

Capital:

- Camp repaired and rebuilt R2D2 VFD pump.
- Camp re-welded main intake pipe feeding pond 16.
- Camp pulled the incubation de-gassing tower and replaced the media.
- Camp replaced pump #3 at the Downstream Intake.
- Pacificorp had several hazard trees removed.
- Pacificorp had Whiting Crane service repair a bulkhead hoist on pond 15-2.
- Camp patched and stopped a leak on the east De-gassing Tower.

Speelyai Hatchery Introduction

Speelyai Hatchery is a PacifiCorp owned and funded facility that is operated by the Washington Department of Fish and Wildlife. It has been in operation since 1958.

Speelyai Hatchery is located 21 miles east of Woodland, WA, just off Highway 503. The hatchery is adjacent to Speelyai Creek on the north shore of Lake Merwin.

Program Goals

- 1,050,000 Spring Chinook transferred to Lewis River Hatchery in May
- 360,000 Spring Chinook transferred to Lewis River Hatchery in December
- 50,000 sub-yearling Spring Chinook @ 80 f/lb planted into the N.F Lewis River
- 1,325,000 Type S Coho eyed eggs transferred to Lewis River Hatchery
- 45,000 Kokanee @ 8.0 f/lb planted into Merwin Reservoir
- 48,000 Kokanee @ 6.9 f/lb planted into Merwin Reservoir
- 36,000 Rainbow Trout @ 2.5 f/lb planted into Swift Reservoir
- 3,500 Rainbow Trout @ 2.5 f/lb planted into Swift power Canal.

Approximately 9,200 gallons per minute can be delivered to the hatchery system by gravity flow from Speelyai Creek.

There is approximately 166,450 cubic feet of rearing space available. This space consists of four 17x3’x3’ intermediate troughs, twenty-four 10’x80’x4’ raceways, four 115’x10’x5’ raceways and one large asphalt pond for adult holding/spawning. Incubation consists of fifty stacks of FAL vertical incubators, two deep troughs and one shallow trough. Staff is also responsible for ten 20’x20’x20’ net pens located in Merwin Reservoir.

Speelyai Hatchery site also includes two residence, hatchery building, two bay storage building, shop/garage, domestic pump house, small storage building and two chemical storage buildings.

Adult Holding

All Spring Chinook and Coho are trapped at the Merwin Fish Collection Facility or the Lewis River Hatchery Ladder and hauled by truck to Speelyai Hatchery. Kokanee are trapped on-site thru the hatchery effluent trap on Speelyai Creek. In the below stocks, the carcass distribution line represents surplus fish not needed for program goals and may go to food banks/tribes, nutrient enhancement, or landfill.

2022 Lewis River Spring Chinook, Hatchery Origin

The first Spring Chinook was received on March 4, 2022. Both ELISA and PCR (Polymerase Chain Reaction) testing that checks DNA extracts for bacterium in salmonid eggs were performed. Adequate number of females were tested to ensure that only gametes from females that tested in the "Below Low" range will be used in the February release groups.

Final Trapping & Disposition

Adults Received	1,281
Jacks Received	16
Adult Mortality (3.1%)	40
Jack Mortality (18.8%)	3
Adults Spawned	1,217
Non-Viable	8
Female Carcass Distribution	16

2022 Lewis River Type S Coho

The first Early Coho was received on September 7, 2022.

Final Trapping & Disposition

Adults Received	1,394
Jacks Received	41
Adult Mortality (12.7%)	177
Jack Mortality (2.4%)	1
Adults Spawned	1,033
Jacks Spawned	15
Non-Viable	0
Adult Carcass Distribution	184
Jack Carcass Distribution	25

2022 Lake Merwin Kokanee

Adult collection started September 13, 2022. Fish were collected from the hatchery effluent Kokanee trap and held in raceway 25.

Final Trapping & Disposition

Adults Received 600

Adults Spawned 600

	CK:SP:LEHA:22:H				KO:NA:MERL:22:M		CO:SO:LEHA:22:H			
	M	F	NVF	J	M	F	M	F	NVF	J
Planted Upstream										
Mortalities	21	19		3			101	76		1
Carcass Distribution		16					67	117		25
Lethal Spawn	585	632	8	13	400	200	509	524	0	15
Live Spawn										
Tags Recovered	393	348		12						
Total	606	667	8	16	400	200	677	717	0	41

Incubation Summary

2022 Lewis River Spring Chinook, Hatchery Origin

Egg Inventory and distribution is as follows: A total of 3,000 eggs ELISA tested above the level of "High" and were destroyed.

Total Egg Take	2,036,000
Egg Loss (5.9%)	121,000
Destroyed	3,000
Fecundity	3,227
Ponded	1,912,000

2022 Lewis River Type S Coho, Hatchery Origin

Egg Inventory and distribution is as follows:

Total Egg Take	1,577,598
Egg Loss (10.8%)	170,300
Shipped	1,407,298
Fecundity	3,011

2022 Lake Merwin Kokanee, Mixed Origin

Egg Inventory and distribution is as follows: At the time of this report, the 2022 Kokanee are still in incubation and will be ponded in January 2023.

Total Egg Take	120,100
Egg Loss (17.1%)	20,500
Destroyed	0
Fecundity	601

Rearing Summary

2020 Lake Merwin Kokanee

On January 31, 2022, the remaining 42,680 Kokanee were released from Speelyai hatchery at an average size of 6.38 f/lb.

Final Stock Inventory

Beginning Balance	129,900
Pounds Ponded	31
Rearing Mortality (7.1%)	9,196
Adjustment	-8,044
Fish Planted	91,260
Pounds Planted	11,067
Feed Fed (lbs.)	7,434
Net Gain (lbs.)	11,782
Conversion	0.67:1

2020 Goldendale Rainbow Trout

On May 24, 2022, 39,900 fish at 2.51 f/lb were hauled to Swift reservoir.

Final Stock Inventory

Beginning Balance	41,433
Pounds Ponded	N/A
Rearing Mortality (3.7%)	1,533
Adjustment	0
Fish Planted	39,900
Pounds Planted	15,896
Feed Fed (lbs.)	11,491
Net Gain (lbs.)	12,709
Conversion	0.90:1

2021 Lewis River Spring Chinook, Hatchery Origin

Coded wire tagging and mass marking were completed on April 25, 2021. In May, 1,064,747 hatchery origin spring Chinook were shipped to Lewis River hatchery at an average size of 135 f/lb. In June, 318,950 were planted in the Lewis River at Pekins boat launch. In December, the remaining 315,160 were shipped to Lewis River hatchery.

Final Stock Inventory

Beginning Balance	1,666,300
Pounds Ponded	1,515
Rearing Mortality (3.1%)	51,081
Adjustment	82,638
Fish Shipped	1,379,907
Pounds Shipped	32,416
Fish Planted	318,950
Pounds Planted	4,137
Feed Fed (lbs.)	25,918
Net Gain (lbs.)	27,191
Conversion	0.74:1

2021 Lake Merwin Kokanee

The onset of BKD forced three early releases of the 2021 Kokanee. Those releases are as follows: On July 13, 2022, 22,860 Kokanee at 61.3 f/lb, August 29, 2022, 44,965 Kokanee at 26.9 f/lb, and October 9, 2022 @ 11.6 f/lb. All were released from Speelyai hatchery into Speelyai bay.

Final Stock Inventory

Beginning Balance	119,000
Pounds Ponded	26
Rearing Mortality (10.0%)	11,888
Adjustment	-4,575
Fish Shipped	0
Pounds Shipped	0
Fish Planted	94,780
Pounds Planted	3,976
Feed Fed (lbs.)	2,918
Net Gain (lbs.)	3,950
Conversion	0.74:1

2021 Goldendale Rainbow Trout

On November 1, 2022, 47,142 fish were received from Merwin hatchery at an average size of 13.0 f/lb. At the time of this report, there are 46,900 on hand at 8.32 f/lb. These fish are currently being reared in pond 13 and are on schedule to be released into Swift reservoir and the Swift Power Canal starting in May 2023.

2022 Lewis River Spring Chinook, Hatchery Origin

At the time of this report, 913,750 have been ponded and are at an average size of 933 f/lb. There are an additional 968,000 in incubation that will be ponded in January. Mass marking and coded-wire tagging will begin on March 6, 2023.

2022 Lake Merwin Kokanee

At the time of this report, there are 120,000 fish in incubation to be ponded in January 2022.

Temperature & Rainfall

	Jan	***Feb***	***Mar***	***Apr***	***May***	***June***	***July***	***Aug***	***Sept***	***Oct***	***Nov***	***Dec***
Avg High (F)	47.7	48.3	49.4	49.4	51.1	52.7	55.2	56.0	55.4	53.0	48.2	46.7
Avg Low (F)	46.3	46.3	47.3	48.5	50.0	52.1	54.1	54.6	52.0	50.3	46.6	45.1
****Rain (inches)***	16.04	6.16	11.06	12.16	10.90	5.55	0.00	0.00	0.66	4.59	17.34	11.8

** 2022 total rainfall accumulation 96.24 inches*

Treatments

Date	Brood Year / Species	Pond Numbers	Treatment Chemical	Disease
1/15 – 8/1	2022 Lewis spring Chinook	Raceways	Formalin Drip	Prophylactic for Costia
2/4 – 3/27	2022 Kokanee	Raceways	Formalin Drip	Prophylactic for Costia
4/15 – 9/28	2022 spring Chinook Brood	Raceways 25-28	Formalin Drip	Fungus
9/30 – 10/30	2022 Type S Coho Brood	Adult pond	Hydrogen Peroxide	Fungus
9/19 – 9/25	2022 kokanee Brood	RW 25	Formalin Drip	Fungus
9/1 – 11/25	2022 spring Chinook	Incubation	Formalin Drip	Fungus
9/30 – 11/23	2022 Kokanee	Incubation	Formalin Drip	Fungus
10/13 – 12/6	2022 Type S Coho	Incubation	Formalin Drip	Fungus

Maintenance & Capital Projects

Maintenance:

- Routine service and maintenance to Ford F250
- Replaced worn outlets on marking trailer cords.
- Routine service and maintenance to Chevy 3500
- Annual service to three phase compressors
- Bi-Annual maintenance to residential HVAC
- Routine service and maintenance to small motors and pumps
- Replace hydraulic pump on Neilson fish pump.
- Annual pruning of trees
- Annual maintenance to back up generator.
- Build net pens to hold CWT retention fish.
- Maintenance to both residences 1 & 2.
- Maintained hatchery roadway (i.e., potholes, etc.).
- Repainted zone lines for receiving brood.
- Replaced bark at entrance sign and other decorative landscapes within facility boundaries.
- Built a lean-to cover to protect boat from the elements from the four seasons.
- Built new yearling screens for raceways.
- Installed yellow chain around spawning area for public safety.
- Installed new aerator and put microbe in the PA pond.
- Repaired boat trailer and serviced the outboard motor.
- Built an irrigation pipe trailer.
- Pulled the grizzly and cleared out debris at intake.
- Installed new UV bulbs for domestic water system.

Capital

- Installed shade cover patches and extensions on raceways.
- Installed new fence and gates around Pond 13.
- Installed two new backflush filters for the facility domestic water system.
- Removal of dead timber around the facility and residences.
- Installed a new generator ventilation.
- Installed additional grating and brackets to the heads of all raceways

Fish & Carcass Distribution

2022 Total Carcass Distribution Summery

	M	F	J
CK:SP:LEHA:22:H	645	678	168
CK:FA:UNKN:22:H	154	142	31
CO:SO:LEHA:22:H	18,884	16,585	3,896
CO:SO:LEWI:22:W	6	5	
CO:NO:LEWI:22:H	12,124	10,652	2,244
CO:NO:LEWI:22:W	68	25	2
CO:NO:LEWI:21:H	19	13	6
SH:SU:MEHA:23:H	1,065	1,612	
SH:WI:MEHA:22:H	724	467	
SH:WI:MEHA:23:H	398	439	
SH:WL:LEWI:22:W		1	
SH:WL:LEWI:22:H			
KO:NA:MERL:22:M	400	200	
Total	**34,487**	**30,819**	**6,347**

	Lower Columbia (CAP) Community Action Team			NW Harvest			Cowlitz Tribe			Total
	M	F	J	M	F	J	M	F	J	
CK:SP:LEHA:22:H				16	3		13		68	**100**
CK:FA:UNKN:22:H			5	141	127	26	4	5		**308**
CO:SO:LEHA:22:H				16,222	14,320	3,720	1,376	712		**36,350**
CO:SO:LEWI:22:W										**0**
CO:NO:LEWI:22:H				9,173	7,525	1,761	354	388		**19,201**
CO:NO:LEWI:22:W										**0**
CO:NO:LEWI:21:H										**0**
CT:AC:LEWI:22:W										**0**
SH:SU:MEHA:23:H		2		458	503		453	934		**2,350**
SH:WI:MEHA:22:H							399	312		**711**
SH:WI:MEHA:23:H		1		214	257		149	139		**760**
SH:WL:LEWI:22:W										**0**
SH:WL:LEWI:22:H										**0**
KO:NA:MERL:22:M										**0**
Total	**0**	**3**	**5**	**26,224**	**22,735**	**5,507**	**2,748**	**2,490**	**68**	

	American Canadian			Landfill			Nutrient Enhancement			Total
	M	F	J	M	F	J	M	F	J	
CK:SP:LEHA:22:H				616	675	95				**1,386**
CK:FA:UNKN:22:H	7	10		2		5				**24**
CO:SO:LEHA:22:H	570	809	123	140	103	13	576	641	40	**3,015**
CO:SO:LEWI:22:W				6	5					**11**
CO:NO:LEWI:22:H	1,508	1,466	448	105	170	1	984	1,103	34	**5,819**
CO:NO:LEWI:22:W	7	9					61	16	2	**95**
CO:NO:LEWI:21:H				19	13	6				**38**
SH:SU:MEHA:23:H	3	3		151	170					**327**
SH:WI:MEHA:22:H				325	155					**480**
SH:WI:MEHA:23:H	2	6		33	36					**77**
SH:WL:LEWI:22:W					1					**1**
KO:NA:MERL:22:M				400	200					**600**
Total	**2,097**	**2,303**	**571**	**1,797**	**1,528**	**120**	**1,621**	**1,760**	**76**	

Mitigation Summary

Stock	**Program Goals**	**Actual Production**
*Spring Chinook	1,350,000 @ 8-12 f/lb	** 1,600,844 @ 8-12 f/lb
Early Coho	1,100,000 @ 16 f/lb	1,354,537 @ 16.2 f/lb
Late Coho	900,000 @ 16 f/lb	800,470 @ 16.1 f/lb
Summer Steelhead	175,000 @ 5.5 f/lb	177,991 @ 5.4 f/lb
Winter Steelhead	100,000 @ 5.5f/lb	103,049 @ 5.4 f/lb
Late Winter Steelhead	50,000 @ 6-8 f/lb	63,453 @ 7.4 f/lb
Kokanee	12,500 pounds	10,663 pounds
Rainbow Trout	20,000 pounds	21,001 pounds

**100,000 Spring Chinook upstream production was suspended and moved to the hatchery downstream production.*

*** Additional fish planted were in June and agreed upon thru the ATS group and funded thru the Southern Resident Killer Whale cost code.*

Lewis River Complex Staff

Complex Manager	Aaron Roberts
Fish Hatchery Specialist 4	Mike Chamberlain
Fish Hatchery Specialist 4	Kevin Young
Fish Hatchery Specialist 3	Scott Peterson
Fish Hatchery Specialist 3	Jesse Cody
Fish Hatchery Specialist 3	Luke Miller
Fish Hatchery Specialist 2	Jim Trammell
Fish Hatchery Specialist 2	Kevin Kitchell
Fish Hatchery Specialist 2	Tiffany Farrar
Fish Hatchery Specialist 2	Jay VonBargen – Retired 10/31/2022.
Fish Hatchery Specialist 2	Chris Roe
Fish Hatchery Specialist 2	Bryan Coyle
Fish Hatchery Specialist 2	Reid Ashley
Fish Hatchery Specialist 2	Grant Sill
Fish Pathologist	Sean Roon

Executive Summary

Adult returns for 2022 for the Lewis River were respectable on all species. Early and Late Coho combined exceeded 65,000 adults and provided all program goals for brood stock, shipping fish upstream and achieving our egg take goal, Spring Chinook returned over 4000 adults which is doubled what was projected for the pre-season run forecast and is continuing showing signs of improvements for 2023. On spring Chinook we were able to meet program goals for brood, upstream and have a consistent fishery in 2022. Summer Steelhead returns were decent this year as they were region wide, we had 3700 Summer Steelhead trapped. Winter Steelhead were our lowest returning fish this year with about 900. We were able to meet program goals for brood stock, egg take and managed to continue our Summer Steelhead recycling program by planting over 1000 adults into the Lewis River to allow anglers another chance to catch them. We also planted Horseshoe Lake with 112 adult winter Steelhead to give anglers an opportunity.

The overall juvenile rearing for all stocks went well with no major issues. Our Spring Chinook release strategies continued in 2022 with an October group, 3 groups in February and a June release group. We are just starting to see our returns from these strategies and the next few years we will be able to pull some data and determine how the future of this program will continue. As for Coho, Steelhead rearing was good with nothing significant to report. Kokanee rearing has been challenging over the last few years with signs of BKD becoming a more consistent presents. Rainbow Trout were planted into Swift Reservoir and the Swift Power Canal. In 2022 we were able to host the annual "Merwin Kids Derby" at Merwin Hatchery after a two-year break and was a success. All remaining fish after the derby were planted into Merwin Reservoir.

All facilities kept up with maintenance of equipment, infrastructure, and hatchery grounds. Each facility had some capital projects completed with no major infrastructure changes. All facilities are looking and operating well thanks to the staff of WDFW and PacifiCorp.

Staff here on the Lewis River system both WDFW and PacifiCorp are some of the best in the industry and committed to facing challenges in front of us now and in the future with both professionalism and dedication.

APPENDIX H –

2023 Final Annual Operating Plan, H&S Program

Final

2023 Annual Operating Plan

HATCHERY AND SUPPLEMENTATION PROGRAM NORTH FORK LEWIS RIVER

Prepared by
the
North Fork Lewis River
Aquatic Technical Subgroup

February 23, 2023

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STRATEGIES AND APPENDICES

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DEFINITION OF TERMS AND ACRONYMS

Area Under the Curve (AUC): a method for estimating salmon escapement by dividing the integral of the escapement curve by the average residence time in the survey area.

Annual Operating Plan (AOP): An annual planning document that describes the methods and protocols needed to implement the North Fork Lewis River Hatchery and Supplementation Plan and Program.

Aquatic Coordination Committee (ACC): Committee formed after signing of the North Fork Lewis River Settlement Agreement (Settlement Agreement) and composed of its signatories. Many of the measures contained in the Settlement Agreement require review and consultation with the ACC prior to implementation. Thus, the committee acts as the governing body for implementing aquatic measures contained within the Settlement Agreement. The committee also approves aquatic habitat funds on an annual basis.

Aquatic Monitoring and Evaluation Plan (AMEP): A comprehensive planning document required by the North Fork Lewis River Settlement Agreement (Section 9). The purpose of the AMEP is to develop methods to evaluate aquatic monitoring and evaluation objectives contained within the North Fork Lewis River Settlement Agreement. These objectives relate to fish passage, reintroduction outcome goals, anadromous and resident species monitoring, and development of the North Fork Lewis River Hatchery and Supplementation Plan.

Aquatic Technical Subgroup (ATS): A subgroup of the Aquatic Coordination Committee intended provide technical recommendations to the ACC. The ATS is focused primarily on developing and reviewing technical aspects of plans, reports and monitoring strategies or objectives related to the Hatchery and Supplementation and Aquatic, Monitoring and Evaluation programs.

Bacterial Coldwater Disease (BCD): Bacterial disease of salmonid fish caused by *Flavobacterium psychrophilum*.

Bacterial Kidney Disease (BKD): Bacterial disease of salmonid fish caused by *Renibacterium salmoninarum.*

Bayesian Goodness of Fit (GOF): a test used to determine whether sample data are consistent with a hypothesized distribution.

Blank wire tag (BWT): A small wire that is uncoded (blank), inserted in the snout of fish, and detectible with handheld wire detection wands or devices. BWT are specific to the integrated late winter steelhead supplementation program and all BWT positive fish are of hatchery origin (HOR).

Brood year (BY): year in which spawning occurs, used to track a single cohort over time.

Coded wire tag (CWT): A small wire with unique codes etched onto the wire, inserted in the snout of fish, and detectible with handheld wire detection wands or devices.

Coefficient of Variation (CV): The ratio of the population standard deviation (σ) to the population mean (μ) *or* in instances when only a sample of data from the population is available CV is estimated by using the sample standard deviation (S) to the sample mean ($\bar{x}$) which shows the extent of variability in relation to the mean of the population. The absolute value of the CV, sometimes known as relative standard deviation, is expressed as a percentage.

- Population CV = σ/μ
- Sample CV = $s/\bar{x}$

Columbia Basin PIT Tag Information System (PTAGIS): A regional database that stores and tracks data from fish with passive integrated transponder (PIT) tags.

Condition factor (K): Fulton's condition factor, K, is a measure of individual fish health that assumes the standard weight of a fish is proportional to the cube of its length:

$$K = 100\left(\frac{W}{L^3}\right)$$

where *W* is the whole body wet weight in grams and *L* is the length in centimeters; the factor 100 is used to bring K close to a value of one (Fulton, 1904).

Distinct Population Segment (DPS): A population or group of populations that is discrete from other populations of the species and significant in relation to the entire species. This along with Evolutionarily Significant Unit (ESU) are used to define Endangered Species Act-listed species (DPS for steelhead and ESU for salmon species).

Effective Population Size (N_e): The average size of a population in terms of the number of individuals that can contribute genes equally to the next generation. Therefore, the effective population size is typically smaller than the actual census size of the population.

Enzyme-Linked Immunosorbent Assay (ELISA): This test uses antibodies and color change to identify viral antigens present in sampled fish tissues.

Ecosystem Diagnostic and Treatment (EDT) model: An analytical habitat-based model that evaluates environmental constraints on a fish population(s) and used to predict the carrying capacity or production potential of specific areas of the North Fork Lewis River such as upstream of Swift Dam.

Endangered Species Act (ESA): Passed in 1973, this piece of United States legislation was designed to protect species from extinction as well as the ecosystems upon which they depend. Listed species are classified as "threatened" or "endangered." The ESA is administered by the U.S. Fish and Wildlife Service and the National Marine Fisheries Service.

Evolutionarily Significant Unit (ESU): A distinct population unit that is reproductively isolated and an important component for the legacy of a species, considered a separate "species" for the purposes of conservation.

F1 generation: First generation offspring, in this case, typically referring to offspring of fish spawned in the hatchery and therefore of hatchery-origin.

F2 generation: Offspring of F1 parents that have spawned naturally and therefore of natural-origin.

Feed conversion ratio (FCR): The amount of feed an animal must consume to gain one kilogram of body weight.

Fish per pound (fpp): Number of juvenile salmon per pound batch weight

Floy tag: Visible tags with unique codes and colors applied to the dorsal side of fish to identify individual fish upon capture or through visual surveys. Floy tags are inserted near the posterior side of the dorsal fin and are intended to lock within the dorsal skeletal bones by means of a T-anchor.

Generalized Random Tessellation Stratified (GRTS) design: provides a probability sample with design-based variance estimators by establishing a spatially balanced, random sample allowing for unequal probability sampling to accommodate field implementation issues.

Hatchery and Genetic Management Plan (HGMP): a technical document that describes artificial propagation management strategies that ensure conservation and recovery of ESA-listed salmon and steelhead populations.

Hatchery and Supplementation Plan (H&S Plan): A 5-year planning document intended to provide the plan and process for implementing the goals of Section 8 (Hatchery and Supplementation Program) of the North Fork Lewis River Settlement Agreement.

Hatchery and Supplementation Program (Program): Defined in Section 8 of the Lewis River Settlement Agreement. The goals of the program are to support (i) self-sustaining, naturally producing, harvestable native anadromous salmonid species throughout their historical range in the North Fork Lewis River Basin, and (ii) the continued harvest of resident and native anadromous fish species.

Hatchery and Supplementation Subgroup (H&S Subgroup): Name of ATS prior to December 2018.

HOB: Hatchery Origin Broodstock**.**

HOR: Hatchery Origin Recruit.

HOS: Hatchery Origin Spawners.

Hatchery Production: Describes the artificial propagation of fish that occurs in a hatchery as opposed to propagation resulting from natural reproduction. In the North Fork Lewis River, the hatchery production program is designed to maintain harvest opportunities downstream of Merwin Dam and in project reservoirs (residents) and to provide both adult and juvenile anadromous fish for early supplementation efforts in the basin.

