APPENDIX C: ROCK CREEK HATCHERY RECONSTRUCTION – PRELIMINARY HATCHERY COOLING SYSTEMS EVALUATION

Prepared by Solarc Engineering, LLC

SOLARC ENGINEERING, LLC
3059 Whitbeck Blvd
Eugene, OR 97405
phone: 541.654.2241

December 18, 2023

Mr. Ryan McCormick, PE
Chief Engineer
Oregon Department of Fish & Wildlife
4034 Fairview Industrial Drive SE
Salem, OR 97302

Dear Ryan,

This letter report summarizes the findings of our initial concept-level investigation into the potential for cooling the hatchery tanks at the Rock Creek Hatchery on the North Umpqua River.

Background

The Rock Creek Hatchery was originally constructed in 1925, making it one of the oldest hatchery facilities in southern Oregon. The Rock Creek Hatchery (RCH) is located on Rock Creek, just above its confluence with the North Umpqua River, and currently supports the spawning and rearing of Chinook, Coho, Steelhead and Trout species native to the region's rivers and lakes.

In the massive Archie Complex Fire of 2020, the hatchery was destroyed, along with 109 homes and 130,000 acres of forest, much of which had historically provided riparian shading along the river's course upstream of the hatchery location. Together with other climate-change impacts, river temperatures have been steadily increasing over time, and are now a key factor in declining populations of fish that return to the river to spawn each year.

It is our understanding that in order to continue to provide the conditions required for reproduction—and therefore to support native fish populations in the region—it is now necessary to find ways to cool the water within the hatchery, especially in the tanks where egg development and fish hatch processes occur. Preliminary planning information for the re-construction of the RCH following the 2020 fires has been provided to us by Ryan McCormick, of the Oregon Department of Fish and Wildlife (ODFW). This preliminary study is intended to examine the potential costs and technical feasibility of including a cooling system in the reconstruction plans, designed to maintain the hatchery water temperatures necessary for the fish being propagated in the Rock Creek Hatchery facility.

Design Criteria

For the purposes of this initial concept investigation, design criteria for a conceptual cooling plant were selected to form a Basis of Design, as follows:

• Portions of hatchery facilities to be cooled:	Hatchery Tanks Only
• Flow rate – Fresh Water from River:	3.0 cfs (1346 gallons/minute)
• Flow rate – Recirculated Tank Water:	10.0 cfs (4488 gallons/minute)
• Flow rate -- Blended Fresh+Recirculated Water:	13.0 cfs (5834 gallons/minute)
• Peak Summer Temperature – Fresh Water from River:	80.0 degrees F

- Temperature – Recirculated Tank Water: 67.0 degrees F
- Temperature – Entering Chillers (Blended Water): 67.7 degrees F
- Temperature – Leaving Chillers (Entering Tanks): 62.0 degrees F
- Temperature – Rise Through Tanks: 5.0 degrees F
- Temperature – Final Discharge to River: 77.0 degrees F

Refer to Appendix A for a drawing depicting a Hatchery Site Plan, with the proposed cooling system included.

Cooling Load Calculations

Using the design criteria presented above, cooling loads were calculated. It is important to note that the cooling load thus derived is an "average peak" value, since the temperature of the fresh water from the river is considered to be an "average peak" value. While this is appropriate for making design decisions regarding total cooling system capacity, the actual cooling load will vary on an hourly basis, following both a diurnal curve, as well as a seasonal one. The varying load can be accommodated in the design of the system, and this has been considered in the equipment selections assumed for this study.

A spreadsheet was developed to perform the load calculations (see Appendix B), which arrive at a total cooling load of 23,340,000 Btu/hr (1,945 tons, nominal) for the design conditions chosen.

Equipment Selections

Several alternatives have been considered and discussed with ODFW in the course of this conceptual evaluation. Because of the very large amount of water to be cooled, and the resulting considerable cooling load to be met, it is clear that direct-evaporation methods, such as spray towers and reservoirs, are not able to provide the required hatchery tank temperature, close to 60 degrees F. The reason is simply that the design wet bulb temperature for the hottest 3 months of the year at the location of the RCH is approximately 70 degrees F, which is the theoretical minimum temperature that could be achieved through evaporation during local design day weather conditions. To be able to maintain tank temperature of 60 degrees F, mechanical cooling is therefore required.

Next, given the high initial cost, operating cost, and space requirements of chillers and related equipment, heat recovery was investigated as a means to reduce the total cooling load, and therefore chiller plant size. In this case, heat recovery is achieved by exchanging thermal energy between the hatchery tank discharge water to the fresh incoming river water, thus retaining much of the cooling effect provided within the hatchery tank system. The calculations shown in Appendix B indicate that by using large plate-and-frame type heat exchangers, the total design cooling load for our concept evaluation purposes is 16,607,000 Btu/hr (1,384 tons, nominal), which represents a reduction in chiller plant size of 29%. Including heat recovery in the system design provides a very large reduction in system costs and overall energy requirement, and is therefore the basis for sizing and selecting the chiller equipment considered in this report.

In selecting the chillers themselves, several considerations must be examined. First, there are two fundamental types of commercially available chiller equipment in today's market: electric-drive chillers (which employ motor-driven compressors and a closed-circuit compression and condensing process), and absorption chillers, which are typically fueled with natural gas (or high-temperature waste heat). Since natural gas is not available at the RCH site, the cooling equipment must therefore be electrically powered. Next, there are two fundamental types of electrically powered chillers that could provide the required cooling for the RCH: 1) Air-cooled/Packaged Chillers; and 2) Water-cooled Centrifugal Chillers with Cooling Towers. While there are many nuanced advantages and disadvantages associated with these two basic alternatives, the most fundamental of these are as follows:

Packaged (Reciprocating, Scroll, or Screw) Air-Cooled Chiller:

Pros:

- Possibly lowest initial construction cost;
- Lowest annual maintenance.

Cons:

- Outdoor operation means much higher ambient sound levels;
- Less energy efficient;
- Highest operating cost;
- Highest electric power / utility service requirement;
- Very large space requirements on the site.

Centrifugal Water-Cooled Chiller:

Pros:

- Indoors, so that chiller sound levels are largely absorbed by enclosing building;
- Highest energy efficiency;
- Lowest operating cost;
- Lowest electric power / utility service requirement;
- Most compact installation footprint on the site.

Cons:

- Annual cooling tower shutdown/startup required (for freeze protection);
- Possibly highest initial construction cost.

While very preliminary construction cost estimates for both types of chiller plant were examined as part of this concept evaluation effort, we have chosen the highest operating efficiency / lowest operating cost system as the basis for this study. This is due the very large electric power requirement for the new cooling plant being considered for the RCH facility, which is far beyond the capacity of existing Pacific Power branch service line and site electrical transformer and switchgear to the site. It also seems logically consistent to aim for the lowest possible energy use in the design of a cooling plant: consider that reducing utility power requirements of the cooling system also reduces the amount of fossil fuel required to generate that power, which also reduces the amount of carbon released to the atmosphere, which is the primary cause of the increasing atmospheric and river temperatures that this plant is designed to mitigate.

Costs for upgrading Pacific Power's service line have not been determined at this time, but it is clear that the packaged air cooled chiller option would, if selected, would require a substantially increase in peak power due to lower overall efficiency. Pacific Power's service costs would also be higher in that case.

Hatchery Cooling Plant Conceptual System

Following the process outlined above, a general cooling plant configuration was designed, including consideration of where each required system component could be placed on the RCH site. We began with a preliminary site plan provided by ODFW, showing the planned re-construction of the hatchery tanks. Plans for the new facility also include disinfection systems on both fresh/makeup river water and recirculated water from the hatchery effluent pipe. The Cooling System Schematic diagram included in Appendix A shows the conceptual cooling plant, together with the new disinfection system planned by ODFW.

The development of design considerations in this study led us to consider and finally to include on-site renewable energy production as part of the concept evaluation presented. It is immediately apparent that there are several good reasons for such an approach:

- All open structures (rearing raceways and hatch tanks) in the hatchery facility absorb a great deal of solar energy directly during daylight hours, which result in increased water temperatures;
- Shading of these open structures can be done using racks supporting solar photovoltaic (PV) panels above them; likewise, new roof structures already planned for the re-constructed hatchery could also support PV panels, providing simultaneous direct solar gain reduction and on-site electricity generation to offset the new cooling system requirements;
- A large amount of sloped land surface adjacent to the RCH is available (and now free of obstructing trees/forestation) for ground-mounted PV panels;
- The river temperature and cooling load tracks in real-time with the solar insolation (amount of radiant energy from the sun; this means that availability of solar energy for PV production is at its annual maximum at the same times as the river temperature reaches its annual maximum;
- The new chiller plant will require a new, much larger, Pacific Power service to the RCH site, which could potentially be completely avoided if a sufficiently large PV system were installed at the facility. A backup generator system and battery storage would be required to match energy production with energy demand at the site.
  The proposed electrical one line diagram (see Appendix A) outlines an option for augmenting the existing Pacific Power electrical service with PV arrays over the ponds and addition of a second backup generator and storage batteries.
- If sized to provide most or all of the peak summertime energy to the new chiller plant, the proposed PV system would actually produce an annual revenue stream through sale of excess PV generated power during

months when the cooling system is not required to run, offsetting energy used during the months that the chiller plant is operating.

Concept-level design work done in preparing this report found that it is technically feasible to achieve—or at least approach—a "Net-Zero" annual energy use condition for the overall hatchery, if that goal is deemed to be important to the ODFW, or to the State of Oregon.

Existing Electric Utility Service and Hatchery Switchgear

(The following description assumes that all existing electrical system components are still operational following the 2020 forest fire.) Two separate Pacific Power electrical services exist at the RCH facility, one serving the Hatchery buildings and equipment, and the second serving the river pump station. The Hatchery is served by an 800 amp, 480 volt overhead service. A service rated transfer switch at the Hatchery allows the facility to be fed from a 250 kW generator. The pump station is served by a separate 600 amp 480 volt underground service. An automatic transfer switch at the pump station allows the river pump to be served from the Hatchery system.

New RCH Electrical Service Required with Cooling Plant

Pacific Power will be conducting a separate evaluation of the system capacity of their current system. For purposes of this study we are assuming the existing Hatchery service can become the source of utility power for the new chiller plant and that 600 amps of continuous power is available from the Utility to operate the chiller plant and existing Hatchery loads. This would be independent of the existing 75 hp river pump, which also would be served from Pacific Power under normal operating conditions.

To serve the combined chiller/hatchery load a 2 megawatt hybrid inverter is proposed. The inverter would receive 600 amps (500KW) of continuous power from the Utility during the months the chiller plant is operating. The inverter would also receive power from a 2 megawatt PV system located on the site. Battery storage would be provided to store excess solar energy produced during the months that the chiller plant is not operating. This excess power would be sent back to the Utility during these months, offsetting energy usage during the chiller operation season. The backup generator system would be upgraded as needed to make up for shortfall in power production and to keep the plant operational when utility power is lost to the site. Initial calculations indicate a 500 kW generator would be adequate for this purpose. The existing 250 kW generator would remain in place to provide additional backup generator capacity. The generator would operate continuously at 50% production during the months the chiller plant is operating and provide 100% backup for the Hatchery and the river pump during the other eight months.

Constraints on Size of Potential New PV Systems at RCH Site

The new system would operate under existing net metering regulations. The maximum photovoltaic system that can be installed under current net metering rules is 2 megawatts. Power generated can offset existing purchased over the course of a 1 year period. The Owner would still need to pay peak demand charges and basic service charges. The same capacity limitation that Pacific Power has on electrical load would apply to receipt of excess power generated under net metering. As a result the inverter system that provides power for the Hatchery and

Chiller Plant would need to also regulate load being received from the Utility and being sent back to the Utility. The mechanical / electrical site plan shows locations for 1.54 megawatt of PV in shading roofs over the existing hatchery ponds.

Backup / Emergency Power System Requirements

The new inverter system would replace the existing 800 amp service and transfer switch with 250 kW backup generator. Existing electrical equipment would be re-fed from the new inverter. The new system would provide 100% backup power for the Hatchery and the river pump. If normal power was interrupted during the season the chiller plant is operating the chiller plant could remain operational at reduced capacity depending on the amount of solar energy being generated during the power outage condition.

The preceding narrative is based on installation of a 2 megawatt photovoltaic system to supplement utility power to the site. In the absence of a photovoltaic system the plant would need a larger diesel generator system to augment the power received from the utility. Initial estimates indicate a 1500 kW generator plant would be required.

Construction Cost Estimate

For the purposes of this report, approximate construction costs have been estimated using engineering experience with similar projects in the region, and preliminary budget quotes provided by equipment suppliers. The cost information presented in this report must be considered to be "Order of Magnitude" estimates, and must be further refined in a subsequent, more detailed study phase.

Note that the construction costs included here are only those associated with the ADDED costs related to the proposed cooling system, and do not include the disinfection / filtration systems already planned for by ODFW.

Table 1. Preliminary Order of Magnitude Construction Cost Estimate.

Item / Description	Qty	Units	Materials Unit Price	Materials Sub Total	Labor Unit Price	Labor Sub Total	Total Cost	Notes
			$	$	$	$	$	
Raw Water Pumps	2	ea	15000	10000	7000	14000	44000	Submersible / VFD, 700gpm
Raw Water Wet Well	1	ea	15000	15000	10000	10000	25000	Prefab Manhole, RW Valve, 1400gpm
Raw Water Filters	2	ea	15000	15000	8000	16000	46000	Auto Backflushing, 700gpm
Heat Exchangers (RW / PE)	2	ea	32000	64000	16000	32000	96000	Plate/Frame Ht Exchangers, 700gpm
Tank Effluent Water Filters	2	ea	15000	15000	8000	16000	46000	Auto Backflushing, 700gpm
Tank Effluent Water Pumps	2	ea	25000	50000	13000	26000	76000	Base Mounted/ VFD, 700gpm
Chilled Water Pumps	2	ea	42000	84000	20000	40000	124000	Vertical Turbine / VFD, 2900gpm
Water Cooled Chillers	2	ea	485000	970000	200000	400000	1370000	750ton Centrifugal / Var. Speed
Cooling Towers	2	ea	410000	820000	200000	400000	1220000	2000gpm, Dual Cell, Open
Condenser Water Pumps	2	ea	34000	68000	16000	32000	100000	2000gpm, Horiz. Split-Case / VFD
Chilled Water Piping, Branch	250	lf	600	150000	250	62500	212500	CS, Insulated / Jacketed, 2900gpm
Chilled Water Piping, Main	200	lf	1200	240000	600	120000	360000	CS, Insulated / Jacketed, 5800gpm
Condenser Water Piping, Branch	150	lf	400	60000	200	30000	90000	CS, Uninsulated, 2000gpm
Condenser Water Piping, Mains	80	lf	1000	80000	500	40000	120000	CS, Uninsulated, 4000gpm
Raw Water Piping	100	Lf	300	30000	150	15000	45000	CS, Uninsulated, 1350gpm
Effluent Water Piping	600	Lf	300	180000	150	90000	270000	CS, Uninsulated, 1350gpm
Chiller Building	3000	sf	125	375000	100	300000	675000	PEMB, Structural, Slab-On-Grade
Tower Slab/Foundation	1300	sf	100	150000	50	75000	225000	Open Slab, Equipment Footings
Raw Water PS Slab/Roof	600	sf	100	60000	50	30000	90000	Slab, Footings, PEMB w/o Walls
Subtotal, Mechanical Systems							5,234,500	
PV Arrays & PV Inverters	1500	kW	4000	6000000	2000	3000000	9000000	
Electrical Switchgear & Batteries	1	ls	300000	300000	200000	200000	500000	
Refeed Existing Equipment	1	ls	20000	20000	20000	20000	40000	
400 Amp Feeders	4800	lf	150	720000	50	240000	960000	
Subtotal, Electrical Systems							10,500,000	
Subtotal Cost							$15,734,500	
Contractor O&P						25%	$3,933,625	
Contingency								
Engineering						5%	$983,406	
Total Cost							$20,651,531	

Next Steps

This study has been prepared to serve as an initial evaluation of feasibility, with a very preliminary estimate of construction cost. If this concept meets ODFW goals from a fisheries biology standpoint and it is decided to further investigate inclusion of a cooling plant in the reconstruction of the Rock Creek Hatchery, the next step is to proceed with a Schematic Design study, in which assumptions can be formulated in greater detail, criteria for cost-effectiveness can be developed, and overall system design can be refined to allow a "Schematic Design Level" construction cost to be determined. In particular, an extremely important need is to obtain the necessary internal studies from Pacific Power to understand what will be needed to provide power to the new hatchery facility, and what involvement in the energy-efficiency goals of such a project they would be willing to provide. This could include, for example, participatory funding and/or incentives, system development costs they would require to be paid by the project owners, time-lines for planning and executing distribution system upgrades or expansion, and—quite importantly—to make clear their requirements for a large solar PV system to be grid-tied to their system.

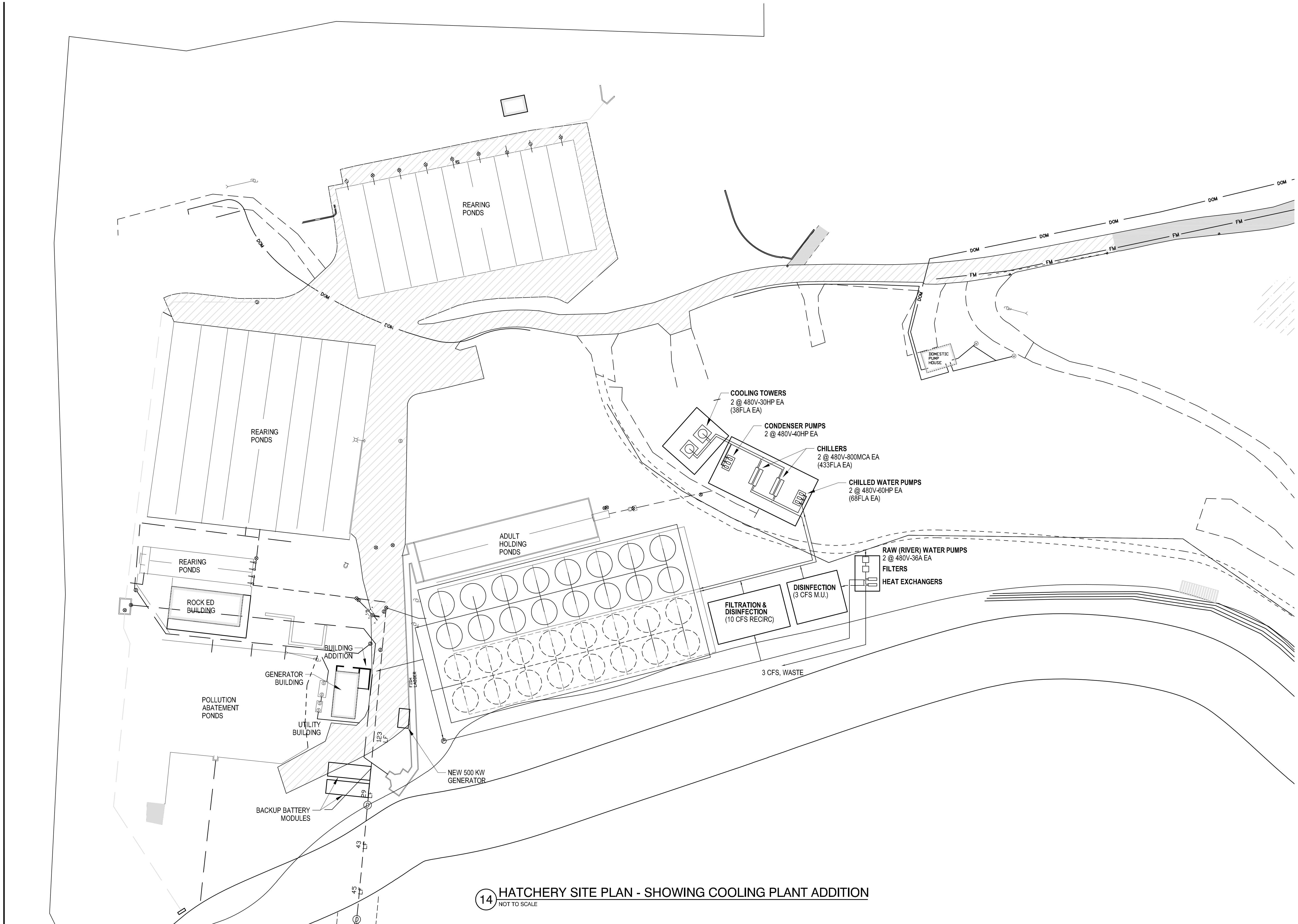
Please call to discuss any questions you may have regarding the details of this letter report, at 541.654.2241 or via e-mail at genej@solarc-eng.com.

Sincerely,

Gene Johnson, P.E.
Principal/Member

GJ/edj

APPENDIX A – DRAWINGS & DIAGRAMS



14 HATCHERY SITE PLAN - SHOWING COOLING PLANT ADDITION

NOT TO SCALE

SOLARC
ENGINEERING LLC – EUGENE, OREGON
3059 WHITBECK BLVD. 97405
541.654.2241

REGISTERED PROFESSIONAL ENGINEER #13759 OREGON JULY 16, 1987 EUGENE D. JOHNSON

EXP. DATE: 6/30/2025

HATCHERY COOLING CONCEPT

ROCK CREEK HATCHERY RENOVATION

OREGON DEPARTMENT OF FISH & WILDLIFE
4034 FAIRVIEW INDUSTRIAL DRIVE SE
SALEM, OREGON 97302

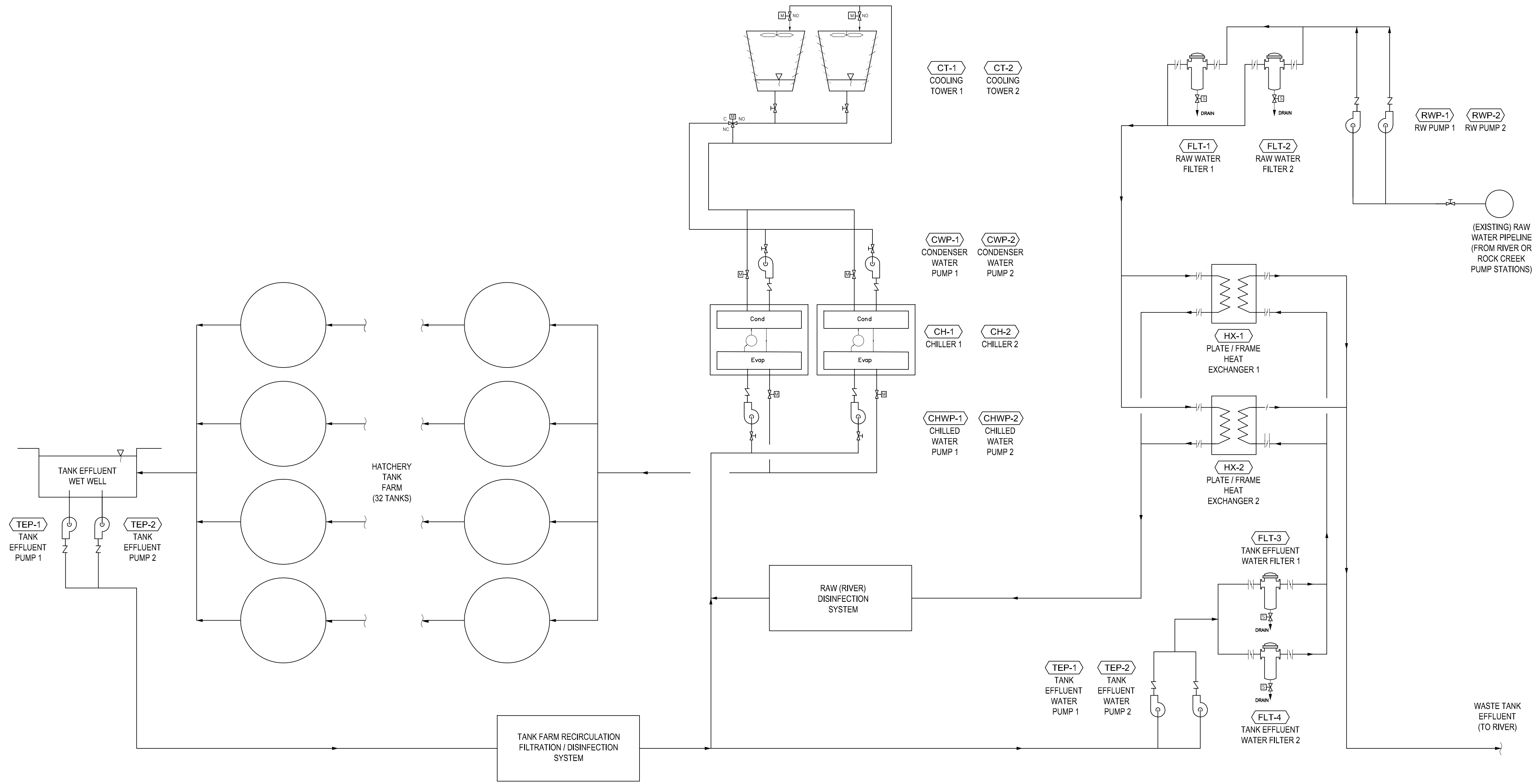
PROJECT NO:	23-001
ISSUE DATE:	12/15/23
DRAFT DATE:	
DRAWN BY:	EDJ
CHECKED BY:	GJ

REVISED:
01

MECHANICAL/ ELECTRICAL SITE PLAN

G001

SHEET X OF X



14 HATCHERY COOLING PLANT SYSTEM CONCEPTUAL SCHEMATIC

NOT TO SCALE

SOLARC

ENGINEERING LLC — EUGENE, OREGON

541.654.2241

3059 WHITBECK BLVD, 97405

REGISTERED PROFESSIONAL ENGINEER #13759 OREGON JULY 16, 1987 EUGENE D. JOHNSON

EXP. DATE: 6/30/2025

HATCHERY COOLING CONCEPT

ROCK CREEK HATCHERY RENOVATION

OREGON DEPARTMENT OF FISH & WILDLIFE

4034 FAIRVIEW INDUSTRIAL DRIVE SE

SALEM, OREGON 97302

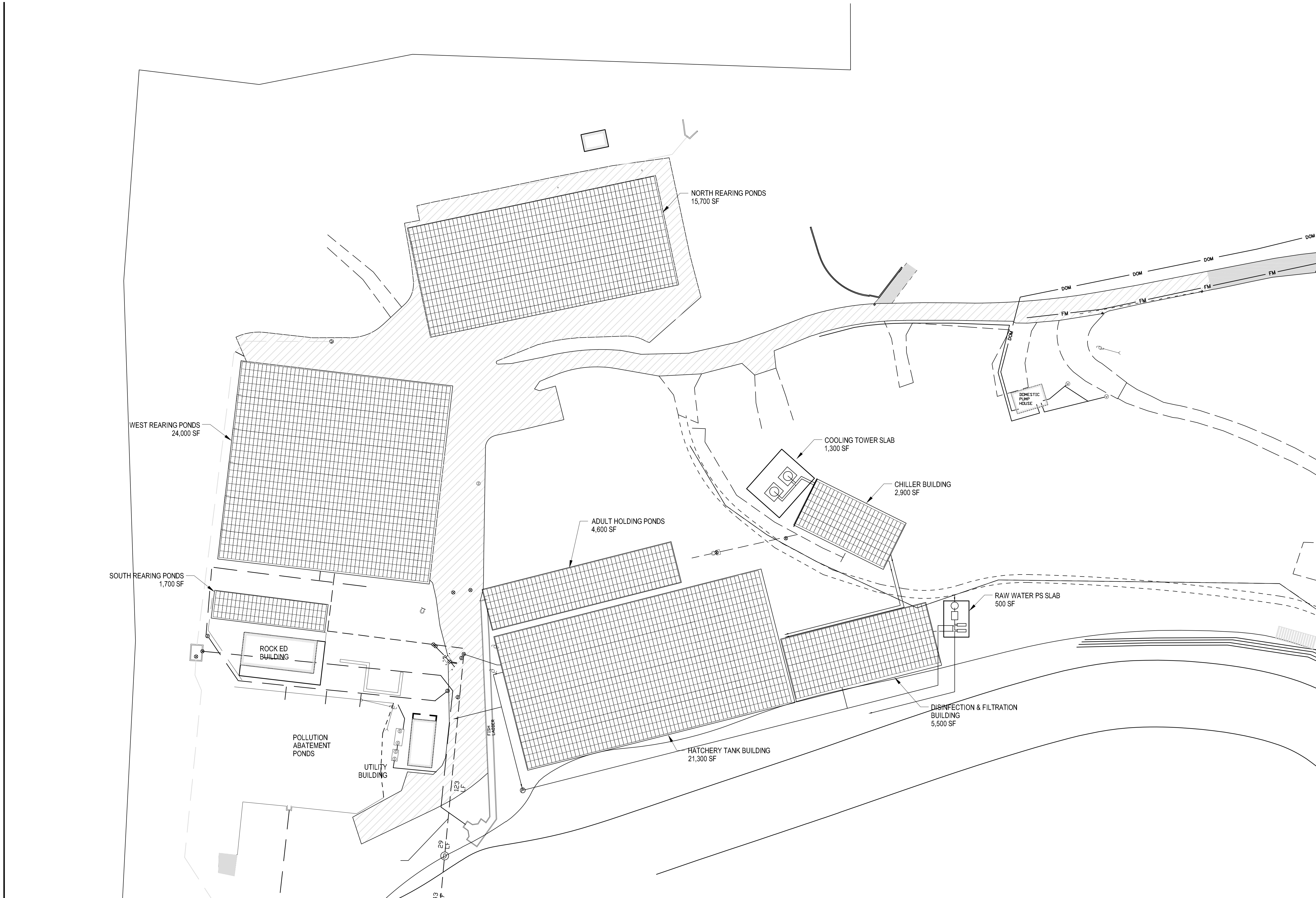
PROJECT NO:	23-001
ISSUE DATE:	12/15/23
DRAFT DATE:	
DRAWN BY:	EDJ
CHECKED BY:	GJ

REVISIONS:

CONCEPT COOLING SYSTEM SCHEMATIC

M501

SHEET X OF X



(14) HATCHERY SITE PLAN - SHOWING SOLAR PV ARRAYS
NOT TO SCALE

SOLARC
ENGINEERING LLC – EUGENE, OREGON
541.654.2241
3059 WHITBECK BLVD. 97405

REGISTERED PROFESSIONAL ENGINEER
#13759
OREGON
JULY 16, 1987
EUGENE D. JOHNSON
EXP. DATE: 6/30/2025

HATCHERY COOLING CONCEPT

ROCK CREEK HATCHERY RENOVATION

OREGON DEPARTMENT OF FISH & WILDLIFE
4034 FAIRVIEW INDUSTRIAL DRIVE SE
SALEM, OREGON 97302

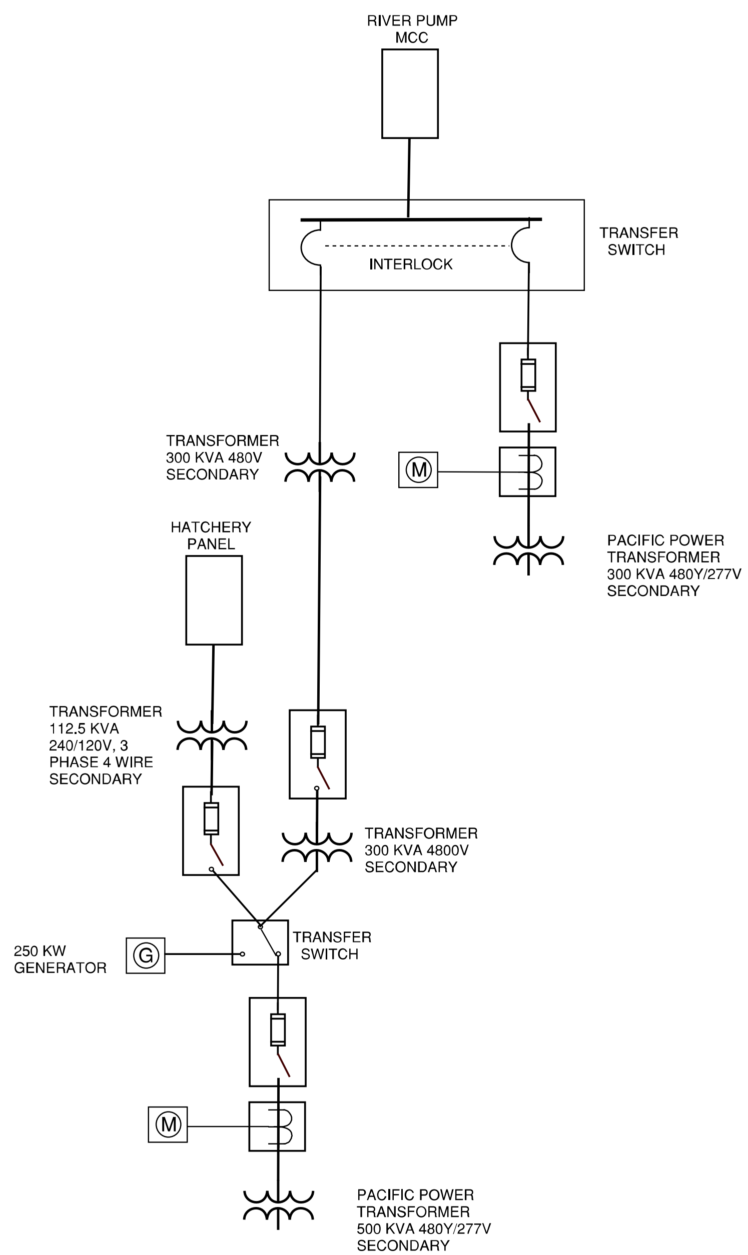
PROJECT NO:	**23-001**
ISSUE DATE:	**12/01/23**
DRAFT DATE:	
DRAWN BY:	**EDJ**
CHECKED BY:	**GJ**

REVISED:
01

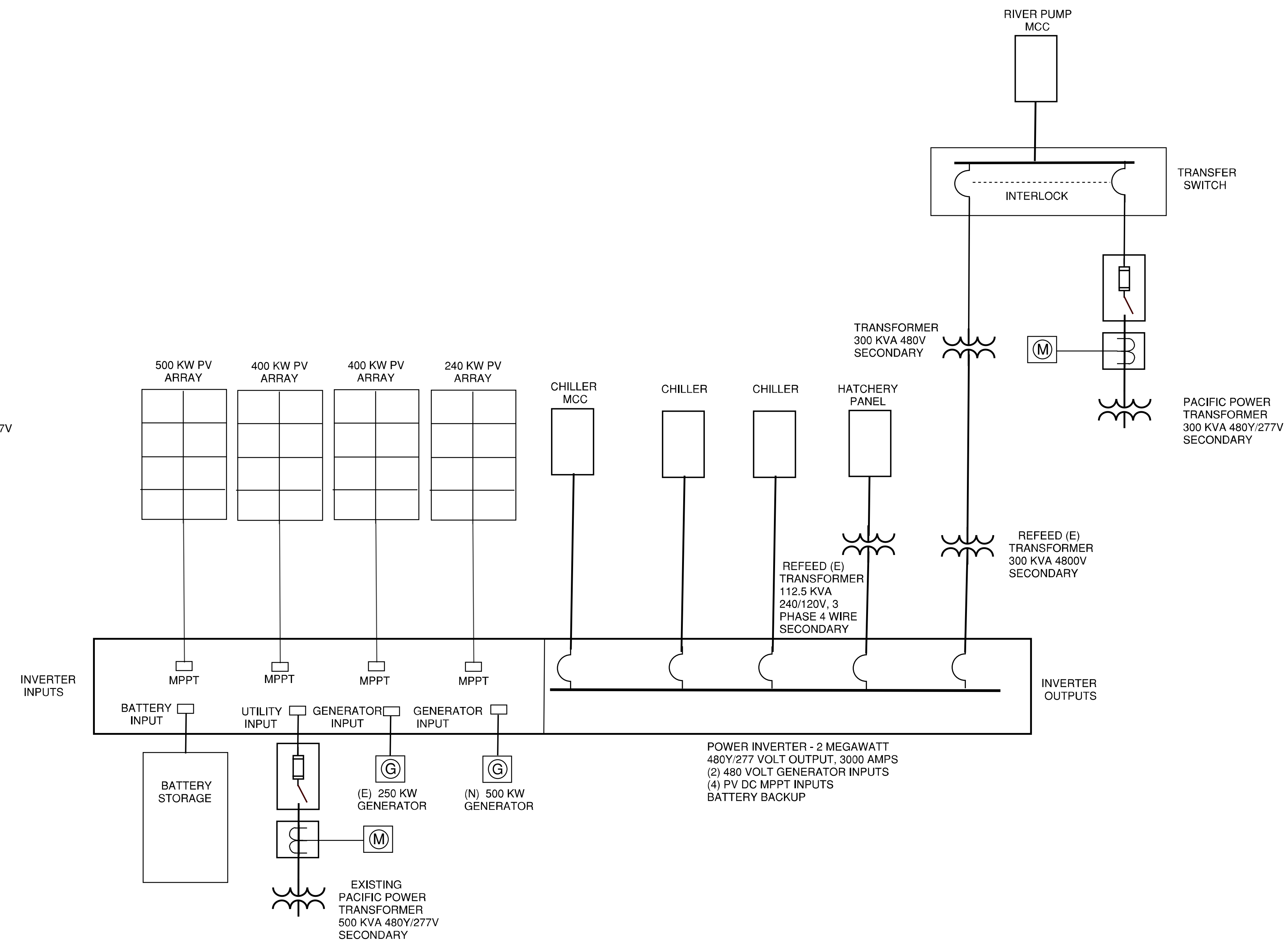
SOLAR PV
SITE
PLAN

G002

SHEET X OF X



EXISTING ELECTRICAL ONE LINE DIAGRAM



REVISED ELECTRICAL ONE LINE DIAGRAM

SOLARC
ENGINEERING LLC — EUGENE, OREGON
3059 WHITBECK BLVD, 97405
541.654.2241

Paradigm Engineering
James Krumsick P.E. LEED AP
85193 Appletree Drive
Eugene, Or. 97405
541 285 1680
jkrumsick@outlook.com

HATCHERY COOLING CONCEPT
ROCK CREEK HATCHERY RENOVATION

OREGON DEPARTMENT OF FISH & WILDLIFE
4034 FAIRVIEW INDUSTRIAL DRIVE SE
SALEM, OREGON 97302

PROJECT NO:	**23-001**
ISSUE DATE:	**12/15/23**
DRAFT DATE:	
DRAWN BY:	JK
CHECKED BY:	GJ

REVISIONS:

ELECTRICAL
SYSTEM
SCHEMATIC

E501

SHEET **X** OF **X**

APPENDIX B – CHILLER & HEAT EXCHANGER LOAD CALCULATIONS

Date:	Wednesday, November 08, 2023
Project:	23-001 ODFW Rock Creek Hatchery Cooling Plant Concept
Spreadsheet:	Cooling Load Calculation.xls (EDJ)

Design Objectives for Cooling Plant Concept:

1. Provide a system to cool blended supply water (fresh/river + recirculation) to circular hatchery tanks.
2. Utilize heat recovery plate/frame heat exchangers to precool fresh/river water using waste water leaving hatchery.

Design Criteria:	Flow cfs	Flow gpm	Temp. degF	Load Btu/hr
Recirc Water Leaving Circular Tanks:	**10.0**	4488	67.0	
Temperature Rise Through Circular Tanks:			**5.0**	
River Water Conditions:	**3.0**	1346	**80.0**	
Supply Water to Chillers:	13.0	5835	70.0	
Supply Water from Chillers:	13.0	5835	**62.0**	Design Objective

(Input values in **Red Bold**)

Chiller Plant Load Calculation **Without** Heat Recovery:	Flow gpm	Temp. degF	Load Btu/hr
Chiller Plant Water, Entering: (recirculation + river):	5835	70.0	
Chiller Plant Water, Leaving (supply to circular tanks):	5835	62.0	
Chiller Plant Load, Btu/Hr:			23,339,160
Chiller Plant Nominal Tons Cooling:			**1,945**

If heat exchanger is inserted between the river and the plant:

Flow & Temperature of Fresh/River Water After Heat Recovery:		Flow gpm	Temp. degF		
River Water Conditions Entering HX: (hot,in)	3.0	1346	80.0		
River Water Conditions Leaving HX: (hot,out)	3.0	1346	70.0	**3.0**	deg F approach
Mixed Water Entering HX: (cold,in)	3.0	1346	67.0	deg F leaving, to river (Note 1)	
Mixed Water Leaving HX: (cold,out)	3.0	1346	77.0		

Chiller Plant Load Calculation **With Heat Recovery**:	Flow gpm	Temp. degF	Load Btu/hr
Chiller Plant Water, Entering: (recirculation + pre-cooled river):	5835	67.7	
Chiller Plant Water, Leaving (supply to circular tanks):	5835	62.0	
Chiller Plant Load, Btu/Hr:			16,606,710
Chiller Plant Cooling Load, Tons:			**1,384**

(This is the assumed scenario: select plate/frame hx)

HX Sizing & Selection:	No. of Units: 2				
		Mfr:	Model:		
Heat Load Duty Rating:	3,366,225	B&G	AP45	3,366,225	BTU/hr
Cold, in degF:	67.0			67	deg F
Cold, out degF:		=========================:		77	deg F
Hot, in degF:	80.0			80	deg F
Hot, out degF:		=========================:		70	deg F
Flow, gpm:	673		Approach:	3	deg F
Pressure drop assumed, psi:	10				

Notes: 1) Confirm with Ryan: NOTE that this temperature will vary with ambient conditions

RIVER TEMPERATURE PROFILE - DESIGN DAY

Time	Hour	Temp (C)	Temp (F)	Load, Tons	kw/ton	kwh
12:00 AM	1	24.3	75.7	1130	0.70	786
1:00 AM	2	24.1	75.4	1107	0.69	760
2:00 AM	3	23.9	75.0	1085	0.68	735
3:00 AM	4	23.7	74.7	1063	0.67	710
4:00 AM	5	23.5	74.3	1041	0.66	686
5:00 AM	6	23.4	74.1	1030	0.65	674
6:00 AM	7	23.4	74.1	1030	0.65	674
7:00 AM	8	23.3	**73.9**	**1019**	**0.65**	662
8:00 AM	9	23.4	74.1	1030	0.65	674
9:00 AM	10	23.5	74.3	1041	0.66	686
10:00 AM	11	23.6	74.5	1052	0.66	698
11:00 AM	12	23.9	75.0	1085	0.68	735
12:00 PM	13	24.4	75.9	1141	0.70	798
1:00 PM	14	24.9	76.8	1196	0.72	864
2:00 PM	15	25.4	77.7	1251	0.75	933
3:00 PM	16	26	78.8	1318	0.77	1018
4:00 PM	17	26.4	79.5	1362	0.79	1077
5:00 PM	18	26.6	**79.9**	**1384**	**0.80**	1107
6:00 PM	19	26.6	79.9	1384	0.80	1107
7:00 PM	20	26.5	79.7	1373	0.80	1092
8:00 PM	21	26.2	79.2	1340	0.78	1047
9:00 PM	22	25.8	78.4	1296	0.76	989
10:00 PM	23	25.4	77.7	1251	0.75	933
11:00 PM	24	25.1	77.2	1218	0.73	891

kwh/day		kwh/season	Electricity Cost at 0.08$/kwh $/season
20340	Total for 24 hour period	2440841.5	$195,267

Assumptions:

0. Temperature data from Ryan, assumed to represent peak design day of cooling season
1. At max river temp (79.9F), corresponding process temperature rise is 5F
2. At min river temp (73.9F), corresponding process temperature rise is 3.5F
3. Cooling Load shown at daily Max and Min river temps were calculated using Cooling Load Spreadsheet and Assumptions 1. and 2.
4. Chiller efficiencies assumed based on centrifugal chiller w/cooling tower: 0.8 kW/ton @ design peak load, and 0.65 kW/ton @ daily min load
5. For immediate simplification purposes, have assumed this daily profile for ALL 4 MONTHS OF COOLING SEASON: this is therefore an exaggerated "worst-case" scenario Monthly analysis will be performed at a later date, which will reduce chiller load profile from peak day shown above, to zero at start/end of annual cooling season.

APPENDIX C – MECHANICAL EQUIPMENT CUT SHEETS

Performance Report

Performance Specification

Project Name: **Oregon State Fish & Wildlife - Rock Creek Hatchery** | Unit Tag: **CH-2** | Qty.: **1** | Model: **YMC2-S2638BBS**

Full Load - Design

Unit	
Model No.	YMC2-S2638BBS
Number of Compressors	1
Compressor Type	Centrifugal
Number of Compressor Circuits	1
Refrigerant	R-513A
Compressor	M6C_295FAC_
Variable Orifice	V3
Performance Data	
Specified Net Capacity [tons.R]	750.0
Rated Net Capacity [tons.R]	750.0
Full Load Efficiency [kW/tons.R]	0.4396
Part Load Efficiency (NPLV.IP) [kW/tons.R]	0.2077
Heat Rejection Capacity [MBtu/h]	10.15
A-Weighted Sound Pressure Level [dB(A)]	77.0
Electrical Data	
Power Supply [V/ph/Hz]	460/3/60.0
Total Input Power [kW]	329.7
Min. Circuit Ampacity [A]	542.0
Max. Circuit Breaker Amps [A]	800.0
Job FLA [A]	433.0
Unit Short Circuit Withstand (STD) [kA]	100
Performance Impacting Options	
Starter Type	Variable Speed Drive W/ Circuit Breaker
Starter Model	HYP0730XHC30*-**C
Isolation Valves	Yes
OptiSound Control	Yes

Weight & Dimensional Data	
Shipping Weight [lbs]	17031
Operating Weight [lbs]	19429
Refrigerant Charge [lbs]	1200
Length [in]	178.9
Width [in]	77.4
Height [in]	101.3

Heat Exchanger Performance

Evaporator		Condenser	
Model*	EC3312-657-3S	Model*	CB2912-497-3S
Fluid Type*	Water	Fluid Type*	Water
Tube MTI No.	657	Tube MTI No.	497 / 492
Passes*	2	Passes*	2
Fouling Factor* [h ft2 F/Btu]	0.000100	Fouling Factor* [h ft2 F/Btu]	0.000250
Entering Fluid Temperature* [ºF]	68.20	Entering Fluid Temperature* [ºF]	80.00
Leaving Fluid Temperature* [ºF]	58.00	Leaving Fluid Temperature* [ºF]	90.00
Flow Rate [USGPM]	1765	Flow Rate [USGPM]	2040
Pressure Drop [ft H2O]	18.1	Pressure Drop [ft H2O]	16.8

* Designates user specified input

YORK

Performance Report

Performance Specification

Project Name: **Oregon State Fish & Wildlife - Rock Creek Hatchery** | Unit Tag: **CH-2** | Qty.: **1** | Model: **YMC2-S2638BBS**

Certified in accordance with the AHRI Water-Cooled Water Chilling and Heat Pump Water-Heating Packages Certification Program, which is based on AHRI Standard 550/590 (I-P) and AHRI Standard 551/591 (SI). Certified units may be found in the AHRI Directory at www.ahridirectory.org. Auxiliary components included in total kW - Chiller controls.

AHRI CERTIFIED® www.ahridirectory.org Water-Cooled Water Chilling and Heat Pump Water-Heating Packages AHRI Standards 550/590 and 551/591

Part Load Performance (Based on Minimum Condenser Water Temperature)

CEFT [ºF]	Percent Load									
	100.0	90.0	80.0	70.0	60.0	50.0	40.0	30.0	20.0	10.0
80.00	0.4396	0.4101	0.3831	0.3599	0.3433	0.3353	0.3353	0.3459	0.3871	0.6630
75.00	0.3874	0.3582	0.3317	0.3079	0.2907	0.2768	0.2655	0.2666	0.2960	0.5302
70.00	0.3376	0.3097	0.2819	0.2576	0.2378	0.2216	0.2109	0.2087	0.2236	0.3218
65.00	0.2911	0.2624	0.2350	0.2136	0.1923	0.1743	0.1607	0.1527	0.1579	0.2086
60.00	0.2577	0.2232	0.1955	0.1713	0.1488	0.1290	0.1181	0.1270	0.1399	0.1935
55.00	0.2680	0.2307	0.1837	0.1412	0.1156	0.1125	0.1216	0.1431	0.2055	0.6454
50.00	0.2704	0.2328	0.1784	0.1288	0.09712	0.1018	0.1106	0.1541	0.2211	0.000
45.00	0.000	0.000	0.2068	0.1505	0.1091	0.09917	0.1051	0.1489	0.2171	0.9040
40.00	0.000	0.000	0.000	0.000	0.1425	0.09652	0.1021	0.1384	0.2123	0.6145
39.00	0.000	0.000	0.000	0.1984	0.1460	0.09634	0.1021	0.1363	0.2112	0.5768
38.00	0.000	0.000	0.000	0.2073	0.1493	0.09621	0.1020	0.1341	0.2096	0.5408
37.00	0.000	0.000	0.000	0.2162	0.1524	0.09607	0.1019	0.1318	0.2080	0.5093
36.00	0.000	0.000	0.000	0.000	0.1552	0.09600	0.1018	0.1296	0.2062	0.4806

* Values are in kW/tons.R

Sound Pressure Levels (Standard)

CEFT [ºF]	Percent Load									
	100.0	90.0	80.0	70.0	60.0	50.0	40.0	30.0	20.0	10.0
80.00	77.0	76.0	75.5	75.0	75.0	75.5	76.0	77.5	80.5	86.0
75.00	76.5	76.0	75.0	74.5	74.5	74.5	74.5	76.0	78.5	86.0
70.00	76.5	76.0	75.0	75.0	73.5	75.0	77.5	80.5	81.5	83.0
65.00	76.5	76.0	76.0	74.5	76.5	81.0	84.0	85.0	86.0	86.5
60.00	77.5	77.5	76.0	78.5	84.0	85.0	86.5	87.0	87.5	87.5
55.00	80.0	79.0	81.5	85.5	86.0	87.5	87.5	88.5	88.5	88.5
50.00	85.0	85.0	87.0	87.0	87.5	88.0	88.5	88.5	88.5	88.5
45.00	85.0	85.0	88.0	88.0	88.0	88.5	88.5	88.5	88.5	88.0
40.00	85.0	85.0	88.0	88.0	88.0	88.5	88.5	88.5	88.5	88.5
39.00	85.0	85.0	88.0	88.0	88.0	88.5	88.5	88.5	88.5	88.5
38.00	85.0	85.0	88.0	88.0	88.0	88.5	88.5	88.5	88.5	88.5
37.00	85.0	85.0	88.0	88.0	88.0	88.5	88.5	88.5	88.5	88.5
36.00	85.0	85.0	88.0	88.0	88.0	88.5	88.5	88.5	88.5	88.5

The octave and A-weighted sound pressure levels are the levels expected to be obtained if measurements are performed in accordance with AHRI Standard 575-08, Method of Measuring Machinery Sound Within Equipment Rooms. Tolerances:The sound levels of identical unit selections can vary due to manufacturing tolerances and test repeatability. Variations of +/- 3dBA on the A-weighted levels and +/- 5dB on the octave band levels are possible.

Performance Report

Performance Specification

Project Name: **Oregon State Fish & Wildlife - Rock Creek Hatchery**	Unit Tag: **CH-2**	Qty.: **1**	Model: **YMC2-S2638BBS**

Unit Configuration Details

	Evaporator	Condenser
Water Box Type	Compact	Compact
Waterside Design Working Pressure [psig]	150	150
Entering Water Nozzle @ Location	L	L
Leaving Water Nozzle @ Location	L	L
Water Box Weight [lbs]	140	424
Cover Plate Weight [lbs]	N/A	N/A
Return Head Weight [lbs]		
Water Weight [lbs]	1195	1203

Weight Breakdown Details

Operating Weight [lbs]	19429	Per Isolator	TBD	Refrigerant (R-513A) Weight [lbs]	1200
Compressor Weight [lbs]		Shipping Weight [lbs]	17031		

Warnings:

Notes:

Compliant with the requirements of the LEED Energy and Atmosphere Enhanced Refrigerant Management Credit (EAc4).

Materials and construction per mechanical specifications - Form 160.84-EG1.

Compliant with ASHRAE 90.1 - 2004,2007.

Compliant with IECC - 2012,2015,2018,2021.

N/A

The product image shown is for illustrative purposes only and is not representative of selected options.

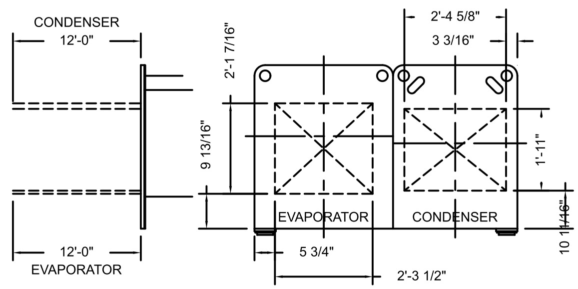
NOZZLE LEGEND

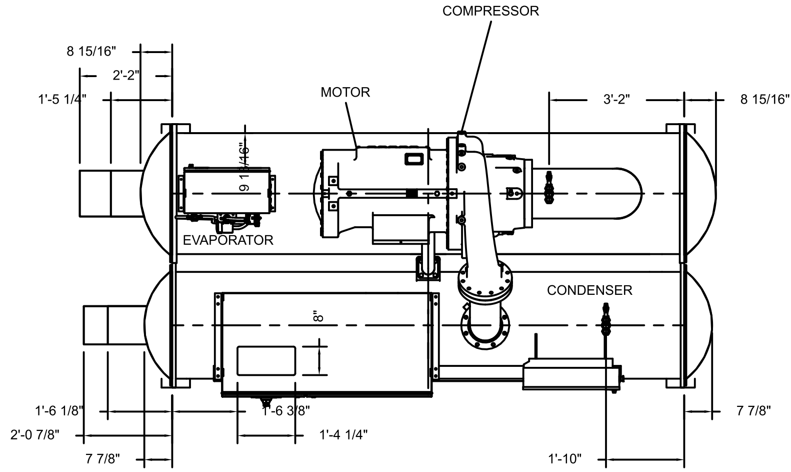
EVAPORATOR INLET	LEFT SIDE	2 PASSES	12 DIA.	(150 Psig DWP)
EVAPORATOR OUTLET	LEFT SIDE	2 PASSES	12 DIA.	(150 Psig DWP)
CONDENSER INLET	LEFT SIDE	2 PASSES	10 DIA.	(150 Psig DWP)
CONDENSER OUTLET	LEFT SIDE	2 PASSES	10 DIA.	(150 Psig DWP)

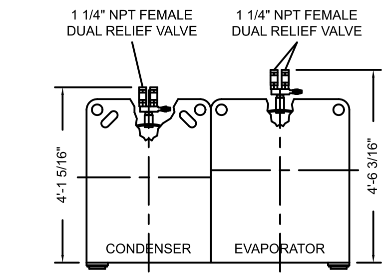
Victaulic Grooved Nozzles (per ANSI / AWWA C-606)

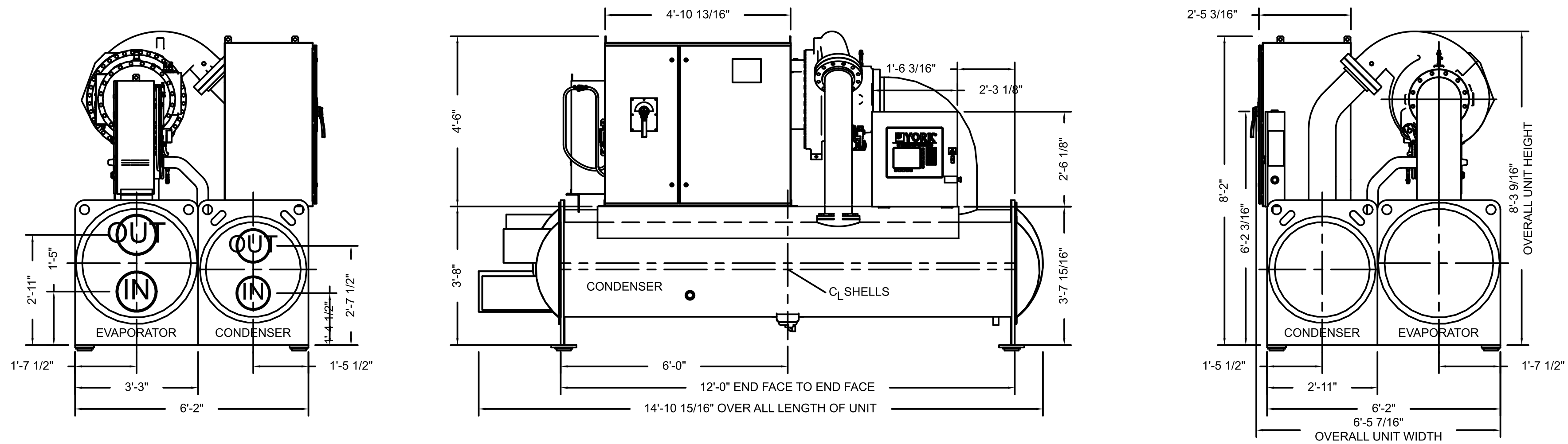
Optional water box hinges not shown.
Overall unit width and inlet nozzle length may increase up to 8".

TUBE PULL AREA DETAIL





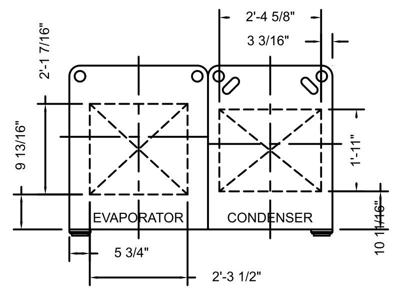


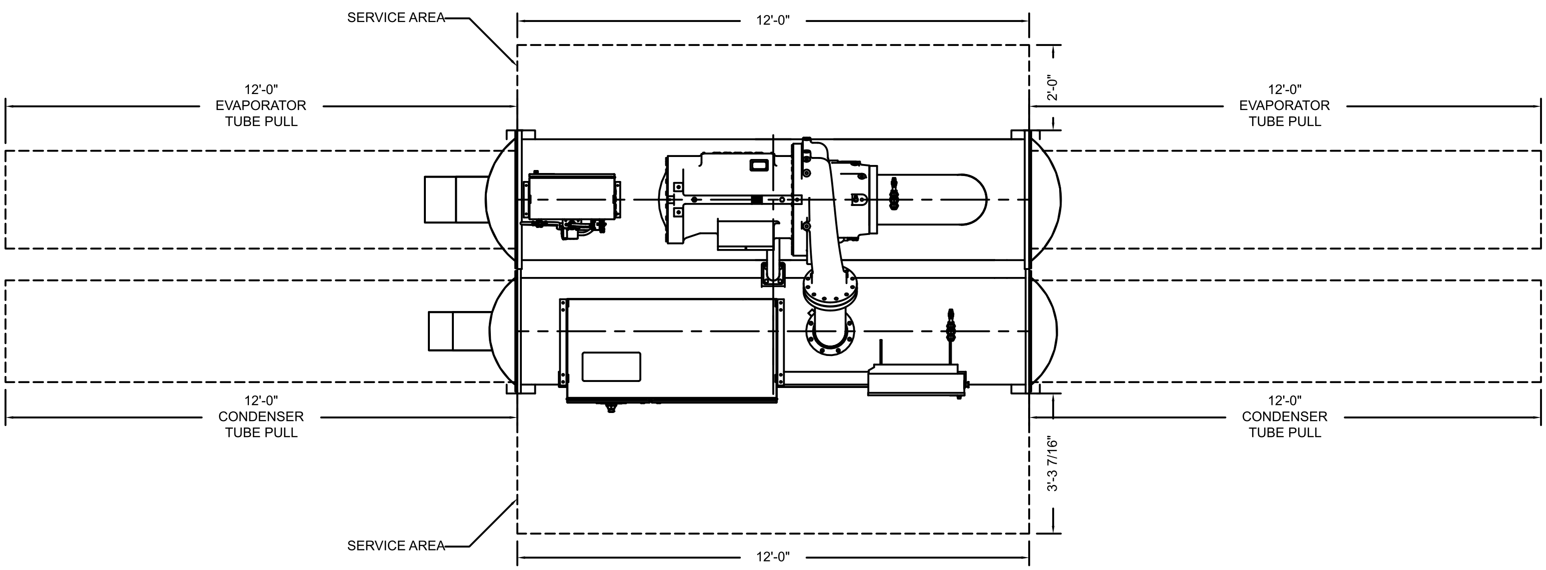


SHIPPING WT.SHIPPING WT. OF HEAVIEST COMPONENT: 17,031 LBS, OPERATING WT. 19,429 LBS, LOAD PER ISOLATOR 0 LBS
(SEE PERFORMANCE PAGE FOR ADDITIONAL SHIPPING WEIGHTS)

PRODUCT DRAWING YORK Magnetic Centrifugal Chiller MODEL: YMC2 **NOT FOR CONSTRUCTION**	COMPRESSOR: M6M6C_295FAC EVAPORATOR: EC3312-657-3S1-2GSL CONDENSER: CB2912-497-3S1-2GSL VSD: HYP0730XHC30B-46C SALES MODEL:	Oregon State Fish & Wildlife - Rock Creek Hatchery UNIT TAG: CH-2	Date: October 27, 2023 Rev. Date: October 27, 2023 Form No.: 160.78-EG1 Dwg. Lev.: 0410 Dwg. Scale: NTS	Johnson Controls

TUBE PULL AREA DETAIL





PRODUCT DRAWING YORK Magnetic Centrifugal Chiller MODEL: YMC2 **NOT FOR CONSTRUCTION**	COMPRESSOR: M6M6C_295FAC EVAPORATOR: EC3312-657-3S1-2GSL CONDENSER: CB2912-497-3S1-2GSL VSD: HYP0730XHC30B-46C SALES MODEL:	Oregon State Fish & Wildlife - Rock Creek Hatchery UNIT TAG: CH-2	Date: October 27, 2023 Rev. Date: October 27, 2023 Form No.: 160.78-EG1 Dwg. Lev.: 0410 Dwg. Scale: NTS

Submittal

Scope of Offer and Clarifications

Unit Tag	Model	GPM	Ft of Head	Qty
CWP-3A/B	14HL	2875	65	1

Scope of Supply:

- CPW-3A/B: (1) 14HL Vertical Turbine Pump Assembly
  - Driver Assembly
    - 60 HP, 1800 RPM
    - 460V/3ph
    - NEMA Premium Efficient Motor with Shaft Grounding, WP1 Enclosure Rating
    - 1.1875" Drive Coupling
    - Motor CD: 31.156"
    - Part Wind Start
    - Motor Steady Bushing
  - Discharge Head Assembly
    - 1.1875"x37.156"x416SS Head Shaft Assembly w/ Bronze Adjusting Nut and Key
    - Ductile Iron Head with 12" 125# Discharge Flange
    - Universal 304SS Shaft Guard
    - 1.1875" Cast Iron Mechanical Seal Housing with Bronze Bearing and Cartridge Seal
    - Tungsten vs. Silicon/316SS/Viton Seal Material
    - Standard Steel HF12 28" W x 28" L x 1" Thick Base Plate
  - Column Assembly
    - ~55.5" of 12" x .375" Wall Steel Water Lubricated Column
    - 1.1875" -12TPI x 120" x 416SS w/ 416SS Couplings
  - Bowl Assembly
    - Lubricated Bowl Assembly with 18-8 SS Fasteners
    - 12" Butt thread, Ductile iron bowls/ discharge case with B10 C932 Bronze Bearing
    - 201SS *Dynamically Balanced* Keyed Impellers
    - 416SS: Bowl Shaft: 8" Water Lube Projection x 1.1875" DIA – 12 TPI
    - 10" NPT, Ductile iron suction case with B10 C932 Bronze bearing
    - Threaded 10" Suction bell
    - 304SS Bolt-On basket strainer with vortex suppression
  - Total Assembly Weight = 2,704 lbs

Exclusions:

- Installation, rigging, wiring, and storage
- Seismic calculations, certifications, isolation, bases, etc
- Labor warranty

735 SW 20th Place 230, Portland, OR 97205
PHONE (971) 717-7123

JB OREGON

Submittal

Pump Dimensional Data

735 SW 20th Place 230, Portland, OR 97205
PHONE (971) 717-7123

**TPL and Total Column Lengths +/- 1.5"
All Dimensions In Inches

PROJECT SPECIFICATIONS

Date:	1/18/2022
Job:	
Config #:	C-49726-w
GPM:	2875
Head FT:	65
Pump Model:	14HL - 1 Stage
Imp. Type:	14HL ENCL. SS
Pump Materials:	Ductile Iron / 201SS
Bowl Bearings:	B10 C932 Bronze
Bowl Shaft:	2.1875" 416SS
Strainer Type:	304SS Bolt-On Basket
Column:	12" x .375" wall
Lineshaft:	1.1875" 416SS
Lineshaft Brgs:	None
Discharge Head:	HF12 Ductile Iron Head
Discharge Flange:	12" 125# Discharge Flange
Seal Type:	Hydro99 Cartridge Seal
Head Shaft:	1.1875" 416SS
Foundation Plate:	Steel

DRIVER INFORMATION

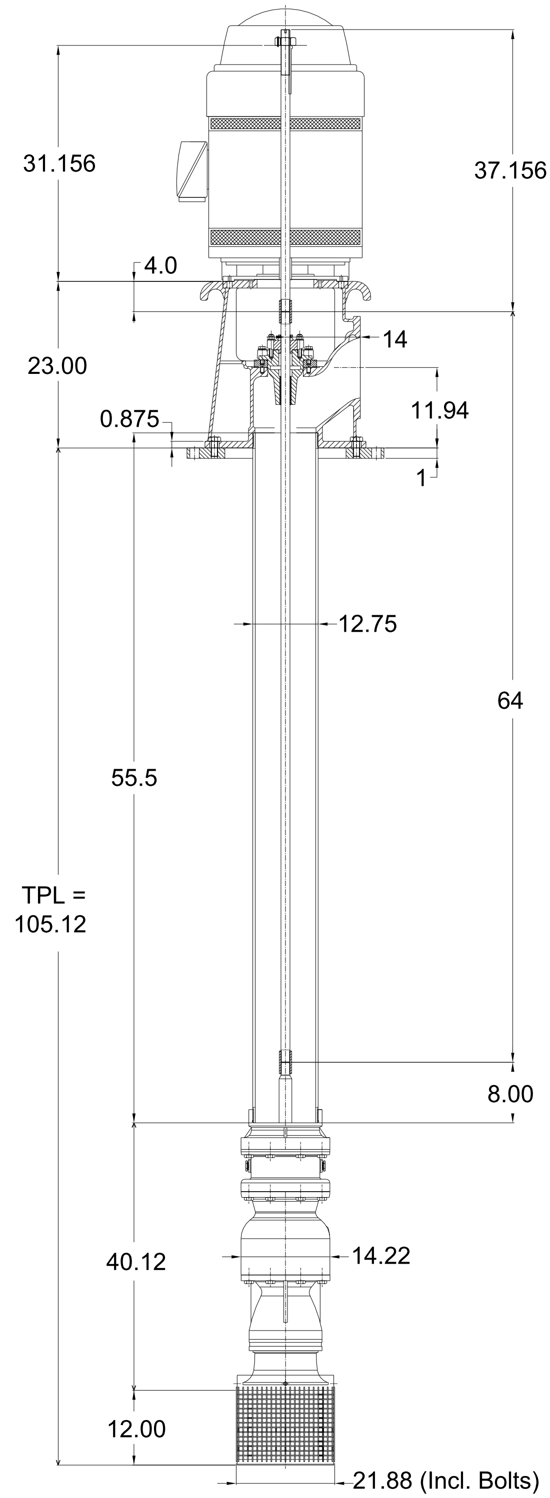
Mfr:	US
Enclosure:	VHS-WP1
HP:	60
RPM:	1800
Phase/Volt:	3/460
Frame:	364TP
Efficiency:	Premium Efficient
NRR or SRC:	NRR

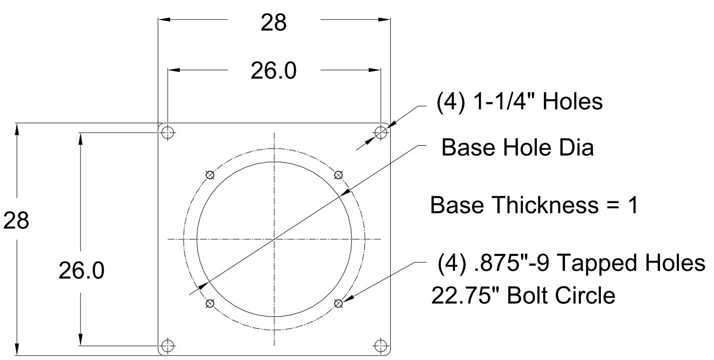
Minimum Submergence

Minimum Submergence from bottom of suction for vortex suppression: 45". *This does NOT include NPSHr needs.

Column Note

The column dimensions, on this side, do not include the bearing spiders.





FOUNDATION PLATE

Estimated Shipping Weight: 2704 Lbs.

NOT FOR CONSTRUCTION

NOTICE

REV	DATE	REVISION	CH

HydrofloPumps Fluid Solutions A Taco Group Company
HYDROFLO PUMPS USA, INC.
7118 LOBLOLLY PINE BLVD.
FAIRVIEW, TN 37062
PHONE: 615.799.9662
FAX: 615.799.5654

14HL - 1 Stage Product Lubricated Vertical Turbine Pump System

REFERENCE	HYDROFLO PUMPS INC. WORK ORDER NO.	CUSTOMER P.O. NO.	General Arrangement Design Specifications
PUMP S.N.	NO. REQD: Qty	DR BY: Config DATE: 1/18/2022	DWG. NO. / SHT. / REV.
MATERIAL: NOTED		CK BY: DATE:	

PAGE 2 DRAWING

Bill Of Materials

ALL DIMENSIONS IN INCHES

ItemNo.	Qty.	Description	Material Grade
1	1	Bowl Shaft	416 Stainless Steel
4	1	Threaded Connector - Discharge	A-536 GR. 65-45-12
5	1	Bearing - Oil Tube Adapter (Half Bearing)	BRZ C932
7	12	Bolt - Threaded Connector	18-8 Stainless Steel
9	2	Pipe Plug - Discharge	A-197 Black Iron
10	1	Bearing - Discharge Case	C93200 Bronze
12	1	Discharge Case	A-536 GR. 65-45-12
14	8	Bolt - Discharge Case	18-8 Stainless Steel
16	1	Bowl	A-536 GR. 65-45-12
18	1	Bearing - Bowl	C93200 Bronze
20	1	Impeller	201 Stainless Steel
24	8	Bolt - Suction	18-8 Stainless Steel
25	1	Suction - Threaded	A-536 GR. 65-45-12
27	1	Sand Collar	201 Stainless Steel
28	1	Bearing - Suction	C93200 Bronze
29	1	Pipe Plug - Suction	A-197 Black Iron
30	1	Threaded Suction Bell	A-48 Class 30B F12101
31	1	Strainer - Bolt-On Basket	304 Stainless Steel

ZOOM FOR DETAIL

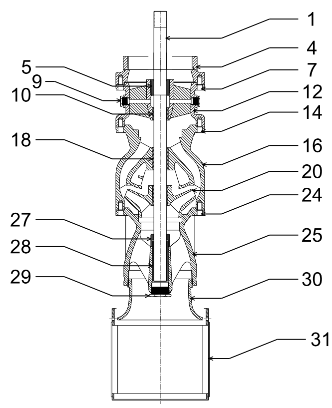
NOT TO SCALE

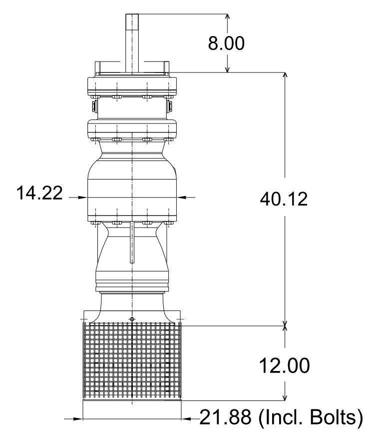
PROJECT SPECIFICATIONS

Date:	1/18/2022
Job:	
Config #:	C-49726-w
GPM:	2875
Head FT:	65
Pump Model:	14HL - 1 Stage
Imp. Type:	14HL ENCL. SS
Pump Materials:	Ductile Iron / 201SS
Bowl Shaft Dia:	2.1875

DRIVER INFORMATION

Mfr:	US
Enclosure:	VHS-WP1
HP:	60
RPM:	1800
Phase/Volt:	3/460
Frame:	364TP
Efficiency:	Premium Efficient
NRR or SRC:	NRR





Estimated Bowl Assy
Weight: 549 Lbs.

NOT FOR CONSTRUCTION

NOTICE

REV	DATE	REVISION	CH

HydrofloPumps Fluid Solutions A Taco Group Company

HYDROFLO PUMPS USA, INC.
7118 LOBLOLLY PINE BLVD.
FAIRVIEW, TN 37062
PHONE: 615.799.9662
FAX: 615.799.5654

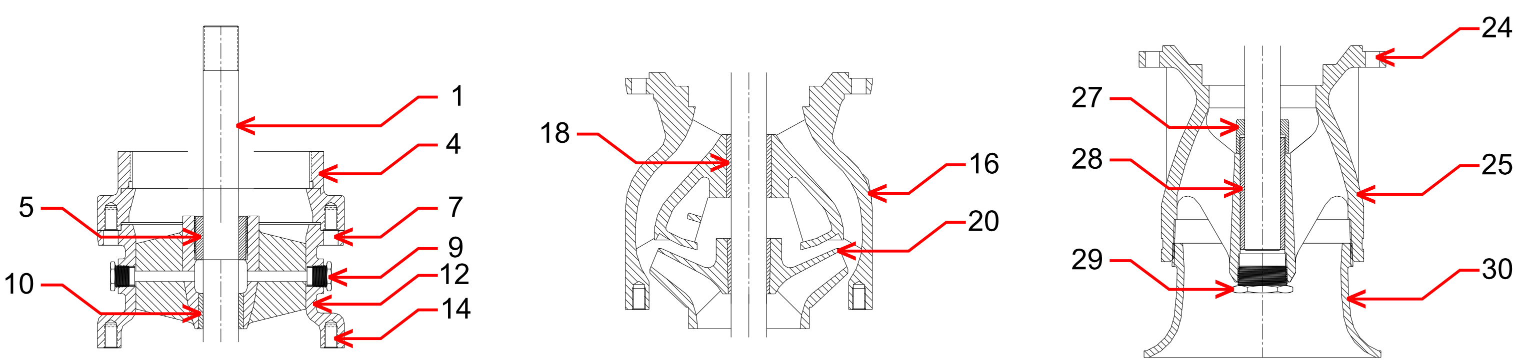
14HL - 1 Stage Water Lube
Vertical Turbine Pump System

REFERENCE	HYDROFLO PUMPS INC. WORK ORDER NO.	CUSTOMER P.O. NO.	General Arrangement Design Specifications
PUMP S.N.	NO. REQD: Qty	DR BY: Config DATE: 1/18/2022	DWG. NO. / SHT. / REV.
MATERIAL: NOTED		CK BY: DATE:	

PAGE 3 DRAWING

Bill Of Materials

ItemNo.	Qty.	Description	Material Grade
1	1	Bowl Shaft	416 Stainless Steel
4	1	Threaded Connector - Discharge	A-536 GR. 65-45-12
5	1	Bearing - Oil Tube Adapter (Half Bearing)	BRZ C932
7	12	Bolt - Threaded Connector	18-8 Stainless Steel
9	2	Pipe Plug - Discharge	A-197 Black Iron
10	1	Bearing - Discharge Case	C93200 Bronze
12	1	Discharge Case	A-536 GR. 65-45-12
14	8	Bolt - Discharge Case	18-8 Stainless Steel
16	1	Bowl	A-536 GR. 65-45-12
18	1	Bearing - Bowl	C93200 Bronze
20	1	Impeller	201 Stainless Steel
24	8	Bolt - Suction	18-8 Stainless Steel
25	1	Suction - Threaded	A-536 GR. 65-45-12
27	1	Sand Collar	201 Stainless Steel
28	1	Bearing - Suction	C93200 Bronze
29	1	Pipe Plug - Suction	A-197 Black Iron
30	1	Threaded Suction Bell	A-48 Class 30B F12101
31	1	Strainer - Bolt-On Basket	304 Stainless Steel



Pump Model: 14HL - 1 Stage

NOT FOR CONSTRUCTION

Config #: C-49726-w

REV	DATE	REVISION	CH

HydrofloPumps Fluid Solutions™ A Taco Group Company

HYDROFLO PUMPS USA, INC.
7118 LOBLOLLY PINE BLVD.
FAIRVIEW, TN 37062
PHONE: 615.799.9662
FAX: 615.799.5654

14HL - 1 Stage Water Lube Vertical Turbine Pump System

REFERENCE	HYDROFLO PUMPS INC. WORK ORDER NO.	CUSTOMER P.O. NO.	General Arrangement Design Specifications
PUMP S.N.	NO. REQD: Qty	DR BY: Config DATE: 1/18/2022	DWG. NO. / SHT. / REV.
MATERIAL: NOTED		CK BY: DATE:	

Submittal

Pump Performance

735 SW 20th Place 230, Portland, OR 97205
PHONE (971) 717-7123

Pump Data Sheet - Hydroflo Pumps USA, Inc.

Company:
Name:
Date: 01/18/2022

HydrofloPumps Fluid Solutions™ A Taco Group Company

Pump:

Size:	14HL (stages: 1)	Dimensions:	
Type:	Vertical	Suction:	10 in
Synch Speed:	1800 rpm	Discharge:	12 in
Dia:	8.97 in	Vertical Turbine:	
Curve:	122211	Eye Area:	
Impeller:	14HL ENCL. SS	Bowl Size:	14 in
		Max Lateral:	1 in
		Thrust K Factor:	17 lb/ft

Fluid:

Name:	Water		
SG:	1	Vapor Pressure:	0.256 psi a
Density:	62.4 lb/ft³	Atm Pressure:	14.7 psi a
Viscosity:	1.1 cP		
Temperature:	60 °F	Margin Ratio:	1

Search Criteria:

Flow:	2875 US gpm	Near Miss:	---
Head:	65 ft	Static Head:	0 ft

Pump Limits:

Temperature:	140 °F	Sphere Size:	1.5 in
Wkg Pressure:	330 psi g	Power:	600 hp

Motor:

Standard:	NEMA	Size:	60 hp
Enclosure:	WP1	Speed:	1800 rpm
Frame:	364T		
Sizing Criteria:	Max Power on Design Curve		

Non-overloading for entire pump curve

Pump Selection Warnings:

None

Max impeller duty point

--- Duty Point ---

Flow:	2875 US gpm
Head:	65.1 ft
Eff:	79.1%
Power:	59.8 hp
NPSHr:	21.8 ft
Speed:	1770 rpm

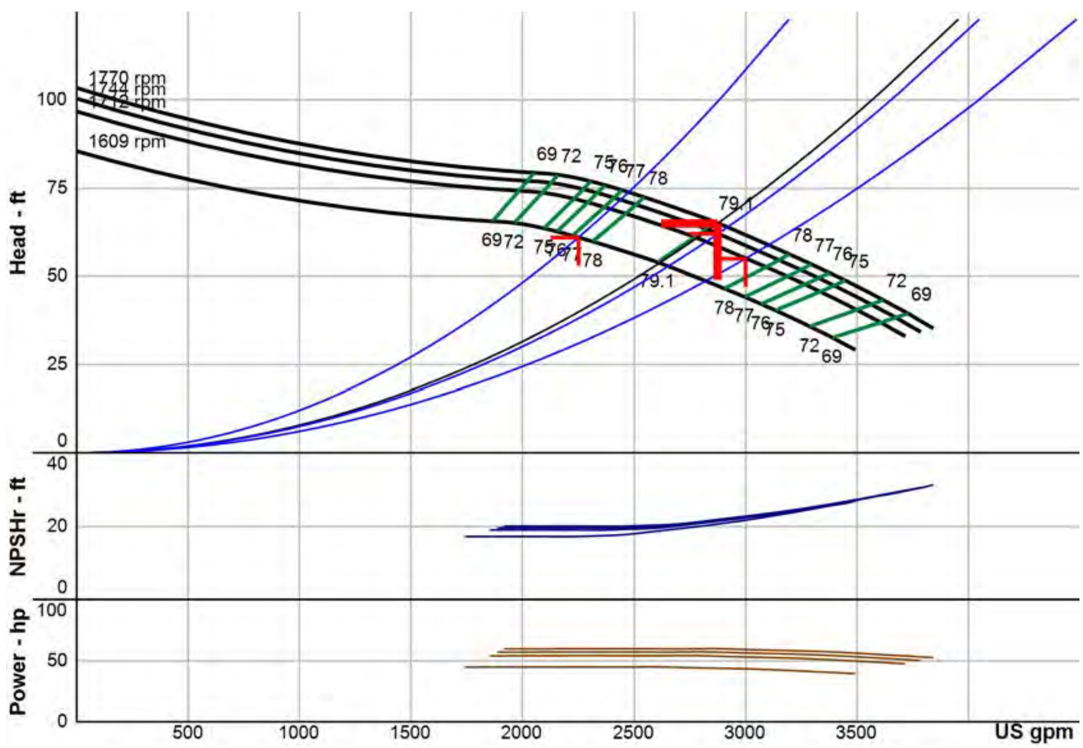
--- Design Curve ---

Shutoff Head:	103 ft
Shutoff dP:	44.8 psi
Min Flow:	573 US gpm

BEP: 79.1% @ 2866 US gpm
NOL Power:
59.8 hp @ 2866 US gpm

--- Max Curve ---

Max Power:
82.4 hp @ 3159 US gpm

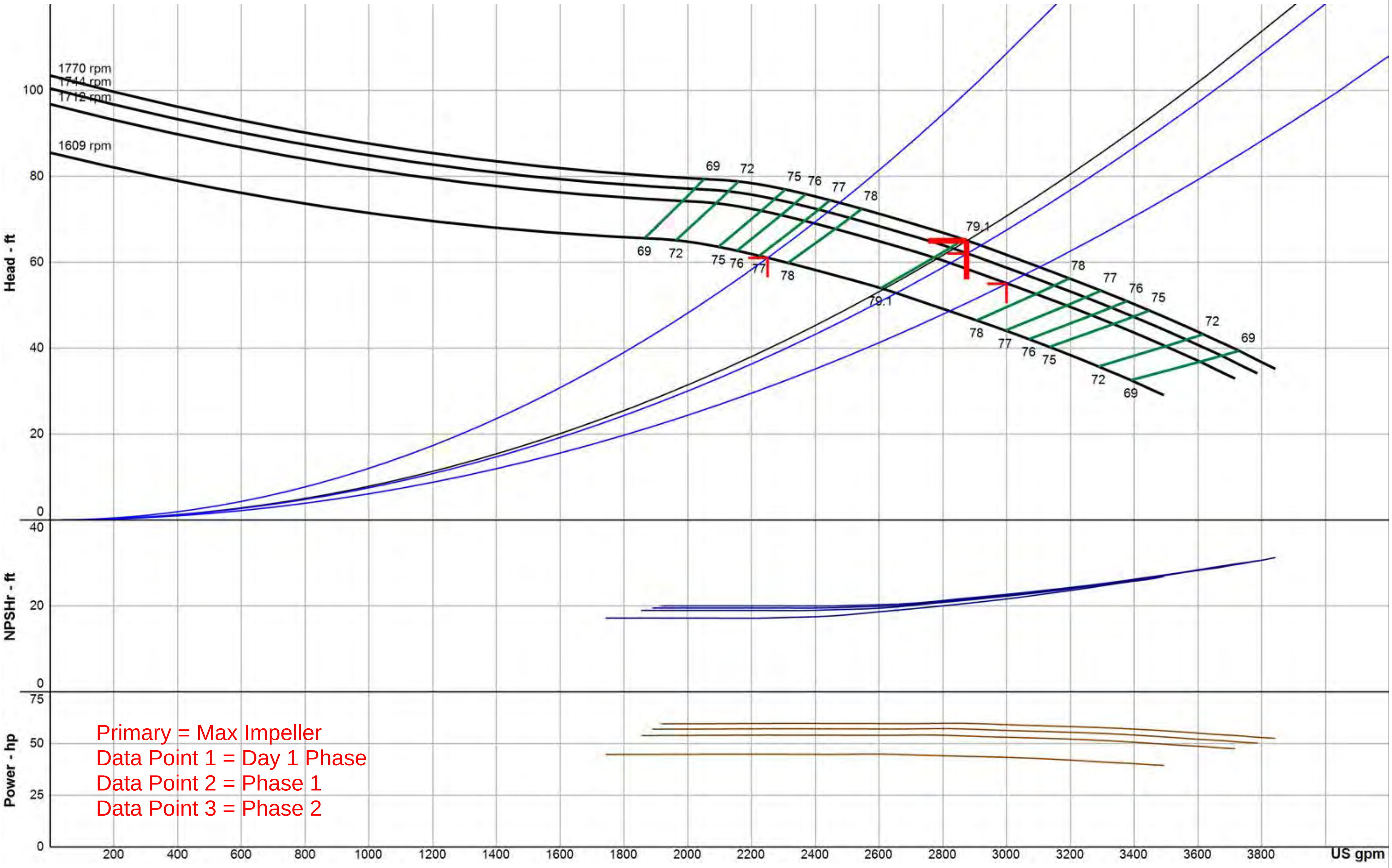


Operating Points:

Data Point	Speed	Flow	Head	NPSHr	Efficiency	Power	Min Flow
	rpm	US gpm	ft	ft	%	hp	US gpm
Primary	1770	2875	65.1	21.8	79.1	59.8	573
1	1609	2250	61	17.2	77.3	44.9	521
2	1712	3000	55.1	22.3	78.6	53.1	554
3	1744	2875	62.1	21.6	79	57	565

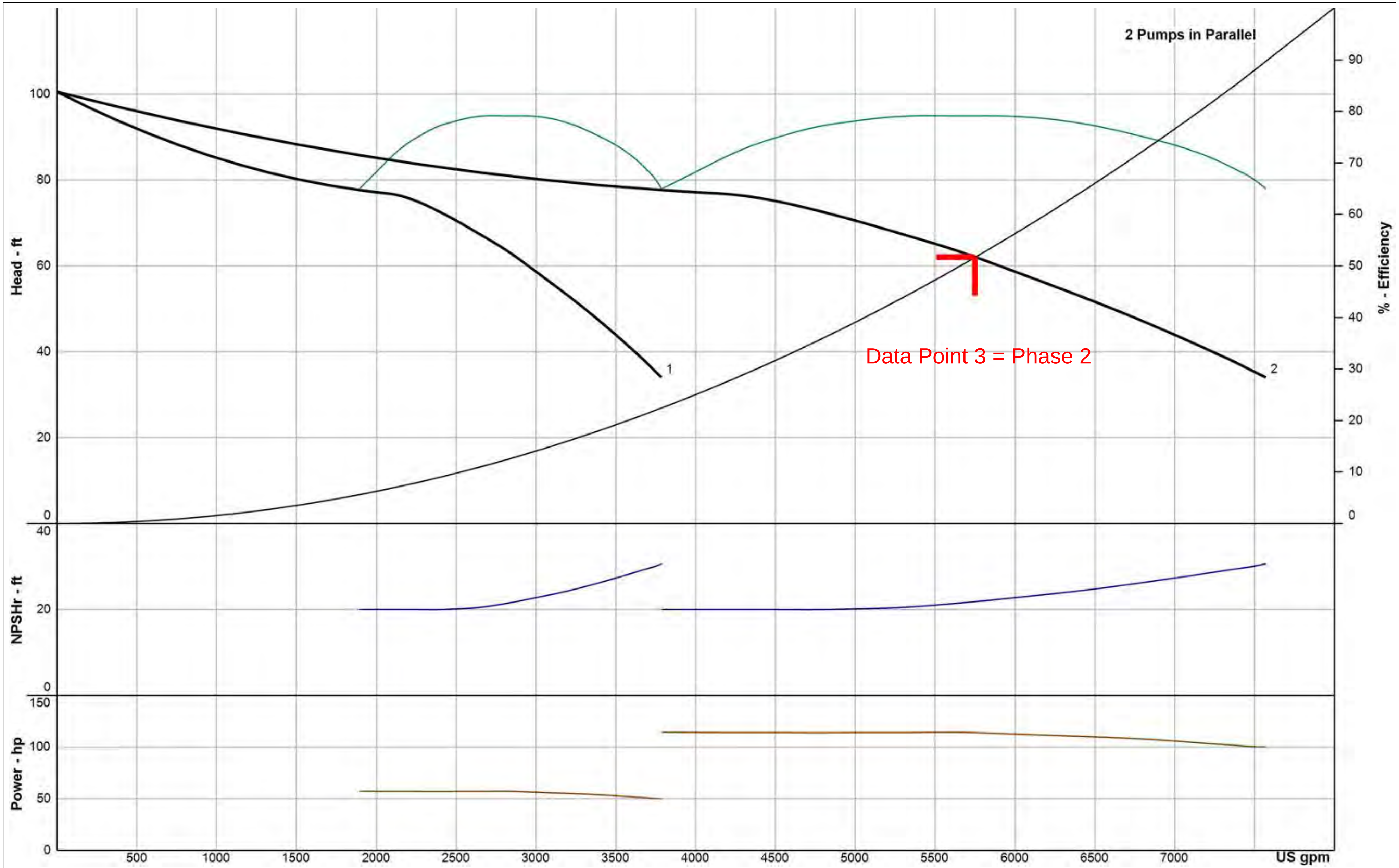
Primary = Max Impeller
Data Point 1 = Day 1 Phase
Data Point 2 = Phase 1
Data Point 3 = Phase 2

Selected from catalog: Hydroflo VS Pumps.60, Vers 18.3



Company:	Hydroflo Pumps USA, Inc.	Size:	14HL (stages: 1)
Name:	Catalog: Hydroflo VS Pumps.60, Vers 18.3	Speed:	1770 rpm
Date: 01/18/2022	Vertical - 1800 rpm	Dia:	8.97 in
	Design Point: 2875 US gpm, 65 ft	Curve:	122211
	Static Head: 0 ft	Impeller:	14HL ENCL. SS

HydrofloPumps Fluid Solutions
A Taco Group Company



Company:
Name:
Date: 01/18/2022

Hydroflo Pumps USA, Inc.
Catalog: Hydroflo VS Pumps.60, Vers 18.3
Vertical - 1800 rpm
Design Point: 5750 GPM @ 62ft
Static Head: 0 ft

Size: 14HL (stages: 1)
Speed: 1744 RPM
Dia: 8.97"
Curve: 122211
Impeller: 14HL ENCL. SS

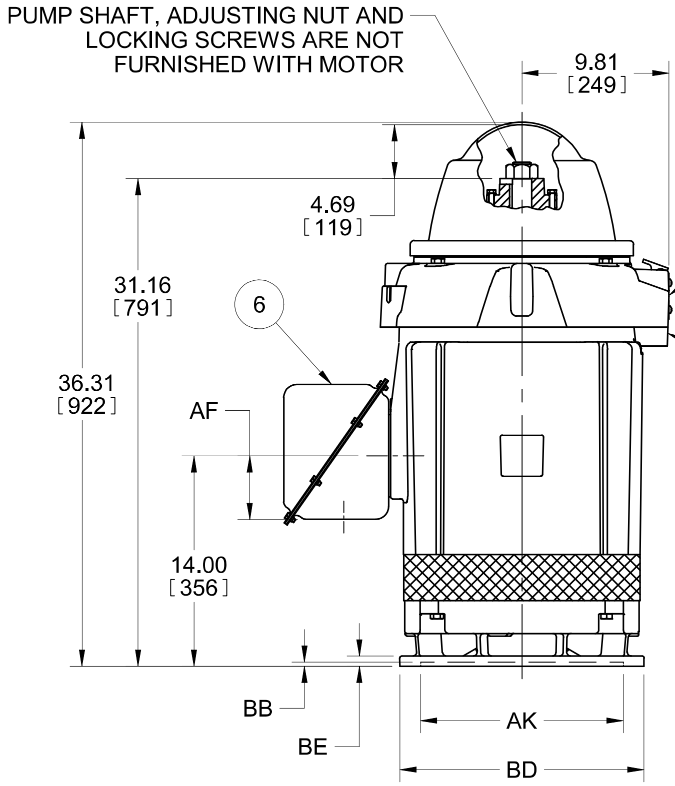
HydrofloPumps Fluid Solutions A Taco Group Company

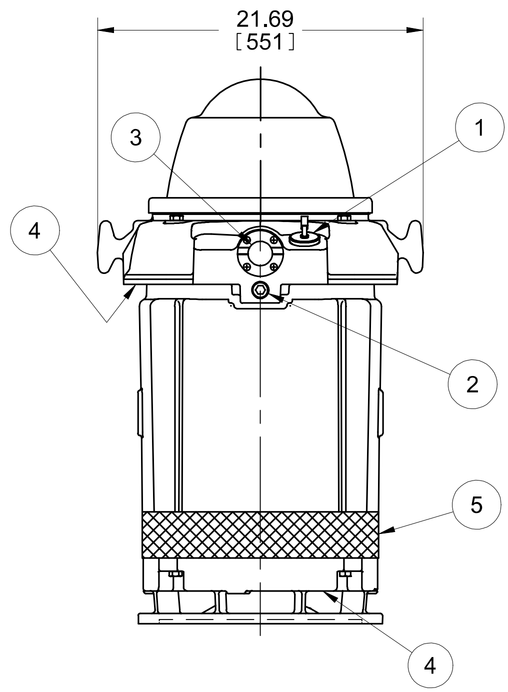
Submittal

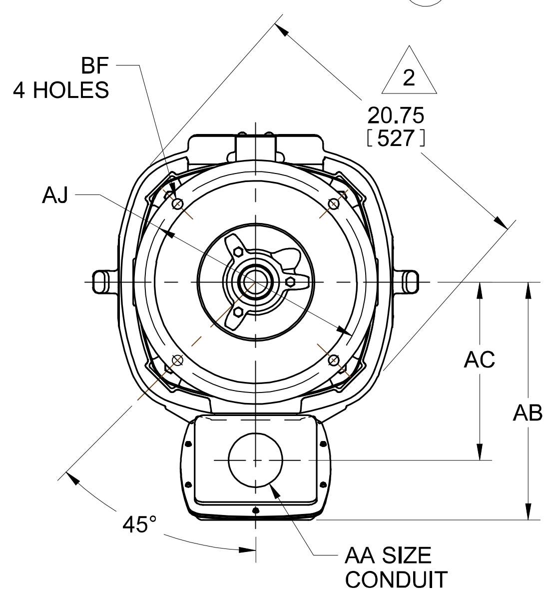
Motor Dimensional Data and Performance

735 SW 20th Place 230, Portland, OR 97205
PHONE (971) 717-7123

EFFECTIVE: **04-SEP-20**	**DIMENSION PRINT**	PRINT: **09-3421**
SUPERSEDES: **06-NOV-19**	**WEATHER PROTECTED TYPE I** **FRAME: 360TP, TPA** **BASIC TYPE: RU**	SHEET: **1 OF 1**







ALL DIMENSIONS ARE IN INCHES AND MILLIMETERS
(TOLERANCES ARE IN INCHES)

UNITS	C/BOX VOLUME (CU. IN.)	AA	AB	AC	AF
IN	470	3.00	15.88	11.88	4.25
MM			403	302	108

FRAME	UNITS	AJ	AK +.005	BB MIN	BD MAX	BE	BF
364, 365TP	IN	14.750	13.500	.25	16.50	.69	.688
	MM	374.65	342.9	6	419	18	17.48
364, 365TPA	IN	9.125	8.250	.19	12.00	.69	.438
	MM	231.78	209.55	5	305	18	11.13

1. CONDUIT OPENING MAY BE LOACTED IN STEPS OF 90 DEGREES. STANDARD AS SHOWN WITH CONDUIT OPENING DOWN.

2 LARGEST MOTOR WIDTH.

FEATURE LISTING

1	UPPER SUMP OIL FILL	6	MAIN CONDUIT BOX		
2	UPPER SUMP OIL DRAIN				
3	UPPER SUMP SIGHT WINDOW				
4	AIR INTAKE				
5	AIR EXHAUST, 360° AROUND				

TOLERANCES	8.250 AK	13.500 AK
FACE RUNOUT	.004 TIR	.007 TIR
PERMISSIBLE ECCENTRICITY OF MOUNTING RABBET	.004 TIR	.007 TIR
TOLERANCE ON AK DIMENSION	+.003	+.005
NON-MACHINED DIMENSIONS MAY VARY BY ±.25		

09-3421/A

Nidec Motor Corporation
St. Louis, Missouri

ISSUED BY
I. GONZALEZ
APPROVED BY
M. RAMIREZ

IHP_DP_NMCA (MAR-2011) SOLIDEDGE

NAMEPLATE DATA

CATALOG NUMBER:	HO60V2SLG			NAMEPLATE PART #:	422707-005		
MODEL	HF72	FR	364TP	TYPE	RUSI	ENCL	WPI
SHAFT END BRG	6211-J - QTY 1			OPP END BRG	7220 BEP - QTY 1		
PH	3	MAX AMB	40 C	ID#			
INSUL CLASS	F	Asm. Pos.		DUTY	CONT		

HP	60		RPM	1785		HP			RPM		
VOLTS	460					VOLTS					
FL AMPS	68.0					FL AMPS					
SF AMPS	79.0					SF AMPS					
SF	1.15	DESIGN	B	CODE	G	SF		DESIGN		CODE	
NEMA NOM EFFICIENCY	95.0	NOM PF	86.9	KiloWatt	44.76	NEMA NOM EFFICIENCY		NOM PF			
GUARANTEED EFFICIENCY	94.1	MAX KVAR		HZ	60	GUARANTEED EFFICIENCY		MAX KVAR		HZ	

HAZARDOUS LOCATION DATA (IF APPLICABLE):

DIVISION		CLASS I		GROUP I	
TEMP CODE		CLASS II		GROUP II	

NEMA Premium

VFD DATA (IF APPLICABLE):

VOLTS	460	AMPS	71.4
TORQUE 1	176.70LB-FT	TORQUE 2	
VFD LOAD TYPE 1	VT/PWM	VFD LOAD TYPE 2	
VFD HERTZ RANGE 1	6-60	VFD HERTZ RANGE 2	
VFD SPEED RANGE 1	180-1800	VFD SPEED RANGE 2	
SERVICE FACTOR	1.00	FL SLIP	
NO. POLES		MAGNETIZING AMPS	
VECTOR MAX RPM		Encoder PPR	
Radians / Seconds		Encoder Volts	

TEAO DATA (IF APPLICABLE):

HP (AIR OVER)		HP (AIR OVER M/S)		RPM (AIR OVER)		RPM (AIR OVER M/S)	
FPM AIR VELOCITY		FPM AIR VELOCITY M/S		FPM AIR VELOCITY SEC			

ADDITIONAL NAMEPLATE DATA:

Decal / Plate	WD=165975,CP=132839	Customer PN	
Notes		Non Rev Ratchet	NRR
Max Temp Rise	80C RISE/RES@1.00SF	OPP/Upper Oil Cap	3 QT/2.8 L
Thermal (WDG)	OVER TEMP PROT 2	SHAFT/Lower Oil Cap	GREASE
Altitude		Usable At	
Regulatory Notes		Regulatory Compliance	
COS		Marine Duty	
Balance	0.08 IN/SEC	Arctic Duty	
3/4 Load Eff.	95.2	Inrush Limit	
Motor Weight (LBS)	730	Direction of Rotation	
Sound Level		Special Note 1	
Vertical Thrust (LBS)	5700	Special Note 2	
Thrust Percentage	100% HT	Special Note 3	
Bearing Life		Special Note 4	
Starting Method		Special Note 5	
Number of Starts		Special Note 6	
200/208V 60Hz Max Amps		SH Max. Temp.	
190V 50 hz Max Amps		SH Voltage	SH VOLTS=115V
380V 50 Hz Max Amps		SH Watts	SH WATTS= 96W
NEMA Inertia		Load Inertia	
Sumpheater Voltage		Sumpheater Wattage	
Special Accessory Note 1		Special Accessory Note 16	
Special Accessory Note 2		Special Accessory Note 17	
Special Accessory Note 3		Special Accessory Note 18	
Special Accessory Note 4		Special Accessory Note 19	
Special Accessory Note 5		Special Accessory Note 20	
Special Accessory Note 6		Special Accessory Note 21	
Special Accessory Note 7		Special Accessory Note 22	
Special Accessory Note 8		Special Accessory Note 23	
Special Accessory Note 9		Special Accessory Note 24	
Special Accessory Note 10		Special Accessory Note 25	
Special Accessory Note 11		Special Accessory Note 26	
Special Accessory Note 12		Special Accessory Note 27	
Special Accessory Note 13		Special Accessory Note 28	
Special Accessory Note 14		Special Accessory Note 29	
Special Accessory Note 15		Special Accessory Note 30	
Heater in C/B Voltage		Heater in C/B Watts	
Zone 2 Group		Division 2 Service Factor	
Note 1		Note 2	
Note 3		Note 4	
Note 5		Note 6	
Note 7		Note 8	
Note 9		Note 10	
Note 11		Note 12	
Note 13		Note 14	
Note 15		Note 16	
Note 17		Note 18	
Note 19		Note 20	
Note 21		Note 22	

NIDEC MOTOR CORPORATION
ST. LOUIS, MO

TYPICAL NAMEPLATE DATA
ACTUAL MOTOR NAMEPLATE LAYOUT MAY VARY
SOME FIELDS MAY BE OMITTED

NIDEC MOTOR CORPORATION
8050 WEST FLORISSANT AVE.
ST. LOUIS, MO 63136

DATE: 11/2/2021

P.O. NO.: HF72
Order/Line NO.: 26910 MN 100

TO:

Model Number: HF72
Catalog Number: HO60V2SLG

REVISIONS:
(NONE)

ALL DOCUMENTS HEREIN ARE CONSIDERED CERTIFIED BY NIDEC MOTOR CORPORATION.
THANK YOU FOR YOUR ORDER AND THE OPPORTUNITY TO SERVE YOU.

