

Oregon Hatchery Research Center 2022 Annual Report

To:
Oregon Legislature
State Fish and Wildlife Director
State Fish and Wildlife Commission

By:
Oregon Hatchery Research Center Board

February 1, 2023



Executive Summary

This is the tenth annual report by the Oregon Hatchery Research Center (OHRC) Board to the Oregon Legislature, Oregon Department of Fish and Wildlife (ODFW) Director, and the State Fish and Wildlife Commission. Included in this report are accounts of:

- Composition and activities of the OHRC Board in 2022;
- Appointment of Dr. Seth White as the new Director of the OHRC;
- Prioritization and approval of research proposed in late 2021, issuance of a second request for proposals (RFP), and review of research proposed for the 2023-25 biennium;
- Outreach and education activities conducted by staff and researchers of the OHRC;
- Continued implementation of the OHRC Strategic Research Plan to fulfill the Center's Mission and Goals, addressing previously defined research focus areas and newly identified priorities, including:
 1. If patterns of mate selection observed in the wild-spawning salmon populations can be emulated in hatcheries to improve the fitness of hatchery fish;
 2. If and how hatchery rearing practices impose selection on salmonids that compromises their fitness in the wild, and how fitness differences between hatchery- and natural-origin fish might be reduced or eliminated;
 3. If and how addition of odorants to hatchery water can improve olfactory imprinting by juvenile salmonids and homing of adults;
 4. If thiamine (vitamin B₁) levels in adult hatchery steelhead are below critical levels and, if so, whether thiamine supplementation could improve fish health;
 5. How ODFW's angler-assisted broodstock collection programs differ through practice and success;
 6. How various rearing practices might affect the microbiomes and immune systems of hatchery-origin salmonids; and
 7. Investigations into the cause of fin erosion and opercular deformities in hatchery steelhead;

A copy of this report can be obtained at <https://www.dfw.state.or.us/fish/OHRC/news.asp>

Table of Contents

Introduction and Purpose of this Report	5
Directorship at OHRC	5
The 2022 OHRC Board.....	6
OHRC Board Composition in 2022	6
OHRC Board Activities in 2022	7
OHRC Board Focus for 2023.....	13
The OHRC Mission.....	13
OHRC Activities in 2022	15
Overview	15
Research.....	16
Education and Outreach	20
Funding of OHRC Operations and Activities	22
Operations, Education, and Outreach Funding	22
Research Funding.....	22
Management Applications of OHRC Research Findings	23
Acknowledgements.....	26
Appendix 1: Detailed Activity Reports for the Oregon Hatchery Research Center	27
OHRC Mission Goals 1 and 2: Research Projects	27
Individual Research Projects	27
The Olfactory Imprinting Project (Mission Goals 1.c., 2.d)	27
Geomagnetic Imprinting by Salmon & Steelhead (Mission Goals 1.c, 2.d)	30
Surrogates for Wild Chinook Salmon and Steelhead Trout (Mission Goals 1.b., 2.a.2., 2.b., 2.d.)	30
Hatchery Domestication Selection Project (Mission Goals 1.a, 1.b., 2.d.).....	32
The Alsea Steelhead “Biter Study” (Mission Goals 1.c., 1.b., 1.c., 2.a.1., 2.a.2., 2.b., 2.c.)	34
Effect of Mate Choice on Fitness (Mission Goals 1.a., 1.b., 1.c., 2.a., 2.b.)	34
Hatchery rearing practices that reduce stress and improve immunity system of hatchery salmon (Mission Goals 1.a., 2.a., 2.b.)	36
Effect of thiamine supplementation on the health and survival of hatchery steelhead (Mission Goals 2.a)	37
Impact of Research	39
Technical Reports, Theses and Peer-reviewed Journal Publications.....	39

Presentations at Research Conferences and Meetings	45
OHRC Workshops	48
OHRC Mission Goal 3: Education and Outreach	48
Appendix 2: Announcement for the OHRC’s 2021 fall workshop, <i>Spawning Fresh Ideas</i>	50
Appendix 3: The OHRC’s 2022 fall Request for Proposals	53
Appendix 4: Summary of Proposals Submitted to the OHRC for 2023-25 Funding.....	59
Projects approved in the 2014 OHRC Research Plan	60
1. Differences caused by mate selection	60
2. Improved homing of hatchery salmon through novel rearing strategies: The Olfactory Imprinting Project	60
New proposals	61
3. How does seasonal timing mediate the effectiveness of hatchery carcass additions? Quantifying benefits to the growth and survival of juvenile Chinook salmon in the Upper Grande Ronde Basin	61
4. Tribal and Non-Tribal Public Perceptions of Oregon Hatcheries for Future Hatcheries Outreach and Engagement	61
5. Does Reduced Winter Growth of Hatchery Summer Steelhead Increase Residualization and Reduce Smolt Abundance in a Production Hatchery?	62
6. Assessment of Individual Variability in Thermotolerance Between Wild-Origin and ODFW Hatchery Stock Steelhead (<i>Oncorhynchus mykiss</i>) of the Alsea River	62
7. Evaluating effects of smolt size, condition, and season of release on the quality and abundance of returning adult hatchery salmon	63
8. Understanding and mitigating the effects of hatchery fish on pre-spawning mortality	63
9. Investigating Mechanisms Driving Low Catchability of Deschutes River Hatchery Steelhead	64

Introduction and Purpose of this Report

This report fulfills the Oregon Hatchery Research Center (OHRC) Board's requirement to report to the Legislative Assembly, the State Fish and Wildlife (ODFW) Director, and the State Fish and Wildlife Commission each calendar year on the findings of research projects carried out by the OHRC, and any recommendations regarding current hatchery management practices based on OHRC research projects.