Hatchery Scientific Review Group (HSRG): An independent scientific review group established by the United States Congress to initiate hatchery reform that balances both conservation and harvest goals.

Infectious hematopoietic necrosis virus (IHNV): Severe viral disease in the *Novirhabdovirus* genus affecting salmonid fish, particularly smolts and younger life stages.

Infectious pancreatic necrosis virus (IPNV): Severe viral disease in the *Birnaviridae* family affecting salmonid fish, particularly smolts and younger life stages.

Jolly-Seber (JS) mark-recapture model: Provides estimates of abundance, survival, and capture rates from capture-recapture experiments. A fully open-population model (allows for births, deaths, immigration and emigration from a population) estimating both recruitment to the population and survival.

Juvenile life stages (parr, transitional, smolt, precocious male):

- Parr – Juvenile salmonid in a non-migratory stage adapted for freshwater residence. Exhibits distinct parr marks, yellow to brown body and fin coloration, or no signs of smoltification.
- Transitional – Juvenile salmonid exhibiting initial signs of smoltification (i.e., a silvery sheen with visible parr marks). Black pigment may be present on dorsal and caudal fins.
- Smolt – Juvenile salmonid that is entering a stage of seaward migration and adapted for survival in sea water. Exhibits a silvery sheen, mostly or completely absent of parr marks, deciduous scales, white or transparent abdominal fins, and black pigment on dorsal and caudal fins.
- Precocious male – Juvenile male fish that mature in their first or second year, prior to going to sea. Fully mature males have soft abdomens and milt may be expressed. Deeper body morphology compared to smolts. Dark body color. Parr marks may be visible. Dark body and abdomen coloration compared to parr and smolt life stages.
- Post smolt – A salmonid that has previously undergone smoltification and has reverted to a freshwater-adapted stage, typically due to being held in captivity in freshwater. Visual indicators of this phenotype are not well described in the literature. Some fading of silver coloration. Parr marks are not expected to re-emerge. Some yellow or brown-orange coloration of the fins. Fading of intense black pigmentation in the fins.

Kelt: A post-spawn iteroparous fish such as a steelhead or cutthroat.

Lewis River Hatchery Complex: Hatchery fish production in the Lewis River Basin originates from the Lewis River, Speelyai, and Merwin hatcheries, collectively known as the Lewis River Hatchery Complex. The three hatcheries share adult return, rearing, and release functions. A detailed description of each of these facilities is presented in Appendix A of the H&S Plan.

Lower Columbia River (LCR): for the purposes of salmon recovery, referring to the Sub-domain of the Columbia River Basin that includes the estuary and all sub-basins upstream to the towns of While Salmon, Washington and Hood River, Oregon.

Major Population Group (MPG): Group of populations, or strata, sharing similar genetic, life-history, and spatial distribution that make up a subgroup of an Endangered Species Act-listed species (e.g., Coastal MPG, Cascade MPG). Viability of all MPGs are necessary for viability of Endangered Species Act-listed species.

Merwin Fish Collection Facility (Merwin FCF): A trapping, collection, and sorting facility located at the base of Merwin Dam. The Merwin FCF processes fish for transport upstream as well as broodstock for hatchery operations.

Native (or indigenous): Fish species that have become established in the North Fork Lewis River Basin without human intervention or being substantially affected by genetic interactions through non-native stocks. Native North Fork Lewis River stocks may be present in areas outside the North Fork Lewis River Basin.

NOB: Natural Origin Broodstock

NOR: Natural Origin Recruit

NOS: Natural Origin Spawners

Natural Production: Fish that are produced in the natural environment without human intervention as opposed to artificial propagation in a hatchery.

North Fork Lewis River (Lewis River): Includes the mainstem Lewis River from its confluence with the Columbia River to its origin (RM 94.2) on the northwestern slope of Mt. Adams, including free flowing sections between hydroelectric dams. Excludes the East Fork Lewis which enters the North Fork Lewis River at RM 3.5.

North Fork Lewis River Settlement Agreement (Settlement Agreement): A binding agreement between the utilities; federal, state, and regional regulatory entities; tribal entities; and non-governmental organizations. The Settlement Agreement establishes the collective agreement of all signatories with respect to the utilities' obligations in mitigating effects of hydropower operation on fisheries, wildlife, recreation, and cultural and aesthetic resources. The Settlement Agreement forms the basis for issuing hydroelectric operating licenses by the Federal Energy Regulatory Commission for the four hydroelectric projects on the North Fork Lewis River.

Ocean Recruits: Total escapement of hatchery- and natural-origin fish including those harvested in the ocean, Columbia River, and terminal fisheries.

Proportion of Hatchery Origin Spawners (pHOS): Proportion of natural origin spawners composed of hatchery origin spawners. Equals HOS/(NOS + HOS).

Proportion of Natural Origin Brood (pNOB): Mean proportion of natural origin spawners contributing to broodstock in a hatchery program. Equals NOB/(HOB + NOB).

Passive Integrated Transponder (PIT) tags: Electronic tags inserted into the dorsal sinus or body cavity of fish that transmit data indefinitely when activated by a specialized antenna or reader. All PIT tags have a unique code allowing on-site identification of individual tagged fish.

Proportionate Natural Influence (PNI): Proportionate natural influence on a population composed of hatchery- and natural-origin fish. Equals pNOB/(pNOB + pHOS).

Regional Mark Information System (RMIS): a collection of online databases that maintain records of coded wire tag release, recoveries and locations.

Residual or Residualism: Salmonids that fail to migrate from their natal streams or stream basin after the majority of their cohort have emigrated in a given year. Depending on the species, residuals may take on several different life-histories including precocious sexual maturation, freshwater residence for a season (e.g., to overwinter) or for an additional year followed by anadromy, or in steelhead, permanent freshwater residence and spawning in multiple years. Salmonids with the potential to express anadromy are considered residuals as long as they reside in freshwater and do not become anadromous.

Returns: Adult steelhead or salmon that have spent at least 1 year at sea and have become sexually mature and have returned to the North Fork Lewis River to spawn.

Smolt Index: A number assigned to juvenile salmon that describes the stage of smolt development based on a visual assessment of skin and fin pigmentation (silvering) and body shape. 1 = parr, 2 = transitional, 3 = smolt, 4 = precocious male, 5 = post-smolt or residual (modified from Gorbman et al., 1982).

Smolt to Adult Ratio (SAR): Survival from the beginning point as a smolt (release) to an ending point as an adult.

Supplementation: The use of artificial propagation to develop, maintain, or increase natural production while maintaining the long-term fitness of the target population, and keeping the ecological and genetic impacts to non-target populations within specified biological limits. In the North Fork Lewis River, the supplementation program is designed to reintroduce spring Chinook, late winter steelhead, and early coho to habitat upstream of Merwin Dam.

Single Nucleotide Polymorphism (SNP): SNP genotyping is the measurement of genetic variations of between members of a species. A SNP is a single base pair mutation at a specific locus, usually consisting of two alleles. SNP arrays can be used to analyze large numbers of samples such as outmigrating smolts or transported steelhead upstream of Swift Dam for less cost than microsatellite genotyping.

Steelhead broodstock: Steelhead captured either through traps or in-river netting that meet predetermined genetic assignment probabilities.

Stubby dorsal fin: A dorsal fin in which the rays have become crooked especially along the leading edge and depressed as compared to naturally produced fish. Stubby dorsal fins are indicative of fish reared in a hatchery environment.

Swift Floating Surface Collector (FSC): A trap and haul facility used to collect, sort, sample, and tag outmigrating smolts from adult and juvenile supplementation programs upstream of Swift Dam. The FSC is located on the forebay of Swift Reservoir and has the ability to operate year-round and through fluctuating reservoir levels. All fish are sorted in the FSC and trucked either downstream of Merwin Dam or returned to the reservoir.

Tangle net: A net designed to entangle the snout (not the gills) of target species through use of smaller mesh sizes. This method is considered a safer alternative to traditional gill netting in which the net material may become wedged under the fish operculum, potentially causing lacerations of the gill lamellae.

Viral hemorrhagic septicemia virus (VHSV): Virus in the genus *Novirhabdovirus,* exclusive to fish and related to IHNV.

EXECUTIVE SUMMARY

The Annual Operating Plan (AOP) focuses on developing methods and protocols for monitoring and evaluating objectives and key questions described in the Hatchery and Supplementation Plan (H&S Plan, 2020). *https://www.pacificorp.com/content/dam/pcorp/documents/en/pacificorp/energy/hydro/lewis-river/license-implementation/ats/A%20-%20HS%20PLAN%20FINAL%202020.pdf*

This AOP is required under Section 8.2.3 of the North Fork Lewis River Settlement Agreement (Settlement Agreement). Section 8.2.3 states that, at a minimum, the AOP must contain the following information:

1. A production section specifying the species and broodstock sources
2. Current hatchery target and juvenile production targets
3. A release section identifying, by species, the rearing schedule and planned distribution of fish and the schedules and location for release
4. A list of facility upgrades to be undertaken in the current year
5. A description of relevant monitoring and evaluation to be undertaken

Sections A, B, and C of this plan are dedicated to the hatchery production components of each of the transport species:

- Section A - Late winter steelhead
- Section B - Spring Chinook
- Section C - Coho salmon

Each section is organized and formatted similarly to maintain consistency within this document to assist in locating specific information for each species. Other sections in this plan include Monitoring and Evaluation (Section D), Adaptive Management (Section E), and Reporting Requirements (Section F).

Monitoring and evaluation activities are described at a high level of detail in Strategies which are attached to the AOP and referenced in Section D of the AOP. Strategies included in the 2023 AOP include:

- Strategy A: Adult Abundance and Composition
- Strategy B: Adult Spatial and Temporal Distribution
- Strategy C: Juvenile Abundance and Migration
- Strategy D: Fish Health Monitoring and Disease Prevention
- Strategy E: Spring Chinook Rearing and Release Evaluation
- Strategy F: Precocity and Morphology Sampling
- Strategy G: Genetic Risk Monitoring (DRAFT; REVISIONS EXPECTED IN 2023)
- Strategy H: Volitional Release

- Strategy I: Smolt-to-Adult Return Rate Estimation (IN PROGRESS)
- Strategy J: Sampling and Data Collection Checklist

AREA OF FOCUS

Generally, the AOP is focused on monitoring hatchery production operations and assessing the risks of these operations on naturally occurring salmonid populations present in the North Fork Lewis River downstream of Merwin Dam (RM 19.5). For purposes of this plan, the North Fork Lewis River is defined as the mainstem Lewis River between Merwin Dam and the confluence of the East Fork Lewis River (RM 3.5).

Hatchery fish production in the Lewis River Basin originates from three separate hatcheries: Lewis River, Speelyai, and Merwin. These facilities are collectively referred to as the Lewis River Hatchery Complex. The facilities share and coordinate hatchery functions such as adult holding, spawning, juvenile rearing and release. A description of each of these facilities and the general hatchery production program is provided on the PacifiCorp website.

https://www.pacificorp.com/content/dam/pcorp/documents/en/pacificorp/energy/hydro/lewis-river/relicensing-documents/AQU_8_Report.pdf

SUMMARY OF SIGNIFICANT CHANGES

A summary of major changes between the 2022 AOP and the 2023 AOP is included in Table ES1.

In 2022, the monitoring and evaluation section of this AOP (Section D) was completely updated to be consistent with revised monitoring objectives of the 2020 H&S Plan. Objectives provided in Section D represent the minimum monitoring benchmarks necessary to meet the requirements of the Settlement Agreement as well as recommendations from the Hatchery and Scientific Review Group (HSRG).

Also in 2022, based on recommendations from the ATS, the Adaptive Management section (Section E) of this plan was also significantly revised to address the new decision-making framework described in the most recent version of the H&S plan.

Strategy K, a pilot study for monitoring total dissolved gas saturation, was fully implemented in 2022 and therefore has been removed from the 2023 AOP. The results of the pilot study will be reported in the 2022 Annual Operating Report.

No other major changes to the framework or activities described were made between the 2022 AOP and 2023 AOP.

Table ES - 1. Summary of Significant Changes to AOP, 2022 to 2023

Section(s)	Change	Rationale
Sections A, B, C	No major changes.	Significant revisions were made to the AOP throughout 2022, incorporated into the 2022 AOP and rolled forward into the 2023 AOP.
Strategies	Removal of Strategy K	Fully implemented and analysed in 2022.
Appendix A	Updates to ATS Work Plan for 2023	The ATS uses a spreadsheet-based calendar to review and prioritize action items and track upcoming discussions and actions; for reference, it is included in the AOP as a working file.

SECTION A LATE WINTER STEELHEAD

1.0 INTRODUCTION

The Lewis River late-winter steelhead integrated-hatchery program (hereafter the “integrated hatchery steelhead program”) has three main components, described in Sections 2, 3, and 4 below: Section 2) broodstock collection and processing for adult program implementation; Section 3) juvenile rearing and release; and Section 4) adult supplementation upstream of Swift Dam. The following sections describe the protocols for implementing the Lewis River late winter steelhead portion of the Hatchery and Supplementation Plan (H&S Plan; PacifiCorp and Cowlitz County PUD, 2020).

2.0 ADULT PROGRAM IMPLEMENTATION

Broodstock collection for the integrated steelhead program is based on three factors: the relative abundance of natural- and hatchery-origin returning adults (Section 2.1), the total collection goal (Section 2.2), and adult return timing (Section 2.3). Adult steelhead are primarily collected at Merwin FCF (Section 2.4) and sampled following a standardized protocol (Section 2.5). Individual adults are sorted and transported either to Merwin Hatchery for broodstock or to the upper watershed to be released above Swift Reservoir (Section 2.6). Adults collected for broodstock are held and monitored (Section 2.7). As the broodstock reach maturation, individuals are live spawned following standardized protocols (Section 2.8). Upon completion of spawning, spawners are returned to river and genetic analysis is completed on all broodstock to evaluate their biological population of origin (Section 2.9).

2.1 Broodstock Collection Strategy

Since the inception of the integrated steelhead program in return year 2009 thru 2021, the broodstock collection strategy has had two main components. First, broodstock was collected using a “100% pNOB” strategy, which meant the broodstock could only be derived from natural-origin adults (i.e., pNOB = 100%). Second, broodstock had to be collected from adults that returned to the NF Lewis River Basin (i.e., no out-of-basin transfers) and preference was given to in-basin recruits that were determined via genetic screening. Subsequently, no hatchery-origin adults were permitted to be used for broodstock.

The primary justification for the original “100% pNOB” strategy was because there was no other existing within-ESU winter steelhead hatchery program to use as a source for broodstock for the NF Lewis program. Over the next decade, the 100% pNOB strategy remained in place even as BWT’s from the Lewis River integrated steelhead program began to return in relatively high numbers. This decision to keep the 100% pNOB strategy was based on the general goal of trying to minimize genetic risks associated with the hatchery program on the natural-origin population (e.g., loss of diversity, domestication). However, the performance of the 100% pNOB collection strategy was never assessed relative to alternative approaches to achieve the goal(s) of the supplementation program.

During the re-write of the Hatchery & Supplementation (H&S) Plan in 2020, the ATS identified the need to develop "transition plans" for all Lewis River hatchery programs. These proposed transitions plans will formally outline the goals of each hatchery program during each recovery phase, identify hatchery performance metrics and priorities associated with each recovery phase, outline current and alternative hatchery program operations, and provide guidance for future hatchery operations. The ATS has not begun developing transition plans for any program. However, over the past year, there have been ongoing discussions within the Lewis ATS to re-assess the integrated steelhead program and potentially update aspects of the current implementation strategy before the completion of the transition plans. These recent discussions were largely initiated by issues with the steelhead broodstock collection in 2021 and in-season discussions that transpired. In short, the ATS began debating whether the existing broodstock collection should be updated to allow for use of hatchery-origin adults.

In January 2022, the ATS met and discussed potential updates to the broodstock collection strategy for the integrated steelhead program. In summary, the ATS decided to change the broodstock collection strategy from 100% pNOB to a "mining rate" strategy that also ensures demographic replacement. Specifically, the mining rate strategy specifies the maximum proportion of natural-origin adults that can be removed for broodstock. However, NORs can only be collected for broodstock once an equivalent number of BWTs have been transported to the upper basin. Unlike the 100% pNOB strategy, which prioritizes returning NOR adults for broodstock, the mining strategy prioritizes NORs spawning in the wild while also allowing for a fixed proportion to be used for broodstock so long as it does not result in an overall net loss. The decision by the ATS to change the broodstock collection strategy was based on several factors, including recent guidance from HSRG (2020), the group discussing hatchery performance metrics and prioritization, and an evaluation of various broodstock collection strategies by WDFW that demonstrated the mining rate strategy outperforms the 100% pNOB strategy for priority metrics during the recolonization phase of recovery (Bentley and Buehrens, *unpublished*).

Beginning in return year 2021-22, a 30% fixed mining rate will be used to collect broodstock for the integrated steelhead program. Here, for every 10 NOR adults that return to the NF Lewis River and are collected at the Merwin FCF or Lewis Hatchery ladder, the first 7 will be transported above Swift Reservoir to spawn in the upper NF Lewis River basin and the next 3 can be collected for broodstock based on collection needs. However, for NOR adults to be collected for broodstock, each individual NOR must be demographically replaced by two integrated steelhead program adults (i.e., BWTs) that are transported to the upper basin. This 2:1 ratio of BWTs transported to NORs collected for broodstock assumes BWTs have a relative reproductive success of 50 percent (e.g., Araki et al. 2007). The number of adults collected for broodstock is based on the overall collection goal (Section 2.3) and the pre-determined collection schedule (Section 2.4). Any broodstock collection needs that cannot be met with NOR adults will be supplemented with BWTs.

2.2 Broodstock Collection Goal

The current goal is to spawn 25 adult females and 25-35 adult males for a total of 50-65 adults. The total collection and spawn goal of 25 females is primarily based on the total egg take target of 90,000 +/- 20%, which is needed to meet the total smolt release target of 50,000 smolts +/- 20% based on the average fecundity of females and the anticipated in-hatchery survival from egg-take to smolt release. The 25-female target is also based on trying to minimize adverse genetic impacts. In short, hatchery supplementation programs can affect the effective population size of the natural-origin population due to alteration of reproductive success for a subset of a population and subsequent contribution rate (stocking proportion) of the artificially propagated parents (Ryman and Laikre, 1991). The smaller the supplementation program, the larger the risks of reducing genetic diversity and the relationship is likely non-linear (Ryman and Laikre 1991). Therefore, depending on the observed fecundity of collected broodstock, females may be partially spawned to assist in meeting the 25-female target without exceeding the egg take goal. However, this decision must be coordinated with WDFW and NMFS before implementation.

In previous years, the total broodstock collection goal was larger than the spawn goal based on expected in-season genetic assignment rates being <1 (i.e., some adults collected for brood would not be used based on their genetic assignment). Now that in-season genetic screening has been discontinued (see Section 2.9), the collection and spawn goal are the same.

2.3 Broodstock Collection Timing

Broodstock collection should occur proportional to the run timing of natural-origin Lewis River winter steelhead (Figure A-1). In January 2022, the ATS assessed the existing brood collection schedule relative to the return timing of NORs at Merwin FCF from (2015-2021) and found that it only captured ~65-70% of the entire NOR run-timing. Therefore, the ATS agreed that the broodstock collection schedule should be updated to match the return timing of NORs and start in mid-December, with one small exception in that collection should end by May 31st (as opposed to the third week of June). This modification results in a 7% reduction in average run-timing relative to NORs which may reduce some genetic diversity but balances the risks associated with spawning late-arriving fish. Specifically, progeny from broodstock spawned after May 31st may be difficult to rear to appropriate release size by the scheduled release time in May of the following year. Risks of releasing under-sized fish include decreased survival and a potential increase in residualism (Hausch and Melnychuk 2012), which may increase ecological interaction with other Endangered Species Act (ESA) listed salmonid populations (i.e., competition and predation).

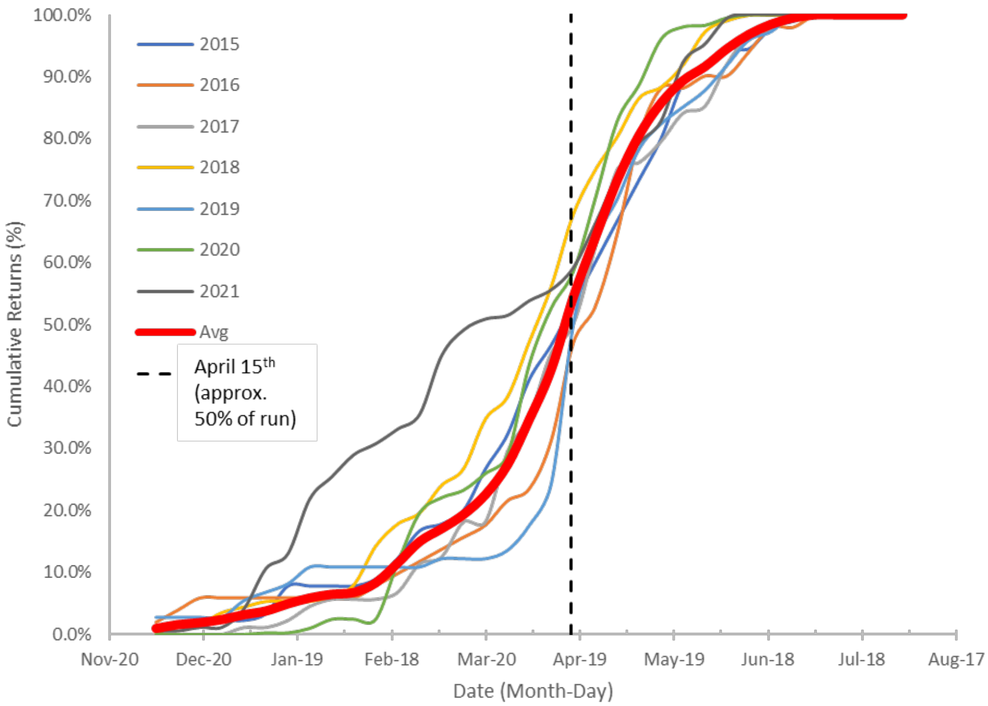

Figure A - 1. Percent cumulative returns of adult NOR winter steelhead at Merwin FCF by year (2015-2021) and the non-weighted average (solid red).

Broodstock collection schedules may be amended in-season relative to the average timing of the first NOR returns (mid-December) in response to run-timing assessments. The origin of the broodstock (NOR, BWT) will be derived by the criteria outlined in Section 2.2. Any broodstock collection targets that are not met for a given week will be added to the following week's targets. The general broodstock collection schedule for winter steelhead is detailed in Figure A-1 and Table A-1.

Table A - 1. Broodstock collection goals for winter steelhead.

Appx. Date (Start of Week)	Females (Weekly)	Males (Weekly)	Total (Weekly)	Females (Cumulative)	Males (Cumulative)	Total (Cumulative)	% Total (Cumulative)
18-Dec	-	1	1	-	1	1	2%
25-Dec	1	-	1	1	1	2	4%
1-Jan	-	-	-	1	1	2	4%
8-Jan	-	1	1	1	2	3	5%
15-Jan	1	-	1	2	2	4	7%
22-Jan	-	-	-	2	2	4	7%
29-Jan	-	1	1	2	3	5	9%
5-Feb	-	-	-	2	3	5	9%
12-Feb	1	-	1	3	3	6	11%
19-Feb	1	1	2	4	4	8	15%

26-Feb	-	1	1	4	5	9	16%
5-Mar	1	1	2	5	6	11	20%
12-Mar	1	1	2	6	7	13	24%
19-Mar	1	1	2	7	8	15	27%
26-Mar	1	1	2	8	9	17	31%
2-Apr	1	2	3	9	11	20	36%
9-Apr	2	2	4	11	13	24	44%
16-Apr	3	4	7	14	17	31	56%
23-Apr	3	3	6	17	20	37	67%
30-Apr	3	3	6	20	23	43	78%
7-May	2	2	4	22	25	47	85%
14-May	1	2	3	23	27	50	91%
21-May	1	2	3	24	29	53	96%
28-May	1	1	2	25	30	55	100%

2.4 Adult Collection Methods

To initiate the late winter steelhead supplementation program, natural-origin winter steelhead were collected from spawning grounds in the lower Lewis River Basin and used as broodstock. For approximately the first decade of the program, adults continued to be primarily collected in the lower mainstem Lewis River via tangle netting, and sometimes hook-and-line, on the spawning grounds. Over the years, more natural-origin adults have returned to the Merwin FCF and preliminary data suggest that a high proportion of the adults collected at Merwin FCF originated in the upper basin. Since return year 2019, broodstock has been exclusively collected from Merwin FCF. The Lewis River Hatchery ladder collects a few NOR and BWT steelhead each year (Kevin Young, *WDFW*, personal communication) but these adults have not been used for broodstock and are transported to the upper basin.