Features:

```
Horsepower ............. 00060.00~00000.00 ~ KW: 44.76
Enclosure .............. WPI
Poles .................. 04~00 ~ RPM: 1800~0
Frame Size ............. 364~TP
Phase/Frequency/Voltage.. 3~060~460
Winding Type ........... Random Wound
Service Factor ......... 1.15
Insulation Class ........ Class "F" ~ Insulife 2000
Altitude In Feet (Max) .. 3300 Ft.(1000 M) ~ +40 C
Efficiency Class ........ Premium Efficiency
Application ............ Vertical Centrifugal Pump
Inverter Duty NEMA MG1 Part 31
Customer Part Number ....
16.5" Base ~ Coupling Size: 1-1/4" Bore, 1/4" Key
Non-Reverse Ratchet ~ Steady Bushing Not Requested
Pricebook Thrust Value (lbs).. 5700
Customer Down Thrust (lbs) ... 5700
Customer Shutoff Thrust (lbs).
Up Thrust (lbs): ~
Inverter Duty Rating Details:
Load Type (Base Hz & Below) .. Variable Torque
Speed Range (Base Hz & Below). 10:1
VFD Service Factor 1.00
Temperature Rise (Sine Wave): "B" Rise @ 1.0 SF (Resist)
Design Letter .......... B
Starting Method ......... PWS (Dual Volt-Low Volt Only)
Duty Cycle ............. Continuous Duty
Load Inertia: NEMA ~ Standard Inertia: 275.00 LB-FT2
Number Of Starts Per Hour: NEMA
Motor Type Code ........... RUSI
Rotor Inertia (LB-FT²)          10.3 LB-FT²
Qty. of Bearings PE (Shaft)     1
Qty. of Bearings SE (OPP)       1
Bearing Number PE (Shaft)       6211-J
Bearing Number SE (OPP)         7220 BEP
```

NIDEC MOTOR CORPORATION
8050 WEST FLORISSANT AVE.
ST. LOUIS, MO 63136

DATE: 11/2/2021

P.O. NO.: HF72
Order/Line NO.: 26910 MN 100

TO:

Model Number: HF72
Catalog Number: HO60V2SLG

REVISIONS:
(NONE)

ALL DOCUMENTS HEREIN ARE CONSIDERED CERTIFIED BY NIDEC MOTOR CORPORATION.
THANK YOU FOR YOUR ORDER AND THE OPPORTUNITY TO SERVE YOU.

Accessories:
Counter CW Rotation FODE
Aegis Ground Ring (SGR)
115 Volt Space Heaters
Special Balance
Thermostats - Normally Closed
Shipping Weight in lbs: 730
Shipping Mass in KG: 330
Standard Leadtime: NA
Est. Weight (lbs ea): 730 ~ F.O.B.:

USE THE DATA PROVIDED BELOW TO SELECT THE APPROPRIATE DIMENSION PRINT

Horsepower	60
Pole(s)	04
Voltage(s)	460
Frame Size	364TP
Outlet Box AF	4.25
Outlet Box AA	3.00

MOTOR PERFORMANCE

MODEL NO.	CATALOG NO.	PHASE	TYPE	FRAME
HF72	HO60V2SLG	3	RUSI	364TP

ORDER NO.	26910	LINE NO.	

MPI:	287854
HP:	60
POLES:	4
VOLTS:	460
HZ:	60
SERVICE FACTOR:	1.15
EFFICIENCY (%):	
S.F.	94.5
FULL	94.5
3/4	95.2
1/2	94.7
1/4	91.9
POWER FACTOR (%):	
S.F.	87
FULL	86.9
3/4	85.3
1/2	79.7
1/4	62
NO LOAD	5.8
LOCKED ROTOR	37.7
AMPS:	
S.F.	79
FULL	68
3/4	52
1/2	37
1/4	24.6
NO LOAD	18.3
LOCKED ROTOR	459.4
NEMA CODE LETTER	G
NEMA DESIGN LETTER	B
FULL LOAD RPM	1785
NEMA NOMINAL / EFFICIENCY (%)	95
GUARANTEED EFFICIENCY (%)	94.1
MAX KVAR	12.4
AMBIENT (°C)	40
ALTITUDE (FASL)	3300
SAFE STALL TIME-HOT (SEC)	27
SOUND PRESSURE (DBA @ 1M)	65
TORQUES:	
BREAKDOWN{% F.L.}	250
LOCKED ROTOR{% F.L.}	227
FULL LOAD{LB-FT}	176.7

NEMA Nominal and Guaranteed Efficiencies are up to 3,300 feet above sea level and 25 ° C ambient

The Above Data Is Typical, Sinewave Power Unless Noted Otherwise

NIDEC MOTOR CORPORATION
ST. LOUIS, MO

Submittal

Warranty

735 SW 20th Place 230, Portland, OR 97205
PHONE (971) 717-7123

Warranty

Warranty and Limitation of Remedies - Each product manufactured by Hydroflo Pumps USA, Inc. is warranted to be free of defects in material and workmanship for one (1) year after the product is first put into operation or eighteen (18) months after the date of shipment, whichever is less, when the product is in the hands of the original owner and the product has been used properly for the purpose which sold; and provided that Seller shall be notified within thirty (30) days from the earliest date on which an alleged defect could have been discovered, and further that the defective good(s) or part(s) shall be returned to the Seller, freight prepaid by such user, at Seller's request. No material will be accepted at Seller's plant without a Return Material Authorization (RMA) number first obtained from Seller. All material returned must be clearly marked with such RMA number. Unless expressly stated otherwise, warranties in the nature of performance specifications furnished in addition to the foregoing on a product manufactured by Hydroflo Pumps USA, Inc., if any, are based on laboratory test corrected for field performance. Due to inaccuracies of field-testing, if any conflict arises between the results of field testing conducted by or for the user, and laboratory tests corrected for field performance, the latter shall control. No equipment shall be furnished on the basis of acceptance by results of field testing. Upon receipt of definite shipping instructions from Seller, Buyer shall return all defective goods to Seller after inspection by Seller. The goods returned must be returned in the same conditions as when received by the Buyer. Defective goods so returned shall be replaced or repaired by the Seller without an additional charge or, in lieu of such replacement or repair, Seller may, at its option, refund the purchase price applicable to such defective goods. Seller agrees to pay return transportation charges not exceeding those which would apply from original destination on all defective goods. However, Seller shall not be liable for such charges when the goods are not defective and Buyer shall be liable for such charges. SELLER'S LIABILITY SHALL BE LIMITED SOLELY TO REPLACEMENT OR REPAIR, OR AT SELLER'S OPTION, TO REFUNDING THE PURCHASE PRICE APPLICABLE TO DEFECTIVE GOODS OR SERVICES. SELLER SHALL IN NO EVENT BE LIABLE FOR ANY CONSEQUENTIAL OR INCIDENTAL DAMAGES. THIS WARRANTY IS IN LIEU OF AND EXCLUDES ALL OTHER WARRANTIES, GUARANTEES OR REPRESENTATIONS, EXPRESS OR IMPLIED BY OPERATION OF LAW, INCLUDING ANY WARRANTY OF MERCHATABILITY OF FITNESS FOR A PARTICULAR PURPOSE. SELLER SHALL HAVE NO LIABILTY ARISING FROM DESIGN FURNISHED BY OTHERS OR FROM ENGINEER'S OR ARCHITECT'S ERRORS OR OMISSION.

Cooling Tower Technical Data Sheet

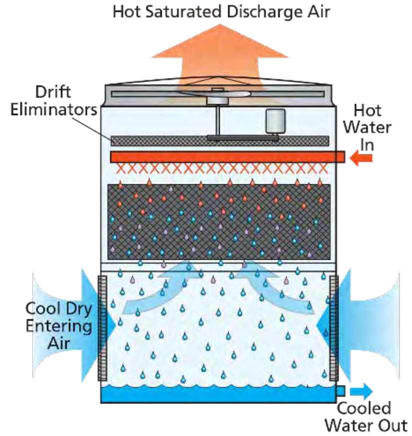
Anthony Tomasi
735 SW 20th Place
Suite 230
Portland, Oregon 97205
503-320-9565
anthonyt@jbarrow.com

(1) AT 212-4M36

Project Details

Project Name : Oregon State Fish & Wildlife - Rock Creek Hatchery
Location: TBD UNK

Date: 10/29/2023
Customer:
Contact:
Contact Email:



Product Description

The original Advanced Technology cooling tower provides an induced-draft, axial fan solution for a wide array of outdoor cooling capacities.

Selection Criteria

	Total	Each Unit
Flow:	4,080.0 GPM	4,080.0 GPM
Fluid:	Water	Water
Entering Fluid Temp:	90.0°F	90.0°F
Leaving Fluid Temp:	80.0°F	80.0°F
Entering Wet Bulb:	70.0°F	70.0°F

Required Capacity

20,400.00 MBH
1,360.00 Tons

Unit Selected

One(1) EVAPCO AT 212-4M36 at 100.3% capacity (20,461.20 MBH)

Product Line is CTI/ECC Certified. Selection is rated in accordance with CTI Standard 201 RS.

Physical Data Per Unit

Overall Dimensions (WxLxH):	11'-10" x 36'-2 1/2" x 17'-6 1/4"
Operating Weight:	43,480 lbs
Shipping Weight:	24,940 lbs
Heaviest Section:	8,440 lbs

*weights and dimensions could vary depending on options selected

IBC Design Capability

IBC Standard Structural Design
1.0 Importance Factor Specified

Seismic(S_{DS}):	up to 1.34 g, z/h = 0
Wind Load(P):	up to 119 psf

Fan Motor Data Per Unit

Number of Fans:	2
# of Fan Motors:	2
Nameplate Power (460/3/60):	30.00 HP Per Motor
Total Connected Nameplate Power:	60.00 HP
Typical Nameplate FLA:	36 Amps Per Motor

*Nameplate FLA could vary

Additional Details Per Unit

Air Flow:	265,800 CFM
Min Sump Sweeper Flow Rate:	477 GPM
Min Sump Sweeper Inlet Pressure:	20 psi

Hydraulic Data

Inlet Pressure Drop:	2.8 psi
Evaporated Water Rate:	32.64 GPM

Layout Criteria

From FACE B/D to wall:	3.00ft
From FACE A/C to wall:	4.00ft
Between FACE B/D ends:	3.50ft
Between FACE A/C sides:	7.00ft

Sound Data(dB(A) @ 5'/50')

Face A (Opp Mtr. Side):	83/70	Face C (Motor Side):	83/70
Face B (End):	82/69	Face D (Opp End):	82/69
Top:	85/76		

Notes: Sound Pressure Levels are according to CTI Standard ATC-128 and verified by an independent CTI-licensed sound test agency. Sound data is shown for 2 cells operating at full speed. The use of frequency inverters (Variable Frequency Drives) can increase sound levels. Sound Options: None

Shipping Data

2 Basin Sections: (WxLxH): 142" x 441" x 91" ; 4030lbs each* | 2 Casing Sections: (WxLxH): 142" x 239" x 129" ; 8440lbs each*
*dimensions and weights above include shipping skids

Accessories

- (1) ASHRAE 90.1-2019 Energy Compliant
- (1) 304 Welded Stainless Steel Cold Water Basin
- (1) Vibration Switch
- (1) Ladder Extension; 3 Feet
- (1) Motor Davit with Base
- (1) IBC Standard Structural Design
- (1) EVAPAK Fill
- (1) Louver Access Door
- (1) Safety Cage
- (1) Stainless Steel Heaters (0F ambient) (4) 9 kW;
- (1) 1.0 Importance Factor Specified
- (1) Equalizer Connection; Bottom; 10"; BFW/GRVD
- (1) External Service Platform with Ladder
- (1) Safety Cage Extension
- (1) Sump Sweeper Piping (High Flow Eductors)

	460/3/60	
(2) Fan Motor: Inverter Capable, Premium Efficient	(2) Fan Motor: Space Heaters	(2) Fan Motor: Shaft Grounding Rings

Anthony Tomasi
735 SW 20th Place
Suite 230
Portland, Oregon 97205
503-320-9565
anthonyt@jbarrow.com

SECTION 23 65 00
COOLING TOWERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes factory assembled and tested, open circuit mechanical induced-draft vertical discharge cooling tower.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, pressure drop, performance curves with selected points indicated, furnished specialties, and accessories.

B. Shop Drawings: Complete set of manufacturer's prints of equipment assemblies, control panels, sections and elevations, and unit isolation. Include the following:

1. Assembled unit dimensions.
2. Weight and load distribution.
3. Required clearances for maintenance and operation.
4. Sizes and locations of piping and wiring connections.
5. Wiring Diagrams: For power, signal, and control wiring. Differentiate between manufacturer installed and field installed wiring.

C. Operation and Maintenance Data: Each unit to include operation and maintenance manual.

1.4 QUALITY ASSURANCE

A. Verification of Performance:

1. The thermal performance shall be certified by the Cooling Technology Institute in accordance with CTI Certification Standard STD-201. Lacking such certification, a field acceptance test shall be conducted within the warranty period in accordance with CTI Acceptance Test Code ATC-105, by a Licensed CTI Thermal Testing Agency.
2. Unit Sound Performance ratings shall be tested according to CTI ATC-128 standard. Sound ratings shall not exceed specified ratings.
3. Unit shall meet or exceed energy efficiency per ASHRAE 90.1-2019.

1.5 WARRANTY

A. Submit a written warranty executed by the manufacturer, agreeing to repair or replace components of the unit that fail in materials and workmanship within the specified warranty period.

1. The Entire Unit shall have a comprehensive five (5) year warranty against defects in materials and workmanship from date of shipment.

2. Fan Motor/Drive System: Warranty Period shall be Five (5) years from date of unit shipment from Factory (fan motor(s), fan(s), fan shaft(s), bearings, mechanical support, sheaves, bushings and belt(s)).

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide cooling towers manufactured by one of the following:

1. EVAPCO Model AT 212-4M36

2. Approved Substitute

2.2 THERMAL PERFORMANCE

A. Each unit shall be capable to cool 4,080.0 GPM of water entering at 90.0° F leaving at 80.0° F at a design entering wet bulb of 70.0° F.

2.3 IBC COMPLIANCE

A. The structure of this product shall be designed, analyzed, and constructed in accordance with the wind and seismic load requirements of the following: 2009 IBC, 2012 IBC, 2015 IBC, 2018 IBC, ASCE/SEI 7-05, ASCE/SEI 7-10, ASCE/SEI 7-16, NFPA 5000. For Importance Factor (I_P) = 1.0, S_{DS} = 1.34 (@ z/h = 0) and P = 119 psf.

2.4 COMPONENTS

A. Description: Factory assembled and tested, induced draft counter flow cooling tower complete with fan, fill, louvers, accessories and rigging supports

B. Materials of Construction

1. All cold water basin components including vertical supports, air inlet louver frames and panels up to rigging seam shall be constructed of Type 304 Stainless Steel. All factory cold water basin seams shall be welded for water tight construction. "Series 300" stainless steel shall not be acceptable as equivalent to Type 304 Stainless Steel. All evaporative cooling equipment utilizing galvanized construction require initial passivation to maximize the service life of the equipment. The site's water treatment vendor should be contacted several weeks prior to adding any water to the system to provide a passivation plan along with associated passivation plan costs.

2. Upper Casing, channels and angle supports shall be constructed of heavy gauge mill hot-dip galvanized steel. Fan cowl and guard shall be constructed of galvanized steel. All galvanized steel shall be coated with a minimum of 2.35 ounces of zinc per square foot of zinc per square foot of area (G-235 Hot-Dip Galvanized Steel designation). During fabrication, all galvanized steel panel edges shall be coated with a 95% pure zinc-rich compound.
All evaporative cooling equipment utilizing galvanized construction require initial passivation to maximize the service life of the equipment. The site's water treatment vendor should be contacted several weeks prior to adding any water to the system to provide a passivation plan along with associated passivation plan costs.

C. Fan(s):

1. Fan(s) shall be high efficiency axial propeller type with aluminum wide chord blade construction. Each fan shall be dynamically balanced and installed in a closely fitted cowl with venturi air inlet for maximum fan efficiency.

D. Drift Eliminators

1. Drift eliminators shall be constructed entirely of Polyvinyl Chloride (PVC) in easily

handled sections. Design shall incorporate three changes in air direction and limit the water carryover to a maximum of 0.001% of the recirculating water rate. Drift eliminators shall be self-extinguishing, have a flame spread of less than 25 under ASTM E84, and shall be resistant to rot, decay and biological attack.

E. Water Distribution System

1. Spray nozzles shall be precision molded ABS, large orifice nozzles utilizing fluidic technology for superior water distribution over the fill media. Nozzles shall be designed to minimize water distribution system maintenance. Spray header and branches shall be Schedule 40 Polyvinyl Chloride (PVC) for corrosion resistance with a steel connection to attach external piping.

F. Heat Transfer Media

1. Fill media shall be constructed of Polyvinyl Chloride (PVC) of cross-fluted design and suitable for inlet water temperatures up to 130° F. The bonded block fill shall be bottom supported and suitable as an internal working platform. Fill shall be self-extinguishing, have a flame spread of less than 25 under ASTM E84, and shall be resistant to rot, decay and biological attack.

G. Air Inlet Louvers

1. The air inlet louvers shall be constructed from UV inhibited Polyvinyl Chloride (PVC) and incorporate a framed interlocking design that allows for easy removal of air inlet louvers for access to the entire basin area for maintenance. The air inlet louvers shall have a minimum of two changes in air direction and shall be of a non-planar design to prevent splash-out and block direct sunlight & debris from entering the basin. Air inlet louvers shall be self-extinguishing, have a flame spread of less than 25 under ASTM E84, and shall be resistant to rot, decay and biological attack.

H. Make up Float Valve Assembly

1. Make up float assembly shall be a mechanical brass valve with an adjustable plastic float.

I. Pan Strainer

1. Pan Strainer(s) shall be all Type 304 Stainless Steel construction with large area removable perforated screens.

J. Pipe Connection Type

1. Any connections provided with a Groove (GVD) or Beveled for Welding/Grooved (BFW/GVD) shall conform to standard groove specification (SGS).

2.5 MOTORS AND DRIVES

A. General requirements for motors are specified in Division 23 Section “Motors”

B. Fan Motor

1. Fan motor(s) shall be totally enclosed, ball bearing type electric motor(s) suitable for moist air service. Motor(s) are Premium Efficient, Class F insulated, 1.15 service factor design. Inverter rated per NEMA MG1 Part 31.4.4.2 and suitable for variable torque applications and constant torque speed range with properly sized and adjusted variable frequency drives.

2. Fan motor(s) shall include strip-type space heaters with separate leads brought to the motor conduit box.

C. Fan Drive

1. The fan drive shall be multigroove, solid back V-belt type with QD tapered bushings

designed for 150% of the motor nameplate power. The belt material shall be neoprene reinforced with polyester cord and specifically designed for evaporative equipment service. Fan sheave shall be aluminum alloy construction. Belt adjustment shall be accomplished from the exterior of the unit.

D. Fan Shaft

1. Fan shaft shall be solid, ground and polished steel. Exposed surface shall be coated with rust preventative.

E. Fan Shaft Bearings

1. Fan Shaft Bearings shall be heavy-duty, self-aligning ball type bearings with extended lubrication lines to grease fittings located on access door frame. Bearings shall be designed for a minimum L-10 life of 100,000 hours.

F. Vibration Switch

1. Unit shall be provided with a Vibration Cutout Switch, operating on 120 VAC feed, to protect the fan and drive assembly from damage in the event of excess vibration. Vibration switch shall be DPDT.

2.6 MAINTENANCE ACCESS

A. Fan Section

1. Access door shall be hinged and located in the fan section for fan drive and water distribution system access.

B. Basin Section

1. Framed removable louver panels shall be on all four (4) sides of the unit for pan and sump access.

C. Internal Working Platform

1. Internal working platform shall provide easy access to the fans, belts, motors, sheaves, bearings, all mechanical equipment and complete water distribution system. The fill shall be an acceptable means of accessing these components.

D. External Service Platform with Ladder

1. An external service platform compliant with OSHA shall be provided at the motor access door of the unit extending the full length of the access door. Each platform shall have at least a 36 in wide walking surface. The platforms shall have galvanized steel grating, supported by galvanized steel framework attached to the unit and surrounded by a handrail, knee rail and toe plate system that is compliant with OSHA. Mounting channels shall be the same material as the casing section (galvanized or stainless steel). A vertical ladder shall be provided from the base of the unit to the platform.

2. Safety cage(s) shall be provided on all vertical ladder(s) and ship mounted. Safety cage(s) shall begin between 7 feet (minimum) and 8 feet (maximum) above grade.

E. Motor Davit with Base

1. Unit shall be provided with mechanical external motor davit assembly which facilitates in removal of larger fan section components. Davit arm shall be constructed of aluminum and base shall be galvanized steel.

F. Louver Access Door

1. Hinged access door in louver shall be provided.

2.7 ACCESSORIES

A. Basin Heater Package

1. Cold water basin shall be fitted with Type 304 Stainless Steel element, electric immersion heater(s) with a separate thermostat and low water protection device. Heaters shall be selected to maintain +40° F pan water at 0 °F ambient temperature.

B. Sump Sweeper Piping

1. Cold water basin shall be fitted with schedule 80 PVC sump sweeper piping complete with high-flow eductor nozzles to facilitate basin cleaning. The system shall contain one inlet connection and one outlet connection per basin.

C. Piping Connections

1. Cold water basin shall be provided with external connections to equalize basin water levels.

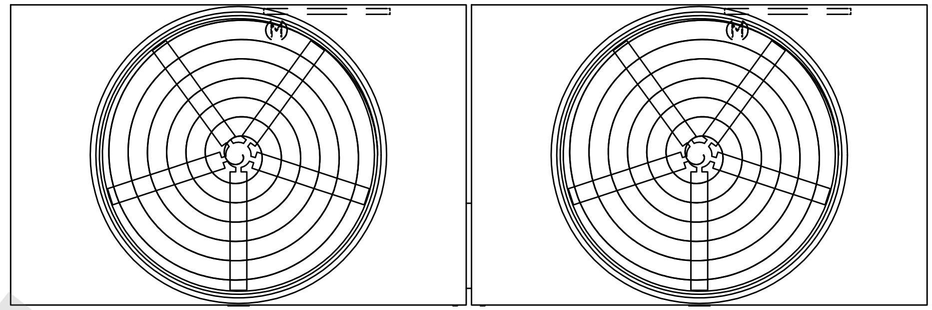
UNIT	COOLING TOWER		EVAPCO, INC.	DWG. #	T3122C48-DRD-ST	REV.	-
MODEL #	AT 212-4M36	SCALE NTS		SERIAL #		DATE	10/29/2023

NOTES:
1. (M)- FAN MOTOR LOCATION
2. HEAVIEST SECTION IS UPPER SECTION
3. MPT DENOTES MALE PIPE THREAD
   FPT DENOTES FEMALE PIPE THREAD
   BFW DENOTES BEVELED FOR WELDING
   GVD DENOTES GROOVED
   FLG DENOTES FLANGE
4. +UNIT WEIGHT DOES NOT INCLUDE ACCESSORIES (SEE ACCESSORY DRAWINGS)
5. MAKE-UP WATER PRESSURE
   20 psi MIN [137 kPa], 50 psi MAX [344 kPa]
6. 3/4" [19MM] DIA. MOUNTING HOLES. REFER TO RECOMMENDED STEEL SUPPORT DRAWING
7. DIMENSIONS LISTED AS FOLLOWS:
   ENGLISH FT-IN
   [METRIC] [mm]

FACE C

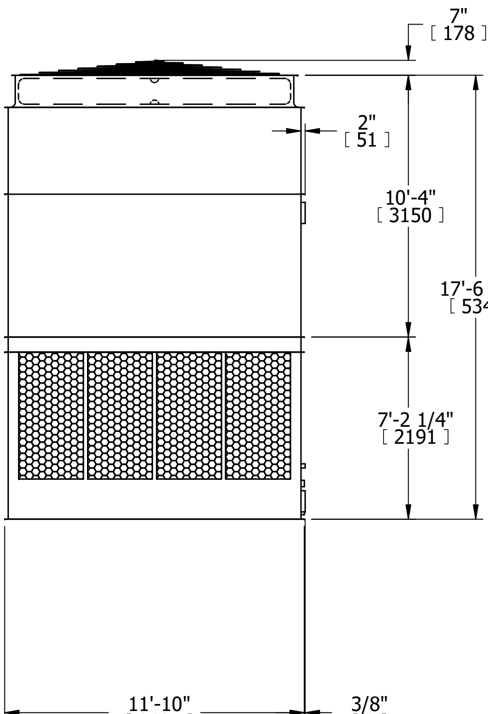
FACE B

PLAN VIEW

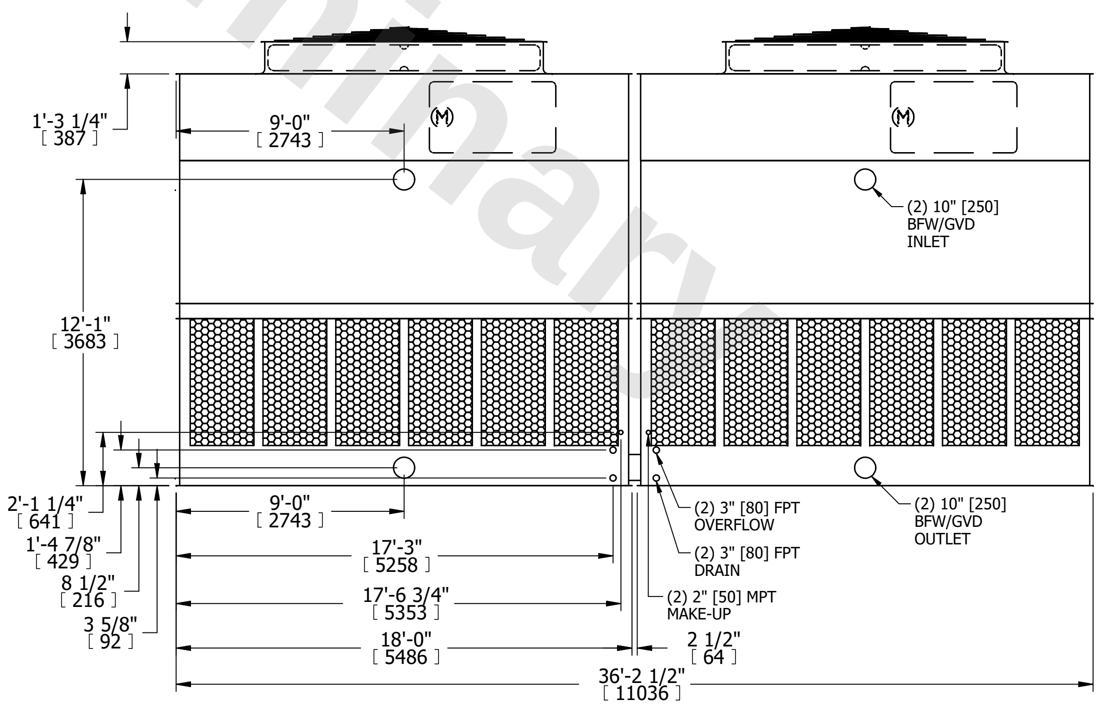


FACE D

FACE A



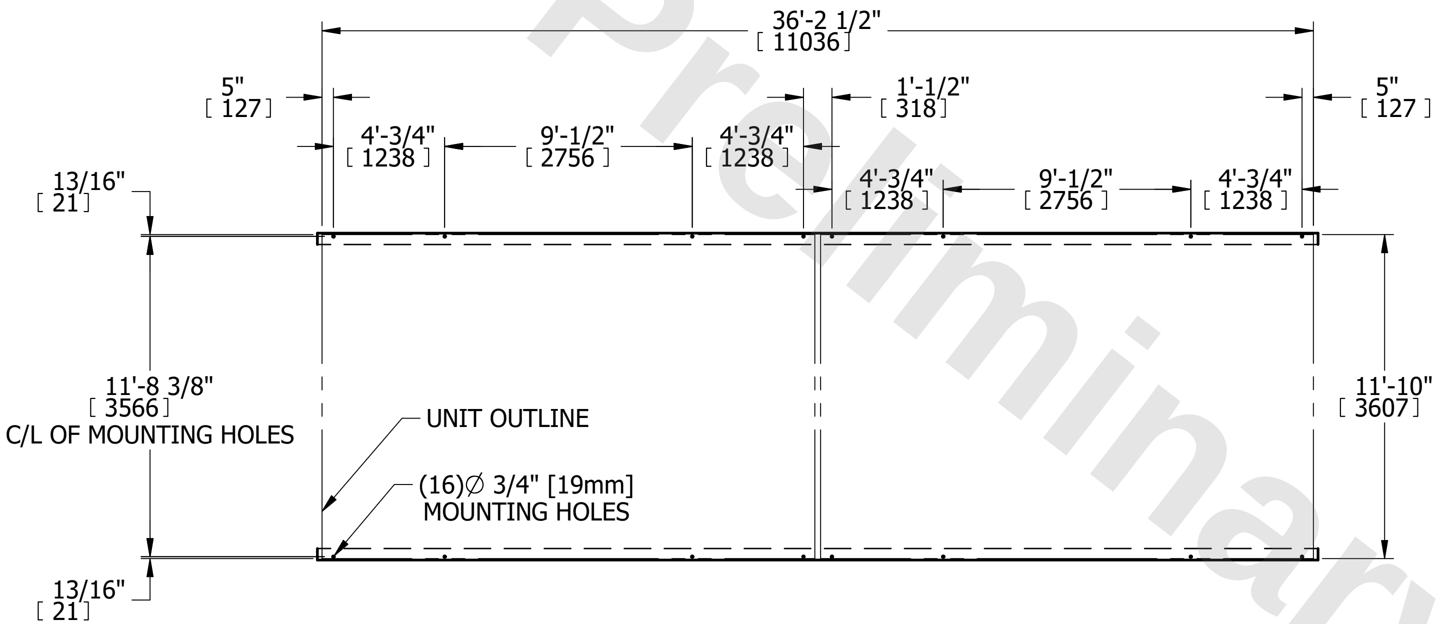
FACE B



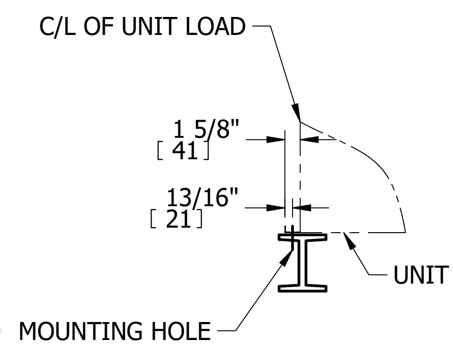
FACE A

SHIPPING WEIGHT	24940 lbs+ [11315] kg+	OPERATING WEIGHT	43480 lbs+ [19725] kg+	HEAVIEST SECTION WEIGHT	8440 lbs+ [3830] kg+	NO. OF SHIPPING SECTIONS	4	DRAWN BY:	KDS

UNIT		TITLE	DWG. #	SCALE	DRAWN BY
AT 212-4M36	EVAPCO, INC.	STEEL SUPPORT CONFIGURATION	SLIX1236-DG	N.T.S.	JLG



PLAN VIEW



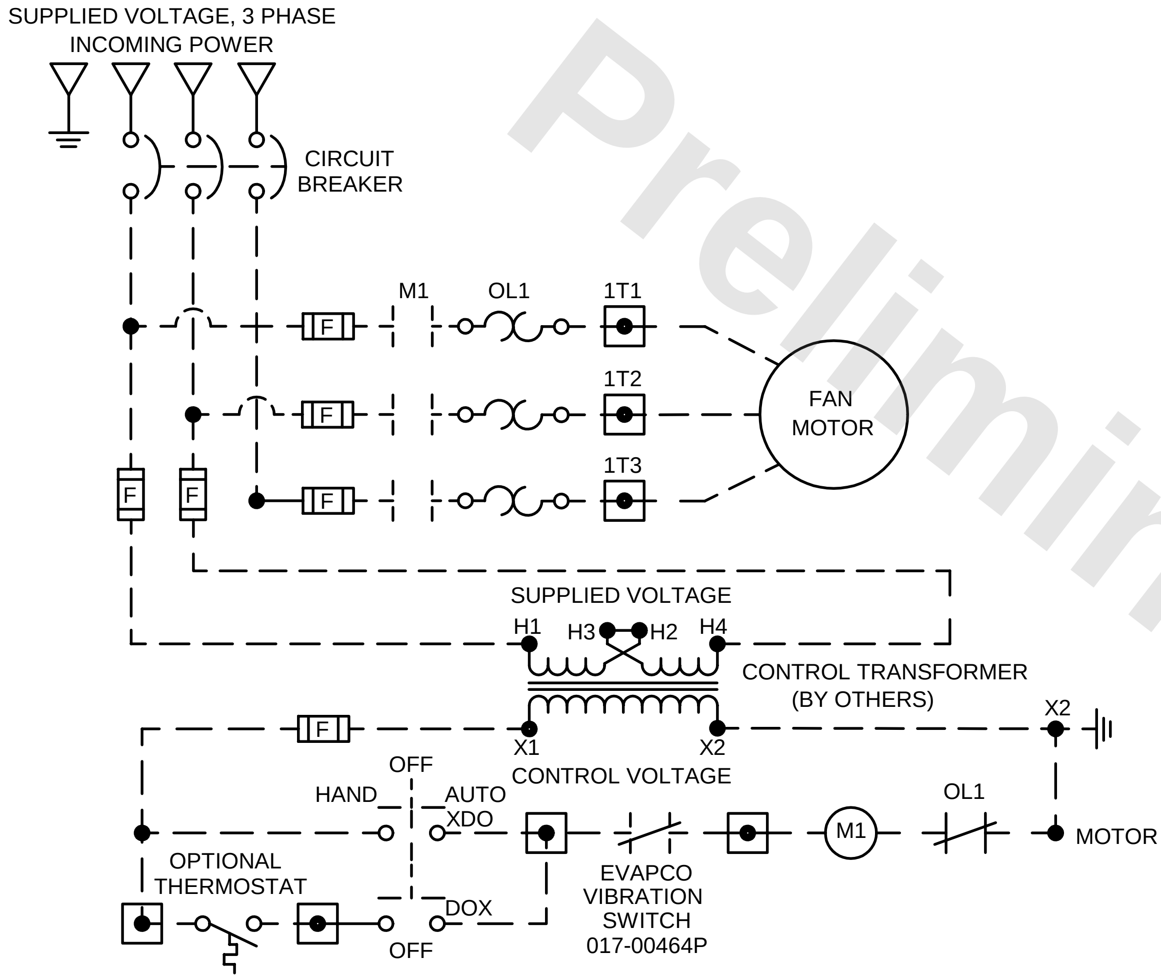
TYPICAL END VIEW

NOTES:

1. BEAMS SHOULD BE SIZED IN ACCORDANCE WITH ACCEPTED STRUCTURAL PRACTICES. MAXIMUM DEFLECTION OF BEAM UNDER UNIT TO BE 1/360 OF UNIT LENGTH NOT TO EXCEED 1/2" [13mm].
2. DEFLECTION MAY BE CALCULATED BY USING 55% OF THE OPERATING WEIGHT AS A UNIFORM LOAD ON EACH BEAM. SEE CERTIFIED PRINT FOR OPERATING WEIGHT.
3. SUPPORT BEAMS AND ANCHOR HARDWARE ARE TO BE FURNISHED BY OTHERS. ANCHOR HARDWARE TO BE ASTM A325 5/8" [16mm] BOLT OR EQUIVALENT.
4. BEAMS MUST BE LOCATED UNDER THE FULL LENGTH OF THE PAN SECTION.
5. SUPPORTING BEAM SURFACE MUST BE LEVEL. DO NOT LEVEL THE UNIT BY PLACING SHIMS BETWEEN THE UNIT MOUNTING FLANGE AND THE SUPPORTING BEAM.
6. THE FACTORY RECOMMENDED STEEL SUPPORT CONFIGURATION IS SHOWN. CONSULT THE FACTORY FOR ALTERNATE SUPPORT CONFIGURATIONS.
7. UNIT SHOULD BE POSITIONED ON STEEL SUCH THAT THE ANCHORING HARDWARE FULLY PENETRATES THE BEAM'S FLANGE AND CLEARS THE BEAM'S WEB.
8. FOR ALL MULTIPLE CELL UNITS, OPERATING WEIGHT OF EACH CELL IS FOUND BY DIVIDING TOTAL OPERATING WEIGHT BY THE NUMBER OF CELLS.
9. WHEN VIBRATION ISOLATION IS REQUIRED, THE VIBRATION ISOLATORS (BY OTHERS) MUST BE LOCATED UNDER THE SUPPORTING STEEL BEAMS AND NOT BETWEEN THE SUPPORTING STEEL BEAMS AND THE UNIT.
10. DIMENSIONS LISTED AS FOLLOWS: ENGLISH FT-IN [METRIC] [mm]

EVAPCO, INC.

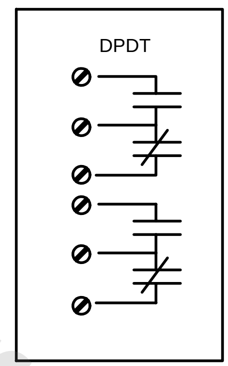
TITLE	DESCRIPTION:	DWG. #
VIBRATION SWITCH	SINGLE SPEED	V1AU0000-EE



SWITCH CONTACT RATING:

15 AMPS, 125, OR 480 Vac; 1/8 HP, 125 Vac; 1/4 HP, 250 Vac; 1/2 AMP, 125 Vdc; 1/4 AMP, 250 Vdc.

WIRING DIAGRAM:



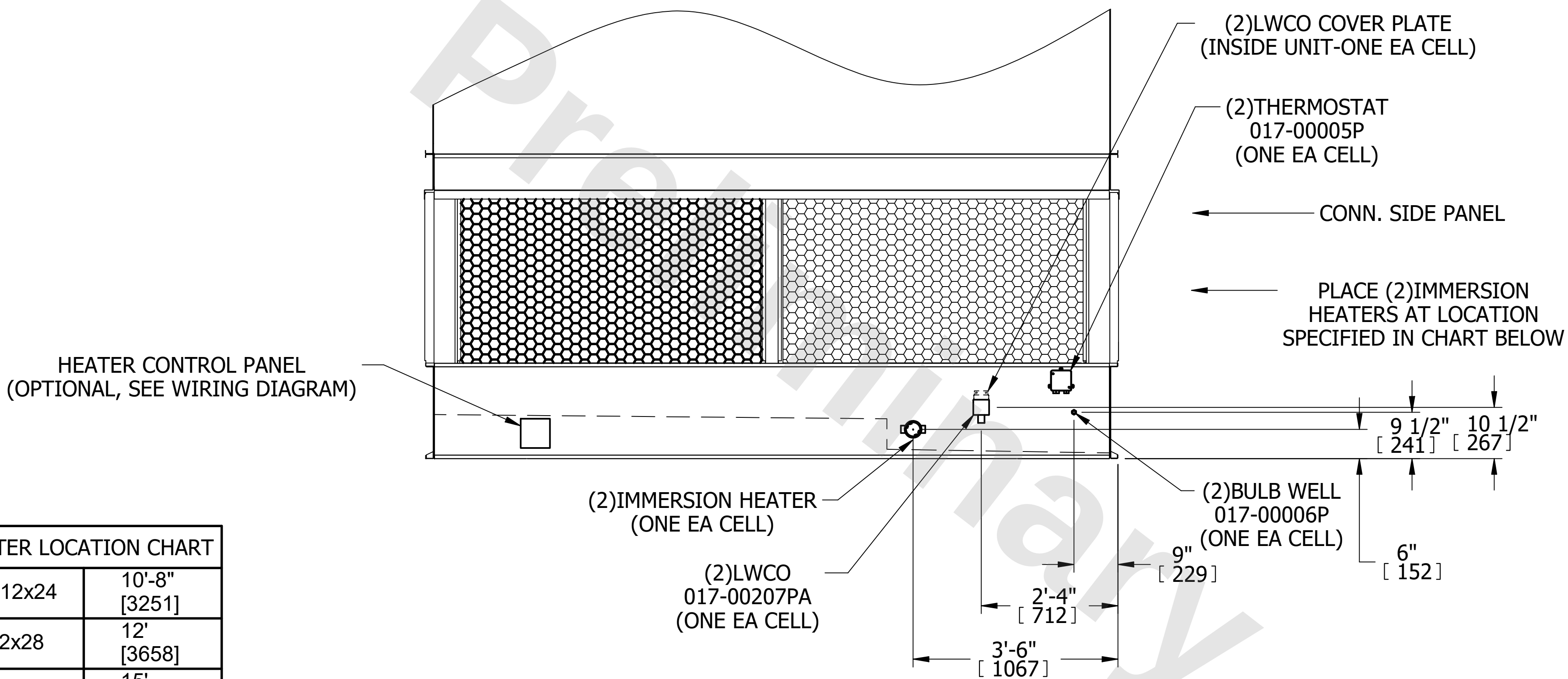
NOTES:

1. DASHED LINES INDICATE WIRING(BY OTHERS)

ADJUSTMENT

ADJUST THE SWITCH SO THAT DURING FULL SPEED START-UP AND UNDER NORMAL CONDITIONS, THE CONTACTS DO NOT TRIP. FIRST, WITH THE MOTOR OFF, TURN THE ADJUSTMENT SCREW COUNTER-CLOCKWISE (MORE SENSITIVE DIRECTION) UNTIL THE SWITCH TRIPS. NEXT, TURN THE ADJUSTMENT SCREW CLOCKWISE 1/8 TURN (LESS SENSITIVE DIRECTION). RESET THE SWITCH BY DEPRESSING THE PUSH-BUTTON RESET LOCATED ON TOP OF THE SWITCH. START THE MOTOR ON FULL SPEED. IF THE MOTOR TRIPS THE SWITCH, THEN TURN THE ADJUSTMENT SCREW CLOCKWISE AN ADDITIONAL 1/8 TURN. RESET THE SWITCH AND START THE MOTOR AGAIN. REPEAT THE ABOVE PROCEDURE UNTIL THE MOTOR CONTINUES TO RUN.

UNIT	TITLE		DWG. #	SCALE	DRAWN BY
AT 212-4M36	HEATER LOCATION	EVAPCO, INC.	HLT4MTYB-DB	N.T.S.	MWR



HEATER LOCATION CHART	
3M,12x24	10'-8" [3251]
12x28	12' [3658]
3M,12x36(2C)	15' [4572]
12x40	17' [5182]

* PLACE HEATER IN SPECIFIED LOCATIONS FROM EACH END TOWARD MIDDLE OF UNIT AND 6" [152] UP FROM BOTTOM OF UNIT.

FACE B

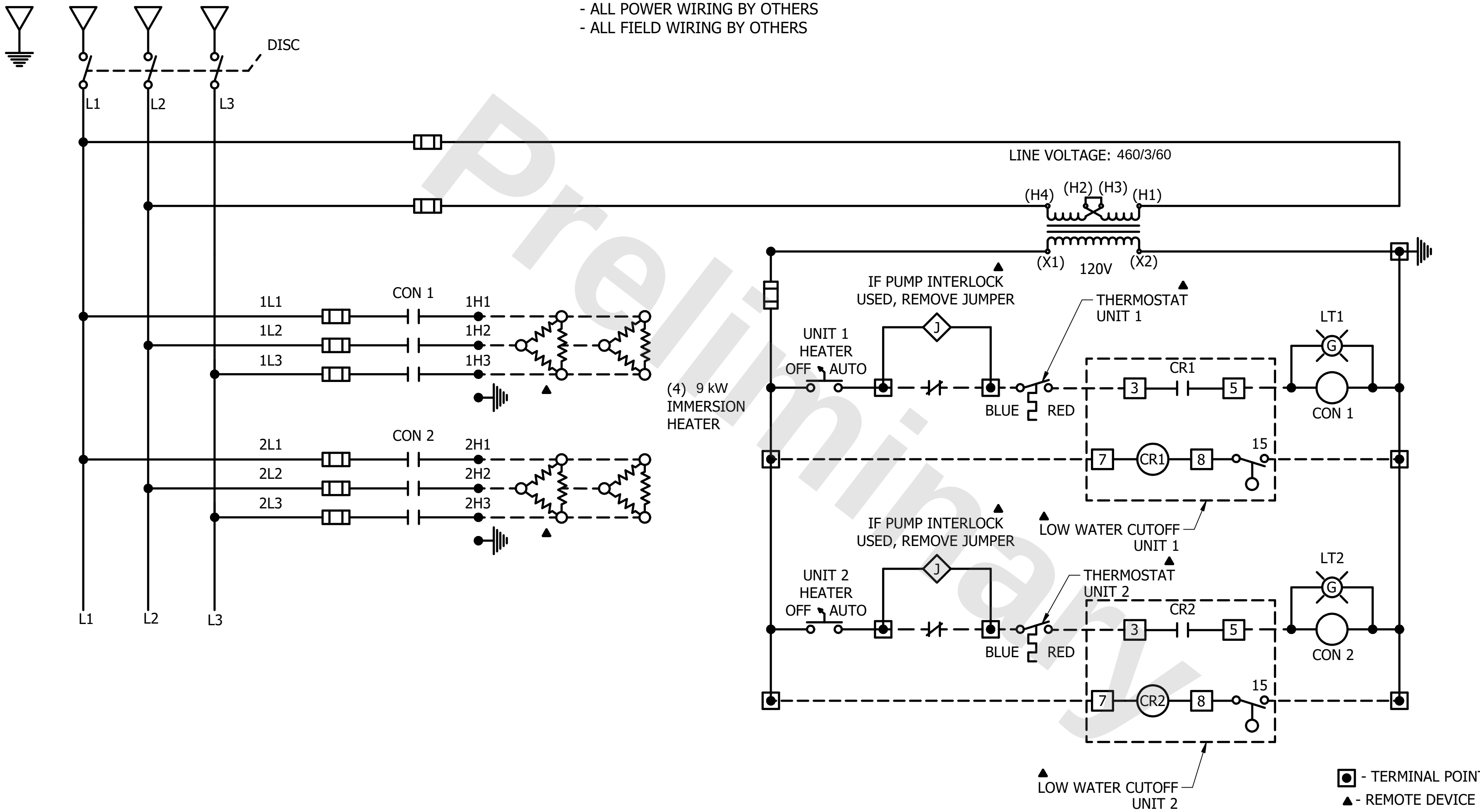
NOTES:

1. PLEASE REFER TO THE EVAPCO EQUIPMENT LAYOUT MANUAL FOR CLEARANCE REQUIREMENTS.
2. ALL NIPPLES ON UNIT ARE NOT SHOWN IN ORDER TO CLARIFY HEATER COMPONENT LOCATIONS.
3. ALL HEATER COMPONENTS BY EVAPCO ARE FACTORY MOUNTED WHEN POSSIBLE.
4. DIMENSIONS LISTED AS FOLLOWS: ENGLISH FT- IN [METRIC] [mm]

UNIT		DWG. #
AT 212-4M36	EVAPCO, INC.	B4AU0000-DC
TITLE: 3Ø HEATER WIRING DIAGRAM 4 HEATERS		SCALE: N.T.S. / DRAWN BY: SLR

LINE VOLTAGE: 460/3/60

RECOMMENDED POWER AND CONTROL WIRING
- ALL HEATERS AND CONTROLS NOT PROVIDED BY EVAPCO TO BE INSTALLED AND WIRED BY OTHERS
- ALL POWER WIRING BY OTHERS
- ALL FIELD WIRING BY OTHERS



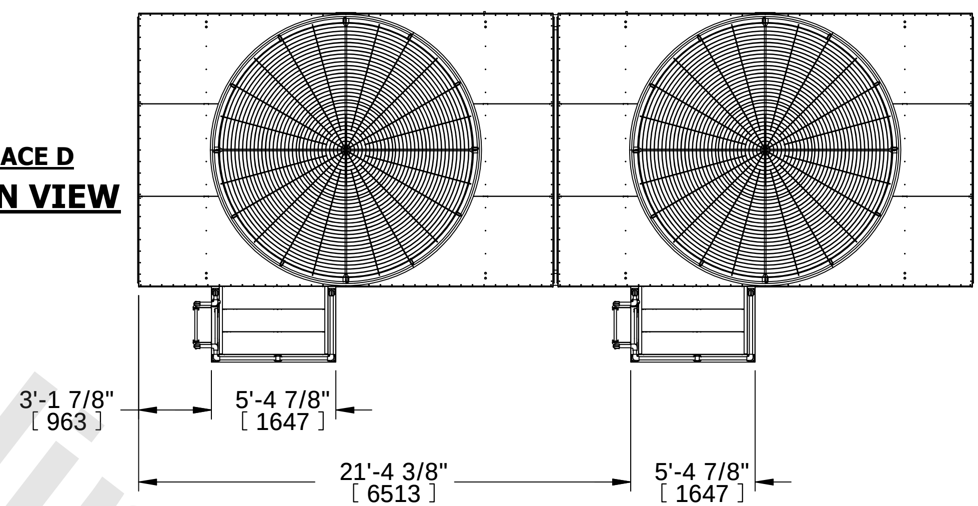
NOTES:
1. DASHED LINES INDICATE FIELD WIRING.
2. THE HEATERS HAVE BEEN SIZED TO MAINTAIN 40° F PAN WATER AT AN AMBIENT TEMPERATURE OF 0° F
3. ALL COMPONENTS BY EVAPCO HAVE TYPE 4 ENCLOSURES.
4. AUXILIARY N.C. CONTACT INTERLOCKS IMMERSION HEATERS WITH SPRAY WATER CIRCULATING PUMP TO DE-ENERGIZE HEATERS WHEN SPRAY PUMP IS RUNNING.
5. (1) CONTACTOR IS SUPPLIED FOR EVERY (2) HEATERS
   - CONTACTOR SHOULD BE WIRED WITH SEPARATE SUPPLY TERMINALS FOR EACH HEATER.
6. (1) CONTACTOR IS SUPPLIED PER CELL OF A MULTICELL UNIT
   - PROVIDES FOR INDIVIDUAL CELL OPERATION.

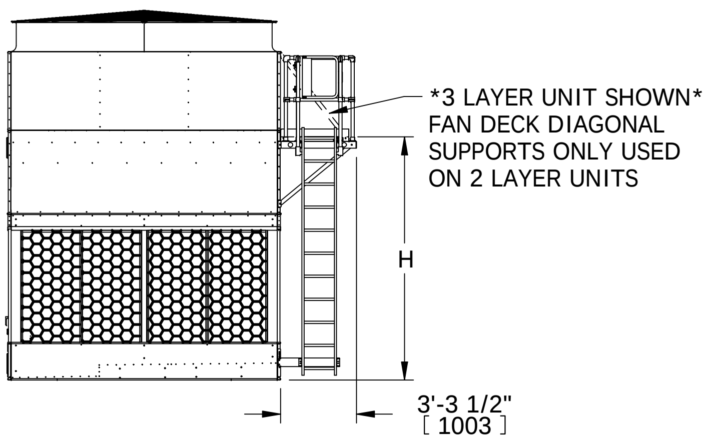
IMMERSION HEATER BY:	EVAPCO
LOW WATER CUTOFF/THERMOSTAT CONTROL BY:	EVAPCO
AUXILIARY N.C. PUMP INTERLOCK BY:	OTHERS
HEATER CONTROL PANEL BY:	OTHERS
TRANSFORMER BY:	OTHERS
HEATER CONTACTOR BY:	OTHERS
FUSED DISCONNECT BY:	OTHERS

UNIT	AT 212-4M36	EVAPCO, INC.	DWG. #	PLT4MT36-DB
TITLE	EXTERNAL SERVICE PLATFORM		SCALE: N.T.S.	DRAWN BY: AMG

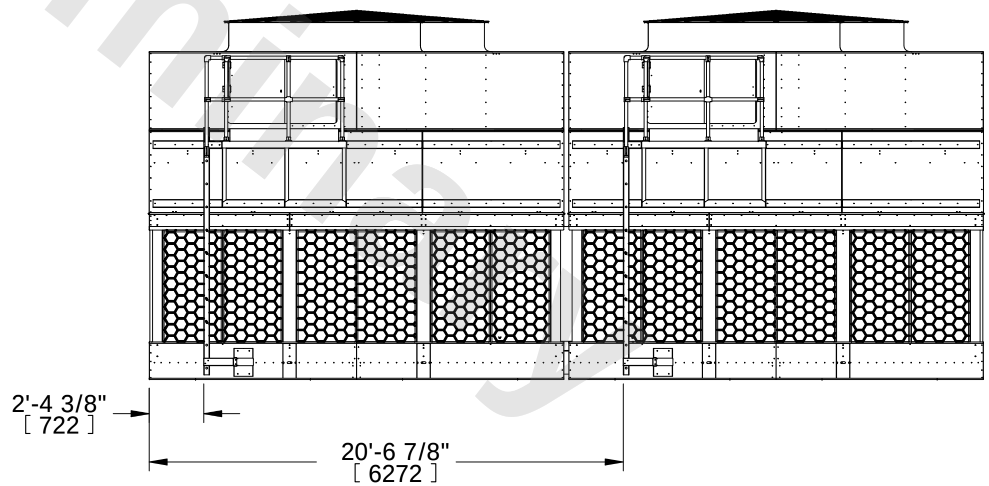
MODEL #	H DIM	
	FT-IN	[mm]
AT-212-2J36, 2K36, 2L36, 2M36, 2N36	10'-6 7/8 "	3223
AT-212-3J36, 3K36, 3L36, 3M36, 3N36, 3O36	11'-6 7/8 "	3527
AT-212-4J36, 4K36, 4L36, 4M36, 4N36, 4O36, 4P36	12'-6 7/8 "	3832
AT-210-2I36, 2J36, 2K36, 2L36, 2M36	9'-5 7/8 "	2892
AT-210-3I36, 3J36, 3K36, 3L36, 3M36, 3N36	10'-5 7/8 "	3197
AT-210-4I36, 4J36, 4K36, 4L36, 4M36, 4N36	11'-5 7/8 "	3502

PLAN VIEW





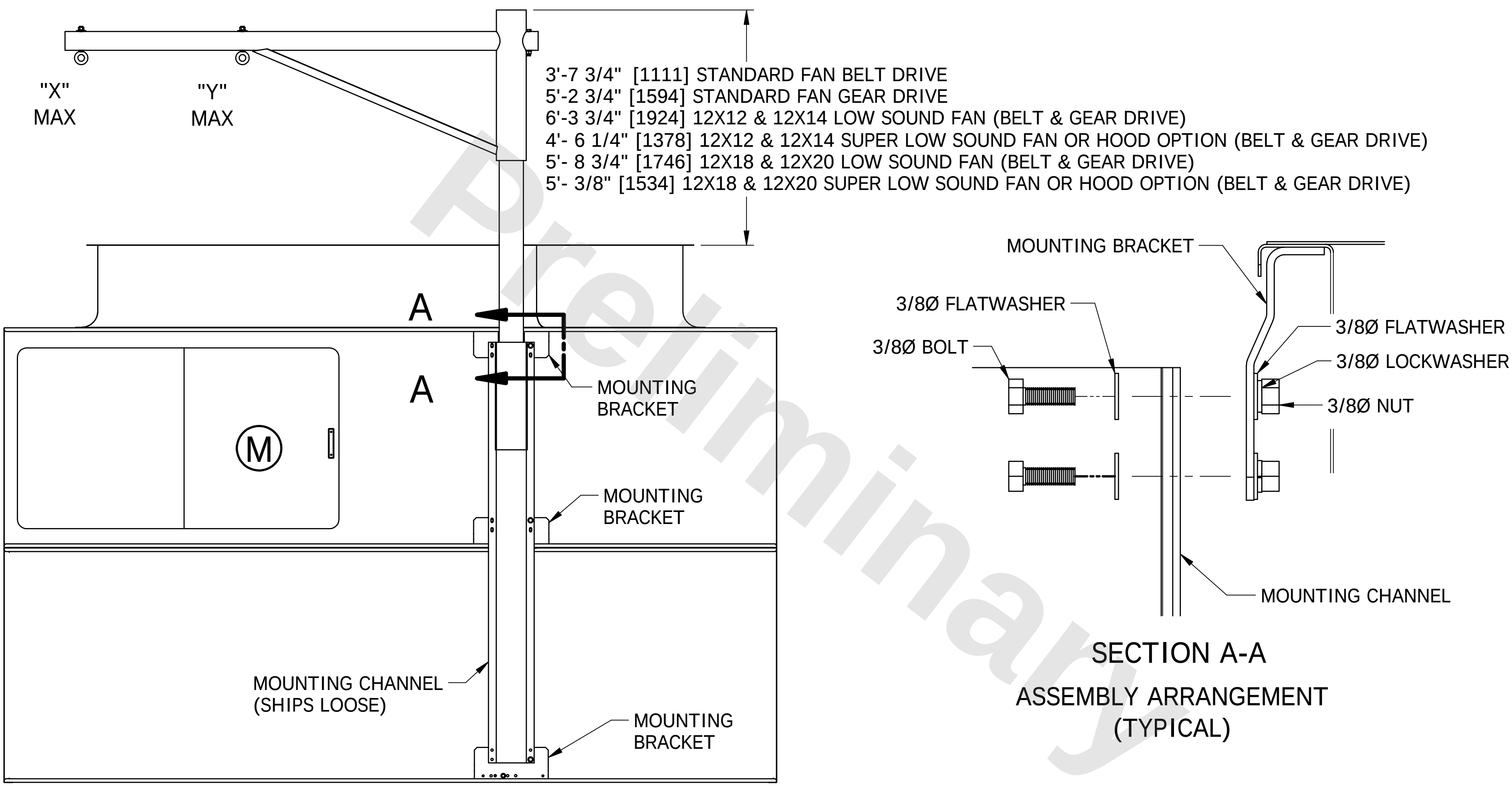
FACE D



FACE C

NOTES:
1. LADDER AND PLATFORM SHIP LOOSE. FIELD INSTALLATION BY OTHERS IS REQUIRED.
2. THE BOTTOM OF THE LADDER DOES NOT EXTEND PAST THE BASE OF THE UNIT. IF THE UNIT IS ELEVATED THEN AN OPTIONAL EXTENDED LADDER PACKAGE SHOULD BE CONSIDERED. (CONSULT FACTORY)
3. REFER TO RIGGING PACK FOR LADDER AND PLATFORM MOUNTING INSTRUCTIONS.
4. EACH PLATFORM AND LADDER ASSY. WEIGHS 620 LBS. [281 KG]
5. DIMENSIONS LISTED AS FOLLOWS: ENGLISH FT-IN
   [METRIC] [mm]

UNIT		DWG. #	
AT 212-4M36	EVAPCO, INC.	MDAITTVW-DI	
TITLE: REMOVABLE DAVIT		SCALE: N.T.S.	DRAWN BY: SLR



FACE C

NOTES:

A. (M) = MOTOR

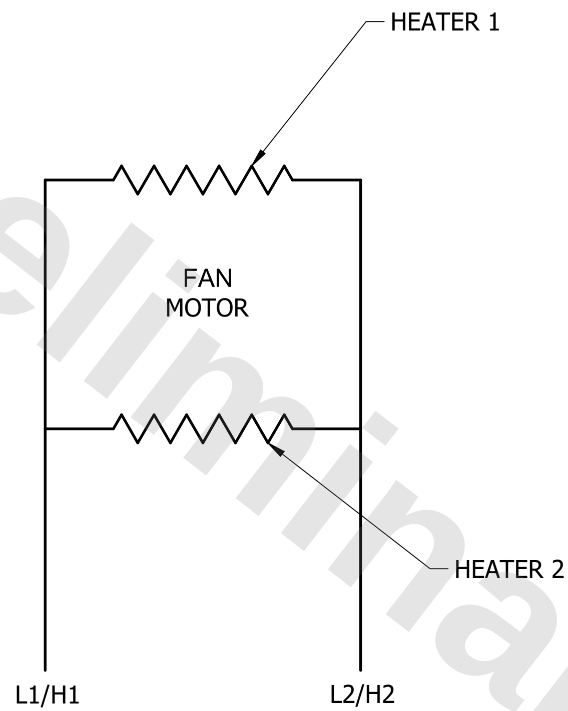
B. DAVIT IS DESIGNED FOR RAISING OR LOWERING EVAPCO FAN MOTORS OR FANS AND GEARS AS UNIT IS EQUIPPED. DO NOT USE FOR ANY OTHER PURPOSE.

C. DAVIT IS DESIGNED TO PIVOT FREELY AND CAN BE REMOVED FROM ITS MOUNTING BASE FOR STORAGE.

D. DIMENSIONS LISTED AS FOLLOWS: ENGLISH FT-IN
[METRIC] [mm]

DAVIT WEIGHT LIMITS (LBS)		
BOX SIZE	"X" MAX	"Y" MAX
12X12	400	1000
12X14	600	1000
12X18 & 20 (110-135 GEARS)	600	1350
12X18 & 20 (155-175 GEARS)	725	1350

UNIT	AT 212-4M36	EVAPCO, INC.	DWG. #	MHAU0000-DB		
TITLE	FAN MOTOR SPACE HEATERS		SCALE	N.T.S.	DRAWN BY	BLL



ELECTRICAL DATA:
VOLTAGE: 120V
CURRENT: <2AMPS

NOTE:
1. FAN MOTOR SPACE HEATERS SHOULD BE ENERGIZED WHEN MOTOR IS OFF TO PREVENT CONDENSATION IN THE MOTOR
2. FAN MOTOR SPACE HEATERS MUST BE SWITCHED OFF WHEN MOTOR IS RUNNING

Full Speed Complete Sound Data

Anthony Tomasi
735 SW 20th Place
Suite 230
Portland, Oregon 97205
503-320-9565
anthonyt@jbarrow.com

Sound Pressure Levels (SPL) in dB RE 0.0002 Microbar
Sound Power Levels (PWL) in dB RE 10-12 Watt

Model	AT 212-4M36
Motor	30.00 HP
# Motors	2
Speed	Full Speed

2 Cell Data

Band	Sound Pressure Level (dB)											Sound Power Level (db)
	End		Motor Side		Opp End		Opp Mtr. Side		Top			
	5.0 ft (1.5m)	50.0 ft (15.2m)	5.0 ft (1.5m)	50.0 ft (15.2m)	5.0 ft (1.5m)	50.0 ft (15.2m)	5.0 ft (1.5m)	50.0 ft (15.2m)	5.0 ft (1.5m)	50.0 ft (15.2m)		
63 HZ	84	78	80	76	84	78	80	76	84	75		109
125 HZ	86	78	85	76	86	78	85	76	91	80		110
250 HZ	85	72	85	73	85	72	85	73	88	80		107
500 HZ	79	65	81	67	79	65	81	67	82	75		102
1 KHZ	74	61	73	63	74	61	73	63	78	66		95
2 KHZ	71	57	73	59	71	57	73	59	76	64		92
4 KHZ	72	56	73	57	72	56	73	57	75	62		90
8 KHZ	74	56	75	57	74	56	75	57	70	57		88
Calc dBA	82	69	83	70	82	69	83	70	85	76		104

Sound option(s) selected: None

Remarks:

1. Sound Pressure Levels are according to CTI Standard ATC-128 and verified by an independent CTI-licensed sound test agency
2. Sound Power Levels are calculated according to the Small Units Section 8
3. Sound from free-field conditions over a reflecting plane with +/-2 db(A) tolerance
4. Noise levels can increase with variable frequency drives depending on the drive manufacturer and the drive configuration
5. Complete unit sound data with all fans operating

66% Speed Complete Sound Data

Anthony Tomasi
735 SW 20th Place
Suite 230
Portland, Oregon 97205
503-320-9565
anthonyt@jbarrow.com

Sound Pressure Levels (SPL) in dB RE 0.0002 Microbar
Sound Power Levels (PWL) in dB RE 10-12 Watt

Model	AT 212-4M36
Motor	30.00 HP
# Motors	2
Speed	2/3 Speed

2 Cell Data

	Sound Pressure Level (dB)											
	End		Motor Side		Opp End		Opp Mtr. Side		Top			Sound
Band	5.0 ft (1.5m)	50.0 ft (15.2m)	5.0 ft (1.5m)	50.0 ft (15.2m)	5.0 ft (1.5m)	50.0 ft (15.2m)	5.0 ft (1.5m)	50.0 ft (15.2m)	5.0 ft (1.5m)	50.0 ft (15.2m)		Power Level (db)
63 HZ	75	70	72	67	75	70	72	67	75	66		100
125 HZ	77	70	77	67	77	70	77	67	82	71		101
250 HZ	76	64	77	65	76	64	77	65	79	72		99
500 HZ	74	58	76	61	74	58	76	61	74	67		94
1 KHZ	74	59	73	62	74	59	73	62	71	61		92
2 KHZ	71	57	73	59	71	57	73	59	69	59		90
4 KHZ	72	56	73	57	72	56	73	57	68	58		89
8 KHZ	74	56	75	57	74	56	75	57	67	56		88
Calc dBA	80	65	81	67	80	65	81	67	78	69		98

Sound option(s) selected: None

Remarks:

1. Sound Pressure Levels are according to CTI Standard ATC-128 and verified by an independent CTI-licensed sound test agency
2. Sound Power Levels are calculated according to the Small Units Section 8
3. Sound from free-field conditions over a reflecting plane with +/-2 db(A) tolerance
4. Noise levels can increase with variable frequency drives depending on the drive manufacturer and the drive configuration
5. Complete unit sound data with all fans operating

50% Speed Complete Sound Data

Anthony Tomasi
735 SW 20th Place
Suite 230
Portland, Oregon 97205
503-320-9565
anthonyt@jbarrow.com

Sound Pressure Levels (SPL) in dB RE 0.0002 Microbar
Sound Power Levels (PWL) in dB RE 10-12 Watt

Model	AT 212-4M36
Motor	30.00 HP
# Motors	2
Speed	50% Speed

2 Cell Data

	Sound Pressure Level (dB)											
	End		Motor Side		Opp End		Opp Mtr. Side		Top			Sound
Band	5.0 ft (1.5m)	50.0 ft (15.2m)	5.0 ft (1.5m)	50.0 ft (15.2m)	5.0 ft (1.5m)	50.0 ft (15.2m)	5.0 ft (1.5m)	50.0 ft (15.2m)	5.0 ft (1.5m)	50.0 ft (15.2m)		Power Level (db)
63 HZ	69	64	66	62	69	64	66	62	69	60		94
125 HZ	71	64	71	61	71	64	71	61	76	65		95
250 HZ	70	59	71	60	70	59	71	60	73	65		93
500 HZ	73	56	74	59	73	56	74	59	69	62		91
1 KHZ	74	59	73	62	74	59	73	62	68	59		92
2 KHZ	71	56	73	59	71	56	73	59	66	58		90
4 KHZ	72	56	73	57	72	56	73	57	65	58		88
8 KHZ	74	56	75	57	74	56	75	57	67	56		88
Calc dBA	80	64	81	66	80	64	81	66	74	66		97

Sound option(s) selected: None

Remarks:

1. Sound Pressure Levels are according to CTI Standard ATC-128 and verified by an independent CTI-licensed sound test agency
2. Sound Power Levels are calculated according to the Small Units Section 8
3. Sound from free-field conditions over a reflecting plane with +/-2 db(A) tolerance
4. Noise levels can increase with variable frequency drives depending on the drive manufacturer and the drive configuration
5. Complete unit sound data with all fans operating

CERTIFICATE OF COMPLIANCE

Independent Sound Validation

All EVAPCO Cooling Towers, Closed Circuit Coolers and Condensers have been tested in accordance with CTI ATC-128, Test Code for Measurement of Sound from Water-Cooling Towers, by a CTI-licensed independent test agency

As outlined in CTI ATC-128, sound testing was conducted on various EVAPCO cooling towers, closed circuit coolers and condenser models by an independent CTI-licensed sound test agency. Sound pressure levels were recorded in the acoustic near-field and far-field locations. Using certified and calibrated precision sound test instruments per test standards, the sound test agency conducted and verified the analysis.

Applicable Codes:
CTI ATC 128

Submittal Data Information

TA Series Pumps

301-618

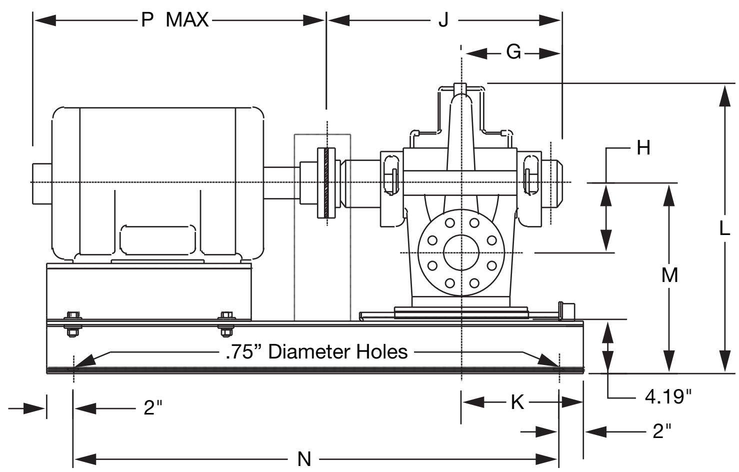
EFFECTIVE: January 17, 2014 SUPERSEDES: September 1, 2010 1160 RPM MODEL 2038

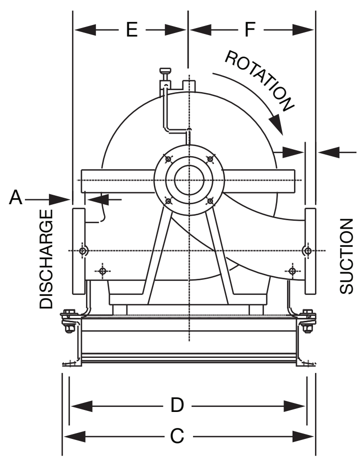
JOB Oregon State Fish & Wildlife - Rock Creek Hatchery ENGINEER ______

CONTRACTOR ______ REP. ______

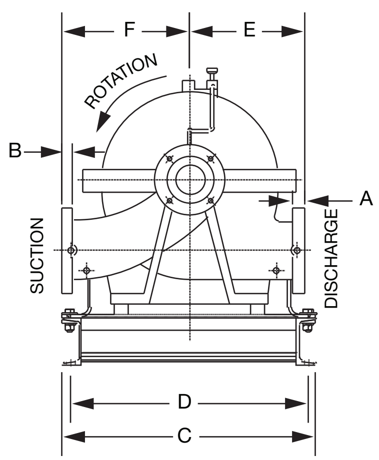
ITEM NO.	MODEL NO.	IMPELLER DIA.	G.P.M.	HEAD/FT.	H.P.	ELEC. CHAR.
CWP-1-2	TA2038	13.05	2040	50	40	460/3/60

WEIGHT ______ PUMP/MOTOR ______





Clockwise Rotation
viewed from the Coupling End



Counterclockwise Rotation
viewed from the Coupling End

SPECIFY ROTATION:

- ❏ Clockwise
- ❏ Counterclockwise

MAXIMUM ASSEMBLY WEIGHT

Motor Frame	Weight Lbs (Kg)
324T - 326T	2079 (943)
364T - 365T	2331 (1057)

DIMENSIONS

Motor dimensions are approximate and vary by manufacturer and motor type.

Model No. Flange Size	HP 1160 RPM	Motor Frame	A DISCHARGE ANSI Class 125	A DISCHARGE ANSI Class 250	B SUCTION ANSI Class 125	B SUCTION ANSI Class 250	C	D	E	F	G	H	J	K	L	M	N	P
2038 10 x 8 (254 x 203)	25	324T	1.13 (29)	1.62 (41)	1.19 (30)	1.88 (48)	27.17 (690)	25.92 (658)	17.69 (449)	18.88 (480)	14.50 (368)	8.88 (226)	34.13 (867)	13.52 (343)	35.69 (907)	22.31 (567)	64.0 (1626)	30.3 (770)
	30	326T																
	40	364T																33.4 (848)
	50	365T																

English dimensions are in inches. Metric dimensions are in millimeters. Metric data is presented in ( ).
Dimensions are subject to change without notice. Do not use for construction purposes unless certified.

MATERIALS OF CONSTRUCTION

Item	Standard	Optional
Casing	Cast Iron ASTM A48 Class 30A	N/A
Impeller	Bronze ASTM B584-836	N/A
Wear Ring	Bronze ASTM B584-836	N/A
Shaft	Carbon Steel AISI 1045	Stainless Steel AISI 420
Insert	Cast Iron ASTM A48 Class 30A	N/A
Shaft Sleeve	Bronze ASTM B584-836	Stainless Steel AISI 420

N/A - Not Available

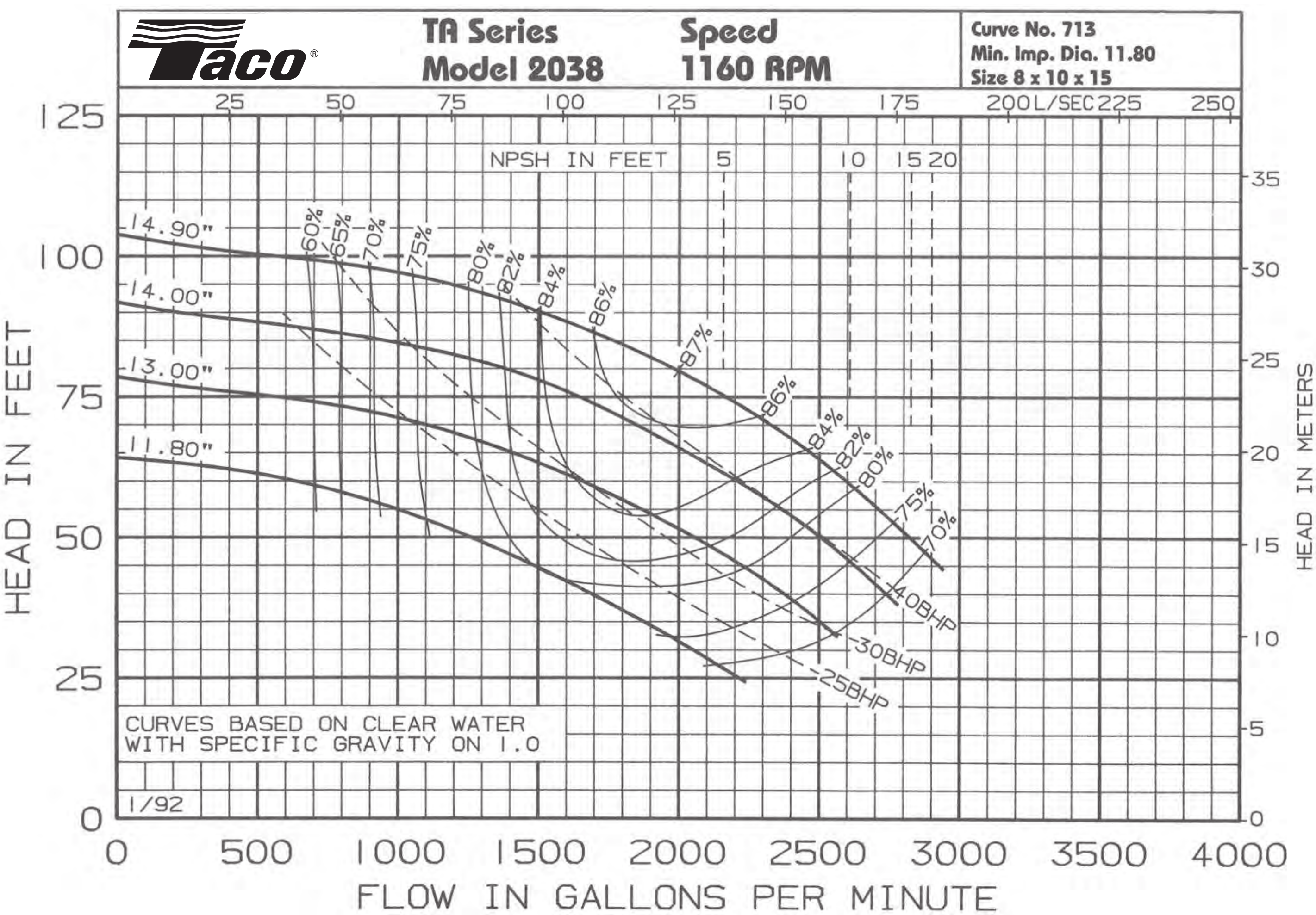
OPERATING SPECIFICATIONS

	Standard	Optional
Flange	ANSI Class 125	ANSI Class 250
Pressure	175 PSIG* (1210 KPA)	300 PSIG** (2070 KPA)
Temperature	250°F (120°C)	250°F (120°C)

Motors: All NEMA Standard (T Frame)
* In accordance with ANSI Standard B16.1 Class 125
** In accordance with ANSI Standard B16.1 Class 250 Dim.

FEATURES

	Standard	Optional
Wear Rings	Case Wear Rings	N/A
Seal Flushing	Recirculation Line	Filter & Abrasive Separators
Motors	All Standard NEMA Motors	
Base	Drip Type Base	
Additional Options	Packed Stuffing Box Two Rotation Options Balanced Mechanical Seals	



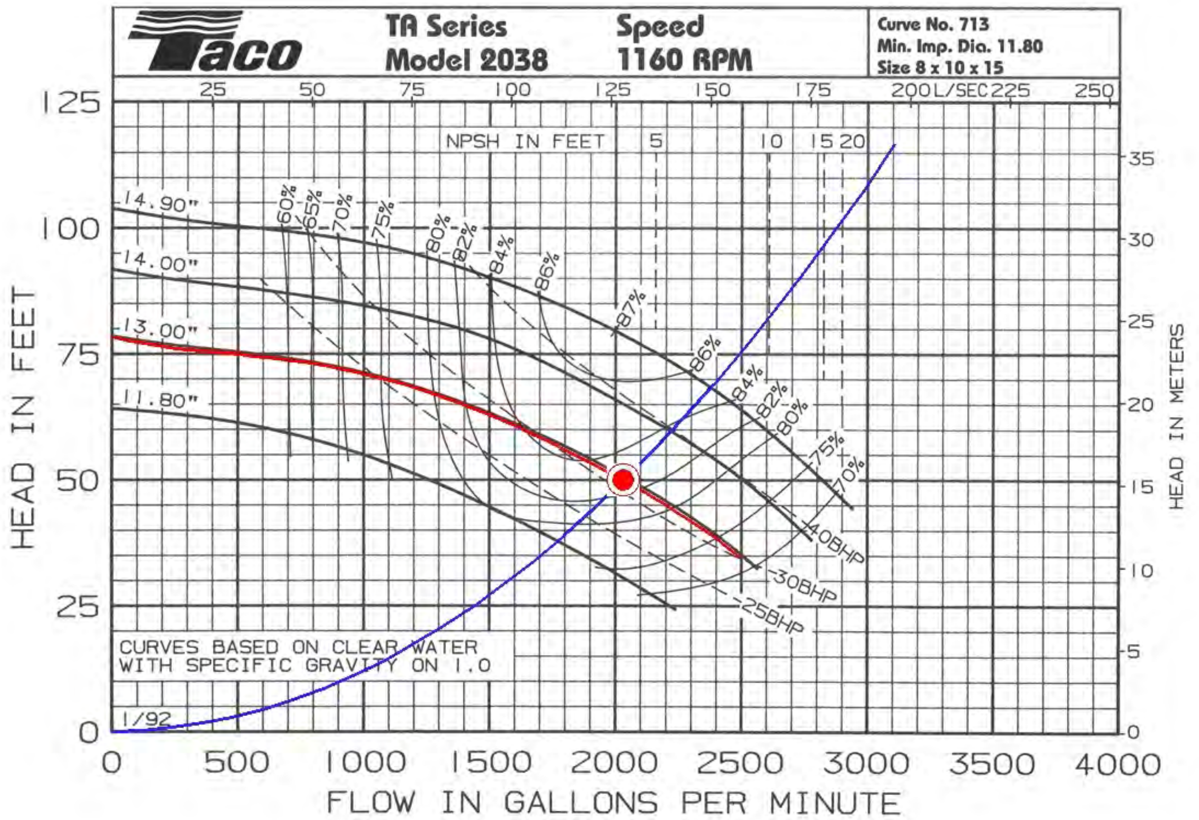
Comments: ______________________________

Taco, Inc., 1160 Cranston Street, Cranston, RI 02920 | Tel: (401) 942-8000 | FAX: (401) 942-2360
Taco (Canada), Ltd., 8450 Lawson Road, Suite #3, Milton, Ontario L9T 0J8 | Tel: (905) 564-9422 | FAX: (905) 564-9436

Horizontal Split Case   Model: TA2038

Tag: CWP-1-2

Flow Rate (GPM):	2040
Head (FT):	50
Working Fluid:	Water @ 60 F
Efficiency (%):	83%
Construction:	Iron
Design Hp:	31.08
Nol Hp:	31.28
Motor Hp:	40
Npsh (Ft):	4
RPM:	1160
Imp Dia:	13.05
Volt/Ph/Hz:	460/3/60
Notes:	



GPX Plate and Frame Heat Exchangers

Bell & Gossett
a xylem brand

C-310F

GPX technology offers maximum efficiency in less space, with outstanding application flexibility.