2.5 Adult Disposition

Adults captured at the Merwin FCF are distributed based on presence of marks, PIT tags and subject to the broodstock collection strategy outlined in Section 2.1. The disposition of adults is illustrated in Figure A-4.

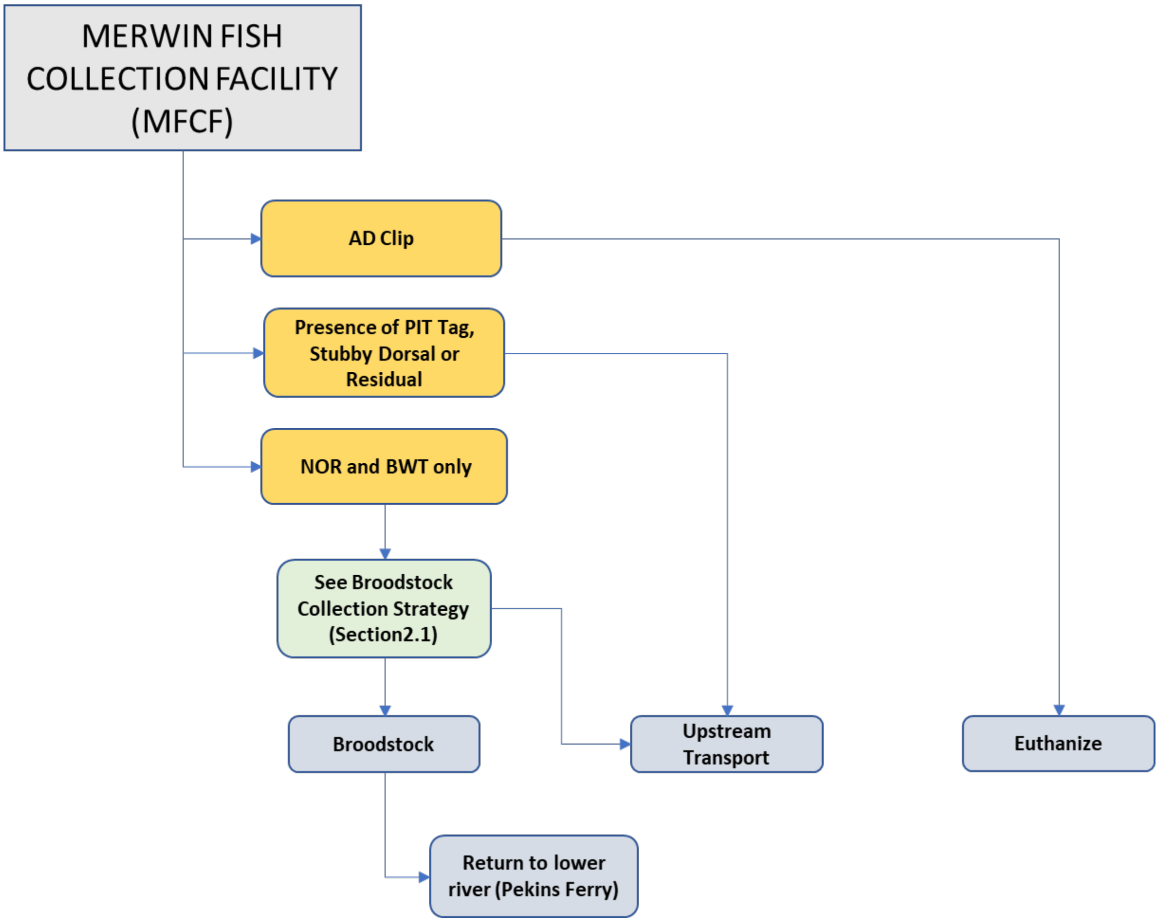

Figure A - 2. Distribution of adult late winter steelhead captured at the Merwin FCF

2.6 Data Collection Protocols

The majority of returning winter steelhead adults are collected and subsequently sampled at the Merwin FCF. The specific data and the group responsible for collection (WDFW, PacifiCorp) will depend on the transport location of each adult (hatchery broodstock or upstream transport) and the total number of adults handled in a given week (i.e., a subset of data are collected based on a sample rate).

For adults that will be transported upstream, staff at Merwin FCF will be responsible for collecting all necessary data fields prior to transport. Every data field will be recorded for each collected adult with the exception of three categories (fork length, scale sample, and tissue sample) that will be sub-sampled on a weekly basis.

For fish designated as broodstock, staff at the Merwin hatchery will be responsible for collecting all necessary data fields with the exception of PIT tagging (Table A-2). All data collected shall be provided to PacifiCorp for annual reporting purposes.

Any adult that does not possess a PIT tag will receive one from the Merwin FCF crew. All PIT tags (new and recaptures) will be uploaded to PTAGIS daily. All other sampling of broodstock will occur during the processing of brood at the hatchery by WDFW staff.

Below is a summary of the data types collected and a brief description of the collection procedure and sample rates (where applicable).

1. **Date of capture** (mm-dd-yyyy)
2. **Capture location** (Merwin FCF, Lewis River Hatchery, Lower Lewis River)
3. **Capture method** (trap/ladder, hook-and-line)
4. **Disposition location** (upstream transport, broodstock, return to river (downstream of Merwin Dam)
5. **Sex** (Male/Female)

   The sex of a fish can be determined by assessing its relative size, shape and secondary characteristics such as maxillary length relative to eye position.
6. **Mark status** (e.g., AD, UM, BWT unknown)

   The mark status of a fish describes any external fin clip(s) or wire tags an individual fish has received. In general, the mark status is used to determine the origin of fish captured. Fish with AD clips (AD) or wire tags in their snout (BWT) are considered as hatchery origin while unmarked fish (UM) lacking a stubby dorsal fin are considered as natural origin.

   Each fish returning to the Merwin FCF will be automatically scanned for the presence of a BWT (mark status = BWT).

   A small proportion of hatchery fish can be "misclipped" where the intention was to remove the adipose fin but was either unsuccessful or only a partial clip of the adipose fin occurred. Partial clips of the adipose fin will be recorded as AD, and any fish possessing a BWT with adipose removed or partially clipped will be designated as "BWT -unknown".
7. **PIT tag status** (Positive or Negative)

   Each fish returning the Merwin FCF is automatically scanned for PIT tag regardless of their mark status. All fish possessing a PIT tag are sampled for length by the Merwin FCF crew and capture data are automatically uploaded to PTAGIS. Steelhead that do not possess a PIT tag, will be tagged by the Merwin FCF crew in the dorsal sinus regardless of where it is transported.
8. **Dorsal fin status** (Positive or Negative)

   A small number of steelhead captured display a stubby dorsal fin (Figure A-5), with no adipose clip or BWT. Based on several years of late winter steelhead genetic analysis, these fish originated from the integrated hatchery supplementation program that either lost their BWT or did not receive a BWT.

To avoid the use of segregated early winter steelhead in the broodstock, all unmarked stubby dorsal positive fish will be transported upstream. Adipose marked fish will be treated as segregated early winter steelhead and transported Merwin hatchery to be euthanized.

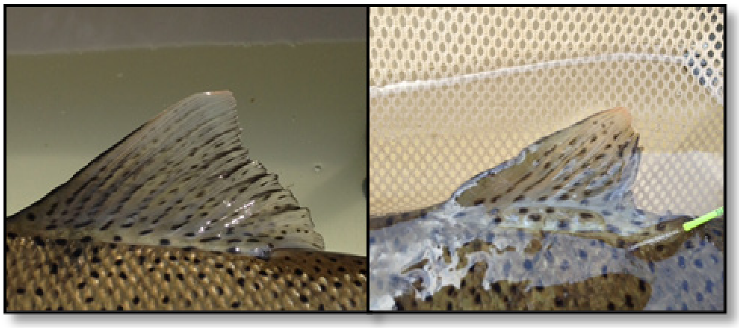

Figure A - 3. Example illustrating the shape of a normal (left) and stubby (right) dorsal fin.

9. **Life History (residual or anadromous)**

   Residuals are identified by color, body shape, and size (Figure A-6). Residuals exhibit deep (and often vibrant) coloration and spotting as opposed to anadromous fish that exhibit a silvery sheen and subdued spotting. Residuals also possess a distinct red or pink lateral stripe. Body shape of residuals is more rotund and are always smaller in size than their anadromous cohorts - typically less than 500 mm in length. Residuals entering the Merwin FCF shall be transported upstream and not selected for broodstock.

Figure A - 4. Residual steelhead encountered during annual tangle netting (note stubby dorsal fin)

10. **Fork length**

A fork length measurement should be taken from the first 10 fish captured at the Merwin FCF per week by origin (i.e., up to 10 NOR and 10 BWT per week). Measure the fork length (FL) of each fish in millimeters from the tip of the jaw or tip of the snout, whichever is greater, to the center of the fork in the tail. All broodstock transported to Merwin hatchery will be measured for length by Merwin hatchery staff

11. **Scale sampled** (Yes/No)

Scales should be collected from the first 10 fish captured per week by origin (i.e., a maximum of 20 scales per week) at the Merwin FCF. Scale samples are not required from stubby dorsal fish as their origin cannot be verified or from PIT tag positive fish as age determination is obtained from the initial PIT tagging event from the Swift FSC as smolts. All broodstock transported to Merwin hatchery will be scale sampled by Merwin hatchery staff.

Scales should be removed and placed on a scale card including date and location of capture and fork length. A new scale card should be used for each capture date. Collect three scales from each fish just above the lateral line and below the posterior insertion of the dorsal fin

12. Tissue Sample

Tissue samples shall be collected from all broodstock transported to Merwin hatchery by Merwin hatchery staff. Meta data should be included for each sample collected.

Tissue samples should be collected from the upper lobe of the caudal fin. Collect as much tissue as possible up to approximately 1/4” X 1/4” in size (hole-punch sized). Samples should be stored at room temperature on either a sheet of blotter (i.e., chromatography) paper or individual vials containing 95% natural ethanol (preservative).

13. Data Collection Responsibility

The sampling of returning late winter steelhead is a shared responsibility between the Merwin FCF and hatchery crews. Generally, sampling of fish transported upstream will be conducted by Merwin FCF crews and sampling of broodstock will be conducted by hatchery crews. As part of initial capture at the Merwin FCF, all steelhead lacking a PIT tag upon capture will be PIT tagged at the Merwin FCF including those transported to Merwin hatchery as broodstock.

Table A - 2. Data collection for late winter steelhead.

Data Type	HOR	NOR
Genetic Tissues	All broodstock sampled	
Fork Length	Merwin Trap (PIT -): 10 BWT per week (PIT +): Sample All (stubby dorsal only): no sample Merwin Hatchery All broodstock sampled	Merwin Trap (PIT -): 10 per week (PIT +): Sample All Merwin Hatchery All broodstock sampled
Scales	Merwin Trap (PIT -) 10 BWT per week (PIT +) none Merwin Hatchery All broodstock sampled	Merwin Trap (PIT -) 10 BWT per week (PIT +) none Merwin Hatchery All broodstock sampled
Fecundity	Individual estimate per female	Individual estimate per female
Note: all AD clipped steelhead are transported to Merwin hatchery to be euthanized		

2.7 Broodstock Holding Protocols

All winter steelhead assigned as potential broodstock will be held at the Merwin Hatchery. Upon arrival, each fish will be Floy tagged and placed into adult holding pond(s). Hatchery staff will check broodstock as needed for maturity starting in the last week of March.

If a female becomes ripe to spawn and no male broodstock are available, the female will be returned to the river; however, all possible precautions will be made to prevent this situation from occurring. The Hatchery and Supplementation steelhead program coordinator in consultation with hatchery management staff will make decisions regarding the release of fish. Collection goals should be reviewed to evaluate the risk to project goals of releasing the fish (i.e., will more females likely be available through future collections).

The following list represents recommendations from WDFW hatchery staff to reduce handling related stress, injury, or mortality of steelhead held at the Merwin Hatchery.

1. The use of only rubberized nets to hold or move steelhead: Rubberized nets are known to reduce descaling and abrasion.
2. Eliminating the use of cotton gloves to handle steelhead in favor of bare hands: Cotton gloves are abrasive on fish and remove the protective mucous on the skin of fish.
3. Aqui-S is used for the safety of the employee and to prevent injury and stress to fish during air spawning from the females and live spawning of the males.
4. Floy tags of several colors are used for quick visual identification of individual fish to limit the number of fish handled when checking for ripeness.

5. Salt and Formalin are used in holding raceways or circular tanks for steelhead. Salt reduces stress and improves oxygen uptake. Formalin is used to control fungi and parasites.

2.8 Genetic Assignment and Analysis

Since the inception of the hatchery steelhead supplementation program, genetic stock identification (GSI) has been used in-season to genetically categorize returning adults and help inform broodstock collection. Originally, the GSI work was completed by National Marine Fisheries Service (NMFS) under a contract with PacifiCorp. NMFS used a microsatellite (13 mSAT loci) based on a reference baseline almost exclusively composed of Lower Columbia steelhead used in Blankenship et al. (2011). In 2020, NMFS declined to renew the contract due to staffing shortages. In 2020 and 2021, WDFW's Molecular Genetics Laboratory (MGL) was awarded the contract to perform this in-season analysis using a single nucleotide polymorphism (SNP) based baseline that was specifically assembled for Lower Columbia steelhead populations and segregated hatchery programs (HW354). For more information on the WDFW MGL assembled Lower Columbia steelhead baseline, see memo written by Todd Seamons to the ATS on April 20th, 2020 (Subject: Assessing the performance of the WDFW Lower Columbia River steelhead SNP reference baseline for genetic stock identification (GSI)).

In January 2022, the ATS agreed to discontinue in-season genetic screening moving forward. This decision was based on three factors (see below). However, the ATS agreed that a post-season analysis was still warranted to continue monitoring the genetic composition of the broodstock and inform future monitoring decisions:

(1) **Past genetic screening results -** In-season results from 2020 & 2021 estimated that 95-100% of fish collected for broodstock were from Cascade MPG, which meant no adults were excluded based on their genetics results and the outlined broodstock collection criteria. Overall, these results suggest that the risk of collecting an out-of-MPG adult is low.

(2) **Performance of SNP-based baseline** – Based on a power analysis of the current SNP-based steelhead baseline (HW354), SNP's analysis has an accuracy rate of about 90 percent in assigning Lewis River origin adults to the Cascade MPG and greater than 99 percnet accuracy in assigning segregated hatchery fish (i.e., Chambers winters and Skamania summers). However, the baseline is only about 50 percent accurate in assigning Lewis River origin adults to Lewis River versus other Cascade MPG populations. Further details can be found in Seamons (2020).

(3) **Relative benefit of in-season screening** – Based on recent genetic results and the relative performance of the SNP-based baseline, the biggest benefit of continuing the in-season genetic screening is that it can accurately help exclude Chambers early winter steelhead from the broodstock. However, genetic screening adds little benefit given that there is little overlap between Chambers and NORs/BWTs, >99% of Chambers can be identified via AD clip (assuming an average mis-clip rate of 1%), and the remaining 1% can likely be identified via their "stubby dorsal" and excluded by

invoking the rule that no adipose intact fish with a stubby dorsal can be retained as broodstock.

2.9 Spawning Protocols

The total collection and spawn goal of 25-35 males is based on the spawning strategy (see Section 3.8). Briefly, a randomized factorial spawning strategy is implemented for hatchery winter steelhead, which is simply the process of spawning individual fish with more than one mate. There are numerous ways to hypothetically implement factorial spawning, but the specific factorial cross is largely dependent on the number of ripe spawners for a given day. In general, the most common cross is 2x2. However, due to the small program size and variable spawn timing, there can be instances when there is a single ripe female on a given day. When this occurs, two males are spawned with one female. The possibility of this occurring necessitates the need for additional males to be collected.

All collected fully mature broodstock will be spawned according to the following protocols, without regard to age, size, or other physical characteristics:

1. No fish shall be excluded except for those with overt disease symptoms or physical injuries that may compromise gamete fertility or viability.
2. All spawned fish will be returned to the lower river.
3. Females will be air spawned.
4. Fully randomized factorial mating protocols are preferred to avoid or reduce selection biases and maintain diversity.
5. If pairwise mating is warranted (e.g., only one ripe female is available) the use of a backup male is preferred to reduce the potential for egg loss from infertile males.
6. If two females and only one male are ripe, a 2x1 cross can occur. However, this is not preferred and efforts should be made to collect additional males from the Merwin FCF if in Phase II collection.
7. Holding males for additional spawning crosses is not permissible.
8. If a ripe spawning female has no mate, that fish will be returned to the river downstream of Merwin Dam in hopes of spawning naturally (see Section 2.10 Release Protocols). All precautions will be taken to prevent this situation from occurring. Whenever possible the decision to release females should occur before the female becomes ripe.
9. During spawning, a fish health specialist will take the necessary viral samples according to standard protocols (see Strategy C).
10. Ovarian fluid will not be drained before fertilization.
11. Eliminate green egg samples: Total egg mass weight will be used to estimate fecundity.

3.0 JUVENILE PROGRAM IMPLEMENTATION

3.1 Egg Take Goals

The egg take goal for this program is 90,000 +/- 20%. This egg take target is based on the smolt release target paired with the average fecundity of females and the anticipated in-hatchery survival. Fecundity is highly variable among native females and this goal is intended to be flexible; however, total egg take should never exceed the maximum level of 108,000. In-season adaptive management will be used to meet egg collection goals through broodstock management.

3.2 Egg Incubation

Eggs from each female are placed into an individual tray to incubate. To reduce the risk of Bacterial Coldwater Disease (BCWD), each egg tray is partitioned in half, which subsequently increases egg density and reduces the flow and mobility of the eggs. Each spawned fish will have its own ozonated water supply. Eggs or fish will not be combined until viral results are known.

3.3 Rearing and Release Schedule

Fish will be transferred to the intermediate raceways located within the incubation building after incubation and hatching. Fish will remain in the intermediate raceways for a period of 6 to 8 months. All source water passes through the hatchery ozone plant for sterilization before entering the incubation building. After 6 to 8 months, or once fish outgrow the intermediate raceways, fish are transferred to outside raceways and ponds where they are subject to untreated water. Table A-4 presents a timeline for the movement of fish by life stage at the Merwin Hatchery.

In addition to monitoring rearing densities and feeding, hatchery staff assesses performance and growth by implementing sampling methods to calculate condition factor (K), estimated variation in length (CV), and feed conversion factor (FCR) for each raceway. For this stock, these assessments are typically completed prior to first feeding (July) and prior to release (May). This is done by sampling 100 fish from each raceway from three locations (upper, middle and lower) for a total of 300 fish per raceway.

Table A - 3. Generalized hatchery production and collection timeline for late winter steelhead

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult Collection	■	■	■	■	■							■
Spawning			■	■	■							
Incubation			■	■	■	■	■					
Ponding	■	■	■	■		■	■	■	■	■	■	■
Tagging (BWT)												■
Volitional Release					■							

3.4 Feeding Type and Requirements

All fish that are ponded for rearing at Merwin Hatchery will be fed the best quality feed available through WDFW vendors. These formulations provide high protein and fat percentages and have proven to provide optimal growth from start to finish (Roberts, 2013).

There is a combination of feeding methods used. Hand feeding is typically done for early rearing troughs and raceways. Hand feeding occurs 2 to 8 times per day depending on life stage. Once fish are transferred to the large rearing ponds, demand feeders are used along with hand feedings 2 to 3 times per week if needed. The incorporation of belt feeders, or other options (underwater feeders) may be employed to provide for extended feeding schedules, or provide more natural methods for fish feeding.

3.5 Marking and Tagging

Once these fish reach a size of 20 to 25 fish per pound (fpp) in December, all are tagged with BWTs in their snout and placed into the rearing ponds until their scheduled release the following May. No other marks or clips are used for the late winter steelhead supplementation program.

3.6 Release Size and Number

Late Winter Steelhead: 50,000 smolts (± 20%) at 5 to 8 fish per pound.

Volumetric methods and individual length measurements are used to estimate the number and size of fish released (see Strategy F). If the rearing goal is exceeded, surplus fish will continue to be reared and released with the program fish. However, this will require notification to NMFS prior to release. The intention of the spawning program is to not exceed the egg take or release targets and precautions should be employed (e.g., partial spawning) if targets are in jeopardy of exceeding the production limits set in this plan.

3.7 Release Timing and Locations

Steelhead smolts are volitionally released over a six-week period, which is scheduled to begin by May 1 of each year.

Fish that actively migrate during the volitional release window are transported to the Merwin boat ramp (RM 19) for planting. Once the volitional window has ended, any remaining fish are transported and planted at Pekins Ferry Boat Ramp (RM 3.1). Alternate lower river release locations may be used if significant bird or pinniped predation is observed at the Pekins Ferry site (e.g., Woodland release ponds, county bridge, island boat ramp, etc.)

4.0 ADULT SUPPLEMENTATION UPSTREAM OF SWIFT DAM

The current transport goal of late winter steelhead is 1,700 adults (H&S Plan 2020). Transport of adult steelhead to the upper Lewis River Basin began in 2012 and has relied primarily on the production of hatchery-origin recruits (BWT) to provide a demographic boost. Over the past decade, there has also been an increase in the abundance of returning adults that are offspring from supplementation efforts upstream of Swift Dam. Because only about 10 percent of steelhead smolts are PIT tagged at the Swift FSC (and thus confirmed as upstream recruits), there remains an unknown portion of natural origin returns that cannot be classified as originating upstream of Swift Dam or downstream of Merwin Dam. However, based on the portion of PIT tagged adults returning from a known number of marks, inferences can be made on the estimated number of returning steelhead that originated upstream of Swift Dam. Therefore, steelhead transported upstream of Swift Dam will include all BWT returns and a portion of NOR returns to the trap. The portion of NOR returns transported upstream will be predicted by the ATS using PIT tag return rates and other factors deemed appropriate by the ATS (e.g., total number of smolts released from the FSC and hatchery production program by year). These estimates (when available) will be reported as part of the Aquatic M&E plan objectives.

Steelhead that are transported above Swift Dam are typically released at the Eagle Cliff Bridge Site. If the Eagle Cliff Bridge site is unavailable or inaccessible, steelhead may also be released at the Swift Camp boat ramp or Swift Dam. In some instances, fish may be released at alternate locations to enhance their distribution into tributaries of upper North Fork Lewis River. These alternate release locations include but are not limited to: Muddy River Bridge, Clear Creek Bridge, and Curly Creek Bridge. If alternate distribution sites are selected, planting trucks will work on a rotating basis for each haul. For example, the first load may be released at Curly Creek Bridge, the second at Muddy River Bridge, and so on. This may not equate to equal portions for each site but should be reasonably close.

SECTION B SPRING CHINOOK

1.0 INTRODUCTION

The Lewis River spring Chinook salmon program is composed of two parts: adult supplementation upstream of Swift Dam and juvenile hatchery production for release downstream of Merwin Dam. Adult supplementation will provide up to 3,000 adults for release upstream of Swift Dam each year to spawn naturally. Juvenile supplementation will rear up to 1,350,000 spring Chinook for release downstream of Merwin Dam.[1] Release timing of juvenile supplementation fish will vary depending on planned evaluations described in Strategy E. Returns from both the adult and juvenile supplementation programs comprise the foundation to meet the primary goals of providing harvest opportunity and creating a self-sustaining population that does not rely on hatchery support (see Settlement Agreement Section 8.4). This section describes the implementation of both the supplementation and hatchery production programs.

2.0 ADULT PROGRAM IMPLEMENTATION

The following sections describe the detailed protocols for implementation of the spring Chinook portion of the H&S Plan.

Prioritized goals for distribution of returning hatchery origin spring Chinook:

1. hatchery broodstock goal
2. Upstream transport goal
3. A fishery managed to allow for #1 and #2 to be achieved.
4. Out-of-basin programs (e.g., other Southern Resident Killer Whale programs, Deep River Net Pen project)

2.1 Broodstock Source and Selection

The Lewis River spring Chinook hatchery program is operated as a segregated program. Therefore, all broodstock transported to hatcheries will be of hatchery origin. Adult returns identified as NOR will be transported to the Lewis River above Swift Dam to help meet the transport target of 3,000 fish. No NOR Chinook will be used to meet juvenile production needs at the hatchery. Adult HOR (adipose fin missing, or adipose fin intact AND CWT snout tag) spring Chinook returns will be used to meet juvenile production (mitigation) targets. Broodstock will be selected over the course of the run, and any surplus spring Chinook will be transported upstream to achieve adult supplementation targets. In years when hatchery returns are weak, it may be necessary to hold surplus Chinook at Lewis River Hatchery in the early portion of the run until it becomes clear the annual broodstock goal will be met. After 50% of the run has been realized, a decision will be made on whether to transport all (or a

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[1] Beginning in 2018, the spring Chinook upper river acclimation program (up to 100,000 juveniles) was suspended by the ACC in favor of releasing these juveniles downstream of Merwin Dam for a period of at least 5 years. This decision was made in an effort to improve adult returns. Annual review of this modification will occur annually between the ACC and the ATS.

portion of) surplus Chinook being held at Lewis River Hatchery upstream of Swift Reservoir. Planning should be coordinated with hatchery staff to ensure that broodstock are collected proportionately over the run curve.

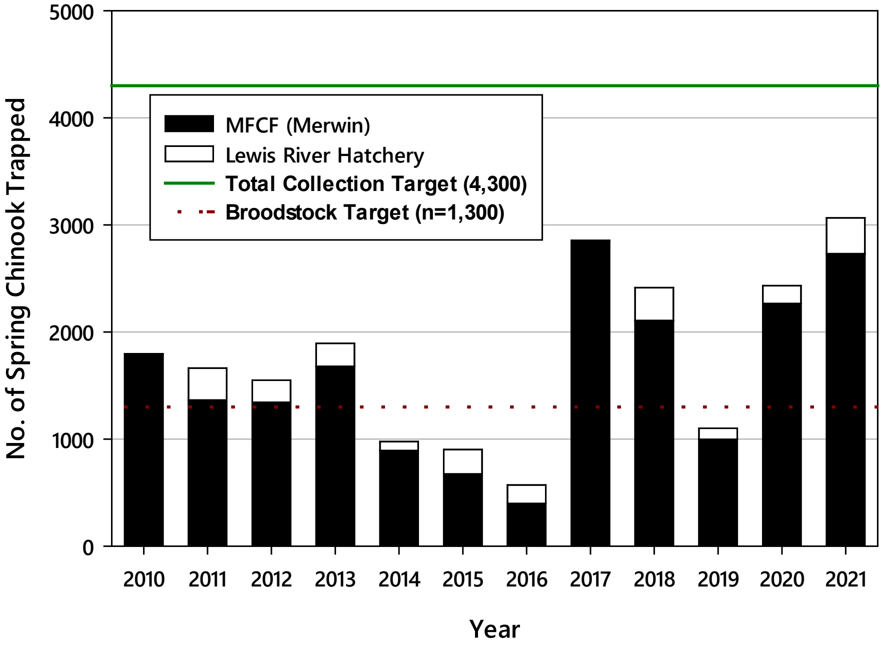


Figure B - 1. Actual number of spring Chinook trapped annually between 2010 and 2021 at both the Merwin FCF and Lewis hatchery ladder.

*Note: *Total collection target includes broodstock (1,300) and adult supplementation target (3,000) upstream of Swift Dam.*

2.2 Broodstock Collection Goal

Spring Chinook broodstock collection goals for the Lewis River programs are as follows:

- Hatchery Broodstock: Approximately 1,300 over the full range of the run with an approximate sex ratio of 2 males for each female.

Collection for hatchery broodstock will be given priority each week. All fish allocated for hatchery broodstock will be transported and held at Speelyai or Lewis River Hatchery. If the weekly quota for hatchery broodstock is not met, then all fish collected during subsequent weeks will be allocated for broodstock until the quota meets the predetermined broodstock collection curve.

All HOR fish collected prior to the peak of the run and designated as adult supplementation (upstream) fish will be transported and temporarily held at Lewis River Hatchery. All fish containing CWTs will be allocated to hatchery broodstock and transported to Speelyai Hatchery. A meeting will be held between PacifiCorp Aquatics Team and WDFW Fish Managers during the week of the anticipated peak of the run to discuss current run numbers and whether fish being held at Lewis River Hatchery can be taken upstream. If adult spring Chinook are returning at a rate at or above the projected running curve for that period, then all fish being held at Lewis River Hatchery will be taken upstream as well as any subsequent fish allocated for adult supplementation. If it appears that adult spring Chinook are returning at a rate exceeding the projected run curve, then it is possible that adults being held at Lewis River Hatchery could be taken upstream earlier. If it is decided that fish being held at Lewis River Hatchery will not be transported upstream by the peak of the run, they will continue to be held until hatchery broodstock goals have been met. Fish allocated for adult supplementation may be reallocated for hatchery broodstock if the adult return rate remains below the projected number.

All spring Chinook less than 24 inches will be considered jacks. Jacks will not comprise more than 5% of the broodstock collection or adult supplementation. Variations to this guidance will be decided in-season through ATS agreement.

2.3 Broodstock Collection Timing

Broodstock collection for the juvenile supplementation program should occur proportionately over the entire run timing. NOR Chinook should be transported upstream at the time of capture if at Merwin FCF or as soon as possible if at Lewis Hatchery trap. Figure B2 illustrates the trap timing of spring Chinook entering the Merwin FCF. Table B1 illustrates the 2023 spring Chinook generalized collection curve for each part of the program described in the previous section.

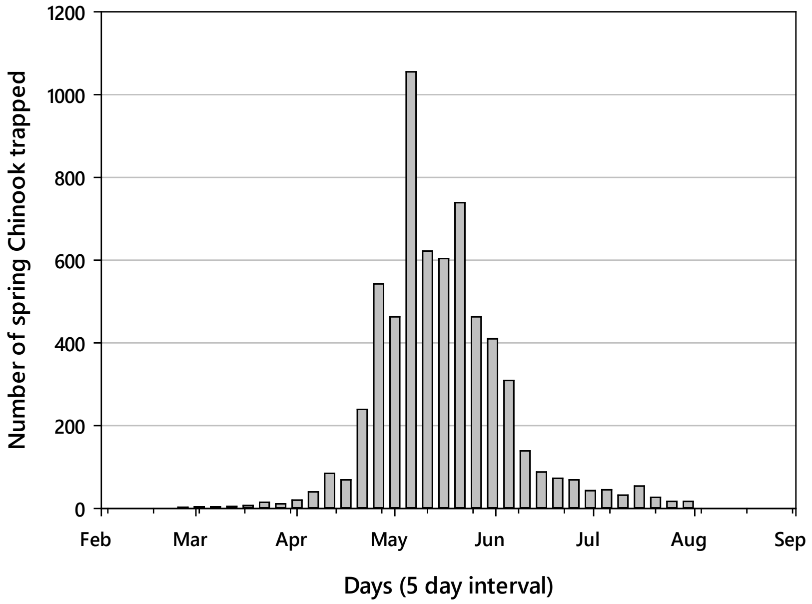


Figure B - 2. Actual number and timing of spring Chinook trapped at the Merwin FCF from 2016 to 2019.

Table B - 1. Spring Chinook generalized allocation schedule for broodstock and adult supplementation

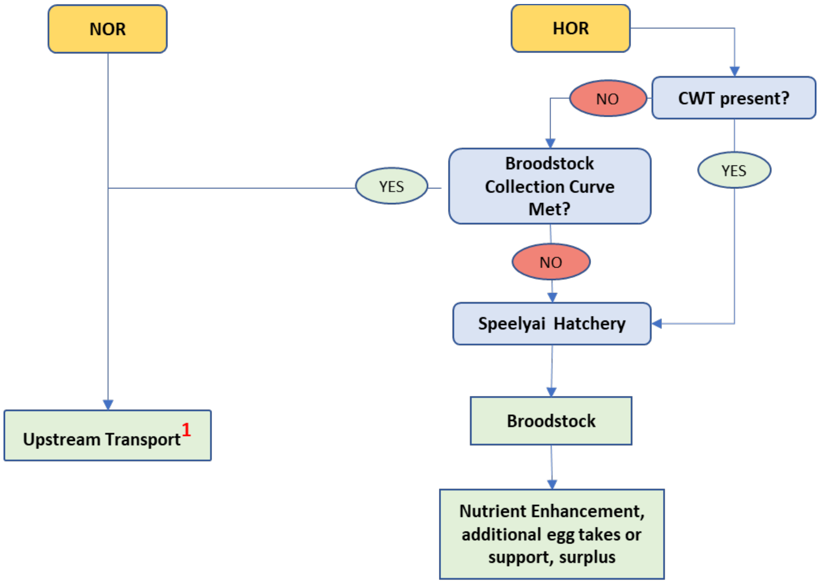
Appx. Date (Start of Week)	Hatchery Brood Stock	Adult Supplementation (Upstream)	Total (Weekly)	Total (Cumulative)	% Total (Cumulative)
2-Apr	21	48	69	69	2%
9-Apr	6	15	21	90	2%
16-Apr	13	28	41	131	3%
23-Apr	61	141	202	333	8%
30-Apr	69	159	228	561	13%
7-May	153	351	504	1065	25%
14-May	169	388	557	1622	38%
21-May	226	516	742	2364	55%
28-May	243	558	801	3165	73%
4-Jun	155	354	509	3674	85%
11-Jun	92	211	303	3977	92%
18-Jun	29	68	97	4074	95%
25-Jun	26	58	84	4158	97%
2-Jul	16	38	54	4212	98%
9-Jul	6	15	21	4233	98%
16-Jul	11	26	37	4270	99%
23-Jul	7	17	24	4294	100%
30-Jul	4	9	13	4307	100%
TOTAL	1,307	3,000	4,307	--	--

2.4 Adult Collection Methods

All broodstock are collected at either the Merwin FCF or Lewis River ladder.

2.5 Adult Disposition

Spring Chinook are either transported upstream or held for broodstock at Speelyai (or temporarily at Lewis River) hatchery depending on broodstock needs, origin and the presence of a CWT. Figure A2 illustrates the distribution protocol to be used for captured spring Chinook salmon.



[1] *ACC may approve increased upstream transport numbers of NOR's based on run size. If not approved, all NOR's in excess of approved transport goal would be returned to the lower river (i.e., never surplused)*

Figure B - 3. Sorting and distribution protocol for Lewis River spring Chinook collected at the Merwin FCF and Lewis River ladder

2.6 Data Collection Protocols

<u>The following data will be recorded for all individuals and for all capture methods.</u>

1. Capture Date (mm-dd-yyyy)
2. Capture Location (Merwin Trap, Lewis River hatchery, in-river)
3. Origin (NOR or HOR)
4. Sex (M/F)
5. Mark Status (PIT, CWT, AD)
6. Life Stage (adult, jack)

<u>The following data will be recorded as a subsample of the total captures.</u>

Data Type	HOR	NOR
Genetic Tissues	No sampling in 2023	
Fork Length	(CWT +): up to 100 (CWT -): none	(PIT -): up to 10 per week (PIT +): sample all

Scales	(CWT +): up to 100 (CWT -): none	(PIT -): up to 10 per week (PIT +): none[2]
Fecundity	Average Fecundity by spawn date (batch)	NA

2.7 Broodstock Holding Protocols

Broodstock are typically collected daily from April 1 through as late as August at the Merwin FCF or Lewis River ladder. All broodstock are transported to Speelyai Hatchery and held until spawning begins in mid-August (Table B2). The exception to this protocol is if the run size forecast is relatively low, fish collection may begin early and fish exceeding weekly broodstock goals may be held at Lewis Hatchery until the approximate half-way (50%) point in the run. At this point, the ATS will determine whether to transport all or a portion of the spring Chinook being held at Lewis hatchery. This determination will be made based on the number of broodstock currently held at Speelyai and predicted trap returns for the remaining run. That is, the likelihood that broodstock goals will be met. Spring Chinook held at Lewis River are treated as if they are to be transported and released upstream of Swift Dam. Broodstock that receive antibiotic injections are not transported, released, used for nutrient enhancement, or donated to any food banks or tribes due to mandated injection withdrawal periods.

2.8 Genetic Assignment and Analysis

See Section D, Objective 7 and Strategy G.

2.9 Spawning Protocols

All collected fully mature broodstock will be spawned using a pairwise (1x1) mating cross with a backup male. No fish shall be excluded except for those with overt disease symptoms or physical injuries that may compromise gamete fertility or viability. All fish are kill spawned, and disposition of carcasses is directed by the WDFW. Note that spawning protocols may change during the transition planning process.

3.0 JUVENILE PROGRAM IMPLEMENTATION

3.1 Egg Take Goals

Egg take required to meet hatchery production goals as set forth in the Lewis River Settlement Agreement (Settlement Agreement) include the following:

Spring Chinook target: 1,755,000 eggs

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[2] Age of PIT tag positive captures will be determined through PTAGIS records

3.2 Egg Incubation

Eggs are incubated in vertical stack incubators. Each female is assigned a number and only one female per tray, unless there are not enough trays towards the last egg take, then two or three fish will be pooled together until results are in from the enzyme-linked immunosorbent assay (ELISA) testing, if testing is performed (see Attachment A - Fish Health and Disease Strategy Plan).

3.3 Rearing and Release Schedule

All spring Chinook from fry to smolt are fed the highest quality feed available from WDFW contracted vendors. Fry will start out being fed 7 days per week. As they grow, the number of days fed per week will be reduced but will not be less than 3 days per week.

Hatchery staff will implement monthly performance sampling and a QA/QC sampling prior to release.

Immediately before the start of the volitional release period (pre-release group), additional sampling is conducted to assess precocity and assign a smolt index for a minimum of 100 smolts per release pond as part of ongoing morphology sampling (See Strategy F for Within-Hatchery Monitoring associated for the Spring Chinook Rearing and Release Study). This sampling is repeated at the end of the volitional release period, immediately before remaining fish are forced out (post-release group), to compare precocity between the pre and post release groups. These methods are described in detail in Strategy E.

Table B - 2. Hatchery production and collection timeline for North Fork Lewis River spring Chinook

	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F
Adult Collection				■	■	■	■																			
Spawning								■	■																	
Incubation								■	■	■	■	■														
Rearing													■	■	■	■	■	■	■	■	■	■	■	■	■	■
Tagging															■	■										
Volitional Release																		■				■				■
Direct Release																		■				■				■

3.4 Feeding Type and Requirements

After ponding, at Speelyai Hatchery, spring Chinook fry are hand-fed with Bio Pro starter feed sizes #0, #1, #2, 1.2 mm and then Bio Clark's Fry 1.5 mm. Fish are fed 2 to 8 times per day. Feed volumes and frequencies follow a growth plan for each rearing group, and small adjustments are made weekly based on actual fish body sizes and feed conversion rates.

After transfer to Lewis River Hatchery, spring Chinook are hand-fed with Bio Clarks Fry once daily, 2 to 5 times per week depending on time of year, growth rates etc. Spring Chinook are hand fed by 1 to 2 staff for each pond.

3.5 Juvenile Marking and Tagging

Juvenile tagging type and location for hatchery-produced spring Chinook are presented in Table 6-1 of the H&S Plan (PacifiCorp and Cowlitz County PUD 2014). The number of tags and tagging groups may be modified annually as part of ongoing evaluations of rearing and release strategies (Strategy E).

A subset of juvenile spring Chinook that are collected at the FSC will be PIT tagged to provide additional information on juvenile transport survival at the release ponds and preliminary information on smolt out-migration timing (based on lower Columbia River detections) and out-of-basin avian predation (based on detections at bird colonies such as East Sand Island). The target is to tag approximately 10-15% of the parr or smolts (> 90mm) that are passed downstream from the Swift FSC. Juveniles captured at the FSC may be fish that were hatchery-reared and released from the juvenile supplementation program in previous years and overwintered upstream of Swift Dam or may be offspring of supplementation program adults.

The hatchery production goal is 1,350,000 smolts with the following three tagging groups:

- Adipose fin clip: 1,050,000
- Adipose fin clip and CWT: 150,000
- CWT only (DIT group): 150,000

3.6 Release Size and Number

Spring Chinook: 1,350,000 smolts at 8, 12, or 80 fish per pound depending on release group (see Table B3)

Volumetric methods and individual length measurements are used to estimate the number and size of fish released (see Strategy F). If the rearing goal is exceeded, surplus fish will continue to be reared and released with the program fish. However, this will require notification to NMFS prior to release. The intention of the spawning program is to not exceed the egg take or release targets and precautions should be employed (e.g., partial spawning) if targets are in jeopardy of exceeding the production limits set in this plan.

3.7 Release Timing and Locations

As described in Strategy E of this plan, most Lewis program spring Chinook (1,350,000) are volitionally released as yearlings in October or February from Lewis River Hatchery directly into the Lewis River. The volitional release includes pulling the screens, lowering the water level slowly over a 2-week period or until 90% or more of the smolts have left on their own. The remaining fish left are then flushed out.

2021 is the fourth year of a study designed to test release strategies and survival between up to five release groups. The study began with BY 2017 and is described in detail in Strategy A. Table B3 shows a summary of the different release groups planned as part of this study, which were designed to test the following variables: release month, date transferred to Lewis River Hatchery, rearing environment, ration level and size at release. This study will continue for at least 3 BYs and strategies will be evaluated each year and changes made if substantial problems are discovered. After 3 years of implementation, in-hatchery survival rates, size-at-release, condition factor at release, fish health (frequency or rates of disease), and physiological status at the time of release will be compared between treatment groups as described in Strategy E. All juveniles are released from the Lewis River Hatchery. Planned releases for 2023 (BY2021 and BY2022) are summarized in Table B-3. Deviations from this plan will be described during reporting.

Table B - 3. Summary of planned annual release groups as part of the spring Chinook rearing and release evaluation (Strategy D)

Release Group	Transfer Month to Lewis River Hatchery	Release Month	Size at Release (fpp)	Planned Tagging[2]		Planned Release (smolts)	Group Description
				AD + CWT	CWT ONLY		
1	May	February	8	37,500	37,500	150,000	Control group
2	December	February	12	37,500	37,500	175,000	Low ration, reared at Speelyai 6 months
3	December	February	8	37,500	37,500	150,000	Normal ration, reared at Speelyai 6 months
4	May	October	12	37,500	37,500	825,000	Released in October
5[1]	NA	June	80	0	50,000	50,000	Released in June
		TOTAL		**150,000**	**200,000**	**1,350,000**	

[1] *A minimum of 50,000 fish will be planted, but if surplus juveniles are available due to better than expected survival etc., they would be released in this group. All fish from this release group will be adipose fin-clipped; up to 50,000 fish will be marked with CWT.*

[2] *The number and type of tags distributed for each release group may be modified as recommended by the ATS based on projected surplus or deficit to planned release numbers.*

4.0 ADULT SUPPLEMENTATION UPSTREAM OF SWIFT DAM

Up to 3,000 spring Chinook (when available) will be transported from the Merwin FCF and Lewis River traps (or acceptable alternative stock) to Eagle Cliff or designated areas upstream of Swift Dam. Ideally, the transport goal would be entirely of natural origin spring Chinook. At present, all NOR returns are transported upstream, however, there are insufficient NOR returns to reach the transport goal. Therefore, HOR spring Chinook (when available) are also transported upstream in an effort to reach the transport goal of 3,000 spring Chinook.

The transport goal of 3,000 spring Chinook is based on EDT analysis completed in 2019. This goal is likely to change as more information becomes available (e.g., IPM’s) and should be reviewed as part of the adaptive management component of this plan. If exceedance of the transport target is recommended by the ATS in any given year (i.e, returns exceed broodstock and upstream transport target), the ATS would seek approval by the ACC prior to exceeding the transport target in this plan.

A minimum of two tanker fish trucks will be used weekly to move captured spring Chinook upstream. Each tanker truck can transport about 100 adult Chinook salmon. Table B - 4 provides a proposed transportation schedule, indicating biweekly numbers to achieve the transport goal of 3,000 over the run period; however, this schedule will not be possible to achieve if run sizes are low relative to the broodstock goal. In years with low pre-season run forecasts, fish will be held at Lewis Hatchery until broodstock goals are met, as described in AOP sections 2.1 and 2.2.

Prior to 2017, transported spring Chinook were released at different locations upstream of Swift Dam to enhance their distribution into streams (seed planting). Eagle Cliff, Muddy River Bridge, Clear Creek Bridge, and Curly Creek Bridge were used to release an approximately equal portion of the transported spring Chinook. To simplify the logistics, fish trucks rotated the release location of each haul. For example, the first load was released at Eagle Cliff, the second at Muddy River Bridge, and so on, resulting in nearly equal portions released at each site. Eagle Cliff was chosen as a preferred site for release as it is not affected by reservoir fluctuations and provides the opportunity for released fish to migrate upstream immediately without having to migrate through reservoir waters that can exceed optimal water temperatures. Distribution of spawning will be monitored annually to determine if spawning distribution is adequate and protocols are adapted as needed.

Table B - 4. Recommended transportation timing of adult spring Chinook for supplementation upstream of Swift Dam

Time Period	Target number of spring Chinook transported upstream of Swift Dam
Apr 15-30	300
May 1- 15	600
May 15-31	1,125
Jun 1-15	750
Jun 15-30	225
TOTAL	**3,000**

SECTION C COHO SALMON

1.0 INTRODUCTION

The Lewis River coho salmon program has two components, upstream adult supplementation and downstream hatchery production. The goal of the adult supplementation program is to transport up to 6,800 early and late adult coho (both NOR and HOR) to the upstream end of Swift Reservoir. This target number of adults was determined through the Ecosystem Diagnostic and Treatment (EDT) process which defines habitat capacity upstream of Swift Dam. The intent of the adult supplementation program is to increase the number of NOR coho salmon returning to the North Fork Lewis River with a long-term goal of passing only NOR coho salmon. The hatchery production goal is to release 1,100,000 segregated early coho smolts and 900,000 integrated late coho smolts annually. The minimum target for NOR integration into late coho hatchery production is 30% per HSRG guidance (HSRG 2014).

2.0 ADULT PROGRAM IMPLEMENTATION

The following section describes the protocols for implementing the coho program of the H&S Plan.

Prioritized Goals for management of returning Lewis River Early Coho:

1. Lewis River broodstock goal
2. Minimum upstream supplementation goal (1,000 Pairs may include NORs and some HORs as needed – early/late Coho)
3. A fishery managed to allow for #1 and #2 to be achieved
4. Additional upstream supplementation (target is 6,800 early and/or lates) and other in-basin programs (none currently planned)
5. Out of basin programs (none currently planned)

Prioritized Goals for management of returning Lewis River Late Coho:

1. Lewis River broodstock goal
2. U.S. v. OR[3] (in combination with other Cascade stratum sources, i.e., Washougal/Kalama)
3. Minimum upstream supplementation goal (1,000 Pairs may include NORs and some HORs as needed – early/late Coho)
4. A fishery managed to allow for #1 -#3 to be achieved
5. Additional upstream supplementation (target is 6,800 early and/or lates) and other in-basin programs (e.g., Educational Remote Site Incubators)
6. Other out of basin programs (none currently planned)

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[3] See 2008-2017 *United States v. Oregon* Management Agreement, May 2008

2.1 Broodstock Source and Selection

Broodstock source for the supplementation program shall be composed of both early (Type S) and late coho (Type N) returning to either the Merwin FCF or Lewis River Hatchery ladder.[4] For adult supplementation, the Merwin FCF is preferred because these fish are assumed to be upstream migrants attempting to reach areas above Merwin Dam. The Lewis River Hatchery ladder will be used primarily for hatchery broodstock collection. All early coho NORs should be passed upstream. A portion of late coho NORs are used for the late coho integrated hatchery program (integration rate minimum goal of 30%).

2.2 Broodstock Collection Goal

In most years, the number of coho salmon returning to traps has been sufficient to achieve both hatchery and upstream supplementation targets of about 10,000 adults (Figure C1). Broodstock comprise both returning adult and precocious males (jacks). The proportion of jacks integrated into the hatchery broodstock may include up to 10% of male spawners (HSRG recommendations). WDFW guidance is for at least 2% of male spawners to be jacks (WDFW HEAT Summer Meetings Handout – Jack Utilization Guidelines and Spawning Citations).

Hatchery Broodstock: Up to 1,400 HOR early adults, depending on fecundity, will be used as broodstock to support the segregated hatchery production goal of 1,100,000 smolts (released annually). An additional 1,000 late returning HOR and NOR adults will be used to support integrated hatchery production of about 900,000 smolts (released annually). The minimum target for NOR integration is 30% for late coho per HSRG guidance. Note that the ATS may discuss changing the broodstock target for 2023 in order to meet requirements of the transition plan.

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[4] On July 21, 2015, the H&S Subgroup agreed to incorporate late coho as a supplementation stock. This decision was affirmed by the ACC on August 13, 2015.