Innovative plate design allows GPX heat exchangers to provide more heat transfer using less space. They perform with one-third to one-fifth the surface area of conventional shell and tube heat exchangers designed for the same application.

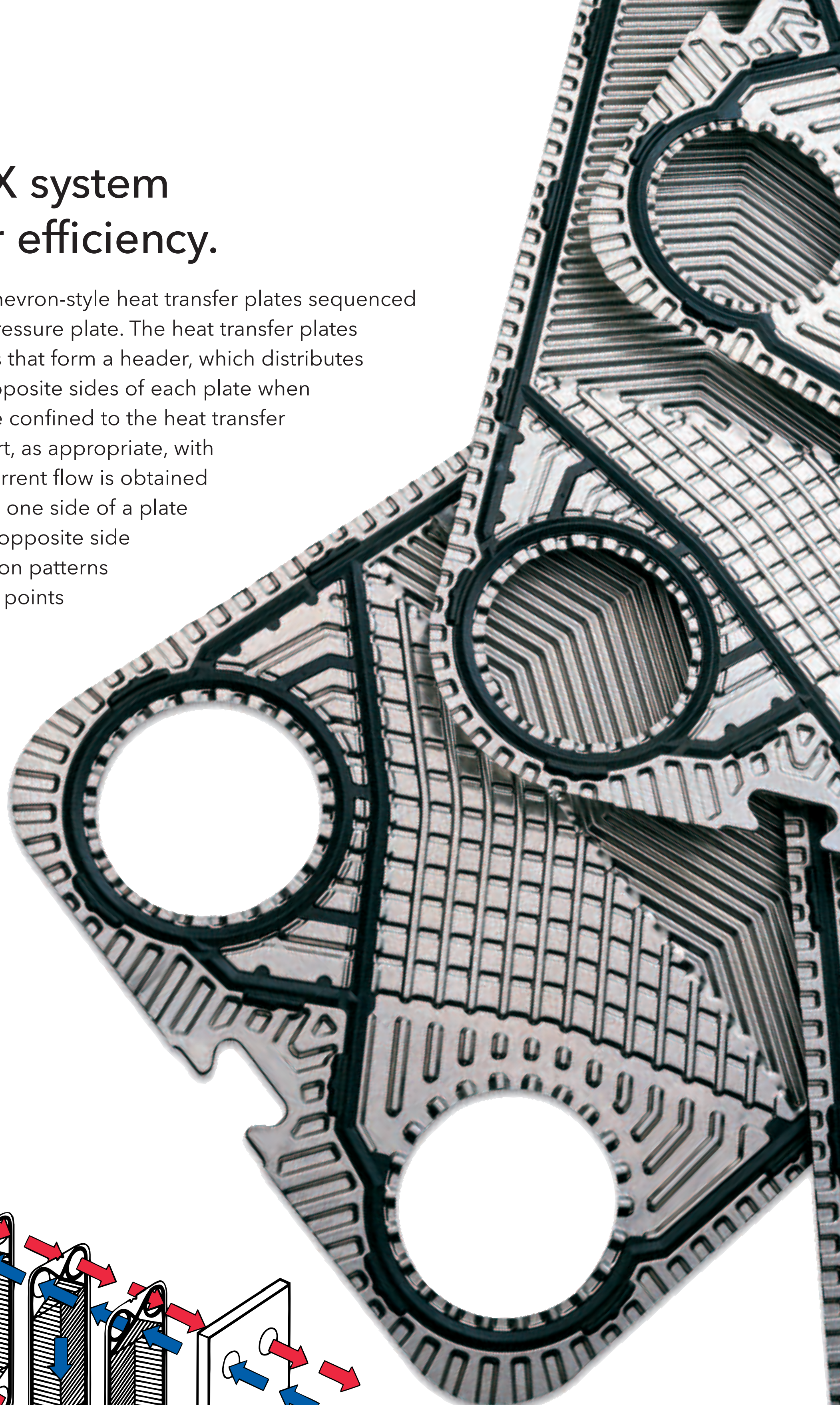
- GPX models have higher surface area to volume ratios than conventional shell and tube heat exchangers.
- GPX offers superior heat transfer coefficients compared to shell and tube heat exchangers.
- GPX offers "true" countercurrent flow, which maximizes the mean temperature difference between the fluids.

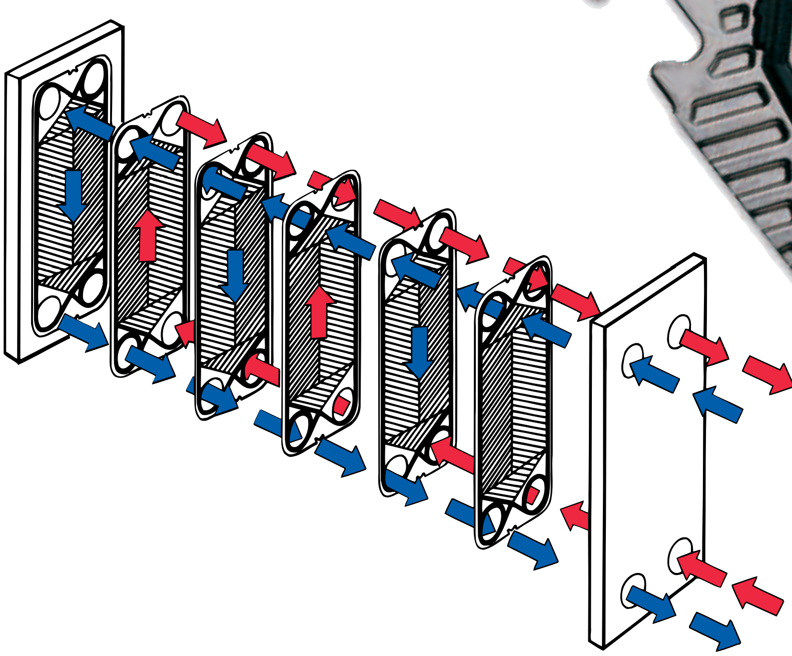
Expansive product line meets a variety of needs.

The GPX line has the capability to meet any size application, and it offers a wide variety of plate construction materials and connection types. You can choose products constructed from 304 or 316 stainless steel, titanium, Hastelloy,® Incolloy® or other metals. Plates can be gasketed, semi-welded, double wall, or free flow, depending on your particular application.

Advanced GPX system offers superior efficiency.

GPX uses a combination of chevron-style heat transfer plates sequenced between a frame plate and pressure plate. The heat transfer plates have holes at the four corners that form a header, which distributes the respective fluids to the opposite sides of each plate when the plates align. The fluids are confined to the heat transfer surface of the plate or the port, as appropriate, with elastomer gaskets. Countercurrent flow is obtained with a given fluid traveling up one side of a plate and the other fluid down the opposite side of the plate. The plate's chevron patterns create metal-to-metal contact points between adjacent plates for added strength. This allows differential pressures equal to the design pressure. The entire assembly is held together with tightening bolts. Carry/guide bars are used to obtain the proper alignment.

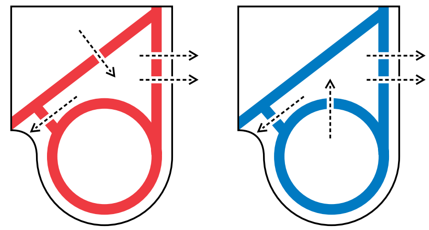




Adaptable construction offers superior versatility.

Double gasket prevents cross-contamination.

GPX models include a one-piece molded gasket. This standard gasket is designed with two rings to confine each fluid to the appropriate port region of the plate, a field region of the gasket to confine the fluid to the heat transfer area of the plate and a vented region in between. This design creates a double gasket with a leak path to atmosphere through the vented region to prevent any cross-contamination of the fluids due to a gasket failure. A leak due to a gasket failure is detected as a leak to atmosphere prior to any chance for cross-contamination. Bell & Gossett offers a variety of glueless and glued gaskets.

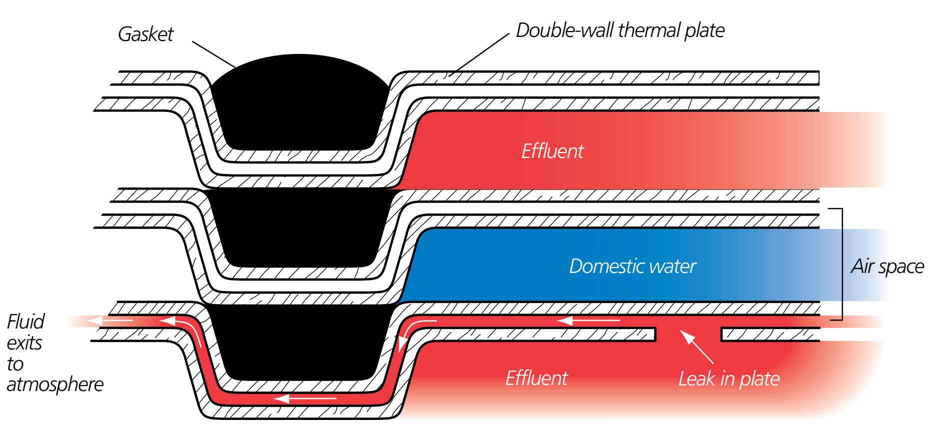


Double gasketing prevents cross-contamination.

Glueless gasket option.

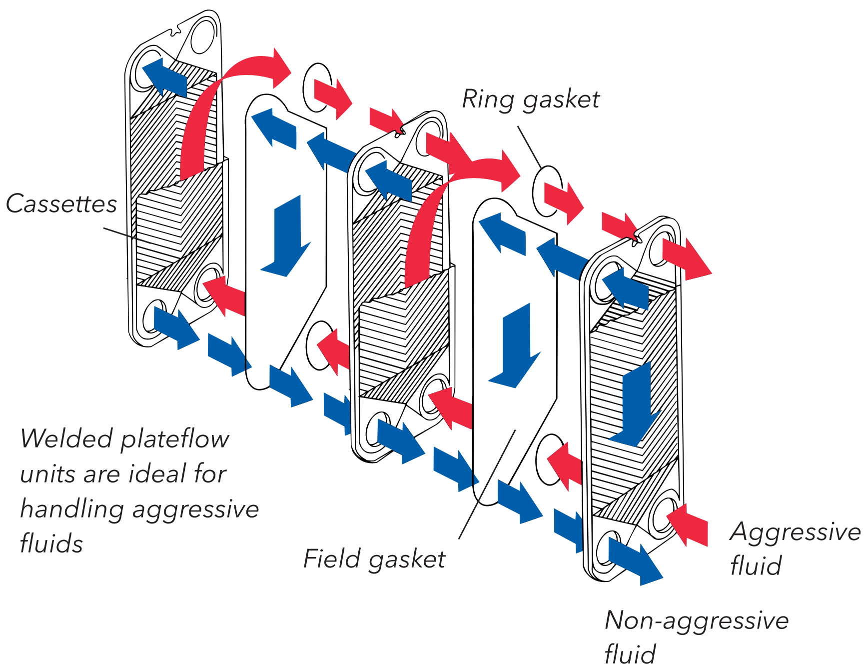
Double Wall Option

The basic GPX design includes a double gasketing feature for extra protection against gasket failure. With double-wall units, that additional protection is extended to guard against plate failure as well. Two plates are positioned together with a unique sealing mechanism at the port holes to form one assembly with air space between the plates. This unique feature protects against contamination of one fluid by another. If one of the plates should corrode and develop a leak, the fluid enters the air space and exits to the atmosphere, instead of entering the opposing passageway.

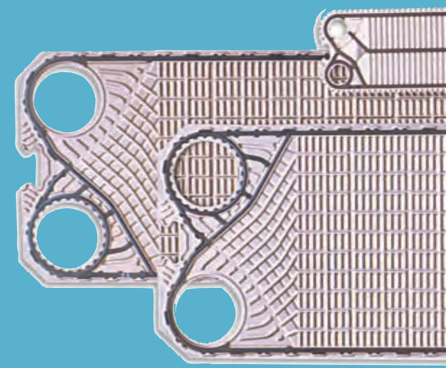


Welded Plate Option

The semi-welded GPX design expands the application envelope of plate heat transfer technology to applications that are aggressive to standard elastomers and other applications where leak prevention is critical. The semi-welded GPX design utilizes two plates laser-welded together to form a cassette. The cassettes form channels within which the welded-side fluid flows. Two ring gaskets and a field gasket are used between adjacent cassettes in the same fashion as gaskets in the standard GPX design. The ring gaskets confine the welded-side fluid between the adjacent cassettes and can be made of highly resistant Teflon® or a more traditional elastomer gasket. The design eliminates the welded side's exposed gasket surface by approximately 90%.

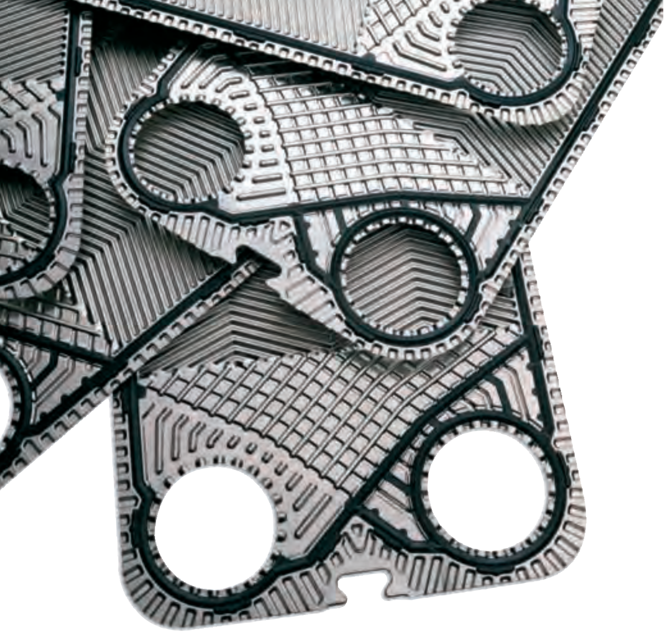


Laser welded plate cassette.



Free Flow Option

Free-flow units offer the same features of basic GPX models, with the added benefit of exceptional clog-resistance. Bell & Gossett free-flow models feature minimum or no metal-to-metal contact points between adjacent plates to reduce points for particles to catch on the plates. Free-flow models can handle fluids with particulate up to 6mm diameter.



Advanced GPX HVAC Solutions

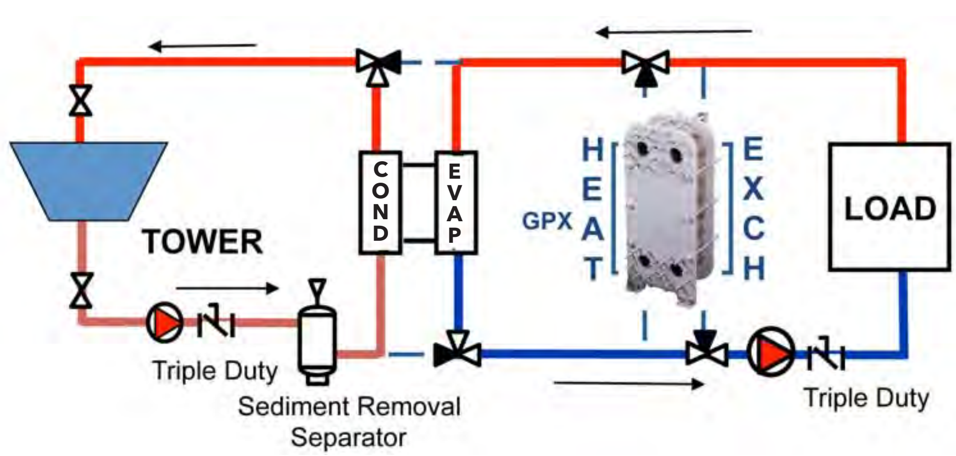
Bell & Gossett is a leading supplier of total HVAC solutions and the GPX gasketed plate heat exchanger is designed to meet the industries needs. Web-based computerized thermal design software provides solutions with the highest rates of heat transfer. These solutions result in smaller units with lower pressure drops. Bell and Gossett provides one of the greatest selection of models for gasketed plate heat exchangers to meet all you HVAC needs.

Typical list of HVAC Applications

- Waterside Economizers
- District Cooling and Heating
- Thermal Storage
- Pressure Interceptor
- Heat Pump

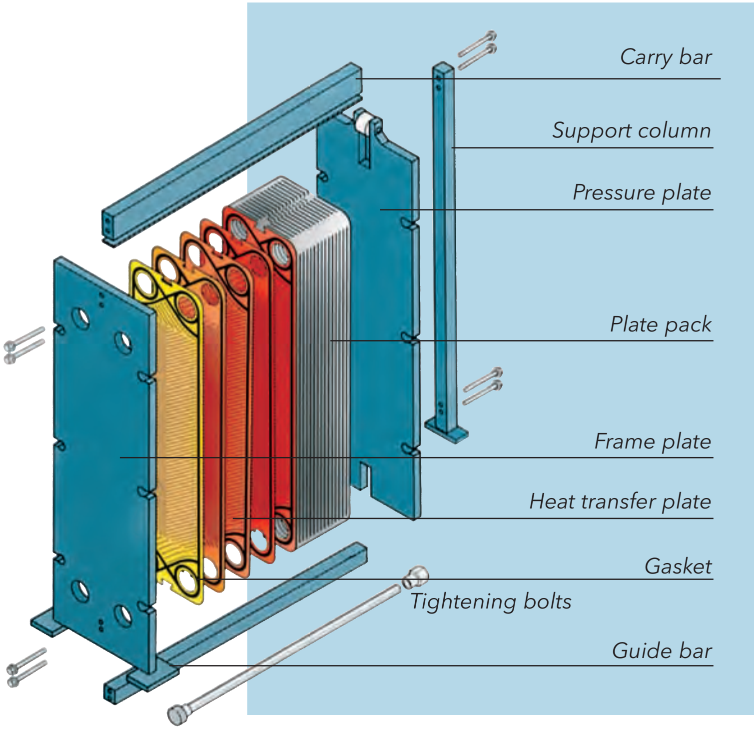
Waterside Economizers

Let Bell & Gossett design a GPX heat exchanger for your waterside economizer system. A water side economizer can utilize climate conditions that minimize chiller operation providing significant savings to the building owner. Bell & Gossett can help you meet the requirements of LEED, ASHRAE 90.1, and AHRI Standard 400.



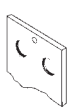
Modular design allows for easy installation and maintenance.

The GPX design makes assembly, inspection and cleaning easy.

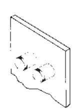


- Easy to install and move.
- Readily expandable and easy to inspect or clean.
- With studded connection, no welding is required.
- Opening or closing the unit does not require disconnecting the piping.
- No special tools needed to tighten plate pack.
- Tightening bolt design allows opening and closing the unit from frame plate.
- GPX has vertical flow, so inlet and outlet connections are above and below each other and on the same plane for easy installation.
- Studded connections withstand higher piping loads than nozzles.

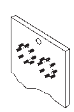
Connection Options



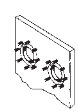
Standard threaded connection



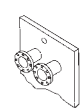
Threaded connection with alloy nozzle



Standard studded connection



Studded connection with alloy lining



Flanged connection

Industry Codes Available

- AHRI Standard 400
- ASME Section VIII Division 1 with U-1 Stamp Construction
- Canadian CRN
- EC Pressure Equipment Directive CE Mark
- China ML

Technical Data	
Performance: Maximum Flowrate (GPM)	18,000 GPM
Max. Heat Transfer Area (Sq.Ft.)	Up to 20,000 Sq. Ft.
Connections: NPT Nozzles - Size (Inches)	1 Inch to 2.5 Inch
Connections: ANSI Studded Size (Inches)	3 Inch to 18 Inch
Frame Materials	Primed and Epoxy Coated Carbon Steel
Plate Materials	Stainless Steel, Titanium, Hastelloy™, Other Higher Alloys
Gasket Materials	Nitrile, EPDM, Viton™
Frame Design Pressure	150 psi and 300 psi Standard. Up to 450 psi by request
Design Temperatures	-31F to 338F
Bolting Materials	Zinc Plated Carbon Steel
Plate Pack Shroud	Aluminum with option for Stainless Steel

Xylem |'zīləm|

1) The tissue in plants that brings water upward from the roots;
2) a leading global water technology company.

We're 12,000 people unified in a common purpose: creating innovative solutions to meet our world's water needs. Developing new technologies that will improve the way water is used, conserved, and re-used in the future is central to our work. We move, treat, analyze, and return water to the environment, and we help people use water efficiently, in their homes, buildings, factories and farms. In more than 150 countries, we have strong, long-standing relationships with customers who know us for our powerful combination of leading product brands and applications expertise, backed by a legacy of innovation.

For more information on how Xylem can help you, go to www.xyleminc.com

xylem
Let's Solve Water

Xylem Inc.
175 Standard Parkway
Buffalo, New York 14240
Phone: (800) 447-7700
Fax: (800) 862-4176
www.xyleminc.com/brands/bellgossett

Bell & Gossett GPX™

Gasketed Plate Heat Exchanger Specification Sheet

175 Standard Parkway
Cheektowaga, New York 14227
1-800-447-7700
www.xylem.com/bellgossett

Customer		Date	Wednesday, November 08, 2023
Inquiry Number	911609	Item Number	

Performance of One Unit: AP45 PN: BY5517 **Units Connected in Parallel:** 1

Fluid Name	Water		Water	
Total Flow	673.00	GPM	673.00	GPM
Inlet Temperature	80.00	°F	67.00	°F
Outlet Temperature	70.00	°F	77.00	°F
Operating Pressure	0.00	PSIG	0.00	PSIG
Pressure Drop, Allow./Calc	10.00/9.99	PSIG	10.00/9.88	PSIG
Density	62.20	lb/ft3	62.23	lb/ft3
Viscosity	0.95	cp	0.98	cp
Specific Heat	1.00	Btu/lbm,°F	1.00	Btu/lbm,°F
Thermal Conductivity	0.35	Btu/ft,h,°F	0.35	Btu/ft,h,°F
Specified Fouling Factor	0.00000	hr,ft2,°F/Btu	0.00000	hr,ft2,°F/Btu

Total Heat Exchanged	3,366,225.00	Btu/h
LMTD	3.00	°F
Overall Heat Transfer Coefficient, Clean/Dirty	927.40/927.40	Btu/hr,ft2,°F
Overall Heat Transfer Coefficient, Service	910.88	Btu/hr,ft2,°F
Effective Surface Area	1,231.39	ft2
Excess Surface	1.79	%

Construction

Number of Passes * Channels	1*130		1*131
Total Number of Plates		262	
Pressure, Design/Test	150/195(PSIG)		150/195(PSIG)
Design Temperature, min/max	32/284(°F)		32/284(°F)
Internal Volume	3.72(ft3)		3.75(ft3)
Inlet Connection(Location)	F1, steel studded port for 150# ansi flange 4.00 "		F3, steel studded port for 150# ansi flange 4.00 "
Outlet Connection(Location)	F4, steel studded port for 150# ansi flange 4.00 "		F2, steel studded port for 150# ansi flange 4.00 "

Plate Material	304
Plate Thickness	0.40 mm
Plate Mix	XMXL-27
Gasket Material	NITRILE HT
Empty/Flooded Weight	2,008 / 2,474 lb
Frame Size / Max. Frame Capacity	59.06 inch / 273 plates
Approvals	ASME Sect VIII Div 1 w/U stamp.
Notes	This heat exchanger is certified by the AHRI Liquid to Liquid heat exchangers certification program based on AHRI Standard 400. AHRI certified units are subject to rigorous and continuous testing, have performance ratings independently measured and are third party verified. Certified units may be found in the AHRI directory at www.ahridirectory.org.

Note: Customer to verify fluid/material compatibility.

Performance evaluation is dependent on customers' ability to provide sufficiently accurate measurements.

Gene Johnson

Figure 1: Filter shown without manual by-pass valve.
Figure 2: Filter shown with manual bypass valve.

ORG-040-LE SHOWN -- ORG-060-LS,ORG-060-LE, ORG-080-LS & ORG-100-LS are Similar

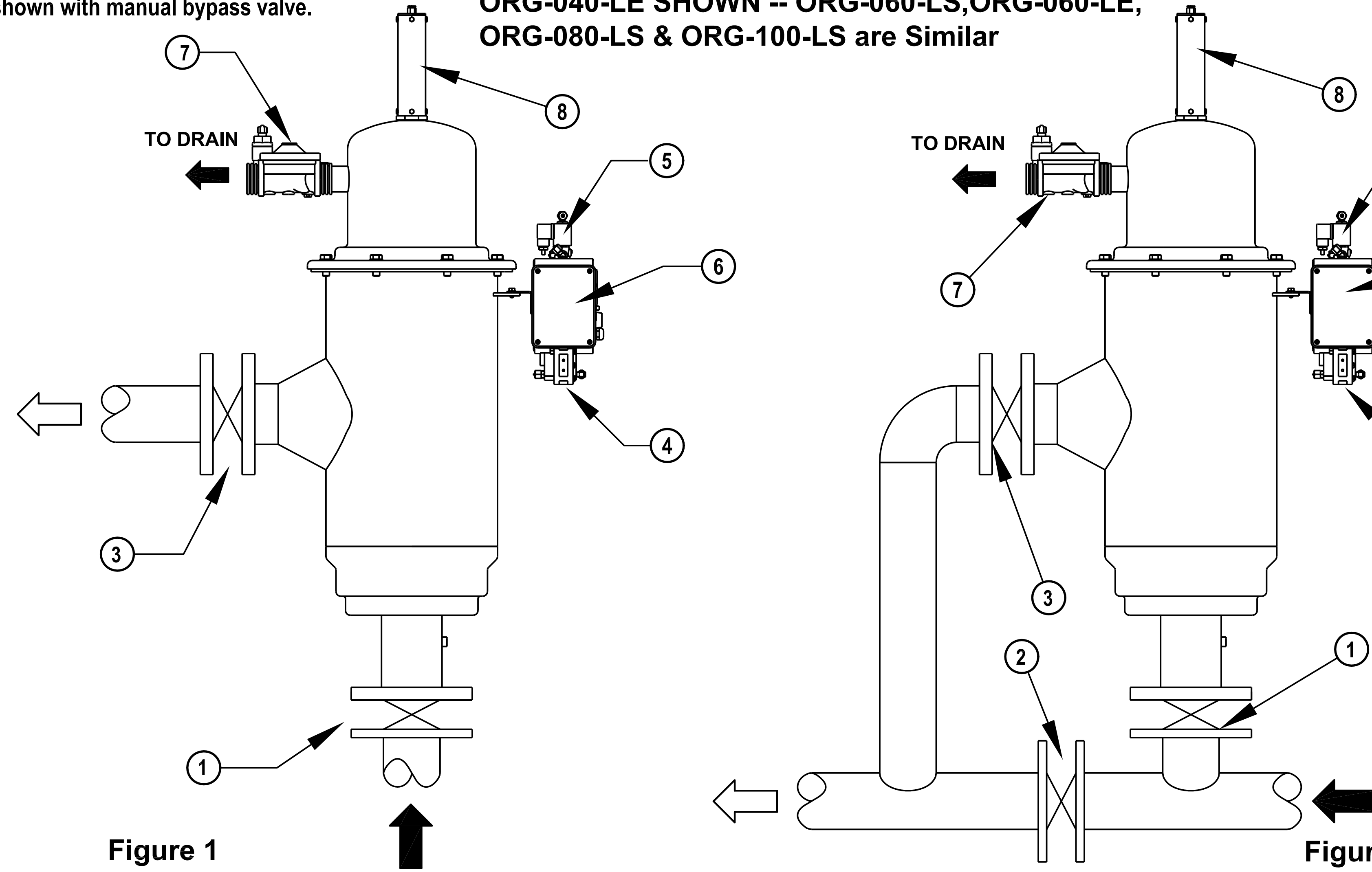


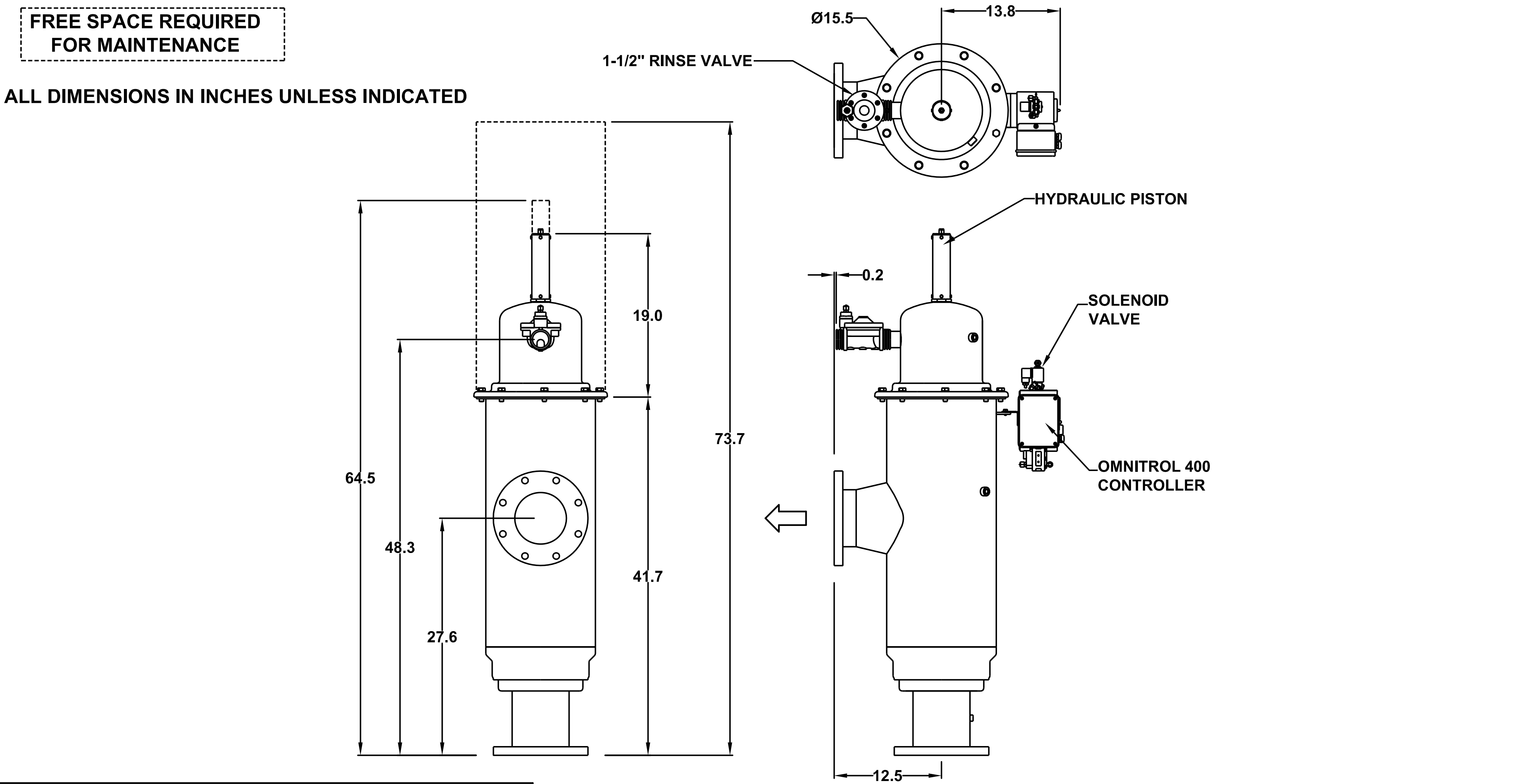
Figure 1

Figure 2

No.	Description	Notes
8	Hydraulic Piston	Connect to the Solenoid
7	1-1/2" Rinse Valve	Pipe to 1-1/2"or Larger Drain
6	Controller	Mounted on Filter Housing Can be Remote Mounted
5	Solenoid Valve	24 V, 60 Hz, 3 way N.O.
4	Differential Pressure Switch	Preset to 7 psi
3	Outlet Valve	Customer Supplied
2	System Bypass Valve	Customer Supplied
1	Inlet Valve	Customer Supplied

NOTE: Drain Line from the Rinse Valve Should have a Coupling to Allow Easy Removal of the Top Section of the Body During Maintenance.

DWG. NO. 2027-1	SCALE: NONE	ORIVAL, INC. 213 S. VAN BRUNT ST. ENGLEWOOD, N.J. 07631 TEL (201) 568-3311, FAX (201) 568-1916
DRAWN BY: G KALINOWSKI	DATE: 10/20/09	ORG 4", 6", 8" & 10" FILTER TYPICAL INSTALLATION LAYOUT



Orival Inc. reserves the right to modify filter dimensions without prior notice.

TECHNICAL DATA

MAXIMUM FLOW RATE:	660 G.P.M.
AVAILABLE SCREEN MICRON SIZES:	5, 10, 15, 25, 30, 40, 50, 80, 100, 120, 150, 200, 400, 800, 1000, 1500, 3000
OPEN AREA STD. SCREEN :	648 SQ. INCHES
OPEN AREA HIGH PERFORMANCE SINTERED MULTI-LAYERED SCREEN:	972 SQ. INCHES
MAXIMUM WORKING PRESSURE:	150 PSIG
MINIMUM INLET PRESSURE REQUIRED DURING RINSE CYCLE:	30 PSIG
MAX. WORKING TEMPERATURE:	150°F
INLET/OUTLET CONNECTIONS:	6" ANSI 150# RF
DRAIN VALVE CONNECTION:	1-1/2" FEMALE
DRAIN HEADER SIZE:	1-1/2" MINIMUM
APPROX. EMPTY WEIGHT: APPROX. FULL OF WATER WEIGHT:	260 LBS. 435 LBS.

DATA SHEET

ORG-060-LE

AUTOMATIC SELF-CLEANING FILTER

ORIVAL, INC.
213 S. VAN BRUNT ST.
ENGLEWOOD, N.J. 07631
TEL (800) 567-9767, (201) 568-3311
FAX (201) 568-1916
www.orival.com
filters@orival.com

Performance Report

Performance Specification

Project Name: **Oregon State Fish & Wildlife - Rock Creek Hatchery**	Unit Tag: **CH-1**	Qty.: **1**	Model: **YVAA0523**

Full Load - Design

PIN								
YVAA0523JP	V46CHVSXXX	SAXLXXXX60	58XDFXXH15	7X1SXXA2BT	XVXXXXGXXX	XXXSXX		
....5...10	....5...20	....5...30	....5...40	....5...50	....5...60	....5...70	....5...80	....5...90

Unit	
Model No.	YVAA0523
Number of Compressors	2
Compressor Type	VSD Screw - Semi Hermetic
Number of Compressor Circuits	2
Capacity Control	10% - 100%
Refrigerant	R-513A
Performance Data	
Net Cooling Capacity [tons.R]	500.0
Total Power Input [kW]	590.0
EER [Btu/W.h]	10.17
NPLV.IP [Btu/W.h]	24.81
A-Weighted Sound Power [dB(A)]	111.0
Electrical Data	
Nominal Voltage / Voltage Limits	460-3-60.0 / 414V - 508V
Compressor kW (each circuit)	273.8 / 274.6
Compressor RLA (each circuit) [A]	394.2 / 394.2
Fan QTY (each circuit)	13 / 13
Fan FLA (each circuit) [A]	2.4 / 2.4
Min. Circuit Ampacity [A]	955.0
Max. Fuse / CB Rating [A]	1200.0
Unit Short Circuit Withstand [kA]	30 kA
Wires Per Phase	4
Wire Range (Lug Size)	1/0 - 750 kcmil
Displacement Power Factor	0.95
Control kVA	3.000

Performance Impacting Options	
End User Application	Data Center / Process Duty
Compressor Style	High Capacity Optimized Part Load Efficiency
Condenser Coil	Post-Coated Microchannel Coils (Environment Guard)
Fan	Low Sound Fans With Variable Speed Control
Sound Attenuation	Standard Factory Sound Kit (Level 0 Reduction)
Weight & Dimensional Data	
Shipping Weight [lbs]	28455
Operating Weight [lbs]	29813
Refrigerant Charge [lbs]	406 / 430
Length [in]	599.3
Width [in]	88.3
Height [in]	94.6

YORK®

Performance Report

Performance Specification

Project Name: **Oregon State Fish & Wildlife - Rock Creek Hatchery** | Unit Tag: **CH-1** | Qty.: **1** | Model: **YVAA0523**

Heat Exchanger Performance

Evaporator		Condenser (Air Cooled)	
Heat Exchanger Type	Hybrid Falling Film	Ambient Air Temperature* [ºF]	105.0
Entering Fluid Temperature* [ºF]	68.20	Altitude* [ft]	0.00
Leaving Fluid Temperature* [ºF]	58.00	Condensing Temperature [ºF]	139.91 / 139.87
Flow Rate [USGPM]	1177	Number of Fans (Circuit 1 / Circuit 2)	13 / 13
Fouling Factor* [h ft2 F/Btu]	0.000100	Total Air Flow [cfm]	325000
Fluid Type*	Water	Total Fan Power [kW]	41.60
Passes*	2		
Pressure Drop [ft H2O]	18.8		
Fluid Volume [USGAL]	146.9		
Evaporating Temperature [ºF]	55.38		
Minimum Flow Rate [USGPM]	550.0		
Maximum Flow Rate [USGPM]	2160		

* Designates user specified input

Certified in accordance with the AHRI Air-Cooled Water-Chilling Packages Using Vapor Compression Cycle Certification Program, which is based on AHRI Standard 550/590 (I-P) and AHRI Standard 551/591 (SI). Certified units may be found in the AHRI Directory at www.ahridirectory.org. Auxiliary components included in total KW - Oil heaters, Chiller controls. Auxiliary power is already included in the compressor and fan power

AHRI CERTIFIED® www.ahridirectory.org
Air-Cooled Water Chilling Packages
AHRI Standards 550/590 and 551/591

Part Load Performance (Based on Standard AHRI Unloading)

Percent Load	Ambient [ºF]	Capacity [tons.R]	Power Input [kW]	Unit Efficiency [Btu/W.h]
100.0	105.0	500.0	590.0	10.17
75.0	86.3	375.0	262.5	17.14
50.0	67.7	250.0	102.0	29.42
25.0	55.0	125.0	42.17	35.57

Project Name: **Oregon State Fish & Wildlife - Rock Creek Hatchery**	Unit Tag: **CH-1**	Qty.: **1**	Model: **YVAA0523**

Sound Power Levels (In Accordance with AHRI 370)

Percent Load	Ambient [ºF]	Octave Band Center Frequency [Hz]								LWA
		63	125	250	500	1000	2000	4000	8000	
100.0	105.0	101.0	101.0	103.0	109.0	107.0	102.0	97.0	88.0	111.0
75.0	86.3	97.0	105.0	114.0	108.0	102.0	92.0	87.0	80.0	109.0
50.0	67.7	93.0	96.0	95.0	99.0	100.0	85.0	80.0	74.0	102.0
25.0	55.0	83.0	91.0	90.0	94.0	92.0	79.0	74.0	66.0	95.0

Note:Unit is equipped with Low Sound Fans With Variable Speed Control.

Measurement of sound pressure used to obtain the sound power data presented is based on AHRI-370.

Air-cooled chillers are rated in terms of sound power not sound pressure. Johnson Controls provides estimates of sound pressure, but this is not the rating metric.

For an air-cooled chiller, sound pressure calculated from sound power varies depending on how the chiller is assumed to behave, i.e. the radiation model. In other words, determining sound pressure from sound power requires making assumptions that result in different answers at a given distance from the chiller. The environment also influences sound pressure in the field installation. Sound pressure estimation radiation models pertaining to air-cooled chillers include the 'traditional' hemispherical model, parallelepiped model and equivalent hemispherical model.

Regarding sound power, Johnson Controls references tolerance limits based on ASHRAE guidelines. These are +/- 6dB in the 63Hz octave band, +/- 4dB in all other octave bands and +/- 3dB for the overall dBA.

Tolerance limits are based on uncertainties associated with:

1. Measurement Test Procedure

2. Repeatability

3. Production / Manufacturing Variability

Standard deviation associated with air-cooled chiller sound data is a measure of spread i.e. it indicates the range of probability of sound levels. Note that for operating conditions other than AHRI's Standard Rating Condition, higher levels of uncertainty can be expected.

Lead times for factory performance testing depend on test laboratory availability. Please confirm with Johnson Controls Customer Service.

Performance at AHRI Conditions

Evaporator		Condenser	
EFT [ºF]	54.00	Ambient Temp. [ºF]	95.0
LFT [ºF]	44.00	Altitude [ft]	0.00
Flow Rate [USGPM]	1197	**Performance**	
Pressure Drop [ft H2O]	20.3	EER [Btu/W.h]	9.513
Fluid Type	Water	IPLV.IP [Btu/W.h]	19.03
Fouling Factor [h ft2 F/Btu]	0.000100	Net Cooling Capacity [tons.R]	500.0
Fluid Volume [USGAL]	146.9		

Note:Unit rated at design condition capacity.

Part Load Performance (Based on AHRI 550/590 - 2018 (IP))

Percent Load	Ambient [ºF]	Capacity [tons.R]	Power Input [kW]	Unit Efficiency [Btu/W.h]
100.0	95.0	500.0	630.7	9.513
75.0	80.0	375.0	321.1	14.01
50.0	65.0	250.0	136.3	22.02
25.0	55.0	125.0	57.27	26.19

Project Name: **Oregon State Fish & Wildlife - Rock Creek Hatchery** Unit Tag: **CH-1** Qty.: **1** Model: **YVAA0523**

Notes:

Country of Origin:Mexico

Min DSD (Factory Purpose/Use Only):154.0 psig

Displacement Power Factor refers to compressor only. Unit Power Factor depends on fan option selected. Calculated value is available by request.

Use Copper Conductors only

Minimum and maximum evaporator flow information are for full load ratings with Water.

Evaporator Passes:2, Condenser Type:T, Fan Type:V

Compliant with ASHRAE 90.1 - NC.

Compliant with IECC - 2012,2015,2018.

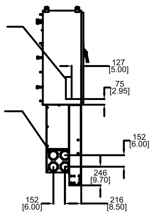
The product image shown is for illustrative purposes only and is not representative of selected options.

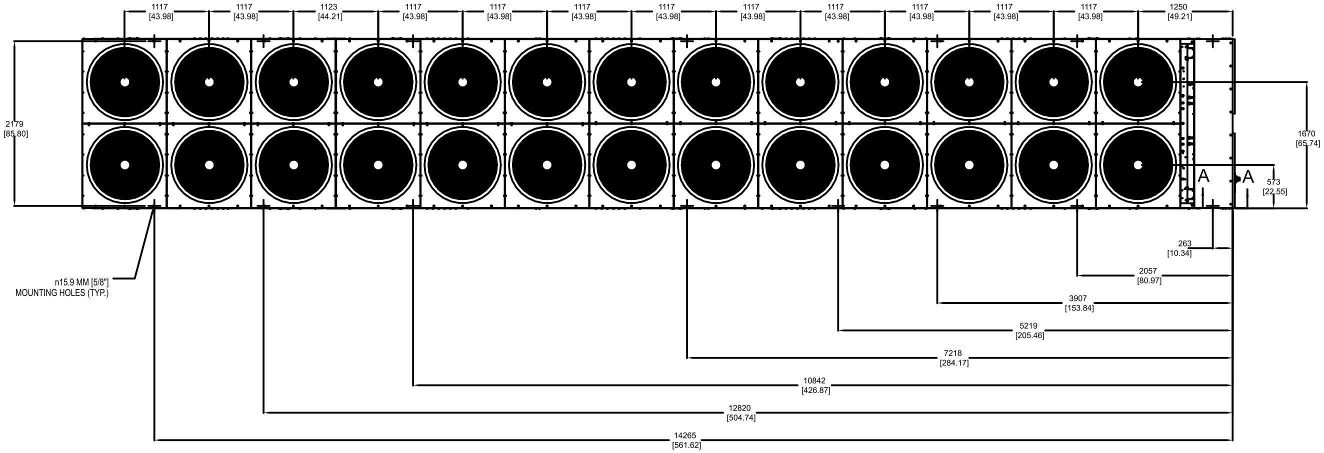
NOTES:
1. PLACEMENT ON A LEVEL SURFACE FREE OF OBSTRUCTIONS (INCLUDING SNOW, FOR WINTER OPERATION) OR AIR RECIRCULATION ENSURES RATED PERFORMANCE, RELIABLE OPERATION AND EASE OF MAINTENANCE. SITE RESTRICTIONS MAY COMPROMISE MINIMUM CLEARANCES INDICATED BELOW, RESULTING IN UNPREDICTABLE AIR FLOW PATTERNS AND POSSIBLE DIMINISHED PERFORMANCE. YORK'S UNIT CONTROLS WILL OPTIMIZE OPERATION WITHOUT NUISANCE HIGH PRESSURE SAFETY CUTOUT; HOWEVER, THE SYSTEM DESIGNER MUST CONSIDER POTENTIAL PERFORMANCE DEGRADATION. ACCESS TO THE UNIT CONTROL CENTER ASSUMES THE UNIT IS NO HIGHER THAN ON SPRING ISOLATORS. RECOMMENDED MINIMUM CLEARANCES: SIDE TO WALL - 6'; REAR TO WALL - 6'; CONTROL PANEL TO WALL - 4'; TOP - NO OBSTRUCTIONS ALLOWED; DISTANCE BETWEEN ADJACENT UNITS - 10'; NO MORE THAN ONE ADJACENT WALL MAY BE HIGHER THAN THE UNIT.
2. WEIGHT AND CENTER OF GRAVITY - REFER TO AVM REPORT.
3. WATER CONNECTIONS ARE GROOVED FOR VICTAULIC CONNECTION.
4. DIMENSIONS IN mm [INCHES].
5. POWER WIRING MUST BE ROUTED TO AVOID INTERFERENCE WITH THE AUTOTRANSFORMER ENCLOSURE LOCATED UNDERNEATH THE CONTROL PANEL

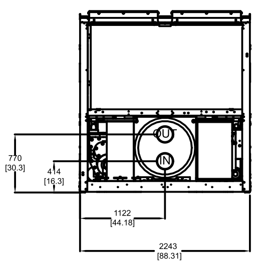
NOZZLE LEGEND

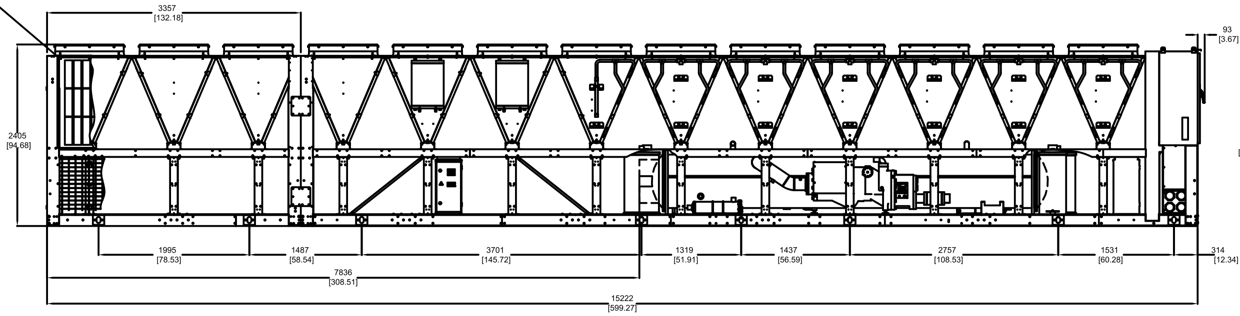
EVAPORATOR INLET LEFT END 2 PASS 8 DIA. (150Psig DWP)
EVAPORATOR OUTLET LEFT END 2 PASS 8 DIA. (150Psig DWP)

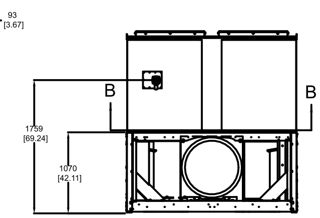
Victaulic Grooved Nozzles (per ANSI / AWWA C-606)











PRODUCT DRAWING YORK YVAA Air Cooled Screw Chiller MODEL: YVAA 0523 **NOT FOR CONSTRUCTION**	Project Name: Location: San Antonio Engineer: Contractor: For:	Sold To: Cust Purch Order#: 6 Contract#: UNIT TAG: CH-1	Date: May 26, 2020 Rev. Date: October 27, 2023 Form No.: 201.28-EG1 Dwg. Lev.: 0817 Dwg. Scale: NTS	Johnson Controls

APPENDIX D – ELECTRICAL EQUIPMENT CUT SHEETS

Eaton Power Xpert Solar Inverter Achieves UL 1741 Listing

By Kathie Zipp | February 18, 2014

Power management company Eaton announced its Power Xpert Solar 1670-kW solar inverter is certified to meet Underwriters Laboratories (UL) 1741-2010 standard by Intertek. The certification is required for solar inverter connection to the electrical grid, and demonstrates reliable and safe performance in utility applications.

Eaton's Power Xpert Solar 1670 kW Inverters

"The UL listing is a major achievement that will allow more customers to take advantage of the field-proven and cost-effective technology," said Chris Thompson, solar business unit manager, Eaton. "When combined with our new monitoring and racking products, Eaton is now able to provide utility-scale customers with a single source for end-to-end balance of system solutions."

With a true megawatt inverter platform and unique transformer coupling approach, the Power Xpert Solar 1670 inverter enables a skid-less inverter station designed to reduce equipment requirements and installation costs. The inverter and transformer are connected through a direct-coupled throat connection engineered to boost system electrical efficiency and reduce cable requirements, pad size and commissioning time.

The Power Xpert Solar inverter can also provide a ±0.91 power factor range without power de-rating. This technology is engineered to help developers and designers eliminate or reduce the amount of equipment required to provide power factor and reactive power (VAR) support.

Eaton is leveraging more than 100 years of experience and expertise in utility and industrial environments to bring to market the Power Xpert Solar utility-scale inverter. Backed by a century of performance and experience with electrical power systems, the robust Power Xpert Solar inverter is engineered to optimize, reliability and cost of ownership.

Tell Us What You Think!

Appendix D: Technical Memorandum – Deferred Hatchery Maintenance

Prepared by QRS Consulting, LLC

Technical Memorandum – Deferred Hatchery Maintenance

To:	Ryan McCormick	Project:	State of Oregon Contract # 835-099-24
From:	Jerrod Vaughn, PE William Zimmerman, PE	cc:	
Date:	6/14/2024	Job No.:	01F2404.00
Subject:	2024 Deferred Hatchery Maintenance Evaluations		

1.0 Background

The State of Oregon's Department of Fish and Wildlife (ODFW) has numerous hatcheries they own, operate and maintain in the State of Oregon. The ODFW has identified specific improvements at eight of these hatcheries. These are Alsea, Bandon, Elk River, Salmon River, Cedar Creek, Trask, Nehalem and Roaring River. In April 2024 ODFW contracted with QRS Consulting, LLC (QRS) to provide a brief description of the proposed improvements, verify their feasibility at a high level and provide a preliminary capital cost for each major element.

REGISTERED PROFESSIONAL ENGINEER
86850PE
Exp. 6-30-26
OREGON
7/10/24
DEC. 13, 2012
WILLIAM ZIMMERMAN

Construction costs provided do not include owner's cost for engineering support services, inspection services and project management costs. These costs are considered very conceptual and have an expected range of plus or minus 50%. Variations in these cost estimates could be significant based on the final scope of the project, selected project approach, year constructed, permitting requirements, and many other variables. These estimates are intended to provide ODFW with an approximate order of magnitude capital costs for long-term and overall budget planning.

2.0 Alsea Hatchery

Items under consideration at the Alsea Fish Hatchery include: an intake screen that meets criteria; realignment of the rearing ponds; and evaluation of available head at the hatchery building.

2.1 Intake Screen

The existing intake screen would meet velocity criterion of 0.4 ft/sec for a flow of no more than 37 cfs, well below the target flow of 47 cfs. The screen is oriented nearly flat to accommodate manual cleaning, which is not ideal for currently supplied automatic screen wipers. A new intake structure would be designed to accommodate a larger screen to meet velocity criterion. A modern wiper and a coarse trash rack would also be included in the design. The effective screen height for the new intake is assumed to be 5 feet. Therefore, the effective screen length would need to be at least 23.5 feet long. To assure compliance, 15%

was added for a length of 27 feet. The new screen wiper would be similar to those commonly supplied by Duperon or Atlas. The new concrete intake would be 30 feet by 30 feet overall in plan view but include a tapered section to the outlet pipe. There would be a slide gate to isolate the intake supply pipe.

Table 2.1 Construction Cost Estimate – Intake Replacement

Low Range	Estimate	High Range
$2.4M	$4.7M	$7.1M

2.2 Rearing Pond Alignment

The twenty 20' by 100' raceways will be replaced by eight 20' by 250' raceways (see Figure 2.1). Each 250' long raceway would be partitioned into thirds for bio-separation. A new 42" main line would start at PT 7 (see ODFW drawing # 1-43), be routed along the north end of the new raceways, and connect to the existing 42" line to the holding pond and fish ladder. The existing 30" line into the hatchery would tee into the new 42" line. The proposed raceway layout would allow for a majority of the construction to occur without interfering with hatchery operations. One potential construction sequencing would be: demo ten rectangular and three circular raceways and associated lines on the north end of the grounds while protecting the water supply line to the hatchery building; construct the new raceways from the west to the east providing pipe stub connections; prior to constructing the far east raceway demo the existing east raceways (west raceways could still be in service); construct discharge lines from the new east raceways and connect to the existing lines to the settling pond and pond 26; demo existing west raceways starting on the north end and construct the discharge lines from the new raceways; construct the new supply line to the new raceways, hatchery building, and fish ladder. For the supply line cut over, maintain water supply to the hatchery building for incubation while putting into service the raceways starting on the west. This would allow fry to be moved to the raceways if needed during the cut-over process.

A ground survey and hydraulic analysis would need to be conducted to verify the validity of the proposed alignment.

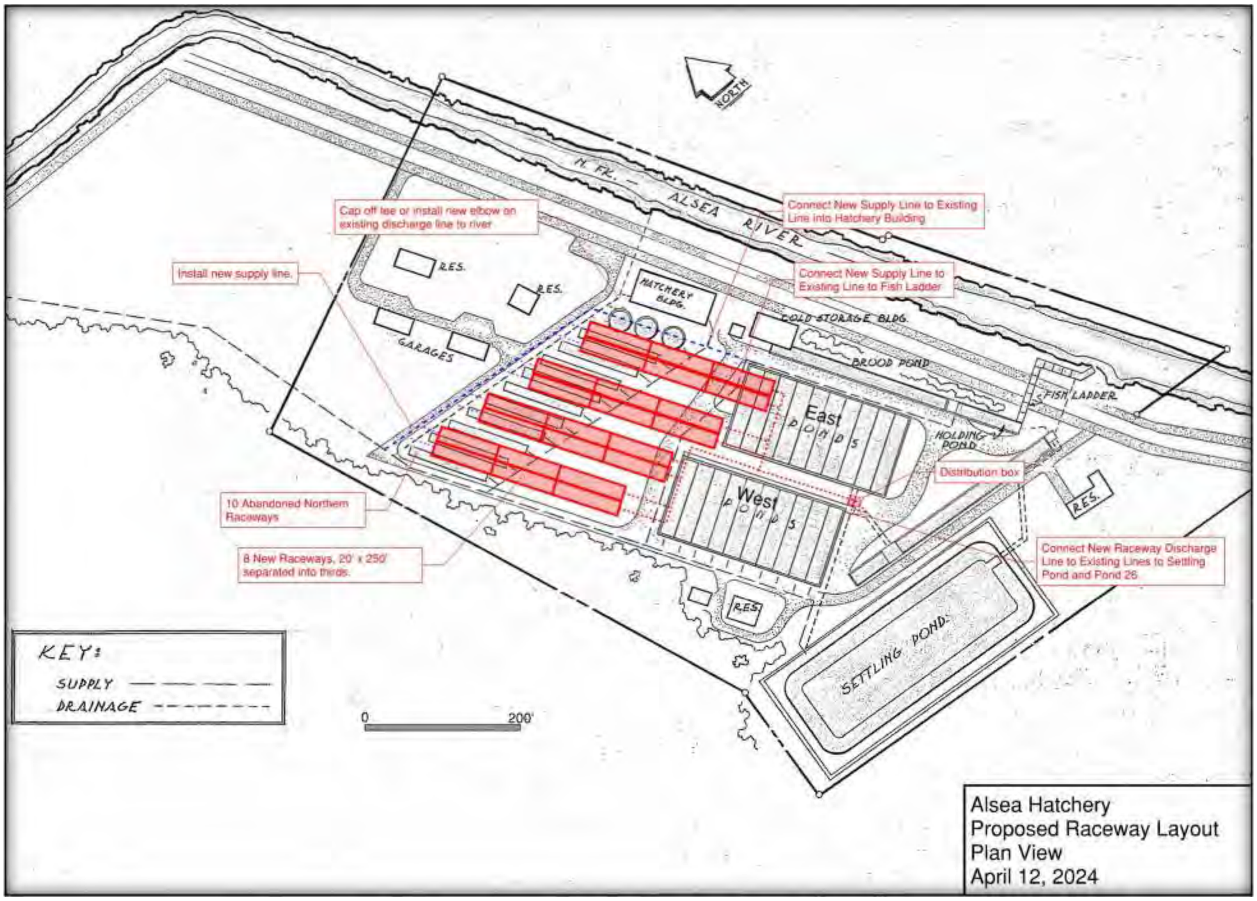


Figure 2.1 – Alsea – Proposed Raceway Layout

Table 2.2 Construction Cost Estimate-Rearing Pond Alignment

Low Range	Estimate	High Range
$5.0M	$10.1M	$15.1M

2.3 Hatchery Building Head Evaluation

Headloss to the hatchery building was calculated using current and proposed conditions. Under current conditions total headloss from the intake to the hatchery building with a 40 cfs main supply flow and 3.8 cfs flowing into the hatchery building is estimated at 3.1 feet. Under the proposed piping plan with a 47 cfs main supply flow, the headloss would increase to 4.4 feet. Comparing both current and proposed conditions with a main supply flow of 47 cfs, the proposed plan would increase the total head loss by 0.3 feet. Since the intake will need to be replaced to meet velocity criterion and the 42” main supply line is over 50 years old, it is suggested that the main supply line be replaced with 48” HDPE pipe with an alignment as shown in Figure 1. This would change the total headloss at the hatchery building to approximately 2.1 feet.

3.0 Bandon Hatchery

Items under consideration at the Bandon Fish Hatchery include removing and relocating the Geiger Creek dam and the Ferry Creek dam.

3.1 Geiger Creek Dam

Geiger Creek dam is a relatively small earth dam with a concrete overflow spillway located on Geiger Creek approximately 300 feet from the Bandon Fish Hatchery. Water from the dam flows into an intake structure and pipe the feeds water to Bandon Hatchery. Excess stream inflow discharges down a concrete overflow spillway and through a 48” diameter culvert. It has been proposed to remove the dam and construct a new diversion structure upstream.

The proposed location of the new diversion structure is approximately 350 feet upstream of the existing dam (see Figure 1). This location is at the approximate upstream end of the existing impoundment and is just downstream of a natural stream bend to the right (north). The diversion would be constructed of steel sheet pile. A geotechnical investigation would need to be conducted to verify soil type similar to the investigation completed for Ferry Dam. There would be an overflow section on the left side of the diversion to take advantage of the natural flow path to the left bank. The pipe entrance would be on the right side for easy personnel access. Lower-level sluice gates and a tilting weir gate in the center of the diversion would provide additional spill capacity during spring runoff as well as a means to flush sediment during runoff and clear floating debris during low flow periods. The diversion would only need to be around 6 feet tall to insure hydraulic entrance losses to the supply pipe are met at the maximum design flow. Final height would be determined, in part, by hydrology of the basin, site geology and spillway capacity.

The existing dam, culvert pipe, and concrete spillway would be removed. The access road to the new diversion would parallel the east bank. A section of stream channel would be constructed from the new diversion along the west side and connect to the stream channel downstream of the existing dam. The new supply pipe would parallel the access road and connect to the existing 14” supply line near Pond 1.

Construction is estimated to last 8 months but is highly dependent on the condition of the excavated material and scheduling constraints.

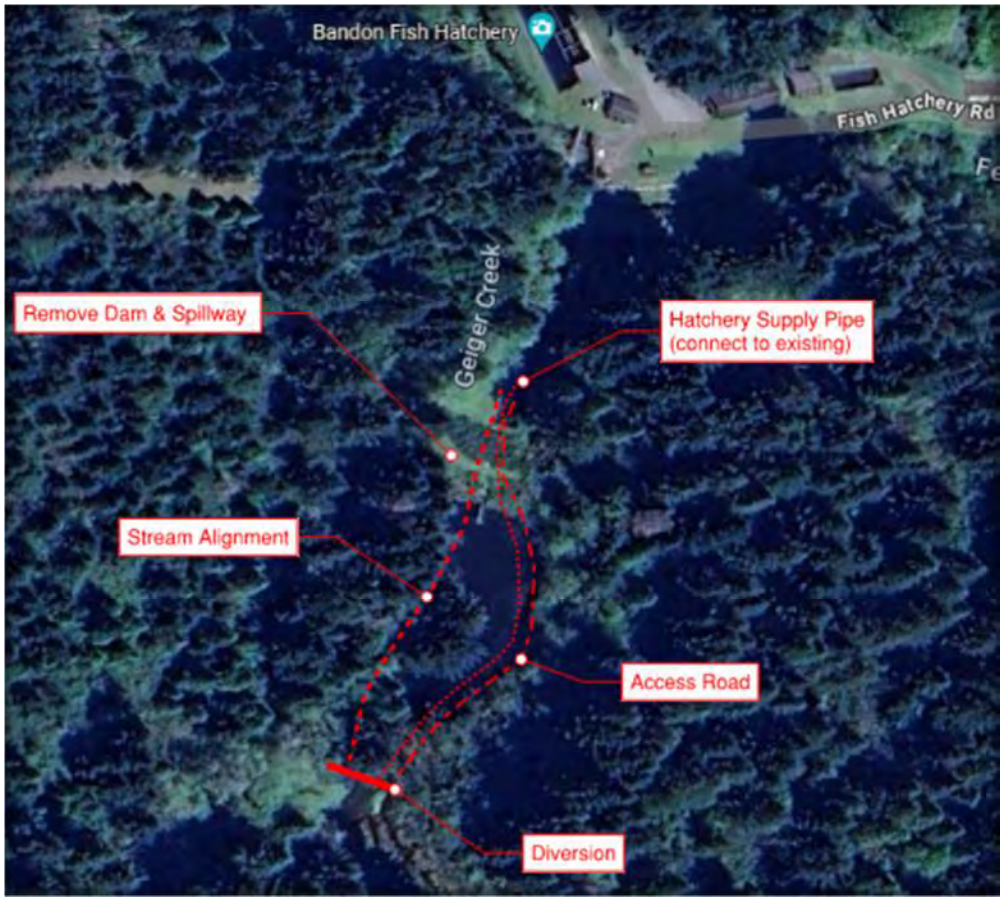


Figure 3.1 – Bandon – Proposed Geiger Creek Dam Relocation

Table 3.1 Construction Cost Estimate – Geiger Creek Dam Relocation

Low Range	Estimate	High Range
$2.2M	$4.4M	$6.6M

3.2 Ferry Creek Dam

Ferry Creek dam is a relatively small earth dam with a concrete overflow spillway located on Ferry Creek approximately 900 feet from the Bandon Fish Hatchery. Water from the dam flows into an intake structure and pipe that feeds water to Bandon Hatchery and the City of Bandon. Excess stream inflow discharges down a concrete overflow spillway and into Ferry Creek. Due to stability concerns arising out of a 2014 Geotechnical Investigation, it has been proposed to remove the dam and construct a new diversion structure upstream.

The proposed location of the new diversion structure is approximately 470 feet upstream of the existing dam and very near the end of the planned dredge work and temporary sandbag diversion noted on sheet R4 of the 1998 City of Bandon Water System Improvements (see Figure 2). This location is narrow and just downstream of a natural stream bend to the right (north). The diversion would be constructed of steel sheet pile which would take advantage of the dense sand layer noted in the geotechnical report. There would be an overflow section on the left side of the diversion to take advantage of the natural flow path to the left bank. The pipe entrance would be on the right side for easy personnel access. Lower-level sluice gates and a tilting weir gate in the center of the diversion would provide additional spill capacity during spring runoff as well as a means to flush sediment during runoff and clear floating debris during low flow periods. The diversion would only need to be around 6 feet tall to insure hydraulic entrance losses to the supply pipe are met at the maximum design flow. Final height would be determined, in part, by hydrology of the basin, site geology and spillway capacity.

The south side of the existing dam and concrete spillway would be removed entirely to accommodate excess flow down Ferry Creek. The north side of the dam would be excavated as needed to provide a smooth vertical transition from its current approach to the new access road. The access road to the new diversion would parallel the north bank. A culvert would need to be installed at the small gulley from the north with outflow directed to Ferry Creek. A section of stream channel would be constructed from the new diversion along the south side to where the concrete spillway ends. The new supply pipe would parallel the access road and connect to the existing 14" supply line on the downstream side of the existing dam.

Construction is estimated to last 8 months but is highly dependent on the condition of the excavated material and scheduling constraints.

One item to note is flow from the small basin approximately 150 feet upstream of the dam and on the north side will not be captured but will flow directly into Ferry Creek. This basin is very small compared to the remainder of the basin feeding Ferry Creek.

Figure 3.2 – Bandon – Proposed Ferry Creek Dam Relocation

Table 3.2 Construction Cost Estimate – Ferry Creek Dam Replacement

Low Range	Estimate	High Range
$2.1M	$4.3M	$6.4M

4.0 Elk River Hatchery

Items under consideration at the Elk River Fish Hatchery include replacement of the hatchery's main water delivery system and installation of a new intake screen that meets current criteria.

4.1 Main Water Delivery System Pipeline Replacement

The existing delivery system includes three pumps located at the intake structure with 12" discharge lines that feed into a 36" main line. The main line is approximately 710' long and feeds a looped series of 16" pipes into twenty-four rearing ponds. The bulk of the discharge flow from the rearing ponds flows into a 30" drain line. At the intake structure, there is a provision for a fourth pump.

Current flow from the three pumps totals 20 cfs. This equates to 6.7 cfs per pump and a discharge velocity of 8.5 ft/sec. The proposed flow is 40 cfs. Assuming the pumps are running near their best efficiency point, it is highly likely that they need to be replaced to accommodate the new flow. Suggested is installing four pumps with 16" discharge lines for a velocity of 7.2 ft/sec. The current 36" diameter main line should be sufficient for the new flowrate solely based on the velocity of 5.7 ft/sec. However, headloss in the main line will increase from 0.9 feet to 3.3 feet. A thorough hydraulic analysis, including hydraulic and energy grade lines, from the intake to the rearing ponds should be completed. Replacing the 36" main line with a 48" line would nearly match the current headloss. The 30" drain line from the raceways may also need to be upsized to accommodate the new flow of 40 cfs. A hydraulic analysis of this line should be completed to verify sizing.

The following cost estimate is based on replacing the existing piping from the pump discharge to the raceways, the 16" raceway piping and the 30" discharge piping all in-kind.

Table 4.1 Construction Cost Estimate – Pipeline Replacement

Low Range	Estimate	High Range
$1.3M	$2.6M	$3.9M

4.2 Intake Screen

The current intake includes a fixed coarse trash rack with bars spaced at 4" on center. The overall width of the rack is approximately 29'-4". Water levels from the base of the rack range from 2' to 12'-6". If the fixed trash rack was replaced with a wedge wire screen and wiper, it is possible to meet the 0.4 ft/sec criterion for a flow of 23 cfs at a depth of 2' and 40 cfs for depths above 3.5'. Without a coarse trash rack there is a risk of damage to the screen and wiper. To accommodate a new coarse trash rack, the intake concrete would need to be extended around 7 to 8'. A new rack and personnel walkway would be added. This would require a cofferdam and water management. Cofferdam type and cost would be significantly impacted by river flow height, which can vary 12'. An alternative solution could be a natural deflector that could be installed during low river flow. The following cost estimate includes extending the intake, a new coarse trash rack, and a screen and wiper.

Table 4.2 Construction Cost Estimate – Intake Replacement

Low Range	Estimate	High Range
$2.6M	$5.1M	$7.7M

5.0 Salmon River Hatchery

Items under consideration at the Salmon River Fish Hatchery include installation of an Obermeyer weir, new fishway with trap, intake screens; perimeter fencing for the rearing and asphalt ponds; and replacement of the pipeline and header valves.

5.1 Intake Area Improvements

The proposed intake area improvements outlined in the drawing set (provided by ODFW), Salmon River Fish Hatchery Intake Redesign, dated in year 2020 include replacing the diversion structure with two separate Obermeyer style weirs, constructing a new hatchery intake further into the river to minimize deposition and a new fishway. The existing pump station will remain intact.

The proposed intake design has a new diversion at a slight acute angle with the intake trash rack with a long and short section of Obermeyer style weirs at two heights. This design would provide operational flexibility for varying river flows. The deeper and shorter weir section next to the intake should allow for flushing sediment and floating debris that collects near the intake while the longer and shallower weir could provide spill capacity at higher river flows. Obermeyer mentioned there may be extra tooling costs for the 14' tall section. ODFW may want to discuss sizing options with Obermeyer prior to finalizing the design. The intake to the hatchery includes two basins, one for the coarse trash rack and another for the fine screens, wipers and pumps with a siphon feed between the two. The concern with this layout is the possibility of fines settling in the first basin. ODFW may want to consider moving the pump station where the siphon is located to minimize the "dead space" between the trash rack and pump inlets. Pump outlet pipes could be routed over the top of the new fishway and into the main header. The fine screens are located adjacent to the pump motors with minimal distance. This would impede work on the pumps and allow trash to fall on or near the pump motors. This distance should be increased. The work plan presented in the drawing set has merit. However, using bulk bags over a gravel bed may require large sump pumps thereby increasing water management costs. The plan also includes fill material downstream at the temporary culverts. This fill will most likely be required by the permitting agencies to be removed completely. Once again increasing construction costs. ODFW may want to consider using a sheet pile cofferdam and resequencing the work such that the short weir section and intake area are completed first. The second stage would only include the long section of weir, but at that time the flow could be directed to the deeper and shorter weir section. Although a sheet pile cofferdam may be more expensive upfront, water management costs, contractor's risk associated with flow variations, and scheduling flexibility may offset this cost. The sheet pile cofferdam may also be easier to permit. Effective cofferdam work is highly dependent on seasonal river flows, site geology, hatchery schedule and construction timing, none of which were included in this scope of work.

ODFW may want to consider as part of the project a value engineering clause for the cofferdam work where the successful bidder is required to work with ODFW on minimizing cost and schedule prior to work commencing.

Table 5.1 Construction Cost Estimate – Intake Area Improvements

Low Range	Estimate	High Range
$5.5M	$11.0M	$16.5M

5.2 Rearing and Asphalt Pond Flood Enclosures

The intent for the enclosures is to keep fish from escaping the ponds during a flood event. The cost below reflects a 4’ high perimeter fence around each of the two large ponds and a single perimeter fence around the seven shorter ponds to the east. The fence would include a concrete footing and stem wall with 1.5” schedule 40 upright posts at 8’ centers; top, mid-span and bottom rails; ¾” maximum fence fabric; and a total of eight 4’ wide gates. Post connections included in the cost are bolted and flush mount so sections can be removed. Details would need to be worked out in the design.

Table 5.2 Construction Cost Estimate – Pond Flood Enclosures

Low Range	Estimate	High Range
$0.9M	$1.8M	$2.7M

5.3 Pipeline and Valve Replacement

The proposed pipeline and valve replacement work includes replacing approximately 115’ of 30” pipe, approximately 500’ of 16” pipe and the pump header and valves. It is assumed engineered shoring will be needed to a maximum depth of 12’ and there is asphalt to be removed and replaced. Construction will be fairly slow due to shoring and replacing the 30” pipe under existing and protected infrastructure. It may be possible to reduce shoring cost by providing sheet pile shoring only along the length of and against the holding ponds and sloping the opposite (south) side of the trench back to meet OSHA requirements. This may impede access to the two buildings in the vicinity. The cost of this work is expected to be less if combined with the intake and diversion replacement.

Table 5.3 Construction Cost Estimate – Pipeline and Valve Replacement

Low Range	Estimate	High Range
$1.0M	$1.9M	$2.9M

6.0 Cedar Creek Hatchery

Items under consideration at the Cedar Creek Fish Hatchery include a drum filter cover, steelhead raceway replacement, and adding four raceways to the asphalt pond.

6.1 Drum Filter Cover

The drum filter cover would be approximately 24’ by 25’ with open steel frame, wood trusses and metal roofing. The foundation would be concrete cylinders placed outside of the existing thickened slab of the existing structure. A potential option would be to attach the cover to the existing structure. This option would require a structural analysis.

Table 6.1 Construction Cost Estimate – Drum Filter Cover

Low Range	Estimate	High Range
$125k	$250k	$375k

6.2 Steelhead Raceway Replacement

The scope of work would include demolishing the existing steelhead raceway ponds 8 through 11 and constructing a set of new raceways. The existing raceways have a footprint of approximately 47’ by 213’. The new raceways would be a set of four, each matching the size of existing raceways 4A and 4B. New ponds 9A/9B would be in series with 8A/8B and ponds 10A/10B would be in series with 11A/11B (see Figure 6.1). The overall footprint would change to approximately 42’ by 240’. Flow availability, pipe sizing and hydraulics would need to be verified.

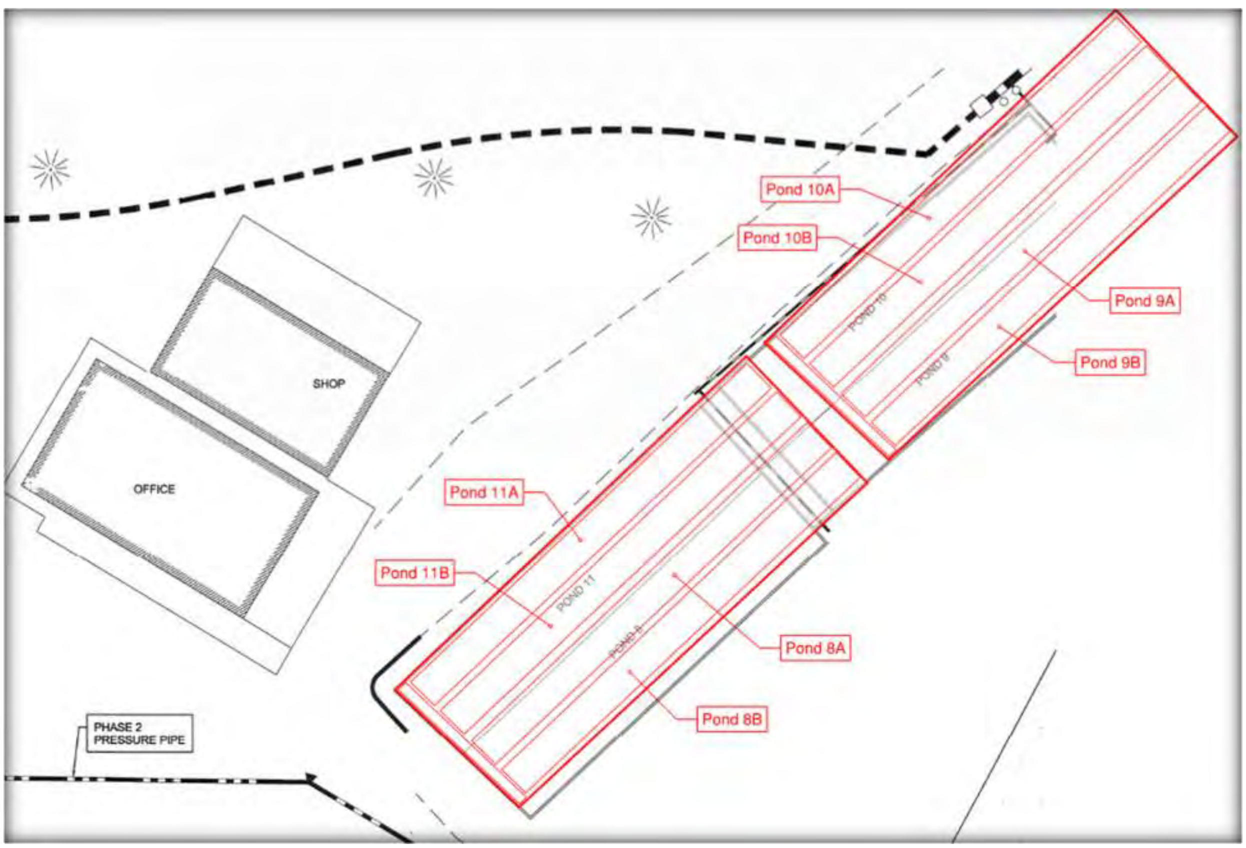


Figure 6.2 – Cedar Creek – Proposed Raceway Layout (Ponds 8-11)

Table 6.2 Construction Cost Estimate – Steelhead Raceway Replacement

Low Range	Estimate	High Range
$2.2M	$4.5M	$6.7M

6.3 Asphalt Pond Expansion

The scope of work includes demolishing the asphalt pond and constructing a set of new raceways. The existing pond has a slightly irregular footprint of approximately 100' by 270'. The new raceways for this location would be a set of four, each matching the size of raceways 4A and 4B. There would be four new ponds arranged like those proposed in Section 6.2 (see Figure 6.2). The overall footprint would change to approximately 42' by 240'. Flow availability, vertical placement, pipe sizing and hydraulics would need to be verified.

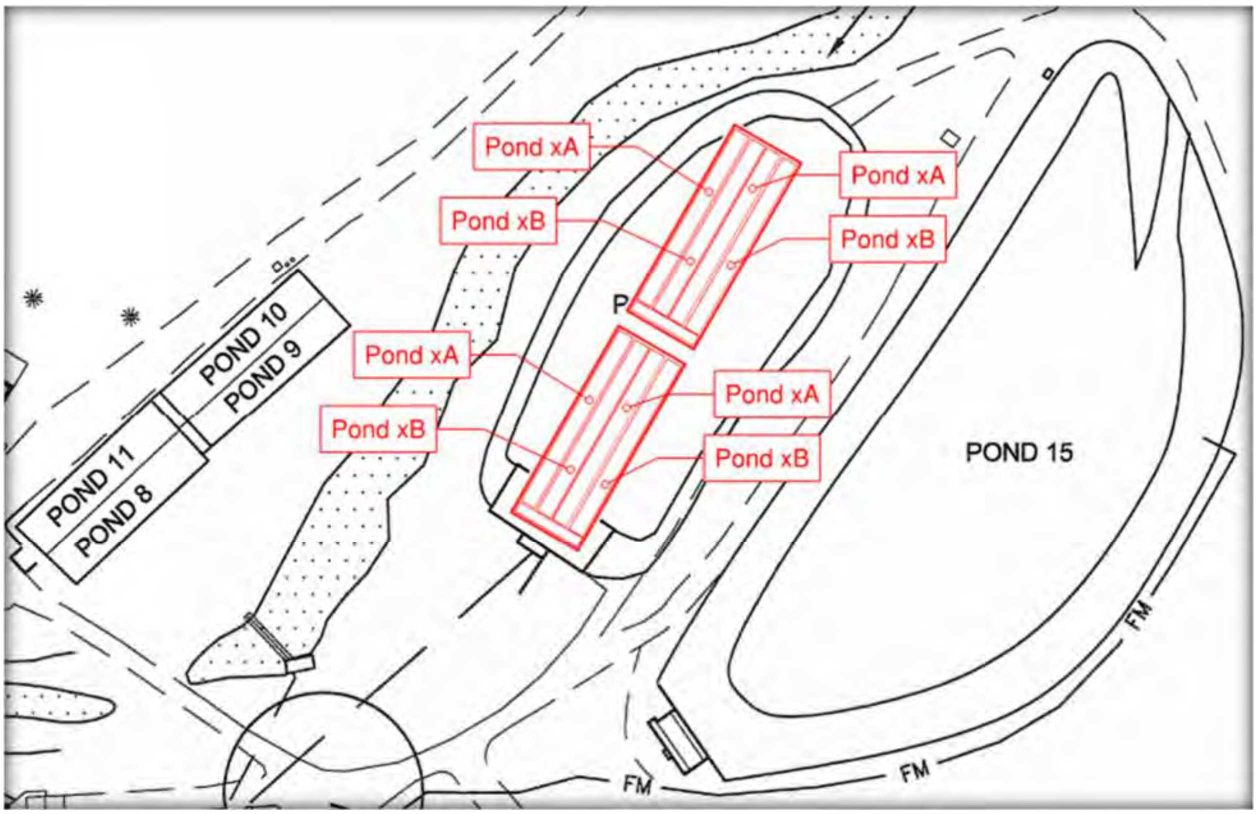


Figure 6.2 – Cedar Creek – Proposed Raceway Layout (Pond 14)

Table 6.3 Construction Cost Estimate – Asphalt Pond Expansion

Low Range	Estimate	High Range
$2.3M	$4.5M	$6.8M

7.0 Trask Hatchery

Items under consideration at the Trask Fish Hatchery include replacing the shop, replacing the abatement pond, installing a new intake structure on Gold Creek, replacing the upper adult holding pond, and expanding the lower adult holding pond.

7.1 Shop Building Replacement

The scope of the work would include demo of the abandoned hatchery building measuring 36' by 60' and the attached 23' by 33' garage and constructing a new shop building for general hatchery and vehicle maintenance. The new shop size suggested is 24' wide by 32' deep with a 10' wide garage door. This size will accommodate an F350 crew cab long box at 22' overall length and work benches along the walls. An overhead crane is not included.

Table 7.1 Construction Cost Estimate – Shop Building

Low Range	Estimate	High Range
$350k	$700k	$1.0M

7.2 Abatement Pond Replacement

The existing irregular-shaped abatement pond is roughly 35' by 50' with a detention volume of approximately 4500 cubic feet. Detention time, based on an inflow of 1 cfs, is approximately 75 minutes. ODFW has suggested the pond be four times this size. The proposed concrete settling pond, see Figure 7.1, has an overall footprint of 55' by 90' and a detention volume of approximately 18,500 cubic feet (4.1 times larger). Incoming water would enter through diffusers to direct the water downward. Water would exit through a launder at the opposite end. The floor near the launder would be sloped to allow equipment into the pond to remove waste material during shutdowns. This design would require a discharge permit into the Trask River.

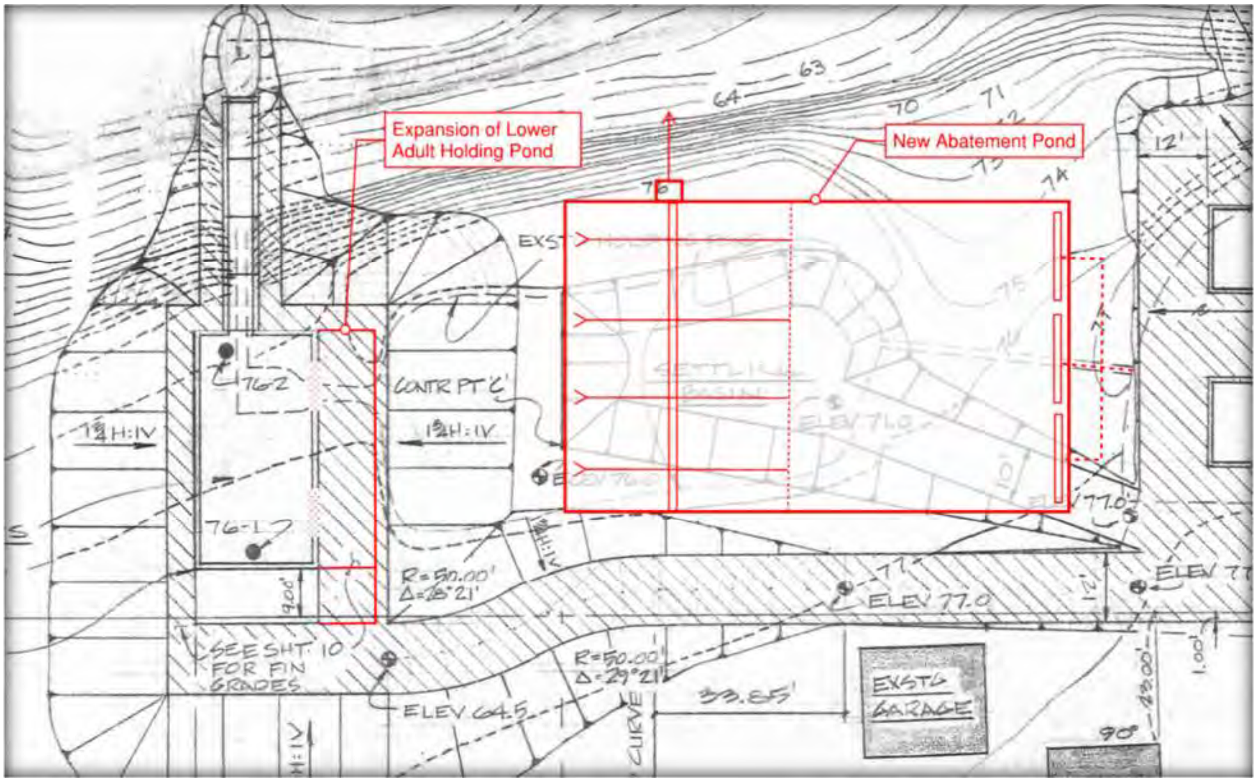


Figure 7.3 – Trask – Proposed Layout -Abatement Pond and Lower Adult Holding Pond

Table 7.2 Construction Cost Estimate – Abatement Pond

Low Range	Estimate	High Range
$0.8M	$1.6M	$2.4M

7.3 Gold Creek Intake

The project includes demolishing the existing Gold Creek canal intake, constructing a new intake on Gold Creek and piping water to the nearby pond. The design flow is 9 cfs. The new intake would have an overall footprint of 10’ by 15’ and equipped with a coarse trash rack, self-cleaning screens and isolating slide gate.

Table 7.3 Construction Cost Estimate – Gold Creek Intake

Low Range	Estimate	High Range
$1.2M	$2.5M	$3.7M

7.4 Upper Adult Holding Pond Replacement

The project includes demolishing the existing 3’4” deep adult holding pond at the upper fish trap and constructing an 8’ deep pond with the same overall footprint of 31’4” by 51’4” in the same location. Given the new pond will be deeper than the fish ladder exit, there will need to be consideration given on how to drain the new pond. This could be pumping using temporary pumps or a drain to the fish ladder or Gold Creek.

Table 7.4 Construction Cost Estimate – Upper Adult Holding Pond Replacement

Low Range	Estimate	High Range
$0.5M	$1.0M	$1.5M

7.5 Lower Adult Holding Pond Expansion

The project includes expanding the existing 21’4” by 41’4” adult holding pond at the lower fish trap. The pond is bounded on the north by the Trask River and bounded on the east, south and west by embankments. It appears from images on Google Earth that the area for expansion on the west side is too small. Expansion to the south is limited to about 20’ and using all 20’ would remove the spawning slab and vehicular access unless a retaining wall was constructed to hold the road embankment. Expanding the pond to the east seems the most reasonable. The area to the east allows for a 10’ expansion without encroaching on the embankment. It appears the embankment starts approximately 12’ from the pond’s east wall. This embankment forms one side of the abatement pond. If expansion of the holding pond occurs in conjunction with construction of the new abatement pond, it may be possible to expand the holding pond 20’ to the east, thereby doubling its size. The cost estimate below reflects a 10’ expansion to the east including a spawning slab and removal of two sections of the existing east wall to allow fish into the new holding area, see Figure 7.1.

Table 7.5 Construction Cost Estimate – Lower Adult Holding Pond Expansion

Low Range	Estimate	High Range
$280k	$560k	$830k

8.0 Nehalem Hatchery

Under consideration at the Nehalem Fish Hatchery is the installation of a new intake screen.

8.1 Intake Screen

The intake consists of a 39’6” long screen with 1-3/16” clear spacing and four pumps located in the downstream 15’6” of the screen. Each pump is within its own bay with a width of 3’3”. The total flow is 24 cfs. Normal water depth within the intake is 3’3”. Locating individual screens at each pump bay would not meet the 0.4 ft/sec maximum approach velocity criterion if each pump had a flowrate of 6 cfs. Locating screens in front of each pair of pumps would also fail this criterion. Replacing the 39’6” screen would meet the approach criterion but would probably fail a hydraulic analysis to show an even velocity distribution across the screen since the pumps are located in the downstream 40% of the screen length. The minimum length of screen to meet approach velocity criterion for a water depth of 3’3” is 18’9”. It may be possible to modify the intake in front of the pumps to meet both approach velocity and velocity distribution criteria, but the solution would need to be verified with hydraulic modeling. Another possible solution would be to raise the water level so the approach velocity in each pump bay is below 0.4 ft/sec. The cost estimate below is for modifying the intake area in front of the pumps, see Figure 8.1. The estimate assumes an intake screen length of 20’, screen wipers, and allowances for demo, concrete and screen supports.

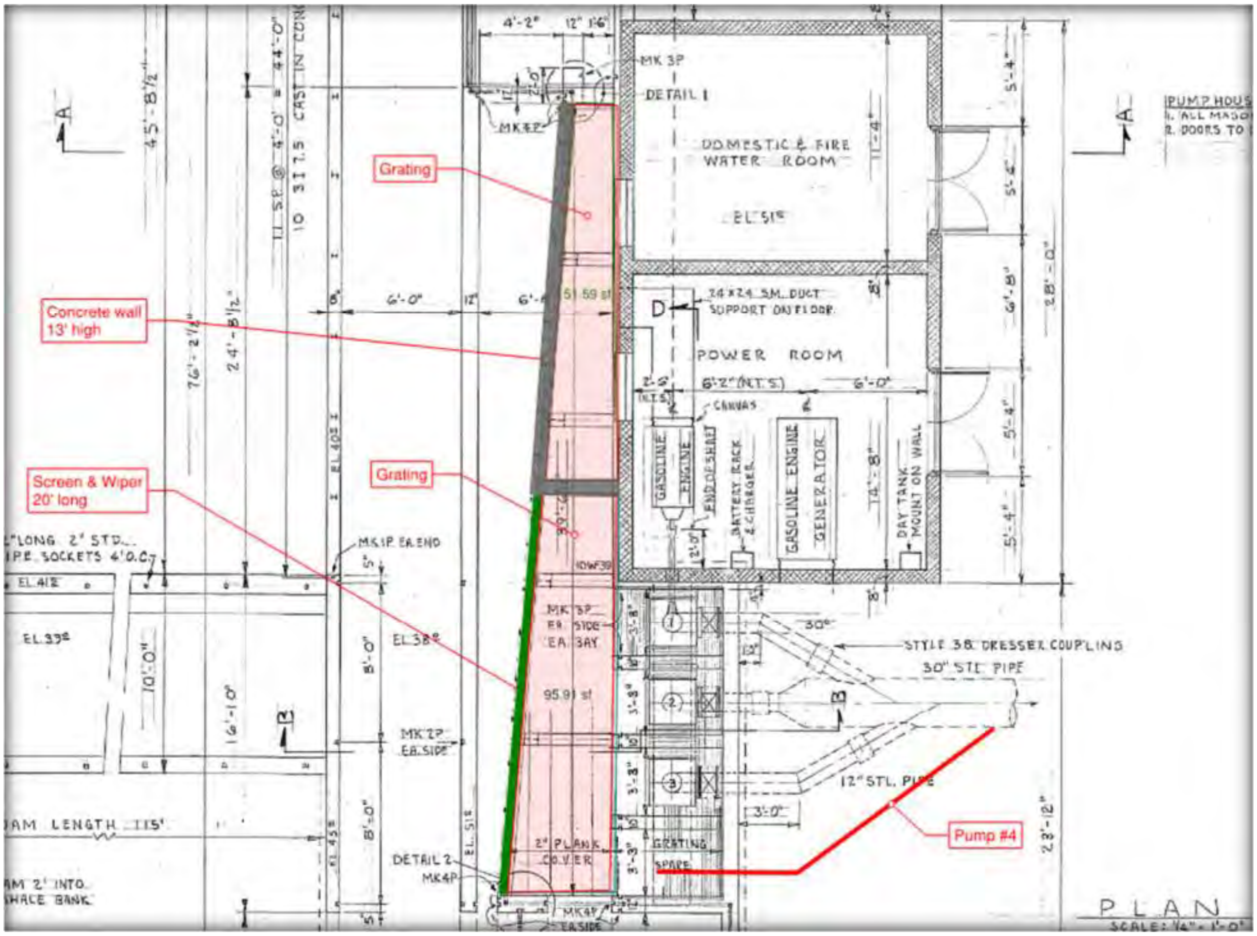


Figure 8.4 – Nehalem – Proposed Intake Layout

Table 8.1 Construction Cost Estimate – Intake Screen

Low Range	Estimate	High Range
$1.5M	$3.1M	$4.6M

9.0 Roaring River Hatchery

Under consideration at the Roaring River Fish Hatchery is a new intake, fish ladder and recirculation system. Intake flow is 33.5 cfs.