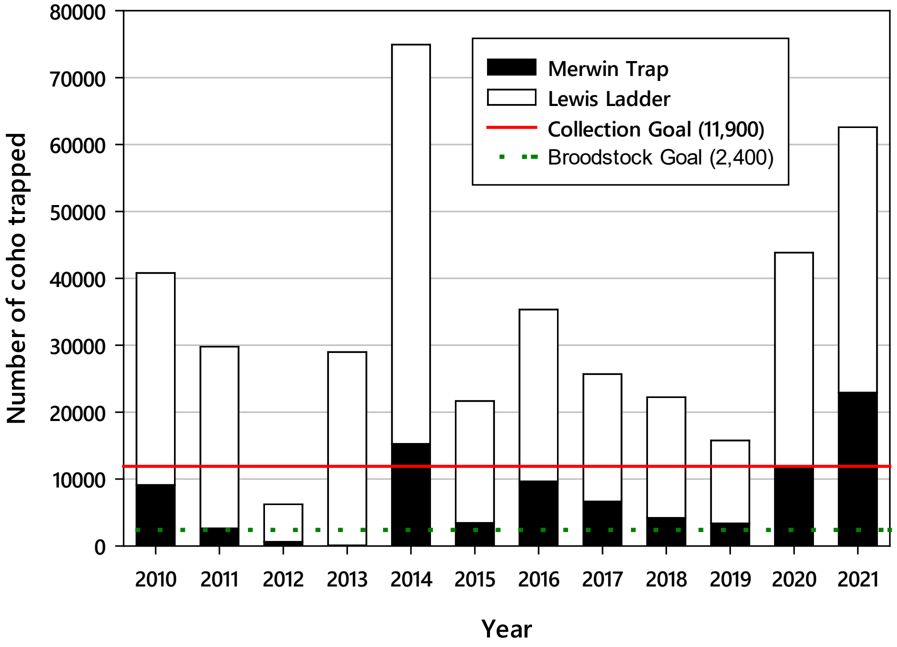

Figure C - 1. Total number of coho trapped annually between 2010 and 2021 at the Merwin Fish Collection Facility and Lewis Hatchery ladder

Note: Collection target line (11,900) represents number of early and late coho needed to meet hatchery broodstock (2,400) and adult supplementation goals (9,500).

2.3 Broodstock Collection Timing

Because the coho program relies on trapping, broodstock collection should occur proportionately over the trap collection curve. Early coho begin entering trapping facilities in early September and peak capture rates are observed in mid to late October. Late coho begin entering trapping facilities in late October and continue through December (Figure C2). Table C-1 provides a proposed collection curve for both early and late coho that is consistent with HSRG recommendations to collect broodstock over the entire collection window.

During the last 2 weeks of October when both early and late stocks are arriving at the traps, staff will visually assign fish to a stock based on coloration and maturation. Fish that cannot be clearly identified by stock are passed upstream unless they are in poor condition, in that case they would be used for nutrient enhancement or allocated to surplus.

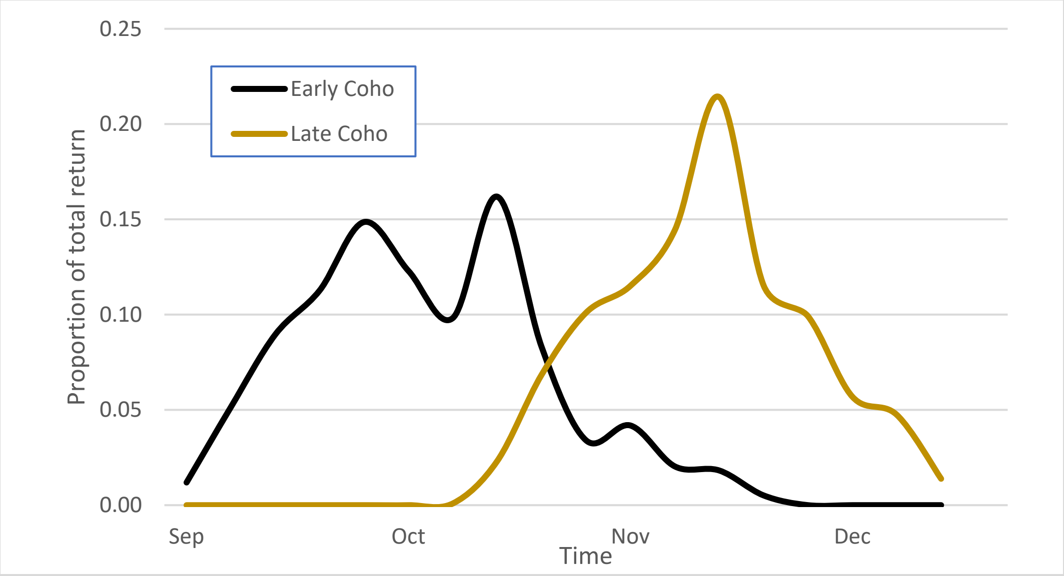

Figure C - 2. Trap entry timing for early and late coho at the Merwin Trap 2017 - 2021.

Table C - 1. Hatchery broodstock collection curve for early and late coho

Period	Number of Coho	Relative Proportion	Relative Percent of the Run	Total (Cumulative)	% Total (Cumulative)
Sep 1-15	50	0.02	2%	50	2%
Sep 16-30	400	0.17	17%	450	19%
Oct 1-15	450	0.19	19%	900	38%
Oct 16-31	550	0.23	23%	1450	60%
Nov 1-15	300	0.13	13%	1750	73%
Nov 16-30	300	0.13	13%	2050	85%
Dec 1-15	200	0.08	8%	2250	94%
Dec 16-31	150	0.06	6%	2400	100%

2.4 Adult Collection Methods

Coho salmon are collected from both the Merwin FCF and Lewis River Ladder. Coho designated as broodstock are held at either Speelyai (earlies) or Lewis River (lates).

2.5 Adult Disposition

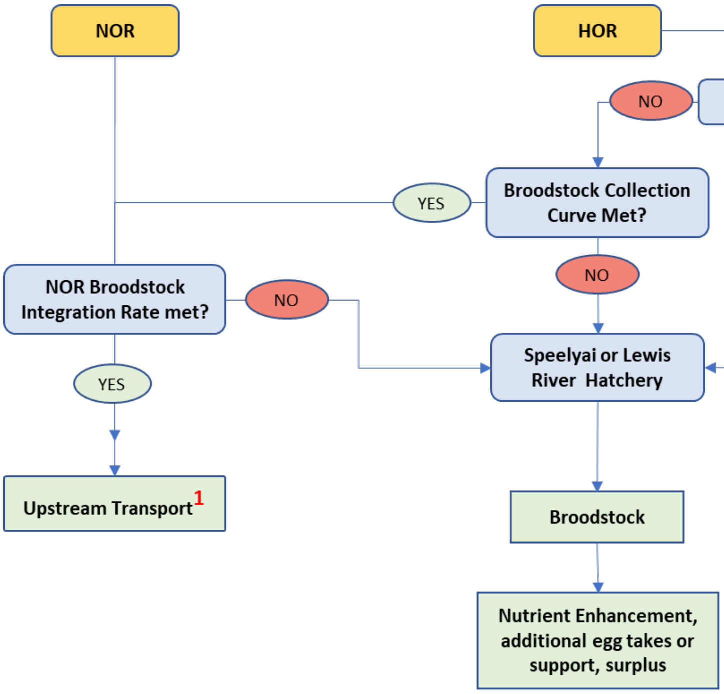

Figure C - 3. Sorting and distribution protocol for Lewis River coho salmon collected at the Merwin trap or Lewis River Ladder

[1] *ACC may approve increased upstream transport numbers of NOR's based on run size. If not approved, all NOR's in excess of approved transport number would either be returned to lower river or integrated into the hatchery broodstock (i.e, never surplused)*

2.6 Data Collection Protocols

The following data will be recorded for all individuals and for all capture methods.

1. Capture Date (mm-dd-yyyy)
2. Capture Location (Merwin Trap, Lewis River hatchery, in-river)
3. Origin (NOR or HOR)
4. Sex (M/F)
5. Mark Status (PIT, CWT, AD)
6. Life Stage (adult, jack)

The following data will be recorded as a subsample of the total captures.

Data Type	**HOR**	**NOR**
Genetic Tissues	Coho: up to 200 samples[5]	
Fork Length	(CWT +): up to 100 (CWT -): none	(PIT -): up to 10 per week (PIT +): sample all
Scales	(CWT +): up to 100 (CWT -): none	(PIT -): up to 10 per week (PIT +): none
Fecundity	Average Fecundity by spawn date (batch)	Average Fecundity by spawn date (batch)[6]

2.7 Broodstock Holding Protocols

Coho broodstock collected at Lewis River Hatchery trap or Merwin FCF are either transported to Speelyai Hatchery for spawning (early coho) or held and spawned at Lewis River Hatchery (late coho).

2.8 Genetic Assignment and Analysis

See Section D, Objective 7 and Strategy G.

2.9 Spawning Protocols

All collected fully mature broodstock will be spawned using a pairwise (1x1) mating cross with no backup male, unless insufficient milt is obtained from the selected male. Wild adults are not currently incorporated into the early Coho segregated program broodstock. Up to 30 percent of the late Coho integrated program broodstock may be comprised of wild fish collected at MCF or Lewis River Hatchery. All wild brood that are rip at the time of spawning are utilized. The integrated portion of the broodstock is spawned with crosses of HxW, WxW or HxH. No fish shall be excluded except for those with overt disease symptoms or physical injuries that may compromise gamete fertility or viability. All fish are kill-spawned, and disposition of carcasses is directed by the WDFW. Note that spawning protocols may change during the transition planning process.

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[5] Three year sampling effot to establish baseline using hatchery broodstock split among early, lates, sex and origin

[6] Late coho fecundity is averaged among HOR and NOR broodstock (i.e., separate average estimates for HOR and NOR broodstock)

3.0 JUVENILE PROGRAM IMPLEMENTATION

3.1 Egg Take Goals

Egg take required to meet hatchery production goals as set forth in the Lewis River Settlement Agreement (Settlement Agreement) include the following:

Early Coho:	1,800,500
Late Coho:	1,400,000

3.2 Egg Incubation and Juvenile Rearing

Early Lewis River coho are spawned at Speelyai Hatchery and the resulting eyed eggs are shipped to the Lewis River Hatchery in November for incubation in vertical stack incubators. Late Lewis River coho are spawned and reared at Lewis River Hatchery.

According to WDFW, incubation conditions are consistent with loading densities recommended by Piper et al. (1982). Water quality and temperatures are generally very good. Stack flows during incubation are 3.6 gallons per minute and all eggs are treated with formalin to keep them free of fungus (WDFW and PacifiCorp 2014).

Hatchery staff will implement performance sampling prior to first feeding and a QA/QC sampling prior to release. These methods are the same as described above in late winter steelhead Section 2.16.

3.3 Rearing and Release Program Schedule

Table C - 2. Hatchery production and collection timeline for North Fork Lewis River coho salmon

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult Collection									■	■	■	■
Spawning									■	■	■	■
Incubation	■	■	■						■	■	■	■
Rearing	■	■	■	■	■	■	■	■	■	■	■	■
Tagging						■	■					
Volitional Release				■	■							

3.4 Feeding Type and Requirement

At the time of ponding, fry are fed 7 days per week, 6 to 8 times per day. Feedings are tapered down to once per day, 2 to 3 times per week as the growth cycle progresses, based on maintaining fish growth and size targets. Fish are fed BioVita starter feed, then BioClark's Fry.

3.5 Juvenile Marking and Tagging

Juvenile tagging type and location for coho salmon are presented in Table 5-1 of the H&S Plan (PacifiCorp and Cowlitz County PUD, 2014) and summarized below. Coho are mass-marked in June when they are about 120 fpp, as follows:

- 1,700,000 AD only
- 150,000 CWT only (double-index tag group)
- 150,000 CWT + AD

A subset of juvenile coho that are collected at the FSC will be PIT tagged to provide additional information on juvenile transport survival at the release ponds and preliminary information on smolt out-migration timing (based on lower Columbia River detections) and out-of-basin avian predation (based on detections at bird colonies such as East Sand Island). The target is to tag approximately 10-15% of the parr or smolts (> 90mm) that are passed downstream from the Swift FSC. Juveniles captured at the Swift FSC are most likely offspring from adult supplementation, or alternatively from residualized coho that eventually become mature and spawn. This scenario, however, has not been observed during fall spawning ground surveys in the upper basin or reservoir tributaries.

3.6 Release Size and Number

- Early Coho – 1,100,000 smolts at 14-16 fish per pound
- Late Coho – 900,000 smolts at 16 fish per pound

Volumetric methods and individual length measurements are used to estimate the number and size of fish released (see Strategy F). If the rearing goal is exceeded, surplus fish will continue to be reared and released with the program fish. However, this will require notification to NMFS prior to release. The intention of the spawning program is to not exceed the egg take or release targets and precautions should be employed (e.g., partial spawning) if targets are in jeopardy of exceeding the production limits set in this plan.

3.7 Release Timing and Location

Coho are volitionally released at Lewis River Hatchery beginning in April by pulling the screens, lowering the water level slowly over an approximately 2-week period (up to 6 weeks) or until approximately 90% or more of the smolts have left on their own. Remaining fish are flushed directly to the river prior to May 20. Prior to beginning the volitional release, an area Fish Health Specialist will evaluate the coho release group’s health and condition.

4.0 ADULT SUPPLEMENTATION UPSTREAM OF SWIFT DAM

The supplementation program relies exclusively on transporting adults upstream of Swift Dam, which began in 2012. Supplementation adults are able to spawn naturally using all available habitats upstream of Swift Dam. Progeny from these transported adults will be collected at the FSC and transported downstream of Merwin Dam to begin their migration to the sea. The program targets up to 6,800 early or late adult coho to be transported over the duration of the run timing. This target was selected through the EDT process to define the spawning capacity upstream of Merwin Dam. The number of NOR coho available for upstream supplementation depends on return rates to the traps and needs of the integrated late coho hatchery program.

Previous trapping data for natural origin coho[7] (Figure C2) are used to create a potential collection schedule to meet the target goal of 6,800 coho (Table C2) for transport in 2023. Ideally, all transported coho would be NORs. However, there are not enough NOR coho to meet the supplementation goal. In addition, Lewis River Hatchery is currently implementing an integrated late coho program on the Lewis River that will use a portion of NOR late coho as broodstock. The supplementation program will use all NORs available that are not used for the integrated late coho hatchery production program.

Transported coho may be released at different locations upstream of Swift Dam to enhance distribution into streams and tributaries. Eagle Cliff, Muddy River Bridge, Clear Creek Bridge, and Curly Creek Bridge will be used to release an equal portion of the transported coho. To simplify the logistics, fish trucks will work on a rotating basis for each haul. For example, the first load will be released at Eagle Cliff, the second at Muddy River Bridge, and so on. This may not equate to equal portions for each site but should be reasonably close.

Table C - 3. Proposed collection rate of coho for broodstock and upstream transport indicting relative and cumulative proportion by two-week period over the collection window

Period	Coho for upstream Transport*	Relative Proportion	Cumulative Proportion
Sep 1-15	200	0.02	
Sep 16-30	1600	0.17	0.19
Oct 1-15	1800	0.19	0.38
Oct 16-31	2100	0.22	0.60
Nov 1-15	1200	0.13	0.73
Nov 16-30	1200	0.13	0.85
Dec 1-15	800	0.08	0.94
Dec 16-31	600	0.06	1.00
Total	9500		

** Values based on supplementation goal of 9,500 adults*

The actual number of adult coho transported may be modified (in-season) by the ATS based on actual returns to the hatchery and traps. The ATS may raise the total number of coho transported upstream to 9,500 adults without prior approval of the ACC. This value was agreed

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[7] NOR coho returns may be progeny from upper river (supplementation program) or lower river spawners. There is no way to differentiate the two groups; However, this is not required because both groups are treated as the same population in this plan.

to by the ACC in previous years when returns to the traps exceeded broodstock and transport targets.

SECTION D MONITORING AND EVALUATION

1.0 INTRODUCTION

Monitoring activities described in this section are intended to meet monitoring objectives contained in the H&S Plan. Objectives are established to monitor population metrics related to abundance, distribution, composition, and potential ecological interactions of hatchery released smolts. Evaluation of the data collected to address these objectives and reporting on how the data trends change over time is critical for assessing population viability (extinction risk) of target populations.

The H&S Plan also lays out "key questions" that are nested within each objective. The key questions direct the research needed to support each objective and are answered by monitoring indicators. The H&S Plan also describes narratively the purpose, population recovery monitoring recommendations, proposed strategies, monitoring indicators, sampling frequency, and limitations or concerns for each objective.

This AOP is intended to provide the necessary level of detail to implement the monitoring component of the H&S plan as described in this section and through the various strategies attached to this plan.

Generally, study methods proposed in this AOP follow established protocols used in the Pacific Northwest. This allows methods to be standardized or improved based on data collection or results from other regional locations. An important component of some objectives is the accuracy and precision with which specific objectives are measured or quantified. NOAA Fisheries has provided guidance with respect to variation (Crawford and Rumsey, 2011), and the intent of this plan is to strive to meet these precision guidelines when practical.

1.1 Objectives

The M&E objectives are classified into four main categories:

- *Administrative:* Includes the reporting and planning documents required by the Settlement Agreement, HGMPs and Biological Opinion(s)
- *Hatchery Monitoring:* The purpose of hatchery evaluation objectives is to operate hatchery programs in a way that maximizes survival and health of program fish to meet production targets and reduces adverse effects on naturally produced ESA listed species.
- *Abundance Monitoring:* Includes objectives related to monitoring trends in juvenile and adult abundance to evaluate the status, trend, and viability of North Fork Lewis River populations of salmon and steelhead.
- *Risk Assessment:* These objectives are directed at monitoring potential risks of hatchery and supplementation programs to ESA listed species.

The hatchery, abundance, and risk assessment monitoring objectives are presented in a standardized format with key questions nested within each objective. For each key question, the general monitoring approach and methods are described (when appropriate) to develop an estimate for each of the metrics associated with each key question. Decision points for adaptive management and limitations or concerns are also described for each monitoring approach (when appropriate).

1.2 Key Questions

Each of the objectives (excluding administrative objectives) have a number of related key questions, presented in the H&S plan. The key questions are specific to each objective and are intended to ensure that specific metrics or benchmarks are addressed in annual reporting. The list of key questions provided in the H&S plan is not intended to be a list of obligations. Rather, the key questions provide monitoring guidance and focus for each of the H&S plan objectives to ensure metrics related to recovery are addressed (e.g., abundance, productivity, diversity and spatial structure). The ATS will determine which key questions are to be addressed annually or periodically (e.g., every 3 years) in the AOP.

1.3 Strategies

Some objectives have complex monitoring designs that often have a higher potential for frequent modifications. To adapt, the ATS reorganized the format used to address different monitoring objectives of the H&S Plan by adding ‘strategies’ to the AOP in 2021. Strategies are standalone planning documents attached to the AOP that follow the same general framework as described below. However, strategies generally provide a more detailed study design as is often required by more complex evaluations. Strategies are essentially ‘living’ plans and components to the AOP that can be updated independently throughout the season, or in future years, without requiring global reformatting of the AOP.

Strategies included in the 2023 AOP include:

Strategy A: Adult Abundance and Composition

Strategy B: Adult Spatial and Temporal Distribution

Strategy C: Juvenile Abundance and Migration

Strategy D: Fish Health Monitoring and Disease Prevention

Strategy E: Spring Chinook Rearing and Release Evaluation

Strategy F: Precocity and Morphology Sampling

Strategy G: Genetic Risk Monitoring

Strategy H: Volitional Release

Strategy I: Smolt-to-Adult Return Rate Estimation

Strategy J: Sampling and Data Collection Checklist

1.4 Framework

Following the framework set forth in the H&S Plan, this section of the AOP expands upon the monitoring strategies, monitoring indicators, sampling frequency and limitations or concerns for addressing each key question. The description of these elements follow a standardized template as follows:

Approach: Briefly, the approach used to quantify and estimate monitoring indicators with an acceptable level of precision and accuracy to address the objective or key questions. Includes references to other sections of the AOP or attached Strategies, where relevant.

Metric or Monitoring Indicator Name and Description: The desired numerical measurement or observation by which the objective is measured.

Targets: The program element endpoint or numeric value that the hatchery and supplementation program seeks to achieve (including precision for numeric targets)

Field Methods: Description of the specific methodology, sampling designs and protocols to collect and store field data in a format required by the analytical methodology adopted.

Analytical Methods and Reporting: Description of the application of the data or specific analysis applied to derive an estimate for each metric assigned to the objective or key question. Includes the description of any formulas, estimators or software used to analyze data sets.

Frequency and Duration: The sampling or data collection frequency and duration for each objective or key question that is being monitored. For example, steelhead redd surveys are conducted once every seven to ten days between March 1 and June 30.

Data Collection and Storage: Parties responsible for the data collection, storage, and location of data files.

Limitations or Concerns: General description noting specific challenges especially those related to field data collection and deployment.

2.0 OBJECTIVES

2.1 Administrative Objectives

The purpose of objectives 1.0 and 1.1 is to obtain ESA coverage for hatchery production and associated program activities. The HGMP represents the proposed operation of each hatchery program and is submitted to NOAA Fisheries for approval. Once approved, NOAA Fisheries will draft and finalize a Biological Opinion regarding the HGMP action and include specific terms and conditions, and reasonable and prudent measures to avoid jeopardizing ESA listed species from continued operation of the hatchery programs.

The purpose of objectives 2.0 through 2.3 is to ensure that reporting and planning requirements of the Settlement Agreement, HGMPs, and Biological Opinion (once issued) are met. The annual hatchery operations and H&S Program reports shall demonstrate whether the HGMP protocols are implemented as proposed. Reporting will include assessing the effectiveness of actions taken to limit the threat of hatchery operations to natural-origin fish as well as documenting whether each hatchery production program is meeting target production levels.

Objective 1.0: NOAA acceptance of a Hatchery and Genetic Management Plan (HGMP) for each hatchery program on the North Fork Lewis River

The following HGMPs are anticipated:

- Summer Steelhead
- Late Winter Steelhead
- Early Winter Steelhead (Chambers Creek stock)
- Spring Chinook
- Early Coho Salmon
- Late Coho Salmon

The ATS will receive updates on this process from WDFW throughout the year. It is anticipated that draft versions of the HGMPs will be provided to ATS members for review; however, the ATS (with the exception of PacifiCorp) will not formally review or comment on the HGMPs. The ATS anticipates discussing issues related to the HGMP's that may influence or modify the goals and objectives of the H&S program. Examples include transition planning from segregated to integrated hatchery programs, harvest management and hatchery production program sizing

Objective 1.1: Receive Biological Opinion for all submitted HGMPs

Continued operation of the hatcheries is critical as the supplementation program relies on hatchery returns for reintroduction efforts upstream of Swift Dam.

Biological Opinions (BiOps) for the Lewis River Hatchery programs will be issued after HGMPs are submitted and accepted by NOAA Fisheries. The ATS will receive updates on this process from WDFW and NOAA Fisheries throughout the year. Once issued, the ATS will need to determine whether the the current H&S Plan and AOP are consistent with BiOp and make necessary revisions to the H&S Plan and AOP to ensure consistency with the BiOp.

Objective 2.0: Finalize a Hatchery and Supplementation Plan every 5 years

The current H&S plan was submitted to the FERC in December 2020. The FERC approved the plan on March 28, 2022. The next rewrite of this plan is scheduled for completion 5 years from FERC acceptance of the H&S plan (March 2027), or as extended by the FERC. The H&S Plan will be revised earlier if required by the HGMPs in Consultation with the ACC and NOAA Fisheries to adaptively manage the programs.

Objective 2.1: Finalize an Annual Operating Plan (AOP)

The AOP is the primary mechanism for adaptively managing the H&S Program. The AOP is developed collaboratively by the ATS on an annual basis and requires approval by the ACC and Services.

The ATS strives to finalize the AOP by December 31 of each year. This is not always possible and the ATS has developed a prioritization protocol for when the AOP is not completed by December 31. This protocol prioritizes the development of the AOP into two distinct phases. Phase 1 focuses on field data collection and monitoring that is initiated during the first half of the year, while Phase 2 focuses on the second half of the year. This allows the ATS to complete monitoring and reporting requirements for those programs that are initiated earlier in the year such as late winter steelhead monitoring and juvenile trapping. Necessary AOP revisions for Phase 1 activities are scheduled for completion by February 1. Phase 2 includes primarily fall monitoring activities such as adult salmon abundance monitoring and is scheduled for completion by July 1.

Objective 2.2: Finalize an Annual Operations Report

PacifiCorp drafts the Annual Operations Report (AOR) in accordance with section 8.2.4 of the Settlement Agreement, outlining reporting requirements pursuant to the AOP. The AOR is provided to the ACC as part of the annual TCC and ACC reporting (Section 14.2.6 of the Settlement Agreement). The AOR reports on all monitoring activities described by the AOP. Section F of the AOP provides the minimum reporting requirements for the AOR as stipulated in the Settlement Agreement. The final AOR is submitted as part of the annual TCC and ACC annual report to the FERC by June 30 of every year.

Objective 2.3: Finalize an Annual Hatchery Report

WDFW drafts the Annual Hatchery Report which summarizes on site hatchery activities including spawning, rearing, feeding, pathogen testing, permit compliance, fish marking, and trapping counts. Because many of the hatchery activities are related to monitoring objectives in the H&S Plan and in Section 8.2.4 of the Settlement Agreement, PacifiCorp attaches the Hatchery Report in their submittal of the Annual Operations Report to FERC. At a minimum, the Hatchery Report includes the following metrics:

- Broodstock received from adult trapping operations, including disposition of adults received.
- Mortality of adults, juveniles and eggs
- Spawning, incubation and rearing summary
- Disease presence, prevention (treatments), and loss by life stage
- Growth rate by month from fry ponding to release as smolts
- Number of fish tagged, tag type, and purpose (experimental, production)
- All fish transfers in or out of the basin including species, number, marks, and life stage
- Production summary providing the total number of smolts released including the timing and locations of released and average smolt size at release.
- Volitional release data including volitional release timing and duration for all species.
- Monthly water temperatures and average rainfall
- Summary of maintenance and capital projects completed

2.2 Hatchery Monitoring Objectives

Objective 3.0: Determine whether hatchery production protocols incorporate best available management practices to support program targets and goals.

The purpose of objective 3.0 is to implement hatchery programs and practices that support the goals of the H&S program, are consistent with best management practices, and incorporate recommendations by the HSRG when possible. This objective also encourages hatchery programs to incorporate new scientific advances when available to continually improve overall hatchery performance in supporting the H&S program.

KEY QUESTION 3A. DO HATCHERY BROODSTOCK COLLECTION PROTOCOLS SUPPORT PROGRAM GOALS?

APPROACH

H&S Program goals are to 1) collect broodstock throughout the entire run timing for each species and 2) ensure the portion of broodstock retained from the total number of fish collected (trapped) follows the composition and retention rates established in collection curves for each species. Details on broodstock collection goals and timing are provided for individual species in Sections A2, B2, and C2.

- Trap entry timing is the number of adults trapped by species, stock and origin, and date (Merwin trap) or week (Lewis River Hatchery Ladder).
- Broodstock collection and selection timing is the number of adults retained for broodstock by species, stock and origin, and date (Merwin trap) or week (Lewis River Hatchery Ladder).
- Broodstock retention rate is the number of adults transferred to hatcheries for broodstock out of the total number of adults trapped by time period, species, stock, origin, and sex.

LIMITATIONS OR CONCERNS

In the early part of the year, if the broodstock collection targets are not projected to be met due to poor predicted returns, the ATS may decide to modify the broodstock collection curve by adjusting the collection timing or number of broodstock to be held at the hatchery. During the collection season, if the trap entry timing or broodstock retention rate deviates significantly from the planned collection curve without justification (e.g., due to poor realized returns), an in-season decision by the ATS may be needed to ensure that broodstock are collected throughout the duration of the run.

Trap entrance timing may not be a precise or accurate indicator of migration or spawn timing. Returning adults may choose to reside in the river for several weeks or months before volunteering into one of the traps. However, because traps are the primary source of hatchery broodstock, trap entry timing is used to determine whether broodstock collection protocols are consistent with targets.

DATA COLLECTION METHODS

Metric or Monitoring Indicator	Targets	Field Methods	Analytical Methods	Frequency and Duration
3A.1.Trap entry timing	Broodstock collection follows collection curves over the course of the trapping period.	See broodstock collection goals and timing for individual species in Sections A2, B2 and C2 of the AOP.	Sum of adults trapped by day or week. Identify first, last, and peak run dates from distribution of daily trap counts.	Data are collected when traps are sorted; daily at Merwin Trap, weekly at Lewis River Hatchery Ladder. Broodstock collection periods: • Steelhead: late January to end of May • Spring Chinook: April 1 to late August • Coho: early September through December
3A.2.Broodstock retention rate	Total broodstock target numbers are met. Broodstock collection rates that are consistent with planned broodstock collection curves for each species. For integrated programs, match collection timing to average NOR return timing.		Broodstock retention rate reported by week as the number of fish held for broodstock out of the total number of fish trapped and sorted (daily/weekly counts, cumulative total, and % cumulative total of annual total). Make comparisons of annual HOR and NOR return timing to 5-year average return time, and to planned and observed broodstock collection curves.	

KEY QUESTION 3B. DO SPAWNING, REARING AND RELEASE STRATEGIES SUPPORT PROGRAM GOALS?

APPROACH

The following metrics are assigned to this key question to ensure hatchery practices are consist with HSRG recommendations and best practices. In general, data on these metrics are collected as part of typical hatchery program operations and will be reported on in the Annual Operating Report, and trends will be evaluated as part of the Adaptive Management process described in Section E.

Not all metrics assigned to this key question are evaluated annually, for instance metrics related to water quality (e.g., temperature, TDG, etc.), avian predation or feeding strategies are evaluated periodically as determined by the ATS.

Integration Rates: For the integrated programs, late winter steelhead and Type N (late) Coho, integration rate targets are described in the Broodstock Collection Strategies (sections A 2.1 and C 2.1 of this document). For steelhead, a "mining rate" strategy is currently in use until the program can transition to use of 100% natural-origin spawners. A 30% fixed mining rate will be used to collect broodstock for the integrated steelhead program. For Coho, the minimum integration rate is 30%.

Spawning matrices and timing: Spawning designs are developed to be aligned with HSRG guidance for conservation of genetic diversity to ensure genetic diversity and relatedness targets are being met (when appropriate). Spawning designs ensure equal contribution from all spawners to the progeny and reduce the effects of artificial selection. Adults selected for broodstock should be similar in size and arrival timing to their natural counterparts whenever possible. Spawning crosses may follow pairwise, factorial or nested designs depending on the program goals (whether the program is integrated or segregated), to mitigate unequal genetic contributions among males, and ensure integration rates of NOR broodstock meet HSRG recommendations (when applicable). Target spawning matrices and timing are described in Sections A 2.8, B 2.8, and C 2.8.

Fecundity: Fecundity is monitored during hatchery spawning to ensure the number of broodstock collected will meet juvenile production targets. If fecundity declines over years, the targeted number of adults needed to achieve hatchery production or natural productivity upstream of Swift Dam may need to be adjusted. The relationship between fish length and fecundity may be evaluated to understand whether trends in fecundity are related to trends in body size. For steelhead, fecundity is measured for individual fish by volumetrically measuring the number of eggs for each female spawned and fork length of each female spawned. For Coho and Chinook, fecundity is estimated from the average number of eggs per female for a given spawn group of females. Fork lengths may be obtained from HOR female spawners processed for CWTs.

Feeding Rations and Delivery Rate: Not applicable in 2023

Avian Predation: Not applicable in 2023

Volitional Release: Refer to Sections A3.7, B3.7, and C3.7 for hatchery release timing for each species. For all species, fish are allowed to leave volitionally for at least a period of 2 weeks. Fish that remain after 2 to 6 weeks, depending on species, are moved into the river by a forced release. See Strategy H for practices at Lewis River Hatcheries and a review of the rationale for various approaches on the timing and duration of volitional release periods.

Water Quality: A TDG mitigation and evaluation plan was specifically evaluated altering the flow characteristics of the inflow into rearing bank 13 at Lewis River hatchery in 2022. In 2023, there are no planned activities.

LIMITATIONS OR CONCERNS

Specific limitations and concerns for the spring Chinook rearing and release study and precocity monitoring are described in Strategy E and F, respectively.

DATA COLLECTION METHODS

Metric or Monitoring Indicator	Targets	Field Methods	Analytical Methods	Frequency and Duration
3B.1. Integration Rates (pNOB; Integrated programs only)	Steelhead: 30% fixed mining rate. Coho: 30% integration rate.	Outlined in Sections A2.1, B2.1, C2.1 of this AOP as part of the broodstock collection process.	NA	In general, data on these metrics are collected as part of typical hatchery program operations and will be reported on in the Annual Operating Report, and trends will be evaluated as part of the Adaptive Management process described in Section E. For spring Chinook salmon, after 3 years of implementation of the Spring Chinook Rearing and Release Plan (Strategy A), in-hatchery survival rates, size-at-release, condition factor at
3B.2. Spawning matrices and timing	Steelhead: Depends on spawners available on a given day; typically 2x2. Spring Chinook and coho: pairwise (1x1) mating cross with a backup male.	Outlined in Sections A2.9, B2.9, C2.9 of this AOP as part of the spawning protocols. The number, timing and composition of spawners used, and type of spawning matrix used for each stock will be recorded (e.g., pairwise, pairwise with backup male, factorial, etc.).	NA	

3B.3. Broodstock Fecundity	NA	Late winter steelhead: Record the estimated number of eggs per female. Early coho and spring Chinook: Average fecundity will be estimated from a subsample of females spawned.	For integrated programs (late winter steelhead and late coho), fecundity will be compared between HOR and NOR. Fecundity and spawn timing data are also used to examine risk to phenotypic diversity described in Objective 7.	release, fish health (frequency or rates of disease), and physiological status at the time of release will be compared between treatment groups.
3B.4. Feeding rations and delivery methods	Not Applicable in 2023			
3B.5. Avian predation rate	Not Applicable in 2023			
3B.6. Volitional releases	Steelhead: May 1; 6-week volitional period. Spring Chinook: February 1, October 15, or June 1; 2-week volitional period. Coho: April for 2 to 6-week volitional period.	The start date and time of volitional release (i.e., when screens are pulled) and the start and end date and time of the forced release period will be recorded for each species and pond.	Report on	
3B.7. Water Quality	Not Applicable in 2023			

KEY QUESTION 3C. ARE ADULT COLLECTION, HANDLING AND DISPOSITION PROTOCOLS CONSISTENT WITH HSRG RECOMMENDATIONS?

APPROACH

This key question relates to sampling and disposition protocols applied to adult fish handled at either the Merwin Trap or Lewis River ladder. Specifically, a sample of HOR and NOR adults for each stock will be used to collect size (fork length) and age (scale samples) data using a representative sample of HOR and NOR returns over the entire run. Size and age data will also be collected at traps and during spawning ground surveys, summarized in Strategy A.

Additionally, the disposition for all salmon and late winter steelhead captures at the traps will be documented to ensure that broodstock and upstream transport collection goals consistent with HSRG guidelines are achieved.

Captures at the Merwin and Lewis River ladder will be grouped into one of the following five disposition categories, with the disposition protocols described in Sections A2.7, B2.7, and C2.7:

1. Retained for broodstock
2. Transported upstream
3. Returned to river downstream
4. Euthanized
5. Mortalities

LIMITATIONS OR CONCERNS

Several generations of adult returns may be necessary to provide adequate size and age data and analysis to support and justify implementation of specific HSRG recommendations.

DATA COLLECTION METHODS

Metric or Monitoring Indicator	Targets	Field Methods	Analytical Methods	Frequency and Duration
3C.1. Size and age of returning HOR and NOR adults	Use of size and age at maturity as indicator of phenotypic diversity among HOR, NOR and integrated programs. See Objective 7.	Subsample of fork lengths and scales from trap returns and in-stream carcass surveys for coho and Chinook. Refer to Strategy A for data collection on spawning grounds.	Size and age data should be visualized and compared between HOR and NOR with distribution plots and point estimates with 95% confidence intervals.	Sampling occurs throughout the duration of the run. Daily (Merwin Trap); weekly (Lewis hatchery ladder and stream surveys).
3C.2. Disposition of adult trap captures assigned to surplus	Meet goals for proportion and timing of adult disposition that are consistent with the H&S Plan and AOP.	Refer to Sections A2.7, B2.7, and C2.7.	Disposition of each captured adult will be recorded throughout the complete return period for each of the transport species.	Daily at Merwin Trap Weekly at Lewis hatchery ladder

KEY QUESTION 3D. WHAT ARE THE ESTIMATED SMOLT-TO-ADULT RETURNS (SAR'S) FOR EACH HATCHERY STOCK OR REARING TREATMENT GROUP?

APPROACH

Smolt-to-adult Return ratio (SAR) is the number of adults produced out of the number of smolts released. SAR is a key metric to estimate the effects of both freshwater and ocean productivity on the survival of hatchery-produced fish from release to their return to Lewis River traps or to spawn naturally. Harvest estimates from ocean fisheries and terminal (in-river) fisheries should also be incorporated into the SAR calculation to account for adults removed prior. The protocols for calculating SAR for Lewis River Hatchery fish will be described in Strategy I.

SAR is also one of the metrics used to evaluate different rearing strategies at the hatchery facilities, including the spring Chinook rearing and release evaluation (summarized in Strategy E).

LIMITATIONS OR CONCERNS

- Tag loss in juveniles.
- Incomplete tag recovery from adult cohorts.
- Time lag in reporting in RMIS.

DATA COLLECTION METHODS

Metric or Monitoring Indicator	Targets	Field Methods	Analytical Methods	Frequency and Duration
3D. Smolt-to-adult Return ratio (SAR) of all hatchery release groups	Adult returns are adequate to meet adult ocean recruit targets given in section 8.3 of the Settlement Agreement.	Collection of CWTs from fish encountered in 1) Lewis River traps 2) Lewis River subbasin spawning grounds, 3) strays to other basins and 4) harvest by stock	CWT data obtained from RMIS based on release codes. Returns include recaptures from: • Adult harvest in all fisheries • Adult spawners • Adult traps Releases are estimated number of CWT smolts released by release group, corrected for estimated tag loss and post-tagging in-hatchery mortality.	Annual SAR estimate for each brood year and release group

KEY QUESTION 3E. IS THE FISH HEALTH MONITORING AND DISEASE PREVENTION STRATEGY EFFECTIVE AT REDUCING INFECTIONS AND LIMITING MORTALITIES?

APPROACH

WDFW's Fish Health Unit is tasked with monitoring population health of all H&S Plan species and operates following standards and objectives outlined in the Salmon Disease Control Policy of the Fisheries Co-Managers of Washington State (WDFW 2006) and State of Washington Fish Health Manual (WDFW 2010). Services include monitoring reported and regulated pathogens in all broodstocks, baseline monitoring throughout the rearing cycle, and direct monitoring for specific disease progression and severity in targeted groups. Common species-specific diagnoses, disease prevention and treatments are described further in Strategy D, *Fish Health Monitoring and Disease Prevention Strategy for Lewis River Hatchery Programs.*

Mortality rates are monitored by life stage by hatchery staff to determine if mortality rates are preventing achieving the production goals.

Fish health monitoring at Lewis River Hatchery Facilities includes

- Routine baseline monitoring
- Directed monitoring (and treatment) in response to any significant loss of fish (>~0.05% loss for consecutive days or exponentially increasing loss pattern) that is suspected to be due to an infectious agent.
- Special monitoring of juveniles for gas bubble trauma, bacterial kidney disease

LIMITATIONS OR CONCERNS

The *Fish Health Monitoring and Disease Prevention Strategy for Lewis River Hatchery Programs* is not intended to be comprehensive protocols, but provide the common approaches for managing perennial disease issues.

BKD is endemic in the Lewis River Spring Chinook Salmon population. BKD prevalence and severity is highly variable year-to-year, confounding the ability to draw linkages to spawning and rearing practices. WDFW Hatchery staff and Fish Health staff will continue to discuss tracking BKD expression and prevalence in all life stages to link prevalence of BKD in progeny to results of females contributing to a rearing unit. Evaluation of current BKD screening protocols will be made on a yearly basis in response to patterns in BKD prevalence, disease severity, and rearing mortality among untested groups.

DATA COLLECTION METHODS

Metric or Monitoring Indicator	Targets	Field Methods	Analytical Methods	Frequency and Duration
3E.1. Infection rates by species and life stage	Ensure the health and productivity of H&S Plan fish	60 adult females of each species are inspected and sampled during spawning All spring Chinook females whose eggs are allocated for February release will be tested for BKD prevalence Rearing juveniles are monitored and examined routinely	Fish health monitoring results are reported and maintained by WDFW and pathogen histories are available at any time upon request. The subsample of juvenile spring Chinook evaluated for BKD at transfer and release will be analyzed to report prevalence (% positive), DNA load, prevalence of severe infections, and prevalence of gross pathology.	Baseline monitoring occurs throughout broodstock collection, spawning, and incubation as described in Strategy D. Directed monitoring occurs as needed.
3E.2. Mortality rates by species and life-stage	Ensure mortality rates are not adversely affecting production targets	If needed, medication will be provided by the veterinarian of record	Results are generally reported as presence/absence, mortality range (normal, increased, epizootic) and % loss (mortality) per day for a given rearing unit. In-hatchery survival reported as survival (S = total count – mortalities) from egg to release for each species and release group.	Special monitoring of juvenile spring Chinook for GBT will occur with an initial baseline examination in June, followed by weekly examinations in August Special monitoring of juvenile spring Chinook for BKD will occur at the times of transfer and release.

KEY QUESTION 3F. DO HATCHERIES INCORPORATE NEW SCIENTIFIC ADVANCES TO IMPROVE FISH CULTURE EFFECTIVENESS AND EFFICIENCY?

APPROACH

Periodic evaluations or reviews of the existing hatchery programs should occur to incorporate advances in the best available science that improve operational efficiency and benefit fish health at each of the three facilities. The focus of these periodic reviews will be the implementation of actions that help the hatchery programs achieve the goals of the H&S Plan (i.e., reintroduction outcome goal). The role of hatcheries is a critical component in meeting H&S goals and operation of the facilities should remain adaptable to the needs of the H&S program, development and transitioning into integrated hatchery programs and the needs of harvest management. Finally, operations should be reviewed of potential risks posed by hatchery management on the long-term viability of naturally producing stocks.

The ATS will conduct periodic reviews and report any recommendations to the ACC or hatchery managers for for modifying the hatchery program's activities to align with the best available science on fish health, behavior, and operational efficiency.

LIMITATIONS OR CONCERNS

Direct comparisons between Lewis River Hatcheries operations and those described from other hatcheries or literature may not be possible. Inferences and assumptions should be identified clearly at the time of review.

DATA COLLECTION METHODS

Metric or Monitoring Indicator	Targets	Field Methods	Analytical Methods	Frequency and Duration
3F. Periodic review of hatchery operations relative to current literature	Implementation of hatchery activities that are based on best available science on maintaining fish health, sustaining harvest, and minimizing genetic or ecological risks.	N/A	The AOR and current hatchery methods will be reviewed and compared to published literature and methods from other hatcheries. The ATS will identify known areas of concern for hatchery operations efficiency or topics of recent advances in hatchery science. Potential outcomes include identification of a data gap, next steps toward making changes in implementation, or recommending an immediate implementation change if evidence supports it.	Hatchery operations will be reviewed every three years. The discussion of the approach to the review will occur in June of the review year, and recommendations will be completed by October of the review year for incorporation into the following AOP for the following year.

Objective 4.0: Adopt strategies that limit potential post-release ecological interactions between hatchery and NOR listed species

The purpose of Objective 4.0 is to limit ecological interactions (predation, competition, residualism and pathogen transmission) between hatchery released juveniles on natural origin listed species. Interactions between hatchery released juveniles and ESA listed species cannot be observed directly. Therefore, this objective relies on "take surrogates" as described by NOAA Fisheries (NMFS 2017) to reduce the potential of adverse interactions between hatchery and natural-origin salmon and steelhead. Each key question provided under this objective relates directly to each take surrogate described by NOAA Fisheries.

KEY QUESTION 4A: DO CURRENT HATCHERY RELEASES RESULT IN SPATIAL AND TEMPORAL OVERLAP BETWEEN HOR AND NOR JUVENILES?

APPROACH

This question will be answered by comparing hatchery release timing and location to the spatial and temporal distribution of natural origin stocks in the NF Lewis River. Potential overlaps will be identified for all hatchery releases and all life stages of natural origin stocks (presence of juveniles in an area can be inferred from known spawning distributions).

Hatchery data on timing and locations for all hatchery releases will be compared to empirical information derived from field activities where natural-origin juveniles and spawners are encountered. Activities that help to characterize the spatial and temporal distribution natural-origin fish in the North Fork Lewis River and its tributaries include adult fish trapping, spawner surveys, juvenile screw trapping, and potentially other presence/absence surveys such as juvenile seining activities downstream of Merwin Dam. Potential or observed overlaps between hatchery releases and NOR stocks will be identified.

LIMITATIONS OR CONCERNS

Overlap in space or time is used as a "take surrogate" for ESA-listed natural-origin fish; it is not a direct measure of take and therefore cannot quantify or estimate actual take related to large hatchery releases in the North Fork Lewis River.

DATA COLLECTION METHODS

Metric or Monitoring Indicator	Targets	Field Methods	Analytical Methods	Frequency and Duration
4A.1. Release locations of hatchery smolts relative in-river spawning locations.	Mitigate potential spatial overlap between hatchery-released juveniles and NOR stocks	Release location(s) of each hatchery pond; multiple locations to include relative portion of total release (e.g., forced release group transferred to Pekins Ferry) Spawner distribution monitored by redd and carcass (spawner) surveys, as described in Strategy B.	compare hatchery release locations to distribution of natural-origin fish inferred from spawning surveys and screw trap captures.	Annually
4A.2. Release timing of hatchery reared smolts relative to presence of NOR	Mitigate potential temporal overlap between hatchery-released juveniles and NOR stocks		Compare hatchery juvenile release dates and encounters of hatchery origin fish with timing of natural-origin fish in the datasets for adult trap entry, spawner surveys, and screw trap encounters.	Annually

KEY QUESTION 4B: DOES THE MIGRATION RATE OF HOR JUVENILES RESULT IN OVERLAP WITH NOR JUVENILES OR SPAWNING ADULTS?

APPROACH

Monitoring migration rate is an indirect method for monitoring post-release behavior of hatchery smolts to infer their potential impacts on NOR species. The timing of hatchery-origin juvenile outmigration after release will be derived from screw trapping in the lower North Fork Lewis River as described in Strategy C. The beginning, peak and end of the volitional release period from the hatchery will be compared to the beginning, peak and end of encounters in the screw traps. The range of migration rates observed and average or median migration rate of hatchery-released smolts will be reported.

LIMITATIONS OR CONCERNS

The migration window of hatchery fish is typically very short (i.e., a few days) and if the traps are not in operation due to mechanical failure, an entire migration window may be missed.

Volitional release periods can last for just a few days if >90% of a group leave quickly, or up to 6 weeks if many fish do not volitionally leave the ponds. The specific timing of when hatchery fish enter the river during a volitional release period may not be precisely known, so travel time to screw traps may be reported as a range based on a range of potential river entry dates. PIT tagging of hatchery fish and use of a fixed PIT tag antenna at the hatchery could be used to determine river entrance timing and inform assumptions about average migration rate.

Screw trapping is planned to occur from March 1 through June 30 (but may be adjusted in season depending on flows); migration rates will not be available for fish emigrating outside of that period, which likely includes spring Chinook salmon that are released in June (as fry), October (as fall yearlings) or February (as spring yearlings).

DATA COLLECTION METHODS

Metric or Monitoring Indicator	Targets	Field Methods	Analytical Methods	Frequency and Duration
4B. Average migration rate and range of migration rates of hatchery released smolts	Rapid outmigration to minimize the period of time that hatchery-origin juveniles may encounter natural-origin fish.	Refer to Sections A3.7, B3.7, and C3.7 for hatchery release timing. Refer to Strategy C for screw trapping methods.	Derive minimum, maximum, and mean or median migration rates from the difference between release date and screw trap capture dates.	Average migration rates will be reported annually for species (or release groups) in context of trends across years, as described in Section E of this document, Adaptive Management.

KEY QUESTION 4C: ARE THE NUMBER OF HATCHERY-RELEASED JUVENILES EQUAL TO OR LESS THAN PRODUCTION TARGETS?

APPROACH

This question will be answered by reviewing hatchery release records documenting the total number of smolts released for each species. The number of fish planted into hatchery rearing vessels is determined by volumetric measurement. The number of fish released is derived from the number planted less any mortalities observed over the rearing period. This information will be compared to hatchery production targets contained in the H&S Plan and Settlement Agreement to ensure that total release number should not exceed 105 percent of production targets. Release targets are shown in Table D-1.

Table D - 1. Total juvenile hatchery production targets for the North Fork Lewis River hatchery complex

Species	Number of fish	Maximum release number
Spring Chinook	1,350,000	1,417,500
Early Winter Steelhead	100,000	105,000
Late Winter Steelhead*	50,000	60,000
Summer Steelhead	175,000	183,500
Coho Salmon	2,000,000	2,100,000

* As specified in Section A3.6 late winter steelhead releases are 50,000 ± 20%

Hatchery release numbers are reviewed annually and any exceedances of target release numbers shall be noted in the Annual Operations Report. Any exceedances will be discussed within the ATS to determine the reason(s) for exceeding the target release number for any species and if necessary, adaptive management actions shall be incorporated into the Annual Operating Plan.