9.1 Intake, Fish Ladder and Recirculation System

QRS reviewed the Roaring River Hatchery Intake & Pipeline Modifications drawing set and associated cost estimate provided by ODFW. The project is delineated into three work areas. Work area 1 includes a new intake with a Farmers screen, a fish ladder and a recirculation water diffuser. Work Area 2 includes the recirculation pump house and collection basin. Work Area 3 outlines details of the main pipe connections. The modifications in Work Area 1 appear to be laid out well other than the close proximity to the property line. If this layout is finalized, there will no longer be vehicular access to the new water diffuser building.

This may or may not be an issue for the ODFW. If this layout is constructed, it is suggested that the water diffuser be constructed prior to the new intake screens to allow for construction vehicles which will lower construction costs. Also suggested is adding vehicle access to the diffuser as part of the design to aid in operation and maintenance. The following cost estimate updates and expands upon the estimate provided by ODFW.

Table 9.1 Construction Cost Estimate – Intake, Fish Ladder, Recirculation System

Low Range	Estimate	High Range
$2.3M	$4.5M	$6.8M

APPENDIX E: CLIMATE VULNERABILITY ASSESSMENT OF OREGON HATCHERY PROGRAMS

Prepared by Oregon State University

Climate Vulnerability Assessment of Oregon Hatchery Programs

December 2024

Prepared for:

Oregon Department of Fish and Wildlife
4034 Fairview Industrial Drive
SE Salem, OR 97302

Prepared by:

Hannah Barrett
Oregon State University
2820 SW Campus Way
Corvallis, OR 97331

Melanie Davis
U.S. Geological Survey
Oregon Cooperative Fish and Wildlife Research Unit
2820 SW Campus Way
Corvallis, OR 97331

Table of Contents

Report roadmap

This report is organized into three main sections. The "Summary" offers an overview of project goals, the brief review of the analytical approach, and key findings. The "Stock Synthesis" section delves into population trends and model results for all assessed hatchery stocks. The "Detailed Methodology" section elaborates on predictor variable selection, modeling, and implementation of the qualitative vulnerability assessment.

Figures and tables are divided into two sections: the “Summary" section contains all primary figures and tables referenced in the Summary text, while the "Stock Synthesis" section includes stock-specific figures and tables referenced in the Stock Synthesis text. In this section, figures and tables are grouped and numbered by species and hatchery stock with numbering consistent with the text.

Summary

Overview

The goal of this project was to assess the vulnerability to climate change impacts for a sample set of hatchery programs representing different geographic areas and primary anadromous species raised in state-managed Oregon hatcheries (Summary Figure 1). Freshwater and marine ecosystem processes can significantly influence salmon and steelhead survival, and understanding how these factors have affected historical returns can help managers evaluate the climate vulnerability of hatchery stocks. We examined stock-specific trends in smolt-to-adult returns (SARs), which represent the proportion of smolts released from the hatchery that are recovered in fisheries or as returning adult spawners. SARs are among the most consistent long-term estimators of survival for hatchery-origin stocks. Depending on the stock, adult recoveries could occur in marine fisheries, freshwater fisheries, returns to the hatchery or another collection facility, and spawning ground surveys. We collected time series data on relevant ecological indicators and used generalized additive models (GAMs) to explore both univariate and multivariate relationships with SARs for each hatchery stock.

An additional aspect of this assessment was to evaluate the climate vulnerability of resident trout stocking programs in the Department's East and West regions, incorporating insights from Oregon Department of Fish and Wildlife (ODFW) staff interviews and published data on the thermal tolerance of hatchery trout stocks. This assessment is provided in the ‘Climate vulnerability of trout stocking programs’ subsection below.

GAM predictor overview

Marine

Early marine conditions, particularly the first summer at sea, are a critical period of survival for Pacific salmon (Duffy and Beauchamp 2011). We compiled a time series dataset of 11 ecologically relevant marine indicators (Summary Table 1). For variables available on monthly or finer time scales, we developed seasonal indicators by calculating the aggregate monthly average for each variable and the mean average seasonal value for winter (January – March) and summer (June – August). To allow comparison on the same scale, all marine indicators were standardized with a mean of 0 and SD of 1 for the given time frame and location. The final time series dataset included data for the first year at sea, plus a 1-year offset (denoted as L1 for a lag of 1-year) to encompass the first two years at sea for each brood year.

Freshwater

Smolts are highly vulnerable during their downstream migration (Healey 1991), and river flow has been found to be positively correlated with survival (Notch et al., 2020). For each hatchery, we identified the nearest downriver U.S. Geological Survey (USGS) gauge station with time series data on river flow (cubic feet per second; CFS, Summary Table 2).

Hatchery

When available, we incorporated hatchery data such as average size of fish at release, the Julian day or month of release, and total number of fish released (Summary Table 2). Variables related to size or number of fish released may help assess density dependence, while variables related to timing of release may help determine optimal environmental conditions during juvenile rearing.

Methods overview

Tag filtering

We generated data sets for Chinook (*Oncorhynchus tshawytscha*) and coho salmon (*Oncorhynchus kisutch*) hatchery programs based on coded wire tag (CWT) release and recapture data from the Pacific States Marine Fisheries Commission's (PSMFC) Regional Mark Processing Center (RMIS; Summary Table 2). We generated estimates of age by subtracting the brood year from return year. We retained tag codes also used in RMIS reports ('tag status' = 1) for analysis. CWT release and recapture data was only available for one of the steelhead (*Oncorhynchus mykiss*) hatchery programs in our analysis. For other steelhead programs, we used freshwater harvest and returns to the hatchery or other collection facility to estimate SARs. To estimate adult steelhead returns by brood year, we used a fixed age structure based on the most recent and representative age-at-return information—as identified by ODFW staff with expert knowledge—for each stock.

Modeling approach

We focused our modeling efforts on hatchery stocks with relatively consistent long-term release and recovery data (Summary Table 2). We standardized all marine environmental predictors; however, freshwater and hatchery-based variables, such as river flow, fish size at release, and date of release, were not standardized to facilitate interpretation of results (keeping variables on the original scale is also useful for determining whether variables are biologically important). We utilized flexible non-linear models (generalized additive models; GAMs) to model SARs for each stock independently to consider their unique migratory timings and exposure to environmental conditions (different ocean distributions, etc.). We first fit a series of GAMs to

SAR data for each stock using a single predictor variable, in an effort to remove those that had unrealistic relationships with SARs. Based on this initial modeling, we then removed predictors with ecologically unrealistic concave-up relationships, where SAR rates were highest at extreme values. From the retained predictor variables, we generated a candidate model set that included all possible combinations of 1–3 predictors. We included river flow (cubic-feet-per-second; CFS) as a consistent predictor due to its hypothesized influence on juvenile survival. We then evaluated the support for each predictor variable across all candidate models using several metrics of predictive ability, and ranked predictors by their effect sizes, identifying those with the most significant impact on SARs. We also assessed the correlation between top predictors and noted any variables with a correlation $\geq |0.6|$ in the Stock Synthesis section. Our aim in comparing variable influence across multiple metrics and many models was to identify those predictors with the strongest relationship to SARs.

Discussion of model results

Due to natural variability across populations, the relative importance of predictors differed among stocks. In some cases, predictors that influenced survival were closely related to hatchery management practices. For example, the survival (in terms of SARs) of coho released from the Cole Rivers and Sandy hatchery programs, fall Chinook released by the Elk River and Salmon River programs, spring Chinook released by the Trask program, and steelhead released by the Alsea, Nehalem, and Wallowa programs was expected to improve with adjustments to average size, timing of release, and/or the total number of fish released. However, for many populations, marine conditions emerged as the most significant predictors of survival. Climate projections forecast rising temperatures and increased variability in marine ecosystems, from the west coast of the USA to the Bering Sea in Alaska. These changes are expected to affect marine conditions by disrupting food availability, altering migration patterns, and increasing the frequency of extreme weather events—all of which could substantially impact fish survival.

Contrary to expectations, river flow did not significantly affect survival for any of the hatchery programs analyzed; however, we anticipate that flow may become more important as climate change continues to alter water availability. River flow was not a top-ranked predictor variable, even though models frequently indicated that survival was maximized at intermediate flows. Paradoxically, in hatchery programs such as the Trask spring Chinook, Big Creek fall Chinook, Rogue (Cole Rivers) coho, Rogue (Cole Rivers) summer steelhead, and Alsea winter steelhead, we observed an inverse relationship where the highest survival occurred at both low and high flows. This unexpected pattern suggests that these results could be confounded by other factors, such as water temperature, or interactions between CFS and other variables like size at release. Additionally, these variable patterns suggest that the optimal release strategy, as it relates to flow, may change over time due to evolving environmental conditions. As a result, strategies that were once optimal may need to be re-evaluated to ensure they remain effective in the face of ongoing change.

In some hatchery programs, modeling results predicted a decrease in survival with increasing numbers of released fish. This relationship provides evidence for density dependent effects and may be driven by increased competition or disease at higher fish densities. The predicted impact of size at release and the number of fish released may also be influenced by interactions between these variables (e.g., releasing fewer but larger fish). Our modeling framework did not incorporate interactions between predictors, which could lead to imprecise results.

The scope of available data can impact the interpretation of results and future impacts. In GAMs, rug plots are used to illustrate the distribution of data points along the x-axis of a predictor variable plot, providing insight into data density. It is important to note that hatchery data like size at release often occur as a cluster around certain values (this may be true if there is little variation in size at release from a hatchery over time), which means the certainty of model predictions decreases as one moves away from these dense areas of data. This applies to environmental variables as well—the relationships derived from GAMs are based on historical data, and projecting into ranges that we have not yet observed (such as future ocean temperatures that are warmer than the historical record) can increase uncertainty.

Important predictor variables

One of the metrics we used to evaluate the predictive performance of models was Root Mean Square Error (RMSE), which indicates how far, on average, a model's predictions of SARs deviate from the actual values. The predictors with the best (lowest) RMSE values varied by candidate model; however, certain marine indices were often among the top two predictors across species and hatchery stocks: Pacific Decadal Oscillation (PDO), North Pacific Gyre Oscillation (NPGO), and Sea Surface Temperature (SST) (Summary Table 3). Together, these metrics indicate that marine conditions during the summer play a prominent role in driving fish survival.

Climate change effects on marine conditions

To understand the long-term effects of a changing climate on survival, it is helpful to forecast predictor variables into the future. Unfortunately, forecasts do not exist for the majority of the metrics that our analysis identified as important drivers. Existing studies using projected physical ocean models have summarized the direction of change for some variables. These studies suggest that while the spatial patterning of PDO may be similar under a warming climate, variability in wind stress and the amplitude of PDO is expected to decrease in the future (Zhang and Delworth 2016). Climate projections have also suggested that NPGO will increase in variability over time and become increasingly coupled with other physical processes (Di Lorenzo et al. 2008). While the intensity of upwelling in the California Current is not expected to increase in future climate scenarios, its duration is projected to slightly decrease, albeit not as much as in other upwelling-fed systems around the world (Wang et al. 2015). Finally, we expect to see increased intensity and variability around marine heat waves (MHWs), coupled with reduced mixed layer depth and increased surface warming (Oliver et al. 2019; Deser et al. 2024).

Assessing population trends

We used dynamic generalized linear models to quantify the long-term (across all years of data) and recent (across the last 5-years of data) trends in SARs, ignoring all other predictors (Summary Table 4). Many hatchery programs demonstrated a negative trend in both average long-term and short-term survival; however, some programs (e.g. Elk River fall Chinook) showed positive long-term and short-term trends. Cyclical patterns of survival were evident in many of the programs, so trend analysis results were sensitive to the particular time frame examined and the choice of a 5-year window to quantify recent trends. The short-term negative SAR trends we observed for many programs were not surprising given that the time series ended during a period of marine ecosystem disturbance (Morgan et al. 2019). Nevertheless, negative long-term SAR trends were observed for several spring Chinook and summer steelhead programs, and some of these stocks are expected to experience elevated climate vulnerability (see next sub-section).

Qualitative vulnerability assessment

To determine the biological sensitivity of Oregon hatchery salmon and steelhead stocks, we conducted a qualitative climate vulnerability assessment, adapting the framework developed by Crozier et al. (2019) to focus on factors most relevant to hatchery fish (Summary Table 5a, 5b). In this framework, an expert panel rated climate change exposure and sensitivity for salmon and steelhead stocks based on a number of attributes. Exposure and sensitivity scores were then combined into a cumulative climate vulnerability rating. Hatchery stocks identified as having the highest vulnerability were spring Chinook salmon from the Upper Willamette River, Middle Columbia River, and Snake River species management units (SMUs), as well as summer steelhead from the Middle Columbia River and Snake River SMUs. All hatchery SMUs were ranked with vulnerabilities of 'high' or lower, with none classified as 'very high.'

Climate vulnerability of trout stocking programs

Oregon Department of Fish and Wildlife's resident trout stocking programs produce approximately 5 million trout annually for release into the state's lakes and rivers. While rainbow trout (*Oncorhynchus mykiss*) make up the majority of stocked fish, other species, such as brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta*), cutthroat trout (*Oncorhynchus clarki*), and tiger trout (a hybrid of brook and brown trout) are stocked in select water bodies. The program also includes the release of kokanee (*Oncorhynchus nerka*) in several lakes.

These stocking programs face potential vulnerabilities due to projected climate change impacts, including rising water temperatures, reduced summer stream flows, and increased wildfire risk. Higher water temperatures and diminished summer water availability can reduce hatchery rearing capacity and elevate the risk of pathogen outbreaks, which could ultimately decrease the number of fish available for stocking. Wildfires pose both immediate threats, such as direct fish losses if hatcheries are affected, and longer-term impacts on watershed water quality. These environmental changes are already influencing trout rearing at some ODFW hatcheries and are expected to accelerate, affecting not only the hatcheries but also the water bodies where trout are stocked—ultimately impacting trout growth, survival, and the overall success of the fishery.

Despite these challenges, ODFW's trout stocking programs are expected to remain resilient in the face of climate change due to several key factors. First, hatchery trout broodstocks are generally maintained at facilities with cold, stable water sources that should continue to provide optimal rearing conditions into the foreseeable future. Eggs and juvenile trout from these facilities can be relocated to other hatcheries to avoid stressful conditions and to take advantage of additional rearing capacity outside of the summer bottleneck period. For example, coastal hatcheries can stock trout in the spring, ahead of the summer's higher temperatures and lower flows. Second, stocking strategies can be adjusted to increase the likelihood that trout are caught before environmental conditions become too stressful, particularly in lakes. ODFW is already implementing in-season adaptations by adjusting stocking schedules based on water quality conditions, with plans to continue these practices in the future. Third, options for utilizing more climate-resilient trout stocks are being explored to improve survival rates and reduce losses to pathogens (Hartman and Porto 2014). For instance, ODFW is evaluating a West Virginia rainbow trout strain that has shown improved resistance to bacterial cold-water disease.

In addition to these strategies, several other adaptations are available to enhance the resilience of trout stocking programs. Infrastructure upgrades at hatcheries could bolster climate resiliency, while the use of different trout broodstocks may provide greater flexibility in fish production. Purchasing trout eggs from private hatcheries—available year-round—could allow shifts in production schedules, enabling trout to reach catchable size earlier in the year. Furthermore, adjusting the size at which fish are stocked (e.g., fingerling vs. legal size) in certain water bodies could be reconsidered based on evolving information about natural productivity and climate change impacts.

With these diverse options for maintaining production and adapting to climate change, ODFW's trout stocking programs are expected to remain resilient and viable into the foreseeable future.

END OF SUMMARY SECTION

Stock Synthesis

This section summarizes SAR trend results and relationships between SARs and predictor variables for each hatchery program. Short term SAR trends, which were based on the most recent five brood years, were negative for most Chinook and coho salmon programs and all steelhead programs (Summary Table 4). These brood years coincided with a period of widespread marine ecosystem disturbance (Morgan et al. 2019), and SARs were generally below average during this period even for programs with a positive short-term trend. Long term SAR trends, which were based on all brood years available for each program (Summary Table 2), were also mostly negative (Summary Table 4). For most programs, a cyclical pattern of survival was also evident. Therefore, long term trend analysis results were sensitive to the start and end point of the time series, including the recent downturn in SARs, and should be interpreted in that context.

The relationships between predictor variables and survival probabilities presented here are correlational and do not imply direct causation. These associations are based on observed patterns and can therefore be interpreted as potential factors influencing survival rather than as definitive causal links.

1. Spring Chinook Salmon

1. **Trask –** The average long-term trend in SARs was slightly negative (Summary Table 4, Synthesis Figure 1.1). The predictors that appear to have the greatest association with survival probability include SST, Marine Heat Wave Cover within the US Exclusive Economic Zone (EEZ), NPGO during the first summer at sea, and PDO during the second summer at sea (Synthesis Table 1.1, Synthesis Figure 1.11). The predictor with the lowest (i.e., best) RMSE score was the total number of fish released, where increasing release numbers were associated with an increased probability of survival (Synthesis Figure 1.11). Correlation between EEZ and SST during the first summer at sea was relatively high (0.77).

2. **Deschutes (Round Butte) –** SARs exhibited a decreasing trend over time, mostly due to a declining trend over the last decade (Summary Table 4, Synthesis Figure 1.2). The most influential predictors for this stock were predominantly related to summertime marine conditions encountered during the second year at sea (Synthesis Table 1.2, Synthesis Figure 1.21). The predictors with the lowest RMSE scores were SST, PDO, NPGO, SST Arc during the second summer at sea, and SST Arc during the second winter at sea. Correlation was high (≥|0.6|) between SST Arc summer L1 and PDO summer L1, SST Arc summer L1 and SST summer L1, and SST Arc summer L1 and SST Arc Winter L1. All other variables had correlations <|0.6|.

3. **McKenzie –** The average long-term trend in SARs was negative, mostly due to a decline during the first 15 years of the time series; SARs have cycled within a relatively stable range since that time (Summary Table 4, Synthesis Figure 1.3). The most influential predictors for this stock were SST, PDO, NPGO during the second summer at sea, NPGO during the first summer at sea, and NPGO during the second winter at sea (Synthesis Table 1.3, Synthesis Figure 1.31). All predictors displayed a concave down relationship with highest predicted survival occurring at intermediate values. Correlation between NPGO summer and NPGO winter L1 was 0.61, all other variables had correlations <|0.6|.

4. **Imnaha –** There was no significant average long-term trend in SARs, which generally increased over the first 20 years of the time series and then decreased more recently (Summary Table 4, Synthesis Figure 1.4). For these fish, the most important predictors of survival were summertime PDO during the first and second years at sea, as well as NPGO during the first summer at sea (Synthesis Figure 1.41). RMSE scores for these predictors were very similar (Synthesis Table 1.4). Increasing PDO during the first summer at sea was negatively correlated with survival probability. In contrast, intermediate values of summertime PDO during the second summer at sea were associated with the highest survival probability. Similarly, intermediate values of NPGO during the first summer at sea were linked to the highest survival probability. All variables had correlations <|0.6|.

5. **Rogue (Cole Rivers) –** The average long-term trend in SARs was negative, and a declining pattern was evident across shorter-term cycles within the time series (Summary Table 4, Synthesis Figure 1.5). The top predictor of survival was summertime MHW intensity, with a relatively low RMSE score (Synthesis Table 1.5). Intermediate values of MHW intensity were predicted to have the lowest survival probability. This result was

counterintuitive, as we would expect increasing MHW intensity to decrease survival. Most of the MHW data was clustered at values less than 1, meaning model accuracy likely decreased as it predicted into areas with less data (i.e., areas of greater than average MHW intensity). The bulk of the range of MHW data show a decreasing survival probability with increasing MHW intensity, whereas only ~3 data points drive the prediction of increased survival with increasing values. Correlation between the summertime EEZ cover and summertime MHW intensity was high (0.84).

2. Fall Chinook Salmon

1. **Salmon River –** The average long-term trend in SARs was slightly negative, but some of the highest SARs in the time series were observed after 2010 (Summary Table 4; Synthesis Figure 2.1). Marine predictors that appeared to drive variation in survival probability included Spring Transition Index (STI) during the second year at sea, summertime SST Arc, and NPGO (Synthesis Table 2.1, Synthesis Figure 2.11). Fish release size and number of fish released were also predicted to increase survival. Increased average size at release and intermediate release numbers were both predicted to increase survival probability. Correlation was low for all marine variables.

2. **Elk River –** The average long-term trend in SARs was slightly positive (Summary Table 4, Synthesis Figure 2.2). The primary predictors associated with survival were average weight at release, NPGO during the second winter at sea, and the Bifurcation Index during the first year at sea (Synthesis Table 2.2, Synthesis Figure 2.21). CFS was not included in this model (Summary Table 2). Increasing the average weight of fish at release was related to an increasing probability of survival. Higher NPGO values during the second winter at sea were also associated with increased survival probability until plateauing at higher values. Higher values of the Bifurcation Index during the first year at sea were associated with increased survival probability. Correlation was low for all marine variables.

3. **Big Creek –** There was no significant average long-term trend in SARs (Summary Table 4, Synthesis Figure 2.3). Key factors that appeared to affect survival included NPGO during the second winter at sea, SST during the first summer at sea, and PDO during the second summer at sea (Synthesis Table 2.3, Synthesis Figure 2.31). An increase in NPGO during the second winter was linked to higher survival probabilities, while higher SST during the first summer and higher PDO during the second summer were both associated with lower survival probabilities. EEZ during the second summer at sea and PDO during the second summer at sea were correlated (0.64), as were EEZ during the second summer at sea and SST during the second summer at sea (0.64).

3. Coho Salmon

1. **Rogue (Cole Rivers) –** The average long-term trend in SARs was negative, and a declining pattern was particularly evident during the last 15 years of the time series (Summary Table 4, Synthesis Figure 3.1). The predictors associated with survival were SST and PDO during the second winter at sea, and the average release weight of fish

(Synthesis Table 3.1, Synthesis Figure 3.11). At winter SST values greater than the standardized mean, survival was predicted to decrease, whereas increasing winter PDO values were predicted to increase survival. Releasing fish at an average release weight of up to ~42.5g was positively correlated with survival. Correlation was low for all marine variables.

2. **Big Creek –** The average long-term trend in SARs was slightly negative (Summary Table 4, Synthesis Figure 3.2). Predictors with the greatest impact on survival included summertime MHW intensity, SST Arc during the first summer at sea, and PDO during the second summer at sea (Synthesis Table 3.2, Synthesis Figure 3.21). Increasing MHW values and higher than average SST Arc values were both correlated with decreased survival probabilities. Intermediate values of PDO were linked to higher survival probability. Correlation was high between summertime MHW intensity and summertime SST Arc (0.72), and between summertime SST Arc and summertime PDO during the second year at sea (0.66).

3. **Sandy –** The average long-term trend in SARs was negative, mostly due to a decline over the first 20 years of the time series. SARs have cycled within a relatively stable range since that time (Summary Table 4, Synthesis Figure 3.3). The most important drivers of survival appeared to be PDO during the second summer at sea, total number of fish released, and NPGO during the first summer at sea (Synthesis Table 3.3, Synthesis Figure 3.31). Increasing the number of fish released increased survival probability. Correlation was low for all marine variables.

4. Summer Steelhead Trout

1. **Siletz –** The average long-term trend in SARs was slightly negative (Summary Table 4). SARs showed an increasing trend from the 1990s until the early 2000s, after which there was a noticeable decline that continued through the 2010s (Synthesis Figure 4.1). The predictors impacting survival were NPGO during the first and second summer at sea, and SST recorded at Station P during the second summer at sea (Synthesis Table 4.1, Synthesis Figure 4.11). Intermediate values of NPGO during the first summer at sea and SST at Station P during the second summer at sea were correlated with the highest probability of survival. Increasing values of NPGO during the second summer at sea were also correlated with a higher probability of survival. NPGO during the first summer at sea and NPGO during the second winter at sea were correlated (0.61).

2. **Rogue (Cole Rivers) –** The average long-term trend in SARs was negative (Summary Table 4, Synthesis Figure 4.2). Predictors with the highest impact to survival were SST during the second winter at sea, SST Arc during the first winter at sea, and STI (Synthesis Table 4.2, Synthesis Figure 4.21). The highest probability of survival was correlated with intermediate values of both STI and SST during the second winter at sea. Higher values of wintertime SST Arc were also correlated with higher survival probability. SST Arc and SST during the second winter at sea were highly correlated (0.82), summertime PDO and SST Arc during the second summer at sea were also correlated (0.66), as were SST Arc during the second winter and second summer at sea (0.66).

3. **Deschutes (Round Butte) –** SARs showed a clear declining long-term trend (Summary Table 4; Synthesis Figure 4.3). It is important to note that this program had a shorter SAR time series than other summer steelhead programs. The key factors that appear to be impacting the survival of this stock were NPGO during the second summer at sea and first winter at sea, and SST recorded at Station P during the second winter at sea (Synthesis Table 4.3, Synthesis Figure 4.31). All these relationships exhibited a concave-down pattern, with the highest probability of survival occurring at intermediate values. Correlation was low for all marine variables.

4. **Wallowa –** The average long-term trend in SARs was negative (Summary Table 4), but examination of the SAR data indicated a trend in which SARs increased for many years and then declined over the last eight years of the time series (Synthesis Figure 4.4). The top predictors of survival for this stock were the total number of fish released, NPGO during the first summer at sea, and the STI (Synthesis Table 4.4, Synthesis Figure 4.41). Increasing the number of fish released was predicted to decrease the probability of survival. Intermediate values of NPGO during the first summer at sea were associated with the highest probability of survival, while intermediate values of STI were linked with the lowest probability of survival. Correlation between summertime SST and EEZ cover was high (0.77).

5. Winter Steelhead Trout

1. **North Fork Nehalem** – There was no significant average long-term trend in SARs, which increased over the first 20 years of the time series and then decreased in recent years (Summary Table 4, Synthesis Figure 4.5). The primary predictors associated with survival were STI, NPGO during the first summer at sea, and the Bifurcation Index during the second year at sea (Synthesis Table 4.5, Synthesis Figure 4.51). STI and NPGO during the first summer at sea both exhibited a concave-down pattern with the highest probability of survival occurring at intermediate values. Increasing values of the Bifurcation Index during the second year at sea were correlated with a decreasing survival probability. Correlation was low for all marine variables.

2. **Alsea** – The average long-term trend in SARs was slightly negative (Summary Table 4). Similar to several other steelhead programs, SARs initially exhibited an upward trend and then declined more recently (Synthesis Figure 4.6). The predictors with the greatest impact on survival were the total number of fish released, STI during the second year at sea, and NPGO during the second winter at sea (Synthesis Table 4.6, Synthesis Figure 4.61). Both STI and NPGO exhibited concave-down relationships, with the highest probability of survival occurring at intermediate values. In contrast, increasing the total number of fish released was correlated with a decreased survival probability. Correlation was low for all marine variables.

END OF SYNTHESIS SECTION

Detailed Methodology

Marine predictor variables

Basin-scale predictors

Basin-scale climate indices have been linked to Pacific salmon productivity across many studies (sensu. Mantua and Hare 2002). Based on this previous work, we considered two basin scale indices, the Pacific Decadal Oscillation (PDO) and the North Pacific Gyre Oscillation (NPGO). The PDO is the dominant year-round pattern of monthly North Pacific Sea surface temperature (SST) variability calculated as the leading Empirical Orthogonal Function (EOF)/ Principal Component (PC) of North Pacific monthly SST variability (poleward of 20°N) (Mantua and Hare 2002). The PDO is a statistical pattern that integrates multiple physical processes, including heat fluxes and wind driven transport related to the Aleutian low (Newman et al. 2016), and it is commonly related to inverse production regimes of Pacific salmon (*Oncorhynchus* spp.) in the Gulf of Alaska and California Current Ecosystem. Like the PDO, the NPGO is a statistical pattern derived using EOF/PC defined as the 2nd dominant mode of sea surface height variability in the Northeast Pacific which captures variability in North Pacific gyre strength. The NPGO is associated with regional and basin-scale variations in wind-driven upwelling and horizontal advection, which control salinity and nutrient concentrations important for phytoplankton fluctuations in the California Current Ecosystem (Di Lorenzo et al. 2008).

We also considered SST Arc as a marine driver of Pacific salmon. Briefly, SST Arc is an indicator of SST variability that spatially resembles the PDO but shows a stronger relationship to SSTs near the North American coast and a weaker connection to those in the central Pacific (Johnston and Mantua 2014). Like the PDO, SST Arc is derived as the leading mode of monthly SST anomalies (derived from empirical orthogonal function; EOF) from monthly gridded NCEP SST data across 60°N–20°N and 180°W–100°W from 1900 - 2012. Notably, SST Arc is used as a physically based metric of the leading EOF mode where a 1 standard deviation anomaly of the leading mode corresponds to an SST Arc deviation of 0.46 °C (Johnston and Mantua 2014), thus, representing regional variability that is more tightly coupled with the northern California Current than other basin-scale metrics like the PDO.

Regional predictors

Sea surface temperature at ocean entry can impact juvenile salmon marine survival. Monthly, gridded SST data is available from the NOAA 0.25 degree Daily Optimum Interpolation Sea Surface Temperature (OISST) climate data record, a data interpolated product. We characterized SST using three marine ecoregions in the California Current Ecosystem determined by Spalding et al. (2007) and applied by Satterthwaite et al (2019) and Gosselin et al. (2021). We calculated the seasonal mean SST across coastal northern California, coastal Oregon, coastal Washington, and Salish Sea ecoregions and standardized each seasonal SST with a mean of 0 and standard deviation of 1. Summer included SST during June, July, and August; winter included SST during January, February and March.

Seasonal means are one important characterization of the marine environment impacting juvenile salmon, but extreme environmental anomalies and variability are an important driver that can also impact salmon survival (Sharma et al. 2013). Recently, the California Current Ecosystem has experienced frequent and severe marine heatwave (MHW) events. We used three indicators that represent intensity, size, and persistence of MHWs. Warm SST events are considered a heatwave when SST anomalies reach the 90th percentile of a 30 year mean for at least 5 days (Hobday et al. 2016). MHW intensity is the SST anomaly once SST has reached heatwave status. MHW cover is the percent coverage of the ocean area within the EEZ that is in heatwave status. Finally, MHW degree day characterizes how long and intense a heatwave is as the cumulative degree days that SST is at or above the long-term mean (base temperature of 0). MHW indices are from NOAA SWFSC Environmental Research Data Services and use Multi-scale Ultra-high Resolution (MUR) SST Analysis Anomaly to derive indices.

Spring Transition Index (STI) and Total Upwelling Magnitude Index (TUMI) are two descriptors of the upwelling seas (Bograd et al. 2009) that influence primary production and forage availability in the northern California Current (Hickey and Banas 2008). STI refers to the timing of onset of the upwelling season and is represented by the date (Julian Day) on which the cumulative upwelling reaches its minimum value and positive upwelling prevails. TUMI represents total upwelling throughout the upwelling season and is the cumulative upwelling from the start date of the STI to the observed end date of the upwelling season. Upwelling data was available from 33°N to 48°N at 3-degree intervals. Upwelling in 45°N aligns with ecoregion 3 (coastal Oregon) and 48°N aligns with ecoregion 2 (coastal Washington); STI and TUMI are highly correlated (Pearson's correlation coefficient 0.75 and 0.72 respectively) across these locations. As a result, we used an average STI and TUMI across 45°N and 48°N for all stocks and standardized these annual indices such that it had a mean of 0 and standard deviation of 1.

Horizontal ocean transport can influence the dynamics of higher-trophic-level species in coastal ecosystems by altering either physical oceanographic conditions or the advection of food resources into coastal areas (Malick et al. 2017). In coastal Washington and British Columbia, the north-south location of the North Pacific Current bifurcation strongly influences productivity of Pacific salmon species (Malick et al. 2017). We used the bifurcation index developed by Malick et al. (2017) as an indicator of transport relevant to Pacific salmon. This index ranges from 0–1 where higher values indicate northern bifurcation and lower values indicate further south.

Freshwater predictor variables

Smolts are highly vulnerable during their downstream migration (Healey 1991), and river flow has been found to be positively correlated with survival (Notch et al., 2020). For each hatchery, we identified the nearest downriver U.S. Geological Survey (USGS) gauge station with time series data on river flow (cubic feet per second; CFS, Summary Table 2). For each program, expert opinion was used to determine months when river flows were most likely to influence smolt survival, and average flow (CFS) during these months was used as a predictor variable.

Hatchery predictor variables

Variables related to size or number of fish released may help assess density dependence, while variables related to timing of release may help determine optimal environmental conditions during juvenile rearing. We incorporated total number of fish released annually and, when available, average size of fish at release (weight in grams, fish per pound) and the calendar day or month of release. Size at release and release timing were available for all programs where analysis was based on CWT data.

Statistical modeling

Stocks included in this analysis have different run and return timing and, as a result, they experience freshwater and early marine environmental conditions during different seasons based on their migratory timing. Therefore, we modeled the effects of predictor variables on SARs from each stock independently and did not consider hierarchical modeling approaches or shared trends. Our approach allows for stock-specific characterizations of environmental conditions that account for each stock's life history strategy.

For each stock, we constructed a series of Generalized Additive Models (GAMs), using the mgcv package in R (R Core Team 2024) which allows for non-linear relationships between predictor variables and responses (Wood 2011). Each GAM modeled the response with a binomial family (logit link). We used the binomial family to model SARs based on the releases and returns each year, rather than model the derived SAR (e.g. total returns/total release)—this approach incorporates variation in the total number released each year such that years with more data get more weight (our approach weights each individual fish equally). To avoid overfitting and comparing millions of models, we limited the potential number of predictor variables included in each model to 2–4 variables. Similarly, we constrained the wiggliness of each relationship by setting the dimensionality of the basis expansion at 3 for each predictor variable (essentially allowing for curves to be no more complicated than quadratic shapes). Flow during outmigration can be an influential driver of juvenile survival (Petrosky and Schaller 2010) and was included in all models when applicable (e.g., flow was not incorporated for one stock with a very short migration to the sea; Summary Table 2).

Because our modeling approach was performed separately for each stock, selection of predictor variables was also conducted independently by stock. As an initial covariate screening, we fit a series of GAMs to SAR data for each stock using a single predictor variable. We then excluded predictor variables with ecologically unrealistic relationships with SAR data. Specifically, we removed predictor variables for which the relationship with SARs was concave up, which represents estimated SAR rates would be highest at extreme low and high values of a predictor (e.g. highest survival at low and high temperatures). Next, we constructed a list of all potential combinations of 1–3 predictor variables from the retained list and added flow as a predictor in each potential model, resulting in a list of potential permutations of 2–4 predictor variables. For each candidate model, we calculated two measures of data support and fit: Akaike's Information Criterion (AIC; Akaike 1973) and Root Mean Squared Error (RMSE) as a measure of predictive accuracy.

Quantifying predictor variable importance

For each stock, we quantified the marginal mean improvement in RMSE and AIC corresponding to each predictor variable across models. We adopted this approach instead of looking at the single best model (lowest RMSE or AIC) because for a given stock there were many models that were able to produce similar fits to the data. Our aim was to identify predictors that consistently contributed to lower RMSE or AIC across models (despite changes in the inclusion or exclusion of correlated predictors), which suggests that those covariates contain unique, meaningful information. For each predictor variable, we used RMSE to evaluate how much predictive capacity increased by inclusion of that predictor variable across models with that predictor. For each potential predictor variable considered in models with m predictor variables, we used the set of n models with m - 1 predictor variables without that predictor as a baseline, and for each calculated the average change in RMSE,

$$p_i = \frac{1}{n}\sum_{j=1}^{n} \frac{RMSE_{j,m-1} - RMSE_{j,m}}{RMSE_{j,m-1}}$$

Where $RMSE_{j,m-1}$ might represent RMSE from a model with 2 predictors, and $RMSE_{j,m}$ would represent the RMSE statistic for the same model, with the predictor variables of interest added (3 predictor variables total). In other words, p_i represents the average improvement in RMSE gained from adding variable X to a model that already has 2 predictor variables. To calculate the mean marginal improvement across models with differing numbers of predictor variables, we calculated the average $\sum_{i=1}^{3} p_i/3$ for each predictor variable (Ward et al. 2024). For visualization purposes, we constructed models for each stock using the predictor variables with the highest average improvement in RMSE.

As a second approach, we calculated the estimated effect sizes for each predictor variable. Estimating effect sizes with GAMs is slightly more complicated than linear models because relationships can be non-linear and asymmetric around the mean. We estimated the average absolute effect size for all marine predictor variables by holding all other predictor variables at their respective means, and evaluating the average change in survival that would result from the predictor variables of interest being decreased or increased by 1 standard deviation. Predictor variables were then ranked in descending order, corresponding to those with the largest to smallest effect sizes.

Calculating trends in SARs

To assess trends in the SAR data—independent of environmental predictor variables—we used dynamic generalized linear models to quantify change through time. Each of our SAR datasets was used to generate a binomial response (total number of releases, total number of returns) for each brood year. We estimated an initial intercept B_0 for the starting year of each time series and treated the trend as a latent random walk $u_t \sim N(u_{t-1}, \sigma)$. We used a binomial distribution (logit link) to relate the observed data with the estimated survival rates $logit(p_t) = B_0 + u_t$; in this framework, the u_t represents a change in log-odds between time steps (negative values correspond to decreases in SAR rates). For each stock we summarized the long-term (average differences of u_t across all years) and average 5-year short-term trend (average differences of u_t over the last 5 years of data). All models were constructed using Stan (Stan Development Team

2024a) and run through R using rstan (R Core Team 2024; Stan Development Team 2024b). We ran 4 parallel chains of 3000 iterations (using the first 50% for burn-in) and ensured all models were free of divergent transitions and had maximum Rhat values < 1.1.

Approach for qualitative vulnerability assessment

Our qualitative climate vulnerability analysis was a modification of the analytical structure developed by Crozier et al. (2019), which used expert opinion to score key environmental exposures that different salmon and steelhead evolutionarily significant units (ESUs) are expected to experience in a changing climate. For our assessment, we modified the list of environmental variables to only include those pertinent to life stages when hatchery fish are outside the hatchery environment (based on expert opinion). We recognize that climate change can also have impacts within the hatchery environment, but assessing these impacts requires facility-specific analyses (e.g., Hanson and Peterson 2014) that were beyond the scope of this assessment. Furthermore, vulnerability to environmental attributes that affect fish during early life history stages will depend on whether potential mitigation measures are implemented at a hatchery facility.

For our assessment, environmental variables were categorized in two groups: a sensitivity group, and an exposure group. Sensitivity was assessed using environmental factors such as estuary stage, marine stage, adult freshwater stage, other stressors, and ocean acidification, while excluding less relevant attributes like early life history, juvenile freshwater stage, cumulative life-cycle effects, hatchery influence, and population viability. The exposure metric was scored based on hydrologic regime, sea level rise, sea surface temperature, ocean acidification, upwelling, and ocean currents. Attributes like stream temperature, summer water deficit, and flooding were excluded because there is greater potential to mitigate their effects with hatchery infrastructure and operations. For the retained scoring attributes, we maintained the numerical values assigned by Crozier et al. (2019) and applied their logic rule for ranking the sensitivity and exposure components. Climate sensitivity and exposure scoring was done by Species Management Unit (SMU), which ODFW defines as a collection of populations from a common geographic region that share similar genetic and ecological characteristics. SMUs often align geographically with federal ESUs but are separated into run types (e.g. spring and fall Chinook) that may be combined in an ESU. For SMUs that did not align with an ESU that was evaluated by Crozier et al. (2019), we either used another source that used similar methods (ODFW 2021) or relied on information from a neighboring ESU. For several SMUs, no appropriate analog was available, and climate vulnerability could not be assessed. The final vulnerability score for each SMU was calculated as the product of the exposure and sensitivity scores.

Acknowledgements

Thanks to helpful feedback from Eric Ward (Northwest Fisheries Science Center, NMFS), Chris Lorion (Oregon Department of Fish and Wildlife, ODFW), Megan Feddern (Northwest Fisheries Science Center, NMFS), Laurie Weitkamp (Northwest Fisheries Science Center, NMFS), and Patti Wohner (Oregon State University, OSU), whose comments and help with analyses improved this report. Micki Varney (ODFW), Joseph Feldhaus (ODFW), Jason Seals (ODFW), Lindsay Powell (ODFW), John Spangler (ODFW), and Dan Van Dyke (ODFW) provided data sets used in the assessment, as well as helpful suggestions on data filtering and environmental variables. Additional reviewer feedback from Megan Sabal (ODFW) improved the clarity and conceptual framework of the report.

Citations

Akaike, H. (1973). Maximum likelihood identification of Gaussian autoregressive moving average models. *Biometrika*, *60*(2), 255-265.

Bograd, S. J., Schroeder, I., Sarkar, N., Qiu, X., Sydeman, W. J., & Schwing, F. B. (2009). Phenology of coastal upwelling in the California Current. *Geophysical Research Letters*, *36*(1).

Crozier, L. G., McClure, M. M., Beechie, T., Bograd, S. J., Boughton, D. A., Carr, M., ... & Willis-Norton, E. (2019). Climate vulnerability assessment for Pacific salmon and steelhead in the California Current Large Marine Ecosystem. *PloS one*, *14*(7), e0217711.

Deser, C., Phillips, A. S., Alexander, M. A., Amaya, D. J., Capotondi, A., Jacox, M. G., & Scott, J. D. (2024). Future Changes in the Intensity and Duration of Marine Heat and Cold Waves: Insights from Coupled Model Initial-Condition Large Ensembles. *Journal of Climate*, *37*(6), 1877-1902.

Di Lorenzo, E., Schneider, N., Cobb, K. M., Franks, P. J. S., Chhak, K., Miller, A. J., ... & Rivière, P. (2008). North Pacific Gyre Oscillation links ocean climate and ecosystem change. *Geophysical research letters*, *35*(8).

Duffy, E. J., & Beauchamp, D. A. (2011). Rapid growth in the early marine period improves the marine survival of Chinook salmon (Oncorhynchus tshawytscha) in Puget Sound, Washington. *Canadian Journal of Fisheries and Aquatic Sciences*, *68*(2), 232-240.

Gosselin, J. L., Crozier, L. G., & Burke, B. J. (2021). Shifting signals: Correlations among freshwater, marine and climatic indices often investigated in Pacific salmon studies. *Ecological Indicators*, *121*, 107167.

Hanson, K. C., & Peterson, D. P. (2014). Modeling the potential impacts of climate change on Pacific salmon culture programs: an example at Winthrop National Fish Hatchery. *Environmental Management, 54*, 433-448.

Hartman, K.J & Porto M.A. (2014). Thermal Performance of Three Rainbow Trout Strains at Above-Optimal Temperatures. *Transactions of the American Fisheries Society, 143*(6), 1445-1454.

Healey, M. C. (1991). Life history of chinook salmon (Oncorhynchus tshawytscha). *Pacific salmon life histories*, 311-394.

Hickey, B. M., & Banas, N. S. (2008). Why is the northern end of the California Current System so productive?. *Oceanography*, *21*(4), 90-107.

Hobday, A. J., Alexander, L. V., Perkins, S. E., Smale, D. A., Straub, S. C., Oliver, E. C., ... & Wernberg, T. (2016). A hierarchical approach to defining marine heatwaves. *Progress in oceanography*, *141*, 227-238.

Johnstone, J. A., & Mantua, N. J. (2014). Atmospheric controls on northeast Pacific temperature variability and change, 1900–2012. *Proceedings of the National Academy of Sciences*, *111*(40), 14360-14365.

Malick, M. J., Cox, S. P., Mueter, F. J., Dorner, B., & Peterman, R. M. (2017). Effects of the North Pacific Current on the productivity of 163 Pacific salmon stocks. *Fisheries Oceanography*, *26*(3), 268-281.

Mantua, N. J., & Hare, S. R. (2002). The Pacific decadal oscillation. *Journal of oceanography*, *58*, 35-44.

Morgan, C. A., Beckman, B. R., Weitkamp, L. A., & Fresh, K. L. (2019). Recent ecosystem disturbance in the Northern California Current. *Fisheries, 44(10)*, 465-474.

Newman, M., Alexander, M. A., Ault, T. R., Cobb, K. M., Deser, C., Di Lorenzo, E., ... & Smith, C. A. (2016). The Pacific decadal oscillation, revisited. *Journal of Climate*, *29*(12), 4399-4427.

Notch, J. J., McHuron, A. S., Michel, C. J., Cordoleani, F., Johnson, M., Henderson, M. J., & Ammann, A. J. (2020). Outmigration survival of wild Chinook salmon smolts through the Sacramento River during historic drought and high water conditions. *Environmental Biology of Fishes*, *103*, 561-576.

Oliver, E. C., Burrows, M. T., Donat, M. G., Sen Gupta, A., Alexander, L. V., Perkins-Kirkpatrick, S. E., ... & Smale, D. A. (2019). Projected marine heatwaves in the 21st century and the potential for ecological impact. *Frontiers in Marine Science*, *6*, 734.

Petrosky, C. E., & Schaller, H. A. (2010). Influence of river conditions during seaward migration and ocean conditions on survival rates of Snake River Chinook salmon and steelhead. *Ecology of Freshwater Fish*, *19*(4), 520-536.

R Core Team. (2024). R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria.

Satterthwaite, W. H., Andrews, K. S., Gosselin, J. L., Greene, C. M., Harvey, C. J., Hunsicker, M., ... & Samhouri, J. F. (2019). Patterns of Synchrony and Environmental Thresholds in the Performance of Forecast Models Used for US West Coast Chinook and Coho Salmon Stocks. *North Pacific Anadromous Fish Commission Technical Report,* 15, 157–160.

Sharma, R., Vélez-Espino, L. A., Wertheimer, A. C., Mantua, N., & Francis, R. C. (2013). Relating spatial and temporal scales of climate and ocean variability to survival of Pacific Northwest Chinook salmon (Oncorhynchus tshawytscha). *Fisheries Oceanography*, *22*(1), 14-31.

Spalding, M. D., Fox, H. E., Allen, G. R., Davidson, N., Ferdaña, Z. A., Finlayson, M. A. X., ... & Robertson, J. (2007). Marine ecoregions of the world: a bioregionalization of coastal and shelf areas. *BioScience*, *57*(7), 573-583.

Stan Development Team. (2024a). Stan Modeling Language Users Guide and Reference Manual, 2.35.

Stan Development Team. (2024b). RStan: the R interface to Stan. R package version 2.32.6.

Wang, D., Gouhier, T. C., Menge, B. A., & Ganguly, A. R. (2015). Intensification and spatial homogenization of coastal upwelling under climate change. *Nature*, *518*(7539), 390-394.

Ward, E. J., Hunsicker, M. E., Marshall, K. N., Oken, K. L., Semmens, B. X., Field, J. C., ... & Tolimieri, N. (2024). Leveraging ecological indicators to improve short term forecasts of fish recruitment. *Fish and Fisheries*.

Wood, S.N. (2011) Fast stable restricted maximum likelihood and marginal likelihood estimation of semiparametric generalized linear models. *Journal of the Royal Statistical Society (B)* 73(1):3-36

Zhang, L., & Delworth, T. L. (2016). Simulated response of the Pacific decadal oscillation to climate change. *Journal of Climate*, *29*(16), 5999-6018

Summary Tables

Summary Table 1 Summary of marine indicators used for modeling smolt to adult returns (SARs) across hatchery stocks.

Indicator	Summary timeline	Scale	Description	Hypothesized relationship
Spring Transition Index (STI)	annual	global	The date (Julian Day) on which the Cumulative Upwelling Index (CUI) reaches its minimum value and positive upwelling prevails.	Negative
Total Upwelling Magnitude Index (TUMI)	annual	global	Total CUI from the start date of the STI to the observed end date of the upwelling season.	Positive
North Pacific Current Bifurcation Index	annual	regional	Interannual variability in the latitude of the North Pacific Current bifurcation as well as the volume of water that bifurcates northward into the Alaska Current and southward into the California Current (Malick et al. 2016). Positive values are associated with increased NPC strength, a northward-shifted bifurcation, and increased transport into the California Current.	Positive
North Pacific Gyre Oscillation (NPGO)	seasonal	basin	Pattern of sea surface height variability which provides a strong indicator of ecosystem dynamics including salinity and phytoplankton concentrations.	Positive
Pacific Decadal Oscillation (PDO)	seasonal	basin	Warm or cool phase climate pattern where changes in temperature and salinity affect species dynamics and distribution.	Negative
Marine Heat Wave Degree Day	seasonal	regional	Expresses how long and intense a heatwave is. Calculated by averaging the points within a region (in this case the US Exclusive Economic Zone, or EEZ) where the Sea Surface Temperature Anomaly (SSTa) is greater than 0 (i.e.. above the 30-year average).	Negative
Marine Heat Wave Intensity	seasonal	regional	Spatial average intensity where average SSTa for all cells in a given area (in this case the EEZ) exceed the heatwave threshold of 1.29 (interpreted as the 90th percentile above the long-term mean).	Negative

Marine Heat Wave Cover within the US Exclusive Economic Zone (US EEZ)	seasonal	regional	Percent coverage of ocean area within the EEZ that is in 'heatwave status' (where SSTa exceeds 1.29) on a given day. Expresses how large a heatwave is near the coast.	Negative
Sea Surface Temperature (SST)	seasonal	regional	Average monthly sea surface temperatures recorded across coastal ocean ecoregions 1-4 of the California Current Ecosystem (Gosselin et al. 2021).	Parabolic
Ocean Station Papa SST	seasonal	regional	SST measured at a long-term ocean climate measurement site located at 50°N, 145°W.	Parabolic
SST Arc	seasonal	regional	The scaled anomalies of SST within the NE Pacific Arc (Johnstone and Mantua, 2013).	Negative

Summary Table 2 Summary of stocks used for analysis with life history and freshwater predictor variable details (RMIS = Regional Mark Information System; LSRCP = Lower Snake River Compensation Plan; HMS = Hatchery Management System).

Program	USGS Station	CFS details	Brood Years	Release dates	Release date as model predictor	Avg. size as model predictor	Life History Details	Data Sources for SAR Analysis
				Spring Chinook				
Trask	Wilson River in Tillamook (14301500)	Average August CFS	1986–2017	Jul–Sep	Month	Y	Released as subyearlings. Adults return Apr–Jun, recovered hatchery Aug–Oct (3–6 y.o.). Segregated stock.	RMIS
Deschutes (Round Butte)	Deschutes near Biggs (14103000)	Average May CFS	1990–2016	Apr–Jun	Month	Y	Released as yearlings. Adults return Mar–Jul, recovered hatchery May–Oct (3–6 y.o.). Integrated stock.	RMIS
McKenzie	Columbia Dalles (113459)	Average April CFS	1981–2016	Jan–Mar	Month	Y	Released as yearlings. Adults return Feb–Jul, recovered hatchery May–Oct (3–6 y.o.). Integrated stock.	RMIS
Imnaha	Columbia Dalles (113459)	Average April CFS	1984–2016	Mar–Apr	Avg. Julian day	Y	Released as yearlings. Adults return May–Jul, recovered hatchery Jul–Sep (3–5 y.o.). Integrated stock.	ODFW LSRCP summary
Rogue (Cole Rivers)	Rogue Grants Pass (14361500)	Average September CFS	1988–2017	Aug–Oct; Mar	Month	Y	Released primarily as subyearlings. Adults return Mar–Jun, recovered hatchery Apr–Sep (3–6 y.o.). Integrated stock.	RMIS
				Fall Chinook				
Salmon River	Siletz (14305500) as proxy	Mean August	1982–2017	Aug	N	Y	Released as subyearlings, short migration to ocean (~4 miles). Adults return Aug–Oct, recovered hatchery Sept–Nov (3–6 y.o.). Integrated Stock.	RMIS
Elk River	NA	NA	1981–2016	Oct–Nov; Feb	N	Y	Released primarily as subyearlings, short migration to ocean (~14 miles). Adults return Sep–Jan, recovered hatchery Oct–Jan (3–6 y.o.). Integrated stock.	RMIS
Big Creek	Columbia Dalles (113459)	Mean April	1986–2017	Mar–May	N	Y	Released as subyearlings, may rear in estuary for a time. Adults return Aug–Oct, recovered hatchery Aug–Oct (3–6 y.o.). Segregated stock.	RMIS

Program	USGS Station	CFS details	Brood Years	Release dates	Release date as model predictor	Avg. size as model predictor	Life History Details	Data Sources for SAR Analysis
					Coho			
Rogue (Cole Rivers)	Rogue Grants Pass (14361500)	Average April CFS	1981–2016	Apr–Jul	Avg. Julian day	N	Released as yearlings. Adults return Sep–Dec (3 y.o.). Integrated stock.	RMIS
Big Creek	Columbia Dalles (113459)	Average April CFS	1981–2016	Apr–May	Avg. Julian day	N	Released as yearlings. Adults return Sep–Dec (3 y.o.). Segregated stock.	RMIS
Sandy	Columbia Dalles (113459)	Average April CFS	1981–2016	Apr–May	Avg. Julian day	N	Released as yearlings. Adults return Sep–Dec (3 y.o.). Segregated stock.	RMIS
					Summer steelhead			
Siletz	Siletz (14305500)	Average April CFS	1992–2016	Apr	N	N	Released as yearlings. Adults return Apr–Aug, caught Jun–Nov (primarily 2–4 y.o.). Segregated stock.	ODFW HMS; harvest estimates; unpublished trap and age data
Rogue (Cole Rivers)	Rogue Grants Pass (14361500)	Average April CFS	1993–2016	Apr–May	N	N	Released as yearlings. Return Apr–Oct, recovered at hatchery May–Nov (early and late runs, primarily 3–4 y.o.). Integrated stock.	ODFW HMS; harvest estimates; unpublished age data
Deschutes (Round Butte)	Deschutes near Biggs (14103000)	Average April CFS	2003–2016	Apr	N	N	Released as yearlings. Return Jun–Sep, recovered at hatchery Oct–Mar (primarily 2–3 y.o.). Segregated stock.	ODFW HMS; harvest estimates; unpublished trap data
Wallowa	Columbia Dalles (113459)	Average April CFS	1986–2016	Apr–May	N	N	Released as yearlings. Adults recovered at hatchery Feb–Jun (peak collection Mar–Apr). Segregated stock.	ODFW LSRCP summary
					Winter steelhead			
North Fork Nehalem	Nehalem at Foss (14301000)	Average April CFS	1993–2016	Mar–Apr	N	N	Released as yearlings. Adults return Dec-Apr (primarily 3-4 y.o.). Segregated stock (recently portion of program converted to integrated).	ODFW HMS; harvest estimates; unpublished age data
Alsea	Alsea at Tidewater (14306500)	Average April CFS	1993–2016	Apr–May	N	N	Released as yearlings. Adults return Dec-Apr (primarily 3-4 y.o.). Includes segregated and integrated stocks.	ODFW HMS; harvest estimates; unpublished age data

Summary Table 3 Predictor variables with top two ranked Root Mean Squared Error (RMSE) for each hatchery stock. The number next to each variable represents its rank.

Species	Program	Predictor variable
Spring Chinook	Trask	1 - Total released
		2- SST summer
	Deschutes (Round Butte)	1 - SST summer L1
		2- PDO summer L1
	McKenzie	1 - SST summer L1
		2- PDO summer L1
	Imnaha	1 - PDO summer L1
		2- PDO summer
	Rogue (Cole Rivers)	1 - MHW intensity summer
		2- TUMI
Fall Chinook	Salmon River	1 - STI L1
		2- SST Arc summer
	Elk River	1 - Average weight
		2- NPGO winter L1
	Big Creek	1 - NPGO winter L1
		2- SST summer
Coho	Rogue (Cole Rivers)	1 - SST winter L1
		2- Average weight
	Big Creek	1 - PDO summer L1
		2- MHW intensity summer
	Sandy	1 - PDO summer L1
		2- Total released
Summer Steelhead	Siletz	1 - NPGO summer
		2- NPGO summer L1
	Rogue (Cole Rivers)	1 - SST winter L1
		2- SST Arc winter L1
	Deschutes (Round Butte)	1 - NPGO summer L1
		2- NPGO winter L1
	Wallowa	1 - Total released
		2- NPGO summer
Winter Steelhead	Nehalem	1 - STI L1
		2- NPGO summer
	Alsea	1 - Total released
		2- STI L1

Summary Table 4 Average long term and short term (5-year) trends in smolt to adult returns (SARs) with their 95% credible intervals. Trends are starred (*) where the credible intervals do not cross zero.

Species	Program	Trend	Mean	SD	2.50%	97.50%
Spring Chinook	Trask	long term *	-0.019	0.002	-0.022	-0.016
		short term *	0.043	0.021	0.002	0.085
	Deschutes (Round Butte)	long term *	-0.097	0.002	-0.101	-0.094
		short term *	-0.426	0.018	-0.461	-0.392
	McKenzie	long term *	-0.056	0.001	-0.057	-0.054
		short term *	-0.129	0.007	-0.143	-0.114
	Imnaha	long term	-0.004	0.003	-0.009	0.002
		short term *	-0.166	0.008	-0.181	-0.151
	Rogue (Cole Rivers)	long term *	-0.109	0.001	-0.110	-0.107
		short term *	-0.091	0.008	-0.107	-0.075
Fall Chinook	Salmon River	long term *	-0.008	0.001	-0.011	-0.005
		short term *	-0.086	0.006	-0.098	-0.075
	Elk River	long term *	0.015	0.001	0.014	0.017
		short term *	-0.103	0.004	-0.111	-0.094
	Big Creek	long term	-0.002	0.002	-0.005	0.001
		short term *	0.21	0.015	0.181	0.24
Coho	Rogue (Cole Rivers)	long term *	-0.063	0.004	-0.072	-0.055
		short term *	-0.289	0.043	-0.374	-0.207
	Big Creek	long term *	-0.010	0.001	-0.013	-0.008
		short term *	0.065	0.01	0.045	0.085
	Sandy	long term *	-0.037	0.002	-0.041	-0.034
		short term *	-0.088	0.02	-0.128	-0.049
Summer Steelhead	Siletz	long term *	-0.015	0.002	-0.018	-0.011
		short term *	-0.304	0.009	-0.322	-0.287
	Rogue (Cole Rivers)	long term *	-0.029	0.001	-0.030	-0.028
		short term *	-0.048	0.004	-0.056	-0.040
	Deschutes (Round Butte)	long term *	-0.050	0.002	-0.053	-0.046
		short term *	-0.079	0.006	-0.090	-0.068
	Wallowa	long term *	-0.031	0.001	-0.033	-0.030
		short term *	-0.366	0.005	-0.377	-0.356
Winter Steelhead	Nehalem	long term	-0.001	0.001	-0.004	0.002
		short term *	-0.417	0.007	-0.431	-0.403
	Alsea	long term *	-0.011	0.001	-0.013	-0.009
		short term *	-0.133	0.005	-0.143	-0.122

Summary Table 5a Logic rule used to assign exposure, sensitivity, and cumulative vulnerability rankings to assessed hatchery programs. This vulnerability scoring process was derived from Crozier et al. (2019), where the sensitivity and exposure of specific salmon and steelhead stocks were expertly ranked using a set of environmental attributes. Specific environmental attributes were considered 'exposure attributes' while others were considered 'sensitivity attributes.' The overall sensitivity and exposure of each stock was assigned a numeric score based on the average score values of their environmental attributes (e.g. if there were >3 environmental attribute means within the sensitivity category with a value of ≥3.5, overall sensitivity was ranked as a 4 or 'Very High'). The product of the overall sensitivity and exposure scores was then used to create a final cumulative vulnerability ranking for each stock. For our analysis, we removed attributes that were not as relevant to hatchery fish (e.g. hatchery influence) or that could be modified within the hatchery environment (e.g. stream temperature, summer water deficit). The remaining environmental attributes, which are expected to impact hatchery fish during life stages outside the hatchery, were used to score their levels of sensitivity, exposure, and cumulative vulnerability.

Overall sensitivity or exposure score	**Numeric score**	**Logic rule**
Very High	4	More than 3 attribute means ≥ 3.5
High	3	More than 2 attribute means ≥ 3
Moderate	2	More than 2 attribute means ≥ 2.5
Low	1	All other scores
Cumulative vulnerability	**Component product**	**Component combinations**
Very High	≥12	Very high/high or Very high/very high
High	8-11	Very high/moderate or High/high
Moderate	4-6	Very high/low, High/moderate, or Moderate/moderate
Low	≤3	High/low, Moderate/low, or Low/low

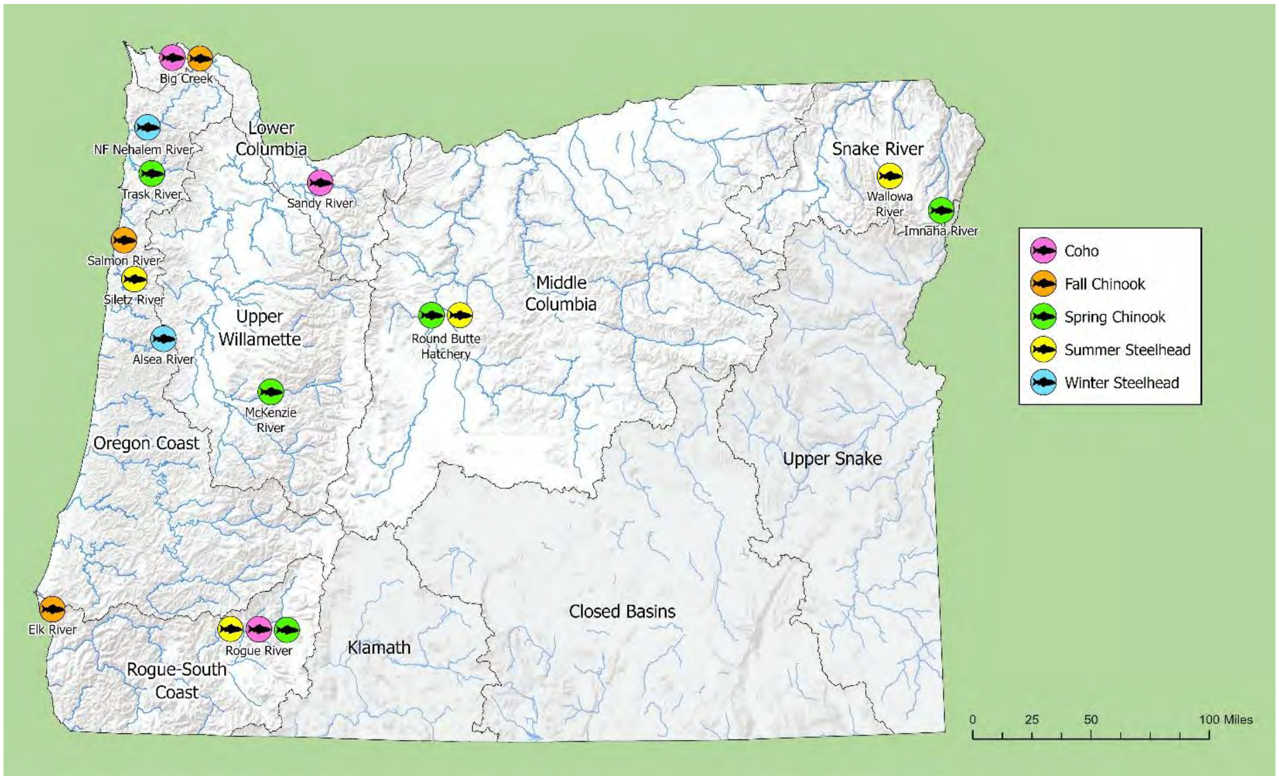
Summary Table 5b Final cumulative ranks for exposure, sensitivity, and vulnerability across Oregon Pacific salmon and steelhead Species Management Units (SMUs). Hatchery stocks included in our quantitative assessment are highlighted in bold. *SAFE = Select Area Fishery Enhancement Program.

Species	SMU	Programs	Exposure Score	Sensitivity Score	Vulnerability Score	ESU
Spring Chinook	Oregon Coast	**Trask**, Nestucca, North Umpqua	High	Low	Low	Based on Lower Columbia River Chinook (not run specific)
	Rogue–South Coast	**Rogue (Cole Rivers)**				NA
	Lower Columbia River	*SAFE, Sandy, Hood	High	Low	Low	Lower Columbia River Chinook (not run specific)
	Upper Willamette River	Clackamas, North Santiam, South Santiam, **McKenzie**, Middle Fork Willamette	High	High	High	Upper Willamette River (spring) Chinook
	Middle Columbia River	**Deschutes (Round Butte)**	High	High	High	Middle Columbia River spring-run Chinook
	Snake River	Catherine Creek, Upper Grande Ronde, Wallowa, **Imnaha**, Lookingglass Creek	High	High	High	Snake River spring/summer-run Chinook
Fall Chinook	Oregon Coast	Necanicum, Trask, Nestucca, **Salmon**, Umpqua, Coos, Coquille, **Elk**	High	Low	Low	Based on Lower Columbia River Chinook (not run specific)
	Rogue–South Coast	Chetco, Indian Creek (Rogue)				NA
	Lower Columbia River	**Big Creek**, Bonneville	High	Low	Low	Lower Columbia River Chinook (not run specific)
	Middle Columbia River	Umatilla				NA

Species	SMU	Programs	Exposure Score	Sensitivity Score	Vulnerability Score	ESU
Coho	Oregon Coast	North Fork Nehalem, Trask, South Umpqua	Moderate	Moderate	Moderate	Oregon Coast Coho
	Rogue–South Coast	**Rogue (Cole Rivers)**	High	Moderate	Moderate	Based on climate vulnerability assessment for coho salmon in the Rogue–South Coast Multi-Species Conservation and Management Plan (ODFW 2021). Used scores for the Upper Rogue population.
	Lower Columbia River	**Big Creek**, *SAFE, **Sandy**	Moderate	Moderate	Moderate	Lower Columbia River Coho
	Middle Columbia River	Umatilla				NA
Summer Steelhead	Oregon Coast	Wilson, Nestucca, **Siletz**, North Umpqua	High	Low	Low	Based on Lower Columbia River steelhead (not run specific)
	Rogue-South Coast	**Rogue (Cole Rivers)**	High	Moderate	Moderate	Based on climate vulnerability assessment for summer steelhead in the Rogue–South Coast Multi-Species Conservation and Management Plan (ODFW 2021). Used scores for the Upper Rogue population.
	Lower Columbia River	Clackamas, Sandy	High	Low	Low	Lower Columbia River steelhead (not run specific)
	Upper Willamette River	Upper Willamette	High	Low	Low	Upper Willamette River (winter) steelhead
	Middle Columbia River	**Deschutes (Round Butte)**, Umatilla	High	High	High	Middle Columbia River (summer) steelhead
	Snake River	**Wallowa**, Little Sheep Creek	High	High	High	Snake River Basin (summer) steelhead

Species	SMU	Programs	Exposure Score	Sensitivity Score	Vulnerability Score	ESU
Winter Steelhead	Oregon Coast	Necanicum, **North Fork Nehalem**, Wilson, Nestucca, Siletz, **Alsea**, Siuslaw, South Umpqua, Tenmile, Coos, North Fork/South Fork Coquille	High	Low	Low	Based on Lower Columbia River steelhead (not run specific)
	Rogue–South Coast	Chetco, Applegate, Rogue	High	Low	Low	Based on climate vulnerability assessment for winter steelhead in the Rogue–South Coast Multi-Species Conservation and Management Plan (ODFW 2021). Used average of scores for the Upper Rogue, Middle Rogue/Applegate, and Chetco populations.
	Lower Columbia River	Big Creek, Clackamas, Sandy	High	Low	Low	Lower Columbia River steelhead (not run specific)

Summary Figures



Summary Figure 1 Map of Oregon state with assessed hatcheries and hatchery stocks.

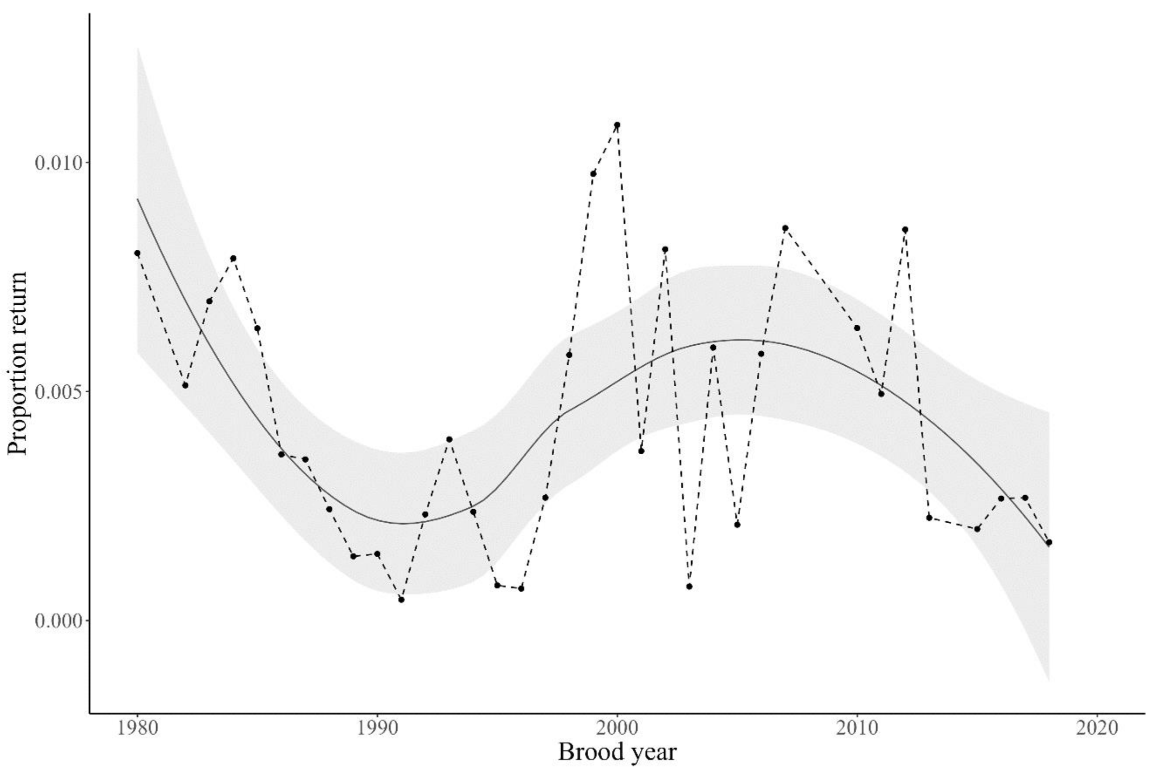
Stock Synthesis Tables and Figures

Spring Chinook Salmon

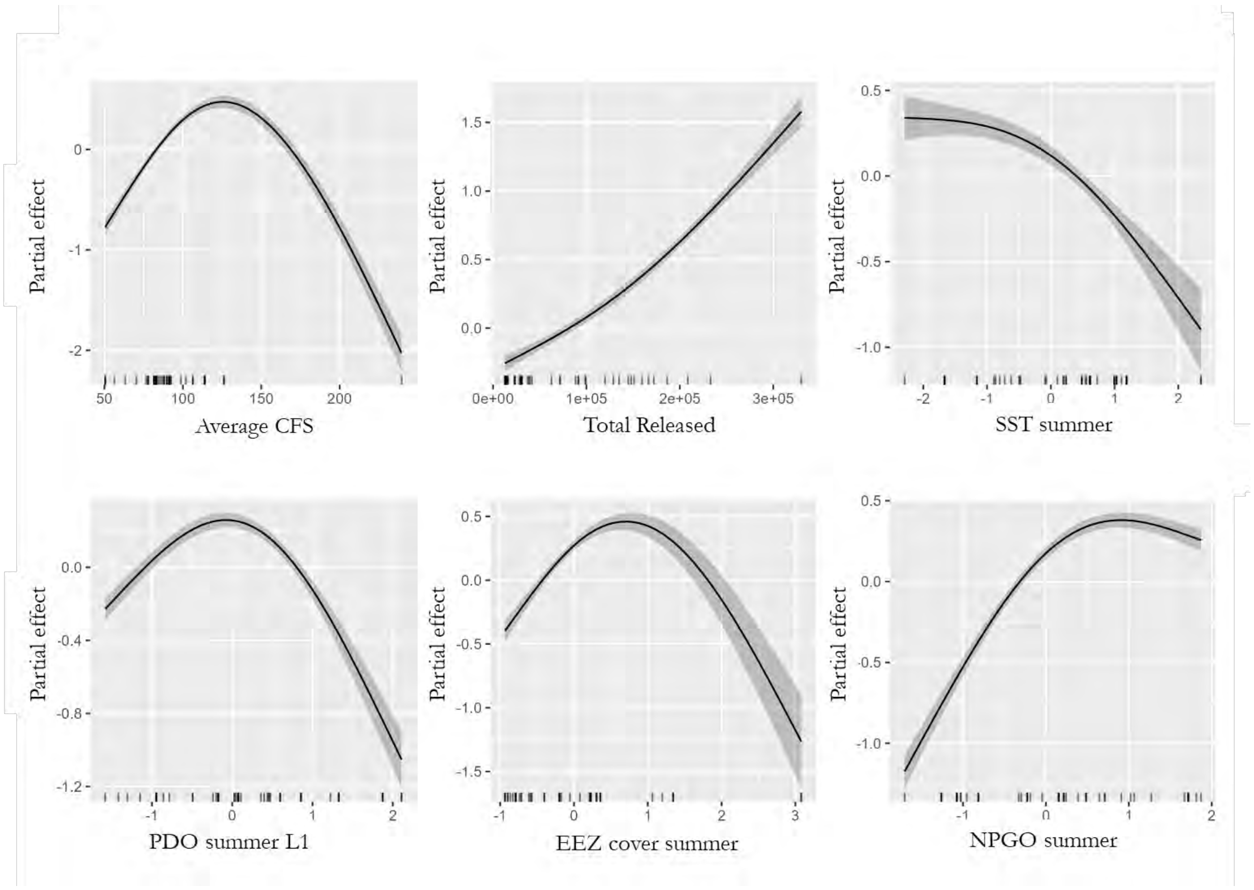
Trask

Synthesis Table 1.1 Table of estimate Root Mean Squared Error (RMSE, lower is better), Akaike's Information Criterion (AIC, lower translates to more data support), and estimated average absolute effect sizes of standardized predictors (larger effects have a bigger impact on the response) for the Trask spring Chinook program.

Predictor	RMSE	AIC	Average absolute effect
Total released	0.7514	1827.76	0.0000
SST summer	0.8620	879.72	0.0011
PDO summer L1	0.8780	644.25	0.0012
EEZ cover summer	0.8930	689.89	0.0016
NPGO summer	0.9185	766.38	0.0017



Synthesis Figure 1.1 Estimated proportion of returning individuals, categorized by brood year, for the Trask spring Chinook program. Points represent empirical means, the solid line represents a LOESS-smoothed fit to the mean proportions, and the grey ribbon represents a 95% confidence interval.

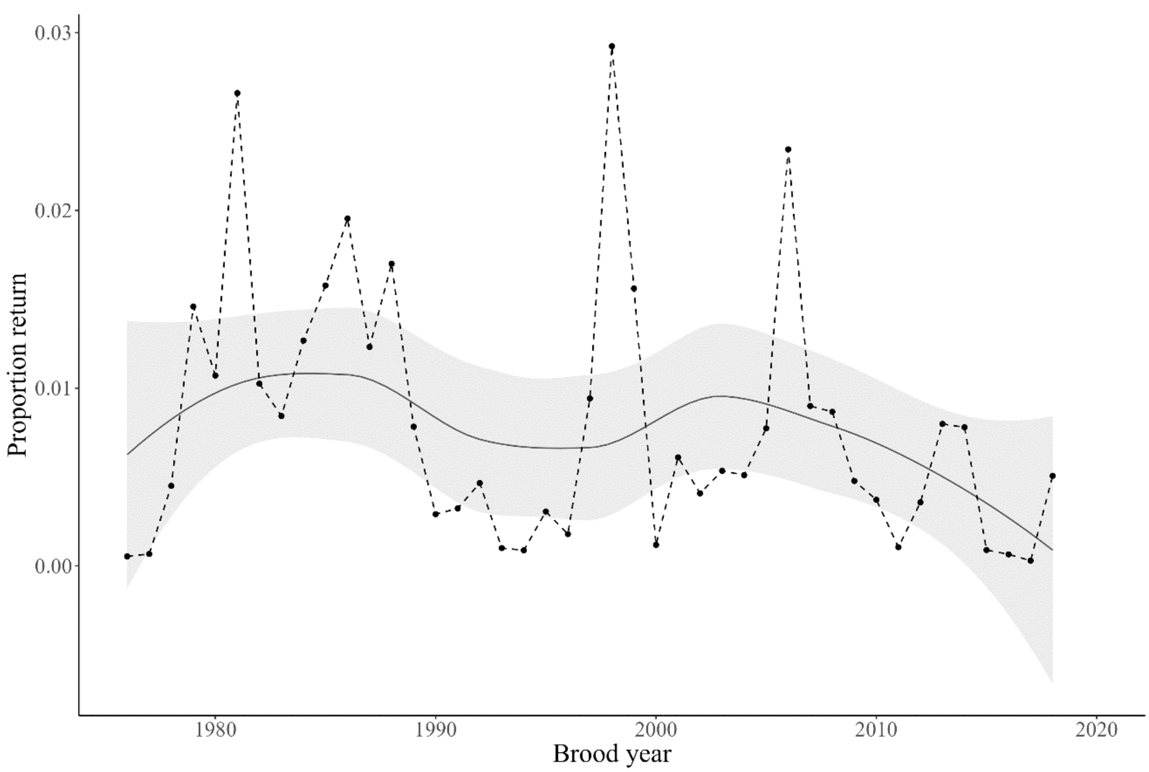


Synthesis Figure 1.11 Estimated partial effects of the top six predictors with the lowest (best) RMSE for the Trask spring Chinook program. Solid lines show the estimated smooth effect (using splines) of each predictor, and the shaded ribbons indicate the 95% confidence intervals for the estimated effects.

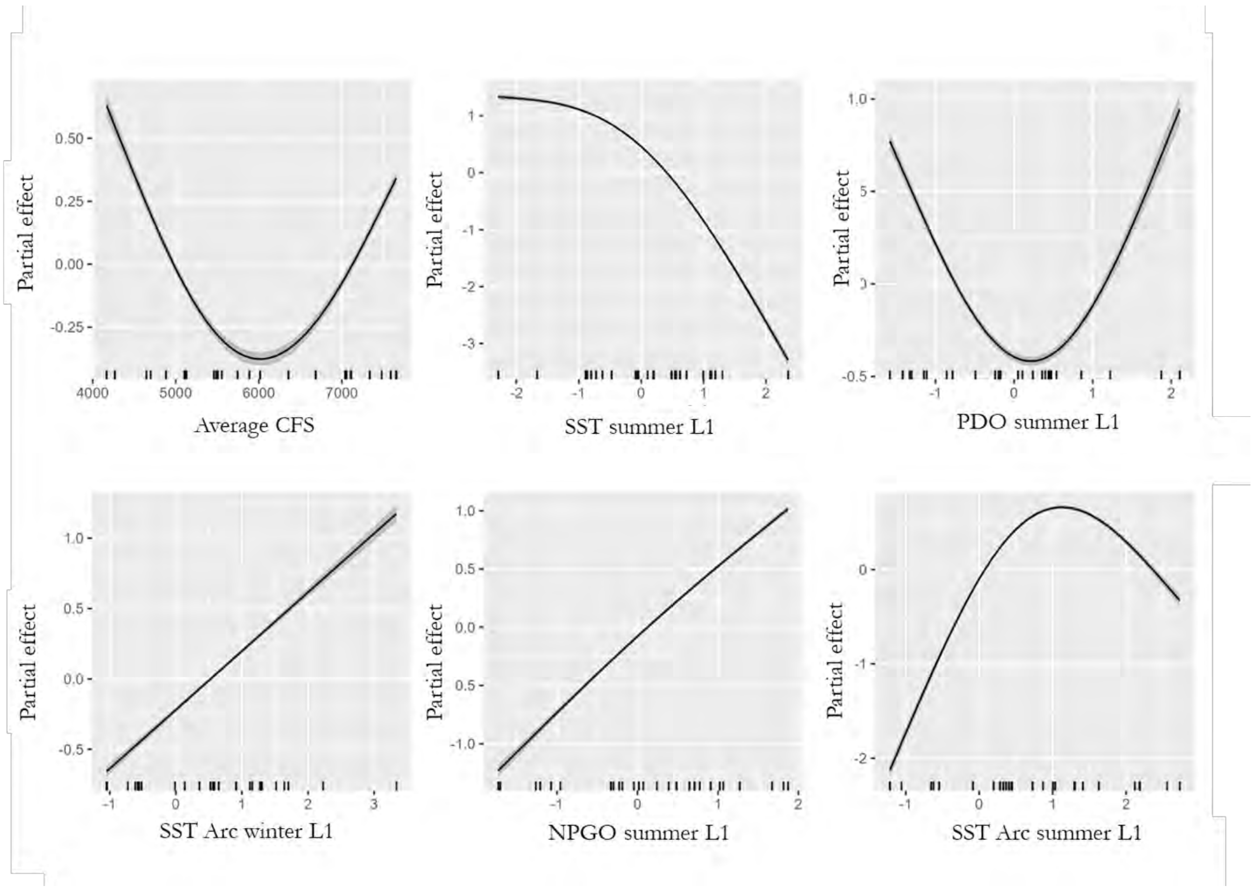
Deschutes (Round Butte)

Synthesis Table 1.2 Table of estimate Root Mean Squared Error (RMSE, lower is better), Akaike's Information Criterion (AIC, lower translates to more data support), and estimated average absolute effect sizes of standardized predictors (larger effects have a bigger impact on the response) for the Deschutes (Round Butte) spring Chinook program.

Predictor	RMSE	AIC	Average absolute effect
SST summer L1	0.8358	12427.95	0.0018
PDO summer L1	0.8947	6912.02	0.0013
SST Arc winter L1	0.8991	8231.66	0.0009
NPGO summer L1	0.9037	10855.42	0.0014
SST Arc summer L1	0.9063	8154.87	0.0021



Synthesis Figure 1.2 Estimated proportion of returning individuals, categorized by brood year, for the Deschutes (Round Butte) spring Chinook program. Points represent empirical means, the solid line represents a LOESS-smoothed fit to the mean proportions, and the grey ribbon represents a 95% confidence interval.

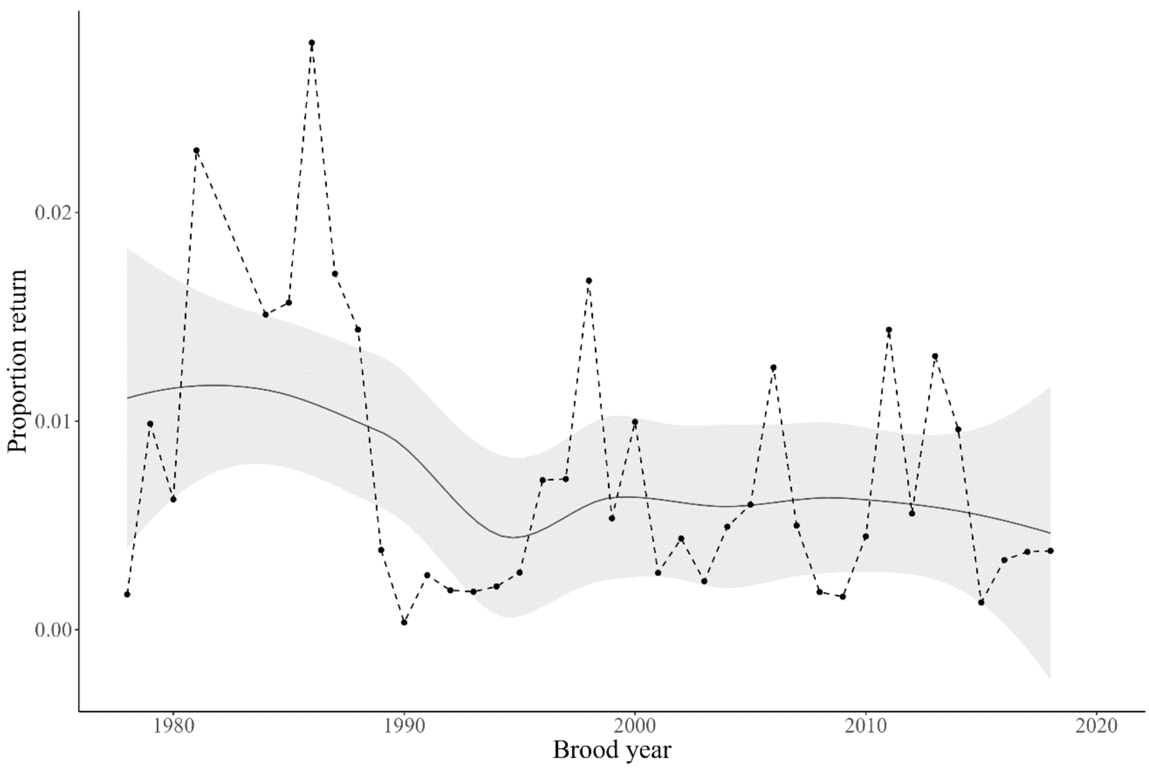


Synthesis Figure 1.21 Estimated partial effects of the top six predictors with the lowest (best) RMSE for the Deschutes (Round Butte) spring Chinook program. Solid lines show the estimated smooth effect (using splines) of each predictor, and the shaded ribbons indicate the 95% confidence intervals for the estimated effects.

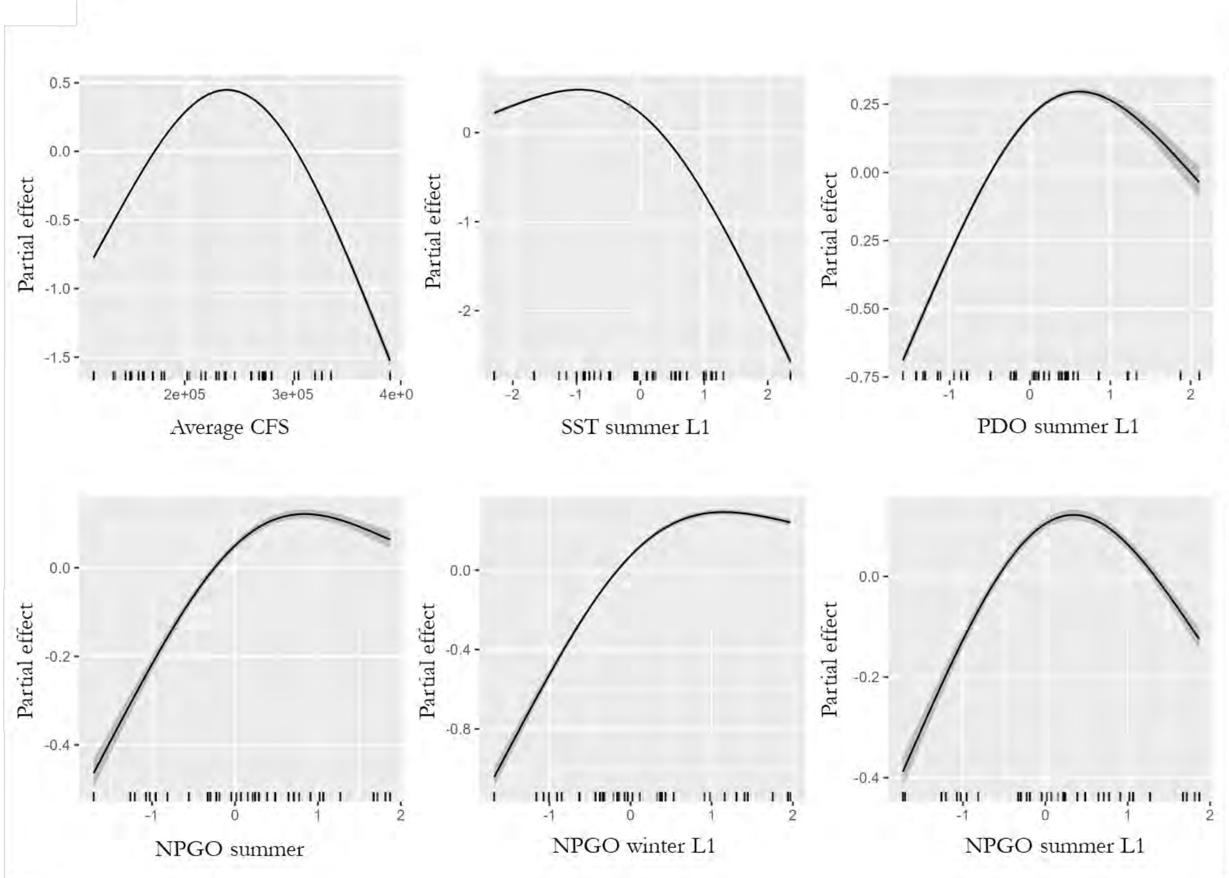
McKenzie

Synthesis Table 1.3 Table of estimate Root Mean Squared Error (RMSE, lower is better), Akaike's Information Criterion (AIC, lower translates to more data support), and estimated average absolute effect sizes of standardized predictors (larger effects have a bigger impact on the response) for the McKenzie spring Chinook program.

Predictor	RMSE	AIC	Average absolute effect
SST summer L1	0.9053	15355.95	0.0066
PDO summer L1	0.9264	12803.31	0.0034
NPGO summer	0.9290	11285.93	0.0023
NPGO winter L1	0.9297	10989.87	0.0051
NPGO summer L1	0.9465	7330.28	0.0018



Synthesis Figure 1.3 Estimated proportion of returning individuals, categorized by brood year, for the McKenzie spring Chinook program. Points represent empirical means, the solid line represents a LOESS-smoothed fit to the mean proportions, and the grey ribbon represents a 95% confidence interval.