LIMITATIONS OR CONCERNS

Number at the time of release is an estimate based on original stocked number less observed mortalities, but may not account for unobserved mortalities (i.e. due to predation).

DATA COLLECTION METHODS

Metric or Monitoring Indicator	Targets	Field Methods	Analytical Methods	Frequency and Duration
4C. Number of total smolts released by species and period	≤ 105% of target release number.	Rearing ponds stocked with number determined volumetrically. Mortalities subtracted over rearing period.	Compare number released to target.	Report annually for each release group.

KEY QUESTION 4D: ARE THE SIZES (LENGTH AND WEIGHT) OF RELEASED HATCHERY JUVENILES EQUAL TO OR LESS THAN PROGRAM TARGETS?

APPROACH

Batch weights are collected monthly to compare actual fish size to programmed size targets by month. Length and weight are measured on a representative subsample of fish from each rearing pond at the time of release.

LIMITATIONS AND CONCERNS

Collecting a representative subsample from large rearing ponds is challenging, especially for groups with more variability in size (e.g. spring Chinook and late winter steelhead).

DATA COLLECTION METHODS

Metric or Monitoring Indicator	Targets	Field Methods	Analytical Methods	Frequency and Duration
4D. Mean and coefficient of variation (CV) in fork length and weight of smolts released by species and release group.	Steelhead: > 180 and < 220 mm. Spring Chinook: 8-12 fpp for October or February releases, 80 fpp for June release (see Strategy E). Coho: 16 fpp.	Batch weights collected monthly. Length measured from a representative subsample (e.g. 100 fish per release group) at the time of release.	Calculate fish per pound (fpp) from weights to compare to targets. Calculate mean and CV of fork length, weight.	Monthly batch weights. Average fork length at the time of release.

KEY QUESTION 4E: WHAT IS THE PRECOCITY RATE FOR HATCHERY JUVENILES BY RELEASE GROUP PRIOR TO SCHEDULED RELEASES?

APPROACH

The Aquatic Technical Subcommittee has discussed potential ways to quantify residualism and determined that measuring precocity in hatchery-reared spring Chinook salmon should be a priority. Precocious maturation refers to male fish that mature toward the end of either their first year (microjacks) or second year (minijacks), as measured from the date of fertilization.

Age 1 Precocity:

At the time of spawning (late-August through October for spring Chinook), fully mature males can be easily identified by their darkened body color and rounded belly and can be identified with a non-lethal screening. Their testes grow to fill most of their abdominal cavity, and milt can be expressed by gently squeezing the fish's abdomen in an anterior to posterior motion. Non-lethal screening may be used to evaluate whether specific rearing or feeding strategies contribute to overall precocity in spring Chinook

Age 2 Precocity:

The two most thoroughly validated indexes of maturity for spring Chinook maturing at 2 years of age require lethal sampling: 11-ketotestosterone (11-kt) levels in the blood plasma and testis weight compared to total body size (Refer to Strategy F for detailed methods). With either method, the distribution of the data tends to be bi-modal and precocious males are identified as individuals with 11-kt or GSI levels above a derived threshold level that separates the two modes.

LIMITATIONS OR CONCERNS

Non-lethal visual screening for precocious males a metric that can be objective, and for spring Chinook salmon in particular, inaccurate for fish released in February, 6 to 7 months prior to typical spawning times. The physiological processes that lead to maturity in spring Chinook may not have progressed enough in February to show detectable differences in physiological indicators; differences between immature and mature groups are more easily discerned later in March and April.

DATA COLLECTION METHODS

Metric or Monitoring Indicator	Targets	Field Methods	Analytical Methods	Frequency and Duration
4E. Precocity Rate	Minimize precocity rates to reduce residualism and interactions between mature juveniles released at the same time as natural spawning in the river. Precocity rate in wild spring Chinook likely to be less than 5% of males.	Non-lethal visual screening for October spring Chinook release group. Periodic lethal 11kt or GSI sampling for February spring Chinook release groups. Refer to Strategy F for details.	Calculate precocity rate as number of precocious males out of total number of males. Refer to Strategy F for details.	Non-lethal visual screening for October spring Chinook release group carried out annually as part of routine morphology monitoring at the time of release. Lethal 11kt or GSI sampling for February spring Chinook release group carried out periodically.

2.3 Abundance Monitoring Objectives

Objective 5.0: Estimate spawner abundance of late winter steelhead, Coho, chum and Chinook downstream of Merwin Dam

The purpose of Objective 5.0 is to collect unbiased, long-term, abundance, distribution and cohort trend data for natural origin adult spawners (Chinook, Coho, chum salmon and late winter steelhead) downstream of Merwin Dam. This includes recovery of CWT tags from salmon carcasses to inform harvest management, and collection of mark and tag status information (i.e., adipose clips and CWT presence) to inform calculation of pHOS and PNI.

A secondary purpose of this objective is to provide data for Objective 22 of the AMEP which describes combining estimates from downstream of Merwin Dam with transport and monitoring data for areas upstream of Swift Dam to evaluate spawning distribution and develop population-level estimates of spawner abundance and productivity for Chinook, Coho and late winter steelhead.

KEY QUESTION 5A: ARE ESTIMATES OF SPAWNER ABUNDANCE UNBIASED AND MEETING PRECISION TARGETS?

APPROACH

For spring Chinook and fall Chinook, which are present in large numbers, spawner abundance is estimated using carcass mark-recapture data in an open-population Jolly-Seber “super population” model, described in Strategy A. When the assumptions of the JS model are met, it produces unbiased estimates of escapement with known levels of precision. Those assumptions are that carcasses have equal catchability, equal survival, no tag loss and readability upon recovery, and instantaneous sampling. The assumptions will be evaluated annually following methods described in Strategy A.

For steelhead, abundance is estimated using redd surveys in the mainstem. If river conditions prevent surveys, area-under-the-curve methods will be used and however this method relies on a number of untested assumptions, and bias in the estimates can not be evaluated.

For coho, abundance in the mainstem North Fork Lewis River is estimated using carcass mark-recapture data in a Jolly-Seber mark-recapture analysis, as described in Strategy A. Uncertainty in mainstem spawner abundance will be reported as the range in potential abundance within associated confidence intervals. Abundance in the tributaries to the North Fork Lewis River are estimated from carcass and redd data collected using a Generalized Random Tessellation Stratified (GRTS) method to predetermine a spatially-balanced set of survey reaches, and data are entered in to a Bayesian multivariate state-space model used for coho throughout the Lower Columbia ESU. Parameters are reported as posterior medians with associated 95% credible intervals.

Chum abundance is too low to evaluate bias in estimates at this time.

LIMITATIONS OR CONCERNS

The estimators may quantify all possible sources of variation better for some species but not others. See Key Question 5B for limitations and concerns for estimating abundance with spawner surveys.

DATA COLLECTION METHODS

Metric or Monitoring Indicator	Targets	Field Methods	Analytical Methods	Frequency and Duration
5A. Mark-recapture modeling assumptions are evaluated to determine if they are met	Generate an unbiased estimate of abundance and composition downstream of Merwin Dam with a CV of 15% or less, on average	Chinook: Carcass mark-recapture. Steelhead: redd survey. Coho: Carcass mark-recapture in mainstem, GRTS and Bayesian multivariate state-space model in tributaries. Refer to Strategy A.	Annual evaluation of assumptions made for modeled estimates of abundance. Refer to Strategy A. Chinook: Open-population Jolly-Seber “super population” analysis to generate abundance estimates by stock, origin, sex and age. Steelhead: redd counts multiplied by fish per redd; AUC if necessary. Coho: Jolly-Seber mark recapture model for mainstem, and Bayesian multivariate state-space model for tributaries, to generate abundance estimates by origin.	Surveys and analyses completed annually.

KEY QUESTION 5B: ARE ANNUAL ESTIMATES OF NATURAL-ORIGIN SPAWNER ABUNDANCE INCREASING, DECREASING OR STABLE?

APPROACH

For spring Chinook and fall Chinook, which are present in large numbers, spawner abundance is estimated using carcass mark-recapture data in an open-population Jolly-Seber “super population” model, described in Strategy A.

For steelhead, abundance is estimated using redd surveys. If river conditions prevent surveys, area-under-the-curve methods may be used.

For coho, abundance in the mainstem North Fork Lewis River is estimated using carcass mark-recapture data in a Jolly-Seber mark-recapture analysis, as described in Strategy A. Abundance in the tributaries to the North Fork Lewis River are estimated from carcass and redd data collected using a Generalized Random Tessellation Stratified (GRTS) method to predetermine a spatially-balanced set of survey reaches, and data are entered in to a Bayesian multivariate state-space model used for coho throughout the Lower Columbia ESU.

Chum abundance is currently low; carcasses that are encountered in Chinook and Coho surveys are enumerated.

LIMITATIONS OR CONCERNS

- For Chinook and Coho, violation of model assumptions may create unknown levels of bias in estimates.
- Assignment of redds to species is complicated by overlapping distributions of relatively large number of fall Chinook with Coho and spring Chinook.
-
- Steelhead abundance estimates are often limited by river conditions in the spring that cause high turbidity or flows and limit surveyors’ ability to identify redds.
- Steelhead are not currently surveyed across their entire spatial distribution in tributaries, thus generated estimates of abundance are likely biased low.

DATA COLLECTION METHODS

Metric or Monitoring Indicator	Targets	Field Methods	Analytical Methods	Frequency and Duration
5B. Total spawner abundance estimates by species, sex and origin, and age.	Annual trends are stable or increasing.	Carcass and redd surveys. Refer to Strategy A.	Chinook: Open-population Jolly-Seber "super population" analysis. Coho: Jolly-Seber mark recapture model for mainstem, and Bayesian multivariate state-space model for tributaries. Steelhead: redd surveys	Surveys and analyses completed annually. Results reported annually by species in context of trends across years, as described in Section E of this document, Adaptive Management.

Objective 5.1: Determine the spatial and temporal distribution of spawning late winter steelhead, coho, chum and Chinook downstream of Merwin Dam

KEY QUESTION 5C: ARE ANNUAL TRENDS IN SPATIAL AND TEMPORAL SPAWNING DISTRIBUTION INCREASING, DECREASING OR STABLE?

APPROACH

For steelhead, spatial and temporal distribution of spawners is estimated using redd surveys.

For Coho salmon in the mainstem North Fork Lewis River, spatial and temporal distribution is determined from live counts and carcasses. Redd surveys are not a reliable estimator in the mainstem due to superimposition with Chinook redds. In tributaries, redd counts and live counts will used to determine Coho distribution.

For Chinook, redd counts and live fish will be enumerated in the mainstem North Fork Lewis River. Standard metrics (e.g. median and standard deviation) will be used to describe abundance. Temporal distribution will be described by calculating median spawn date using weekly derived estimates of abundance using the Jolly-Seber model, and a cumulative distribution plot of abundance will be generated.

Chum salmon are present in low numbers; changes in spatial or temporal distribution will not be evaluated.

Spawner survey methods are described in Strategy A. Redd locations are recorded using GPS and data are time stamped. The number of redds or spawners per mile and per period will be calculated and compared across years to identify shifts in spatial or temporal distribution.

LIMITATIONS OR CONCERNS

Steelhead redd surveys are not performed if visibility is low or spill from Merwin Dam has been initiated. Poor visibility can also prevent identification of coho redds or live fish. Discerning Chinook and coho redds is challenging and substantial redd superimposition occurs between the species.

DATA COLLECTION METHODS

Metric or Monitoring Indicator	Targets	Field Methods	Analytical Methods	Frequency and Duration
5C. Estimate of redds, carcasses or live spawners by reach and time period	Proportion of redds per reach is stable or increasing	Spawner surveys described in Strategy A with spatial and temporal data recorded using GPS as described in Strategy B.	Median spawner number per reach and median spawn date per week to be calculated.	Surveys and analyses completed annually. Results reported annually by species in context of trends across years, as described in Section E of this document, Adaptive Management.

Objective 6.0: Estimate juvenile outmigrant abundance for late winter steelhead, coho, and Chinook downstream of Merwin Dam

The purpose of Objective 6.0 is to estimate the abundance of juvenile outmigrants by species and origin for the North Fork Lewis River downstream of Merwin Dam. Capture and sample juvenile fish to note morphological differences between HOR and NOR smolts, as well as other juvenile non-migrants (i.e., fry and parr).

KEY QUESTION 6A: ARE ESTIMATES OF NOR JUVENILE OUTMIGRANT ABUNDANCE UNBIASED AND MEETING PRECISION TARGETS?

APPROACH

Outmigration abundance is estimated through the use of rotary screw traps in the lower North Fork Lewis River. Trap operation and analysis protocols are described in Strategy C.

These traps capture a portion of the total number of juveniles passing the trap location. Trap efficiency is estimated using a mark-recapture approach in which trapped fish are marked, released upstream of the trap, and some percentage are recaptured. The estimated capture efficiency of the trap is used to derive estimates of abundance for juveniles passing the trap. Approaches for estimating trap efficiency and abundance by species, life-stage, and by week are an ongoing topic of ATS discussion.

Estimates of abundance are only useful if they are unbiased (i.e., accurate) and relatively precise. A recovery monitoring goal for juvenile salmon migrants is to have data with a CV on average of 15 percent or less, and steelhead migrant data with a CV on average of 30 percent or less. Assumptions of the estimator must be met, and variance must be estimated in an unbiased manner. Because it is not possible to estimate the level of bias, study designs should strive to meet all the assumptions of the estimator(s) to the extent practical. These assumptions are summarized in Strategy C, briefly:

1. The population is closed to immigration, emigration, births, and deaths.
2. No mark or tag loss (from fish marked for estimating trap efficiency).
3. No mark-related mortality.
4. All fish have equal probability of being caught and marked in the first event.
5. Marked fish mix completely with unmarked fish between sampling events.

LIMITATIONS OR CONCERNS

Juvenile outmigrant trapping can be complicated and requires development of clear study designs or protocols, project review and adaptive management to be successful. Estimates of abundance can be biased if the assumptions of the mark-recapture estimator are not met (e.g., equal survival and capture probability among marked and unmarked groups). Testing assumptions and describing how mark-recapture assumptions are being met is critical for developing unbiased estimates. The ability to specifically test all assumptions for the North Fork Lewis River smolt trapping project may be limited and should utilize results and recommendations from other juvenile migrant studies when applicable (e.g., tag retention studies).

In past years, it has been difficult to mark, and subsequently recapture enough juveniles to generate unbiased estimates of abundance. To reduce bias in the estimates, the ATS may evaluate whether the following methods are practical for implementation:

- Pooling of data to increase the sample size and power to improve the precision of estimates, however, this method can produce biased estimates and is not favored by WDFW.
- The use of marked hatchery releases as a surrogate for mark-recapture in smolt traps. However, capture probability may not be the same between HOR and NOR smolts due to differences in size or behavior, violating assumption number 4 of the estimator.
- Increasing the mark rate at the screw trap to increase the number of total marks available for recapture.
- Use of Cedar Creek screw trap captures to increase the number of NOR marks available for recapture.
- In theory, the use of juveniles captures from other sources (e.g., the Swift FSC, Cedar Creek, additional upstream trap) may provide the ability to increase the number of marked smolts available for capture to estimate capture efficiency. However, there are a number of considerations to assess when determining whether these sources are feasible:
    - Can marked fish can be released safely for both staff and marked fish?
    - What is the number of marked fish needed to make meaningful inferences regarding capture efficiency?
    - Are marked release groups representative of their NOR counterparts (e.g., size, behavior and migration timing)?
    - Does the use of alternative sources impact other required monitoring needs?
    - Are there any ESA regulatory restrictions on trapping or releasing additional marks into the NF Lewis River?
    - Is the use of juveniles from alternative sources practical from an operations, safety and regulatory obligations in the Settlement Agreement?

Behavior or migration rates between the traps and the mouth of the Lewis River cannot be described by the screw trap catches alone. More work is needed to quantify the number of fish residing (e.g., nonmigrants) upstream of the trap post-release to estimate residualism rates.

Trapping is inherently difficult in larger rivers due to debris load, variable flows (including spill) and mechanical failures – most of which are unavoidable consequences of operating floating traps in large rivers. Trap operation in the North Fork Lewis River may be limited by high streamflow conditions in late winter and spring as well as lower flow periods in the summer.

DATA COLLECTION METHODS

Metric or Monitoring Indicator	Targets	Field Methods	Analytical Methods	Frequency and Duration
6A. Precision and accuracy of abundance estimates.	VSP precision and accuracy targets are met: CV < 15% (salmon) and < 30% (steelhead)	Rotary screw traps will be used to capture a portion of the total number of juveniles passing the trap location. Mark-recapture of those fish will be used to test trap efficiency. Refer to Strategy C	Quantify whether assumptions of the estimator are met. See Strategy C for details.	See Strategy C. Annual juvenile outmigrant sampling. Traps checked every morning, 7 days per week, from March 1 through June 30. Trapping dates may be adjusted depending on river flows. Additional daily trap checks may be warranted during peak migration.

KEY QUESTION 6B: IS THE ABUNDANCE OF NOR JUVENILE OUTMIGRANTS BY SPECIES AND OUTMIGRATION YEAR INCREASING, DECREASING, OR STABLE?

APPROACH

Outmigration abundance is estimated through the use of rotary screw traps in the lower North Fork Lewis River. Abundance estimates are derived from trap efficiencies. Trap operation and analysis protocols are described in Strategy C. Trapped salmonids will be identified by species, life-stage (based on size), and origin (based on hatchery marking). The assignment of fish to these groups will follow a decision tree developed and used by WDFW in other trapping operations, included in Strategy C.

In addition to reporting abundance estimates, a power analysis will be conducted for each juvenile migrant population being monitored to determine the power of the data to detect a significant change in abundance and recommended sample sizes to be able to detect change over time.

Annual estimates of NOR juvenile outmigrant abundance will be reported in the Annual Operating Report for a given cohort, in some cases to include numbers of fish from the same cohort that out-migrate at different lift-stages. Data will be reported in context with previous years of data to make a determination if numbers are increasing, decreasing, or stable. The approach for annual reporting of trends and ACC review of the data are described in Section E of this document, Adaptive Management.

LIMITATIONS OR CONCERNS

Generating unbiased estimates of juvenile NOR outmigrant abundance is limited by low numbers of NOR captures in rotary screw traps. Trapping is limited to the major spring outmigration period for Chinook, coho, and steelhead (March 1 through June 30, trapping dates may be adjusted depending on river flows); fish migrating outside of this window will not be sampled.

DATA COLLECTION METHODS

Metric or Monitoring Indicator	Targets	Field Methods	Analytical Methods	Frequency and Duration
6B.1. Trend in total NOR outmigrants by species and cohort.	Annual trends are stable or increasing.	Screw trapping to capture outmigrants. Refer to Strategy C.	Derive estimates of abundance based on trap efficiency. Refer to Strategy C.	Juvenile outmigrant abundance and morphology sampling carried out annually. Traps checked every morning, 7 days per week, from March 1 through June 30. Trapping dates may be adjusted depending on river flows.

KEY QUESTION 6C: WHAT ARE THE MORPHOLOGICAL CHARACTERISTICS OF OUTMIGRATING NOR JUVENILES RELATIVE TO THEIR CONSPECIFIC HOR JUVENILES?

APPROACH

Outmigration of NOR juveniles is monitored through the use of rotary screw traps in the lower North Fork Lewis River. Trap operation and analysis protocols are described in Strategy C. Morphological information is collected from fish captured in rotary screw traps. Fish are identified as natural origin by lack of hatchery marks, and categorized as fry, parr, transitional, subyearling smolt, yearling smolt based on size and external coloration following the decision tree included in Strategy C. Size and smolt development are similarly collected at the time of release for hatchery-reared fish as described in sections A 3.7, B 3.7, and C 3.7 of this AOP.

LIMITATIONS OR CONCERNS

Hatchery-origin juveniles for this program to optimize high rates of smoltification, post-release survival and faster outmigration compared to natural-origin fish. No changes have been proposed for changing hatchery-origin size or release targets relative to natural-origin fish.

Similar to estimates of abundance, unbiased estimates of natural-origin outmigrant size and smoltification will be limited by low numbers captured in the screw traps and the timing of trapping operations between March 1 and June 30.

DATA COLLECTION METHODS

Metric or Monitoring Indicator	Targets	Field Methods	Analytical Methods	Frequency and Duration
6C. Comparison of fish size, life-stage and age-class between NOR and HOR juveniles.	No relevant target for natural-origin outmigrants; hatchery-origin outmigrant size based on optimizing post-release performance.	Refer to Sections A 3.7, B 3.7 and C 3.7 of this document for data collection at the time of release. Up to 10 fry per day and 50 subyearling/ transitional/ parr per day per category to be sampled for fork length during screw trapping. Refer to Strategy C.	Average size to be calculated from representative subsample at hatchery release and in screw trapping. The component of those subsampled made up by different life-stages and age classes should also be reported.	Juvenile outmigrant abundance and morphology sampling carried out annually. Traps checked every morning, 7 days per week, from March 1 through June 30. Additional daily trap checks may be warranted during peak migration. Refer to Strategy C.

2.4 Risk Assessment Objectives

Objective 7.0: Monitor the extent of genetic risks associated with integrated and segregated hatchery programs on naturally spawning listed populations in the North Fork Lewis River

The purpose of Objective 7 is to develop and implement a comprehensive genetic monitoring plan to assess the potential threats that hatchery programs may pose to naturally-spawning anadromous salmon and steelhead in the Lewis River. The monitoring of genetic risks and minimization of adverse effects is a requirement of the Settlement Agreement. This objective provides guidance on assessing (1) the genetic risks posed by the hatchery production programs and (2) whether the H&S Program is achieving or capable of achieving 'genetic viability' of reintroduced stocks.

The initial goal of this section of the AOP is to identify the baseline levels of genetic diversity and domestication as the starting point for observing changes and trends in the future. Focus species would include winter steelhead, coho salmon, spring Chinook, fall (tule) Chinook, and late-fall (bright) Chinook salmon. Five biologically-relevant populations existing within the designated boundaries of NF Lewis recovery populations (LCFRB 2010) including 1) the segregated hatchery programs and natural spawners in 2) the lower mainstem NF Lewis River below Merwin Dam, 3) tributaries to the lower NF Lewis River, 4) the upper mainstem NF Lewis River above Swift Dam, and 5) tributaries to the upper NF Lewis River.

The detailed approach and methods for monitoring genetic risk (Key Questions 7A and 7B) are described in Strategy G. Genetic baselines would be developed for the segregated hatchery populations and naturally-spawning/integrated hatchery programs. Tissue samples for genetic analysis will be collected from all adults used for broodstock, adults encountered in spawning surveys, and juveniles encountered in smolt traps or Swift Reservoir Floating Surface Collector.

The metrics used for assessing domestication (Key Question 7C) are described in Objective 8.

The metrics used for assessing phenotypic diversity (Key Question 7D) are components of Objectives 3, 4, and 6.

The information addressing each key question under this objective are summarized in the following sections.

LIMITATIONS OR CONCERNS

- Given the long history of hatchery production in the Lewis River basin along with the biological and environmental complexities that govern the impacts of hatchery programs and their progeny on wild populations, it is unlikely that the metrics generated from this plan can definitively answer the four key questions identified in Objective 7 (i.e., have hatchery programs affected the diversity of natural-origin populations?). However, in combination, these metrics will assess the genetic status of Lewis River populations, qualitatively assess the impacts of current hatchery programs on natural-origin populations, and help guide future hatchery operations that promote long-term genetic viability.

- The correct interpretation of results of genetic tests relies heavily on tissue collections that are representative of the intended populations or groups. Uncertainty of the genetic tests is dependent on the number of samples collected and successfully processed.
- Among- and within-population genetic variation may change due to factors other than hatchery production, including gene flow (straying) from other populations and natural selection. The SNP markers intended to be used here may, with adequate baseline data, allow detection of gene flow from outside into the NF Lewis River.
- Many of the SNP markers are assumed to be neutral (i.e., are not linked to traits under selection). Violation of this assumption would lead to incorrect interpretation of the data. Genomic methods are available and can be used to look for regions of the genome that may be under selection and associated with environmental variables. However, these methods are prohibitively expensive and are not currently part of routine hatchery monitoring.
- Genetic methods, technology, and markers continue to evolve and thus may substantially change between timesteps. In order to make valid comparisons among timesteps, the same marker panels must be used for all samples. Any substantial changes in method, technology, or markers may necessitate the re-processing of samples from earlier timesteps.
- The monitoring plan lacks monitoring of adaptive genetic diversity that uses genetic techniques. Some markers linked to adaptive diversity are known (e.g., Chinook/steelhead GREB markers, Chinook Y haplotype markers [age at maturity in males], Prince et al. 2017, Hess et al. 2016, McKinney et al. 2020) and could be used in monitoring efforts.
- Biological-based metrics of phenotypic diversity likely vary due to a combination of genetic and environmental factors and it may not be possible to determine whether such changes are good or bad for the population in terms of survival and persistence.
- Evaluating genetic- and biological-based metrics together provides the most comprehensive means of evaluating hatchery programs and the risks to natural spawning populations they affect. However, there is no consensus on how these metrics should influence adaptive management decisions.
- It is expected that Lewis River populations of salmon and steelhead will remain in the re-colonization phase well past the next rewrite of the H&S plan (scheduled in 2025) and hatchery supplementation will likely continue. However, Lewis River hatchery programs are scheduled for re-evaluation in the coming years through the development of “transition plans”. Changes to broodstock management may subsequently impact genetic risks to natural-origin populations. Thus, this plan may need to be updated accordingly.

KEY QUESTION 7A: HAVE THE LEWIS RIVER HATCHERY PROGRAMS IMPACTED THE AMONG-POPULATION DIVERSITY OF NATURALLY SPAWNING POPULATIONS?

APPROACH

Among-population diversity is measured as relative genetic differences among biological populations. Hatchery production can reduce among-population diversity when hatchery fish successfully spawn with natural-origin adults from biological populations other than those used as broodstock. Reductions of among-population diversity may reduce the long-term viability of the metapopulation through genetic homogenization and outbreeding depression.

DATA COLLECTION METHODS

Metric or Monitoring Indicator	Targets	Field Methods	Analytical Methods	Frequency and Duration
7A. Pariwise genetic distance (F_{st}), combined with dendograms, multi-variate clustering analyses.	See Strategy G.	See Strategy G.	See Strategy G.	Collect tissue samples annually. Analyses of genetic distance at least every third generation.

KEY QUESTION 7B: HAVE THE LEWIS RIVER HATCHERY PROGRAMS IMPACTED THE WITHIN-POPULATION DIVERSITY OF NATURALLY SPAWNING POPULATIONS?

APPROACH

Within-population diversity describes the amount of genetic diversity within a biological population and is important for the long-term resilience of the population. Reduced within-population diversity is an indication of inbreeding (i.e., increased allelic identity by descent), which may lead to inbreeding depression and reduced long-term viability. Hatchery production increases the risks of reducing within-population diversity of natural-origin populations because hatcheries spawn only a subset (sometimes a very small subset) of the entire population which is then amplified via the increased survival afforded by hatchery rearing. Segregated programs that use only hatchery-produced fish for broodstock are especially susceptible to reductions in within-population diversity.

DATA COLLECTION METHODS

Metric or Monitoring Indicator	Targets	Field Methods	Analytical Methods	Frequency and Duration
7B.1. Effect population size (Ne) 7B.2. Effective number of breeders (Nb) 7B.3. Inbreeding coefficient (FIS) 7B.4. Average heterozygosity 7B.6. Allele frequencies 7B.7. Linkage Disequilibrium (LD)	See Strategy G.	See Strategy G.	See Strategy G.	See Strategy G.

KEY QUESTION 7C: HAVE THE LEWIS RIVER HATCHERY PROGRAMS INCREASED THE RISK OF DOMESTICATION FOR NATURALLY SPAWNING POPULATIONS?

APPROACH

Domestication reduces the long-term fitness of populations through the proliferation of alleles which improve performance in domestic settings (i.e., hatcheries) while reducing performance in natural settings (domestication selection). However, there are currently no genetic techniques (e.g., domestication genes or markers) to assess the level of domestication within populations. Therefore, the following metrics based on biological data will be used to assess the potential for domestication of populations that spawn naturally.

- pHOS is the proportion of naturally-spawning adults that are of hatchery origin for a given population and year. An index of gene flow between a hatchery population and its companion natural population.
- pNOB is the proportion of hatchery broodstock composed of natural-origin adults each year. An index of gene flow between hatchery and natural-origin fish within the hatchery.
- PNI describes the collective effects of pHOS and pNOB; describes potential for interbreeding in both hatchery and natural components of the population.
- PEHC estimates interbreeding between hatchery and natural-origin spawners based on genetic parentage analysis of offspring.

DATA COLLECTION METHODS

Metric or Monitoring Indicator	Targets	Field Methods	Analytical Methods	Frequency and Duration
7C.1. Proportion hatchery-origin spawners (pHOS)	Specific HSRG-recommended targets apply, see Objective 8	See Objective 8	See Objective 8	Calculated annually
7C.2. Proportion natural-origin brood (pNOB)	A component of PNI target. Does not apply to segregated programs.	See Objective 8	See Objective 8	Calculated annually
7C.3. Proportion natural influence (PNI)	Specific HSRG-recommended targets apply, see Objective 8	See Objective 8	See Objective 8	Calculated annually

7C.4 Proportion Effective Hatchery Contribution (PEHC)	No specific targets recommended. Program should avoid increase in PEHC over time. Not relevant for integrated programs.	See Objective 8	See Objective 8	Calculated annually

KEY QUESTION 7D: HAVE THE LEWIS RIVER HATCHERY PROGRAMS IMPACTED THE PHENOTYPIC DIVERSITY OF NATURALLY SPAWNING POPULATIONS?

APPROACH

A potential result of declining genetic diversity and increasing domestication may include observable changes in phenotypic traits of naturally spawning populations. These traits may have some genetic component; however, there are currently few genetic markers with known allelic associations with phenotype. Therefore, the following metrics based on fitness traits will be used to assess phenotypic diversity.

DATA COLLECTION METHODS

Metric or Monitoring Indicator	Targets	Field Methods	Analytical Methods	Frequency and Duration
7D.1 Timing of adult return, spawning and juvenile outmigration.	See Key Questions 3A and 3B for adults. See Key Question 4B for juveniles.	See Key Questions 3A and 3B for adults. See Key Question 4B for juveniles.	See Key Questions 3A and 3B for adults. See Key Question 4B for juveniles.	See Key Questions 3A and 3B for adults. See Key Question 4B for juveniles.
7D.2 Size and age of returning adults and juvenile outmigrants.	See Key Question 3C for adults. See Key Question 4D and 6C for juveniles.	See Key Question 3C for adults. See Key Question 4D and 6C for juveniles.	See Key Question 3C for adults. See Key Question 4D and 6C for juveniles.	See Key Question 3C for adults. See Key Question 4D and 6C for juveniles.
7D.3 Broodstock Fecundity	See Key Question 3B	See Key Question 3B	See Key Question 3B	See Key Question 3B

Objective 8.0: Determine the percent hatchery-origin spawners (pHOS), proportionate natural influence (PNI) and pNOB (for integrated programs)

The purpose of Objective 8.0 is to monitor the genetic influence of hatchery programs on natural populations using HSRG-recommended metrics and targets (Table D-2).

Table D - 2. Current population designations (LCFRB 2010), hatchery program types, and HSRG-recommended targets for pHOS and PNI for the North Fork Lewis River salmonid populations.

Population	Current Hatchery Program Type	Current Population Designation	HSRG pHOS Target	HSRG PNI Target
Spring Chinook	Segregated	Primary	< 5%	NA
Fall Chinook	None	Primary	< 5%	NA
Coho	Integrated (Late)	Contributing	< 30%	≥ 0.50
Coho	Segregated (Early)	Contributing	< 5%	NA
Winter Steelhead	Integrated (Late)	Contributing	< 30%	≥ 0.50
Winter Steelhead	Segregated (Early)	Contributing	< 5%	NA
Summer Steelhead	Segregated	Stabilizing	< 5%	NA
Chum	None	Primary	< 5%	NA

KEY QUESTION 8A: WHAT ARE THE TRENDS IN PHOS, PNI, PNOB AND PEHC AND DO THEY MEET HSRG RECOMMENDATIONS BY PROGRAM (WHEN APPLICABLE)?

APPROACH

Hatchery-origin and natural-origin spawners will be differentiated based on hatchery marks or tags; marking strategies vary by species and are described in sections A3.5, B3.5, C3.5. The calculation of pHOS, pNOB, and PNI rely on accurate spawner abundance estimates for each group based on assignments made in the field as described in Strategy A. PEHC is similar to pHOS in that it measures gene flow between hatchery and natural-origin fish based on spawner composition, however PEHC is calculated using genetic data of offspring to estimate parentage, described in greater detail in Strategy G.

- pHOS is the proportion of adults spawning naturally that are hatchery-origin spawners (HOS) for a given population and year.
- pNOB is the proportion of a hatchery broodstock composed of natural-origin adults each year.

- PNI is the proportion of natural influence on a population composed of hatchery and natural origin fish (i.e., integrated program).
- PEHC estimates interbreeding between hatchery and natural-origin spawners based on genetic parentage analysis of offspring.

Steelhead

Because steelhead are iteroparous, the number of fish of each origin must be made based on observations of live steelhead. A draft multi state mark-recapture model was developed by the U.S. Geological Survey to estimate pHOS in the population of late winter steelhead that spawn in the North Fork Lewis River downstream of Merwin Dam. The model used data collected in 2018 and 2019 to derive estimates of pHOS. However, since 2019 the practice of using tangle nets became a concern and this invasive method was affecting spawning steelhead behavior and success in the lower river, especially as the spawning period progressed. In 2023, the ATS will need to decide on whether an alternative model should be developed or adopt alternative collection methods to sample in-river steelhead.

Chinook and Coho Salmon

Seasonal surveys of Chinook and Coho salmon carcasses are performed weekly throughout the spawning periods for Chinook and Coho salmon, outlined in Objective 5.1 and Strategy A. The origin (NOR, HOR, or Unknown) is recorded for sampled carcasses. The number and composition of carcass recoveries is a direct result of the recovery probability for each individual carcass, which are influenced by many factors (e.g., spawning timing, spatial distribution, sex and size of carcass), therefore, total estimates of pHOS will be derived by weighting of raw recovery data by relative abundance as described in Strategy A.

LIMITATIONS OR CONCERNS

Steelhead

The current steelhead model assumes that capture efficiency at the Merwin Trap is 100 percent and that all fish are correctly identified and recorded (e.g. noting residuals that migrate to the Merwin Trap). Additionally, while this model does not address all possible contingencies (e.g. capture efficiency varying among groups, or different rates of residualism among hatchery and natural populations), the posterior predictive check demonstrates that the model is adequate for the main goal of estimating the proportion of hatchery-origin spawners. However, the possibility for extensions or variations of the model to be evaluated in the future with more formal model comparison techniques remains.

Chinook Salmon

There is substantial temporal and spatial overlap between spring and fall runs of Chinook in the North Fork Lewis River, reducing the ability to reliably differentiate between fall and spring run Chinook in the field. Misidentification of carcasses as either spring or fall run will affect pHOS estimates because the vast majority of fall run Chinook are of natural origin whereas the spring run is predominantly of hatchery-origin from the segregated hatchery program.

Coho Salmon

A substantial portion of returning Coho either are trapped or spawn in tributaries of the mainstem North Fork Lewis River. Because most of the carcass recovery effort is focused on the mainstem, sampling may not be representative of the total returns to the basin. pHOS will not be reported separately for early and late Coho.

DATA COLLECTION METHODS

Metric or Monitoring Indicator	Targets	Field Methods	Analytical Methods	Frequency and Duration
8A.1. Proportion hatchery-origin spawners (pHOS)	See Table D-2 above for population-specific targets.	For Chinook and Coho spawner origin is derived from spawner surveys. Refer to Strategy A. Methods for determining pHOS in steelhead are to be determined in coordination with the ATS.	pHOS = Number of HOS/(HOS + NOS)	Calculated annually
8A.2. Proportion natural-origin brood (pNOB)	A component of PNI target. Applies only to integrated programs. Late winter steelhead uses a pNOB target of 1 to achieve a PNI ≥ 0.50. Late coho follows a recommended integration rate (e.g., 30 percent) based on the designation for each stock or	For each integrated program (late winter steelhead and late coho), the origin and sex of each fish spawned will be recorded.	pNOB = NOB / (HOB + NOB). pNOB will be calculated within each spawning matrix, and for the total number of spawners.	Calculated annually

	population (e.g., primary, contributing, or stabilizing.)			
8A.3.Proportion natural influence (PNI)	See Table D-2 above for population-specific targets. This metric is influenced substantially by the pNOB. For example, if the broodstock incorporates 100 percent natural origin fish, PNI estimates cannot be less than 50 percent.	N/A	PNI = pNOB/(pNOB+pHOS)	Calculated annually
8A.4.Proportion Effective Hatchery Contribution (PEHC)	No specific targets recommended. Program should avoid increase in PEHC over time. Not relevant for integrated programs.	N/A	Refer to Strategy G.	Calculated annually

Objective 9.0: Monitor the post-release behavior of hatchery smolts and their potential impacts on native and ESA-listed species present downstream of Merwin Dam.

The purpose of Objective 9.0 is to provide a means for direct monitoring of ecological interactions between HOR and NOR juveniles if in-hatchery monitoring metrics described under Objective 4 are not achieved. This objective shall remain inactive for as long as the metrics described in Objective 4 remain measurable and within the targets provided each year in the AOP.

SECTION E ADAPTIVE MANAGEMENT

The ATS is tasked with reviewing technical aspects of program implementation within a given calendar year. The ATS Work Plan (Appendix A) is a calendar of ATS activities, program production tasks, and monitoring and evaluation strategies. The work plan also identifies specific decision points that the ATS tracks throughout the year. Adaptive management will be used to periodically evaluate and adjust activities covered by the AOP, including H&S Program implementation and the monitoring and evaluation (M&E) activities described in Section D.

1.0 REVIEW MILESTONES

As envisioned in section 8.2 of the Settlement Agreement, program components will be evaluated in the following processes and documents:

- The H&S Annual Operating Report (AOR) compiles all information gathered pursuant to implementation of the H&S Plan, including recommendations for the ongoing management of the H&S Program, and is provided to the ACC for review and comment. The AOR is intended to provide estimates or results for each of the key questions and related objectives (Section D) evaluated each year. The AOR will include key highlights, accomplishments and technical recommendations to focus the ACC review as part of the Executive Summary. It is important to note that while the AOR provides estimates and results from annual monitoring activities and may recommend technical changes to program or M&E implementation, it does not provide decisions on the continuation of specific monitoring actions, management decisions, nor would the results reported trigger changes to management without further review. This decision-making process is the role and adaptive management function of the ATS and ACC as described in the following section.
- The H&S Plan will be updated every five years at a minimum, in coordination with the ACC and with the approval of the Services. (More frequent updates may be triggered by changes to the regulatory or management landscape, such as the approval of new HGMPs.) The update will consider recommendations from members of the ACC and the 10-year Comprehensive Review (described below), and identify those recommendations that have not been incorporated into the H&S Plan with a brief statement as to why the changes were not made. It is expected that information brought forward in the AORs will provide the basis for ACC recommendations for updating the H&S Plan.
- A Comprehensive Review will be undertaken every 10 years. In consultation with the ACC, an independent consultant will be hired to assess the H&S Program for the factors described in section 8.2.6 of the Settlement Agreement. The Comprehensive Review will consider all available data collected and reported as part of the AORs to evaluate the program's effectiveness and impacts in light of recent scientific advancements in hatchery science.

2.0 ROLES IN PROGRAM REVIEW AND DECISION-MAKING

2.1 Aquatic Coordination Committee (ACC)

The ACC is responsible for implementing the Settlement Agreement with the ability to implement changes to the Settlement Agreement through a Consultation process as defined in Section 14 of the Settlement Agreement. Therefore, modifications to the H&S Program implementation that may influence the Settlement Agreement or the Outcome Goal of the Agreement, require review and approval by the ACC prior to implementation. The ATS must request approval by the ACC of decisions that go beyond technical modifications, include programmatic recommendations, or decisions that modify interpretation of the intent of the H&S Program as described in Section 8 of the Settlement Agreement,. Prior to approval, the ACC may require use of the Decision-Making Template (see ACC ground rules document) to document and record decisions relating to implementation of the Lewis River Settlement Agreement or overall Outcome Goal of the Agreement.

2.2 Aquatic Technical Subgroup (ATS)

The ATS functions as a technical advisory group to the ACC. The ATS reviews and revises the AOP annually with a focus on technical approaches and protocols, with consideration for how changes in methods may affect the continuity of datasets and program implementation. The ATS may also make in-season decisions to ensure continuity of program implementation, such as adjusting broodstock collection curves in response to actual size and timing of an annual return. Reviewing and revising the AOP with flexibility for in-season adjustments ensures program implementation and M&E activities are achieved each year.

3.0 ADAPTIVE MANAGEMENT DECISION MAKING PROCESS

Adaptive management of the H&S Program is done through a cycle of annual and periodic steps (as defined in the Settlement Agreement) that provide the means to modify the H&S Program through formal decision making.

The first step in the adaptive management process is the annual reporting of program performance trends. This step is achieved upon distribution of the AOR. Where available, the AOR provides annual results in the context of multi-year trends. The report includes a brief Executive Summary identifying notable trends and key concerns from the past year, and recommendations for adjustments to monitoring and evaluation activities.

The second step is an annual 30-day ACC review process which includes the following:

- Coinciding with the distribution of the review draft of the AOR to the ACC, PacifiCorp will summarize key findings during the ACC meeting in May to highlight accomplishments and identify any notable concerns to assist the ACC in their review.
- Upon completion of the 30-day review, the ACC, in coordination with the ATS, may recommend revisions to the AOP for the subsequent year in the form of informal consultations or request for decision using the ACC Decision Template.

The third step is to update the H&S Plan every 5-years, either in response to ACC recommendations based on data trends that are tracked by the ATS and reported in the AOR, or in response to recommendations given in the Comprehensive Periodic Review (described next).

The fourth and final step is a Comprehensive Periodic Review of longer-term data trends in the H&S Program every 10-years. This review will be undertaken by an independent third party to identify data gaps and modifications to the program implementation to ensure the H&S Program is achieving the stated goals, stipulated in Section 8 of the Settlement Agreement. The ATS shall review conclusions and results from the Comprehensive Periodic Review to determine whether formal program decisions or trigger points are warranted and, if so, develop recommendations for ACC review and approval using the ACC Decision Template.

The elements of the adaptive management cycle are shown in Figure E-1 and schedule in Table E-1, below.

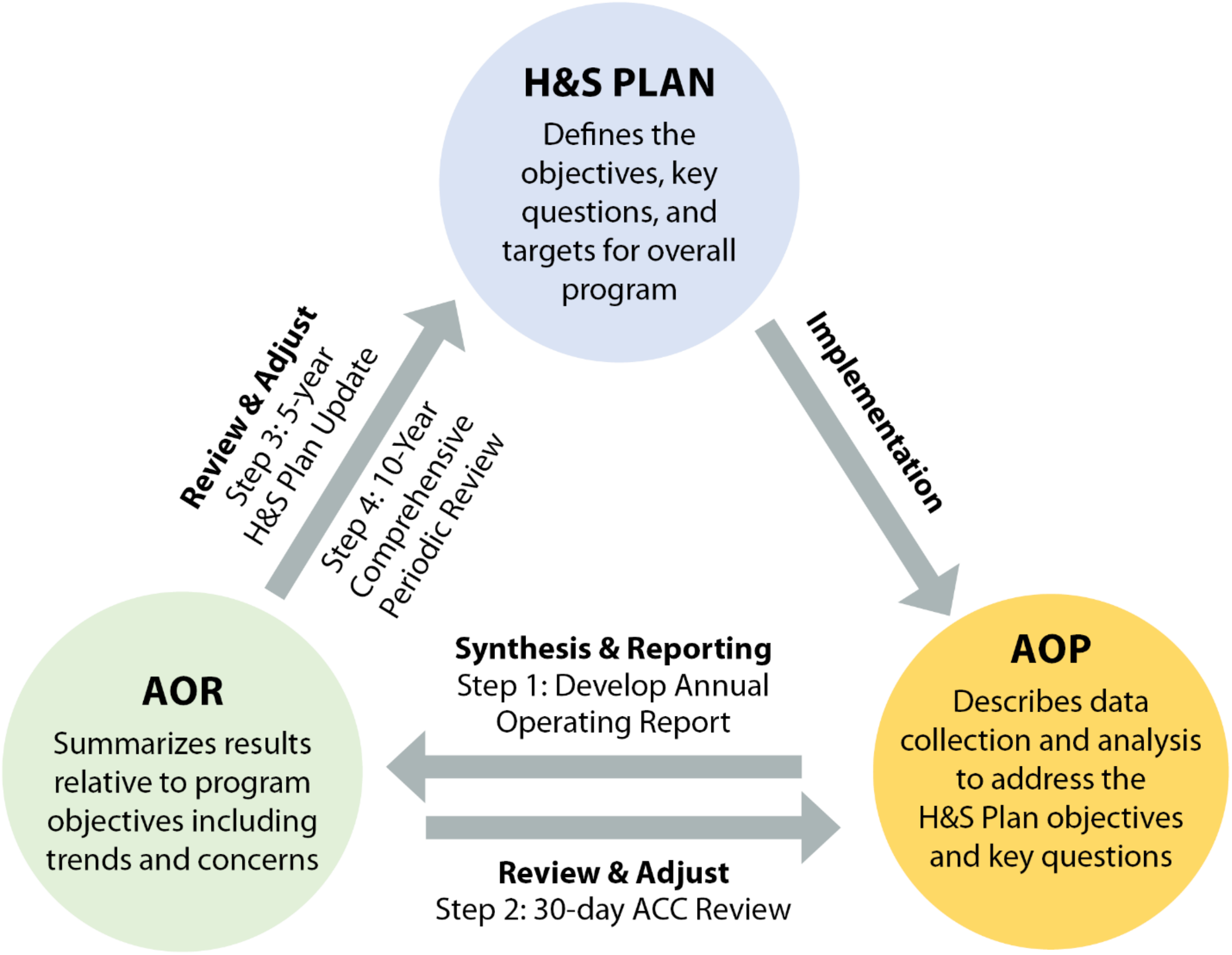

Figure X-X Graphical depiction of the H&S Program adaptative management approach and cycle through its corresponding plans (H&S Plan, AOP), reports (AORs), and review processes

Table E - 1. Adaptive Management Milestones

		2023				2024					2025				2026				2027				2028				2029				2030				2031			
Annual Operating Report Development	PacifiCorp	▨	▨			▨	▨			▨	▨	▨			▨	▨			▨	▨			▨	▨			▨	▨			▨	▨			▨	▨		
Annual Operating Report Review	ACC, ATS		▨				▨					▨				▨				▨				▨				▨				▨				▨		
Annual Operating Plan Revisions	ATS			▨	▨			▨	▨				▨	▨			▨	▨			▨	▨			▨	▨			▨	▨			▨	▨			▨	▨
Comprehensive Periodic Review	Indep. Reviewer																																	▨	▨	▨	▨				
H&S Plan Update	ATS														▨	▨	▨	▨																	▨	▨	▨	▨

SECTION F REPORTING REQUIREMENTS

Annual reporting of AOP implementation and monitoring of objectives is provided as part of the Lewis River Annual Operations Report, distributed for review in late April of each year. According to the Settlement Agreement, the annual report will include, at a minimum, the following:

1.0 ADULT COLLECTION AND SPAWNING

- Collection numbers by location and method
- Collection numbers compared to targets
- Genetic assignment results for steelhead
- Spawning protocols and numbers
- Transportation numbers by date, species, and sex ratios (actual versus goals)
- Distribution of all collected species
- Disposition of any species

2.0 EGG INCUBATION AND JUVENILE REARING/RELEASE

- Egg take – actual versus goals
- Egg to fry survival – numbers of fish ponded
- Pathogen screening results
- Rearing strategies that differ from routine operations (e.g., use of circular rearing strategies)
- Smolt releases, length, and location (actual versus goals)
- Tagging and marking summary (PIT tags and BWTs)

3.0 MONITORING AND EVALUATION

Results of activities undertaken for each monitoring and evaluation objective. Reporting will be completed in accordance with the 2020 H&S Plan Objectives; however, these objectives are not described in this 2021 version of the AOP because it has yet to be approved by FERC. At a minimum, these monitoring and evaluation results reported will include the following along with associated confidence intervals and coefficient of variance, where applicable:

- Adult escapement estimates (abundance) downstream of Merwin Dam
- Adult composition (hatchery versus natural origin) on spawning grounds downstream of Merwin Dam
- Spatial and temporal distribution of spawning downstream of Merwin Dam
- Juvenile migration and residualism estimates of hatchery releases downstream of Merwin Dam
- Hatchery juvenile monitoring for ecological interactions with NOR smolts
- Summaries of screw trapping results including locations fished, time periods fished, catch rates (relative abundance) by species (composition), trapping efficiency, and estimates of juvenile abundance by species

- Distribution maps of redd locations and counts for each species

4.0 CONSISTENCY AND ADHERENCE WITH HSRG GUIDELINES

Annual reporting may include recommendations to ensure that Lewis River hatchery operations are consistent with recommendations of the HSRG.

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