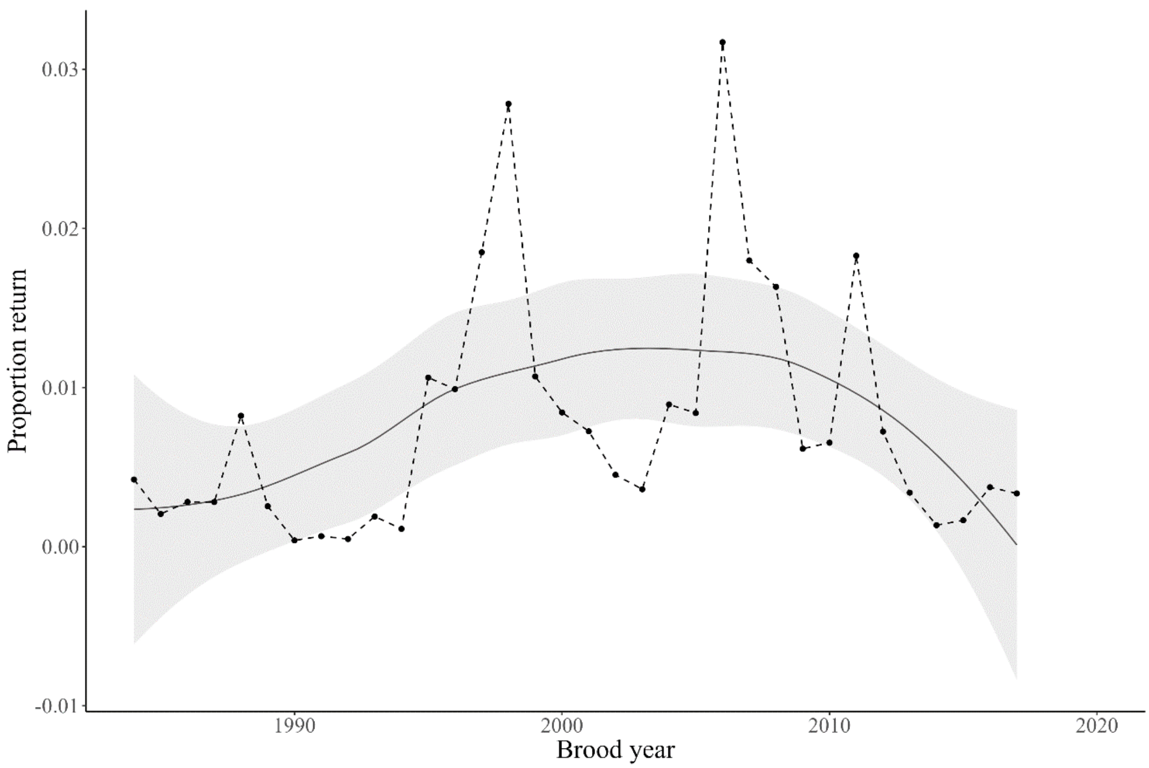


Synthesis Figure 1.31 Estimated partial effects of the top six predictors with the lowest (best) RMSE for the McKenzie spring Chinook program. Solid lines show the estimated smooth effect (using splines) of each predictor, and the shaded ribbons indicate the 95% confidence intervals for the estimated effects.

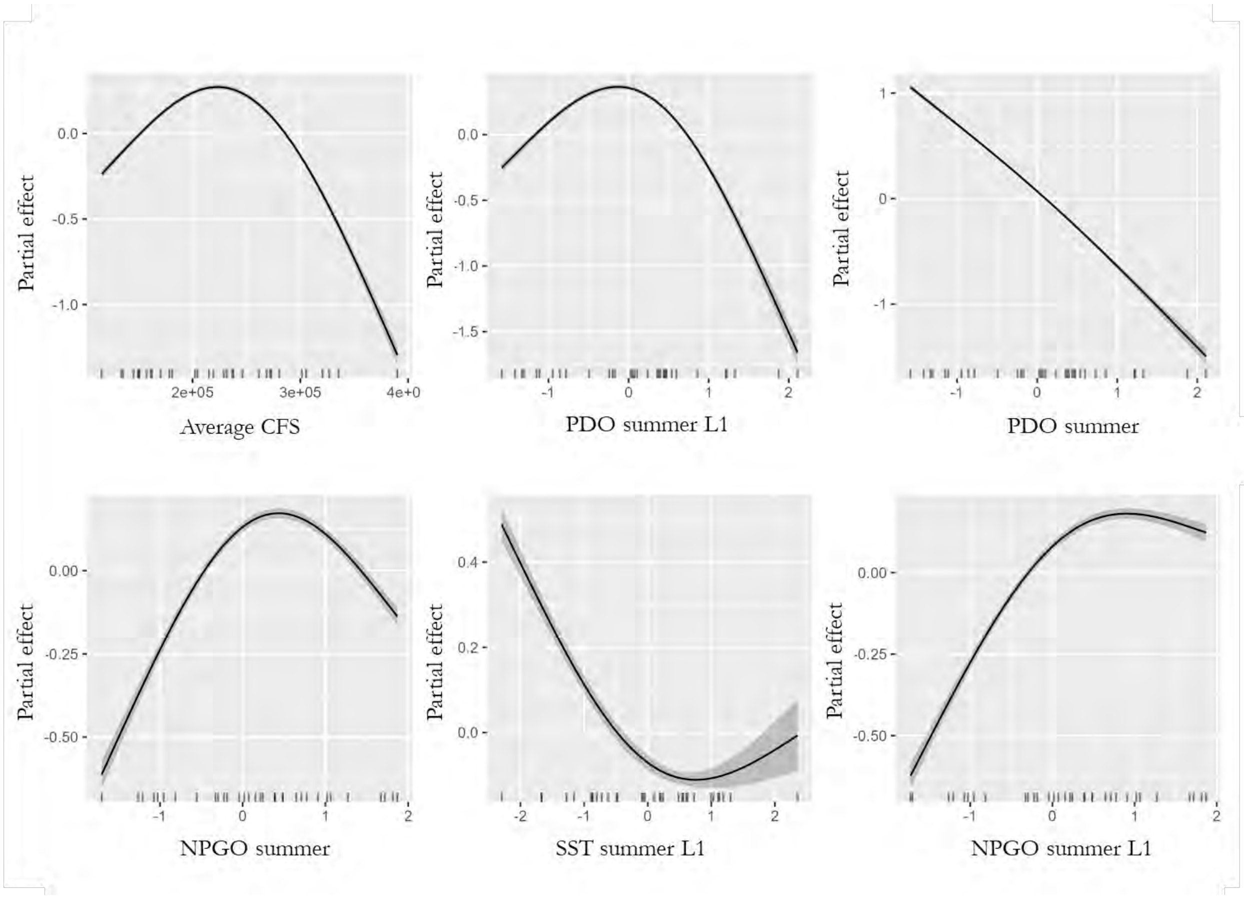
Imnaha

Synthesis Table 1.4 Table of estimate Root Mean Squared Error (RMSE, lower is better), Akaike's Information Criterion (AIC, lower translates to more data support), and estimated average absolute effect sizes of standardized predictors (larger effects have a bigger impact on the response) for the Imnaha spring Chinook program.

Predictor	RMSE	AIC	Average absolute effect
PDO summer L1	0.8501	15171.64	0.0040
PDO summer	0.8506	25447.42	0.0080
NPGO summer	0.8509	15905.93	0.0019
SST summer L1	0.8849	10407.27	0.0014
NPGO summer L1	0.9034	16992.91	0.0023



Synthesis Figure 1.4 Estimated proportion of returning individuals, categorized by brood year, for the Imnaha spring Chinook program. Points represent empirical means, the solid line represents a LOESS-smoothed fit to the mean proportions, and the grey ribbon represents a 95% confidence interval.

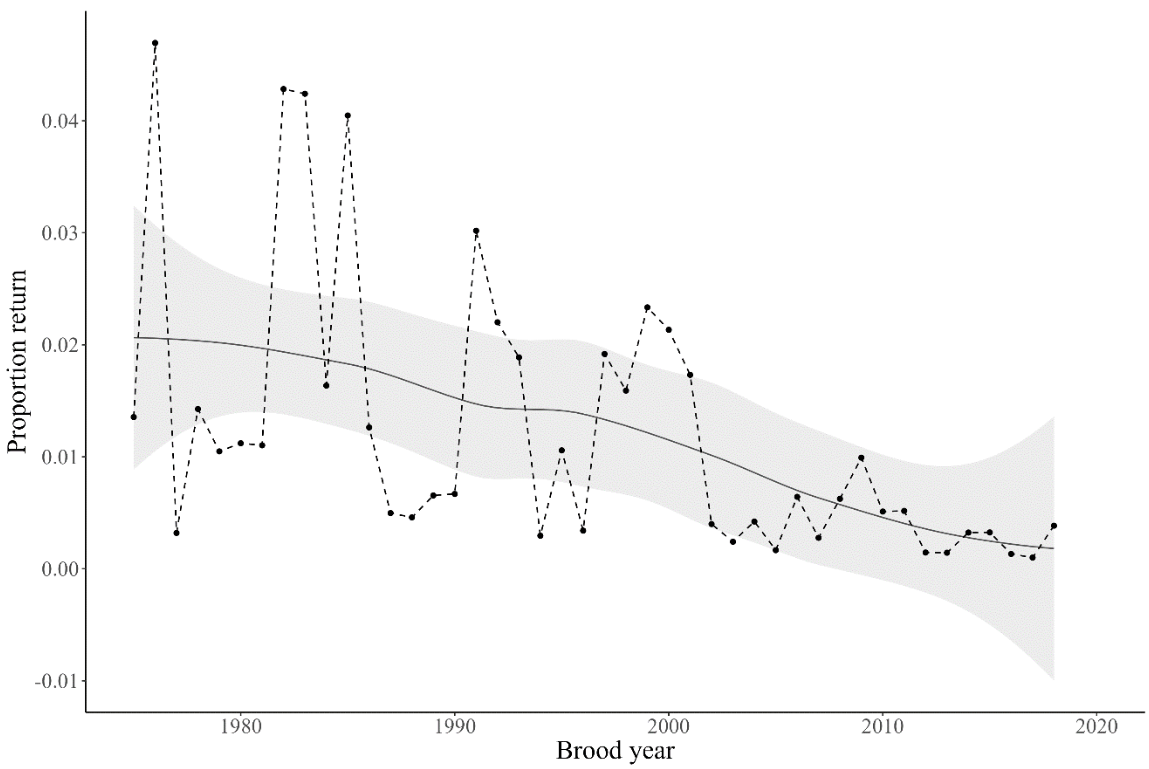


Synthesis Figure 1.41 Estimated partial effects of the top six predictors with the lowest (best) RMSE for the Imnaha spring Chinook program. Solid lines show the estimated smooth effect (using splines) of each predictor, and the shaded ribbons indicate the 95% confidence intervals for the estimated effects.

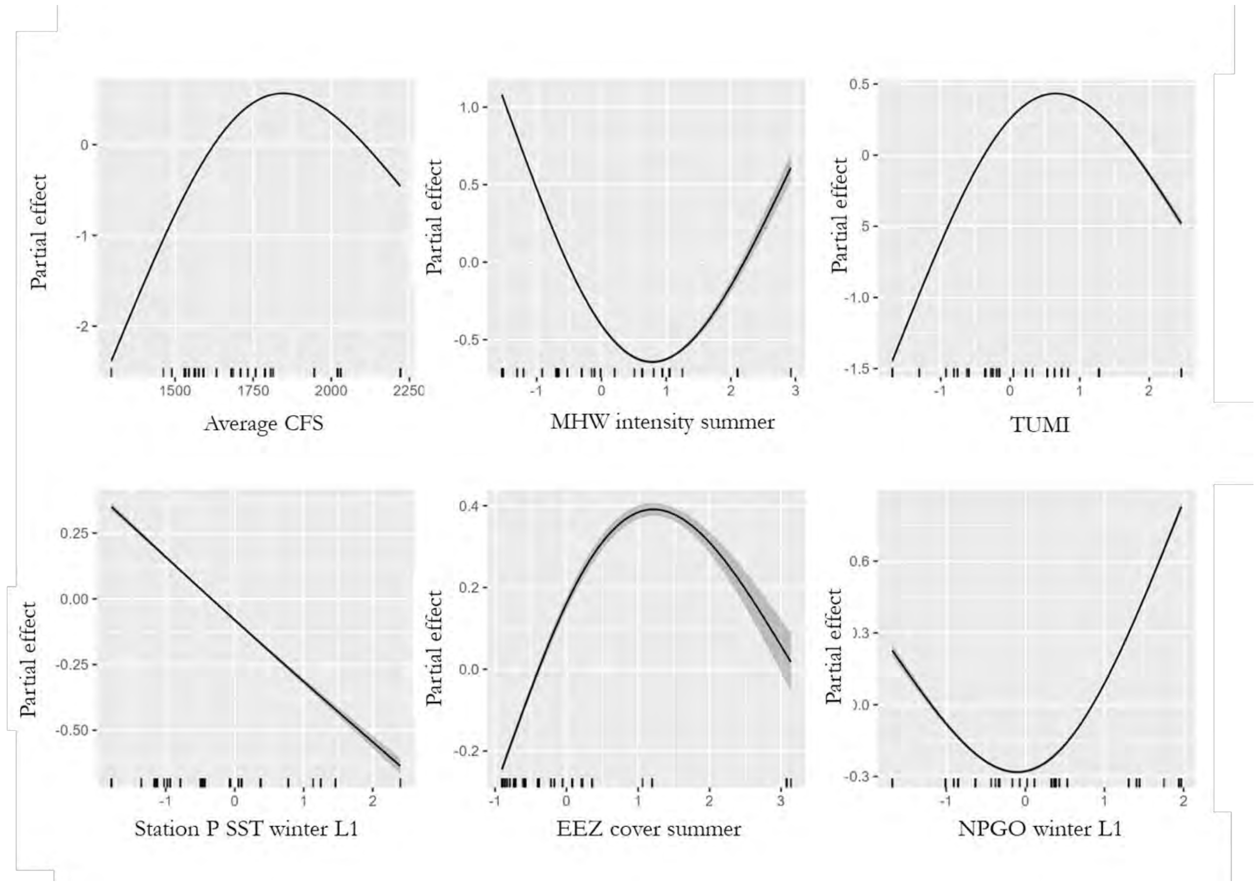
Rogue (Cole Rivers)

Synthesis Table 1.5 Table of estimate Root Mean Squared Error (RMSE, lower is better), Akaike's Information Criterion (AIC, lower translates to more data support), and estimated average absolute effect sizes of standardized predictors (larger effects have a bigger impact on the response) for the Rogue (Cole Rivers) spring Chinook program.

Predictor	RMSE	AIC	Average absolute effect
MHW intensity summer	0.7600	62487.83	0.0058
TUMI	0.8608	58185.74	0.0027
Station P SST winter L1	0.8648	34098.32	0.0018
EEZ cover summer	0.8836	27171.64	0.0023
NPGO winter L1	0.9109	47301.06	0.0024



Synthesis Figure 1.5 Estimated proportion of returning individuals, categorized by brood year, for the Rogue (Cole Rivers) spring Chinook program. Points represent empirical means, the solid line represents a LOESS-smoothed fit to the mean proportions, and the grey ribbon represents a 95% confidence interval.



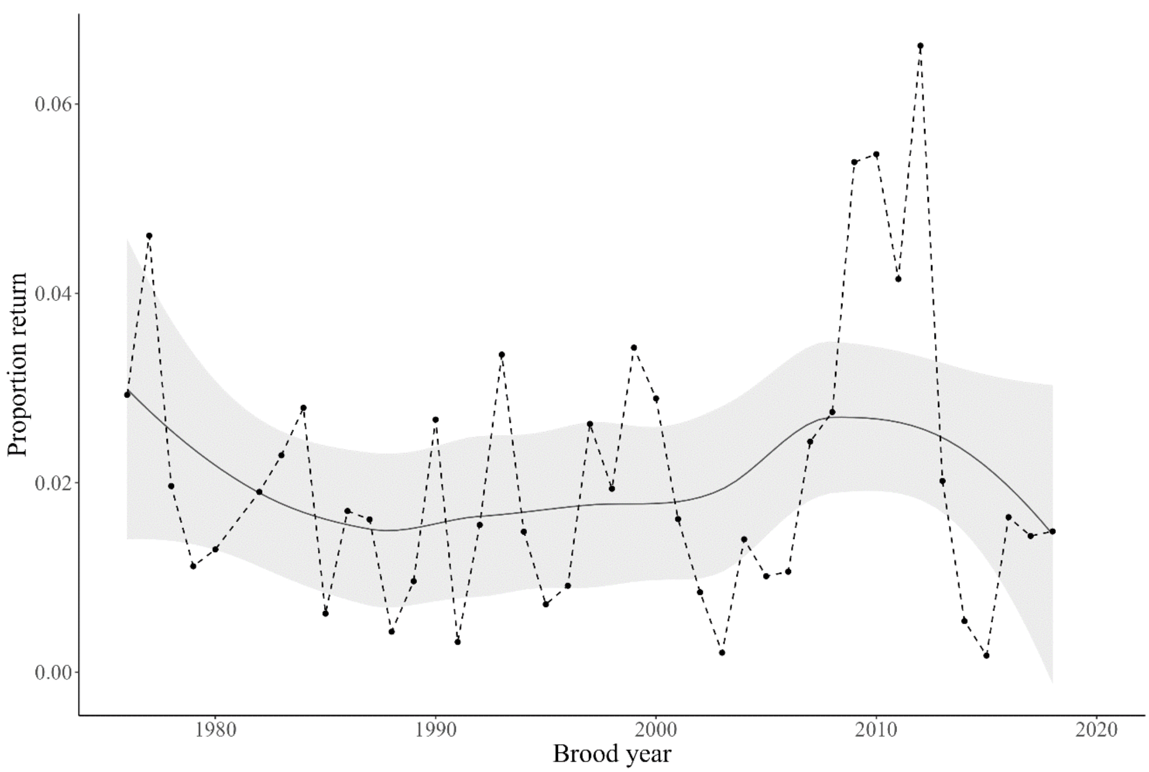
Synthesis Figure 1.51 Estimated partial effects of the top six predictors with the lowest (best) RMSE for the Rogue (Cole Rivers) spring Chinook program. Solid lines show the estimated smooth effect (using splines) of each predictor, and the shaded ribbons indicate the 95% confidence intervals for the estimated effects.

Fall Chinook Salmon

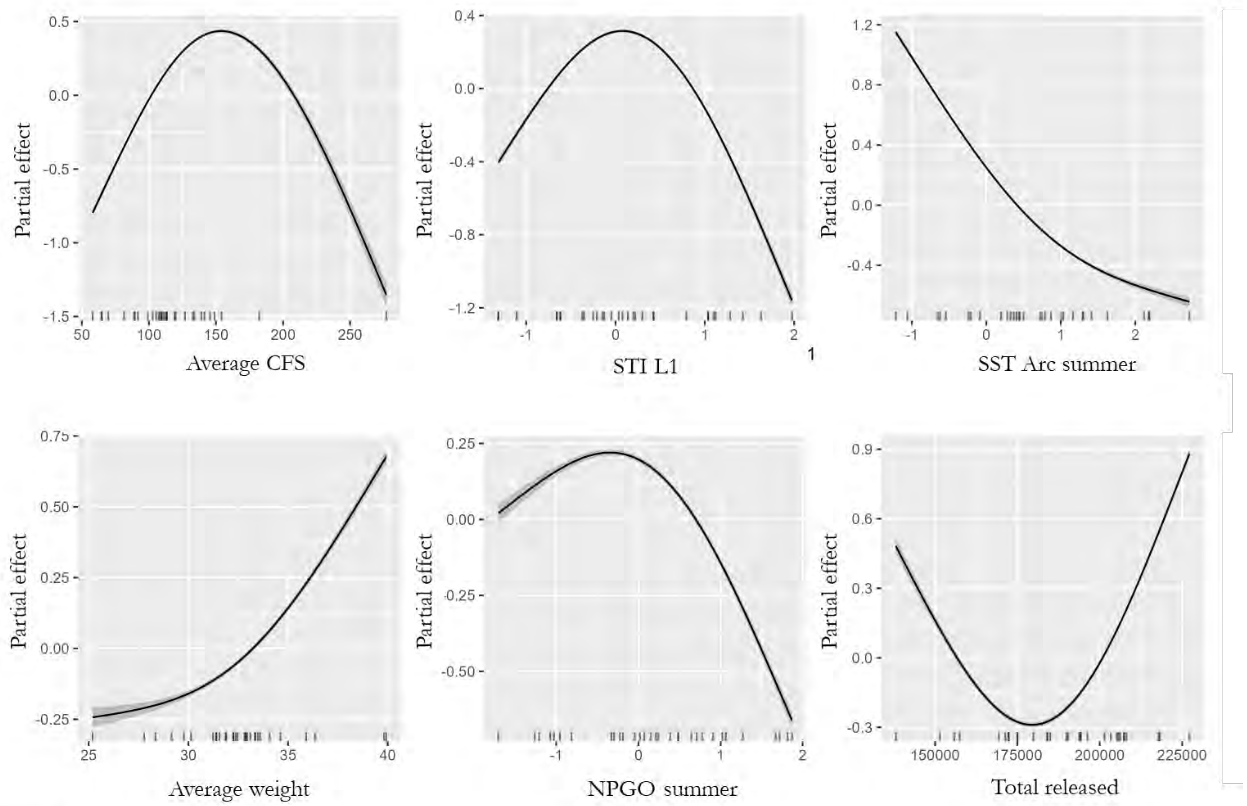
Salmon River

Synthesis Table 2.1 Table of estimate Root Mean Squared Error (RMSE, lower is better), Akaike's Information Criterion (AIC, lower translates to more data support), and estimated average absolute effect sizes of standardized predictors (larger effects have a bigger impact on the response) for the Salmon River fall Chinook program.

Predictor	RMSE	AIC	Average absolute effect
STI L1	0.8954	5763.15	0.0944
SST Arc summer	0.9029	8180.55	0.1121
Average weight	0.9248	5308.78	0.0025
NPGO summer	0.9435	4750.21	0.0385
Total released	0.9451	4975.40	0.0000



Synthesis Figure 2.1 Estimated proportion of returning individuals, categorized by brood year, for the Salmon River fall Chinook program. Points represent empirical means, the solid line represents a LOESS-smoothed fit to the mean proportions, and the grey ribbon represents a 95% confidence interval.

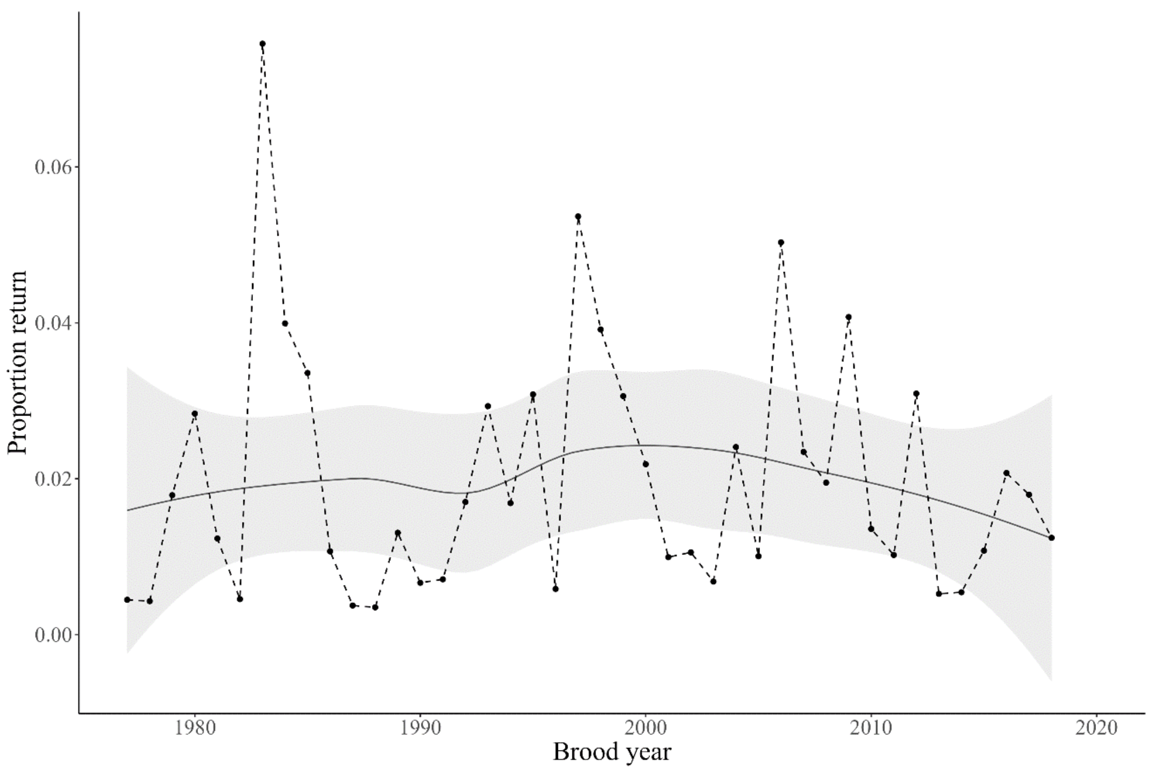


Synthesis Figure 2.11 Estimated partial effects of the top six predictors with the lowest (best) RMSE for the Salmon River fall Chinook program. Solid lines show the estimated smooth effect (using splines) of each predictor, and the shaded ribbons indicate the 95% confidence intervals for the estimated effects.

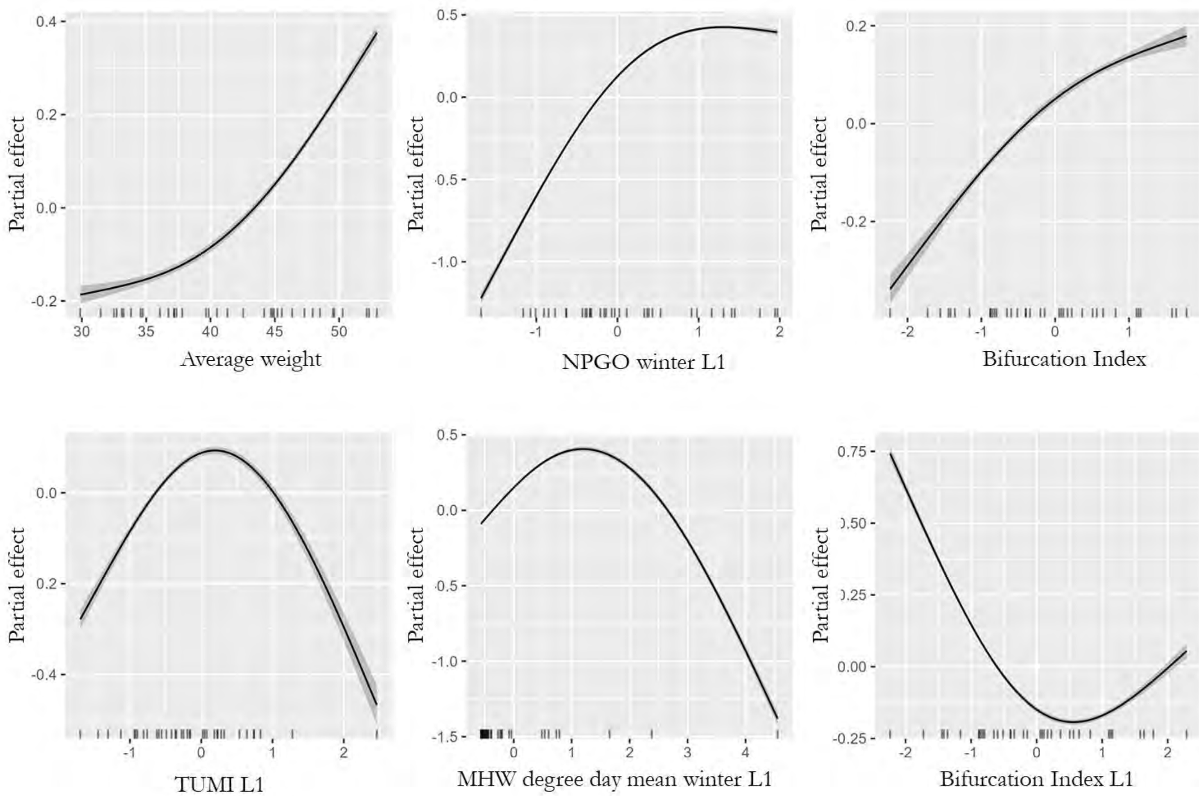
Elk River

Synthesis Table 2.2 Table of estimate Root Mean Squared Error (RMSE, lower is better), Akaike's Information Criterion (AIC, lower translates to more data support), and estimated average absolute effect sizes of standardized predictors (larger effects have a bigger impact on the response) for the Elk River fall Chinook program.

Predictor	RMSE	AIC	Average absolute effect
Average weight	0.9722	2790.82	0.0001
NPGO winter L1	0.9754	8000.06	0.0098
Bifurcation Index	0.9795	1330.74	0.0026
TUMI L1	0.9866	4004.19	0.0028
MHW degree day winter L1	0.9874	2779.02	0.0073



Synthesis Figure 2.2 Estimated proportion of returning individuals, categorized by brood year, for the Elk River fall Chinook program. Points represent empirical means, the solid line represents a LOESS-smoothed fit to the mean proportions, and the grey ribbon represents a 95% confidence interval.

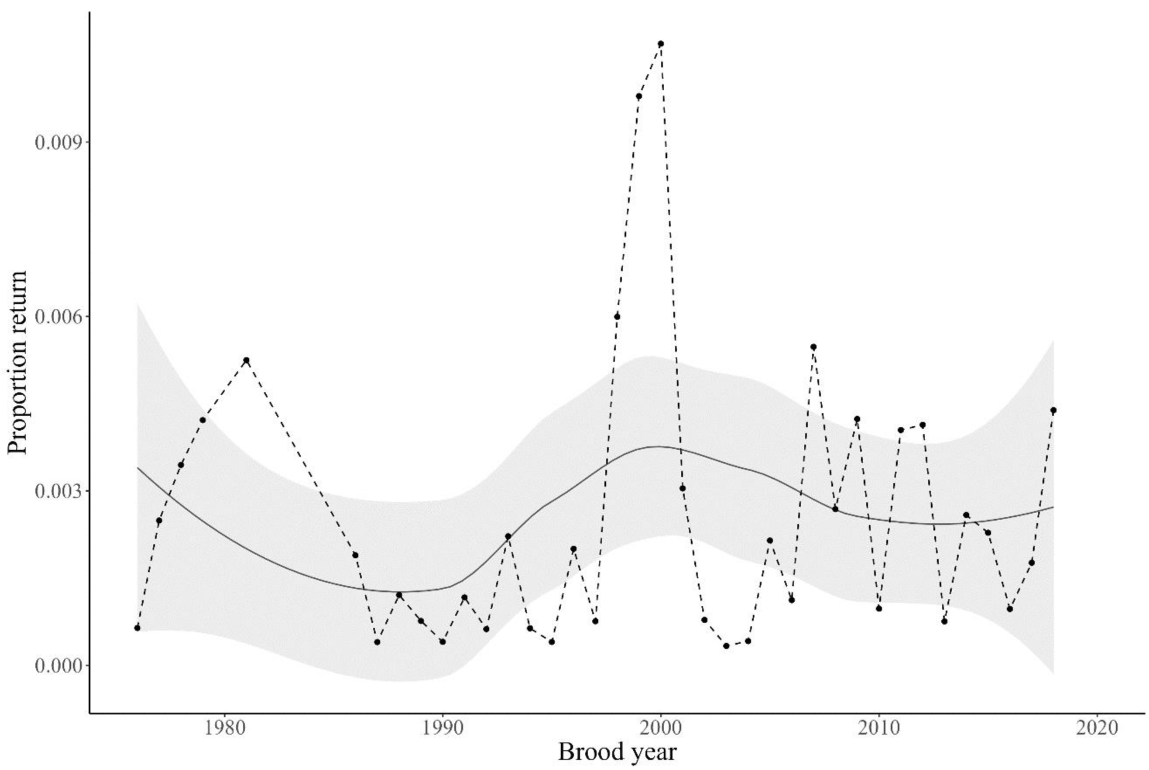


Synthesis Figure 2.21 Estimated partial effects of the top six predictors with the lowest (best) RMSE for the Elk River fall Chinook program. Solid lines show the estimated smooth effect (using splines) of each predictor, and the shaded ribbons indicate the 95% confidence intervals for the estimated effects.

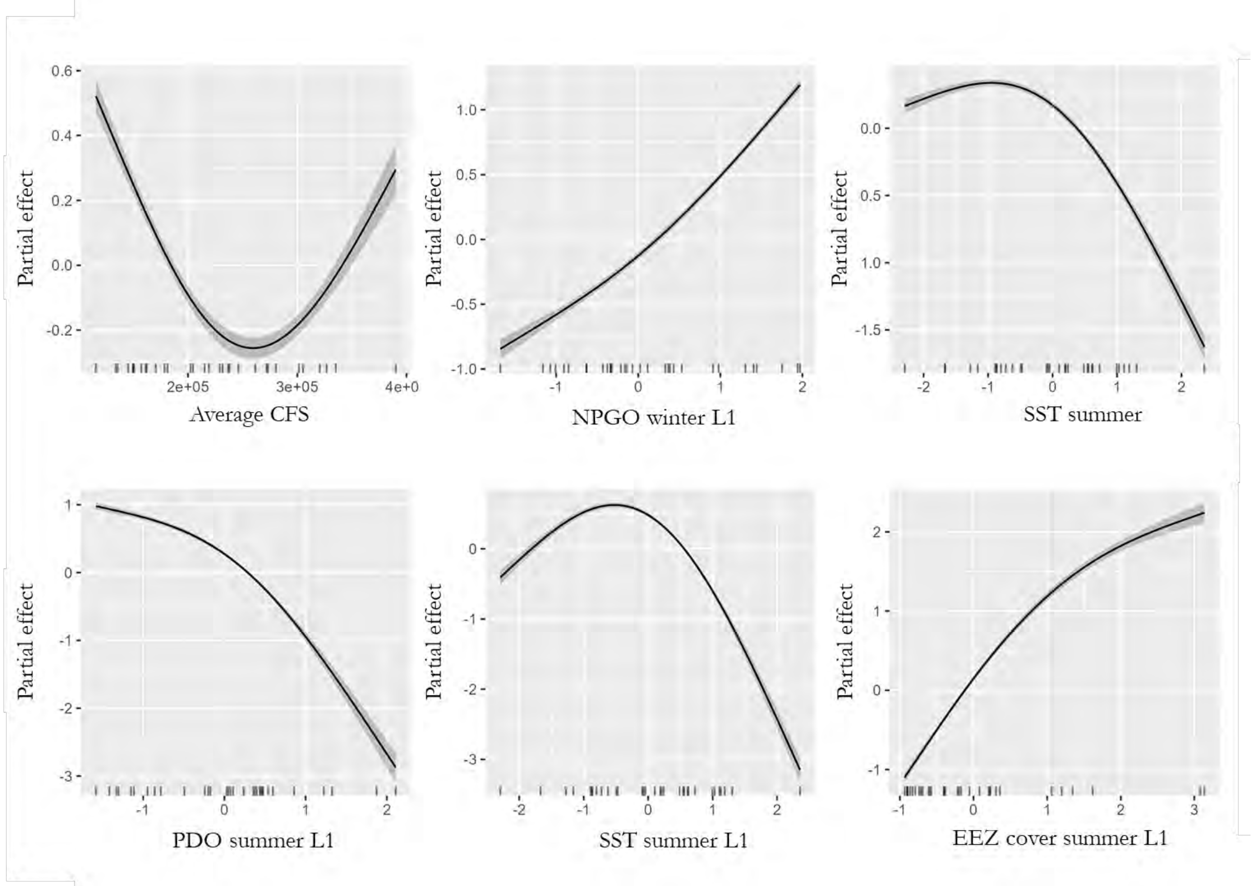
Big Creek

Synthesis Table 2.3 Table of estimate Root Mean Squared Error (RMSE, lower is better), Akaike's Information Criterion (AIC, lower translates to more data support), and estimated average absolute effect sizes of standardized predictors (larger effects have a bigger impact on the response) for the Big Creek fall Chinook program.

Predictor	RMSE	AIC	Average absolute effect
NPGO winter L1	0.8497	3620.80	0.0019
SST summer	0.9257	2045.94	0.0010
PDO summer L1	0.9466	3071.71	0.0022
SST summer L1	0.9517	3515.14	0.0011
EEZ cover summer L1	0.9519	966.70	0.0040



Synthesis Figure 2.3 Estimated proportion of returning individuals, categorized by brood year, for the Big Creek fall Chinook program. Points represent empirical means, the solid line represents a LOESS-smoothed fit to the mean proportions, and the grey ribbon represents a 95% confidence interval.



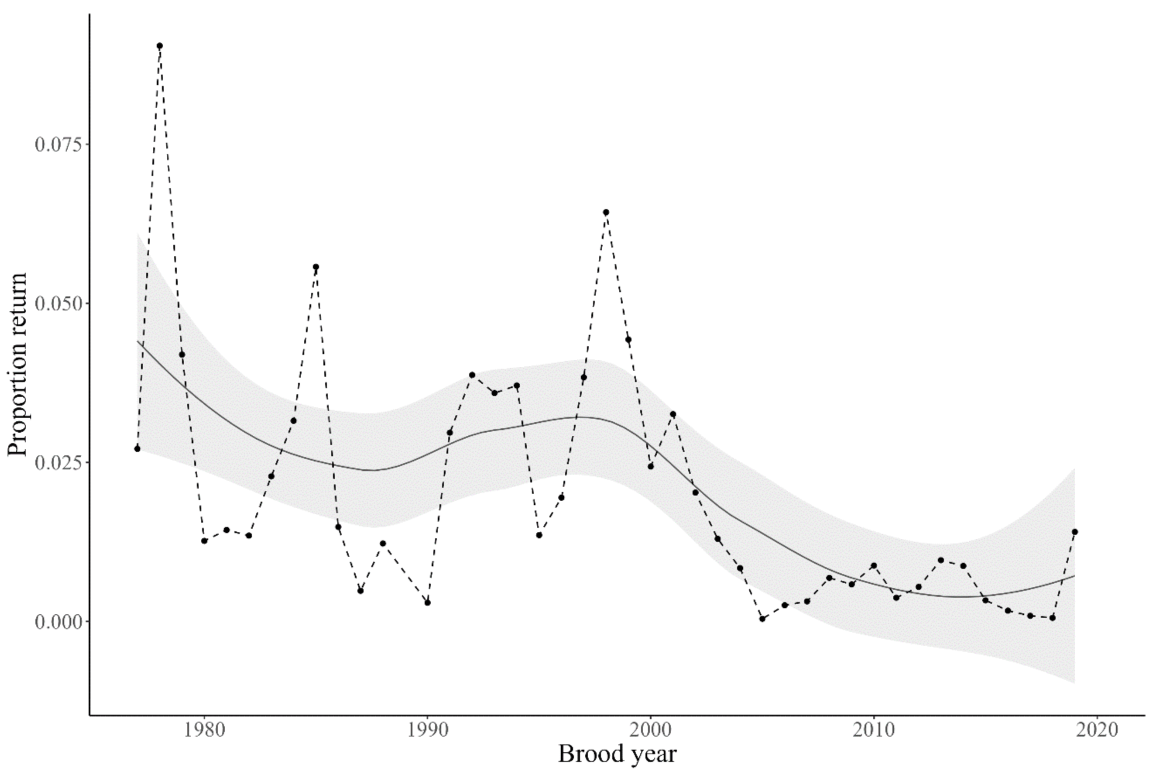
Synthesis Figure 2.31 Estimated partial effects of the top six predictors with the lowest (best) RMSE for the Big Creek fall Chinook program. Solid lines show the estimated smooth effect (using splines) of each predictor, and the shaded ribbons indicate the 95% confidence intervals for the estimated effects.

Coho Salmon

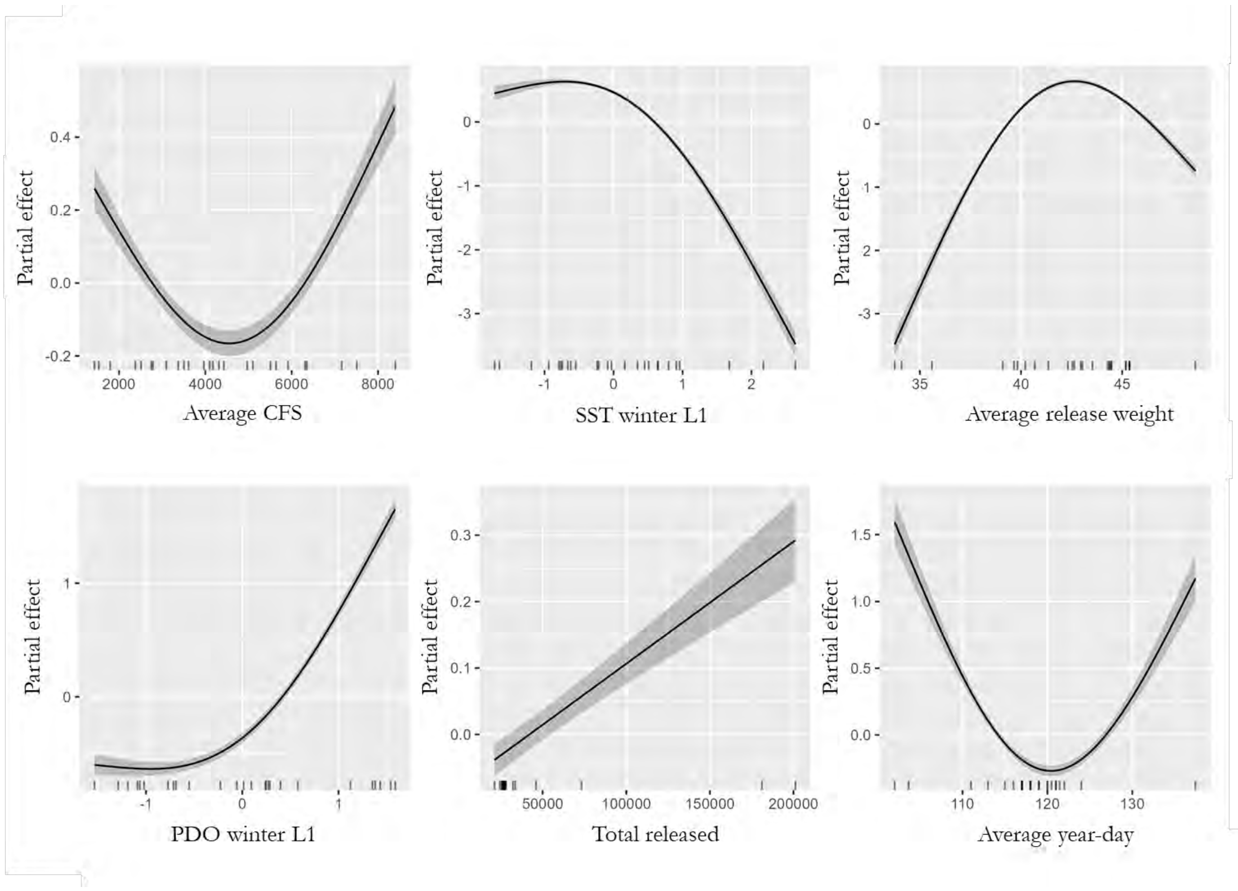
Rogue (Cole Rivers)

Synthesis Table 3.1 Table of estimate Root Mean Squared Error (RMSE, lower is better), Akaike's Information Criterion (AIC, lower translates to more data support), and estimated average absolute effect sizes of standardized predictors (larger effects have a bigger impact on the response) for the Rogue (Cole Rivers) coho program.

Predictor	RMSE	AIC	Average absolute effect
SST winter L1	0.8726	1964.13	0.0062
Average weight	0.8730	2347.68	0.0000
PDO winter L1	0.8933	1861.14	0.0175
Total released	0.9002	2436.24	0.0000
Average year-day	0.9049	1666.55	0.0000



Synthesis Figure 3.1 Estimated proportion of returning individuals, categorized by brood year, for the Rogue (Cole Rivers) coho program. Points represent empirical means, the solid line represents a LOESS-smoothed fit to the mean proportions, and the grey ribbon represents a 95% confidence interval.

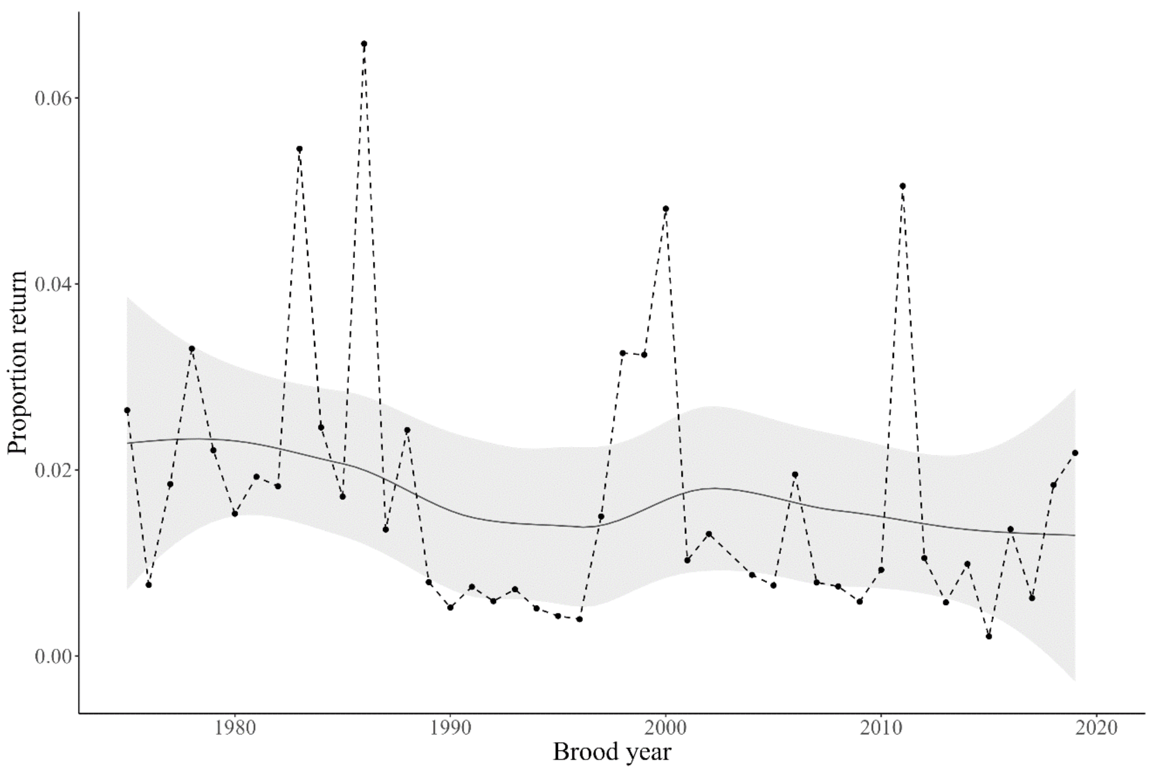


Synthesis Figure 3.11 Estimated partial effects of the top six predictors with the lowest (best) RMSE for the Rogue (Cole Rivers) coho program. Solid lines show the estimated smooth effect (using splines) of each predictor, and the shaded ribbons indicate the 95% confidence intervals for the estimated effects.

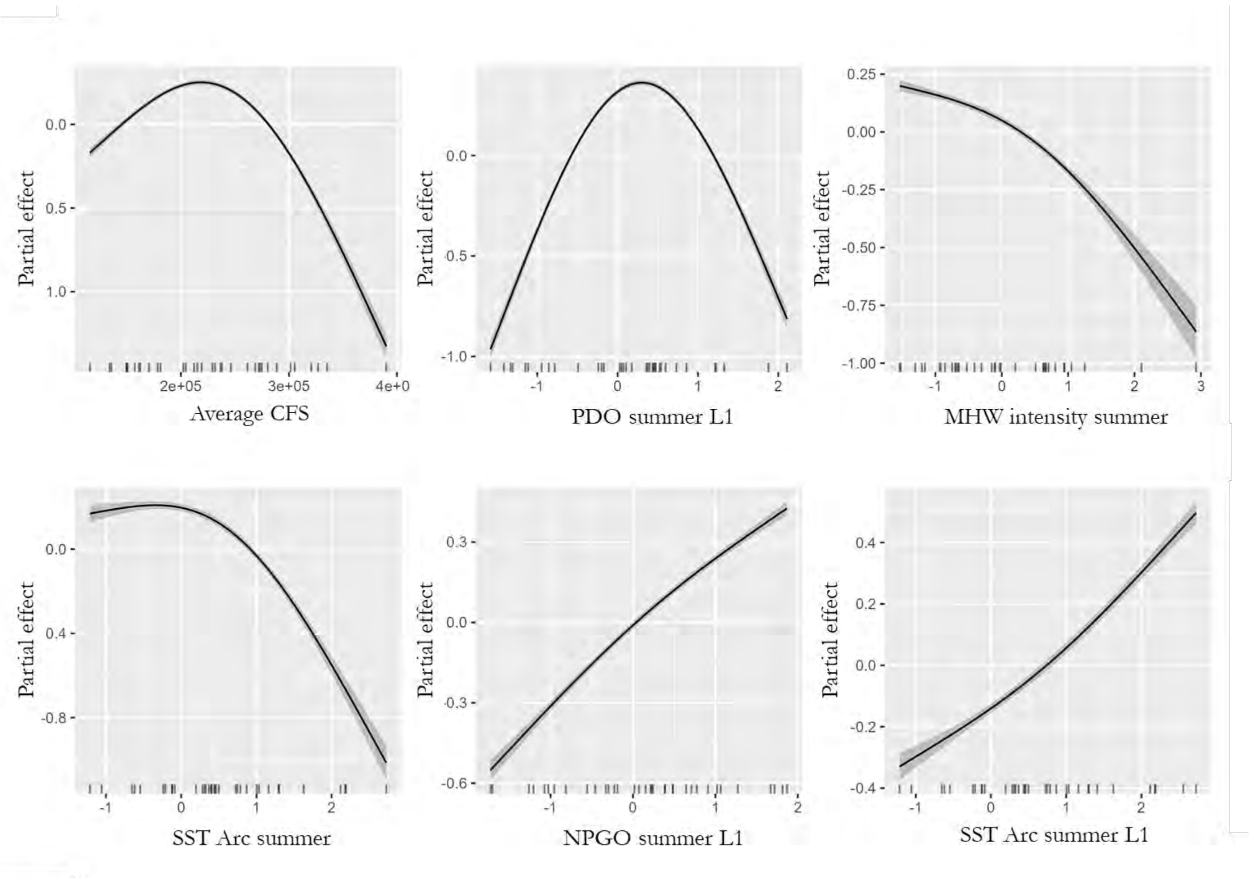
Big Creek

Synthesis Table 3.2 Table of estimate Root Mean Squared Error (RMSE, lower is better), Akaike's Information Criterion (AIC, lower translates to more data support), and estimated average absolute effect sizes of standardized predictors (larger effects have a bigger impact on the response) for the Big Creek coho program.

Predictor	RMSE	AIC	Average absolute effect
PDO summer L1	0.8947	6092.34	0.0085
MHW intensity summer	0.9089	4652.10	0.0040
SST Arc summer	0.9426	3657.36	0.0027
NPGO summer L1	0.9446	2442.28	0.0068
SST Arc summer L1	0.9475	3347.86	0.0046



Synthesis Figure 3.2 Estimated proportion of returning individuals, categorized by brood year, for the Big Creek coho program. Points represent empirical means, the solid line represents a LOESS-smoothed fit to the mean proportions, and the grey ribbon represents a 95% confidence interval.

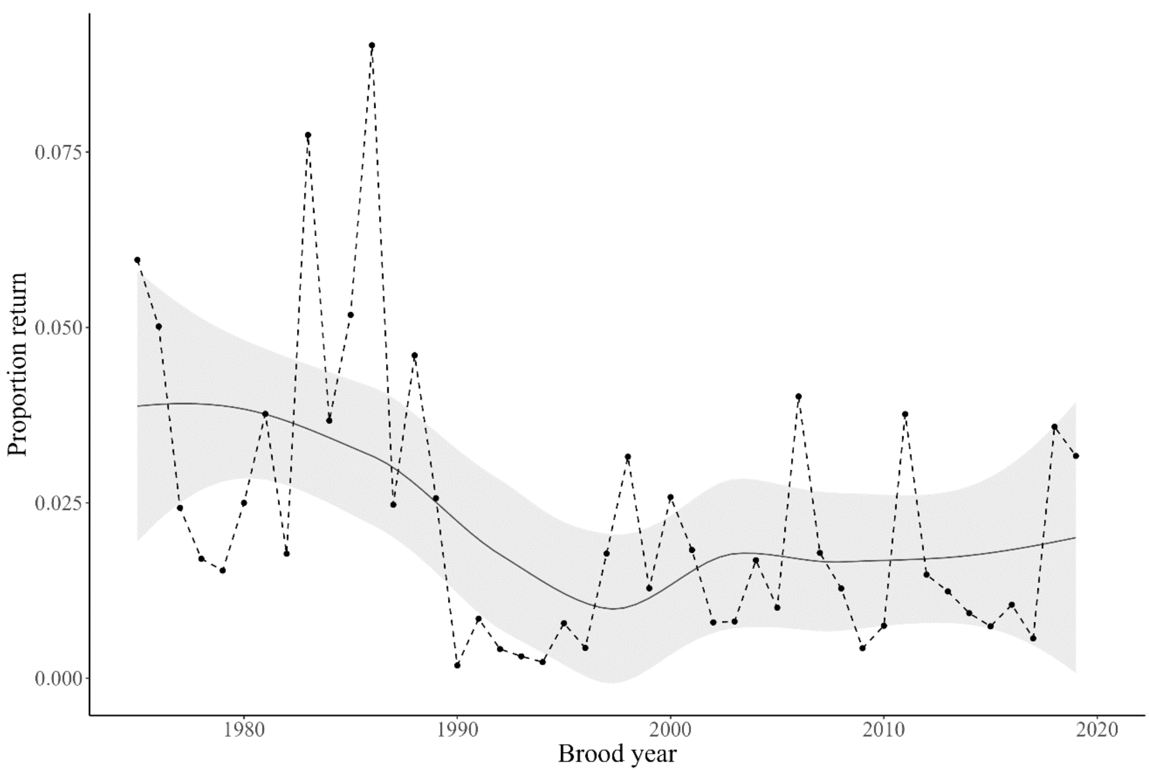


Synthesis Figure 3.21 Estimated partial effects of the top six predictors with the lowest (best) RMSE for the Big Creek coho program. Solid lines show the estimated smooth effect (using splines) of each predictor, and the shaded ribbons indicate the 95% confidence intervals for the estimated effects.

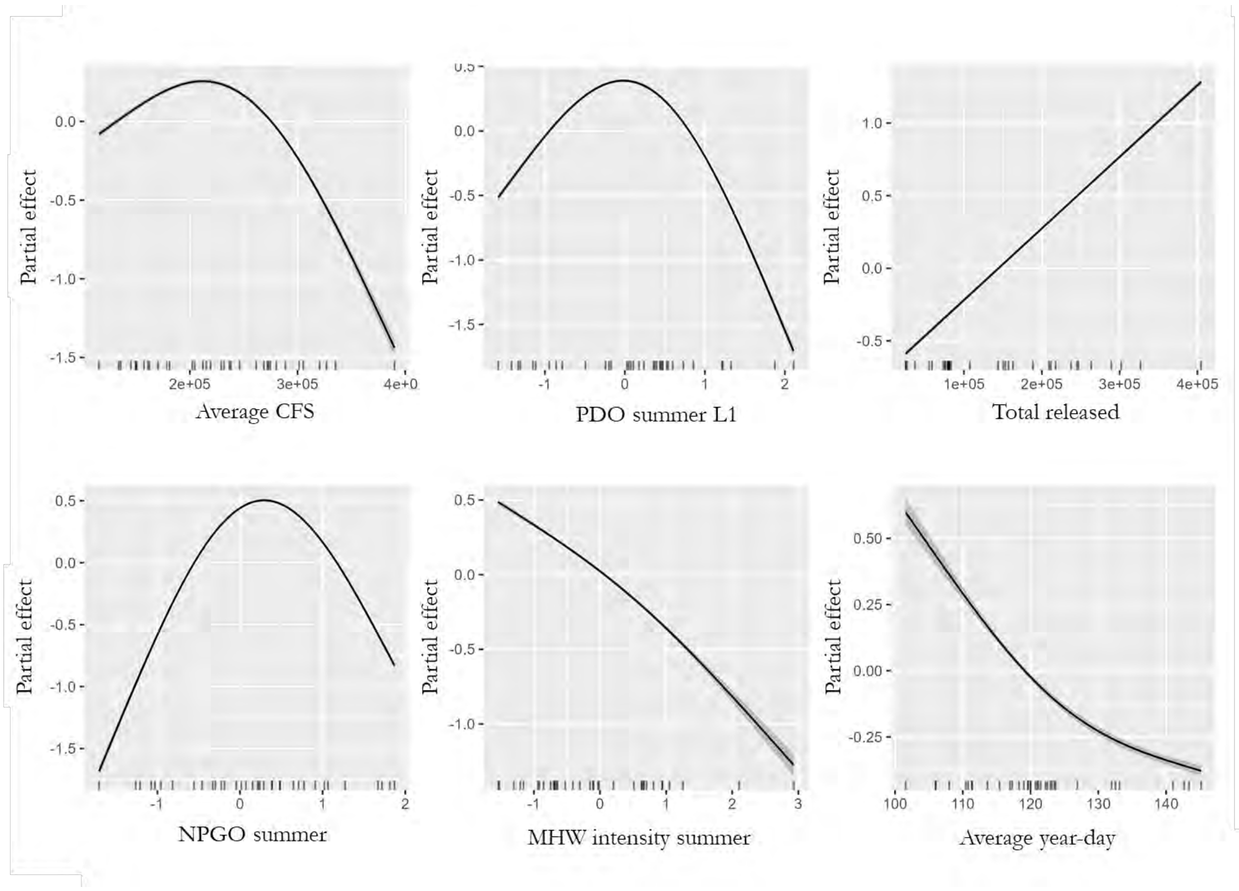
Sandy

Synthesis Table 3.3 Table of estimate Root Mean Squared Error (RMSE, lower is better), Akaike's Information Criterion (AIC, lower translates to more data support), and estimated average absolute effect sizes of standardized predictors (larger effects have a bigger impact on the response) for the Sandy coho program.

Predictor	RMSE	AIC	Average absolute effect
PDO summer L1	0.8665	15979.08	0.0082
Total released	0.9103	16571.63	0.0000
NPGO summer	0.9318	11722.87	0.0091
MHW intensity summer	0.9385	13385.37	0.0070
Average year-day	0.9560	11175.91	0.0085



Synthesis Figure 3.3 Estimated proportion of returning individuals, categorized by brood year, for the Sandy coho program. Points represent empirical means, the solid line represents a LOESS-smoothed fit to the mean proportions, and the grey ribbon represents a 95% confidence interval.



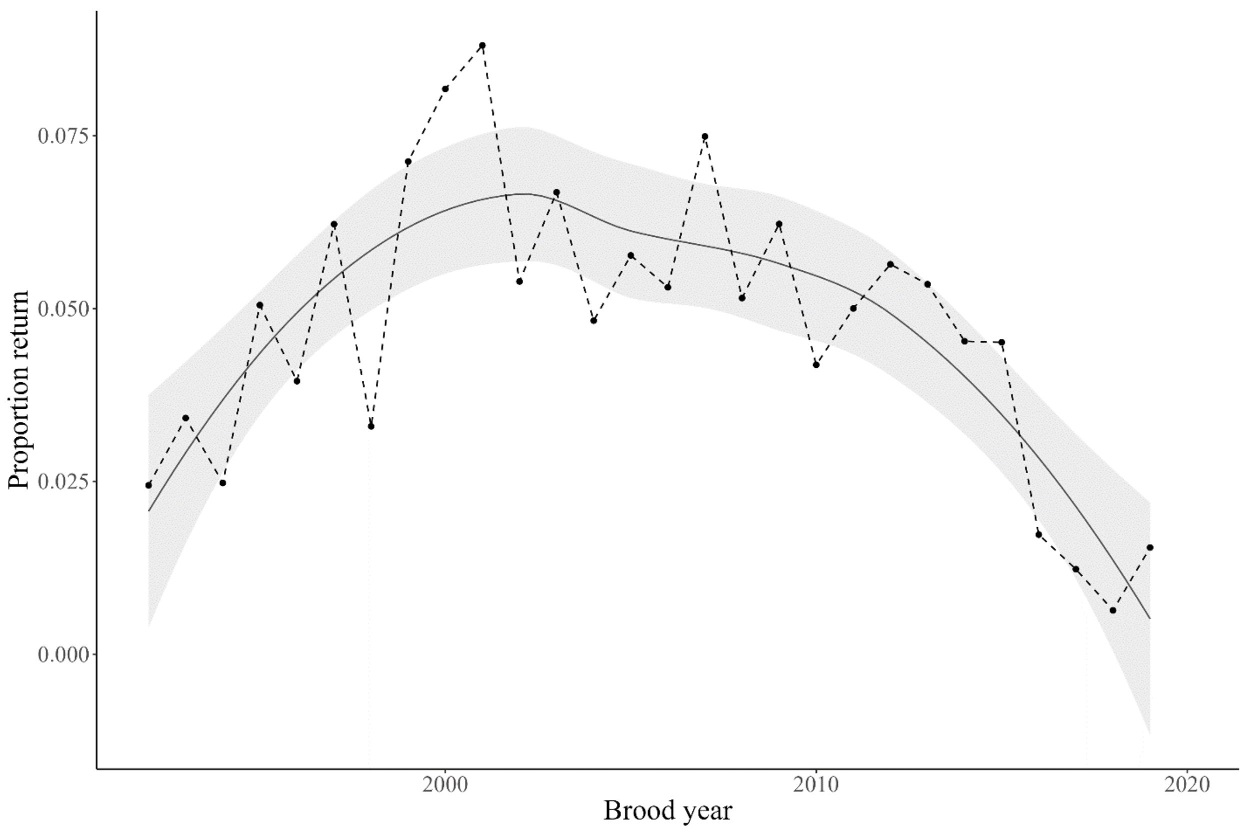
Synthesis Figure 3.31 Estimated partial effects of the top six predictors with the lowest (best) RMSE for the Sandy coho program. Solid lines show the estimated smooth effect (using splines) of each predictor, and the shaded ribbons indicate the 95% confidence intervals for the estimated effects.

Summer Steelhead

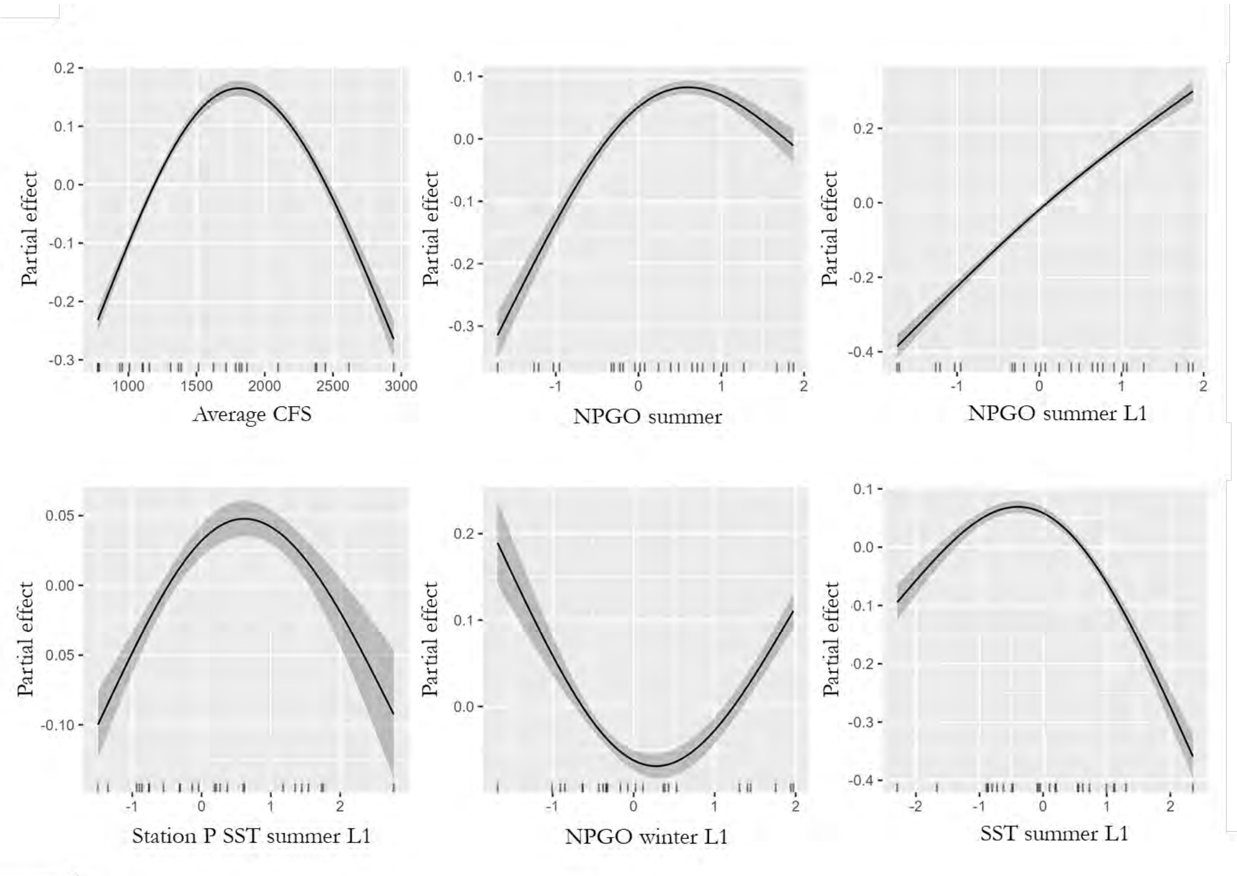
Siletz

Synthesis Table 4.1 Table of estimate Root Mean Squared Error (RMSE, lower is better), Akaike's Information Criterion (AIC, lower translates to more data support), and estimated average absolute effect sizes of standardized predictors (larger effects have a bigger impact on the response) for the Siletz summer steelhead program.

Predictor	RMSE	AIC	Average absolute effect
NPGO summer	0.8168	2562.28	0.0053
NPGO summer L1	0.8431	2437.84	0.0107
Station P SST winter L1	0.8637	1539.79	0.0024
NPGO winter L1	0.9294	1502.37	0.0046
SST summer L1	0.9330	775.43	0.0035



Synthesis Figure 4.1 Estimated proportion of returning individuals, categorized by brood year, for the Siletz summer steelhead program. Points represent empirical means, the solid line represents a LOESS-smoothed fit to the mean proportions, and the grey ribbon represents a 95% confidence interval.

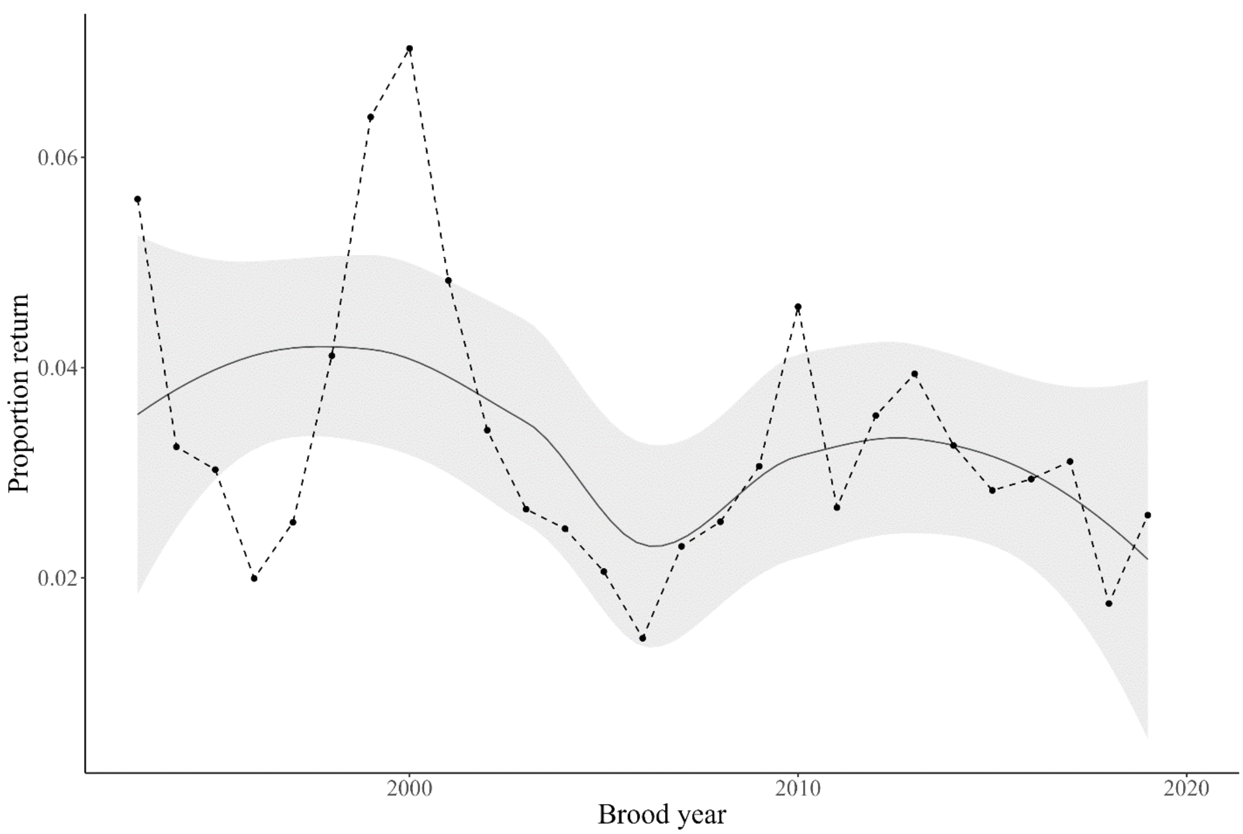


Synthesis Figure 4.11 Estimated partial effects of the top six predictors with the lowest (best) RMSE for the Siletz summer steelhead program. Solid lines show the estimated smooth effect (using splines) of each predictor, and the shaded ribbons indicate the 95% confidence intervals for the estimated effects.

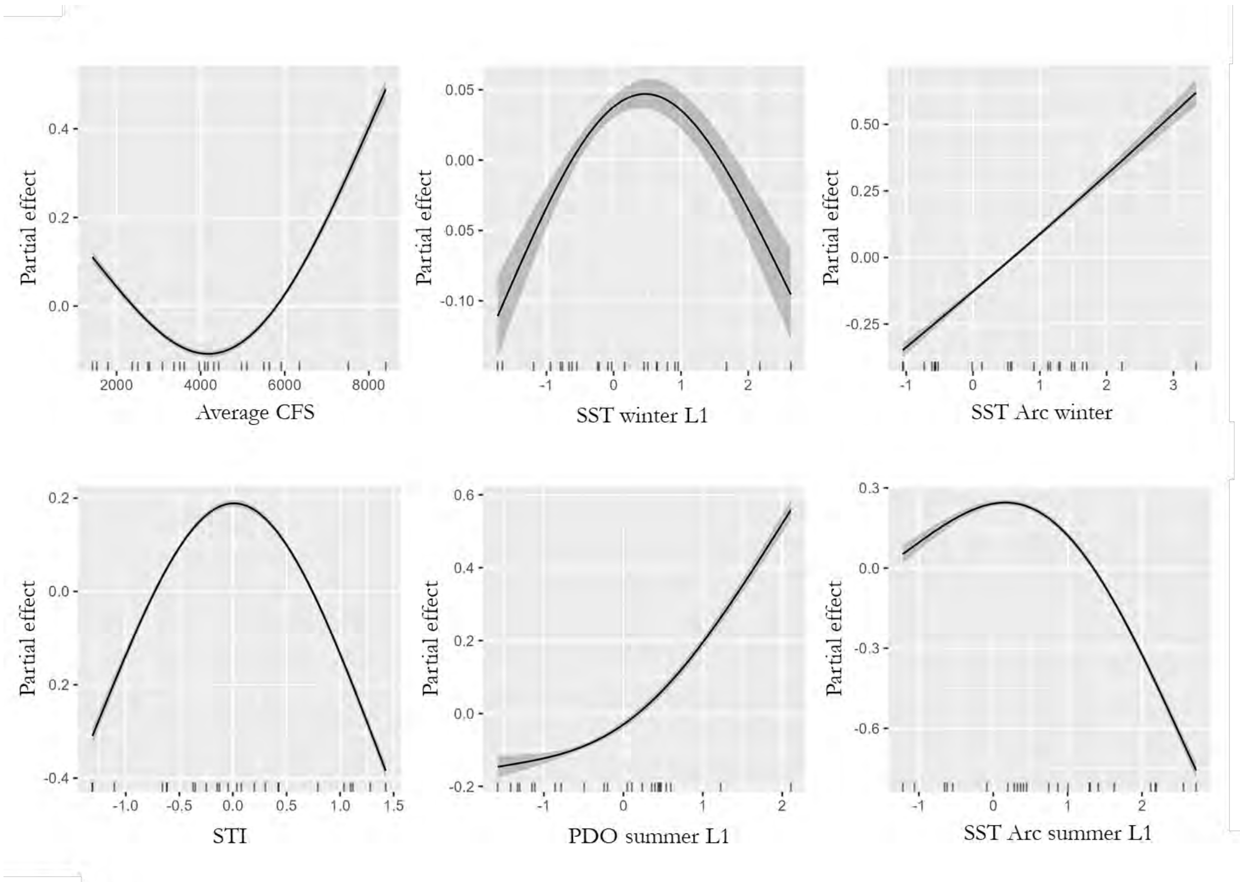
Rogue (Cole Rivers)

Synthesis Table 4.2 Table of estimate Root Mean Squared Error (RMSE, lower is better), Akaike's Information Criterion (AIC, lower translates to more data support), and estimated average absolute effect sizes of standardized predictors (larger effects have a bigger impact on the response) for the Rogue (Cole Rivers) summer steelhead program.

Predictor	RMSE	AIC	Average absolute effect
SST winter L1	0.8820	3333.65	0.0014
SST Arc winter L1	0.8854	3218.78	0.0083
STI	0.9008	4328.75	0.0108
PDO summer L1	0.9102	4052.88	0.0066
SST Arc summer L1	0.9112	4673.86	0.0048



Synthesis Figure 4.2 Estimated proportion of returning individuals, categorized by brood year, for the Rogue (Cole Rivers) summer steelhead program. Points represent empirical means, the solid line represents a LOESS-smoothed fit to the mean proportions, and the grey ribbon represents a 95% confidence interval.

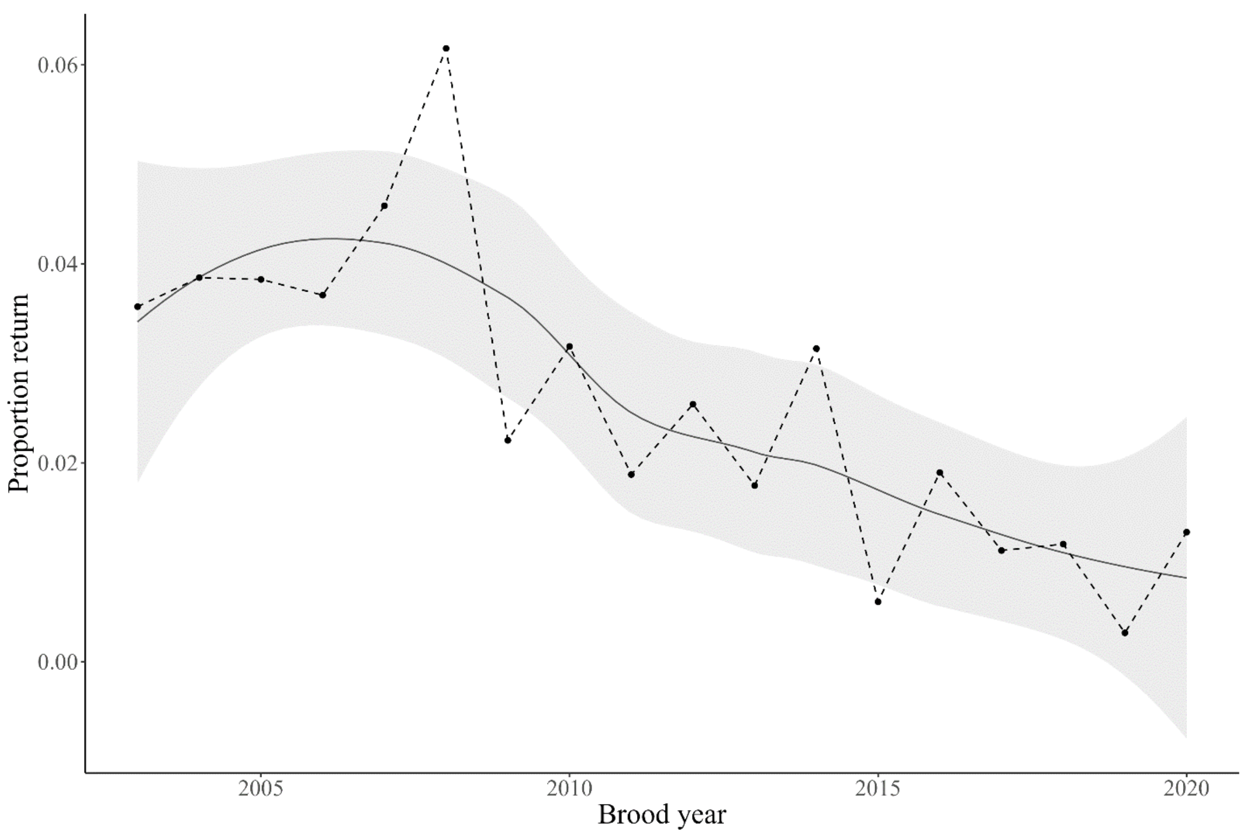


Synthesis Figure 4.21 Estimated partial effects of the top six predictors with the lowest (best) RMSE for the Rogue (Cole Rivers) summer steelhead program. Solid lines show the estimated smooth effect (using splines) of each predictor, and the shaded ribbons indicate the 95% confidence intervals for the estimated effects.

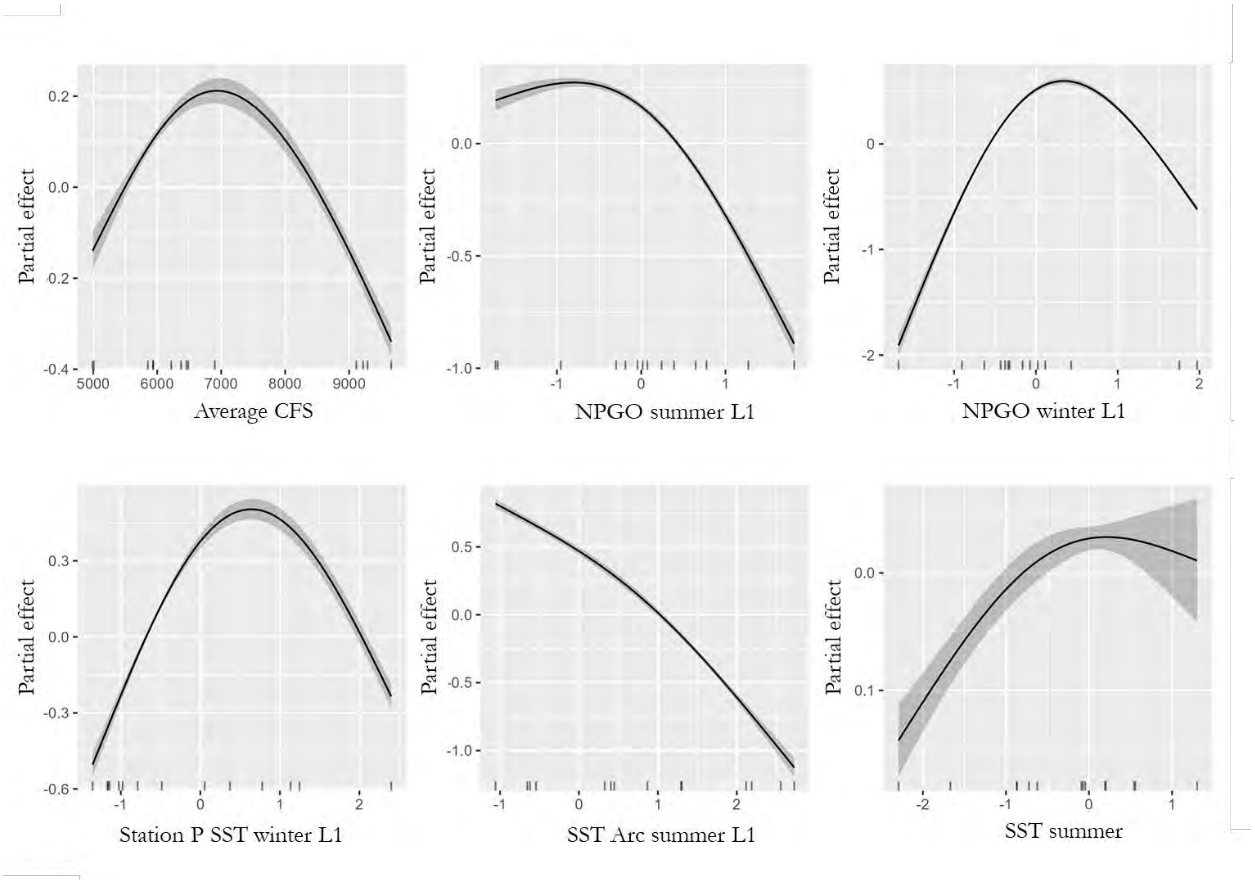
Deschutes (Round Butte)

Synthesis Table 4.3 Table of estimate Root Mean Squared Error (RMSE, lower is better), Akaike's Information Criterion (AIC, lower translates to more data support), and estimated average absolute effect sizes of standardized predictors (larger effects have a bigger impact on the response) for the Deschutes (Round Butte) summer steelhead program.

Predictor	RMSE	AIC	Average absolute effect
NPGO summer L1	0.6350	5691.70	0.0310
NPGO winter L1	0.7176	3008.43	0.0562
Station P SST winter L1	0.7781	4796.54	0.0350
SST Arc summer L1	0.8132	5039.36	0.0458
SST summer	0.8216	3931.33	0.0032



Synthesis Figure 4.3 Estimated proportion of returning individuals, categorized by brood year, for the Deschutes (Round Butte) summer steelhead program Points represent empirical means, the solid line represents a LOESS-smoothed fit to the mean proportions, and the grey ribbon represents a 95% confidence interval.

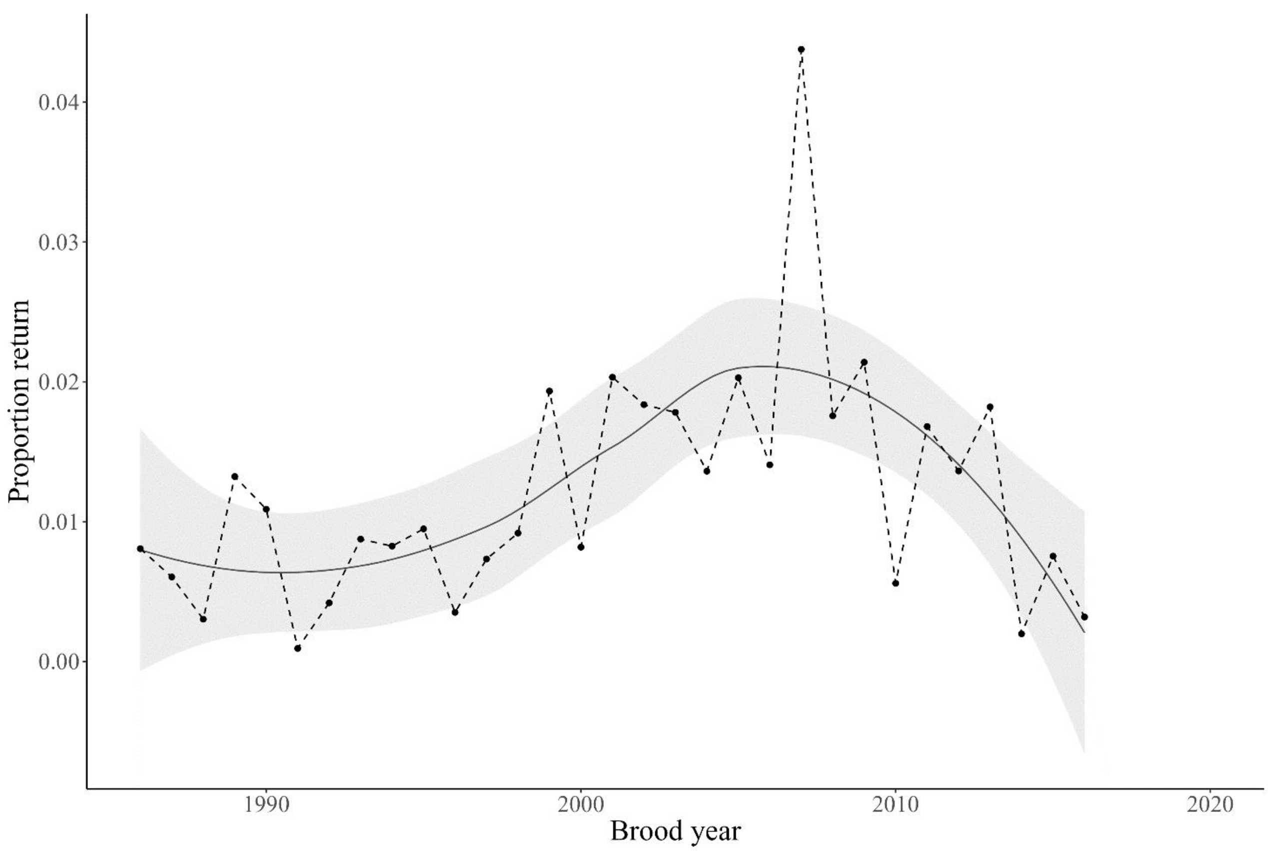


Synthesis Figure 4.31 Estimated partial effects of the top six predictors with the lowest (best) RMSE for the Deschutes (Round Butte) summer steelhead program. Solid lines show the estimated smooth effect (using splines) of each predictor, and the shaded ribbons indicate the 95% confidence intervals for the estimated effects.

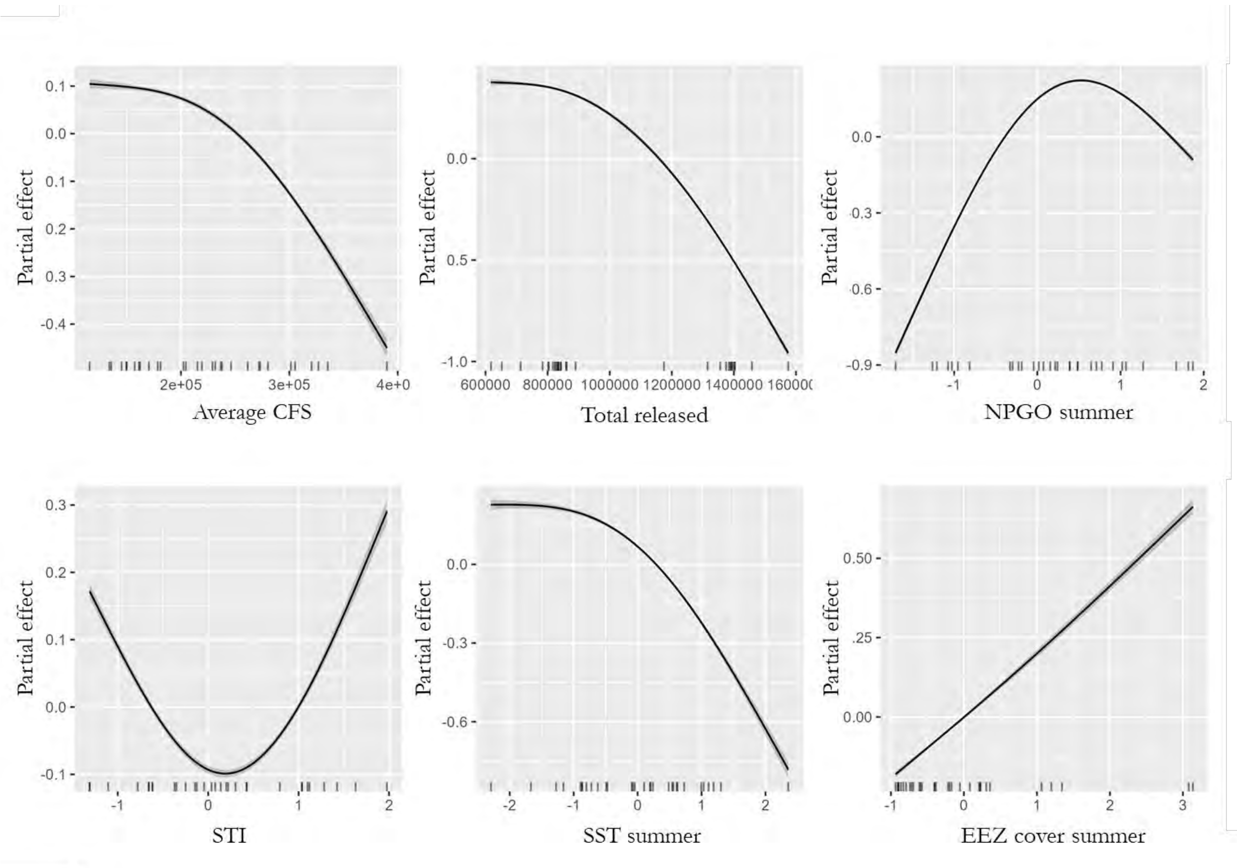
Wallowa

Synthesis Table 4.4 Table of estimate Root Mean Squared Error (RMSE, lower is better), Akaike's Information Criterion (AIC, lower translates to more data support), and estimated average absolute effect sizes of standardized predictors (larger effects have a bigger impact on the response) for the Wallowa summer steelhead program.

Predictor	RMSE	AIC	Average absolute effect
Total released	0.8627	59462.34	0.0000
NPGO summer	0.8848	24201.21	0.0039
STI	0.9440	13661.10	0.0027
SST summer	0.9535	14913.02	0.0037
EEZ cover summer	0.9635	7256.62	0.0037



Synthesis Figure 4.4 Estimated proportion of returning individuals, categorized by brood year, for the Wallowa summer steelhead program. Points represent empirical means, the solid line represents a LOESS-smoothed fit to the mean proportions, and the grey ribbon represents a 95% confidence interval.



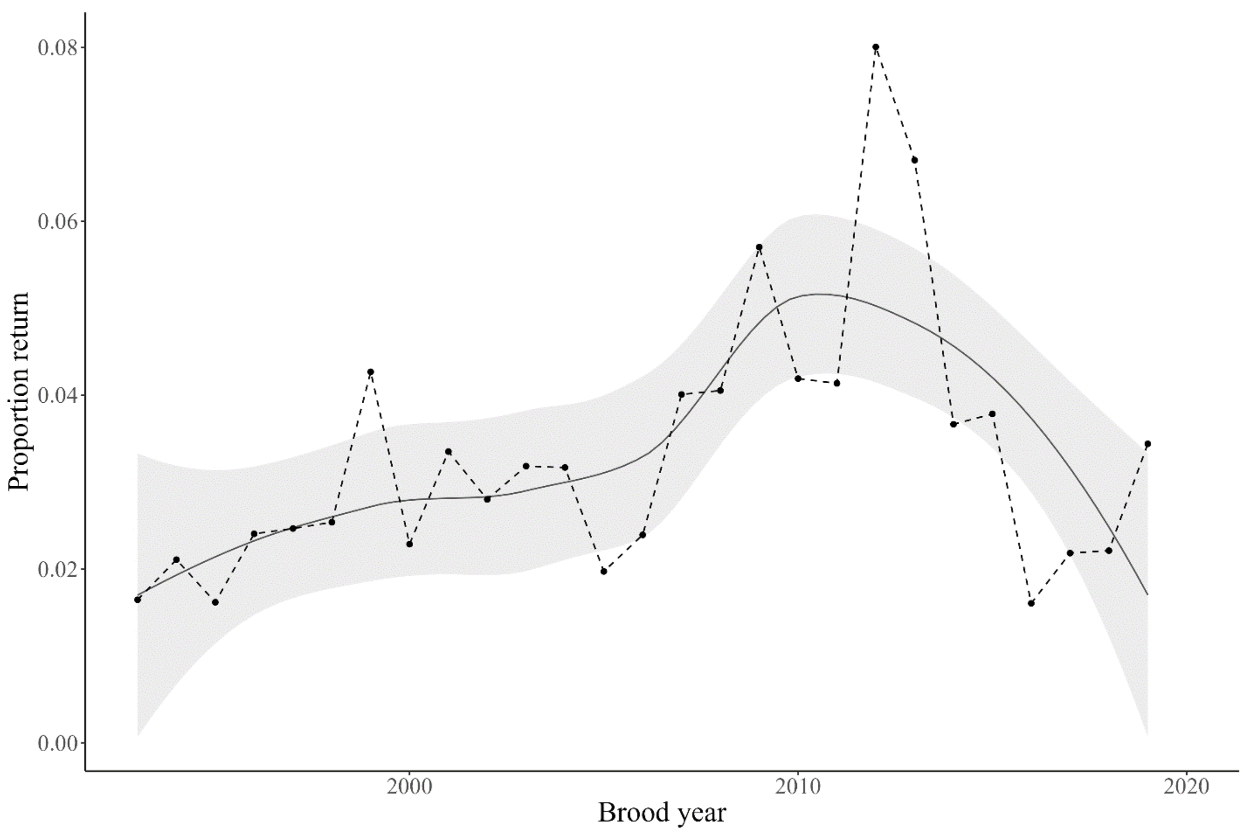
Synthesis Figure 4.41 Estimated partial effects of the top six predictors with the lowest (best) RMSE for the Wallowa summer steelhead program. Solid lines show the estimated smooth effect (using splines) of each predictor, and the shaded ribbons indicate the 95% confidence intervals for the estimated effects.

Winter Steelhead

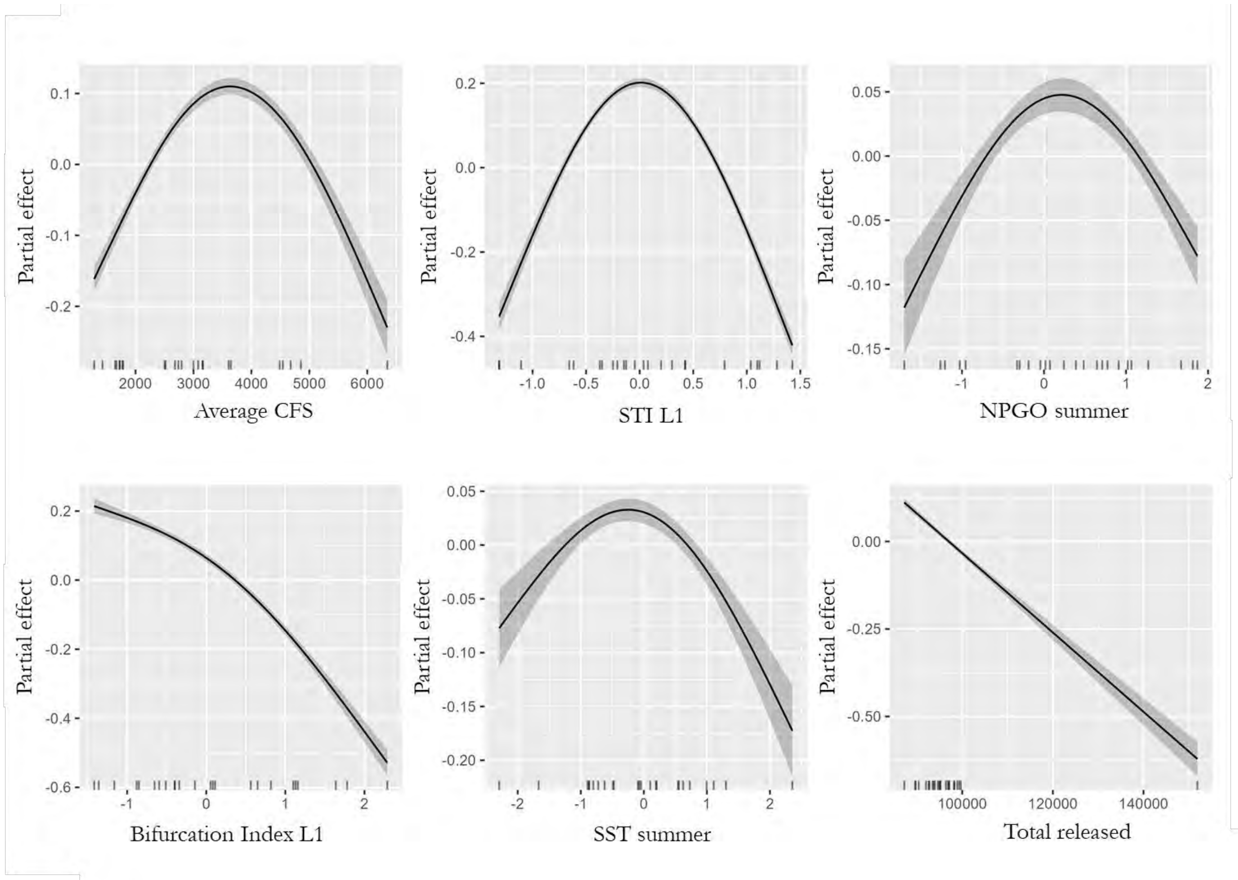
North Fork Nehalem

Synthesis Table 4.5 Table of estimate Root Mean Squared Error (RMSE, lower is better), Akaike's Information Criterion (AIC, lower translates to more data support), and estimated average absolute effect sizes of standardized predictors (larger effects have a bigger impact on the response) for the North Fork Nehalem winter steelhead program.

Predictor	RMSE	AIC	Average absolute effect
STI L1	0.8468	4193.16	0.0361
NPGO summer	0.8978	2879.46	0.0061
Bifurcation Index L1	0.9208	1936.86	0.0182
SST summer	0.9406	1089.50	0.0041
Total released	0.9467	1996.00	0.0000



Synthesis Figure 4.5 Estimated proportion of returning individuals, categorized by brood year, for the North Fork Nehalem winter steelhead program. Points represent empirical means, the solid line represents a LOESS-smoothed fit to the mean proportions, and the grey ribbon represents a 95% confidence interval.

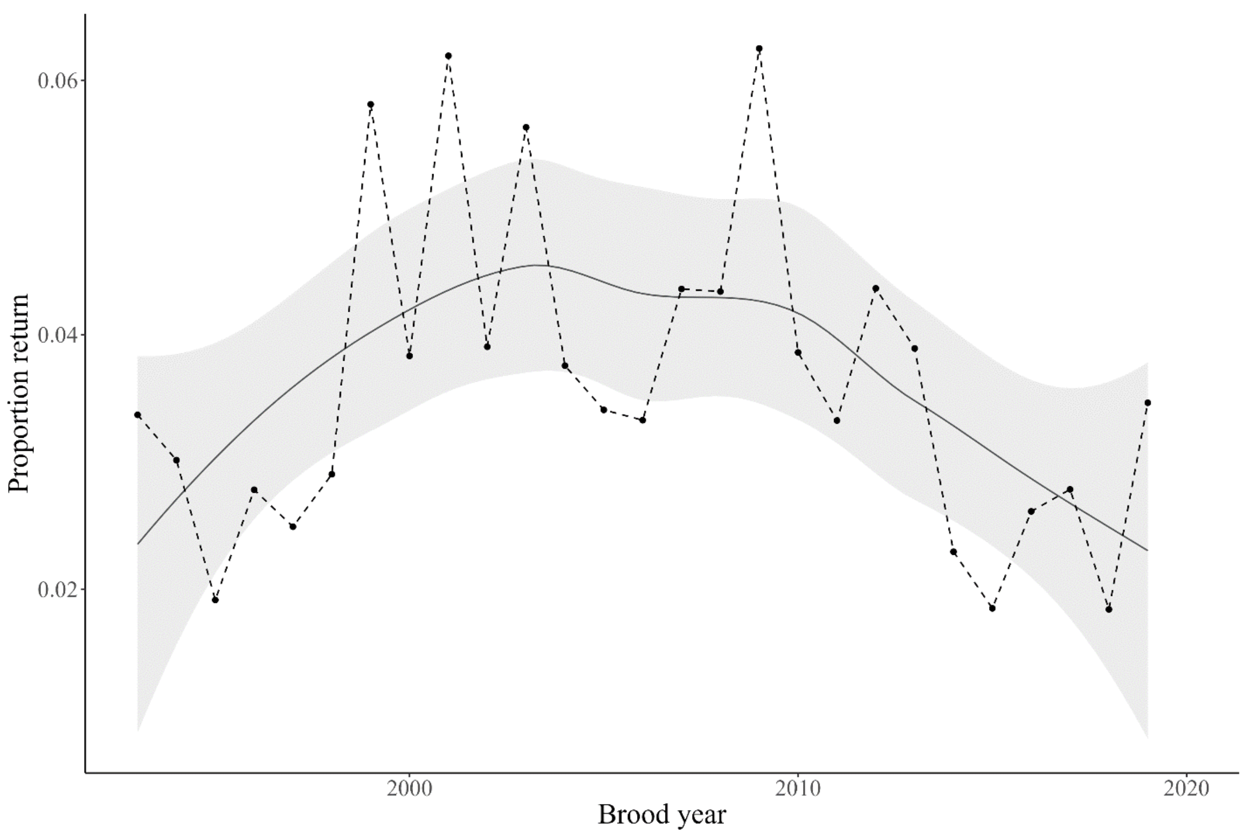


Synthesis Figure 4.51 Estimated partial effects of the top six predictors with the lowest (best) RMSE for the North Fork Nehalem winter steelhead program. Solid lines show the estimated smooth effect (using splines) of each predictor, and the shaded ribbons indicate the 95% confidence intervals for the estimated effects.

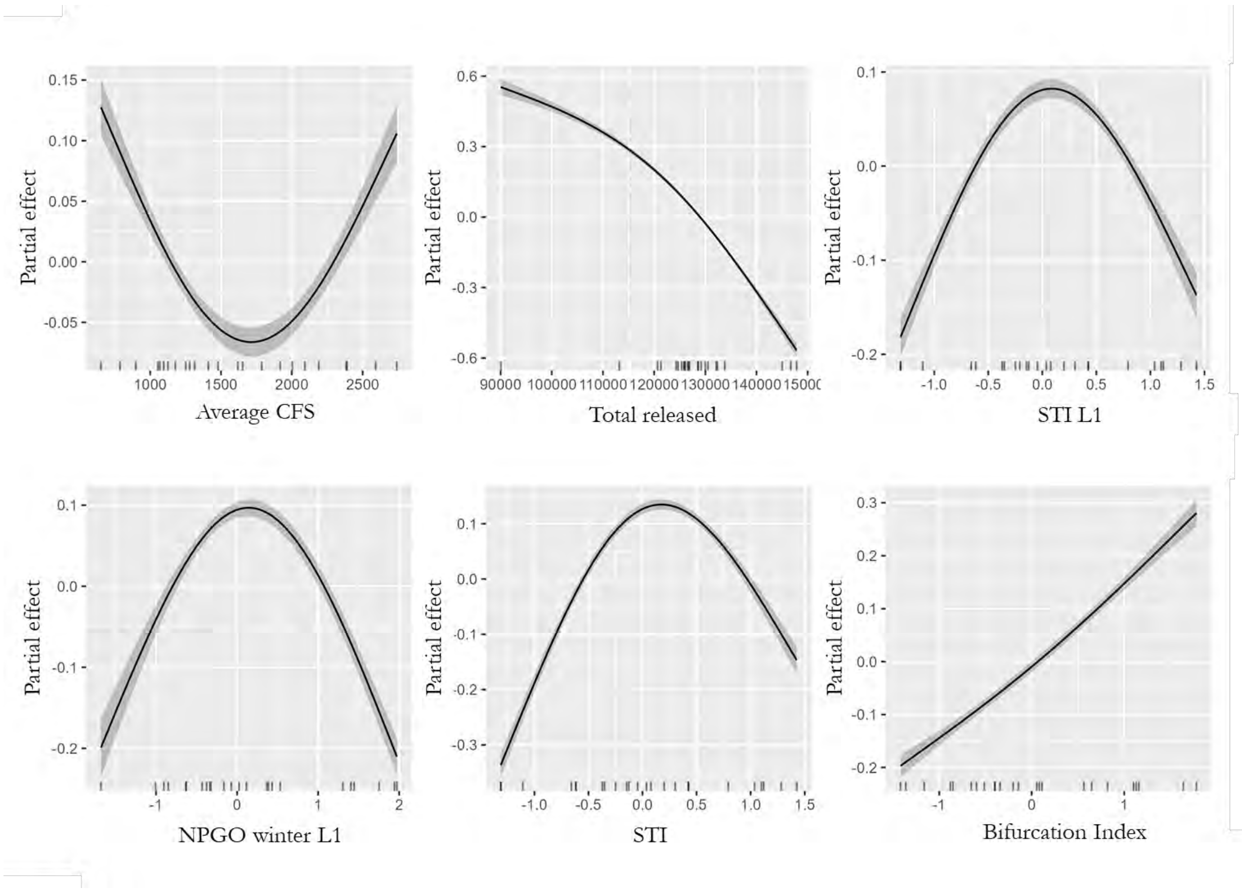
Alsea

Synthesis Table 4.6 Table of estimate Root Mean Squared Error (RMSE, lower is better), Akaike's Information Criterion (AIC, lower translates to more data support), and estimated average absolute effect sizes of standardized predictors (larger effects have a bigger impact on the response) for the Alsea winter steelhead program.

Predictor	RMSE	AIC	Average absolute effect
Total released	0.8159	3332.44	0.0000
STI L1	0.8444	3026.86	0.0170
NPGO winter L1	0.9067	2063.74	0.0127
STI	0.9197	1638.36	0.0251
Bifurcation Index	0.9239	1781.57	0.0180



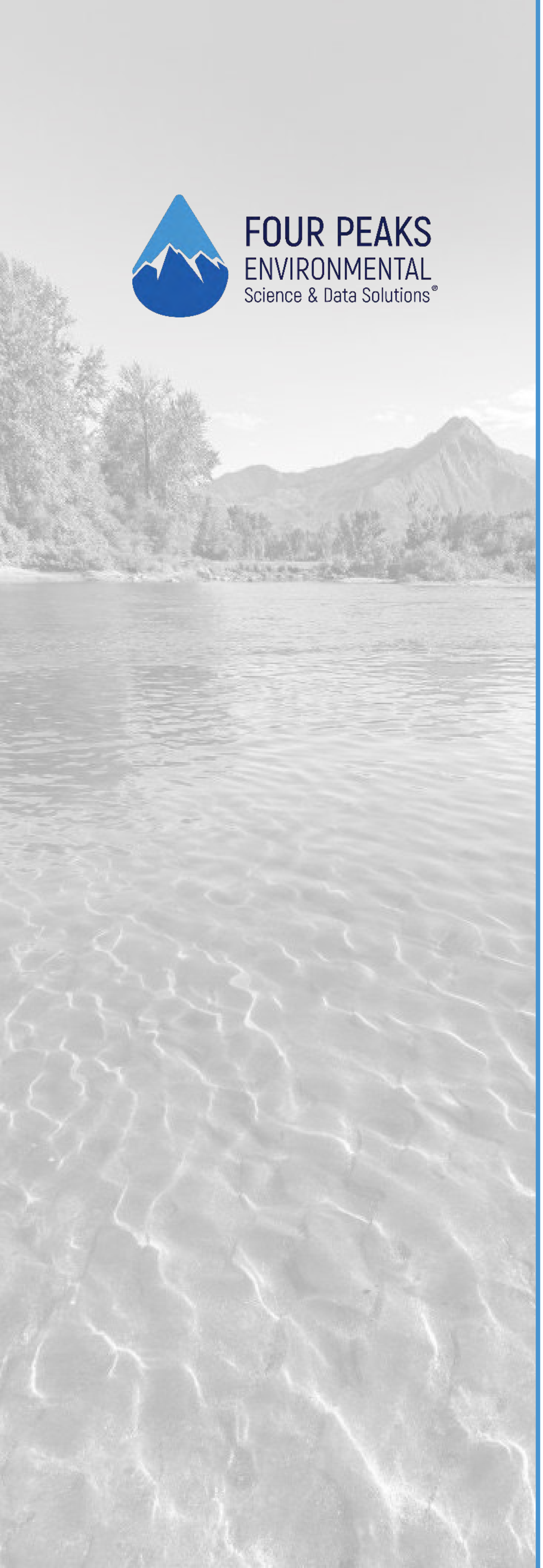
Synthesis Figure 4.6 Estimated proportion of returning individuals, categorized by brood year, for the Alsea winter steelhead program. Points represent empirical means, the solid line represents a LOESS-smoothed fit to the mean proportions, and the grey ribbon represents a 95% confidence interval.



Synthesis Figure 4.61 Estimated partial effects of the top six predictors with the lowest (best) RMSE for the Alsea winter steelhead program. Solid lines show the estimated smooth effect (using splines) of each predictor, and the shaded ribbons indicate the 95% confidence intervals for the estimated effects.

APPENDIX F: OREGON DEPARTMENT OF FISH AND WILDLIFE FUTURE HATCHERY NEEDS ASSESSMENT

Prepared by Four Peaks Environmental Science & Data Solutions



OREGON DEPARTMENT OF FISH AND WILDLIFE FUTURE HATCHERY NEEDS ASSESSMENT

August 2024

Prepared for
Oregon Department of Fish & Wildlife
4034 Fairview Industrial Drive SE
Salem, Oregon 97302

Prepared by
Four Peaks Environmental
Science & Data Solutions
338 South Mission Street
Wenatchee, Washington 98801

Table of Contents

List of Figures

List of Tables

Abbreviations

Abbreviation	Definition
A/P	abundance and productivity
CRBE	Columbia River Basin Endorsement
DPS	Distinct Population Segments
ELS	Electronic Licensing System
ESA	Endangered Species Act
ESU	Evolutionarily Significant Units
MPG	major population group
NOAA	National Oceanic and Atmospheric Administration
ODFW	Oregon Department of Fish and Wildlife
SMU	Species Management Units
SONCC	Southern Oregon and Northern California Coast
VSP	Viable salmonid population

Executive Summary

The Oregon State Legislature directed Oregon Department of Fish and Wildlife (ODFW) to undertake a climate vulnerability assessment of state-owned fish hatcheries, including an assessment of the likely impact of climate change on the future need for hatchery programs. This report addresses these future hatchery needs by assessing the status and trends of the Evolutionary Significant Units (ESUs)/Species Management Units (SMUs)/Distinct Population Segments (DPSs)[1], their climate vulnerability, hatchery production, and recreational angler use to identify future needs based on biological risk and hatchery status. While there are slight differences in ESU/SMU/DPS geographic boundaries, the boundaries and regions are similar enough to produce comparisons that successfully achieve the goal of identifying future hatchery needs.

This report groups status and trend data by region in tables broken down into ESU/SMU/DPS and population/major population group (MPG), as appropriate. Viable salmonid population (VSP) status and overall ESU/SMU/DPS risk are taken or adapted from the most recent management and/or assessment documents available for each ESU/SMU/DPS. In certain cases, data were not available for some or all VSP parameters or data had to be converted into VSP parameters. ESU/SMU/DPS overall risk is Moderate or higher for the majority of the ESU/SMU/DPSs examined. Comparatively fewer ESU/SMU/DPSs are ranked as Moderate or lower ESU/SMU/DPS overall risk. Three ESU/SMU/DPSs lack sufficient information to be ranked.

Climate change vulnerability of each ESU/SMU/DPS is identified based on an Exposure and Sensitivity Ranking (vulnerability) and the ESU/SMU/DPSs adaptive capacity (Crozier et al. 2019). Sufficient data were not available to determine adaptive capacity for all ESU/SMU/DPSs. The majority of the ESU/SMU/DPSs have an Exposure and Sensitivity Ranking of High or Very High. This indicates that the majority of ESU/SMU/DPSs are at substantial risk due to climate change. Adaptive capacity for all ESU/SMU/DPSs is above Moderate except the Southern Oregon and Northern California Coast Coho Salmon ESU, which was low. Overall, despite being at substantial risk due to climate change, most ESU/SMU/DPSs have some capacity to adapt to changes, thereby partially mitigating climate risk.

Hatchery programs are designated as either harvest or conservation programs. Within the harvest hatchery programs, there are two different program types: mitigation and harvest augmentation. Within conservation hatchery programs, there are seven program types, though only supplementation and recovery/restoration are discussed in this report. A hatchery may serve two or more program types and some hatchery programs will have harvest and conservation functions. The overwhelming majority of

[1] Evolutionary Significant Units (ESUs) and Distinct Population Segments (DPSs) are federal designations given by the National Oceanic and Atmospheric Administration. An ESU is a population or group of populations that is substantially reproductively isolated from conspecific population groups and is an important component of the evolutionary legacy of the species. A DPS is a population or group of populations of vertebrates that is distinct from other populations of the species and significant in relation to the whole species. It is the smallest taxonomic unit that can be protected under the Endangered Species Act. Species Management Unit (SMU) is a State designation given by Oregon Department of Fish and Wildlife. An SMU is a collection of populations from a common geographic region that share similar genetic and ecological characteristics.

hatchery programs examined here were solely harvest programs. Only four programs were solely conservation programs, with two supplementation programs and two recovery/restoration programs.

This report uses the volume of licenses, tags, and endorsements as a proxy to gauge the popularity of Oregon fisheries in general, to determine the approximate number of recreational fishery resource users and to examine trends in fisheries use over time. Most angling licenses have shown a significant decreasing trend over the last ~30 years driven primarily by declines in the 1990s. Most tags and endorsements have steadily declined across approximately the same period. This decline is most pronounced for license sales and there appears to be a gap opening between angling license sales and salmon and steelhead (*Oncorhynchus* species) tags and endorsements. This suggests that anglers may be shifting from salmon and steelhead to other types of fisheries. This indicates decreased demand for angling opportunity in general and salmon and steelhead angling opportunity in particular that seems likely to continue.

Harvest can be used as a measure of the importance of hatchery-origin fish to the maintenance of fisheries for specific ESU/SMU/DPSs. The larger a proportion of the fishery is made up of hatchery fish, the more important hatchery production may be to that fishery. Mark-selective fisheries can impact the proportion of hatchery fish in the harvest and, in a mark-selective fishery, overall harvest may be the best proxy. However, this is the best currently available quantitative metric to assess the importance of hatchery programs that is reasonably assignable down to the species, run-type, and ESU/SMU/DPS level. Harvest numbers also cannot capture the importance or impact of catch-and-release fisheries and the Electronic Licensing System (ELS) data reported here does not include paper harvest cards still available and in-use by most Oregon anglers. Therefore, the total numbers of fish reported here should be considered a minimum estimate of harvest.

A large majority of total reported harvest for most fisheries is made up of hatchery-origin fish. Hatchery-origin fish make up the largest proportion of the steelhead *O. mykiss* reported harvest, a large majority of Coho Salmon *O. kisutch* harvest, and a simple majority of total reported harvest for Chinook Salmon *O. tshawytscha* across both run-types. However, most spring Chinook Salmon ESU/SMU/DPS still have greater than 70% proportion hatchery-origin reported harvest, with fall Chinook Salmon proportions all less than ~60%. This demonstrates the importance of hatcheries in sustaining popular individual fisheries and angling throughout the state.

Mitigation hatchery programs exist to mitigate the impacts to fish habitat from the construction and operation of dams and other human developments. A large percentage, if not all, of the hatchery programs supporting ESU/SMU/DPSs in the Lower Columbia, Middle Columbia, Upper Willamette, Snake River, and Rogue-South Coast, as well as Oregon Coast Coho Salmon, are at least partially mitigation programs. These hatchery programs generally provide mitigation for dams, including those on the mainstem Columbia River and Snake River, in the Willamette and Rogue basins, and elsewhere in the state. As long as these dams continue to exist, there will be a future need for these mitigation hatchery programs to mitigate their impacts to fish habitat.

Harvest augmentation hatchery programs exist to increase fishing and harvest opportunity in areas where no mitigation programs exist. A substantial proportion of the hatchery programs supporting ESU/SMU/DPSs in the Lower Columbia and Oregon Coast, as well as Rogue-South Coast, are solely harvest augmentation or partially harvest augmentation programs. License, tag, and endorsement sale trends suggest the potential for lower demand for hatchery-supported salmon and steelhead fisheries in the future. This lower level of demand and support does not necessarily indicate a reduced future need and is unlikely to affect all fisheries in the same way or to the same degree. Obtaining additional metrics of the importance and popularity of specific fisheries and the importance of hatchery origin fish to those fisheries will be valuable in managing future need.

Conservation hatchery programs use hatchery fish to enhance the viability of natural populations while limiting impacts to those populations within acceptable bounds or use the best available broodstock to establish a population in habitat currently vacant for that native species. Relatively few conservation hatchery programs currently exist in the state of Oregon. However, federal/state listing status and climate vulnerability demonstrate a need to continue all existing conservation hatchery programs and increase the need for conservation hatchery programs targeting many ESU/SMU/DPSs throughout the state. Finally, a population's rating within this needs assessment should not be misconstrued as discounting any ecological, social, or cultural value associated with those populations.

Climate change is a substantial, additional uncertainty for both harvest augmentation and conservation hatchery programs. Wild ESU/SMU/DPSs are unlikely to be able to absorb more harvest demand. However, under climate change, the most important consideration may not be current harvest opportunity but the risk of ongoing harvest to the continued existence of the ESU/SMU/DPS. This could be further influenced by changing angler preferences. The evolving dynamics of climate change and interacting with angler demand and preferences create substantial uncertainty in future needs and will require flexible management approaches.

This assessment substantiates a future need for a combination of mitigation, harvest augmentation and conservation hatchery programs for a variety of different species in multiple regions. This mix of hatchery programs will continue to support fishery and conservation goals and objectives throughout the state of Oregon.

1 Introduction

Once abundant in their home range, Pacific salmon and steelhead (*Oncorhynchus* species) have decreased substantially as a result of stressors that include habitat degradation and fragmentation, temperature regime alterations, competition and predation, overharvest, and pathogens (ODFW and NMFS 2011; Lorenzen et al. 2012; Quinn 2018). To combat these losses and increase fishery resource availability, intervention has occurred locally, regionally, nationally, and internationally to bolster Pacific salmon and steelhead populations. The Oregon Department of Fish and Wildlife (ODFW) currently supports many efforts to both naturally and artificially increase Pacific salmon and salmonid productivity. As part of ODFW's mission statement, "To protect and enhance Oregon's fish and wildlife and their habitats for use and enjoyment by present and future generations," the agency currently participates in a robust fish hatchery program that produces different stocks of Chinook Salmon *O. tshawytscha*, Coho Salmon *O. kisutch*, Chum Salmon *O. keta*, and steelhead *O. mykiss*. There are 33 hatcheries that ODFW operates, with 77 hatchery production programs that exist within these facilities (ODFW 2024a), although not all facilities produce Pacific salmon species.

There are currently two hatchery program types: conservation and harvest, which are further sub-divided into program types (detailed definitions of hatchery types and programs can be found in Section 4). Conservation hatcheries include supplementation, recovery (restoration), captive brood, captive rearing, egg banking, cryopreservation, and experimental. However, only supplementation and recovery are discussed within this report. Harvest hatcheries have two different program types: harvest augmentation and mitigation. All salmon and steelhead, and some trout hatcheries that are anticipated to interact with listed species, are operated under specific hatchery genetic management plans (HGMPs) or Section 10 permits that permit specific production levels as approved by the National Oceanic and Atmospheric Administration (NOAA).

The Oregon State Legislature directed ODFW to undertake a climate vulnerability assessment of state-owned fish hatcheries, including an assessment of the likely impact of climate change on the future need for hatchery programs. This report aims to identify these future hatchery needs by assessing the status and trends of Evolutionary Significant Unit (ESU)/Species Management Unit (SMU)/Distinct Population Segments (DPSs) while considering climate change vulnerability, hatchery production of Pacific salmon and steelhead species, and recreational angler use. While we recognize that there are slight differences in the boundaries of similarly named ESU/SMU/DPSs based on species, the boundaries and regions are similar enough to produce comparisons that successfully achieve the goal of identifying future hatchery needs.

Terminology was a challenge when attempting to aggregate status and trends, climate assessments, hatchery programs and recreational angling metrics across multiple management documents and data sources authored by state and federal agencies. Terms such as ESU, SMU, and DPS have specific legal definitions but also common meanings, which can lead to confusion. It is tempting and common to use, for instance, "ESU" to describe both the Upper Willamette ESU Chinook Salmon (a specific species within a location) and the Upper Willamette ESU as a physical location. However, ESU as a physical location might not describe the same area or set of rivers/streams for the different species.

In an attempt to limit confusion in this report, we adopt the following naming conventions. ESU, DPS, and SMU will be used consistent with their legal definitions to describe combinations of location and species as defined by National Marine Fisheries Service (NMFS) or the state (e.g., Upper Willamette DPS winter steelhead). When referring to a grouping of these location and species combinations, "ESU/SMU/DPS" will be used. When describing or aggregating data and results by a physical location, "region" will be used. In some cases that physical location may also be consistent with the location component of an ESU/SMU/DPS designation. Finally, species and/or species/run-type will be used when aggregating ESUs, SMUS, or DPSs across locations by species and run-type.

This report is organized into discrete sections (i.e., Section 2 Status and Trends, Section 3 Climate Change Vulnerability, Section 4 Hatchery Programs, and Section 5 Angler Licenses, Tags, Endorsements, and Harvest) designed to provide details on the biological status and trends, vulnerability to climate change, existing hatchery program status, and recreational angler use and harvest. Each of these sections will present existing data down to the lowest level available. In the case of biological status and trends and vulnerability to climate change, risk scores are given, taken from existing literature and standardized assessments. These risk scores are then aggregated into biological vulnerability score by ESU/SMU/DPS. For certain sections (e.g., Anglers Licenses and Tags and Endorsements) some or all of the data lack sufficient resolution to develop risk scores down to the level of ESU/SMU/DPS. In those cases, data are discussed down to the lowest defensible level. The overall vulnerability and hatchery status by ESU/SMU/DPS for each section are then combined, using a standardized methodology, described in Section 6 Assessment and Conclusions, to arrive at an assessment of future needs for mitigation, harvest augmentation, and conservation hatchery programs for all ESU/SMU/DPSs.

2 Status and Trends

Status and trend data are grouped by region and presented as tables organized into ESU/SMU/DPS and population/major population group (MPG), as appropriate. Each table first identifies the listing status (both federal and state listing) for each species within the ESU/SMU/DPS. Federally listed species are designated as threatened (T) or endangered (E). Species of concern (SOC) is noted where applicable despite it being a separate federal designation used by NMFS to denote species with concerns regarding status and threats, but for which insufficient information is available to list under the Endangered Species Act (ESA) (69 FR 19975). State-listed species are designated as threatened (T) or endangered (E). The State may also designate species as sensitive critical (SC), or sensitive (S). Sensitive species are defined as small or declining populations, are at-risk, and/or are of management concern. Next, the table defines the populations within each ESU/SMU/DPS and lists their risk based on individual and overall viable salmonid population (VSP) parameters (McElhaney et al. 2000). VSP parameters indicate an ESU/SMU/DPS's risk and not necessarily their status. In other words, Low does not mean a population is in poor status but that it is at low risk. Finally, each table reports an overall ESU/SMU/DPS risk.

VSP parameters used within this report include combined abundance/productivity, diversity, and spatial structure. We focused on these parameters because 1) they are reasonable predictors of population health and viability, 2) they reflect general processes that are important to all populations of all species, 3) they allow us to draw general conclusions about an ESU's extinction risk even without detailed, species-specific information, and 4) they are widely accepted and used throughout the salmon and steelhead literature. For a complete discussion of VSP, its parameters, and their application, see McElhaney et al. 2000.

VSP status and overall ESU/SMU/DPS risk were obtained or adapted from the most recent management and/or assessment documents available for each ESU/SMU/DPS. In certain cases, data were not available for some or all VSP parameters or data had to be converted into VSP parameters. For example, VSP parameters are not available for all ESU/SMU/DPS, but similar types of categorical ranking data are available and were translated into the VSP framework. Extirpated populations are also noted within the tables where applicable.

NMFS Status and Viability Assessments and State Management Plans (e.g., Rogue–South Coast Multi-Species Conservation and Management Plan, Coastal Multi-Species Conservation and Management Plan, and Rogue Fall Chinook Plan; ODFW 2024b) were recent sources that provided consistent, comparable biological parameters using standardized methods (i.e., VSP) that facilitated comparisons across ESU/SMU/DPSs. The Implementation Plan for the Reintroduction of Anadromous Fishes into the Oregon Portion of the Upper Klamath Region (ODFW and Klamath Tribes 2021) was also used for Klamath River Coho and Chinook Salmon in particular. Where no more recent management documents existed, status and trends were taken from the Oregon Native Fish Status Report (ODFW 2005). In limited cases, the status of individual major population groups (MPGs)/populations has likely changed from the most recent assessment though a more formal analysis was not available to document the change (e.g., likely status improvement in Clackamas Coho Salmon MPG and decline in Coquille Fall Chinook Salmon MPG). The exact references used for each ESU/SMU/DPS are cited in the tables.

2.1 Snake River Region

In the Snake River Region, both the Snake River spring/summer ESU and fall Chinook Salmon ESU are threatened at both the federal and state level (Table 2-1). The Snake River steelhead DPS is threatened at the federal level and sensitive at the state level.

The status and trends risk evaluation of the Snake River Region (Ford 2022) is summarized in Table 2-1. Within the Snake River Region, fall Chinook Salmon were given an overall ESU risk of Viable, steelhead were Moderate, and spring/summer Chinook Salmon were Moderate to High. The overall VSP status for spring/summer Chinook Salmon ranges from High to Maintained, where five of the six populations rank High and the only Maintained population is in the Minam River. Fall Chinook Salmon had an overall Viable VSP rating. We equated this to a “low to moderate” rating based on Table 18 in Ford 2022, where fall Chinook Salmon were given a low Abundance/Productivity (A/P) score and a moderate Spatial Structure (SS)/Diversity score. This allowed us to convert the fall Chinook Salmon risk score to the same scale used by other ESU/SMU/DPSs. Steelhead ranked Moderate to Low in VSP status, where three of the five steelhead populations ranked as Viable.

Table 2-1. Snake River ESU/DPS federal and state listing status and risk evaluation from existing research and monitoring efforts by species and population.

Species (Citation)	MPG or Population	Listing Status		VSP Risk Status				ESU/SMU/DPS Overall Risk
		Federal	State	A/P	Diversity	SS	Overall	
Spring/Summer Chinook (Ford 2022, Page 33)	Wenaha	Threatened	Threatened	High	Moderate	Moderate	High	Moderate to High
	Lostine			High	Moderate	Moderate	High	
	Minam			Moderate	Moderate	Moderate	Maintained	
	Catherine			High	Moderate	Moderate	High	
	Grand Ronde (Upper)			High	Moderate	High	High	
	Imnaha Mainstem			High	Moderate	Moderate	High	
Fall Chinook (Ford 2022, Page 51)	Lower Snake River	Threatened	Threatened	Low	No Data	Moderate	Viable	Low to Moderate (Viable)
Steelhead (Ford 2022, Page 71)	Lower Grande Ronde	Threatened	Sensitive	High	Moderate	Moderate	High	Moderate
	Joseph Creek			Low	Low	Low	Viable	
	Grand Ronde River (Upper)			Very Low	Moderate	Moderate	Viable	
	Wallowa River			High	Low	Low	High	
	Imnaha River			Very Low	Moderate	Moderate	Viable	

2.2 Middle Columbia Region

In the Middle Columbia region, only the Middle Columbia steelhead DPS is both federal and state listed (threatened and sensitive critical; Table 2-2). Both Middle Columbia spring and fall Chinook Salmon ESUs have no federal listing but are designated by the State as sensitive.

The status and trends risk evaluation of the Middle Columbia region (Ford 2022; ODFW 2005) are presented in Table 2-2. Within the Middle Columbia region, steelhead were the only species that had sufficient data to determine an overall ESU/SMU/DPS risk, leading to a ranking of Moderate. Spring and fall Chinook Salmon populations lacked ESU-wide risk rankings and were ranked only at the population or MPG level. Overall VSP status for steelhead included High, Maintained, Viable, and Highly Viable designations. Steelhead within this DPS included two extirpated populations in Oregon (Crooked River and Willow Creek). Of the extant populations, only one is designated as a High overall risk. Spring and fall Chinook Salmon all carry overall VSP statuses of Viable where not extirpated.

Table 2-2. Middle Columbia ESU/SMU/DPS federal and state listing status and risk evaluation from existing research and monitoring efforts by species and population.

Species (Citation)	MPG or Population	Listing Status		VSP Risk Status[1]				ESU/SMU/DPS Overall Risk
		Federal	State	A/P	Diversity	SS	Overall	
Steelhead (Ford 2022, Page 93)	Fifteenmile	Threatened	Sensitive Critical	Moderate	Low	Low	Maintained	Moderate[3]
	Deschutes River Westside			High	Moderate	Moderate	High	
	Deschutes River Eastside			Moderate	Moderate	Moderate	Maintained	
	John Day Lower Mainstem			Moderate	Moderate	Moderate	Maintained	
	NF John Day River			Very Low	Low	Low	Highly Viable	
	MF John Day River			Very Low	Moderate	Moderate	Viable	
	SF John Day River			Very Low	Moderate	Moderate	Viable	
	John Day Upper Mainstem			Moderate	Moderate	Moderate	Maintained	
	Umatilla River			Moderate	Moderate	Moderate	Maintained	
	Walla Walla River			Moderate	Moderate	Moderate	Maintained	
	Willow Creek			Functionally Extirpated				
	Crooked River			Extirpated				
Spring Chinook (ODFW 2005)	Lower Deschutes[2]		Sensitive	Low	Low	Low	Viable	No Data
	Metolius[2]			Extirpated				
	Crooked River[2]			Extirpated				
	NF John Day River[2]			Low	Low	Low	Viable	
	MF John Day River[2]			Low	Low	Low	Viable	
	Upper John Day River[2]			Low	Low	Low	Viable	
	Umatilla River[2]			Extirpated				
	Walla Walla River[2]			Extirpated				
Fall Chinook (ODFW 2005)	Deschutes River		Sensitive	Low	Low	Low	Viable	No Data
	John Day[2]			Extirpated				
	Umatilla[2]			Extirpated				
	Walla Walla River[2]			Extirpated				
	Mainstem[2]			No Data	No Data	No Data	No Data	
Coho (ODFW 2005)	Umatilla			Extirpated				No Data
	Wallowa			Extirpated				

Note:

1. Some species listed here as "extirpated" may have active re-introduction efforts under way.
2. Data extracted prior to VSP framework was used and translated into VSP terminology by ODFW for ODFW 2005.
3. Middle Columbia DPS Steelhead Overall Risk includes populations in Washington (denoted with +)

2.3 Lower Columbia River Region

Within the Lower Columbia River region, the Lower Columbia River Chinook, Coho, and Chum Salmon ESUs, and the Lower Columbia River steelhead DPS all carry a federal Threatened listing (Table 2-3). All species are also state listed as sensitive critical, except for Coho Salmon, which have an endangered state status.

The status and trends risk evaluation of the Lower Columbia region (NOAA 2022) is presented in Table 2-3. All species are designated as having a Moderate overall ESU risk ranking. For all species and populations within this ESU, there is not sufficient information to fulfill conditions required for the VSP framework to produce a population-specific overall VSP status. Abundance/productivity was the only parameter that was evaluated, and abundance/productivity status designations ranged from Very High to Low. Of the 31 populations, 15 carry a designation of Very High, while 9 are designated as High.

Table 2-3. Lower Columbia ESU/DPS federal and state listing status and risk evaluation from existing research and monitoring efforts by species and population.

Species (Citation)	MPG or Population	Listing Status		VSP Risk Status				ESU/SMU/DPS Overall Risk[1]
		Federal	State	A/P	Diversity	SS	Overall	
Fall Chinook (NOAA 2022 Pages 36, 37, 40 and Ford 2022, Page 130)	Big Creek	Threatened	Sensitive Critical	Very High	No Data	No Data	No Data	Moderate
	Clatskanie			Very High	No Data	No Data	No Data	
	Youngs Bay			High	No Data	No Data	No Data	
	Scappoose			No Data	No Data	No Data	No Data	
	Clackamas (Late)			High	No Data	No Data	No Data	
	Sandy (Late)			High	No Data	No Data	No Data	
	Sandy			Low	No Data	No Data	No Data	
	Hood			High	No Data	No Data	No Data	
	Upper Gorge			High	No Data	No Data	No Data	
	Lower Gorge			Low	No Data	No Data	No Data	
Spring Chinook (NOAA 2022, Pages 36, 37, 40 and Ford 2022, Page 130)	Sandy	Threatened	Sensitive Critical	Low	No Data	No Data	No Data	
	Hood			Very High	No Data	No Data	No Data	
Coho (NOAA 2022, Pages 36, 37, 40 and Ford 2022, Page 143)	Clatskanie	Threatened	Endangered	Very High	No Data	No Data	No Data	Moderate
	Scappoose			High	No Data	No Data	No Data	
	Youngs Bay			Low	No Data	No Data	No Data	
	Big Creek			Low	No Data	No Data	No Data	
	Clackamas			Very High	No Data	No Data	No Data	
	Sandy			High	No Data	No Data	No Data	
	Lower Gorge			Very High	No Data	No Data	No Data	
	Upper Gorge/Hood			Very High	No Data	No Data	No Data	
Chum (NOAA 2022, Pages 36, 37, 40 and Ford 2022, Page 156)	Youngs Bay	Threatened	Sensitive Critical	Very High	No Data	No Data	No Data	Moderate
	Big Creek			Very High	No Data	No Data	No Data	
	Clatskanie			Very High	No Data	No Data	No Data	
	Scappoose			Very High	No Data	No Data	No Data	
	Clackamas			Very High	No Data	No Data	No Data	
	Upper Gorge			Very High	No Data	No Data	No Data	
	Lower Gorge			Low	No Data	No Data	No Data	
Winter Steelhead (NOAA 2022, Pages 36, 37, 40 and Ford 2022, Page 156)	Clackamas	Threatened	Sensitive Critical	High	No Data	No Data	No Data	Moderate
	Sandy			Low	No Data	No Data	No Data	
	Lower Gorge			Very High	No Data	No Data	No Data	
	Hood			High	No Data	No Data	No Data	

Species (Citation)	MPG or Population	Listing Status		VSP Risk Status				ESU/SMU/DPS Overall Risk[1]
		Federal	State	A/P	Diversity	SS	Overall	
Summer Steelhead (NOAA 2022, Pages 36, 37, 40 and Ford 2022, Page 156)	Hood	Threatened	Sensitive Critical	Very High	No Data	No Data	No Data	

Note:

1. Overall Risk for Lower Columbia Region ESU/DPSs also includes populations in Washington. This is why overall risk does not necessarily align with population level risk.

2.4 Upper Willamette Region

Within the Upper Willamette region, the Upper Willamette spring Chinook Salmon ESU is federally listed as threatened and state designated as sensitive critical. The Upper Willamette DPS Steelhead is federally listed as threatened and state designated as sensitive (Table 2-4).

The status and trends risk evaluation for the Upper Willamette region (Ford 2022) is presented in Table 2-4. Spring Chinook Salmon were designated as having a Moderate overall ESU risk ranking, and Steelhead are designated as having a Moderate to High overall ESU risk ranking. There was insufficient information to develop an overall VSP risk for either spring Chinook Salmon or steelhead. For both species, abundance/productivity was the only parameter available for evaluation. Abundance/Productivity risk designations ranged from Very Low to Very High for spring Chinook Salmon. All populations of steelhead in this ESU are designated as High risk for abundance/productivity.

Table 2-4. Upper Willamette ESU/DPS federal and state listing status and risk evaluation from existing research and monitoring efforts by species and population.

Species (Citation)	MPG or Population	Listing Status		VSP Risk Status				ESU/SMU/DPS Overall Risk
		Federal	State	A/P	Diversity	SS	Overall	
Spring Chinook (Ford 2022, Page 179)	Clackamas	Threatened	Sensitive Critical	Very Low	No Data	No Data	No Data	Moderate
	Molalla			Very High	No Data	No Data	No Data	
	North Santiam			Very High	No Data	No Data	No Data	
	South Santiam			High	No Data	No Data	No Data	
	Calapooia			Very High	No Data	No Data	No Data	
	McKenzie			High	No Data	No Data	No Data	
	Middle Fork Willamette			Very High	No Data	No Data	No Data	
Winter Steelhead (Ford 2022, Page 189)	Willamette Falls Count	Threatened	Sensitive	High	No Data	No Data	No Data	Moderate to High
	Molalla				No Data	No Data	No Data	
	North Santiam				No Data	No Data	No Data	
	South Santiam				No Data	No Data	No Data	
	Calapooia				No Data	No Data	No Data	

2.5 Rogue-South Coast Region

Within the Rogue-South Coast region, Southern Oregon and Northern California Coast (SONCC) Coho Salmon are the only species listed at the federal level (Threatened; Table 2-5). Rogue-South Coast SMU summer steelhead and spring Chinook Salmon are designated as sensitive by the state but are not federally listed. Rogue-South Coast SMU winter steelhead and Rogue-South Coast SMU fall Chinook Salmon do not have a federal or state designation.

The Klamath Mountain Province DPS winter and summer steelhead and SONCC ESU Coho Salmon are discussed under this region, as the Oregon populations included in those federal ESU/DPSs have substantial, if not total, overlap with those included in the Rogue-South Coast Multi-Species Conservation and Management Plan. SONCC ESU Coho Salmon are threatened at the federal level and are listed as sensitive critical by the state. Also note that all these ESU/DPSs include populations in northern California.

SONCC ESU Coho Salmon in the upper Klamath River are effectively extirpated from Oregon waters, though they continue to exist in California waters of the lower Klamath River. This is anticipated to change in the near future with the removal of dams on the Klamath River allowing SONCC Coho Salmon access to the mainstem Klamath River and tributaries up to at least Keno Dam (ODFW and Klamath Tribes 2021). Currently, reoccupation of historical habitat will be allowed via volitional movement and dispersion upstream of former dam sites. However, ODFW and the Klamath Tribes (2021) have also developed a reintroduction plan, should that be necessary, and California Department of Fish and Game has a draft version of a similar plan at the time of this writing.

The status and trends risk evaluation for the Rogue-South Coast region (ODFW 2021; ODFW and Klamath Tribes 2021; NOAA 2023) is presented in Table 2-5. Rogue-South Coast SMU winter Steelhead have a Very Low overall ESU/SMU/DPS risk ranking, and both Rogue-South Coast SMU summer steelhead and SONCC ESU Coho Salmon have Moderate ESU/SMU/DPS overall risk rankings. Overall VSP status for Rogue-South Coast SMU winter steelhead populations were either Viable or Highly Viable, Rogue-South Coast SMU summer steelhead populations were Viable, and SONCC ESU Coho Salmon designations were either Moderate or High Risk.

Data for Rogue River fall and spring Chinook Salmon are monitored and managed under different management plans (ODFW 2013; ODFW 2019) using different criteria than other species within this region (ODFW 2021). Therefore, the standardized VSP criteria have not been calculated for them. However, abundance and spawner distribution and density have been calculated and are reasonably equivalent to the abundance and productivity criteria of the VSP. Moreover, the management plans define conservation and desired thresholds for abundance and spawner distribution and density for both these run-types. Therefore, to allow standardization with the metrics in this report, we have defined the abundance and productivity (A/P) criteria as follows for Rogue-South Coast SMU fall and spring Chinook Salmon:

- Low: below Conservation Criterion
- Moderate: between Conservation Criterion and Desired Status
- High: above Desired Status

This allows a standardized way of translating existing management criteria into qualitative categories for evaluation within this report. The SONCC Chinook Salmon ESU, which include populations in the Rogue spring and fall Chinook SMUs in Oregon and additional populations in north California, has an overall ESU/SMU/DPS risk ranking of Low and overall VSP status for populations within the ESU range from Viable to Moderate to Highly Viable.

Table 2-5. Rogue-South Coast ESU/SMU/DPS federal and state listing status and risk evaluation from existing research and monitoring efforts by species and population.

Species (Citation)	MPG or Population	Listing Status		VSP Risk Status				ESU/SMU/DPS Overall Risk
		Federal	State	A/P	Diversity	SS	Overall	
Winter Steelhead (ODFW 2021, Page 24)	Elk			Very Low	Very Low	Very Low	Highly Viable	Very Low
	Euchre			Very Low	Very Low	Very Low	Highly Viable	
	Hunter			Very Low	Very Low	Very Low	Highly Viable	
	Pistol			Very Low	Very Low	Very Low	Highly Viable	
	Chetco			Very Low	Very Low	Very Low	Highly Viable	
	Winchuck			Very Low	Very Low	Very Low	Highly Viable	
	Lower Rogue			Low	Very Low	Very Low	Viable	
	Illinois			Low	Very Low	Very Low	Viable	
	Middle Rogue/Applegate			Low	Very Low	Very Low to Low	Viable	
	Upper Rogue			Low	Low	Low	Viable	
Summer Steelhead (ODFW 2021, Page 24)	Middle Rogue/Applegate		Sensitive	No Data	Low	Very Low	Viable	Moderate
	Upper Rogue			No Data	Low	Low	Viable	
Coho (ODFW 2021, Page 24; ODFW and Klamath Tribes 2021, Page 13)	Elk	Threatened	Sensitive Critical	High	Low	Low to Moderate	High Risk	Moderate
	Illinois			Moderate	Low	Low to Moderate	Moderate	
	Middle Rogue/Applegate			Moderate	Low	Low	Moderate	
	Upper Rogue			Moderate	Low	Low to Moderate	Moderate	
	Upper Klamath River and Tributaries		Sensitive	EXTIRPATED				
Spring Chinook (ODFW 2019, Page 7 and NOAA 2024, Page 129)	Rogue		Sensitive	Moderate	No Data	No Data	No Data	Low

Species (Citation)	MPG or Population	Listing Status		VSP Risk Status				ESU/SMU/DPS Overall Risk
		Federal	State	A/P	Diversity	SS	Overall	
Fall Chinook (NOAA 2024, Page 129 and ODFW 2022, page 2 and 9)	Lower Rogue			Very Low	Very Low	Very Low to Low	Highly Viable	Low
	Upper Rogue			Very Low	Low to Moderate	Low	Highly Viable to Viable	
	Hunter			Low to Moderate	Very Low to Low	Low	Viable to Moderate	
	Pistol			Low	Very Low to Low	Very Low to Low	Viable	
	Chetco			Low	Low to Moderate	Very Low to Low	Viable	
	Winchuck			Low	Very Low to Low	Very Low to Low	Viable	

2.6 Oregon Coast Region

Within the Oregon Coast region, one of the six species is listed at the federal or state level (Table 2-6). Only Oregon Coast ESU Coho Salmon are federally designated as threatened and are listed as sensitive by the state. Oregon Coast SMU spring Chinook are listed as sensitive at the state level but do not have federal listings. Chum Salmon are sensitive critical at the state level but do not have federal listings. Oregon Coast SMU winter and summer steelhead are both federal species of concern. Oregon Coast SMU summer steelhead are listed as sensitive by the state, and Oregon Coast SMU winter steelhead do not have a state designation.

The status and trends risk evaluation for the Oregon Coast region is presented in Table 2-6. Overall, ESU/SMU/DPS risk rankings were either Very Low for Oregon Coast SMU Chinook and Oregon Coast SMU winter steelhead or Moderate to High for Oregon Coast SMU spring Chinook and Chum Salmon. Where sufficient data were available, most populations across species were given overall VSP status of Viable. Three populations—Elk River Chinook Salmon, South Umpqua River spring Chinook Salmon, and Netarts Chum Salmon—were found to be not viable. There was insufficient information to fulfill conditions required for the VSP framework to produce a population-specific overall VSP status for Oregon Coast ESU Coho Salmon, and in most cases, there was insufficient information to fulfill these requirements for Oregon Coast SMU Chum Salmon. However, note that both had sufficient information to make determinations of overall ESU risk, as reported above.

Table 2-6. Oregon Coast ESU/SMU/DPS federal and state listing status and risk evaluation from existing research and monitoring efforts by species and population.

Species (Citation)	MPG or Population	Listing Status		VSP Risk Status				ESU/SMU /DPS Overall Risk
		Federal	State	A/P	Diversity	SS	Overall	
Chinook (ODFW 2014, Page 161)	Necanicum			Very Low	Moderate	Low	Viable	Very Low
	Nehalem			Low	Moderate	Very Low	Viable	
	Tillamook			Low to Moderate	Moderate to High	Very Low to Low	Viable	
	Nestucca			Low	Moderate to High	Very Low to Low	Viable	
	Salmon			Very Low	Moderate	Low to Moderate	Viable	
	Siletz			Very Low	Moderate	Very Low	Viable	
	Yaquina			Very Low	Moderate	Very Low	Viable	
	Alsea			Very Low	Moderate	Very Low	Viable	
	Yachats Aggregate			No Data	Moderate	Very Low	Viable	
	Siuslaw			Very Low	Moderate	Very Low	Viable	
	Lower Umpqua			No Data	Moderate	Very Low	Viable	
	Middle Umpqua			No Data	Moderate	Very Low	Viable	
	South Umpqua			Very Low	Moderate	Very Low	Viable	
	Coos			Very Low	Moderate	Very Low	Viable	
	Coquille			Very Low	Moderate to High	Very Low	Viable	
	Floras			Low	Moderate	Very Low	Viable	
	Sixes			Very Low	Moderate	Very Low	Viable	
	Elk			Moderate	Moderate	Very Low	Not Viable	
Spring Chinook (ODFW 2014, Page 161)	North Umpqua		Sensitive	Very Low	Moderate	Very Low	Viable	Moderate
	South Umpqua			Moderate	Moderate	Moderate	Not Viable	
Chum (ODFW 2014, Page 161)	Necanicum		Sensitive Critical	No Data	No Data	No Data	No Data	Moderate to High
	Nehalem			Very Low	No Data	No Data	Viable	
	Tillamook			Low	No Data	No Data	Viable	
	Netarts			Moderate	No Data	No Data	Not Viable	
	Nestucca			No Data	No Data	No Data	No Data	
	Salmon			No Data	No Data	No Data	No Data	
	Siletz			No Data	No Data	No Data	No Data	
	Yaquina			Very Low	No Data	No Data	Viable	
	Alsea			No Data	No Data	No Data	No Data	
	Siuslaw			No Data	No Data	No Data	No Data	
	Umpqua			No Data	No Data	No Data	No Data	
	Coos			No Data	No Data	No Data	No Data	
	Coquille			No Data	No Data	No Data	No Data	

Species (Citation)	MPG or Population	Listing Status		VSP Risk Status				ESU/SMU /DPS Overall Risk
		Federal	State	A/P	Diversity	SS	Overall	
Winter Steelhead (ODFW 2014, Page 162)	Necanicum	Species of Concern		No Data	Low	Low	Viable	Very Low
	Nehalem			Very Low	Low	Very Low	Viable	
	Tillamook			No Data	Low	Very Low	Viable	
	Nestucca			No Data	Low	Very Low	Viable	
	Salmon			No Data	Low	Low	Viable	
	Siletz			No Data	Low	Very Low	Viable	
	Yaquina			No Data	Low	Very Low	Viable	
	Alsea			No Data	Low	Very Low	Viable	
	Yachats Aggregate			No Data	Low	Very Low	Viable	
	Siuslaw			No Data	Low	Very Low	Viable	
	Lower Umpqua			No Data	Low	Very Low	Viable	
	Middle Umpqua			No Data	Low	Very Low	Viable	
	North Umpqua			Very Low	Low	Very Low	Viable	
	South Umpqua			No Data	Low	Very Low	Viable	
	Tenmile			No Data	Low	Low	Viable	
	Coos			No Data	Low	Very Low	Viable	
	Coquille			No Data	Low	Very Low	Viable	
	Floras			No Data	Low	Very Low	Viable	
	Sixes			No Data	Low	Low	Viable	
Summer Steelhead (ODFW 2014, Page 162)	Siletz	Species of Concern	Sensitive	Very Low	Low	Very Low	Viable	Moderate
	North Umpqua			Very Low	Low	Very Low	Viable	
Coho (Ford 2022, Page 267)	Necanicum	Threatened	Sensitive	No Data	No Data	No Data	No Data	Low to Moderate
	Nehalem			No Data	No Data	No Data	No Data	
	Tillamook			No Data	No Data	No Data	No Data	
	Nestucca			No Data	No Data	No Data	No Data	
	Salmon			No Data	No Data	No Data	No Data	
	Siletz			No Data	No Data	No Data	No Data	
	Yaquina			No Data	No Data	No Data	No Data	
	Alsea			No Data	No Data	No Data	No Data	
	Yachats Aggregate			No Data	No Data	No Data	No Data	
	Siuslaw			No Data	No Data	No Data	No Data	
	Lower Umpqua			No Data	No Data	No Data	No Data	
	Middle Umpqua			No Data	No Data	No Data	No Data	
	North Umpqua			No Data	No Data	No Data	No Data	
	South Umpqua			No Data	No Data	No Data	No Data	
	Tenmile			No Data	No Data	No Data	No Data	

Species (Citation)	MPG or Population	Listing Status		VSP Risk Status				ESU/SMU /DPS Overall Risk
		Federal	State	A/P	Diversity	SS	Overall	
	Coos			No Data	No Data	No Data	No Data	
	Coquille			No Data	No Data	No Data	No Data	
	Floras			No Data	No Data	No Data	No Data	
	Sixes			No Data	No Data	No Data	No Data	

2.7 Section Summary

In summary, fourteen ESU/SMU/DPSs are federally listed as Threatened, one is state-listed as Endangered (Lower Columbia Coho Salmon SMU), eight are state-listed as Sensitive-Critical, and 11 are state-listed as Sensitive (Table 2-7). Five have no federal or state listing status.

ESU/SMU/DPS risk was Moderate or higher for 16 of the 26 ESU/SMU/DPSs examined (Moderate: 11, Moderate to High: 5). Comparatively fewer species (7) were ranked as Moderate or lower ESU/SMU/DPS risk (Moderate to Low: 2; Low: 2; Very Low: 3). All species in the Middle Columbia region, except the Steelhead DPS, lacked sufficient information to be ranked.

Table 2-7. Summary of Federal and State Listing Status and ESU/SMU/DPS Risk Rating.

Region	Species	Federal Listing Status	State Listing Status	ESU/SMU/DPS Risk Rating
Snake River	Fall Chinook	T	T	Low to Moderate
	Spring/Summer Chinook	T	T	Moderate to High
	Steelhead	T	S	Moderate
Middle Columbia	Coho			NA
	Fall Chinook		S	NA
	Spring Chinook		S	NA
	Steelhead	T	SC	Moderate
Lower Columbia	Coho	T	E	Moderate
	Fall Chinook	T	SC	Moderate
	Spring Chinook	T	SC	Moderate
	Chum	T	SC	Moderate
	Winter Steelhead	T	SC	Moderate
	Summer Steelhead	T	S	Moderate
Upper Willamette	Spring Chinook	T	SC	Moderate
	Steelhead	T	S	Moderate to High
Rogue-South Coast	Coho	T	S/SC	Moderate
	Fall Chinook			Low
	Spring Chinook		S	Low
	Winter Steelhead			Very Low
	Summer Steelhead		S	Moderate
Oregon Coast	Coho	T	S	Low to Moderate
	Fall Chinook			Very Low
	Spring Chinook		S	Moderate
	Chum		SC	Moderate to High
	Winter Steelhead			Very Low
	Summer Steelhead		S	Moderate

3 Climate Change Vulnerability

Climate change in Oregon is predicted to have an adverse impact on salmon and steelhead populations. According to a 2023 report lead by the Oregon Climate Change Research Institute (OCCRI 2023), air temperature has increased by approximately 2.2°F every century since 1895 and at the current rate, Oregon is projected to experience annual temperature increase of 5°F by the 2050s and 8.2°F by the 2080s, with the greatest increase during summer. OCCRI also found that precipitation is projected to increase during the winter and decrease during the summer. Additionally, OCCRI indicated that there will be an increase in extreme temperature events and a greater frequency and intensity of droughts. All of these factors (see OCCRI 2023 for full listing and detailed discussion) can have adverse effects on fish populations and require proper consideration to ensure sustainability of populations and species within Oregon.

Climate change vulnerability of ESU/SMU/DPS was identified based on an Exposure and Sensitivity Ranking (vulnerability) and the species' Adaptive Capacity (Crozier et al. 2019). Exposure and Sensitivity Rankings range from Low to High, where the low end of the scale indicates lower exposure and/or sensitivity to a changing climate. Adaptive capacity ranges from Low to High as well, where High adaptive capacity indicates a greater ability to adapt to changing climatic conditions.

The exposure metric is used to describe the magnitude of projected environmental changes that could occur by mid-century. Exposure considers both freshwater and marine stages. In freshwater, stream temperature, summer water deficit, flooding, and hydrologic regime are evaluated (Crozier et al. 2019). In the marine environment, sea level rise, sea surface temperature, ocean acidification exposure, upwelling, and ocean currents are evaluated (Crozier et al. 2019). Scorers independently read the collated data regarding each species within each DPS and assigned each exposure attribute described above as Low, Moderate, High, or Very High (Crozier et al. 2019).

The sensitivity metric is used to describe biological sensitivity to changes in climate by considering different life-stages, biological characteristics and geographic range within each DPS (Crozier et al. 2019). Sensitivity evaluates early life history, juvenile freshwater stage, estuary stage, marine stage, adult freshwater stage, cumulative life-cycle effects, hatchery influence, other non-climate stressors, population viability, and ocean acidification sensitivity (Crozier et al. 2019). Scorers independently read the collated data regarding each species within each DPS and assigned each exposure attribute described above as Low, Moderate, High, or Very High (Crozier et al. 2019).

Adaptive capacity is defined as "the potential for a system to respond to environmental change by genetic adaptation or by a non-genetic phenotypic change that mitigates negative environmental impacts" (Crozier et al. 2019; Working Group II Report 2). Proxies used to measure this capacity included stressors, population status, hatchery influence, and life cycle complexity, and were scored as Low, Moderate, or High (Crozier et al. 2019).

Sufficient data were not available to determine adaptive capacity for all ESU/SMU/DPSs. These species include the Oregon Coast Chum Salmon and steelhead SMUs (winter steelhead and summer steelhead), Rogue-South Coast Chinook Salmon SMUs, and Middle Columbia fall Chinook and Coho Salmon SMUs. Also, Crozier et al. (2019) did not always produce separate rankings for different run types of the same species. Exposure and sensitivity and adaptive capacity rankings are reported down to either the species or run-type within species, if available.

3.1 Snake River Region

Overall, the Snake River Region scored High to Very High in exposure and sensitivity rating and Moderate to High in adaptive capacity (Table 3-1). Exposure scores were driven by Moderate to High freshwater exposure attributes and Very High ocean acidification exposure despite scoring Low to Very Low in marine exposure (Crozier et al. 2019). Life cycle sensitivity scores for this region ranged from Low to High, driven by high sensitivity at adult freshwater, juvenile freshwater, and cumulative life cycle stages though early life history was ranked as Low.

Snake River ESU spring/summer Chinook Salmon have the greatest exposure and sensitivity to climate change and is ranked as Very High (Table 3-1). Both Snake River ESU Fall Chinook Salmon and Snake River DPS steelhead are categorized as having a High exposure and sensitivity ranking. While all runs of Snake River ESU Chinook Salmon in this region have a high adaptive capacity, Snake River DPS steelhead only have a Moderate adaptive capacity.

Crozier et al. (2019) determined that the juvenile freshwater stages and adult stage of the spring/summer Chinook Salmon were vulnerable to stream temperature increases. Crozier et al. (2019) also determined that the adult stages of steelhead were most vulnerable to higher stream temperatures. Freshwater in the Snake River is highly dominated by snow fall and has large implications for both hydrologic regimes and stream temperatures (Crozier et al. 2019). The loss of snowpack in these regions is reflected in the freshwater exposures scores. Additionally compounding these threats are the run timing (spring and summer) and longer migration routes, which increase time of freshwater exposure (Crozier et al. 2019).

Table 3-1. Snake River ESU/DPS vulnerability and adaptive capacity.

Species/Run-Type	Exposure and Sensitivity Ranking	Adaptive Capacity
Spring/Summer Chinook	Very High	High
Fall Chinook	High	High
Steelhead	High	Moderate

Source: Crozier et al. 2019

3.2 Middle Columbia River Region

Climate data sufficient to conduct a climate analysis and provide exposure and sensitivity and adaptive capacity scores only existed for Middle Columbia spring Chinook Salmon ESU and steelhead DPS. Middle Columbia spring Chinook Salmon ESU and steelhead DPS scored High for exposure and sensitivity and Moderate for adaptive capacities (Table 3-2). Exposure scores were driven by High rankings for stream temperature and hydrologic regime. Marine exposure was driven by sea surface temperature and ocean acidification exposure. Life cycle sensitivity was ranked High for Middle Columbia ESU spring Chinook Salmon; however, steelhead ranked Low to Moderate in these categories.

Crozier et al. 2019 cites stream temperatures as being the greatest factor affecting freshwater exposure for both species. Freshwater in the interior Columbia River is highly dominated by snowpack and reduction of snowpack region-wide has large implications for both hydrologic regimes and stream temperatures (Crozier et al. 2019). Crozier et al. (2019) determined that the juvenile freshwater stages and adult stage of the spring Chinook Salmon were vulnerable to stream temperature increases and variation in hydrologic regimes, where adults are particularly affected by seasonal ambient temperature (spring and summer migration timing) and longer migrations. Marine exposure to ocean acidification also greatly affects both species, which has largely occurred because of increased levels of carbon dioxide in the atmosphere (Doney et al. 2009). Climate sensitivity rankings for the Middle Columbia River region are provided in Table 3-2.

Table 3-2. Middle Columbia River ESU/SMU/DPS vulnerability and adaptive capacity rankings.

Species/Run-Type	Exposure and Sensitivity Ranking	Adaptive Capacity
Spring Chinook	High	Moderate
Fall Chinook	No Data	No Data
Steelhead	High	Moderate
Coho	No Data	No Data

Source: Crozier et al. 2019

3.3 Lower Columbia River Region

Overall, Lower Columbia Chinook and Chum Salmon ESU and Steelhead DPS all were categorized with Moderate exposure and sensitivity rankings, while Lower Columbia ESU Coho Salmon have a High ranking. Adaptive capacity is High for both Lower Columbia DPS steelhead and Lower Columbia ESU Chinook Salmon, and Moderate for both Lower Columbia ESU Coho and Chum Salmon. Freshwater exposure was driven by High rankings for stream temperature increases, where ocean acidification exposure was ranked as Very High for both species (Crozier et al. 2019). Life cycle sensitivity was found to be Low to Moderate for all ESUs in this region (Crozier et al. 2019).

Crozier et al. (2019) identified stream temperature change for Coho Salmon and steelhead as the greatest risk to species in this region with stream temperature posing the greatest risk to the Coho Salmon's juvenile freshwater stage (Crozier et al. 2019). Rankings in freshwater exposure are generally lower for the species in this region, likely the result of different climate types. Note that Crozier et al. (2019) did not differentiate between spring-run and fall-run Chinook Salmon and winter and summer steelhead in their analysis. Climate sensitivity rankings for the Lower Columbia River region are provided in Table 3-3.

Table 3-3. Lower Columbia River ESU/DPS vulnerability and adaptive capacity rankings.

Species/Run-Type	Exposure and Sensitivity Ranking	Adaptive Capacity
Steelhead	Moderate	High
Chinook	Moderate	High
Coho	High	Moderate
Chum	Moderate	Moderate

Source: Crozier et al. 2019

3.4 Upper Willamette River Region

Upper Willamette Chinook Salmon ESU and steelhead DPS have exposure and sensitivity rankings of Very High and High, respectively, and both have Moderate adaptive capacities. Exposure scores were driven by Moderate to High freshwater exposure attributes and Very High ocean acidification exposure despite scoring Low to Very Low in marine exposure (Crozier et al. 2019). Life cycle sensitivity scores for this region ranged from Low to High, driven by high sensitivity at adult freshwater, juvenile freshwater, and cumulative life cycle stages though early life history was ranked as Low.

Crozier et al. (2019) identified a vulnerability to stream temperature increase for Upper Willamette Chinook Salmon and steelhead during the adult freshwater stage. Chinook Salmon are particularly vulnerable to temperature changes as adults in freshwater because of the seasonal ambient temperatures (spring and summer migrations) and longer migration pathways (Crozier et al. 2019). Upper Willamette ESU spring Chinook Salmon can face serious exposures to high temperatures in modified river systems, which can result in high pre-spawn mortality (Keefer et al. 2015; Bowerman et al. 2017; Crozier et al. 2019). Climate sensitivity rankings for the Upper Willamette region are provided in Table 3-4.

Table 3-4. Upper Willamette River ESU/DPS vulnerability and adaptive capacity rankings.

Species/Run-Type	Exposure and Sensitivity Ranking	Adaptive Capacity
Chinook	Very High	Moderate
Steelhead	High	Moderate

Source: Crozier et al. 2019

3.5 Rogue-South Coast Region

Within this region, exposure and sensitivity rankings ranged from Low to Moderate to High. SONCC ESU Coho Salmon face the greatest exposure and sensitivity, and Rogue-South Coast SMU winter steelhead have the lowest. Rogue-South Coast SMU winter steelhead and summer steelhead were determined to have moderate adaptive capacities, SONCC ESU Coho Salmon were determined to have low adaptive capacities, and Rogue-South Coast SMU spring Chinook and fall Chinook Salmon lacked sufficient data to assign exposure and sensitivity or adaptive capacity ratings.

These species were not analyzed in Crozier et al. 2019, which is the source material from which other rankings in this section here taken. However, ODFW (2021) provided rankings that are directly comparable for Oregon populations only and these are presented here. Climate and ocean change risk (which this report equates to exposure and sensitivity ranking) is Low to moderate for all populations and species, with the exception of one SONCC ESU Coho Salmon population (M. Rogue/Applegate) (ODFW 2021). The ODFW Rogue-South Coast Multi-Species Conservation and Management Plan does not identify specific life-history segments that face the greatest exposure and sensitivity. However, ODFW states both freshwater and ocean conditions are likely to affect species within the ESU in varying degrees (ODFW 2021). Climate sensitivity rankings for the Rogue-South Coast region are provided in Table 3-5.

Table 3-5. Rogue-South Coast ESU/SMU/DPS vulnerability and adaptive capacity rankings.

Species/Run-Type	Exposure and Sensitivity Ranking	Adaptive Capacity
Coho	High	Low
Spring Chinook	No Data	No Data
Fall Chinook	No Data	No Data
Winter Steelhead	Low	Moderate
Summer Steelhead	Moderate	Moderate

Notes: Includes SONCC Chinook and/or Coho Salmon
Source: ODFW 2021

3.6 Oregon Coast Region

Oregon Coast ESU/ SMU steelhead have high exposure and sensitivity and moderate adaptive capacity rankings (Wade et al. 2013). Freshwater exposure for these species was dominated by increasing stream temperature, which received a High ranking. Oregon Coast SMU steelhead were also found to have increased exposure to changes in hydrologic regimes (i.e., flow).

Crozier et al. determined a climate ranking for Oregon Coast ESU Coho Salmon but not Oregon Coast ESU Chinook Salmon (2019). However, based on findings from Crozier et al. 2019, it is expected that Oregon Coast SMU spring Chinook Salmon and Oregon Coast ESU Coho Salmon will both experience high exposure to increased stream temperatures. Conversely, Oregon Coast fall Chinook Salmon will likely have limited exposure to elevated stream temperature during their juvenile freshwater phase. Further, the findings of Crozier et al. (2019) suggest that more southern coastal populations will face greater challenges in freshwater (High rankings in both increased stream temperature and flooding) and in the marine environment (High to Very High rankings for sea level rise, upwelling, sea surface temperature, and ocean acidification). Wade et al. 2013 present findings that Oregon Coast SMU steelhead face increased exposure to higher stream temperatures and more extreme changes in hydrologic regimes, although locality within the Oregon Coast region may vary slightly. Chum Salmon exposure and sensitivity and adaptive capacity were not determined for the Oregon Coast. Climate sensitivity rankings for the Oregon Coast region are provided in Table 3-6.

Table 3-6. Oregon Coast vulnerability and adaptive capacity rankings.

Species/Run-Type	Exposure and Sensitivity Ranking	Adaptive Capacity
Coho	High	Moderate
Chinook	High[1]	Moderate[1]
Steelhead	High	No Data
Chum	No Data	No Data

Note:

1. A comprehensive review of climate effects for Chinook Salmon does not exist. Given that Coho Salmon were evaluated in this area and that Chinook Salmon are predominately fall-run, Coho Salmon parameters were used for Chinook Salmon in this case.

Source: Crozier et al. 2019 for Coho and Chinook, steelhead was taken from Wade et al. 2013.

3.7 Section Summary

Of the 17 ESU/SMU/DPSs that could be assigned an exposure and sensitivity ranking, 12 had an exposure and sensitivity ranking of High or Very High. There was only one case (Rogue-South Coast SMU winter steelhead) of an exposure and sensitivity ranking being designated as Low. This indicates that the majority of ESU/SMU/DPSs are at substantial risk due to climate change. Adaptive capacity for all ESUs is above Moderate, except for SONCC ESU Coho Salmon, which have been designated as having a Low capacity to adapt to climate change. This indicates that SONCC ESU Coho Salmon likely face a greater risk to climate change than other species due to their low adaptive capacity. Sufficient data were not available to determine the exposure and sensitivity and/or adaptive capacity for all ESU/SMU/DPSs. These species include Oregon Coast Chum Salmon and steelhead SMUs (winter steelhead and summer steelhead), Rogue-South Coast SMU spring and fall Chinook Salmon, and Middle Columbia Coho and fall Chinook Salmon SMUs. Overall, despite being at substantial risk due to climate change, most ESU/SMU/DPSs combinations have moderate or greater capacity to adapt to changes, thereby partially mitigating climate change risk.

Climate exposure and sensitivity likely has the greatest uncertainty around predicted effects on fish populations. Climate change is predicted to affect the region with increased air temperatures and more extreme weather events (OCCRI 2023). Climate-related local extinctions have happened or are currently occurring worldwide, and a recent study found that 74% of the freshwater species surveyed had experienced local extinctions due to range shifts (Wiens 2016). While Pacific salmon can have high adaptive capacity to climate change, amplification of existing stressors may inhibit adaptive capacity, further increasing the need for future hatchery support.

4 Hatchery Programs

It is the policy of the state of Oregon that wildlife (including fish) must be managed to prevent serious depletion of any indigenous species and to provide the optimum recreational and aesthetic benefits for present and future generations of the citizens of this state (ORS 496.012). Hatchery programs are a management tool that can be used to meet both conservation and recreational needs. In Oregon, hatchery programs are designated as either harvest or conservation programs. Within the harvest hatchery programs, there are two different program types: mitigation and harvest augmentation. Mitigation program types are “used pursuant to an agreement to provide fishing and harvest opportunities lost as a result of habitat deterioration, destruction, or migration blockage” (ODFW 2013). Harvest augmentation program types are “used to increase fishing and harvest opportunities where there is no mitigation program in place” (ODFW 2013). The primary purpose of both these program types is to provide fishery and harvest opportunities regardless of the reason why such harvest opportunity enhancement may be necessary.

Within conservation hatchery programs, there are seven program types: supplementation, recovery/restoration, captive brood, captive rearing, egg banking, cryopreservation, and experimental. Of these seven program types, only supplementation and recovery/restoration are discussed in this report. Supplementation program types are designed to route “a portion of an imperiled wild population through a hatchery for part of its life cycle to gain a temporary survival boost or brings in suitable hatchery produced fish or naturally produced native fish from outside the target river region to supplement the imperiled local population” (ODFW 2013). Recovery program types (also listed as “restoration” in other documents) outplant “suitable non-local hatchery produced or naturally produced native fish to establish a population in habitat currently vacant for that native species using the best available broodstock” (ODFW 2013). All hatchery programs and program types considered within this report produce Pacific salmon and steelhead for various purposes and uses that coincide with predetermined goals and desired outcomes while aligning with the agency’s mission.

This report categorized each hatchery program into one of the four program types discussed above (harvest augmentation, mitigation, supplementation, and recovery/restoration). In some cases, a hatchery may serve two or more program types and some hatchery programs will have harvest and conservation functions. It was not possible to apportion production from a given hatchery into the different hatchery program types when operating within the same hatchery. ODFW hatchery programs were grouped and reported below by ESU/SMU. Species, program name, hatchery stock, hatchery name, program type, and smolt release target are listed for each ESU/SMU. Some hatcheries produce smolts for more than one species. Hatcheries that are not managed by ODFW were excluded from this evaluation, including those operated by a federal agency, tribe, or private entity.

4.1 Snake River Region

There are three hatcheries in the Snake River region that produce five different stocks of spring/summer Chinook Salmon and two different summer steelhead stocks (Table 4-1). Mitigation hatchery programs for fall Chinook Salmon do exist but are not administered by the State of Oregon. There are 1,390,000 spring Chinook Salmon smolts and 1,015,000 summer steelhead smolts released from these hatcheries annually. Program specific smolt and pre-smolt annual release targets range from 150,000 to 800,000 individuals within this region. All spring/summer Chinook Salmon program types within this region are a combination of mitigation and supplementation. Summer steelhead program types, likewise, are either mitigation or a combination of mitigation and supplementation. The hatchery production in this region is dominated by mitigation programs, with all seven hatchery programs mitigation based.

While not part of the ODFW hatchery system, there are fall Chinook Salmon mitigation hatcheries in two neighboring states: one in Washington, and two in Idaho. Additionally, there is the “Acclimation Ponds Program,” which contains three separate ponds that occur in both Washington, Idaho, and Oregon (two located on the Snake River, and one located on the Clearwater River), where all fish are sourced from Lyons Ferry Hatchery (Washington). These hatcheries and acclimation sites receive resources from Idaho Power, U.S. Fish and Wildlife Service, Nez Perce Tribe, and Bonneville Power. These mitigation hatcheries not owned or operated by Oregon, are discussed here but are not included in Table 4-1.

Table 4-1. Summary of Snake River region hatchery programs.

Species/Run	Program Name	Hatcheries	Program Type	Release Target
Spring Chinook	Lower Snake River Compensation Plan (LSRCP) Imnaha Spring/Summer Chinook	Lookingglass	Mitigation/ Supplementation	490,000
	Lookingglass Hatchery Catherine Creek Spring/Summer Chinook	Lookingglass	Mitigation/ Supplementation	150,000
	Grande Ronde Endemic Spring Chinook Salmon Supplementation Program (GRESCSP)	Lookingglass, Wallowa	Mitigation/ Supplementation	250,000
	Lookingglass Creek Spring/Summer Chinook	Lookingglass, Irrigon	Mitigation/ Supplementation	250,000
	GRESCSP; Lostine River stock	Lookingglass	Mitigation/ Supplementation	250,000
Summer Steelhead	LSRCP Grande Ronde Region Summer Steelhead	Wallowa, Irrigon	Mitigation	800,000
	LSRCP Little Sheep Creek Summer Steelhead	Wallowa, Irrigon	Mitigation/ Supplementation	215,000

Note: Data sourced from Hatchery Program Management Plans and Hatchery Genetic Management Plans for the respective Hatcheries. (https://www.dfw.state.or.us/fish/hatchery/)

4.2 Middle Columbia Region

There are four hatcheries in the Middle Columbia region that produce one stock of Coho Salmon, one stock of fall Chinook Salmon, two spring Chinook Salmon stocks, and two summer steelhead stocks (Table 4-2). Annual release targets include 1,500,000 fall Chinook Salmon smolts, 1,120,000 spring Chinook Salmon smolts, 312,000 summer steelhead smolts, and 1,000,000 Coho Salmon smolts. Program-specific smolt and pre-smolt release targets range from 150,000 to 1,500,000 individuals within this region. The Coho and fall Chinook Salmon program types are both mitigation. Spring Chinook Salmon program types are supplementation or a combination of mitigation and recovery. Summer steelhead program types are, likewise, supplementation or a combination of mitigation and recovery. The hatchery production in this region is dominated by mitigation programs, with four of the six hatchery programs mitigation based.

Table 4-2. Summary of Middle Columbia River region hatchery programs.

Species/Run	Program Name	Hatcheries	Program Purpose	Smolt/Pre-Smolt Release Target
Coho Salmon	Umatilla River Coho	Bonneville, Irrigon, Cascade	Mitigation	1,000,000
Fall Chinook	Umatilla River Fall Chinook	Umatilla, Bonneville	Mitigation	1,500,000
Spring Chinook	Round Butte Hatchery Deschutes River Spring Chinook	Round Butte	Mitigation/ Recovery	310,000
	Umatilla Spring Chinook	Umatilla	Supplementation	810,000
Summer Steelhead	Round Butte Hatchery Summer Steelhead	Round Butte	Mitigation/ Recovery	162,000
	Umatilla River Summer Steelhead	Umatilla	Supplementation	150,000

Note: Data sourced from Hatchery Program Management Plans and Hatchery Genetic Management Plans for the respective Hatcheries. (https://www.dfw.state.or.us/fish/hatchery/)

4.3 Lower Columbia River Region

There are 17 hatcheries that produce fish released in the Lower Columbia region including three stocks of Coho Salmon, three stocks of fall Chinook Salmon, four spring Chinook Salmon stocks, and one Chum Salmon stock (Table 4-3). Annual release targets include 9,050,000 fall Chinook Salmon smolts, 4,780,000 spring Chinook Salmon smolts, 3,635,000 Coho Salmon smolts, 300,000 Chum Salmon smolts, 565,000 winter steelhead, and 250,000 summer steelhead. Program-specific smolt and pre-smolt release targets range from 200,000 to 5,200,000 individuals within this region. Coho Salmon program types are either mitigation or a combination of mitigation and harvest augmentation. Fall Chinook Salmon program types are either harvest augmentation or mitigation. Spring Chinook Salmon program types are either mitigation, a combination of mitigation and harvest augmentation, or harvest augmentation and recovery/restoration. Chum Salmon program types are entirely recovery oriented. The hatchery production in this region is dominated by mitigation programs, with eight of the twelve hatchery programs mitigation based.

Table 4-3. Summary of Lower Columbia River region hatchery programs.

Species/Run	Program	Hatcheries	Program Purpose	Smolt/Pre-Smolt Release Target
Coho Salmon	Sandy River Coho Salmon	Sandy	Mitigation/ Harvest Augmentation	300,000
	Big Creek Coho Salmon	Big Creek	Mitigation/ Harvest Augmentation	535,000
	Bonneville Hatchery Coho Salmon	Bonneville, Cascade	Mitigation	300,000-1,000,000
	SAFE Coho Salmon	Bonneville, Sandy, Cascade, Clackamas	Mitigation	1,800,000
Fall Chinook	Big Creek Hatchery Tule Fall Chinook Salmon	Big Creek, Klaskanine	Harvest Augmentation	5,200,000

Species/Run	Program	Hatcheries	Program Purpose	Smolt/Pre-Smolt Release Target
	Bonneville Hatchery Tule Fall Chinook Salmon	Bonneville, Washougal (WA)	Mitigation	1,600,000
	Select Area Bright (SAB) Fall Chinook Salmon	Klaskanine, SF Klaskanine, Big Creek	Harvest Augmentation	2,250,000
Spring Chinook	Sandy Hatchery Spring Chinook	Sandy, Clackamas, Oxbow, Cascade	Mitigation/ Harvest Augmentation	200,000
	Clackamas Hatchery Spring Chinook	Clackamas, Bonneville	Mitigation/ Harvest Augmentation	880,000
	Hood River Production	Moving Falls Fish Facility, Parkdale Fish Hatchery, Round Butte	Recovery/ Harvest Augmentation	250,000
	SAFE Spring Chinook Salmon	Clackamas, Minto, Marion Forks, South Santiam, Gnat Creek, Big Creek	Mitigation	3,450,000
Chum Salmon	Big Creek Hatchery Chum Salmon Recovery Program	Big Creek	Recovery	300,000
Winter Steelhead	Big Creek Hatchery Winter Steelhead	Big Creek, Klaskanine, Gnat Creek	Harvest Augmentation	140,000
	Clackamas River Winter Steelhead	Clackamas, Oak Springs, Bonneville	Harvest Augmentation	265,000
	Sandy River Winter Steelhead	Sandy, Oak Springs, Bonneville	Mitigation /Harvest Augmentation	160,000
Summer Steelhead	Clackamas River Summer Steelhead	Clackamas South Santiam, Bonneville	Harvest Augmentation	175,000
	Sandy River Summer Steelhead	Sandy, South Santiam, Bonneville, Oak Springs	Harvest Augmentation	75,000

Note: Data sourced from Hatchery Program Management Plans and Hatchery Genetic Management Plans for the respective Hatcheries. (https://www.dfw.state.or.us/fish/hatchery/)

4.4 Upper Willamette River Region

There are eight hatcheries in the Upper Willamette region that produce four stocks of spring Chinook Salmon and one stock of out-of-basin summer steelhead for the Upper Willamette River Region (Table 4-4). There are no native summer steelhead populations in the Upper Willamette DPS. Annual release targets include 4,229,750 spring Chinook Salmon smolts and 547,500 summer steelhead smolts. Program-specific smolt and pre-smolt release targets range from 547,500 to 1,900,000 individuals within this region. The Upper Willamette River region spring Chinook Salmon and summer steelhead hatchery programs are entirely for mitigation.

Table 4-4. Summary of Upper Willamette River region hatchery programs.

Species/Run	Program	Hatcheries	Program Purpose	Smolt/Pre-Smolt Release Target
Spring Chinook	McKenzie River Spring Chinook Salmon	McKenzie	Mitigation	604,750
	Middle Fork Willamette Spring Chinook Salmon	Willamette	Mitigation	1,900,000
	North Santiam River Spring Chinook Salmon	Marion Forks, Minto	Mitigation	704,000
	South Santiam River Spring Chinook Salmon	South Santiam, Willamette	Mitigation	1,021,000

Species/Run	Program	Hatcheries	Program Purpose	Smolt/Pre-Smolt Release Target
Summer Steelhead	Upper Willamette Summer Steelhead	Leaburg, Minto, Roaring River, South Santiam, Willamette	Mitigation	547,500

Note: Data sourced from Hatchery Program Management Plans and Hatchery Genetic Management Plans for the respective Hatcheries. (https://www.dfw.state.or.us/fish/hatchery/)

4.5 Rogue-South Coast Region

There are three hatcheries in the Rogue-South Coast region that produce one Coho Salmon stock, two stocks of fall Chinook Salmon, one spring Chinook Salmon stock, three winter steelhead stocks, and one summer steelhead stock (Table 4-5). Annual release targets include 290,000 fall Chinook Salmon smolts, 1,700,000 spring Chinook Salmon smolts, 100,000 Coho Salmon smolts, 313,000 winter steelhead smolts, and 220,000 summer steelhead smolts. Program-specific smolt and pre-smolt release targets range from 50,000 to 1,700,000 individuals within this region. Coho Salmon, spring Chinook Salmon, and summer steelhead programs within this region are entirely for mitigation. Fall Chinook Salmon hatchery programs are all harvest augmentation, and winter steelhead programs are all mitigation or harvest augmentation. The hatchery production in this region is dominated by mitigation programs, with five of the eight hatchery programs that are mitigation-based.

Table 4-5. Summary of Rogue-South Coast region hatchery programs.

Species/Run	Program	Hatcheries	Program Purpose	Smolt/Pre-Smolt Release Target
Coho Salmon	Cole Rivers Hatchery Coho Salmon	Cole Rivers	Mitigation	100,000
Fall Chinook	Indian Creek STEP Hatchery (Fall Chinook Salmon)	Indian Creek (STEP)	Harvest Augmentation	90,000
	Chetco River Fall Chinook Salmon	Elk River	Harvest Augmentation	200,000
Spring Chinook	Rogue River Spring Chinook Salmon	Cole Rivers	Mitigation	1,700,000
Winter Steelhead	Rogue River Winter Steelhead	Cole Rivers	Mitigation	132,000
	Cole Rivers Hatchery Winter Steelhead (Applegate River)	Cole Rivers	Mitigation	131,000
	Chetco Winter Steelhead	Elk River	Harvest Augmentation	50,000
Summer Steelhead	Cole Rivers Hatchery Summer Steelhead	Cole Rivers	Mitigation	220,000

Note: Data sourced from Hatchery Program Management Plans and Hatchery Genetic Management Plans for the respective Hatcheries. (https://www.dfw.state.or.us/fish/hatchery/)

4.6 Oregon Coast Region

There are 19 hatcheries that produce fish stocked into the Oregon Coast region including three stocks of Coho Salmon, eight fall Chinook Salmon stocks, three spring Chinook Salmon stocks, 10 winter steelhead stocks, and three summer steelhead stocks (Table 4-6). Annual release targets include 3,263,000 fall Chinook smolts, 972,000 spring Chinook Salmon smolts, 1,125,000 winter steelhead smolts, 150,000 summer steelhead smolts, and 260,000 Coho Salmon smolts. Program-specific smolt and pre-smolt release targets range from 60,000 to 2,093,000 individuals within this region. Summer steelhead, winter steelhead, and spring Chinook Salmon hatchery programs within this region are all harvest augmentation program types. Coho Salmon hatchery programs are either mitigation or harvest augmentation. Fall Chinook Salmon hatchery programs are predominantly harvest augmentation with a single recovery program for the Coquille River. This is the only region where hatchery production is not dominated by mitigation with only one of 27 programs mitigation based.

Table 4-6. Summary of Oregon Coast region hatchery programs.

Species/Run	Program	Hatcheries	Program Purpose	Smolt/Pre-Smolt Release Target
Coho Salmon	Nehalem Hatchery Coho Salmon	Nehalem	Harvest Augmentation	100,000
	Trask Hatchery Coho Salmon	Trask	Harvest Augmentation	100,000
	Umpqua River Region Coho Salmon	Rock Creek (Cole Rivers)	Mitigation	60,000
Fall Chinook	Trask Hatchery Fall Chinook Salmon	Trask	Harvest Augmentation	150,000
	Cedar Creek Hatchery/Rhoades Pond Fall Chinook Salmon (Nestucca)	Cedar Creek, Rhoades Pond (STEP)	Harvest Augmentation	100,000
	Salmon River Fall Chinook Salmon	Salmon River	Harvest Augmentation	200,000
	Lower Umpqua River Region Fall Chinook Salmon	Rock Creek (Elk River), GRWB Facility (STEP)	Harvest Augmentation	170,000
	Coos River Fall Chinook Salmon	Bandon, Cole Rivers, Morgan Creek (STEP), Noble Creek (STEP), Millicoma Interpretive Center (STEP)	Harvest Augmentation	2,093,000
	Coquille River Fall Chinook Salmon	Bandon, Cole Rivers	Harvest Augmentation	175,000
	Coquille Fall Chinook Conservation Hatchery Program	Bandon, Elk River	Recovery	100,000
	Elk River Fall Chinook Salmon	Elk River	Harvest Augmentation	275,000
Spring Chinook	Trask River Hatchery Spring Chinook Salmon/Whiskey Creek Hatchery Spring Chinook Salmon	Trask, Whiskey Creek (STEP)	Harvest Augmentation	400,000
	Cedar Creek Hatchery Spring Chinook Salmon (Nestucca)	Cedar Cr	Harvest Augmentation	230,000
	Umpqua River Spring Chinook Salmon	Rock Cr (Cole Rivers)	Harvest Augmentation	342,000

Species/Run	Program	Hatcheries	Program Purpose	Smolt/Pre-Smolt Release Target
Winter Steelhead	Nehalem Hatchery Winter Steelhead	Nehalem	Harvest Augmentation	130,000
	Trask Hatchery Winter Steelhead	Trask	Harvest Augmentation	150,000
	Cedar Creek Hatchery Winter Steelhead Program (Nestucca)	Cedar Creek	Harvest Augmentation	140,000
	Siletz River Winter Steelhead	Alsea	Harvest Augmentation	50,000
	Alsea Hatchery Winter Steelhead	Alsea	Harvest Augmentation	140,000
	Siuslaw River Winter Steelhead	Alsea, Roaring River, Letz Creek (STEP)	Harvest Augmentation	100,000
	Umpqua River Winter Steelhead	Rock Creek (Cole Rivers)	Harvest Augmentation	150,000
	Tenmile Region Steelhead	Bandon, Cole Rivers	Harvest Augmentation	25,000
	Coos River Winter Steelhead	Bandon, Cole Rivers	Harvest Augmentation	125,000
	Coquille River Winter Steelhead	Bandon	Harvest Augmentation	115,000
Summer Steelhead	Cedar Creek Hatchery Summer Steelhead	Cedar Creek	Harvest Augmentation	100,000
	Siletz River Summer Steelhead	Cedar Creek, Roaring River	Harvest Augmentation	50,000
	Umpqua River Region Summer Steelhead	Rock Creek	Program terminated by Oregon Fish and Wildlife Commission in 2022	

Note: Data sourced from Hatchery Program Management Plans and Hatchery Genetic Management Plans for the respective Hatcheries. (https://www.dfw.state.or.us/fish/hatchery/)

4.7 Section Summary

The overwhelming majority of hatchery programs examined here (68) were harvest programs (i.e., mitigation, harvest augmentation, a combination of both or mitigation combined with a conservation component) (Table 4-7). Mitigation programs or combinations involving mitigation account for thirty-four programs. However, eight of these are combinations that include a conservation (I.e., recovery or supplementation) component. Mitigation programs make up nearly two-thirds or more of hatchery programs in four of six regions. The only exception is the Oregon Coast, where 24 of 26 active hatchery programs are harvest augmentation. Of the remaining two, one is mitigation (i.e., harvest) and the single conservation program is a recovery program for Coquille fall Chinook Salmon. Of all the hatchery programs examined, only four programs were solely conservation programs with two supplementation programs and two recovery/restoration programs. As noted above, other programs have a conservation component, but they were also combined with a harvest component. This clearly shows the predominance of harvest programs, specifically mitigation programs.

Table 4-7. Hatchery Programs by Program Type summarized across region.

Region	Number of Programs (#)	Mitigation Programs (#)	Harvest Augmentation Programs (#)	Conservation Programs (#)
Snake River	10	10	--	--
Middle Columbia	6	4	--	2
Lower Columbia	17	9	6	2
Upper Willamette	5	5	--	--
Rogue-South Coast	8	5	3	--
Oregon Coast	26	1	24	1

Considered by species and run-type, spring Chinook Salmon have the most programs at 19 with 11 classified as harvest, 1 conservation and 7 a combination. Fall Chinook Salmon rank next, with 17 programs split between 16 harvest and 1 conservation. All 16 winter steelhead programs are harvest (2 mitigation, 13 harvest augmentation, and 1 a combination of both). Summer steelhead's 10 programs are harvest (7), a combination (2), and conservation (1). There are 9 Coho Salmon programs, which are all harvest. Finally, Chum Salmon has a single conservation-oriented recovery program in the Lower Columbia ESU.

Figure 4-1 displays the number of hatchery programs by species and run type for the six regions considered in this report. The Oregon Coast region has the most hatchery programs followed by the lower Columbia and Snake River regions. Figure 4-2 displays the total number of salmon or steelhead released by program type for the same six regions. The Lower Columbia region releases by far the largest number of fish despite having far fewer programs than the Oregon Coast region. As noted above, in all regions except the Oregon Coast, production for mitigation programs is a far greater proportion than any other program type. In the Oregon Coast region, production is dominated by harvest augmentation.

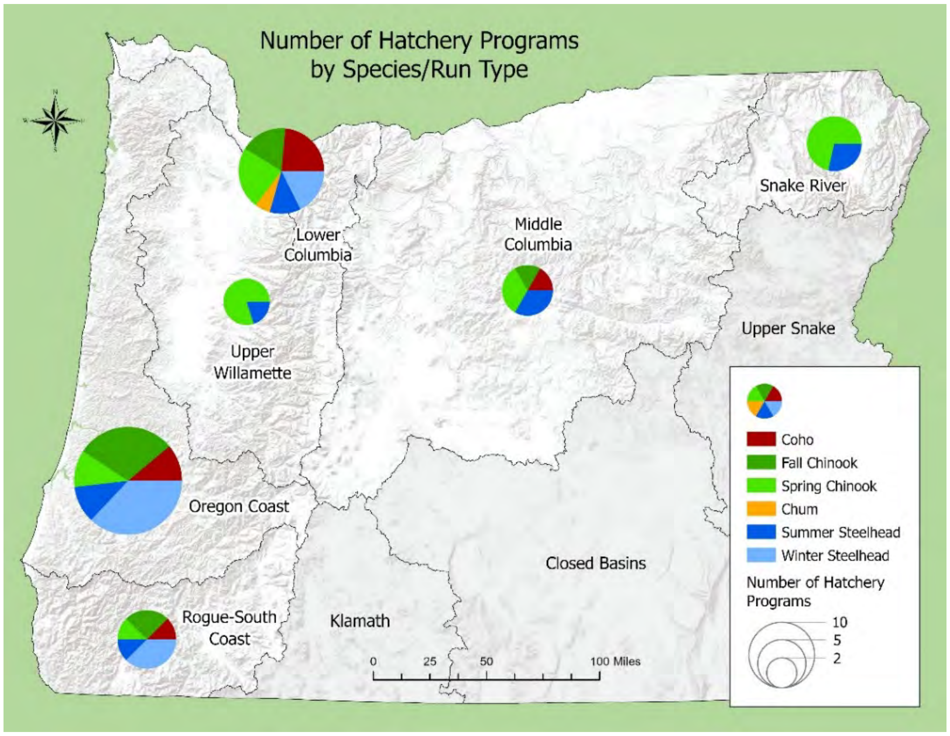


Figure 4-1. Number of hatchery programs by species and run-type.

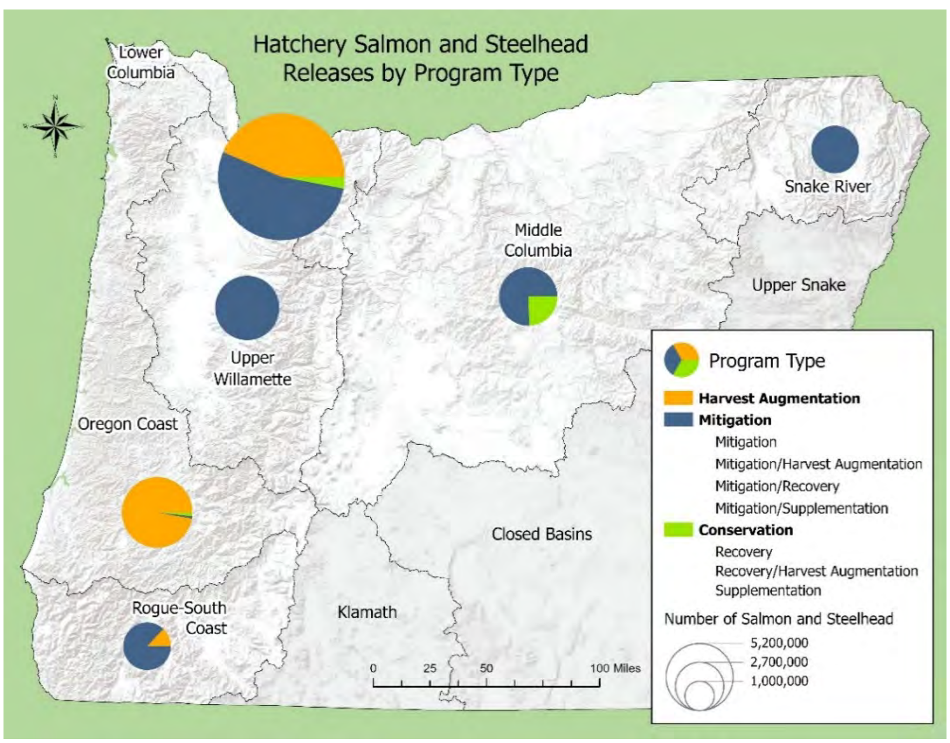


Figure 4-2. Hatchery salmon and steelhead releases (number of fish) by program type.

5 Angler Licenses, Tags, Endorsement Sales, and Harvest

5.1 Angler Licenses

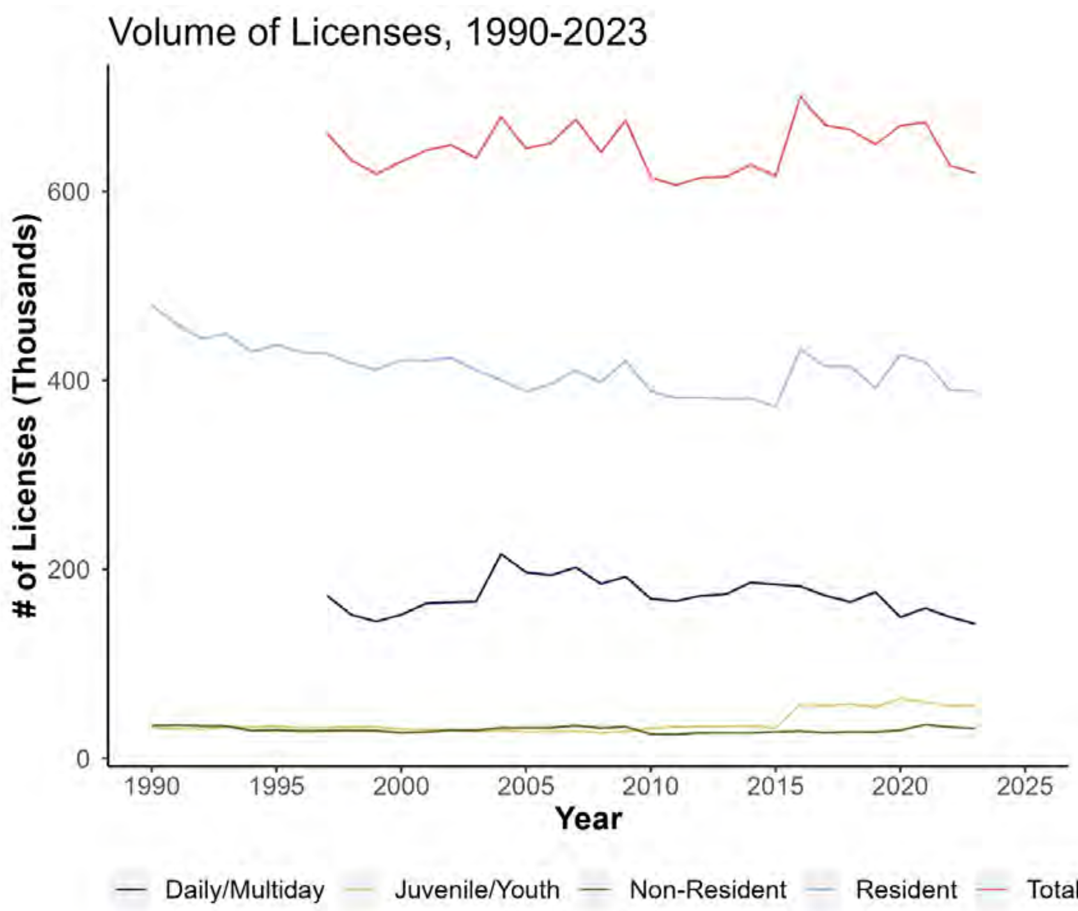
Angler engagement and interest is an important component of fisheries management and should inform decisions on future hatchery need and production. The volume of angler licenses and tags sold can be used as a proxy to 1) gauge the popularity of Oregon fisheries in general, 2) to determine the approximate number of recreational fishery resource users, and 3) to examine trends in fisheries use over time. Using the annual number of licenses sold, we assessed the general trends in angler use (Figure 5-1). License sales provided a longer and more consistent time-series than other fishing-related products sold by the state, such as endorsements and tags, and provided a better overall view of general angler trends.

Resident angling licenses have experienced a statistically significant decrease ($p << 0.001$; $R^2 = 0.42$) since 1990. However, this decrease primarily occurred in the 1990s and license sales have experience interannual variation, but have been relatively stable since about 1997. Non-resident license sales have stayed relatively consistent since 1997 ($p = 0.14$) though there has been a slight increase in the last 2 to 3 years which, if continued, could become a significant trend in the future.

Juvenile/youth license sales have experienced a statistically significant increase ($p << 0.001$; $R^2 = 0.50$)) driven primarily by a sharp increase in 2016, which has since visually appeared to level out. This was due to the elimination of the Juvenile Resident and Juvenile Non-Resident Angling License and the implementation of a single Youth License, which covers both hunting and fishing. It is unknown how many youth may be purchasing the license for fishing only, hunting only, or both.

Sales of daily/multiday licenses fluctuated year-to-year but displayed no upward or downward trend ($p = 0.45$) across the entire time-series. Daily/multiday sales were enumerated using a different method prior to 1997 that, when combined with current methods, artificially inflated the estimate of the total number of licenses sold prior to 1997 and, thus, were not included in the analysis. Total license sales were therefore not calculated or shown prior to 1997 to ensure that total number were based on the same set of licenses. If Daily/Multiday license sales were included prior to 1996, it produced the erroneous appearance of a large increase in license sales from 1996 to 1997. Therefore, the total number of licenses (annual and daily/multiday) in Figure 5-1 prior to 1996 is conservative because of exclusion of the Daily/Multiday license during the 1990 to 1996 period.

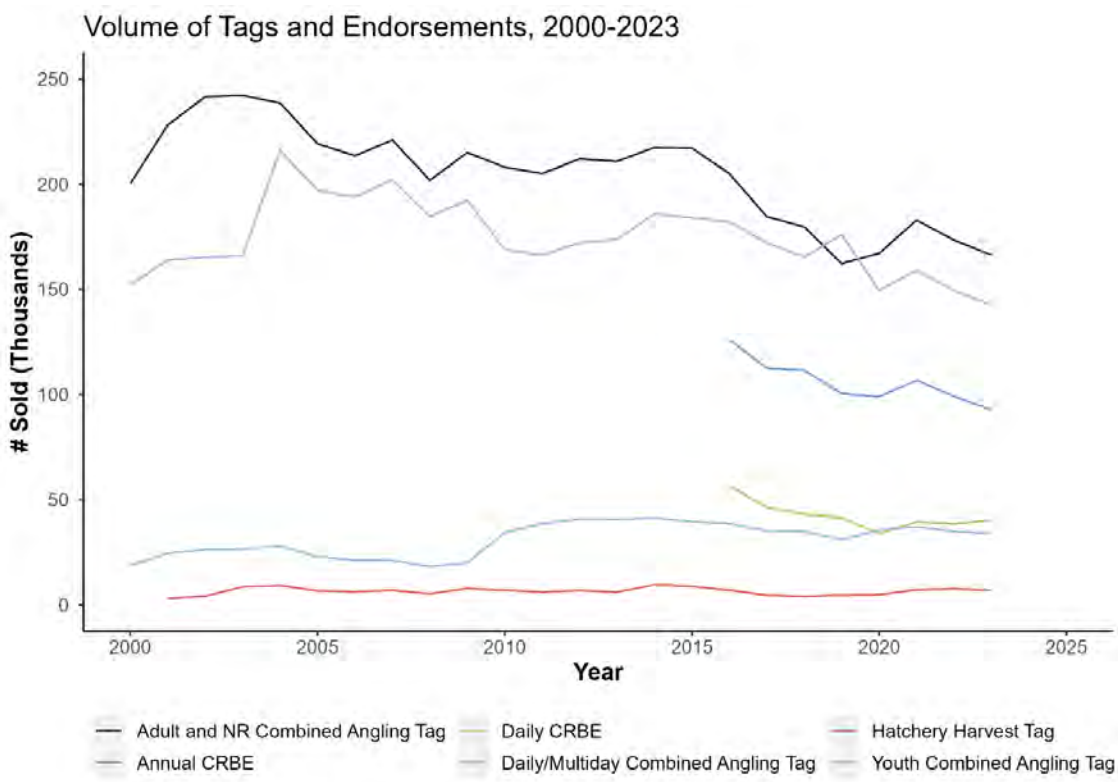
Total licenses from 1997 to present show no significant trend upward or downward ($p = 0.72$). However, this could be an artifact of the inability to include pre-1997 data in the total. Given that resident licenses make up the largest portion of total license sales, it is likely that downward trends in resident licenses would manifest in total license sales if the entire period of record since 1990 could be analyzed. The significant but numerically much smaller increase in Youth licenses seems unlikely to counteract the downward trend in resident licenses. This suggests that overall angler interest and engagement, analyzed using angling license sales as a proxy, experienced a downward shift through the late 1990s and stabilized after. This may represent a stable but lower level of demand for general angling opportunity that seems likely to continue into the future.



Note: Daily/Multiday licenses prior to 1996 are not included.

Figure 5-1. Volume of licenses sold from 1990 to 2023.

The volume of tags and endorsements from 2000 to present were assessed to evaluate trends in Columbia River Region fishing (Columbia Region River Endorsement; CRBE), fishing for steelhead or salmon generally for residents and non-residents (Combined Angling Tag), and hatchery harvest (Hatchery Harvest Tag) (Figure 5-2). Although a combined angling tag is included with SportsPac, daily and multi-day angling licenses, there is no way to know how many of these anglers are targeting salmon and steelhead. The CRBE endorsement and non-resident Combined Angling Tag were implemented in 2016 and are therefore only presented from 2016 to present. Rogue-South Coast Steelhead Validation and Rogue-South Coast Wild Steelhead Harvest Tag are not included; 2023 was the first year that they were required for angling for steelhead in that area and no meaningful analysis would be possible on a single year of data. However, they represent an interesting future data source as they will be the only tag/endorsement that indicates at least the intent (i.e., angler interest) to fish a specific ESU/SMU/DPS. The CRBE can likewise be seen as indicating at least intent to fish the Lower Columbia, Upper Willamette, Mid-Columbia, or Snake River ESU/SMU/DPSs. However, it is not species-specific nor restricted to a single ESU/SMU/DPS so is more likely a general proxy for interest in salmon and steelhead fishing.



Notes: Tags included are hatchery harvest tag and the combined angling tag for residents, non-residents, and youth. Only Columbia River Region endorsements (CRBE) were considered at the time of this report. Combined angling tags for Adults and Youth offered through the SportsPac license are included in totals.

Figure 5-2. Volume of tags and endorsements sold from 2000 to 2023.

In general, there is a noticeable decreasing trend in anglers purchasing tags and endorsements. Initially, there were increases on an annual basis from 2000 to 2003. However, this trend reversed starting in 2004 and has steadily declined since. The Adult Combined Angling Tag showed the most significant decrease in overall sales ($p << 0.001$; $R^2 = 0.66$) and the Daily/Multi-day Combined Angling Tags also showed a marginally significant decrease in sales ($p = 0.05$; $R^2 = 0.12$), though this trend would likely be more highly significant if not for relatively low sales in the early 2000s. Prior to 2016, the Combined Angling Tag was not split based on residency. In order to keep comparisons and trends consistent across the time-series, resident and non-resident Adult Combined Angling Tags are presented as a single line in the figure. The Youth Combined Angling Tag shows an increase in sales ($p <<0.001$; $R^2 = 0.43$), though this is primarily driven by the creation of the Youth SportsPac in 2010. Both daily ($p < 0.05$; $R^2 = 0.48$) and annual ($p < 0.01$; R2 = 0.73) CRBE sales have also declined significantly since their implementation in 2016. Hatchery Harvest tag sales are the only tag or endorsement that has stayed relatively stable since 2000 ($p = 0.93$). The similar observed trends across tags/endorsements are not unexpected since combinations of multiple tags are often required to fish a given location and species combination (e.g., Combined Angling Tag and CRBE).

Hatchery Harvest Tags have the lowest sales relative to the other tags and endorsements. This is likely because a Hatchery Harvest Tag is not required, and hatchery harvest information may be placed onto the Combined Angling Tag. Hatchery Harvest Tags can be used to record harvest of hatchery-origin fish only in lieu of placing them on a Combined Angling Tag. If a Hatchery Harvest Tag is purchased, or not, a Combined Angling Tag is still required when fishing for steelhead or salmon, which likely is a stronger proxy for angler engagement in salmon and steelhead fishing.

Most angling licenses have shown a stable trend recently despite decreases in the 1990s. However, most tags and endorsements have steadily declined across the last 10 to 25 years depending on when they were implemented. This decline is most pronounced for adult tag sales and there appears to be a gap opening between angling license sales, salmon and steelhead tags, and endorsements. This suggests that anglers may be shifting from salmon and steelhead to other types of fisheries. Which fisheries these anglers are shifting to and what their motivations are is an interesting set of questions beyond the scope of the current study.

While license sales have been relatively stable since a decline through the 1990s, tag and endorsement sales have declined over the same period. This seems to indicate slightly declining or stable but variable demand for general angling opportunity and a reduced demand for salmon and steelhead angling opportunity that seems likely to continue into the future.

5.2 Harvest

Harvest can be used as a measure of the importance of hatchery-origin fish to the maintenance of fisheries for specific species within ESUs. The larger a proportion of the harvest that is made up of hatchery fish, the more important hatchery production may be to that fishery. Therefore, fisheries with high proportions of hatchery origin fish may need continuing, and perhaps increased, hatchery production, while fisheries with low proportions are generally less dependent on hatchery production to support angler demand.

Mark-selective fisheries impact the proportion of hatchery fish in the harvest. If unmarked fish cannot be retained at all, or only at certain times of year and/or locations, this affects hatchery-origin harvest as a proportion of the total harvest. However, mark-selective fisheries are usually implemented where too few natural-origin fish return to provide a viable fishery or where hatchery fish are providing harvest opportunity and “protecting” threatened natural-origin populations. Therefore, in mark-selective situations the total number of fish is likely the most important indicator of hatchery production’s importance to the fishery.

Harvest numbers also cannot capture the importance or impact of catch-and-release fisheries or angling. Certain locations may have catch-and-release fisheries at certain times of the year that are popular with anglers. However, generally catch-and-release fisheries target natural-origin populations, which are not supported by hatchery production. Therefore, the impact of catch-and-release fisheries on the populations of interest to this study remains unclear.

Harvest data examined here was reported through ODFW’s Electronic Licensing System (ELS). This system provides anglers with the ability to report date, location, and species/run-type in real-time via a smartphone application. This reporting is mandatory for anglers who select the ELS, and all salmon or steelhead harvested must be immediately reported via the app. However, it is important to note that anglers are not required to report unless they harvest a fish, so catch-and-release angling and/or angling effort with no harvest will not be represented. Also, since the data are self-reported by anglers, there may be some reporting error in location, species/run-type and/or hatchery versus natural-origin. This will result in certain mark-selective/hatchery-only fisheries reporting a proportion of hatchery harvest slightly less than 100%. For the purposes of this study, this reporting error has negligible influence. Over-reporting is unlikely as anglers are only allotted a certain number of fish on their tags after which they must purchase another. Finally, in some fisheries, hatchery fish with no adipose fin clip or other distinguishing mark may be present. These fish would not be reported as hatchery origin fish in ELS, which introduce some certainty into the analysis.

The ELS data reported here does not include paper harvest cards still available and in-use by a majority of Oregon anglers. Therefore, ELS numbers reported here are useful for evaluating the proportion of hatchery fish in the harvest and the scale of harvest in a given area, but do not represent total harvest.

The ELS data are summarized as total harvest over the 5 years from 2019 to 2023 by species within region. The proportion of harvest over the same time period made up of hatchery-origin fish is used as a measure of hatchery-origin fish importance and impact in this assessment except in mark-selective fisheries as discussed above. Since this is a rate and not an absolute number, unless it is believed the angling behavior (i.e., location, catch rate, reporting rate, mis-identification rate, etc.) of anglers choosing ELS reporting is significantly different to those choosing paper harvest cards, these numbers should represent a reasonable approximation of hatchery importance and impact on specific species, run-types, and ESU/SMUs.

5.2.1 Snake River Region

Figure 5-3 shows total harvest for all species and run types for the Snake River region. Summer steelhead represents the largest part of the harvest within the ESU with nominal harvest of Coho Salmon and spring and fall Chinook Salmon. No winter steelhead harvest was reported. Almost the entire reported harvest of summer Steelhead (99%) consisted of hatchery-origin fish. Hatchery origin fish make up a substantial percentage of Coho Salmon (83%), fall Chinook Salmon (62%), and spring Chinook Salmon (91%) harvested, as well.

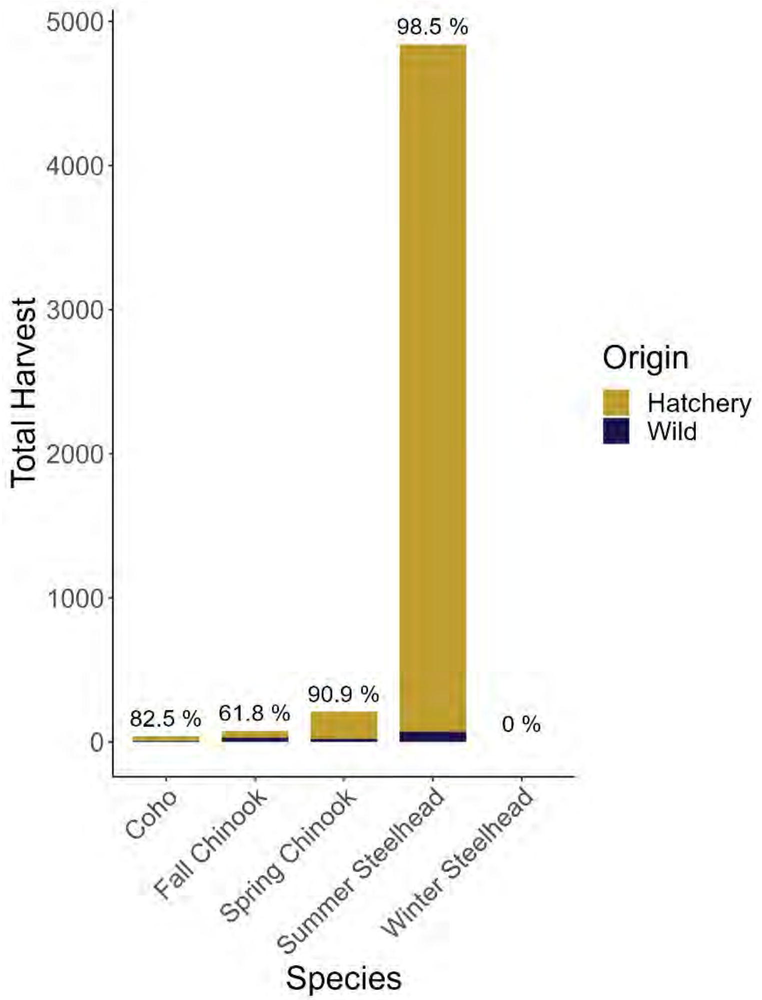


Figure 5-3. Total harvest with the proportion of hatchery-origin fish within the total harvest as reported in the ELS for species and run type within the Snake River region, 2019 to 2023.

5.2.2 Middle Columbia Region

Figure 5-4 shows total harvest for all species and run types for the Middle Columbia region. These totals include upriver fish stocks that are not returning to rivers in this region. Fall Chinook Salmon comprise the largest portion of the reported harvest with Coho Salmon, summer steelhead, and spring Chinook Salmon following in descending order. No winter steelhead were reported harvested. Hatchery-origin fish make up almost the entire reported harvest of spring Chinook Salmon (98%) and summer steelhead (98%), while hatchery-origin fish make up a large majority of Coho Salmon reported harvest (70%) and a third of fall Chinook Salmon reported harvest (33%).

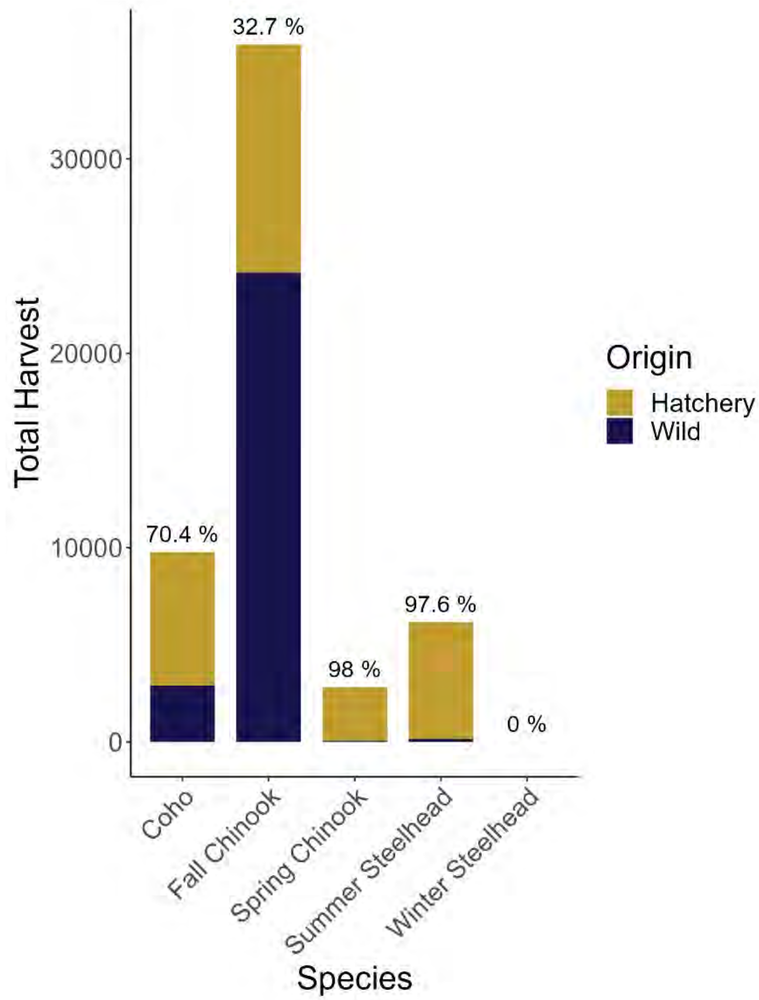


Figure 5-4. Total harvest as reported in the ELS for species and run type within the Middle Columbia region, 2019 to 2023.

5.2.3 Lower Columbia Region

Figure 5-5 shows total harvest for all species and run-types for the Lower Columbia region. These totals include upriver fish stocks that are not returning to rivers in this region. Fall Chinook Salmon comprise the largest portion of the total reported harvest with Coho Salmon, summer steelhead, and spring Chinook Salmon following in descending order. Hatchery-origin fish constitute nearly the entire harvest of summer steelhead (97%), winter steelhead (98%), Coho Salmon (98%), and spring Chinook Salmon (95%). Hatchery origin fish make up most of the fall Chinook Salmon reported harvest (53%).

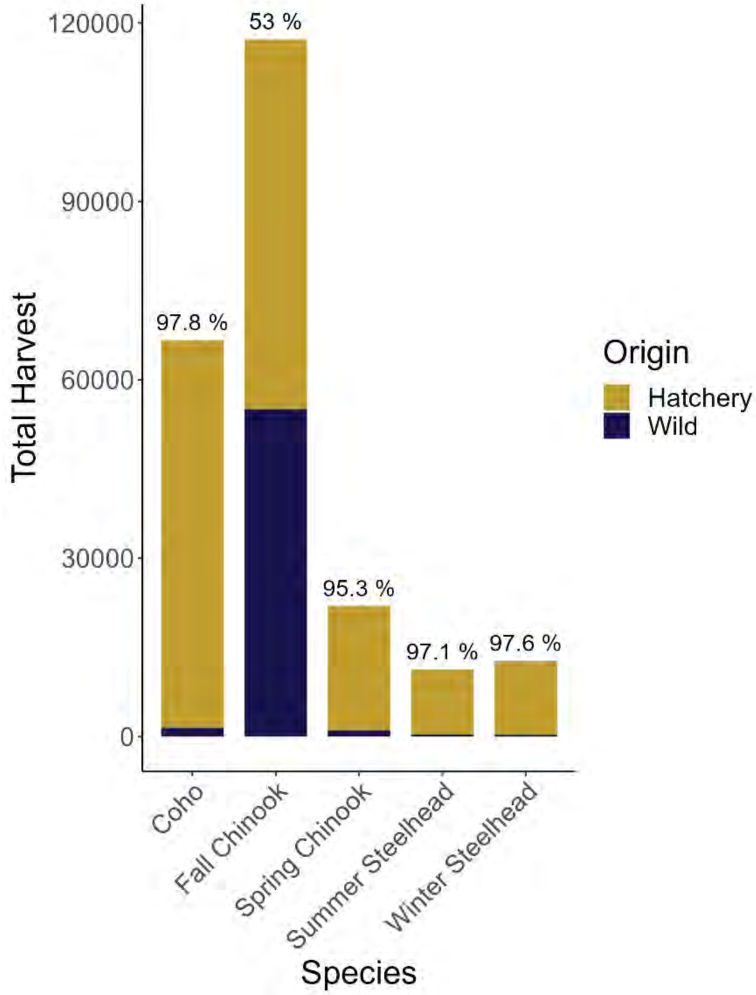


Figure 5-5. Total harvest as reported in the ELS for species and run type within the Lower Columbia region, 2019 to 2023.

5.2.4 Upper Willamette Region

Figure 5-6 shows total harvest for all species and run types for the Upper Willamette region. Spring Chinook Salmon comprise the largest portion of the total reported harvest with Coho Salmon and summer steelhead, making up most of the remainder. There are also nominal numbers of fall Chinook Salmon and winter steelhead reported harvested. Hatchery-origin fish make up nearly the entire total reported harvest for spring Chinook Salmon (98%), summer steelhead (95%), and winter steelhead (96%). Hatchery-origin fish make up a smaller proportion of fall Chinook Salmon reported harvest (33%) and a negligible portion of the Coho Salmon harvest (7%).

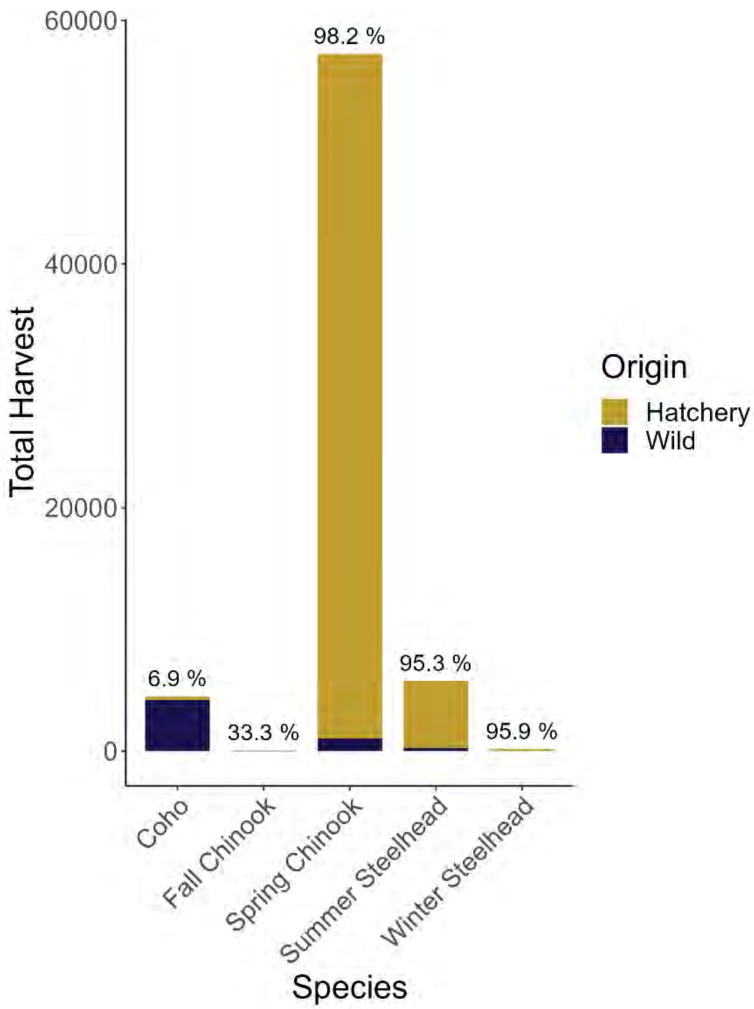


Figure 5-6. Total harvest as reported in the ELS for species and run type within the Upper Willamette region, 2019 to 2023.

5.2.5 Rogue-South Coast Region

Figure 5-7 shows total harvest for all species and run types for the Rogue-South Coast region. Fall Chinook Salmon, spring Chinook Salmon, summer steelhead, and winter steelhead all made up substantial portions of the total reported harvest for this SMU. Coho Salmon made up a much smaller portion of the total reported harvest. Hatchery-origin fish made up nearly the entire reported harvest for summer steelhead (94%) and a large majority of the reported harvest for Coho Salmon (92%) and spring Chinook Salmon (80%). Hatchery-origin fish made up most of the reported harvest for winter steelhead (59%), but only a negligible portion of the fall Chinook Salmon reported harvest (10%).

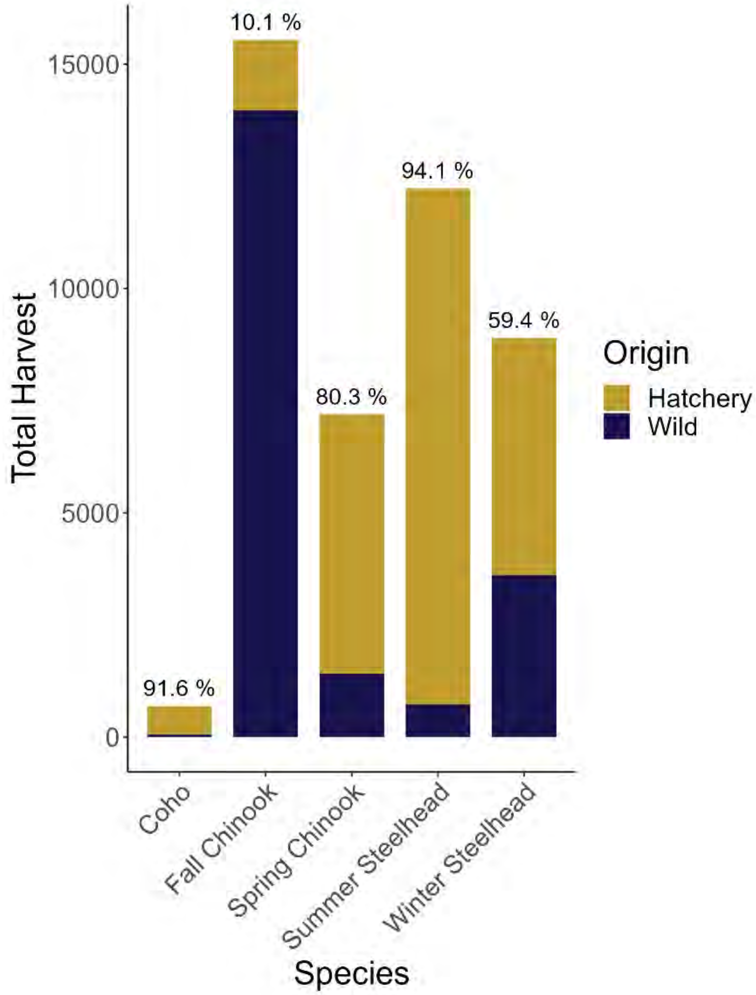


Figure 5-7. Total harvest as reported in the ELS for species and run type within the Rogue-South Coast region, 2019 to 2023.

5.2.6 Oregon Coast Region

Figure 5-8 shows total harvest for all species and run types for the Oregon Coast region. Fall Chinook Salmon and winter steelhead made up the majority of total reported harvest with Coho Salmon and spring Chinook Salmon making up most of the rest. Summer steelhead constituted a substantially smaller portion of the total reported harvest. Hatchery-origin fish made up nearly the entire reported harvest for winter steelhead (97%) and summer steelhead (97%). Hatchery-origin fish made up a large majority of the reported harvest for spring Chinook Salmon (72%), but only a quarter of fall Chinook (24%) and Coho Salmon (25%) reported harvest.

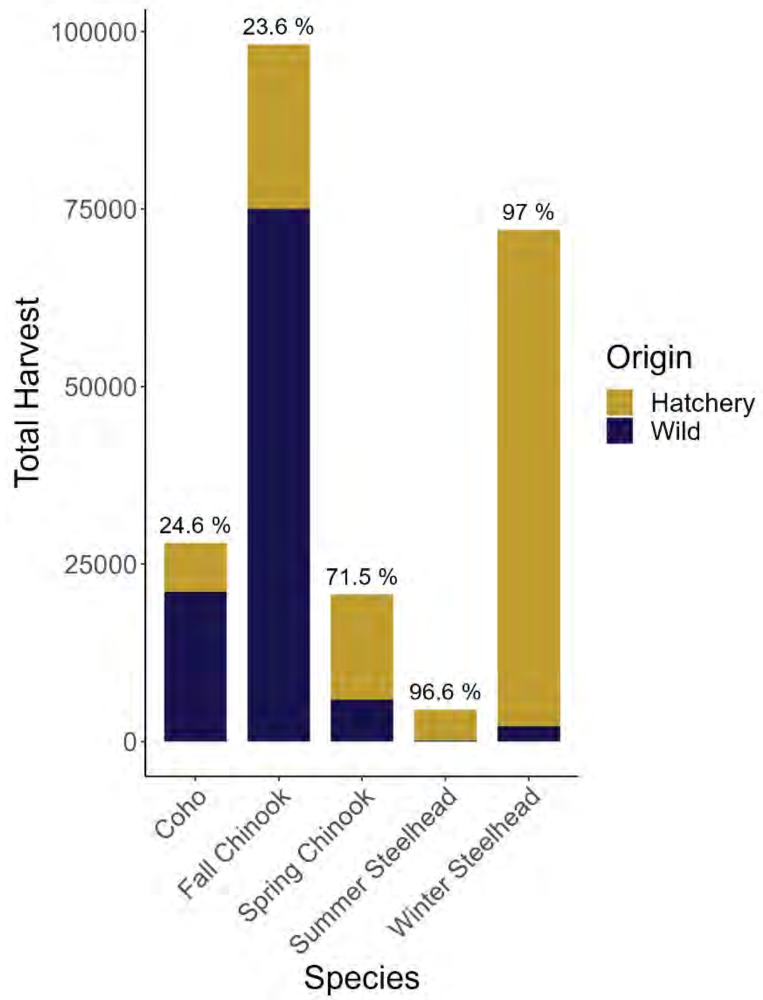


Figure 5-8. Total harvest as reported in the ELS for species and run type within the Oregon Coast region, 2019 to 2023.

5.2.7 Ocean Coho Salmon Harvest

The ocean Coho Salmon fishery is an important fishery for this species constituting nearly five times the total harvest (~326,000 fish) of the next largest fishery (Lower Columbia region). Hatchery origin Coho Salmon make up the majority (80%) of Coho Salmon harvest reported for the ocean fishery.

5.3 Section Summary

Resident angling license sales, the bulk of the license sales in the state, have been relatively stable since a decline through the 1990s. This seems to indicate recently stable but annually variable future demand for general angling opportunity in Oregon. However, purchases of salmon and steelhead tags and endorsements have steadily declined across a comparable period. This decline could be caused by a number of factors including generational shifts in recreational preferences, individual angler shifts in preference, or real or perceived decline in opportunity for salmon and steelhead harvest, which are beyond the scope of this assessment. Also, it is not possible to determine if this reflects a shift into warmwater (e.g., bass, panfish, walleye) or trout fisheries. Trout fisheries, including those supported by hatchery trout releases, will be an important part of the future of Oregon fisheries but were beyond the scope of this report. Depending on what is driving the decrease in tags and endorsement sales, it does indicate the potential for lower demand and support for hatchery-supported salmon and steelhead fisheries in the future.

This lower level of demand and support since the late 1990s is likely to affect all fisheries but not necessarily in the same way or to the same degree across all fisheries. Currently available license, tag, and endorsement data lack sufficient spatial resolution to indicate anything about the popularity or importance of specific fisheries. Considering how to obtain additional metrics of the importance and popularity of specific fisheries and the importance of hatchery origin fish to those fisheries would be valuable. As mentioned in Section 5.1, the Rogue-South Coast Steelhead Validation represents an interesting opportunity to collect such information while also contributing financial support to an SMU-specific species.

Coho Salmon made up the largest reported harvest from 2019 to 2023 (~435,000 fish over all 5 years combined) of all species and run types across the state, with most of the reported harvest coming from the ocean fishery. Chinook Salmon (~402,000 over all 5 years combined) are a close second with most of that total reported harvest represented by fall Chinook Salmon (~267,000 over all 5 years combined from estuary and freshwater only). Steelhead are the smallest proportion of total harvest (~124,000 over all 5 years combined) with the winter run-type making up the large majority (~94,000 over all 5 years combined).

A large majority of total reported harvest for most fisheries is made up of hatchery-origin fish. Hatchery origin fish made up the largest proportion of the steelhead reported harvest (94%) with a proportion of hatchery-origin harvest greater than 95% in all steelhead ESU/SMU/DPSs, with the exception of the Rogue-South Coast region winter steelhead fishery (59%). Likewise, hatchery-origin fish made up the large majority (78%) of the Coho Salmon fishery, although that proportion has been on a consistent year-over-year decline from 2019 (90%), to 2021 (86%), and to 2023 (57%). This may be due to strong runs of wild Coho Salmon in recent years. However, the causes of this decline in hatchery proportion are beyond the scope of this report. Hatchery-origin fish make up a slight majority (52%) of total reported harvest for Chinook Salmon across both run-types. However, most spring Chinook ESU/SMUs still have greater than 70% proportion hatchery-origin reported harvest with fall Chinook Salmon proportions all less than ~60%. Overall statewide, hatchery-origin salmon and steelhead make up 70% of reported ELS harvest, demonstrating the importance of hatcheries in sustaining popular individual fisheries and angling throughout the state.

While species within each ESU/SMU vary greatly in harvest numbers, that does not discount the importance or significance of any given population. Harvest numbers also do not consider the number of people participating in catch and release angling. To sustain angler utilization of fishery resources, region and species-specific angler metrics are a valuable source of information when guiding and identifying the recreational importance of hatchery programs.

6 Assessment and Conclusions

Future need will be driven by multiple factors including wild fish conservation status, climate vulnerability, ongoing habitat impacts requiring mitigation and angling opportunity demand. If, for example, wild fish vulnerability is high and climate vulnerability is high, that may indicate a higher need for conservation measures to include hatchery supplementation. Assessment of future hatchery need considered specific components from the previous four sections that represented vulnerability, status, and need. The preceding four sections were used to assess biological vulnerability (Section 2), climate vulnerability (Section 3), current hatchery status (Section 4), and angler trends/need (Section 5). These criteria were used to inform an assessment of future hatchery need by region and ESU/SMU/DPS.

6.1 Assessment Methods

Biological vulnerability for each ESU/SMU/DPS was determined based on federal and state listing status and climate exposure and sensitivity risk. These two metrics were selected to evaluate biological and climate vulnerability because they were available for most populations and were representative at a broad enough scale to identify needs at the ESU/SMU/DPS scale.

Federal and state listing scores were assigned a score from 1 to 5 according to a pre-defined rule set (Table 6-1). In cases where a federal and state listing were not consistent (e.g., federal = Threatened but state = Sensitive Critical), the higher of the two scores was assigned. In cases where multiple ESU/SMU/DPSs were combined within a region and the ESU/SMU/DPSs had different listings, the higher of the two scores was also assigned. This was appropriate to ensure biological vulnerability reflected the highest possible need rather than risk understating vulnerability.

Table 6-1. Federal/state listing scoring criteria for biological vulnerability assessment.

Federal Listing	State Listing	Federal/State Listing Score	Federal/State Listing Category
None	None	1	Very Low
None	Sensitive	2	Low
None	Sensitive Critical	3	Moderate
Threatened	Threatened	4	High
Endangered	Endangered	5	Very High

Climate exposure and sensitivity scores were also assigned a score from 1 to 5 (Table 6-2). These were based primarily on climate exposure and sensitivity categories assigned in Crozier et al. 2019. However, in cases where Crozier et al. did not assign a category, alternative comparable sources (e.g., Wade et al. 2013) were used. In situations where no source could be found to assign categories, a species with similar run timing and life history may have been used to approximate an exposure and sensitivity score (e.g., Oregon Coast Coho used for Oregon Coast Chinook).

Table 6-2. Climate exposure and sensitivity scoring criteria used for biological vulnerability assessment.

Climate Exposure and Sensitivity Category	Climate Vulnerability Score
Very Low	1
Low	2
Moderate	3

Climate Exposure and Sensitivity Category	Climate Vulnerability Score
High	4
Very High	5

Values for federal/state listing category and climate vulnerability were then averaged to create an overall Biological Vulnerability score.

Table 6-3 displays status and vulnerability metrics for federal/state listing categories and climate vulnerability and the vulnerability scores generated by applying the criteria presented in Table 6-1 and Table 6-2 above. Then it displays their average to calculate an overall Biological Vulnerability Score and assigns that score a categorical ranking (e.g., very low, low, moderate) for overall biological vulnerability.

To assess future need for hatchery programs, all ESU/SMU/DPSs were evaluated in each of three categories (mitigation, harvest augmentation, and conservation) according to a set of decision rules established for each category. Future needs for a given ESU/SMU/DPS may differ between categories. For instance, an ESU/SMU/DPS may have “no” future need for mitigation hatchery programs as there is no dam requiring mitigation in that ESU/SMU/DPS. However, it may be “increasing” in future need for conservation hatchery programs due to high biological vulnerability and no current conservation hatchery programs.

For mitigation hatchery programs, as long as the associated dams or other impacts to fish habitat continue to exist, there will be a future need for mitigation hatchery programs. Therefore, ESU/SMU/DPSs with existing mitigation needs were classified as having future need (i.e., “yes”) for mitigation hatchery programs and those without have been identified as having no future need (i.e., “no”) for mitigation hatchery programs.

For harvest augmentation hatchery programs, we considered biological vulnerability, existing mitigation hatchery programs, existing harvest augmentation programs, and climate vulnerability. If an ESU/SMU/DPS had an existing harvest augmentation hatchery program, that ESU/SMU/DPS was classified as having an ongoing future need (i.e., “yes”). For these ESU/SMU/DPSs, we did not evaluate whether the need was likely to increase or decrease due to uncertainty about future trends in angler demand. If an ESU/SMU/DPS did not have an existing harvest augmentation program but had an existing mitigation program, that ESU/SMU/DPS was not rated (i.e., “--") because future needs potentially could be addressed by mitigation hatchery programs. If an ESU/SMU/DPS did not have existing mitigation or harvest augmentation program and had a climate vulnerability of greater than low, it was classified as having “increasing” need for a harvest augmentation hatchery program. Note that this instance did not occur in practice.

For conservation hatchery programs, the biological vulnerability score, as calculated above, was used to determine the future need. This seemed most appropriate since conservation hatchery programs are intended to recover and or support an ESU/SMU/DPS independent of mitigation or harvest needs. Therefore, the primary drivers of future need for conservation hatcheries would be the population status as reflected in the federal/state listing status and vulnerability to future climate impacts as reflected in climate vulnerability and exposure. If an ESU/SMU/DPS had an existing conservation hatchery program, that ESU/SMU/DPS was classified as having an ongoing future need (i.e., “yes”). If an

ESU/SMU/DPS did not have an existing conservation hatchery program, but had a biological vulnerability greater than low, that ESU/SMU/DPS was classified as having an “increasing” future need.

Table 6-3. Summary table of ESU/SMU/DPS Biological Vulnerability.

ESU/SMU/DPS	Species	Biological Vulnerability						
		Federal Listing Status	State Listing Status	Listing Score	Climate Exposure & Sensitivity	Climate Vulnerability Score	Biological Vulnerability Score	Biological Vulnerability Status
Snake River	Fall Chinook	T	T	4	High	4	4	High
	Spring/Summer Chinook	T	T	4	Very High	5	4.5	High to Very High
	Steelhead	T	S	4	High	4	4	High
Middle Columbia	Coho			1	NA		1	*Insufficient Data*
	Fall Chinook		S	2	NA		2	*Insufficient Data*
	Spring Chinook		S	2	High	4	3	Moderate
	Steelhead	T	SC	4	High	4	4	High
Lower Columbia	Coho	T	E	5	High	4	4.5	High to Very High
	Fall Chinook	T	SC	4	Mod	3	3.5	Moderate to High
	Spring Chinook	T	SC	4	Mod	3	3.5	Moderate to High
	Chum	T	SC	4	Mod	3	3.5	Moderate to High
	Winter Steelhead	T	SC	4	Mod	3	3.5	Moderate to High
	Summer Steelhead	T	S	4	Mod	3	3.5	Moderate to High
Upper Willamette	Spring Chinook	T	SC	4	Very High	5	4.5	High to Very High
	Steelhead	T	S	4	High	4	4	High
Rogue-South Coast	Coho	T	S/SC	4	High	4	4	High
	Fall Chinook			1	NA		1	*Insufficient Data*
	Spring Chinook		S	2	NA		2	*Insufficient Data*
	Winter Steelhead			1	Low	2	1.5	Very Low to Low
	Summer Steelhead		S	2	Mod	3	2.5	Low to Moderate
Oregon Coast	Coho	T	S	4	High	4	4	High
	Fall Chinook			1	High	4	2.5	Low to Moderate
	Spring Chinook		S	2	High	4	3	Moderate
	Chum		SC	3	NA		3	*Insufficient Data*
	Winter Steelhead			1	High	4	2.5	Low
	Summer Steelhead		S	2	High	4	3	Moderate

6.2 Assessment Results and Discussion

6.2.1 Mitigation Programs

Mitigation hatchery programs exist to mitigate the impacts to fish habitat from the construction and operation of dams and other human developments. These programs are important to supporting non-tribal (i.e., recreational and commercial) and tribal (i.e., commercial and subsistence) fisheries. Some mitigation programs (about seven) operate in combination with all three other types of hatchery programs (i.e., harvest augmentation, recovery, and supplementation).

A large percentage, if not all, of the hatchery programs supporting ESU/SMU/DPSs in the Lower Columbia, Middle Columbia, Upper Willamette, Snake River, and Rogue-South Coast, as well as Oregon Coast Coho Salmon, are either solely mitigation or partially mitigation programs (Table 6-4). These hatchery programs provide mitigation for dams, including those on the mainstem Columbia River and Snake River, in the Willamette and Rogue basins, and elsewhere in the state. As long as these dams continue to exist, there will be a high future need for these mitigation hatchery programs to mitigate their impacts to fish habitat. This classification applies only to mitigation programs. ESU/SMU/DPSs identified as having no future need (i.e., “no”) for mitigation hatchery programs may have a different classification based on harvest augmentation or conservation need as discussed in the following two sections.

Table 6-4. Summary table of federal and state listing status, hatchery status, and future need for mitigation hatchery programs.

ESU/SMU	Species	Biological Vulnerability		Hatchery Status		Future Mitigation Need
		Federal Listing Status	State Listing Status	Mitigation Program (#)	Mitigation Production (# of fish)	
Snake River	Fall Chinook	T	T	3	UNK	Yes
	Spring/Summer Chinook	T	T	5	1,650,000	Yes
	Steelhead	T	S	2	1,015,000	Yes
Middle Columbia	Coho			1	1,000,000	Yes
	Fall Chinook		S	1	1,500,000	Yes
	Spring Chinook		S	1	310,000	Yes
	Steelhead	T	SC	1	162,000	Yes
Lower Columbia	Coho	T	E	4	3,635,000	Yes
	Fall Chinook	T	SC	1	1,600,000	Yes
	Spring Chinook	T	SC	3	4,530,000	Yes
	Chum	T	SC	0	0	No
	Winter Steelhead	T	SC	1	160,000	Yes
	Summer Steelhead	T	S	0	0	No
Upper Willamette	Spring Chinook	T	SC	4	4,229,750	Yes
	Steelhead	T	S	1	547,500	Yes
Rogue-South Coast	Coho	T	S/SC	1	100,000	Yes
	Fall Chinook			0	0	No
	Spring Chinook		S	1	1,700,000	Yes
	Winter Steelhead			2	263,000	Yes
	Summer Steelhead		S	1	220,000	Yes
Oregon Coast	Coho	T	S	1	60,000	Yes
	Fall Chinook			0	0	No
	Spring Chinook		S	0	0	No
	Chum		SC	0	0	No
	Winter Steelhead			0	0	No
	Summer Steelhead		S	0	0	No

6.2.2 Harvest Augmentation Programs

Harvest augmentation hatchery programs exist to increase fishing and harvest opportunity in areas where no mitigation programs exist. These programs support non-tribal (i.e., recreational and commercial) and tribal (i.e., commercial and subsistence) fisheries. Some of these programs (about four) operate in combination with other types of hatchery programs, including mitigation and recovery.

A substantial proportion of the hatchery programs supporting ESU/SMU/DPSs in the Lower Columbia and Oregon Coast, as well as Rogue-South Coast, are solely harvest augmentation or partially harvest augmentation programs (Table 6-5). All ESU/SMU/DPSs within the Oregon Coast ESU/SMU/DPS, as well as Lower Columbia summer steelhead and the Rogue-South Coast fall Chinook Salmon, had a future need for harvest augmentation hatchery programs. All other ESU/SMU/DPS were not classified under harvest augmentation due to substantial mitigation programs. Lower Columbia Chum Salmon ESU and Oregon Coast Chum Salmon ESU were not applicable because fisheries do not currently exist and populations are likely to be handled under conservation hatchery programs for the foreseeable future.

Future fishery demand is directly linked to future need for harvest augmentation programs as harvest augmentation primarily exists to support fisheries. We considered a number of metrics to estimate future fishery demand for inclusion into the harvest augmentation future need metric. However, as discussed above in Section 5.1, it is not possible to break fishery demand down by ESU/SMU/DPS using currently available data. One alternative would have been to apply declining tag and endorsement sales to all ESU/SMU/DPSs uniformly, for example, by reducing the future need rating downwards for all ESU/SMU/DPSs. However, given that the cause of the decline is not clear (e.g., generational preferences, individual angler preferences, real/perceived decline in opportunity) and since this alternative would be applied uniformly across all ESU/SMU/DPS, it would not provide any real differentiation between ESU/SMU/DPS, would be uninformative, and was not included.

Another alternative was to include the proportion of hatchery fish in the ELS-reported harvest. The larger a proportion of the fishery is made up of hatchery fish, the more dependent that fishery is on hatchery production and, presumably, the more popular hatchery fish are within that fishery. While that metric can be broken down by region and species/run-type, many fisheries (e.g., most Lower Columbia River fisheries) are mark-selective meaning only hatchery fish may be harvested. This is typically driven by the wild ESU/SMU/DPS having too poor a status to support harvest and would obviously substantially increase the proportion of hatchery fish in reported harvest. Given the ongoing stressors of climate change, the wild ESU/SMU/DPSs are unlikely to recover to the point of sustaining regular harvest of wild fish. Therefore, unless the status of the wild ESU/SMU/DPS changed substantially, hatchery proportion is still a good indicator of the importance of hatchery production to the fishery.

Though declining tag sales (see Section 5.1) indicate a possible ongoing reduction in demand for future salmon and steelhead angling opportunity, this does not necessarily represent a clear indication that there will not be some future need for harvest augmentation. Angler demand is highly variable depending on weather, run forecasts, and actual size and economic conditions (e.g., increase in license sales during the COVID 19 pandemic) and could change rapidly. For example, angler demand may increase rapidly if real or perceived harvest opportunity increased rapidly. This could alter the future need for harvest augmentation for specific species and programs without changes to overall angler demand (i.e., demand shifts from steelhead to spring Chinook Salmon or shifts from Columbia River to coastal fisheries). Future ESA listing/delisting of various ESU/SMU/DPSs (e.g., consideration of the Oregon Coast and SONCC Chinook ESUs for listing) could impact future need for harvest augmentation to allow continued harvest opportunity while protecting ESA-listed ESU/SMU/DPSs. Finally, factors beyond the control of management agencies (e.g., ocean productivity declines) may impact future need to the point where programs are no longer advantageous and/or cannot be maintained.

Table 6-5. Summary table of climate exposure and sensitivity, hatchery status, and future need for harvest augmentation hatchery programs.

ESU/SMU	Species	Climate Exposure & Sensitivity	Hatchery Status: Harvest Augmentation Program	Hatchery Status: Harvest Augmentation Production	Future Harvest Augmentation Need [1]
Snake River	Fall Chinook	High	0	0	--
	Spring/Summer Chinook	Very High	0	0	--
	Steelhead	High	0	0	--
Middle Columbia	Coho	NA	0	0	--
	Fall Chinook	NA	0	0	--
	Spring Chinook	High	0	0	--
	Steelhead	High	0	0	--
Lower Columbia	Coho	High	2	835,000	Yes
	Fall Chinook	Mod	2	7,450,000	Yes
	Spring Chinook	Mod	3	1,330,000	Yes
	Chum[2]	Mod	0	0	NA
	Winter Steelhead	Mod	3	565,000	Yes
	Summer Steelhead	Mod	2	250,000	Yes
Upper Willamette	Spring Chinook	Very High	0	0	--
	Steelhead	High	0	0	--
Rogue-South Coast	Coho	High	0	0	--
	Fall Chinook	NA	2	290,000	Yes
	Spring Chinook	NA	0	0	--
	Winter Steelhead	Low	1	50,000	Yes
	Summer Steelhead	Mod	0	0	--
Oregon Coast	Coho[3]	High	2	200,000	Yes
	Fall Chinook	High	7	3,163,000	Yes
	Spring Chinook	High	3	972,000	Yes
	Chum[2]	NA	0	0	NA
	Winter Steelhead	High	10	1,125,000	Yes
	Summer Steelhead	High	2	150,000	Yes

Notes:

1. ESU/SMU/DPSs with "--" have mitigation programs.
2. Chum Salmon populations are currently too small to be harvestable and are unlikely to rebound to a level allowing harvest in the foreseeable future.
3. The current mitigation program for Oregon Coast Coho Salmon ESU is relatively small and may not meet future harvest augmentation needs.

6.2.3 Conservation Programs

Conservation hatchery programs (e.g., supplementation and recovery) use hatchery fish to enhance the viability of natural populations while limiting impacts to those populations within acceptable bounds or use the best available broodstock to establish a population in habitat currently vacant for that native species, respectively. Some of these programs (about four) operate in combination with other types of hatchery programs including mitigation and recovery.

Relatively few conservation hatchery programs exist in the state of Oregon (Table 6-6). Based on biological vulnerability scores, all ESU/SMU/DPSs with existing conservation hatchery programs (e.g., Snake River spring/summer Chinook Salmon ESU, Snake River steelhead DPS, Middle Columbia spring Chinook Salmon ESU, and Middle Columbia steelhead DPS, and Columbia River Chum Salmon ESU, and Oregon Coast fall Chinook Salmon SMU) will have an ongoing future need for these programs. The Snake River fall Chinook Salmon ESU, Lower Columbia Coho and fall Chinook Salmon ESU and winter and summer steelhead DPS, the Upper Willamette spring Chinook Salmon ESU and steelhead DPS, the Rogue-South Coast Coho Salmon SMU, the Oregon Coast Coho Salmon ESU, and the Oregon Coast spring Chinook Salmon and summer steelhead SMUs will all have an increasing future need for conservation hatchery programs. The Rogue-South Coast winter and summer steelhead SMUs and Oregon Coast winter steelhead SMU have no foreseeable future need for conservation hatchery programs. The Middle Columbia fall Chinook and Coho Salmon SMUs, the Rogue-South Coast fall and spring Chinook Salmon SMUs, and Oregon Coast Chum Salmon SMU could not be reliably scored since no climate exposure and sensitivity rating could be assigned.

Table 6-6. Summary table of biological vulnerability, hatchery status, and future need for conservation hatchery programs.

ESU/SMU /DPS	Species	Biological Vulnerability							Hatchery Status		Future Conservation Need
		Federal Listing Status	State Listing Status	Listing Score	Climate Exposure & Sensitivity	Climate Vulnerability Score	Biological Vulnerability Score	Biological Vulnerability Status	Conservation Program (#)	Conservation Production (# of Fish)	
Snake River	Fall Chinook	T	T	4	High	4	4	High	0	0	Increasing
	Spring/Summer Chinook	T	T	4	Very High	5	4.5	High to Very High	5	1,650,000	Yes
	Steelhead	T	S	4	High	4	4	High	1	215,000	Yes
Middle Columbia	Coho			1	NA		1	*Insufficient Data*	0	0	*Insufficient Data*
	Fall Chinook		S	2	NA		2	*Insufficient Data*	0	0	*Insufficient Data*
	Spring Chinook		S	2	High	4	3	Moderate	2	1,120,000	Yes
	Steelhead	T	SC	4	High	4	4	High	2	312,000	Yes
Lower Columbia	Coho	T	E	5	High	4	4.5	High to Very High	0	0	Increasing
	Fall Chinook	T	SC	4	Mod	3	3.5	Moderate to High	0	0	Increasing
	Spring Chinook	T	SC	4	Mod	3	3.5	Moderate to High	1	250,000	Yes
	Chum	T	SC	4	Mod	3	3.5	Moderate to High	1	300,000	Yes
	Winter Steelhead	T	SC	4	Mod	3	3.5	Moderate to High	0	0	Increasing
	Summer Steelhead	T	S	4	Mod	3	3.5	Moderate to High	0	0	Increasing
Upper Willamette	Spring Chinook	T	SC	4	Very High	5	4.5	High to Very High	0	0	Increasing
	Steelhead	T	S	4	High	4	4	High	0	0	Increasing
Rogue-South Coast	Coho	T	S/SC	4	High	4	4	High	0	0	Increasing
	Fall Chinook			1	NA		1	*Insufficient Data*	0	0	*Insufficient Data*
	Spring Chinook		S	2	NA		2	*Insufficient Data*	0	0	*Insufficient Data*
	Winter Steelhead			1	Low	2	1.5	Very Low to Low	0	0	No
	Summer Steelhead		S	2	Mod	3	2.5	Low to Moderate	0	0	No
Oregon Coast	Coho	T	S	4	High	4	4	High	0	0	Increasing
	Fall Chinook			1	High	4	2.5	Low to Moderate	1	100,000	Yes
	Spring Chinook		S	2	High	4	3	Moderate	0	0	Increasing
	Chum		SC	3	NA		3	*Insufficient Data*	0	0	*Insufficient Data*
	Winter Steelhead			1	High	4	2.5	Low to Moderate	0	0	No
	Summer Steelhead		S	2	High	4	3	Moderate	0	0	Increasing

This assessment substantiates a future need for a combination of mitigation, harvest augmentation, and conservation hatchery programs for a variety of different species in multiple regions (Table 6-7). This mix of hatchery programs will continue to support fishery and conservation goals and objectives throughout the state of Oregon.

Although producing and releasing more fish would immediately increase population numbers, hatchery fish can introduce both genetic and ecological risks to wild fish, which can lead to further negative impacts to the population (Kostow 2009). Hatchery production under optimized management can help minimize these impacts to aid the natural production of imperiled fish (see also Four Peaks 2024). This future needs assessment provides a review of future hatchery need as it exists today. However, regular and ongoing evaluation of hatchery program objectives and strategies will best support populations.

Climate change is a substantial, additional uncertainty for both harvest augmentation (Section 6.2.2 above) and conservation hatchery programs (Section 6.2.3). Most current climate change scenarios indicate that wild fish ESU/SMU/DPSs are unlikely to be able to absorb more harvest demand. This may lead to increased future need for harvest augmentation programs for additional ESU/SMU/DPSs. However, under climate change, the most important consideration may not be current harvest opportunity but the risk of ongoing harvest to the continued existence of the ESU/SMU/DPS indicating future need for conservation hatchery programs in addition to or in place of harvest augmentation. This could be further influenced by changing angler preferences for the type of fishery (i.e., harvest v. catch-and-release), though, so far, notable catch-and-release fisheries seem to have emerged primarily among steelhead anglers. The evolving dynamics of climate change interacting with angler demand and preferences create uncertain and shifting future needs, which may impact multiple program types and will require flexible and adaptive management approaches.

Rankings for ESU/SMU/DPSs could be further refined within the needs assessment framework based on the addition of information or data not included within the current framework. Refining the future needs of these fish would work to promote the longevity of these populations in areas where biological and climate change risk factors threaten their continued existence. Ideally, hatchery investment level would reflect the associated ecological risk to compensate for potential losses due to non-production related factors (i.e., climate, harvest, human-impacts to habitat).

Table 6-7. Summary table of Future Need for Mitigation, Harvest Augmentation and Conservation Hatchery Programs and Overall Future Hatchery Need.

ESU/SMU	Species	Future Mitigation Need	Future Harvest Augmentation Need	Future Conservation Hatchery Need	Future Hatchery Need
Snake River	Fall Chinook	Yes	--	Increasing	Yes, Increasing
	Spring/Summer Chinook	Yes	--	Yes	Yes
	Steelhead	Yes	--	Yes	Yes
Middle Columbia	Coho	Yes	--	*Insufficient Data*	Yes
	Fall Chinook	Yes	--	*Insufficient Data*	Yes
	Spring Chinook	Yes	--	Yes	Yes
	Steelhead	Yes	--	Yes	Yes

ESU/SMU	Species	Future Mitigation Need	Future Harvest Augmentation Need	Future Conservation Hatchery Need	Future Hatchery Need
Lower Columbia	Coho	Yes	Yes	Increasing	Yes, Increasing
	Fall Chinook	Yes	Yes	Increasing	Yes, Increasing
	Spring Chinook	Yes	Yes	Yes	Yes
	Chum	No	NA	Yes	Yes
	Winter Steelhead	Yes	Yes	Increasing	Yes, Increasing
	Summer Steelhead	No	Yes	Increasing	Increasing
Upper Willamette	Spring Chinook	Yes	--	Increasing	Yes, Increasing
	Steelhead	Yes	--	Increasing	Yes, Increasing
Rogue-South Coast	Coho	Yes	--	Increasing	Yes, Increasing
	Fall Chinook	No	Yes	*Insufficient Data*	Yes
	Spring Chinook	Yes	--	*Insufficient Data*	Yes
	Winter Steelhead	Yes	Yes	No	Yes
	Summer Steelhead	Yes	--	No	Yes
Oregon Coast	Coho	Yes	Yes	Increasing	Yes, Increasing
	Fall Chinook	No	Yes	Yes	Yes
	Spring Chinook	No	Yes	Increasing	Yes, Increasing
	Chum	No	NA	*Insufficient Data*	No
	Winter Steelhead	No	Yes	No	Yes
	Summer Steelhead	No	Yes	Increasing	Yes, Increasing

References

Bowerman, T., Roumasset, A., Keefer, M.L., Sharpe, C.S., and Caudill, C.C. 2017. Prespawn mortality of female Chinook salmon increases with water temperature and percent hatchery origin. *Trans Am Fish Soc.* 147:31-42.

Crozier, L.G., M.M. McClure, T. Beechie, S.J. Bogard, D.A. Boughton, M. Carr, T.D. Cooney, J.B, Dunham, C.M. Greene, M.A. Haltuch, E.L. Hazen, D.M. Holzer, D.D. Huff, R.C. Johnson, C.E. Jordan, I.C. Kaplan, S.T. Lindley, N.J. Mantua, A. Wietkamp, T.H. Williams, and E. Willis-Norton. 2019. Climate vulnerability assessment for Pacific salmon and steelhead in the California Current Large Marine Ecosystem. *PLoS ONE* 14: e0217711.

Doney, S.C., Fabry, V.J., Feely, R.A., Kleypas, J.A. 2009. Ocean acidification: the other CO2 problem. *Ann Rev Mar Sci.* 1:169-92. doi: 10.1146/annurev.marine.010908.163834. PMID: 21141034.

Ford, M. J., editor. 2022. Biological Viability Assessment Update for Pacific Salmon and Steelhead Listed Under the Endangered Species Act: Pacific Northwest. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-171. Available at: https://doi.org/10.25923/kq2n-ke70.

Four Peaks Environmental & Data Science Solutions. 2024. Review of Regulatory Approval Process and Management Requirements for Hatchery Programs in Oregon. Prepared for Oregon Department of Fish and Wildlife.

Keefer, M.L. Clabough, T.S., Jepson, M.A., Naughton, G.P., Blubaugh, T.J., and Joosten, D.C. 2015. Thermal exposure of adult Chinook salmon in the Willamette River Basin. *Journal of Thermal Biology* 48:11-20.

Kostow, K. 2009. Factors that contribute the ecological risks of salmon and steelhead hatchery programs and mitigating strategies. *Rev Fish Biol Fisheries* 19:9-31.

Lorenzen, K., C.M, Beveridge, and M. Mangel. 2012. Culture fish: integrative biology and management of domestication and interactions with wild fish. *Biological Reviews* 87:639-660.

McElhany, P., M.H. Ruckelshaus, M.J. Ford, T.C. Wainwright, and E.P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-42,156 p.

National Oceanic and Atmospheric Administration (NOAA). 2022. 2022 5-Year Review: Summary & Evaluation of Lower Columbia River Chinook Salmon, Columbia River Chum Salmon, Lower Columbia River Coho Salmon, Lower Columbia River Steelhead. Available at: https://repository.library.noaa.gov/view/noaa/48670.

NOAA. 2024. Biological Status of Oregon Coast and Southern Oregon/Northern California Coastal Chinook Salmon: Report of the Status Review Team. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-189. Available at: https://doi.org/10.25923/0htj-5q59.

Oregon Climate Change Research Institute (OCCRI). 2023. Sixth Oregon climate assessment. Published January 2023. Oregon State University, Corvallis, Oregon.

Oregon Department of Fish and Wildlife (ODFW). 2005. 2005 Oregon Native Fish Status Report, Volume II – Assessment Methods & Population Results. Available at: https://www.dfw.state.or.us/fish/ONFSR/report.asp.

ODFW. 2013. Conservation Plan for Fall Chinook Salmon in the Rogue Species Management Unit. Available at: https://dfw.state.or.us/fish/CRP/docs/rogue_fall_chinook/Rogue_CHF_Plan_Final_1-11-13.pdf

ODFW. 2014. Coastal Multi-Species Conservation and Management Plan. Available at: https://www.dfw.state.or.us/fish/CRP/docs/coastal_multispecies/CMP_main_final.pdf

ODFW. 2019. Rogue Spring Chinook Salmon Conservation Plan Comprehensive Assessment and Update. Available at: https://www.dfw.state.or.us/fish/CRP/docs/rogue_spring_chinook/Final%20Rogue%20Spring%20Chinook%20Salmon%20Conservation%20Plan%20Comprehensive%20Assessment%20and%20Update.pdf

ODFW. 2021. Rogue–South Coast Multi-Species Conservation and Management Plan. Available at: https://www.dfw.state.or.us/fish/CRP/docs/rogue_south_coast_multispecies/RSP_main_final.pdf

ODFW. 2022. Annual Progress Report for 2022 Fall Chinook Salmon Conservation Plan Rogue Species Management Unit Oregon Department of Fish and Wildlife Rogue Watershed District. Available at: https://www.dfw.state.or.us/fish/crp/docs/rogue_fall_chinook/2022%20Rogue%20Fall%20Chinook%20Annual%20Report.pdf

ODFW. 2024a. "ODFW Hatcheries." Oregon Department of Fish and Wildlife [website]. Available at: https://www.dfw.state.or.us/fish/hatchery/.

ODFW. 2024b. "Native Fish Conservation – Conservation and Recovery Plans." Oregon Department of Fish and Wildlife [website]. Available at: https://www.dfw.state.or.us/fish/CRP/conservation_recovery_plans.asp

ODFW and National Marine Fisheries Service (NMFS). 2011. Upper Willamette River conservation and recovery plan for Chinook Salmon and steelhead. ODFW. Available at: https://repository.library.noaa.gov/view/noaa/15981

ODFW and the Klamath Tribes. 2021. Implementation Plan for the Reintroduction of Anadromous Fishes into the Oregon Portion of the Upper Klamath Region. Available at: https://www.dfw.state.or.us/fish/CRP/docs/klamath_reintroduction_plan/ODFW%20and%20The%20Klamath%20Tribes_Upper%20Klamath%20Region%20anadromous%20reintroduction%20implementation%20plan_Final%202021.pdf

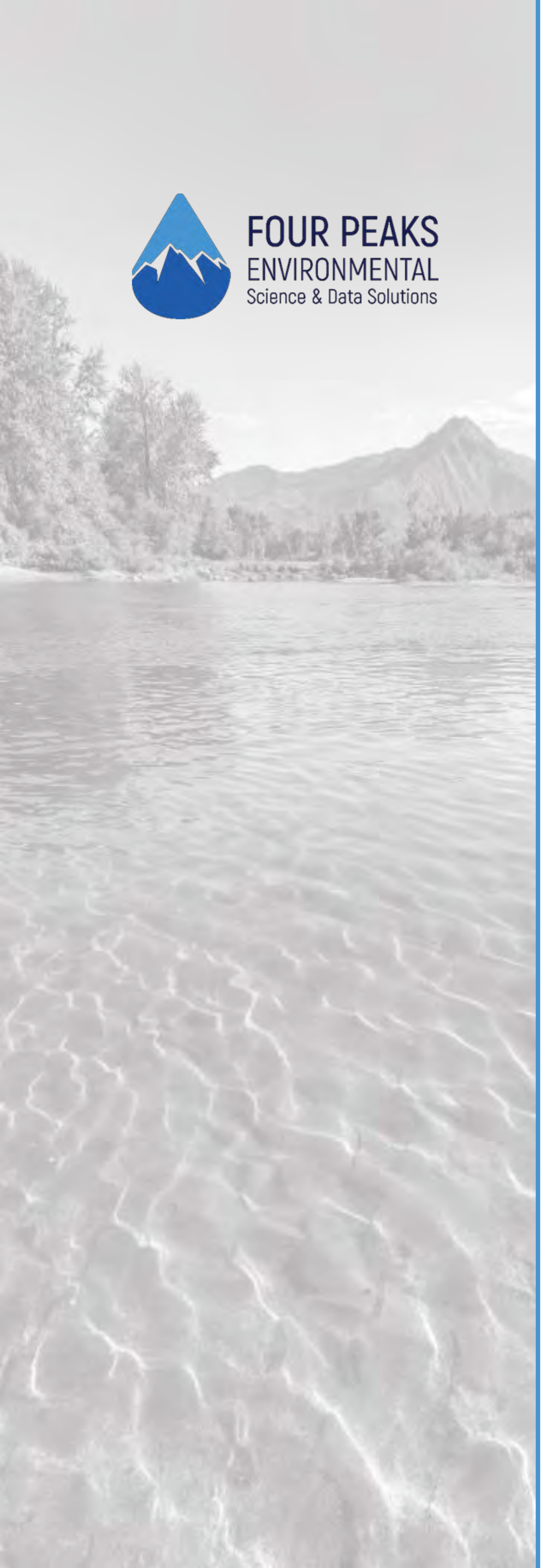
Quinn, Thomas P. 2018. The behavior and ecology of Pacific salmon and trout. University of Washington Press.

Wade, A. A., T. J. Beechie, E. Fleishman, N. J. Mantua, H. Wu, J. S. Kimball, D. M. Stoms, and J. A. Stanford. 2013. Steelhead vulnerability to climate change in the Pacific Northwest. *Journal of Applied Ecology* 50: 1093-1104.

Wiens, J.J. 2016. Climate-related local extinctions are already widespread among plant and animal species. *PLoS Biol.* 14(12):e2001104. https://doi.org/10.1371/journal.pbio.2001104 PMID: 27930674

Appendix G: Review of Regulatory Approval Process and Management Requirements for Hatchery Program in Oregon

Prepared by Four Peaks Environmental Science & Data Solutions



REVIEW OF REGULATORY APPROVAL PROCESS AND MANAGEMENT REQUIREMENTS FOR HATCHERY PROGRAMS IN OREGON

August 2024

Prepared for

Oregon Department of Fish and Wildlife
4034 Fairview Industrial Drive SE
Salem, Oregon 97302

Prepared by

Four Peaks Environmental
Science & Data Solutions
338 South Mission Street
Wenatchee, Washington 98801

Table of Contents

Figures

Tables

Abbreviations

Abbreviation	Definition
BA	Biological Assessment
DPS	Distinct Population Segment
EA	Environmental Assessment
EIS	Environmental Impact Statement
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
FHMP	Fish Hatchery Management Policy
HGMP	Hatchery and Genetic Management Plan
HPMP	hatchery program management plan
NEPA	National Environmental Policy Act
NLAA	Not Likely to Adversely Affect
NOAA Fisheries	National Oceanic and Atmospheric Administration Fisheries Service
NPDES	National Pollutant Discharge Elimination System
OAR	Oregon Administrative Rules
ODFW	Oregon Department of Fish and Wildlife
OHRC	Oregon Hatchery Research Center
Services	combined National Oceanic and Atmospheric Administration Fisheries Service and U.S. Fish and Wildlife Service
SMU	species management unit
STEP	Salmon and Trout Enhancement Program
USFWS	U.S. Fish and Wildlife Service

Executive Summary

In the state of Oregon, approximately 42 million hatchery-produced Pacific salmon, steelhead, and trout are planted into public waters annually. The Oregon Department of Fish and Wildlife (ODFW) operates 33 fish hatcheries plus 13 rearing ponds, acclimation sites, and trapping facilities. The primary purpose of most hatchery programs is to support recreational and commercial fisheries. Other programs are focused on conservation of depleted, threatened, or endangered populations and the reintroduction of native species. Although hatchery programs are intended to provide a positive benefit for fisheries or conservation, interaction between hatchery and wild populations occurs with potential risk to wild populations. The ODFW has developed policies to guide the design and implementation of hatchery programs to reduce potential negative impacts of hatchery fish on wild populations while still achieving programmatic goals. In addition, hatchery programs that culture or potentially interact with U.S. Endangered Species Act (ESA) threatened or endangered populations must comply with the terms and conditions and reasonable and prudent measures resulting from consultations under the ESA.

Hatchery programs designed to augment or provide harvest opportunities have successfully supported commercial, tribal, and recreational fisheries. These fisheries contribute to both economic and cultural aspects of societies. Harvest hatchery programs are managed to ensure risk to naturally produced native fish is within acceptable and clearly defined limits. Conservation hatchery programs play an important role in supplementing natural populations, reintroduction of species, and the conservation and recovery of imperiled populations. Conservation programs are designed to provide a survival advantage compared to survival in the natural environment while having minimal impact on genetic, ecological, and behavioral characteristics of natural populations. Hatcheries also serve an educational role in communities and schools, providing opportunities to learn about fish populations, biology, and conservation.

Although hatchery programs are operated with the goals of providing conservation or harvest benefits, all hatchery programs potentially impose risks on natural populations. The type and level of risk can vary with the type of program and the status of the natural population(s) it interacts with. Risks related to the operation of hatcheries fall into four broad categories: genetic, ecological, fish health, and environmental. Genetic risks occur because the hatchery environment differs from the natural environment to the extent that hatchery fish can genetically diverge from natural populations, potentially causing loss of fitness in the natural population. Ecological risks occur when hatchery fish detrimentally interact with natural-origin fish in the natural environment. Fish health risks occur because the operation of fish hatcheries has the potential to amplify pathogens and parasites, or to introduce novel pathogens, potentially putting natural populations at risk. Hatcheries must comply with environmental regulations to maintain water quality related to water withdrawals and discharge. Water must be properly treated and monitored when it is returned to a stream. The ODFW implements and complies with hatchery conservation and management strategies, policies, and plans to minimize impacts of hatchery programs on wild fish. These documents include The Native Fish Conservation Policy, the Fish Hatchery Management Policy, the Fish Health Management Policy, Hatchery Genetic and Management Plans, and the Conservation Plans for the State of Oregon. These policies and plans provide guidelines for the management of wild and hatchery fish in Oregon.

Many of the hatchery programs operated by ODFW may directly or indirectly interact with federally listed threatened or endangered salmonid species, necessitating consultation under the federal ESA. The consultation process to obtain authorization under the ESA for a hatchery program involves numerous steps. The process entails development of a Hatchery and Genetic Management Plan (HGMP), initiation of consultation with the listing federal agency, and following the consultation process through each step, working with the federal agency. HGMPs are comprehensive plans describing all aspects of hatchery programs, facilities, and effects on natural populations. HGMPs are the instruments used in federal ESA consultation for hatcheries and are submitted to obtain authorization to operate hatchery programs under the ESA. ODFW has developed HGMPs for Oregon hatchery facilities which contain the specific program objectives and provide detailed information on the operational guidelines and management strategies for each program to achieve the objectives and to maintain the genetic integrity of the natural populations and hatchery programs. ESA authorizations typically contain reasonable and prudent measures and terms and conditions designed to minimize the risk of take of listed species. In addition, the federal listing agency must develop a recovery plan that may contain additional measures that are designed to minimize risk and enhance the probability of recovery of the listed species that could affect the hatchery program.

The ODFW has developed policy documents and management plans to address hatchery program operation, management practices to minimize impacts of hatchery programs on native fish populations, management practices for fish health in the fish hatcheries, and hatchery operational practices to avoid environmental impacts. The strategies in these hatchery conservation and management policies and plans are implemented to minimize impacts of hatchery programs on native, wild fish, including populations listed as threatened or endangered under the ESA. The ODFW has established a comprehensive approach to minimize the effects of hatchery programs on the native wild fishes of Oregon. These ODFW policies are also consistent with measures typically employed to minimize negative impacts on listed species.

1 Introduction

In the state of Oregon, approximately 42 million hatchery-produced Pacific salmon, steelhead, and trout are planted into public waters annually. The species planted include Chinook Salmon *Oncorhynchus tshawytscha*, Coho Salmon *O. kisutch*, steelhead trout *O. mykiss*, Chum Salmon *O. keta*, and resident trout species. The primary purpose of most hatchery programs is to support recreational and commercial fisheries. Other programs are focused on conservation of depleted, threatened, or endangered populations and the reintroduction of native species. Releases of hatchery fish typically occur within the native ranges of the species in river reaches where naturally reproducing native populations are present. Consequently, although hatchery programs are intended to provide a positive benefit for fisheries or conservation, interaction between hatchery and wild populations occurs with potential risk to wild populations. The Oregon Department of Fish and Wildlife (ODFW) has developed policy measures to guide the design and implementation of hatchery programs to reduce potential negative impacts of hatchery fish on wild population while still achieving programmatic goals. In addition, hatchery programs that culture or potentially interact with federal Endangered Species Act (ESA) threatened or endangered populations must comply with the terms and conditions and reasonable and prudent measures resulting from consultation under the ESA.

2 Status of Native Fish Species and Regulatory Overview

Currently, there are 23 federally-listed fish species (Evolutionarily Significant Units [ESU] or Distinct Population Segments [DPS])[1] in Oregon; 17 of these are trout, salmon, or steelhead species (i.e., salmonid species; Table 1). Four of the federally listed salmonid fish species are also listed under the Oregon Endangered Species Act (Table 1). ODFW has been identified as a state land owning or managing agency and has responsibilities under Oregon Administrative Rules (OAR) 635-100-0135[2] and 635-100-0140[3]. However, OAR 635-100-0170[4] states, "An incidental take permit shall not be issued for any species listed under the federal ESA. An incidental take permit or statement issued by a federal agency shall be considered a waiver of any state protection measures or requirements otherwise applicable to the actions allowed by the federal agency;" therefore this report focuses on the federal ESA regulatory process.

Table 1. State and Federal Threatened and Endangered Fish Salmonid Species in Oregon

ESU/DPS	Scientific Name	Status	
		State	Federal
Bull Trout (Range-Wide)	*Salvelinus confluentus*		Threatened
Columbia River Chum Salmon	*Oncorhynchus keta*		Threatened
Lahontan Cutthroat Trout	*Oncorhynchus clarkii henshawi*	Threatened	Threatened
Lower Columbia River Chinook Salmon	*Oncorhynchus tshawytscha*		Threatened
Lower Columbia River Coho Salmon	*Oncorhynchus kisutch*	Endangered	Threatened
Lower Columbia River Steelhead	*Oncorhynchus mykiss*		Threatened
Middle Columbia River Steelhead	*Oncorhynchus mykiss*		Threatened
Oregon Coast Coho Salmon	*Oncorhynchus kisutch*		Threatened
Snake River Chinook Salmon (Fall)	*Oncorhynchus tshawytscha*	Threatened	Threatened
Snake River Chinook Salmon (Spring/Summer)	*Oncorhynchus tshawytscha*	Threatened	Threatened
Snake River Sockeye Salmon	*Oncorhynchus nerka*		Endangered
Snake River Steelhead	*Oncorhynchus mykiss*		Threatened
Southern Oregon/Northern California Coast Coho Salmon	*Oncorhynchus kisutch*		Threatened
Upper Columbia River Spring Chinook Salmon	*Oncorhynchus tshawytscha*		Endangered
Upper Columbia River Steelhead	*Oncorhynchus mykiss*		Threatened
Upper Willamette River Chinook Salmon	*Oncorhynchus tshawytscha*		Threatened
Upper Willamette River Steelhead	*Oncorhynchus mykiss*		Threatened

Note:
Source: ODFW 2024a

Hatchery programs that propagate salmonid species are most likely to have negative interactions with native salmonid populations but may interact with non-salmonid species. This report focuses on

[1] Federally listed species are listed at the ESU or DPS level, where each ESU or DPS can include one or more closely related populations.
[2] Endangered Species Management Plans for State Land Owning or Managing Agencies Survival Guidelines for Species Listed as Threatened or Endangered https://oregon.public.law/rules/oar_635-100-0135
[3] Endangered Species Management Plans for State Land Owning or Managing Agencies https://oregon.public.law/rules/oar_635-100-0140
[4] Threatened and Endangered Species Incidental Take Permits https://oregon.public.law/rules/oar_635-100-0170

management of hatchery programs and how negative interactions with native salmonid populations are minimized.

Hatcheries generally need substantial volumes of water for operation. These volumes require water rights to withdraw water from surface or ground water supplies. In addition, the effluent from hatcheries is typically discharged to surface waters adjacent to the facilities and is regulated under the National Pollutant Discharge Elimination System (NPDES). Hatcheries that propagate less than 20,000 pounds of cold-water animals (fish) per year may not require a NPDES permit to operate (EPA 2024).

3 Overview of Hatchery Programs in Oregon

The ODFW operates 33 fish hatcheries plus 13 rearing ponds, acclimation sites, and trapping facilities. Of these hatcheries, 7 are federally funded, 9 are state funded, 14 are funded by a combination of state and federal funds, and 1 is funded by a power producer. In addition, the Oregon Legislature created ODFW's Salmon and Trout Enhancement Program (STEP) in 1981 to create opportunity for volunteers to participate in the restoration of native stocks of salmon and trout. One facet of STEP is working in collaboration with ODFW to culture and release trout and salmon. STEP's program goals are to rehabilitate and improve natural habitat and native fish stocks, ensure that harvest does not exceed fish population's reproductive capability, provide for citizen volunteer participation in achieving ODFW's fish management objectives, and support public education programs (ODFW 2024b).

Hatchery programs in Oregon propagate approximately 42 million fish annually, comprising numerous species across a variety of geographic locations. Hatchery programs support recreational, commercial, and treaty fisheries; mitigation obligations; and conservation efforts (McMillan et al. 2023). Losses to wild populations caused by overfishing, loss of habitat, and blockage of migratory routes resulted in the widespread use of hatcheries to boost fish abundance (Waples 1991). Hatchery program types are broadly categorized as harvest or conservation and are further delineated by the incorporation of natural origin broodstock (integrated) or maintain the hatchery program separately from the natural population by using only hatchery origin fish for broodstock (segregated). Integrated programs are designed to support natural populations or provide fisheries opportunity while reducing the genetic risks of domestication and loss of fitness. Segregated programs are designed to provide fisheries opportunity while having minimal interaction with natural origin populations, thus reducing the impact and risk of these programs (ODFW 2010; HSRG 2004, 2009; Figure 1). Some harvest programs are segregated from the natural population(s), while other programs, termed conservation/harvest, are integrated and designed with harvest and conservation goals. In addition, some harvest programs include natural origin fish in the broodstock (integrated) to minimize genetic risk to natural populations but are operated and managed for fisheries opportunity. Harvest programs are further divided into augmentation and mitigation programs. Mitigation programs are funded and operated to mitigate for an environmental impact, such as the effects of a hydroelectric project. Augmentation programs are non-mitigation programs that support fisheries. The integrated conservation/harvest programs function as both conservation and harvest programs, supporting both the natural population and contributing to harvest opportunities. These programs are sometimes stepping-stone programs intended to incorporate a progressively greater proportion of natural-origin fish in the broodstock to transition from harvest to conservation support programs. Conservation programs are subdivided into restoration/recovery and supplementation programs. Restoration/recovery programs are designed to support recovery of listed species or to restore populations to vacant habitat. Supplementation programs are designed to boost depleted populations. The role of conservation programs ranges from supplementing depressed natural populations to programs designed to recover imperiled populations to maintaining refugial populations or genetic material for populations facing extinction. In some cases, mitigation programs are used for conservation goals.

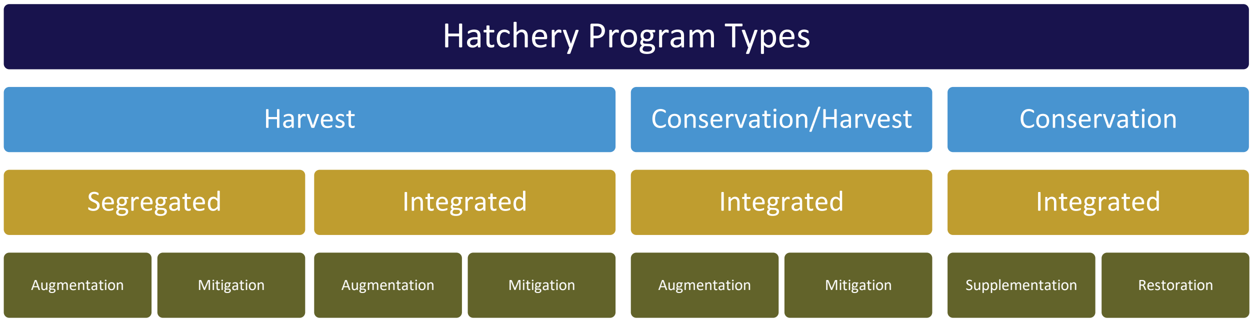


Figure 1. Hierarchy of hatchery program types

Harvest programs exceed all other classes of programs combined, comprising over 73% of hatchery production. Conservations programs comprise about 9% and conservation/harvest programs comprise over 16% of production (Table 2). In addition, there are 36 STEP programs that release over 3.4 million fish to State waters (Table 3). The STEP program also provides approximately 130,000 eggs to over 660 schools for the Egg-to-Fry educational program.

Table 2. Oregon Hatchery Program Summary[1]

Program Class	Number of Programs	Total Release Target
Conservation	13	3,799,000
Conservation/Harvest	13	6,903,750
Mitigation and Harvest Augmentation	75	30,338,760
Grand Total	101	41,041,510

Note:

1. Releases include some fish that are raised or acclimated at Salmon and Trout Enhancement Program (STEP) facilities. See Table 3.

Table 3. Summary of Salmon and Trout Enhancement Program Production

Watershed District	Education	Harvest/ Education	Harvest (Acclimation)[1]	Conservation (Acclimation)	Grand Total
Coos/Coquille	--	1,798,500	420,000	--	2,218,500
Deschutes	--	--	--	60,000[2]	60,000
Rogue	--	90,000	--	--	90,000
Mid-Coast	22,000	20,000	--	--	42,000
North Coast	52,200	200,000	40,000	--	292,200
North Willamette	--	--	375,000	--	375,000
Umpqua	--	245,000	--	--	245,000
Statewide Egg to Fry Program	130,000	--	--	--	130,000
Grand Total	**204,200**	**2,353,500**	**835,000**	**60,000**	**3,452,700**

Notes:

1. Release totals do not include all programs with STEP volunteer assistance at acclimation sites.
2. Releases are part of the Deschutes reintroduction programs above the Pelton/Round Butte Project.

Fish production targets and program types vary across the state. Most conservation fish production and conservation programs are located in the Deschutes, Grand Ronde, John Day, and North Willamette watershed districts. The Lower Columbia watershed district (harvest program) has substantially larger fish releases than the other watershed districts, and conservation/harvest programs are most numerous and release the most fish in the John Day and South Willamette watershed districts (Table 4; Table 5). The STEP program releases are concentrated in the Coos/Coquille, North Coast, North Willamette, and Umpqua watershed districts.

Table 4. Summary of fish production targets by hatchery program type in each watershed district

Watershed District	Program Type			Grand Total
	Conservation	Conservation/Harvest	Harvest	
Deschutes	1,929,000	250,000	50,000	2,229,000
Grand Ronde	1,390,000	215,000	801,460	2,406,460
John Day	150,000	1,860,000	1,575,000	3,585,000
Lower Columbia	--	--	16,169,100	16,169,100
North Coast	--	--	2,414,350	2,414,350
North Willamette	300,000	--	2,187,000	2,487,000
Rogue	--	--	3,032,250	3,032,250
South Willamette	--	4,578,750	547,500	5,126,250
Umpqua	30,000	--	3,562,100	3,592,100
Grand Total	3,799,000	6,903,750	30,338,760	41,041,510

Table 5. Summary hatchery program types in each watershed district

Watershed District	Program Type			Grand Total
	Conservation	Conservation/Harvest	Harvest	
Deschutes	5	1	2	8
Grand Ronde	5	1	3	9
John Day	1	3	3	7
Lower Columbia	--	--	9	9
North Coast	--	--	21	21
North Willamette	1	--	7	8
Rogue	--	--	14	14
South Willamette	--	8	2	10
Umpqua	1	--	14	15
Grand Total	13	13	75	101

4 Benefits of Hatchery Programs

Hatchery programs designed to augment or provide harvest opportunities have successfully supported commercial, tribal, and recreational fisheries (Heard 2001; Paquet et al. 2011; HSRG 2014). The majority (70% to 80%) of Pacific Northwest coastal fisheries are supported by hatchery programs (Trushenski et al. 2010). Hatchery-supported fisheries contribute to the economic (Naish et al. 2007) and cultural aspects of societies (Earth Economics 2021; HSRG 2014). Highland Economics (2022) estimated that the recreational fishery catch in Oregon comprises 68% hatchery salmon and steelhead and 70% hatchery trout. Similarly, the commercial catch of salmon in Oregon comprises 70% hatchery fish. Hatcheries also serve an educational role in communities and schools, providing opportunities to learn about fish populations, biology, and conservation (ODFW 2017). Hatchery programs play an important role in supplementing natural populations, reintroduction of species, and the conservation and recovery of imperiled populations (Naish et al. 2007; Paquet et al. 2011). Janowitz-Koch et al. (2017) found that a Chinook Salmon supplementation program provided a long-term demographic boost to the population. Hess et al. (2012) concluded that a Chinook Salmon supportive breeding hatchery program can successfully boost population size with minimal impacts on fitness of the wild population. Hatchery programs implementing HSRG hatchery management principles in the Columbia River basin improved the conservation status of steelhead, Chinook Salmon, and Coho Salmon populations while providing increased harvest (Paquet et al. 2011). Nuetzel et al. (2023) conducted research suggesting that reintroduction of Spring Chinook Salmon to Lookingglass Creek, Oregon, using juveniles from hatchery captive broodstock had the adaptive capacity to contribute to recovery goals. For threatened and endangered stocks, hatchery programs offer pathways to demographically support the populations and to conserve genetic diversity (Naish et al. 2007).

5 Risks of Hatchery Programs

All hatchery programs potentially impose risks on natural populations. The type and level of risk can vary with the type of program and the status of the natural population(s) it interacts with. The ESA listing of threatened and endangered Pacific salmon and steelhead species in the 1990s through present coincided with research and concerns related to the effects of hatchery programs on West Coast salmon and steelhead natural populations. In a recent review of over 200 peer-reviewed publications on the effects of hatchery programs on wild fish, McMillan et al. (2023) found that production programs (synonymous with harvest programs) and production-supplementation programs (roughly synonymous with conservation-harvest programs) carried the greatest adverse effects (75% and 74% of publications reviewed, respectively) and had no beneficial effects (0% of publications reviewed). Recovery programs (roughly synonymous with conservation programs) had the lowest adverse effects (4% of publications reviewed) and the greatest beneficial effects (29% of publications reviewed).

The greatest risk concerns have centered around genetic issues related to relative reproductive success, survival, and phenotypic characteristics of hatchery and wild fish in natural environments (Kostow 2009). Much of the management focus has been on attempting to operate hatchery program that are genetically isolated from natural populations (segregated programs) and programs that intentionally integrate natural-origin fish in the broodstock to foster gene flow between the hatchery and natural populations to minimize divergence (integrated programs). Harvest programs are often segregated programs while conservation programs are typically integrated. These two management strategies carry varying risks for the native populations.

Fish propagated in a hatchery tend to become adapted to the hatchery environment. This process, known as domestication selection, poses a risk to wild populations when there is introgression between hatchery and wild fish (Busack and Currens 1995; Howe et al. 2024). Genetic risks to wild populations include direct genetic effects and indirect genetic effects. Direct genetic effects occur when hatchery fish hybridize with wild fish, potentially leading to loss of interpopulation genetic diversity and outbreeding depression (Waples 1991). Loss of genetic diversity may occur when locally adapted populations become more homogenized due to the presence of hatchery fish, particularly if hatchery fish are not derived from local broodstock or are present on spawning grounds due to straying. Outbreeding depression is a loss of fitness in offspring that may occur when hybrids are produced from stocks with genetic incompatibility, such as may occur when a hatchery stock that has diverged from the natural population spawns with wild fish.

Indirect genetic effects include reduced population size and low effective population size (Waples 1991). Reduction in the wild population size, which may occur through mechanisms of interaction with hatchery fish such as loss of diversity and outbreeding depression, as well as ecological effects such as competition, predation by hatchery fish, disease, and shifts in natural predator abundance. Reduction in population size may also occur when mixed stock fisheries comprising hatchery and wild fish results in serious declines in the less abundant wild stock. Reduced abundance can have an indirect effect on genetic population structure and selection regimes, potentially causing directional genetic changes in wild populations (Waples 1991). Populations with low effective population size (a genetic concept approximately related to the number of individuals that reproduce per generation) can result in a loss of genetic variability, limiting the evolutionary potential of the population to adapt to changing conditions and compromising its long-term ability to survive. Low effective population size can also lead to inbreeding depression that can result in loss of fitness (Waples 1991).

Ecological risks occur when hatchery fish detrimentally interact with natural-origin fish in the natural environment. This is often related to the size of the program and physical and behavioral differences between hatchery and wild fish. Productivity of wild populations may be significantly reduced by hatchery programs, even when there are no genetic risks (Kostow 2003, 2009). Other processes related to hatchery programs that pose risk to native populations include disease effects, fisheries effects, epigenetic effects, and hatchery effects on the ocean (McMillen et al. 2023). Hatchery strategies have been developed and implemented to decrease these risks, such as incorporating local-origin, wild fish in broodstock, increasing phenotype similarity between hatchery and wild fish, or segregating hatchery and wild fish.

Ecological implications have received less emphasis than genetic implications in risk analyses of hatchery programs (Kostow 2009). Management strategies designed to reduce genetic risks may sometimes, paradoxically, increase ecological risks, such as the use of local broodstock, high proportions of wild fish in broodstock, and increased reproductive success of hatchery fish (Kostow 2009). Kostow (2009) identified the following factors that contribute to the ecological risk of hatchery programs:

- **Large releases of hatchery fish**: Large scale releases of hatchery fish can magnify even relatively small ecological interactions. Large release numbers coupled with habitat degradation or loss and high harvest rates may interact to affect wild populations. Although large releases of hatchery fish may also have genetic implications, ecological risks can operate without genetic interactions.
- **Density-dependent mortality increased by hatchery fish**: Density dependence affects survival relative to the abundance of juvenile salmonids. At low densities, survival increases. Survival decreases as populations increase, and ultimately, density dependence limits survival when the population approaches carrying capacity. Such effects may occur in freshwater or marine environments. When large numbers of hatchery fish are present, wild populations can experience density dependent growth or survival as if the wild population is much larger than it actually is, decreasing the productivity of the wild population.
- **Hatchery fish do not emigrate after release**: Hatcheries may release fish prior to the smolt stage (the life stage that emigrates to the marine environment) intentionally, such as fry, parr, or pre-smolts. In addition, some hatchery programs may, unintentionally, produce fish that residualize in the freshwater environment despite being part of a smolt-release hatchery strategy. In general, the more time spent in freshwater by anadromous hatchery fish, the greater the opportunity for and effect of ecological interactions with wild fish, such as density dependent decreased growth and survival, competition for food and territories, predation, and disease transmission.
- **Physical difference between hatchery and wild fish**: To increase their survival, hatchery fish are often grown to a larger size at release than their wild conspecifics. This size advantage may infer a competitive advantage over wild fish and increase their ability as predators. Hatchery fish may also demonstrate more aggressive behavior than wild fish, conveying a competitive advantage to hatchery fish. Spawn timing may differ between hatchery and wild fish. Earlier spawning fish are likely to have offspring that emerge earlier than later spawning fish. These offspring would

have the opportunity to establish prior residence over later emerging fish, and they would be bigger due to the additional time for growth. Both of these characteristics are strong determinants of success in competitive interactions (Rhodes and Quinn 1998).

If hatchery fish spawn later than wild fish, they may disturb the wild fish redds, reducing the reproductive success of the wild fish. Return and spawn timing has been shifted inadvertently by some hatchery programs. Selecting fish to shift hatchery run and spawn timing has also been used as a management strategy. It has been used to temporally isolate hatchery and wild spawners to minimize introgression or to enhance fishing opportunities by increasing the time when fish are available to catch.

- **Fish Health:** Hatcheries may amplify pathogens and/or introduce novel pathogens. These pathogens may be transmitted to fish in the natural environment, putting native populations at risk. The effluent from hatcheries, high density of fish in hatchery fish culture systems, and large numbers of fish released all may contribute to increase the risk of transmitting pathogens to natural populations. Hatcheries may acquire novel pathogens, putting the hatchery program(s) and native species at risk. Recently, a novel *Myxidium* parasite was discovered at three ODFW trout hatcheries. The outbreak was contained by following biosecurity measures and disposing of the fish in infected raceways. However, this event illustrates the potential risk of disease in fish hatcheries and the importance of biosecurity protocols and the fish health staff (ODFW 2024c)
- **Environmental effects**: Potential environmental effects of hatcheries include diminished water quality through discharge of effluent containing suspended solids, chemicals, or water temperature that differs from the natural environment. Discharge from hatcheries may result in eutrophication, toxic chemicals in the natural environment, or undesirable changes in water temperature in the natural environment. Native fish may be entrained in hatchery intakes or outfalls (ODFW 2010). Outfalls may cause false attraction, where fish are attracted to the outfall due to flow, odor, or water temperature. This may cause undesirable changes in fish behavior.

6 Strategies to Reduce the Risks of Hatchery Programs

Numerous management strategies have been developed and employed to attempt to reduce the genetic and ecological risks of operating hatchery programs to wild populations. For conservation programs, genetic effects may be addressed by using native broodstock (of the target population), incorporating wild fish in the broodstock (integrated program; HSRG 2004, 2009), attempting to maintain a sufficiently large effective population size to avoid deleterious genetic drift (Busack and Currens 1995), and limiting the proportion of hatchery-origin adults on the spawning grounds (HSRG 2004, 2009). In some intensive conservation programs, genetic methods are used to identify broodstock of the correct stock to avoid inadvertently incorporating fish from other populations (Busack and Currents 1995) and are used to develop estimates of relatedness among the broodstock to optimize spawning crosses to avoid inbreeding.

Segregated harvest programs address genetic effects by using only hatchery-origin fish for broodstock. The returning fish are subject to fisheries, and the programs are normally designed to return fish to a terminal location (such as a hatchery fishways/trap) so they can be removed, minimizing the number of hatchery fish that can reproduce with wild fish in nature. These harvest program management strategies contribute to fisheries while decreasing the number of returning adult hatchery fish that escape to the natural spawning grounds. For all hatchery programs it is recommended to mark 100% of the fish and release fish in locations where they can be managed as returning adults to limit the number on the spawning grounds (HSRG 2004, 2009).

Ecological effects (HSRG 2004, 2009; Kostow 2009) may be addressed by releasing smaller numbers of hatchery fish, releasing numbers of hatchery fish within the carrying capacity of the system (HSRG 2004, 2009; Kostow 2009), releasing hatchery fish of similar size to wild fish (Rhodes and Quinn 1999), limiting the total number of hatchery fish released at a regional scale, releasing only actively migrating smolts, locating release locations away from sensitive habitat, using acclimation sites to influence homing to desired reaches, operating hatchery programs to synchronize return migration and spawning timing with wild fish, restricting the number (proportion) of hatchery fish spawning in reaches with wild fish (HSRG 2004, 2009), marking 100% of the hatchery fish to facilitate mark-selective fisheries, and identifying hatchery fish for management activities such as broodstock collection and sampling and for monitoring and evaluation and research (HSRG 2004, 2009; Kostow 2009).

Environmental effects can be addressed by operational improvements and/or facility improvements. Effluent should be treated in treatment ponds and/or by filtering to remove solids and chemicals to meet water quality standards. Water temperature issues, normally caused by discharging water that has warmed in relation to water in the natural environment, should be monitored. Operational changes may alleviate this issue. More problematic water temperature challenges could require re-design of the water system, treatment system, or rearing environment in the hatchery to reduce unwanted temperature differences in the discharge water. Entrainment of fish at water intakes or outfalls is addressed by properly screening intakes and outfalls to prevent fish from entering. False attraction, where fish are attracted by flow, odors, or desirable water temperature from outfalls, is not easily remedied without re-directing the discharge to another location. Many hatcheries have non-consumptive water rights requiring that water be returned to the river. This requirement may make it more difficult to address false attraction issues.

6.1 Policy Documents

Hatchery programs are operated to provide conservation and fisheries benefits. However, the operation of hatchery programs also carries risks to native species and the natural environment. The overarching goal of a hatchery program is to achieve programmatic benefits while minimizing these risks. ODFW implements and complies with hatchery conservation and management strategies and policies and plans to minimize impacts of hatchery programs on wild fish. These documents include the Native Fish Conservation Policy (ODFW 2002), Fish Hatchery Management Policy (FHMP; ODFW 2010), Fish Health Management Policy (ODFW 2003), hatchery program management plans (ODFW 2024d), and the conservation plans for the State of Oregon. These policies and plans provide guidelines for the management of wild and hatchery fish in Oregon. In addition, consultations under ESA typically result in terms and conditions and reasonable and prudent measures in biological opinions and permits. ESA recovery plans for listed species may dictate how hatchery programs integrate with overall recovery strategies and actions.

6.1.1 The Native Fish Conservation Policy

The 2002 Native Fish Conservation Policy is in place to ensure the conservation and recovery of native fish in Oregon (ODFW 2002; revised 2003). This policy's main focus is conserving naturally produced native fish, which is a result of the ESA delisting decision criteria and the foundation of long-term sustainability of native species and hatchery programs alike (ODFW 2002). This policy provides the basis for management of hatcheries, fisheries, habitat, predators, competitors, and pathogens as they relate to the sustainable production of naturally produced native fish. The policy has three areas of emphasis: (1) the defensive conservation approach to ensure the avoidance of serious depletion of native fish; (2) the proactive conservation approach to restore and maintain native fish at levels providing ecological and societal benefits; and (3) consistent with native fish conservation, ensure that opportunities for fisheries and other societal resource uses are not unnecessarily constrained (ODFW 2002).

The policy lists three conservation goals:

1. Prevent the serious depletion of any native fish species by protecting natural ecological communities, conserving genetic resources, managing consumptive and nonconsumptive fisheries, and using hatcheries responsibly so that naturally produced native fish are sustainable.
2. Maintain and restore naturally produced native fish species, taking full advantage of the productive capacity of natural habitats, in order to provide substantial ecological, economic, and cultural benefits to the citizens of Oregon.
3. Foster and sustain opportunities for sport, commercial, and tribal fishers consistent with the conservation of naturally produced native fish and responsible use of hatcheries.

The policy outlines a number of key elements, including the following:

- Naturally produced fish are foundational for the long-term sustainability of native fish species in all geographic regions of the State. The ODFW shall manage native fish to maintain and restore naturally reproducing native fish species, provide recreational commercial, cultural, and aesthetic benefits of optimum native fish populations to present and future citizens, and contribute benefits to their ecosystems.

- Hatcheries shall be used responsibly to meet the goals of this policy. ODFW shall weigh options for conservation actions to restore naturally producing native fish such that the management actions address and help remedy the primary factors of decline, consider economic effects, and consider the potential for success.
- Native fish shall be managed at the species management level and incorporate population structure within species management units and base sustainability standards on biological attributes related to species performance.
- Fisheries management shall use precautionary strategies when faced with scientific uncertainty but may keep biological risks within acceptable limits using monitoring and evaluation with responsive management, and also implement research to address uncertainties.
- Non-native fish and hatchery-based fisheries shall be managed to optimize fisheries consistent with the conservation of naturally produced species.

The success of the Native Fish Conservation Policy largely depends on conservation plans that are developed for locally-adapted individual species management units. The plans will be implemented incrementally depending on availability of funding and prioritization by ODFW, which are affected by tribal governments, management partners, and the public (ODFW 2002). Once developed, the State will continue to maintain these plans.

The policy includes implementing conservation plans that include a range of options for recovery strategies, fisheries, and the responsible use of hatchery fish, such as is prescribed in the state conservation plans and the National Oceanic and Atmospheric Administration Fisheries Service (NOAA Fisheries) recovery plans. The highest priority shall be placed on management units that contain fish listed under the federal or state ESAs, contain state-sensitive species, or contain native fish populations exhibiting continued decline or risk of extirpation. Management units that have new hatchery programs or programs in need of substantial change are also emphasized in the policy.

Other items described in the policy include education and training requirements related to the Policy for ODFW staff, Commissioners, and management partners and interim criteria for management unit status and performance to ensure conservation of native fish. The policy also describes how to implement the criteria to classify a management unit as “at risk” (ODFW 2002). This policy is used to identify and prioritize native populations for conservation measures and to provide operational protocols for hatcheries to minimize the effects of their programs on naturally producing native fish populations and species.

6.1.2 Fish Hatchery Management Policy

The 2010 FHMP is currently used for ODFW hatchery operations and describes hatcheries as a tool for management and conservation of fisheries and the range of possible applications of this policy (ODFW 2010). This document provides general guidelines and measures for fish culture programs regarding genetic resources of native fish populations spawned or reared within hatcheries. The FHMP also describes best management practices that ensure conservation of both hatchery- and natural-origin fish, which are important to maintaining fisheries opportunities and for the natural production of native fish (ODFW 2010).

The goals of the FHMP include fostering and sustaining fishing opportunities while maintaining conservation priorities for naturally reproducing native fish populations, contributing to the sustainability of naturally reproducing native fish populations, maintaining genetic integrity and resources of native fish populations that are spawned or reared in captivity, and minimizing adverse ecological impacts to watersheds (ODFW 2010). Operating principles identified by the FHMP include removing as many random mortality effects as possible without influencing native fish life or experience in their habitats. This operating principle is dependent upon funding, program type, facility, and operational flexibility. The policy requires that hatchery program management plans (HPMPs) shall be developed and implemented in consultation and coordination with management partners and the public, in coordination with native fish conservation plans. Other operating principles include managing hatchery programs to provide optimum fishery opportunities and conservation benefits, maximizing the quality of fish produced at state hatcheries, and using monitoring and evaluation protocols to assess and achieve program objectives (ODFW 2010).

The FHMP provides a comprehensive policy for the planning and coordination of management objectives, the identification and development of hatchery program objectives, fish culture operational guidelines, facility operational guidelines, monitoring and evaluation goals, record keeping, and staff training requirements (ODFW 2010). The FHMP is a centralized source for general information about hatchery management but does not provide exhaustive detail for each point and should be used with other regulatory literature.

6.1.3 Hatchery Program Management Plans

The 2010 FHMP dictates that hatchery management plans shall be developed following the objectives and guidelines in the FHMP. There have been 33 HPMPs developed for hatchery facilities operated by ODFW that detail hatchery facilities, program design, and operational parameters following the FHMP guidelines (ODFW 2024d). These HPMPs provide descriptions of the facilities and staffing, descriptions and goals of the programs, and detail how the programs are designed and managed to meet the following objectives of the FHMP:

- Foster and sustain opportunities for sport, commercial, and tribal fishers consistent with the conservation of naturally produced native fish.
- Contribute toward the sustainability of naturally-produced native fish populations through the responsible use of hatcheries and hatchery-produced fish.
- Maintain genetic resources of native fish populations spawned or reared in captivity.
- Restrict the introduction, amplification, or dissemination of disease agents in hatchery-produced fish and in natural environments by controlling egg and fish movements and by prescribing a variety of preventative, therapeutic, and disinfecting strategies to control the spread of disease agents in fish populations in the state.
- Minimize adverse ecological impacts to watersheds caused by hatchery facilities and operations.
- Communicate effectively with other fish producers, managers, and the public.

6.1.4 Fish Health Management Policy

Published in 2003, the ODFW Fish Health Management Policy describes measures that minimize the impact of fish diseases on Oregon’s fish resources (ODFW 2003). This document applies to all ODFW hatchery operations including STEP, fish propagation projects, cooperative salmon hatchery programs, and the non-departmental import, transport, release, or rearing of non-aquaria species (ODFW 2003). It is ODFW’s responsibility to restrict the introduction, amplification, and dissemination of disease agents in hatchery-origin fish and in natural environments (ODFW 2003). This is accomplished through controlling the transfer of fish and eggs among hatchery facilities and to the natural environment, applying preventative measures and treatments, using therapeutics, and following disinfecting strategies. Further, the objectives of the Fish Health Management Policy are achieved through inspecting and detecting disease agents in fish from both fish hatcheries and natural environments while also requiring the containment and treatment of disease agents (ODFW 2003).

Defined within the policy are Category I through Category IV (ranked from most to least serious) fish diseases and pathogens (ODFW 2003). These category definitions briefly cover the types of pathogens and a non-exhaustive list of diseases within each category. Criteria for importing, exporting, or transferring fish, as it relates to fish health and the transmission of pathogens, is also covered within the document (ODFW 2003). The Fish Health Management Policy lists additional resources for fish disease management, such as the American Fisheries Society Fish Health Blue Book[5], and other documents that may be used to support fish health efforts. Inspection and detection requirements for departmental and non-departmental fish culture programs are outlined. Containment and treatment of diseases and the requirements for using fish carcasses in stream enrichment projects are also defined. The policy is used as a guide to maintain fish health within hatchery settings and prevent negative fish health impacts to hatchery fish and natural-origin fish that may occur as a result of hatchery operations.

6.1.5 Conservation Plans for the State of Oregon and Endangered Species Act Recovery Plans

The Native Fish Conservation Policy (ODFW 2002) requires the development of conservation plans for locally-adapted individual fish species management units (ODFW 2024e). Each plan includes identification of a species management unit, description of the desired biological status of the unit, the unit's current status, short- and long-term strategies to conserve the unit, assessment of the primary factors causing the gap between the current and desired status, the monitoring and evaluation (or research) needed to gauge success of the plan, a process for modifying corrective strategies, measurable criteria, reporting requirements, and potential impacts to other native fish species (ODFW 2002). The conservation plans contain hatchery-related management actions including smolt release targets and targets/limits for the percentage of hatchery fish on the spawning grounds (pHOS).

Federal ESA recovery plans are non-regulatory documents that include the path and tasks required to restore and secure listed populations to become self-sustaining. Recovery plans are developed with federal, state, tribal, local governmental, nongovernmental, and other interested parties. Recovery plans are intended to result in a listed species being reclassified from endangered to threatened status or result in the delisting and removal of the species from ESA protections. Recovery plans include specific management actions necessary to achieve species recovery; objective, measurable criteria for delisting; and estimates of the time and costs required to achieve the plan's goal.

Table 6 lists the state and federal plans for species management units (SMUs), ESUs, and DPSs in Oregon.

[5] https://units.fisheries.org/fhs/fish-health-section-blue-book-2020/

Table 6. Conservation plans and federal recovery plans for species management units, evolutionarily significant units, and distinct population segments in Oregon

SMU, ESU, or DPS	Entity	Plan Name	Year
Coastal Chinook Salmon, Spring Chinook Salmon, Chum Salmon, Winter Steelhead, and Summer Steelhead SMUs	State	Coastal Multi-Species Conservation and Management Plan	2014
Lower Columbia River Coho, Lower Columbia River Chinook, Columbia River Chum ESUs, and Lower Columbia River Steelhead DPS	State/ Federal	Lower Columbia River Conservation and Recovery Plan for Oregon Populations of Salmon and Steelhead	2010
Mid-Columbia Steelhead DPS	State/ Federal	Conservation and Recovery Plan for Oregon Steelhead Populations in the Middle Columbia River Steelhead Distinct Population Segment	2010
Oregon Coast Coho ESU	State	Oregon Coast Coho Conservation Plan for the State of Oregon	2007
	Federal	Recovery Plan for Oregon Coast Coho Salmon Evolutionarily Significant Unit	2016
Rogue Fall Chinook Salmon SMU	State	Conservation Plan for Fall Chinook Salmon in the Rogue Species Management Unit	2013
Rogue Spring Chinook Salmon SMU	State	Rogue Spring Chinook Salmon Conservation Plan	2007
Southern Oregon/Northern California Coast Coho ESU; Rogue-South Coast Winter Steelhead SMU; Rogue Summer Steelhead SMU	State	The Rogue–South Coast Multi-Species Conservation and Management Plan	2021
Upper Willamette Spring Chinook ESU and Winter Steelhead DPS	State/ Federal	Upper Willamette River Conservation and Recovery Plan for Chinook Salmon and Steelhead	2011
Snake River Basin Fall Chinook DPS	Federal	ESA Recovery Plan for Snake River Fall Chinook Salmon (*Oncorhynchus tshawytscha*)	2017
Snake River Spring- and Summer-Run Chinook Salmon and Snake River Basin steelhead	Federal	ESA Recovery Plan for Snake River Spring/Summer Chinook Salmon (*Oncorhynchus tshawytscha*) & Snake River Basin Steelhead (*Oncorhynchus mykiss*)	2017
Southern Oregon/Northern California Coast ESU of Coho Salmon	Federal	Final Recovery Plan for the Southern Oregon/Northern California Coast Evolutionarily Significant Unit of Coho Salmon (*Oncorhynchus kisutch*)	2014
Coterminous United States Bull Trout DPS	Federal	Recovery Plan for the Coterminous United States Population of Bull Trout	2015
Lahontan Cutthroat Trout	Federal	Lahontan Cutthroat Trout (*Oncorhynchus clarkii henshawi*) Recovery Plan	1995
		Updated Goals and Objectives for the Conservation of Lahontan Cutthroat Trout (*Oncorhynchus clarkii henshawi*)	2019

6.2 Oregon Hatchery Research Center

The Oregon Hatchery Research Center (OHRC) is a cooperative research project between the ODFW and the Oregon State University Department of Fisheries, Wildlife, and Conservation Sciences. OHRC research is vital to the success and implementation of hatchery programs by informing hatchery management that better supports angler opportunity and wild fish conservation. The center is also charged with helping Oregonians understand the role and performance of hatcheries in responsibly protecting Oregon's native fishes. The OHRC focuses on the following three areas of research:

1. Understand mechanisms that may create differences between hatchery and wild fish
2. Develop approaches to manage hatchery fish that conserve and protect native fish
3. Methods to increase imprinting and homing back to the hatchery

The research the OHRC conducts is published in peer-reviewed journals and is used to inform the management of hatchery program and wild fish population in Oregon.

6.3 Hatchery Practices to Limit Negative Effects of Hatcheries on Wild Fish

ODFW has developed specific objectives for hatchery programs to minimize negative effects on wild fish. In general, every hatchery program shall achieve the following goals:

1. Provide conservation and/or a fishery benefit.
2. Provide a net survival advantage (egg to adult) over naturally produced fish.
3. Have minimum adverse interactions of hatchery programs on native fish populations and watershed health such as competition, predation, genetic introgression, and disease amplification.
4. Have minimum adverse effects of hatchery programs on native fish populations and watershed health such as water quality and quantity, solid and chemicals waste, and fish passage.
5. Hatchery programs shall be sustainable over time.

The hatchery program objectives are detailed in the 33 Hatchery Program Management Plans and are summarized in Section 6.1.3. Hatchery programs are broadly categorized into two types: harvest and conservation.

Harvest programs operate to enhance or maintain fisheries without impairing naturally reproducing populations (Figure 2). Harvest programs are often segregated programs where only hatchery-origin fish are collected for broodstock and natural-origin fish are excluded. Alternatively, many harvest programs are integrated. These two strategies are both intended to reduce negative impacts on natural populations: segregated programs attempt to keep hatchery and natural origin fish separate by minimizing hatchery fish access to natural spawning areas, while integrated programs minimize the risk of domestication selection in the hatchery from affecting natural populations. Fish from hatchery harvest programs and naturally-produced native fish are managed separately in fisheries and on spawning grounds, as necessary for conservation. This may be accomplished by spatial and/or temporal segregation and also by marking hatchery fish so they can be identified by hatchery staff and biologists as well as by anglers and in harvest operations (i.e., mark-selective fisheries). There are two types of harvest programs:

1. Harvest augmentation programs, which are used to increase fishing and harvest opportunities where there is no mitigation program in place
2. Mitigation programs, which are used pursuant to an agreement to provide fishing and harvest opportunities lost as a result of habitat deterioration, destruction, or migration blockage

Harvest hatchery programs are managed to ensure risk to naturally produced native fish is within acceptable and clearly defined limits. Harvest programs may use only hatchery-origin fish for broodstock from existing programs and manage for minimal spatial or temporal overlap between hatchery- and natural-origin fish in spawning areas. Alternatively, some harvest programs may incorporate broodstock derived from naturally-produced native fish or transition to naturally produce native fish for broodstock. These approaches will depend on which broodstock strategy will best meet the conservation objectives of the natural populations.

Conservation programs operate to maintain or increase the number of naturally-produced fish without reducing the productivity of naturally-reproducing populations (Figure 3). Conservation programs are designed to provide a survival advantage compared to survival in the natural environment with minimal impact on genetic, ecological, and behavioral characteristics of natural populations. Implementation of conservation programs shall include monitoring and evaluation to control risks and assess achievement of program goals. Once program goals of a conservation program are met, the program will be discontinued. There are numerous strategies cited in the FHMP (ODFW 2010) that can be used to develop and implement a conservation program. These include:

- Supplementation – a portion of an imperiled population is propagated in a hatchery to increase survival and provide a demographic boost to the population. In some cases, naturally produced native fish from outside the river basin may be used to supplement an imperiled population.
- Restoration – The best available, suitable non-local hatchery or natural-origin native broodstock are used to propagate and out-plant fish to establish a population in habitat that is vacant of that fish species.
- Captive broodstock – maintains a portion or all of an imperiled population in a protected hatchery environment for the entire life cycle to maximize survival and the number of progeny produced.
- Captive rearing – maintains a portion of an imperiled population in the hatchery environment for part of its life cycle that cannot be maintained in the wild.
- Egg banking – temporarily relocates a population from habitats that cannot sustain the population to another natural or artificial habitat that can support the population.
- Cryopreservation – freezes sperm from naturally produced native fish for later use in conservation.
- Experimental – investigates and resolves uncertainties relating to the use of hatcheries as a fish conservation tool.

Both conservation and harvest hatchery programs are managed to minimize negative effects on natural populations while achieving programmatic goals. These management strategies seek to minimize negative genetic consequences that may result from the hatchery programs through:

- Implementation of risk reduction strategies for identification of the source population for broodstock collection,
- Composition of hatchery and wild fish in the broodstock,
- Spawning matrix design,
- Minimization of domesticating selection in the hatchery environment,
- Reduction of straying of returning adults,
- Minimization of precocial maturation and residualism in the hatchery population,
- Control of the proportion of hatchery spawners on the natural spawning grounds, and
- Control of the spatial and temporal distribution of hatchery and wild spawners on the spawning grounds.

Behavioral and ecological effects are addressed by culturing fish to appropriate size and physiological readiness to minimize competition and predation, maximize migratory behavior, and manage the spatial distribution and proportion of hatchery to wild spawners in nature.

Genetic Effects – Broodstock and Spawning Strategies: Broodstock sources are chosen to meet programmatic goals. Harvest programs may use segregated broodstock composed entirely of hatchery-origin fish to maintain segregation between hatchery and wild populations and to avoid mining wild fish for broodstock. For conservation and some integrated harvest programs, ideally the broodstock source is the target conservation population. Imperiled populations may not be sufficiently large to safely collect broodstock to support a hatchery program. Depending upon relative risks and benefits, broodstock sources may be obtained from best donor population, hatchery or wild, to supplement an imperiled population or to reintroduce fish to vacant habitat. Conservation hatchery programs should be managed to achieve sufficient effective population size to minimize genetic drift. Spawning matrices can be employed to maximize effective population size in smaller programs. Harvest programs are generally large and are not at risk of genetic drift risks.

Genetic Effects – Gene Flow Management: The ratio of hatchery-origin to natural-origin fish in the broodstock should be designed to achieve conservation goals. Conservation programs typically use broodstock composed of 50% to 100% natural-origin fish to maintain desired gene flow between the natural and hatchery populations to prevent divergence. Broodstock should be collected throughout the temporal distribution of the run to avoid inadvertently shifting run and spawn timing. The age structure of fish selected for broodstock should generally reflect the natural population age structure. The proportion of hatchery fish on the spawning grounds (proportion of hatchery-origin spawners [pHOS]) should be managed to not exceed the target proportion. This allows demographic contribution of the hatchery fish to the natural population while minimizing the effects of hatchery gene flow to the natural population. The goal of managing the proportion of hatchery- and natural-origin fish in the broodstock and on the spawning grounds is to have a net geneflow where the natural-origin influence exceeds the hatchery-origin influence in the integrated hatchery and wild populations.

Genetic Effects – Intensive Hatchery Measures: More intensive measures to maintain the population and diversity may be employed when a population is imperiled and at risk of going extinct, such as captive broodstock, captive rearing, or egg banking programs. These types of program are not currently employed in Oregon.

Ecological Effects – Migratory Behavior: Hatchery fish are released to the natural environment, and for anadromous salmonids, are expected to migrate to the marine environment shortly after release. Hatchery programs have size targets at release for hatchery fish. These targets vary by species and life history types, but also may vary depending on empirical information for specific programs or similar program types. Juvenile fish that are too small may not be physiologically ready to smolt and may not migrate to sea and remain in the stream (residualize). Male fish that are too large at release or grew too quickly in the hatchery may sexually mature at an early age (precocity) and also residualize. Growth trajectory and ultimate size at release both affect the tendency to residualize or become precocial. Survival of juveniles migrating to sea is often positively associated with size at release, but size may also affect the rates of residualism and precocity, and the rate males return from sea as jacks. Juvenile hatchery fish that do not migrate to sea may compete with and prey upon threatened or endangered native fish in the freshwater environment. In addition to the potential negative ecological consequences, the presence of precocial fish and residuals in hatchery populations concomitantly reduces the return of adult hatchery salmon from sea.

Genetic and Ecological Effects – Homing and Straying: The release location and the water upon which the fish have been reared will affect their homing (or straying) upon return from sea as adults. Anadromous salmonids imprint on water sources during freshwater rearing from larval stages through smolting (Keefer and Caudill 2014). Exposing juveniles to water that is not from the location where they are to return may result in excessive straying where hatchery fish return to locations that are undesirable, such as straying into another population or failing to home to critical reaches where managers are attempting to increase the population.

Genetic and Ecological Effects – Managing Hatchery Fish on the Spawning Grounds: Disposition of hatchery-origin adults that return to collection facilities, such as a hatchery fish ladder and trap, follows protocols outlined in the FHMP. The disposition depends in part on the type of program, harvest or conservation, the fish are from. Fish may be collected as broodstock, allowed to spawn in the natural environment, provided for tribal ceremonial and subsistence use, carcasses used for nutrient enhancement in streams, provide additional fishing opportunities, and other uses. Management of adult returns for harvest programs typically minimizes the number of hatchery fish in the natural spawning areas. Conservation programs strive to manage the proportions of hatchery and naturally produced fish in spawning areas. The proportions of natural and hatchery-origin fish in conservation program broodstock and on spawning grounds of population supplemented by conservation programs is designed to foster greater gene flow from the natural population than the hatchery population in the integrated natural-hatchery population to provide a survival advantage while minimizing negative effects on genetic, behavioral, and ecological characteristics of the target populations. In addition, management of hatchery spawners can reduce competition and redd superimposition on the spawning ground and subsequent density dependent effect on progeny.

Genetic and Ecological Effects – Implement Monitoring and Evaluation Program: Conservation programs implement monitoring and evaluation programs to assess progress toward meeting goals and control ecological and genetic risks. Conservation programs proceed with caution to avoid negative effects and optimize positive effects on the population. Success of conservation programs is tied to remediating the causes of the decline that necessitated the conservation hatchery program. When the goals of the conservation program are achieved, the program will be discontinued.

Monitoring and evaluation programs are used to gauge hatchery program success in meeting program and fish management objectives. Monitoring and evaluation programs can improve understanding of the reasons for success or failure, provide risk containment, and provide results to inform adaptive management programs. In order for monitoring and evaluation programs to function effectively, clear goals and objectives for management actions must be defined. Monitoring and evaluation programs should be designed to address the uncertainty of risks: programs with greater uncertainty will require more rigorous approaches. The monitoring and evaluation program shall use generally accepted scientific principles and measures to gather multi-generational information to evaluate hatchery programs relative to the measurable criteria that has been developed for each program. Each hatchery program management plan shall describe how the operations and objectives will be evaluated. Although monitoring and evaluation programs themselves carry some risk to natural populations through collecting and handling fish in the natural environment, they are a critical component of implementing hatchery programs to avoid risks to natural population and improve the programs to achieve objectives and goals.

Fish Health: Hatchery programs have the potential to amplify infectious agents and introduce novel infectious agents to the natural environment, imposing risk to natural native populations. To minimize the probability of this happening, implementation of the hatchery programs and facility operations shall comply with fish health requirements as outlined in the Fish Health Management Policy (ODFW 2003). The policy requires the facility manager to ensure all fish stocks are inspected for a fish health examination a minimum of six weeks before release, transfer, or importation into the state. Regular monitoring must be performed by an ODFW fish health specialist, including screening for parasitic and bacterial agents, and viral examinations. Examinations for *Myxobolus cerebralis*, agent of whirling disease, must be conducted annually. The Facility Manager must direct the treatment or destruction of fish infected with any disease agent that may adversely affect the health of the fish of the State. When live fish have a disease agent, the ODFW shall follow the rules for containment of fish disease agents as described in the Fish Health Management Policy. The Policy describes preventative measures to reduce the probability of disease outbreaks and protocols for therapeutic treatments. The protocol also describes the fish health requirements for using carcasses or fish components for stream enrichment programs.

Environmental Effects: Hatchery facilities shall be designed and operated to minimize impacts to natural populations and their habitats. Water intakes and outfalls shall be screened to avoid entraining wild fish. Facilities that rear programs that can be a risk to endemic populations shall have outfalls double screened to prevent escapes. Hatcheries shall comply with legal obligations including water rights, water use reporting, chemical use and reporting, and fish passage. Water quality standards shall conform to the NPDES permits and reporting requirements. Operation of well-maintained hatchery facilities according to operational rules and regulations helps minimize the effects of hatcheries on the natural environment and native fish populations.

Accurate record keeping is vital for tracking hatchery operations and ensuring that programs are being operated and managed as designed, and that the facility is operating properly. Accurate records help ascertain reasons for problems and confirm successful implementation of programs.

Fish hatchery personnel are trained to assure awareness of and compliance with hatchery program management plans and continuing education on new scientific and technological developments. Hatchery personnel are critical to rearing healthy fish to program specifications and identifying potential problems, such as fish escapes or disease outbreaks. Well trained personnel ensure that hatchery programs and management plans are implemented as designed to reduce effects on natural populations.

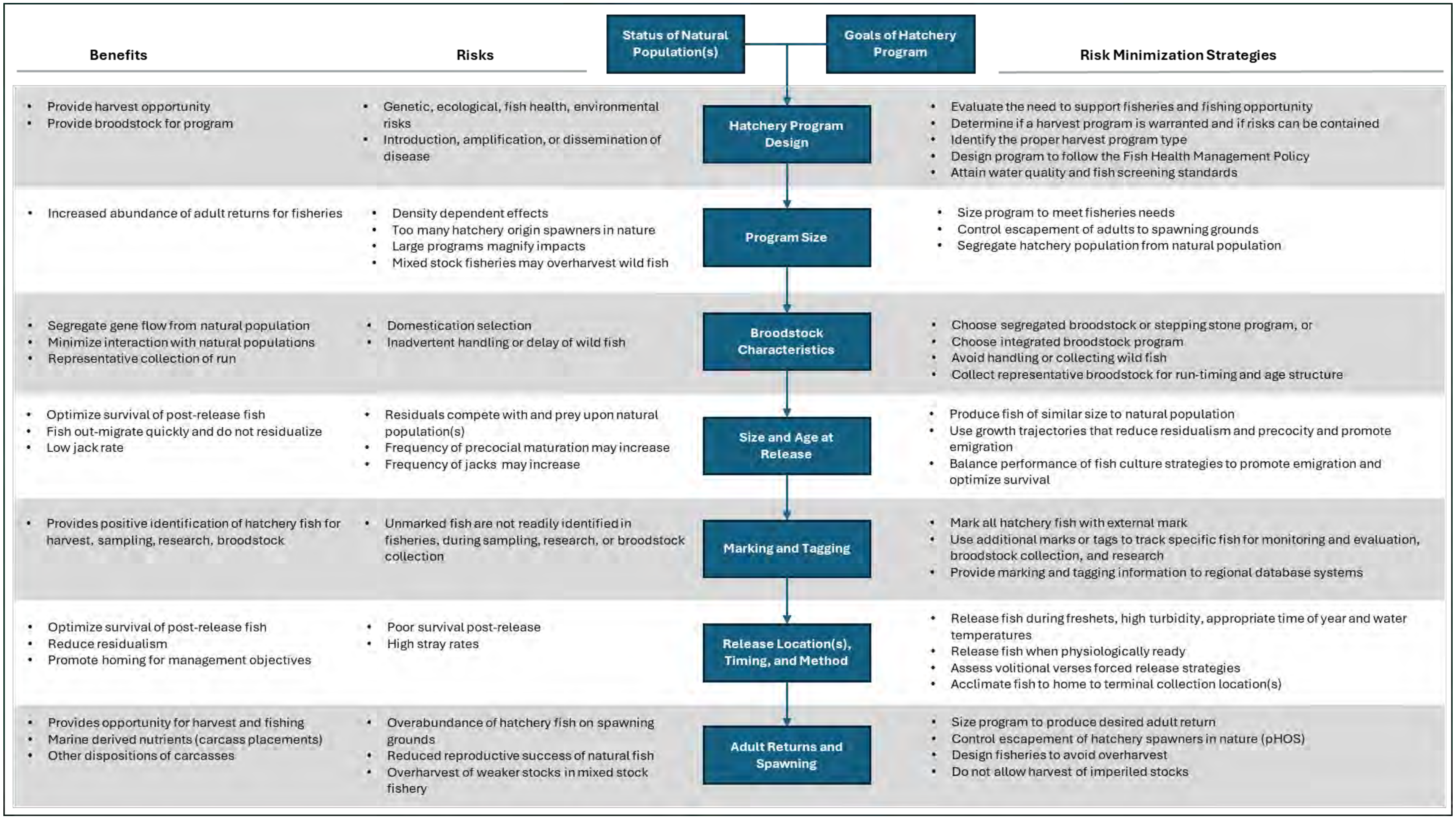


Figure 2. Hatchery harvest program conceptual model for limiting impacts to wild fish and achieving management goals

Status of Natural Population(s) → Hatchery Program Design ← Goals of Hatchery Program

Benefits	Risks		Risk Minimization Strategies
• Conservation of population • Maintain diversity • Restore ecological services	• Genetic, ecological, fish health, environmental risks • Introduction, amplification, or dissemination of disease	**Hatchery Program Design**	• Evaluate the need for a conservation program • Determine if a program is warranted (risk analysis) • Identify the proper conservation program type • Design program to follow the Fish Health Management Policy • Attain water quality and fish screening standards
• Increased abundance of spawners • Demographic support of depleted or imperiled population	• Density dependent effects • Too many hatchery origin spawners in nature • Mining wild fish for broodstock • Large programs magnify impacts	**Program Size**	• Size program to meet conservation needs • Do not exceed carrying capacity • Avoid mining wild fish • Consider effective population size issues related to program size
• Gene flow with natural population • Representative collection of run	• Mining natural population • Effective population size issues • Domestication selection • Divergence from natural population	**Broodstock Characteristics**	• Choose integrated broodstock with natural population, or • Choose best available stock • Avoid overcollection of wild fish • Collect representative broodstock for run-timing and age structure
• Optimize survival of post-release fish • Fish out-migrate quickly and do not residualize • Jack rate similar to wild population	• Residuals compete with and prey upon natural population(s) • Frequency of precocial maturation may increase • Frequency of jacks may increase	**Size and Age at Release**	• Produce fish of similar size to natural population • Use growth trajectories that reduce residualism and precocity and promote emigration • Balance performance of fish culture size targets to promote emigration and optimize survival
• Provides positive identification of hatchery fish for harvest, sampling, research, broodstock	• Unmarked fish are not readily identified in fisheries, during sampling, research or broodstock collection	**Marking and Tagging**	• Mark all hatchery fish with external mark • Use additional marks or tags to track specific fish for monitoring and evaluation, broodstock collection, and research • Provide marking and tagging information to regional database systems
• Optimize survival of post-release fish • Reduce residualism • Promote homing to achieve management objectives	• Poor survival post-release • High stray rates	**Release Location(s), Timing, and Method**	• Release fish during freshets, high turbidity, appropriate time of year and water temperatures • Release fish when physiologically ready • Assess volitional verses forced release strategies • Acclimate fish on natal water (fish imprint from egg to smolt so the longer fish are exposed to natal water the higher the probability of homing successfully)
• Increase abundance of spawners • Provides hatchery origin broodstock • Provides opportunity for harvest (if sustainable) • Marine derived nutrients	• Overabundance of hatchery fish on spawning grounds • Reduced reproductive success of natural fish • Overharvest of weaker stocks in mixed stock fishery	**Adult Returns and Spawning**	• Size program to produce desired adult return and spawner abundance • Control escapement of hatchery spawner in nature (pHOS) • Assess relative reproductive success of hatchery and natural origin fish • Design fisheries to avoid overharvest • Do not allow harvest of imperiled stocks

Figure 3. Hatchery conservation program conceptual model for limiting impacts to wild fish and achieving management goals

6.4 Hatchery and Genetic Management Plans

HGMPs are comprehensive plans describing all aspects of hatchery programs, facilities, and effects on natural populations. HGMPs are instruments used in federal ESA consultation that are used in place of a Biological Assessment (BA) for hatchery program consultations and are submitted to obtain authorization to operate hatchery programs under the ESA. ODFW has developed 77 HGMPs for Oregon hatchery facilities (Table 7) which contain the specific program objectives and provide detailed information on the operational guidelines and management strategies for each program to achieve the objectives and to maintain the genetic integrity of the natural populations and hatchery programs. HGMPs also include detailed information on the status of the affected populations, take of ESA-listed species, other species that may interact with program, details of the hatchery facilities and management of the program. The HGMPs also describe the monitoring and evaluation program and research programs, as applicable. HGMPs are specific to hatchery programs for different species and locations and provide a comprehensive description of the objectives, operational details, facilities detail, assessment detail, and information on the interaction of the program with other species or populations, particularly focusing on ESA-listed populations. HGMPs are the instrument used to enter the consultation process with NOAA Fisheries to obtain authorization to operate hatchery programs and ensure compliance with the ESA. Each HGMP section addresses specific information, actions, and activities for the proposed program. This information includes:

Section 1 provides the general program description, background information such as finding source, responsible organization or individuals, location of the program, goal of the program, program type, justification for the program, performance standards and indicators, expected size of the program, and watersheds targeted by the program, date program started or is intended to start, and current program performance.

Section 2 provides key information related to potential program effects on ESA-listed salmonid populations and the operation of fish propagation programs. It includes detailed descriptions of ESA-listed salmonid populations affected by the program and their status. This section also describes activities that may lead to take, estimates of annual take, and contingency plans if allowable take is exceeded.

Section 3 describes the hatchery program's alignment with ESU-wide hatchery plan or other regionally accepted policies, management plans, cooperative agreements, memoranda of understanding, memoranda of agreement, or other management plans or court orders under which program operates. It describes fisheries that benefit from the program and indicates recent harvest levels and rates for program-origin fish. This section also describes species that could be negatively affected by the program, and species that could negatively affect the program.

Section 4 provides quantitative and narrative descriptions of the hatchery water source, and potential limitations to production related to the water source. It also describes measures that will be taken to avoid take of listed natural fish as a result of hatchery water withdrawal, screening of intakes or outfalls, or effluent discharge.

Section 5 provides comprehensive information of the hatchery facilities, including facilities or equipment for broodstock collection, fish transport, broodstock holding and spawning, incubation, rearing, acclimation and/or release. The section also describes past fish mortality events. The section describes backup and risk aversion measures to minimize take of listed fish related to facility failure, water loss, disease, flooding, or other events.

Section 6 describes information on the broodstock-origin and identity. The section includes the number of natural-origin fish that will be collected for broodstock, levels of natural-origin fish in the broodstock, genetic or ecological differences between the proposed broodstock and natural stocks in the target area. The section describes risk aversion measures to minimize adverse genetic or ecological effects on natural-origin listed fish as a result of broodstock selection practices.

Section 7 describes collection of broodstock, the program broodstock goal, fish health procedures, and disposition of carcasses. The section also includes risk aversion measures that will be applied to minimize the likelihood for adverse genetic or ecological effects on listed natural fish resulting from the broodstock collection program.

Section 8 describes fish mating procedures that will be used, including choice of spawners, fertilization protocols, cryopreservation of gametes (if applicable), and describes risk aversion measures that will be applied to minimize the likelihood for adverse genetic or ecological effects on listed natural fish resulting from the mating scheme.

Section 9 describes incubation and rearing protocols, including life stage survivals, egg take, incubation procedures, ponding protocols, and fish health and monitoring procedure during incubation. Rearing protocols are described for ponding to release, including information on feed, rearing conditions, fish health monitoring, smolt development, and use of “natural” rearing methods (if applicable). The section includes risk aversion measures that will be applied to minimize the likelihood of adverse genetic and ecological effects on listed fish under propagation.

Section 10 describes the fish release levels, and release practices applied through the hatchery program, including proposed release numbers, locations, history of fish releases, dates of release, transportation (if applicable) and acclimation. The section also includes marking, disposition of surplus fish, pre-release fish health certification, and risk aversion measures to minimize the likelihood for adverse genetic and ecological effects on listed fish resulting from fish releases.

Section 11 describes the monitoring and evaluation plan performance indicators, including plans to collect data and staffing and logistical capacity to implement the monitoring and evaluation program. The section includes risk aversion measures that will be applied to minimize the likelihood for adverse genetic and ecological effects on listed fish resulting from monitoring and evaluation activities.

Section 12 describes research programs conducted in direct association with the hatchery program described in this HGMP. The section also describes risk aversion measures that will be applied to minimize the likelihood for adverse ecological effects, injury, or mortality to listed fish as a result of the proposed research activities.

Table 7. Summary of the number of Hatchery and Genetic Management Plans developed for ODFW operated hatchery programs by fish species

Watershed District	Chum Salmon	Coho Salmon	Fall Chinook Salmon	Rainbow Trout	Spring Chinook Salmon	Spring/Summer Chinook Salmon	Summer Steelhead	Winter Steelhead	Grand Total
Lower Columbia and Estuarine Area	--	3	3	--	1	--	--	--	7
Deschutes	--	--	--	--	2	--	1	1	4
Grand Ronde	--	--	--	--	--	5	2	--	7
John Day	--	1	1	--	1	--	1	--	4
North Willamette	1	1	--	--	2	--	2	2	8
South Willamette	--	--	--	1	4	--	1	--	6
North Coast	--	3	3	1	3	--	2	8	20
Rogue	--	1	3	--	1	--	1	3	9
Umpqua	--	2	3	1	1	--	1	4	12
Grand Total	**1**	**11**	**13**	**3**	**15**	**5**	**11**	**18**	**77**

7 Endangered Species Act Consultation Process

7.1 Hatchery Program Federal Consultation Process

The federal ESA provides a program for the conservation of threatened and endangered plants and animals and the habitats in which they are found. The NOAA Fisheries Service (NOAA Fisheries; also known as the National Marine Fisheries Service or NMFS) is the lead federal agency for marine species, including the Pacific salmon and steelhead species and the U.S. Fish and Wildlife Service (USFWS) is the lead agency for species that do not live in marine environments (collectively, the “Services”). However, the delineation of some migratory species covered by the Services is not entirely obvious. The ESA requires federal agencies, in consultation with the USFWS and/or NOAA Fisheries, to ensure that actions they authorize, fund, or carry out are not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of designated critical habitat of such species. This process requires the services to obtain their own authorization under the ESA before approving a proposed hatchery program because authorization under ESA is a federal action. This typically results in a Biological Opinion and Incidental Take Statement to the federal agency from NOAA Fisheries and/or the USFWS. The Incidental Take Statement issued to NOAA Fisheries and/or the USFWS also covers the hatchery operator.

The ESA prohibits any action that causes a "take" of any listed species. In addition, import, export, interstate, and foreign commerce of listed species are all generally prohibited.

Two forms of take are defined in the ESA: Take (also known as direct take) and Incidental Take. Take means "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct." Incidental Take is Take that is unintentional, but not unexpected. When a species is listed as endangered, take prohibitions are automatically extended to it under ESA Section 9. When a species is listed as threatened, the listing federal agency (NOAA Fisheries or USFWS) must issue protective regulations in order to extend any take prohibitions to the species under ESA Section 4(d).

The operation of fish hatcheries may interact with federally listed threatened or endangered species. Although fish hatchery programs are intended to provide conservation benefit, increase target fish populations, or increase fish abundance to support fisheries, the operation of such programs may cause direct or indirect take of federally listed species, particularly federally listed fish species such as Pacific salmon species, steelhead, or bull trout. The owners and/or operators of fish hatchery facilities must obtain coverage under the ESA to continue operations, or risk violating the ESA.

The operation of fish hatcheries may cause direct take of a species when a listed species is being propagated in the hatchery facility. Such programs are typically conservation hatchery programs designed to conserve and recover a listed species. Alternatively, indirect take may be caused by the operation of hatchery programs when the process of capturing broodstock or releasing juvenile fish causes take of a listed species that is not the subject of the hatchery program. For example, a program that rears and releases steelhead may incidentally take listed Chinook salmon during broodstock collection or when juveniles are released to the natural environment and prey upon or compete with the listed Chinook juveniles.

When ESA consultation is required, a Section 7 consultation is performed initially. There are several consultation avenues that are available to authorize an action under the ESA: Actions that result only in indirect take are consulted on under Section 7. Actions that may result in indirect take of species listed as threatened may be authorized under the 4(d) rule. Actions that result in direct take of listed species or the incidental take of an ESA-listed species by a non-federal entity are authorized under Section 10. In special cases, an experimental population, often used for reintroduction of a species, may be authorized under Section 10(j). The authorization type applied to a consultation request depends upon the type of action that is proposed, how it might interact with ESA-listed populations, and the ESA status of the affected population (Figure 5).

7.2 Endangered Species Act Section 7 Consultations

NOAA Fisheries is the lead federal agency for ESA listings of Pacific salmon and steelhead species and performs consultations on these species. USFWS is the lead agency for resident species, such as Bull Trout and Lahontan Cutthroat Trout, and performs consultations on these species. Both Services may be involved in a consultation if an action affects species each agency is responsible for.

The Services uses Section 7 of the ESA to authorize hatchery and fishing actions that are funded, authorized, or carried out by a federal agency. Under Section 7 of the Endangered Species Act, federal agencies must consult with NOAA Fisheries or USFWS when any action the agency carries out, funds, or authorizes may affect species listed as threatened or endangered under the ESA, or any critical habitat designated for it. The Section 7 consultation process follows several steps to determine if a consultation is needed, and if a required consultation can be address through the informal or formal processes (Figure 4). Under Section 7, the Services can authorize take that is incidental to the operation of a hatchery program or to the conduct of a fishery.

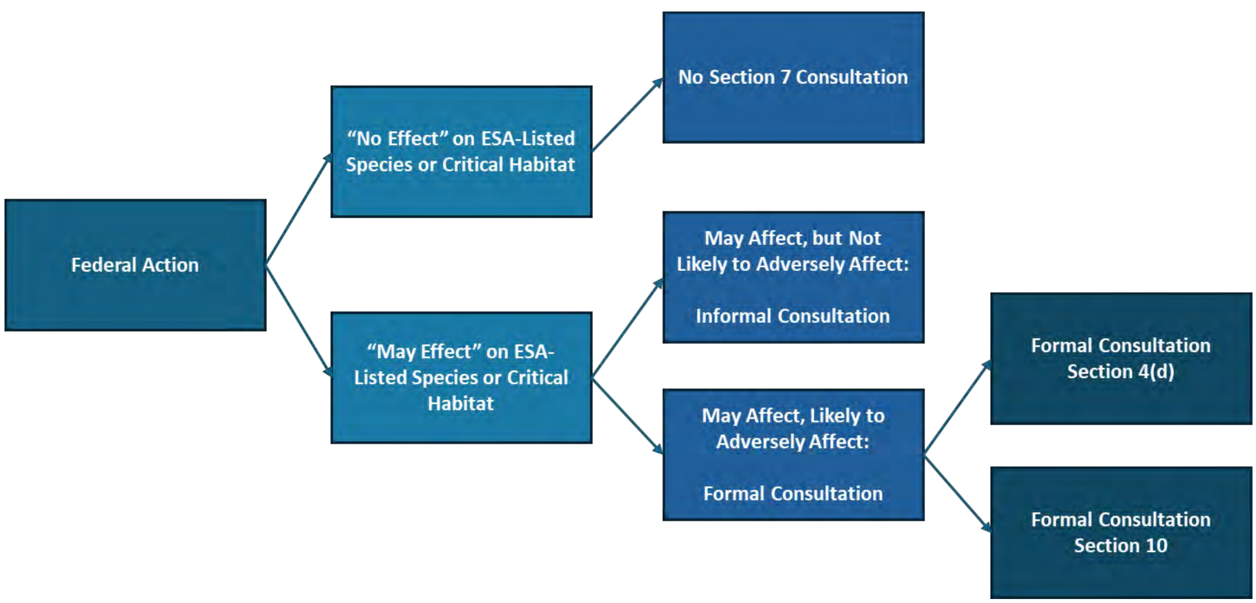


Figure 4. Initial steps required to determine if an Endangered Species Act consultation is required and the level of consultation required for a proposed action

7.2.1 No effect determination

Prior to entering into Section 7 consultation, a federal agency makes a determination that an action does or does not affect all listed species and critical habitat in the action area. If the determination finds that there is no effect, no Section 7 consultation is required and the agency documents the "No Effect" determination in order to explain why section 7 consultation is not necessary.

7.2.2 Informal Consultation

Informal consultation may be used when a federal action agency determines that the action is Not Likely to Adversely Affect (NLAA) listed species and/or critical habitat. When a federal agency makes this determination regarding the proposed action, they submit an informal consultation request to NOAA Fisheries or USFWS. The NLAA determination is made when effects on ESA listed species and/or critical habitat are expected to be extremely unlikely to occur, are so small they cannot be meaningfully measured, detected, or evaluated, or all effects benefit the species and/or critical habitat. NOAA Fisheries or USFWS will provide a letter of concurrence or non-concurrence to the action agency once they receive enough information to make a determination. Issuance of the concurrence letter terminates the consultation process and no further consultation is necessary.

7.2.3 Formal Consultation

If an informal consultation does not result in a "Not Likely to Adversely Affect" (NLAA) determination because adverse effects to listed species are expected, the action agency must request formal consultation. NOAA Fisheries must comply with the NEPA when issuing an Incidental Take Statement. To initiate formal consultation, the action agency must provide information that is typically assembled by the action agency in a BA. However, for hatchery actions, NOAA Fisheries has developed the HGMP template, used in place of a BA, that encompasses the information normally included in a BA in a comprehensive format suitable for conveying information on hatchery program and facilities.

The HGMP is submitted to NOAA Fisheries with a letter making a "Likely to Adversely Affect" determination to request formal consultation. NOAA Fisheries reviews the consultation request, requests more information if needed, and once all the information necessary to initiate formal consultation is acquired, sends a letter of sufficiency to the applicant.

As part of the consultation process, an effects analysis is performed whereby NOAA Fisheries applies the best available scientific information, identifies the types of circumstances and conditions that are unique to individual hatchery programs, then refines the range in effects for a specific hatchery program. The analysis of a Proposed Action addresses six factors:

1. The hatchery program does or does not remove fish from the natural population and use them for hatchery broodstock
2. Potential hatchery fish and the progeny of naturally spawning hatchery fish on spawning grounds and encounters with natural-origin and hatchery fish at adult collection facilities
3. Potential interactions of hatchery fish and the progeny of naturally spawning hatchery fish in juvenile rearing areas, the migration corridor, estuary, and ocean,
4. Research, Monitoring, and Evaluation (RM&E) that exists because of the hatchery program
5. Operation, maintenance, and construction of hatchery facilities that exist because of the hatchery program
6. Fisheries that would not exist but for the hatchery program, including terminal fisheries intended to reduce the escapement of hatchery-origin fish to spawning grounds.

NOAA Fisheries (or USFWS) then drafts a Biological Opinion (BiOp) based on the effects analysis that typically includes an incidental take statement. Following consultation, a BiOp and an incidental take statement authorizing the incidental take (if appropriate) are issued to the federal agency. The intent of a BiOp is to ensure that the proposed project or action will not reduce the likelihood of survival and recovery of an ESA-listed species. A BiOp typically includes conservation recommendations that further the recovery of ESA-listed species. The biological opinion includes reasonable and prudent measures as needed to minimize any harmful effects and may require monitoring and reporting to ensure that the project or action is implemented as described. ESA Section 7 requires the Services to complete the formal consultation within 135 days of receiving all necessary information to conduct the consultation. This timeline can be extended if both agencies agree more time is needed, and in practice this is often the case.

7.2.4 Reinitiated Consultation

Sometimes after completion of consultation, the action changes, a new species is listed, or critical habitat is designated or revised while the action is ongoing. Take may occur when not exempted or other relevant new information becomes available. These scenarios may result in the need to revise the effects analysis in the Biological Opinion or in an informal consultation letter. Reinitiation of consultation is required and shall be requested by the action agency or by NOAA-Fisheries or USFWS. Conditions when consultation may be reinitiated include:

1. If the amount or extent of taking specified in the incidental take statement is exceeded
2. If new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered
3. If the identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the biological opinion or written concurrence
4. If a new species is listed or critical habitat designated that may be affected by the identified action.

Reinitiation is not always required if the conditions change; the changes need to result in the level and/or type of effects to exceed the level and/or type of effects that have previously been considered in the consultation. If reinitiation is necessary, the action agency must follow a similar process as used in informal and/or formal consultation.

7.2.5 Programmatic Consultation

A programmatic consultation addresses an agency’s multiple actions on a program, region or other basis. A programmatic approach streamlines the consultations for broad agency programs or multiple similar, frequently occurring, or routine actions with predictable effects on listed species and/or critical habitat, thus reducing the amount of time spent on individual project-by-project consultations. However, hatchery programs are not generally suitable for programmatic consultation because each hatchery program and setting contains unique combinations of hatchery program types for various species and potentially various listed species that may be affected.

7.2.6 Emergency Consultation

The Endangered Species Act recognizes the need to respond immediately to emergencies. An emergency is a situation involving an act of God, disasters, casualties, national defense or security emergencies, etc., and includes response activities that must be taken to prevent imminent loss of human life or property. Where emergency actions are required that may affect listed species and/or their critical habitats, an action agency may not have the time for the administrative work required by normal consultation procedures under non-emergency conditions. NOAA Fisheries or USFWS will expeditiously process emergency consultations so Federal agencies can complete their critical missions in a timely manner while still providing the protections afforded to listed species and critical habitat under the ESA.

7.3 Endangered Species Act Permits and Authorizations on the West Coast Sections 4(d) and 10(a) of the Endangered Species Act

The Services issue permits and authorizations under sections 4(d) and 10(a) of the ESA for direct and incidental take of listed species in Oregon under carefully defined circumstances and as long as such take will not jeopardize the continued existence of the species or adversely modify its critical habitat. Federal actions, such as ESA Section 4(d) authorizations or ESA Section 10 permits, may require additional analysis under the National Environmental Policy Act (NEPA).

7.3.1 Endangered Species Act Section 10 Authorization

Direct take of listed species, whether listed as threatened or endangered, may be authorized under Section 10(a)(1)(A) of the ESA. Direct take is only permissible for scientific purposes or if used to enhance the propagation or survival of listed species. Hatchery programs that propagate listed species for conservation are authorized under Section 10 10(a)(1)(A).

Section 10(a)(1)(B) may authorize indirect take of a listed species by a non-federal entity. Hatchery programs operated by a non-federal entity that do not rear or release listed species but might encounter them during such activities as broodstock collection or monitoring may be permitted under Section 10(a)(1)(B).

7.3.2 Endangered Species Act Section 4(d) Authorization

ESA Section 4(d) applies only to the indirect or direct take of species listed as threatened and directs NOAA Fisheries or USFWS to issue regulations necessary to conserve species listed as threatened (also known as 4(d) rules). The Services use Section 4(d) rules to allow for regulatory flexibility and to help streamline ESA compliance for actions that have long-term benefits despite generally low levels of take in the short term and that do not contribute to the threats to the continued existence of a species. ESA Section 4(d) rules are federal actions that trigger consultation under Section 7 of the ESA. As a result, a Section 7 consultation must be completed prior to making a Section 4(d) determination. NOAA Fisheries has identified criteria (identified as “limits”) for fishery and hatchery plans that minimize impacts on listed salmon and steelhead. The Section 4(d) rules use the established limits to apply take prohibitions to all actions except those within the specified limits of the rules. If these criteria are met, then additional federal protections are not needed and so, under Section 4(d) of the ESA, take prohibitions would not apply. Actions that meet the Section 4(d) limits may be authorized by the Services.

7.3.3 Designating Experimental Populations under the Endangered Species Act: Section 10(j)

Section 10(j) of the ESA allows the Services to designate populations of listed species as "experimental" to support the reintroduction of at-risk species to foster long-term recovery. This designation allows the Services to re-establish self-sustaining populations in regions that are outside the species' current range when doing so fosters its conservation and recovery.

An experimental population is a geographically-described group that is isolated from other existing populations of the species. The Services must determine whether the population is "essential" to the survival of the species (i.e., the species will go extinct without the reintroduction of this population) or "non-essential" (i.e., the reintroduced population will contribute to restoring the species, but its recovery can be achieved without the population). Individuals in the experimental population are classified as threatened, not endangered, under the ESA. This designation allows the Services to reduce the legal protections required by the ESA, protecting individuals, municipalities, and others who may accidentally harm the fish while engaged in otherwise lawful activities.

Designating experimental allows the Services to advance recovery objectives by re-establishing self-sustaining populations, while simultaneously protecting private landowners, tribes, and local, state, and federal governments from ESA liabilities while they work to develop long-term conservation measures for the species.

7.3.4 The National Environmental Policy Act

NEPA (1970) requires federal agencies to review the environmental effects of any proposed actions they are implementing, funding, authorizing, or otherwise involved in. NEPA requires the federal government to use all practicable means to create and maintain conditions under which humans and nature can exist in productive harmony. The range of actions covered by NEPA is broad, ranging from federal land actions and publicly funded facilities, but also includes permit applications, such as for coverage under the ESA.

Federal agencies use the NEPA process to evaluate the environmental and related social and economic effects of proposed actions. The NEPA process also provides opportunity for public review and comment on the evaluations.

The NEPA process begins when a federal agency develops a proposal to take a major federal action, such as consultation under the ESA. Federal agencies prepare detailed statements assessing the environmental impact of, and alternatives to, major federal actions that may significantly affect the environment. The environmental review under NEPA can involve three different levels of analysis. An action may be categorically excluded if the federal action does not individually or cumulatively have a significant effect on the human environment. This is often not applicable to hatchery programs. If a federal agency determines that an action is not categorically excluded, an Environmental Assessment (EA) must then be prepared. The EA determines whether or not a federal action has the potential to cause significant environmental effects. Generally, the EA includes a brief discussion of:

1. The need for the proposed action
2. Alternatives to the proposed action
3. The environmental impacts of the proposed action and alternatives
4. A listing of agencies and persons consulted

If the agency determines that the action will not have significant environmental impacts, the agency will issue a Finding of No Significant Impact (FONSI). A FONSI is a document that presents the reasons why the agency has concluded that there are no significant environmental impacts projected to occur upon implementation of the action.

If the EA determines that the environmental impacts of a proposed Federal action will be significant, an Environmental Impact Statement (EIS) may be required. An EIS is normally reserved for actions determined to significantly affect the quality of the human environment. Individual hatchery programs normally do not trigger the need for an EIS. The regulatory requirements for an EIS are more detailed and rigorous than the requirements for an EA.

Biology and the NEPA Process

A thorough environmental review in an EIS or EA includes a discussion of the following biological resources:

1. Habitats and Vegetative Communities
2. Migratory Corridors
3. Plants, Wildlife, and Fisheries
4. Special Status Species (such as threatened and endangered species)

Impact Avoidance, Minimization, Mitigation and/or Compensation

One of the most important parts of the NEPA process is to determine which permits are required prior to an action, such as an ESA Section 7 Consultation. The NEPA process not only identifies actions that require authorization, but it allows the public an opportunity to comment on the proposed action.

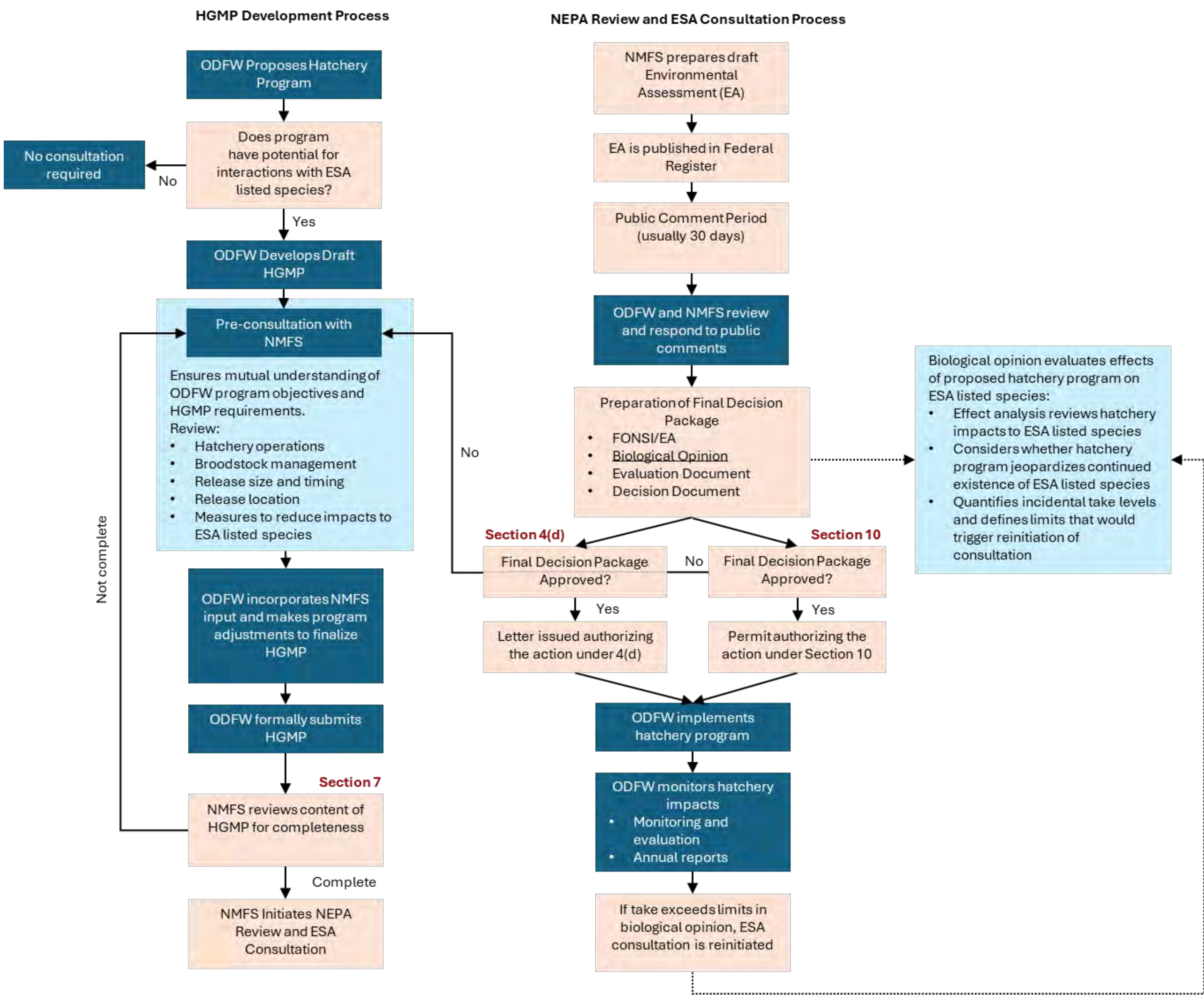


Figure 5. Federal Endangered Species Act consultation process for proposed hatchery programs under Section 4(d) and Section 10

7.3.5 Summary of the ESA Consultation Process

Although the entire scope of the ESA consultation process is quite complex, the consultation process for the operation of hatchery programs (the action) has been well defined. The ODFW may propose a hatchery program to NOAA Fisheries or USFWS for pre-consultation. If the program has no potential for interaction with a listed species or the only effects are beneficial, a finding of No Effect will conclude the process. If there may be an effect, the action may enter informal consultation and be resolved, or proceed to formal consultation. Under formal consultation, the process proceeds through Section 7 of the ESA and dependent on the status of listed species that may be affected and the scope of the proposed action, the consultation may be performed under Section 4(d) or Section 10. Formal consultation for a hatchery program requires development and submission of an HGMP by ODFW. Once the submitted HGMP has been determined to be sufficient, the ESA consultation process commences. The federal consulting agency initiates the NEPA review process by developing an EA and publishing it in the federal register for public comment. The EA (and public comments) is used to determine if the project will have a significant impact or not (the FONSI process). The EA and analysis of significant impact determine the type of consultation that will be required (informal or formal) and, if formal consultation is required, the type of authorization the action will require. The federal consulting agency develops a BiOp based on the HGMP and other information it requires to conduct an effects analysis, determines if the action jeopardizes the continued existence of the species, and quantifies incidental take levels and triggers that would reinitiate consultation. A final decision package is approved and the ODFW receives notice that it is authorized to implement the program under Section 4(d) or Section 10 of the ESA. The ODFW implements the hatchery program, conducts monitoring and evaluation, and produces an annual report. Reinitiation of the consultation may occur if take limits are exceeded, or if the action changes, a new species is listed, or critical habitat is designated or revised.

The ODFW operates hatchery programs to minimize risk to native natural populations and in particular, ESA listed populations. The management and implementation of hatchery program management strategies that minimize risk to natural populations is consistent with the terms and conditions and reasonable and prudent measure often included in the federal consultation decision documents. These strategies are crucial for the protection of native natural fish populations in Oregon and enable the ODFW to operate hatchery programs to provide the benefits of creating and enhancing fisheries opportunities and conservating native fish populations.

8 Conclusions

The ODFW operates numerous fish hatcheries, rearing ponds, acclimation sites, and trapping facilities. Operation of hatchery programs strives to achieve the benefits of the programs for fisheries and conservation while minimizing negative impacts to native fishes. Many of the programs operated at these facilities may directly or indirectly interact with federally listed threatened or endangered salmonid species, necessitating consultation under the federal ESA. The consultation process to obtain authorization under the ESA for a hatchery program involves numerous steps. The process entails, development of a HGMP, initiation of consultation with the listing federal agency, and following the consultation process through each step, working with the federal agency. Consultations may result in authorization to operate a program under Section 4(d) or Section 10 of the ESA, depending on if the listed species is threatened or endangered and if operation of the hatchery program may result in direct or indirect take. ESA authorizations typically contain reasonable and prudent measures (RPMs) and terms and conditions (T&Cs) in the biological opinion and ESA permit designed to minimize the risk of take of listed species. These RPMs and T&Cs must be met to operate the program. Under the ESA, the federal listing agency must develop a recovery plan that may contain additional measures that are designed to minimize risk and enhance the probability of recovery of the listed species that could affect the hatchery program. The ODFW has developed policy documents and management plans to address hatchery program operation, management practices to minimize impacts of hatchery programs on native fish populations, management practices for fish health in the fish hatcheries, and hatchery operational practices to avoid environmental impacts. The strategies in these hatchery conservation and management policies and plans are implemented to minimize impacts of hatchery programs on native, wild fish, including populations listed as threatened or endangered under the ESA. The ODFW has established a comprehensive approach to minimize the effects of hatchery program in the native, wild fishes of Oregon. These ODFW policies are also consistent with measures typically employed to minimize negative impacts on listed species.

References

Busack, C. A. and K. P. Currens. 1995. Genetic Risks and Hazards in Hatchery Operations: Fundamental Concepts and Issues. American Fisheries Society Symposium. 15:71-80.

Earth Economics. 2021. The Sociocultural Significance of Pacific Salmon to Tribes and First Nations. Special Report to the Pacific Salmon Commission.

EPA (U.S. Environment Protection Agency). 2024. National Pollutant Discharge Elimination System (NPDES) Aquaculture NPDES Permitting. https://www.epa.gov/npdes/aquaculture-npdes-permitting#:~:text=A%20fish%20farm%2C%20hatchery%20or,not%20need%20an%20NPDES%20permit. Accessed on May 11, 2024.

Heard, W. R. 2001. Alaska Salmon Enhancement: A Successful Program for Hatchery and Wild Stocks. U.S.-Japan Cooperative Program in Natural Resources (UJNR) Technical Report No. 30.

Hess, M. A., C. D. Rabe, J. L. Vogel, J. J. Stephenson, D. D. Nelson, and S. R. Narum. 2012. Supportive breeding boosts natural population abundance with minimal negative impacts on fitness of a wild population of Chinook salmon. Molecular Ecology · October 2012.

Highland Economics. 2022. Economic Contribution & Value of Hatcheries in Oregon & Washington. Prepared for Hatchery & Wild Coexist. Prepared by: Highland Economic, LLC 2425 NE 50th Ave, Suite 13103 Portland, OR.

Howe, N. S., M. C. Hale, C. D. Waters, S. M. Schaal, K. R. Shedd, and W. A. Larson. 2024. Genomic evidence for domestication selection in three hatchery populations of Chinook salmon, *Oncorhynchus tshawytscha*. Evolutionary Applications. 2024;17:e13656. https://doi.org/10.1111/eva.13656.

HSRG (Hatchery Scientific Review Group). 2004. Hatchery Reform: Principles and Recommendations of the HSRG. Long Live the Kings, 1305 Fourth Avenue, Suite 810, Seattle, WA 98101 (available from www.hatcheryreform.org).

HSRG. 2009. Columbia River Hatchery Reform System-Wide Report. With Funding Support from: Bonneville Power Administration, National Oceanic and Atmospheric Administration, Northwest Power and Conservation, Council Pacific States Marine Fisheries Commission, U.S. Congress.

HSRG. 2014. On the Science of Hatcheries: An updated perspective on the role of hatcheries in salmon and steelhead management in the Pacific Northwest. A. Appleby, H.L. Blankenship, D. Campton, K. Currens, T. Evelyn, D. Fast, T. Flagg, J. Gislason, P. Kline, C. Mahnken, B. Missildine, L. Mobrand, G. Nandor, P. Paquet, S. Patterson, L. Seeb, S. Smith, and K. Warheit. June 2014; revised October 2014.

Janowitz-Koch, I., C. Rabe, R. Kinzer, D. Nelson, M. A. Hess, and S. R. Narum. 2017. Long-term evaluation of fitness and demographic effects of a Chinook Salmon supplementation program. Evolutionary Applications. 12:456–469.

Keefer, M. L. and C. C. Caudill. 2014. Homing and straying by anadromous salmonids: a review of mechanisms and rates. Reviews in Fish Biology and Fisheries 24:333-368.

Kostow, K. 2003. Factors that Influence Evolutionarily Significant Unit Boundaries and Status Assessment in a Highly Polymorphic Species, *Oncorhynchus mykiss*, in the Columbia Basin. Oregon Department of Fish and Wildlife. Information Report #2003-04. October 15, 2003.

Kostow, K. 2009. Factors that contribute to the ecological risks of salmon and steelhead hatchery programs and some mitigating strategies. Reviews in Fish Biology and Fisheries. DOI: 10.1007/s11160-008-9087-9.

Kostow, K. 2012. Strategies for reducing the ecological risks of hatchery programs: Case studies from the Pacific Northwest. Environmental Biology of Fishes. May 2012.

Kostow, K., A. R. Marshall and S. R. Phelps. 2012. Naturally Spawning Hatchery Steelhead Contribute to Smolt Production but Experience Low Reproductive Success. Transactions of the American Fisheries Society 132:780–790.

McMillan, J. R., B. Morrison, N. Chambers, G. Ruggerone, L. Bernatchez, J. Stanford, and H. Neville. 2023. A global synthesis of peer-reviewed research on the effects of hatchery salmonids on wild salmonids. Fisheries Management and Ecology. 30:446–463. Available from: https://doi.org/10.1111/fme.12643.

Naish, K., J. E. Taylor, P. S. Levin, T. P. Quinn, J. R. Winton, D. Huppert, and R. Hilborn. 2007. An Evaluation of the Effects of Conservation and Fishery Enhancement Hatcheries on Wild Populations of Salmon. Advances in Marine Biology, 53.

NMFS (National Marine Fisheries Service). 2016. Recovery Plan for Oregon Coast Coho Salmon Evolutionarily Significant Unit. National Marine Fisheries Service, West Coast Region, Portland, Oregon.

Nuetzel, H. M., P. F. Galbreath, B. J. Staton, C. A. Crump, L. M. Naylor, and G. E. Shippentower. 2023. Improved productivity of naturalized spring Chinook salmon following reintroduction from a hatchery stock in Lookingglass Creek, Oregon. Can. J. Fish. Aquat. Sci. 80: 375–392 (2023) | dx.doi.org/10.1139/cjfas-2022-0114.

ODFW (Oregon Department of Fish and Wildlife). 2002. Native fish conservation policy. Original November 8, 2022, revised September 12, 2003. Accessed at https://www.dfw.state.or.us/fish/CRP/nfcp.asp

ODFW. 2003. Fish health management policy. Oregon Administrative Rules 635-007-0960 through 635-007-1000. September 12. https://www.dfw.state.or.us/fish/hatchery/docs/fish_mgmt_policy.pdf

ODFW. 2010. Fish hatchery management policy. Oregon Administrative Rules 635-007-0542 through 635-007-0548. December 3. https://www.dfw.state.or.us/fish/hatchery/docs/hatchery_mgmt.pdf.

ODFW. 2010. Lower Columbia River Conservation & Recovery Plan for Oregon Populations of Salmon & Steelhead. August 6, 2010. https://www.dfw.state.or.us/fish/CRP/docs/lower-columbia/OR_LCR_Plan%20-%20Aug_6_2010_Final.pdf.

ODFW. 2014. Coastal multi-species conservation and management plan. Accessed at https://www.dfw.state.or.us/fish/CRP/coastal_multispecies.asp

ODFW. 2017. Oregon Fish Eggs to Fry Program. https://www.dfw.state.or.us/fish/STEP/resources-education.asp Accessed July 5, 2024.

ODFW. 2024a. Threatened, Endangered, and Candidate Fish and Wildlife Species in Oregon. Accessed at https://www.dfw.state.or.us/wildlife/diversity/species/threatened_endangered_candidate_list.asp Accessed May 9, 2024.

ODFW. 2024b. The Salmon and Trout Enhancement Program (STEP). https://www.dfw.state.or.us/fish/step/. Accessed May 13, 2024.

ODFW. 2024c. Novel parasite detected in trout at three Oregon fish hatcheries. ODFW Resources, News Releases. March 19, 2024. https://www.dfw.state.or.us/news/2024/03_Mar/031924.asp

ODFW. 2024d. ODFW Hatcheries. https://www.dfw.state.or.us/fish/hatchery/. Accessed May 13, 2024.

ODFW. 2024e. Native Fish Conservation – Conservation Recovery Plans https://dfw.state.or.us/fish/CRP/conservation_recovery_plans.asp. Accessed May 13, 2024

Paquet, P. J., T. Flagg, A. Appleby, J. Barr, L. Blankenship, D. Campton, M. Delarm, T. Evelyn, D. Fast, J. Gislason, P. Kline, D. Maynard, L. Mobrand, G. Nandor, P. Seidel & S. Smith. 2011. Hatcheries, Conservation, and Sustainable Fisheries—Achieving Multiple Goals: Results of the Hatchery Scientific Review Group's Columbia River Basin Review. Fisheries, 36:11, 547-561.

Rhodes, J. S. and T. P. Quinn. 1998. Factors affecting the outcome of territorial contests between hatchery and naturally reared coho salmon parr in the laboratory. Journal of Fish Biology. 53. 1220–1230.

Rhodes, J. S. and T. P. Quinn. 1999. Comparative Performance of Genetically Similar Hatchery and Naturally Reared Juvenile Coho Salmon in Streams. North American Journal of Fisheries Management. 19:670–677.

Trushenski, J., T. Flagg, and C. Kohler. 2011. Use of Hatchery Fish for Conservation, Restoration, and Enhancement of Fisheries. Inland Fisheries Management in North America. Third Edition. Chapter 9. American Fisheries Society. Editors: Wayne A. Hubert, Michael C. Quist.

Waples, R. S. 1991. Genetic Interactions Between Hatchery and Wild Salmonids: Lessons from the Pacific Northwest. Canadian Journal of Fisheries and Aquatic Sciences. 48 (Suppl. 1): 124-133.