This report constitutes the tenth report of the OHRC Board to the Legislative Assembly, the State Fish and Wildlife Director and the State Fish and Wildlife Commission. Herein, we detail the activities of the OHRC Board during the 2022 calendar year, with reference to past activities; describe the funding and implementation of the Research Plan for the OHRC, as was adopted by the OHRC Board in 2014; and relate scientific information and recommendations produced through research conducted at the OHRC in 2022. This report also outlines the focus for the Board in 2023.

Directorship at OHRC

Through the first months on 2022, Dr. Marc Johnson (ODFW) continued as interim Director of the OHRC, while OSU and ODFW continued their search and hire process to fill the permanent position. Dr. Johnson vacated the interim position after having completed over a year of service in that role, but continues to serve as ODFW liaison to the OHRC. Following Dr. Johnson's tenure, Dr. Selina Heppell (OSU) began service as interim OHRC Director in May of 2022, and continued to serve in this role through much of the year.

Meanwhile OSU continued its process to select and hire a new, permanent Director for the OHRC. Throughout the course of the search and hire process, members of the OHRC Board had opportunity to attend teaching and research seminars presented by candidates for the OHRC Director position. OHRC Board members provided feedback and recommendations directly to Dr. Heppell and ODFW Director, Curt Melcher, at various stages of the search and hire process.

On September 30, 2022, Dr. Seth White began his appointment as Director of the OHRC. An alum of OSU, Dr. White brings a wealth of experience to his new position at OHRC. Formerly serving as Senior Fisheries Scientist with the Columbia River Inter-Tribal Fish Commission and a Fulbright Scholar to the Czech Republic, Dr. White has developed numerous, large-scale research projects aimed to improve fish recovery efforts, with a primary emphasis on Pacific salmonids.

Upon his arrival in September, Dr. White immediately engaged with the OHRC Board and took charge with implementation of the OHRC's request for research proposals to be awarded in the 2023-25 biennium, as described later in this report. Dr. White also assumed role as Principal Investigator for the Olfactory Imprinting Project, initiated by Dr. David Noakes and subsequently led by Dr. Carl Schreck.

The 2022 OHRC Board

Per Oregon Revised Statute 498.825¹, the Director of ODFW is to appoint a 15-member board, consisting of 12 voting members and 3 non-voting members.

The 12 voting members shall represent the following interests:

- 1) Oregon Salmon Commission
- 2) Columbia River gillnet salmon fishery
- 3) wild fish advocacy organizations (2 members)
- 4) statewide sport angling organizations (2 members)
- 5) agricultural industry
- 6) coastal ports
- 7) forest products industry
- 8) the independent scientific community
- 9) fish habitat restoration interests
- 10) Oregon Indian tribes

The 3 non-voting members of the Board shall represent:

- 1) Oregon Department of Fish and Wildlife
- 2) Oregon State University
- 3) federal agency related to fish management

OHRC Board Composition in 2022

In March of 2022, two new members were appointed to the OHRC Board. Mr. Seth Isenberg filled the position previously held by Mr. Brad Halverson, representing Wild Fish Advocacy, and Mr. Peter Gruendike was appointed as representative for Fish Habitat Restoration.

Seth Isenberg's higher education includes degrees in Natural Resources (BS) and Zoology (MS), with additional studies in Evolutionary Ecology. He has served as a board member for Trout Unlimited for over 20 years and is a passionate angler.

Peter Gruendike brings over 16 years of experience in the field of fisheries, having worked for various state and federal agencies, as well as private sector consulting. He has managed a number of river restoration projects and has recently been involved with the large-scale Klamath River Dam Removal Project.

The composition of the OHRC Board, as of December 31, 2022, is presented in Table 1.

¹ https://oregon.public.law/statutes/ors_498.825

Table 1: OHRC Board members by interest group and term expiration date.

Position	Member	Term Expiration
Oregon Salmon Commission	Dwight Collins	06/30/25
Columbia River Gillnet	Derek Wall	06/30/25
Wild Fish Advocacy	Tom Alkire	06/30/25
Wild Fish Advocacy	Seth Isenberg	06/30/23
Sport Anglers	Jack Smith	06/30/23
Sport Anglers	Lindsay Ball	06/30/23
Agriculture	Ted Simon	06/30/24
Coastal Ports	Chuck Pavlik	06/30/24
Forestry	Scott Starkey	06/30/23
Independent Science	Steve Jacobs	06/30/25
Fish Habitat Restoration	Peter Gruendike	06/30/25
Oregon Indian Tribes	Travis Mackie	06/30/25
Federal Agency	Lance Kruzic	Indefinite, non-voting
OSU	Carl Schreck	Indefinite, non-voting
ODFW	Shaun Clements	Indefinite, non-voting

OHRC Board Activities in 2022

Overview

Public health and safety precautions, intended to limit the spread of COVID-19, were exercised through much of 2022. Through the first half of the year, the OHRC Board continued to meet virtually. However, as health risks subsided, the OHRC Board met in-person on June 14, 2022, at the OHRC (with virtual participation as option). This was the first in-person OHRC Board meeting since March of 2020.

Board Meeting Highlights

Due to the substantial workload and abbreviated duration of most online meetings, the OHRC Board met seven times during 2022, focusing much attention on election of a new Board Chair, reviewing ongoing research, and developing funding recommendations for new research. Agendas and minutes for all OHRC Board meetings are posted on the center's website at <https://www.dfw.state.or.us/fish/OHRC/minutes.asp>.

The first OHRC Board meeting of 2022 was held on January 28th. This brief, special meeting was held online, with sole purpose to elect a new Board Chair. Mr. Scott Starkey had been nominated for the Chair position during the Board's previous meeting, but procedural complications had obscured the outcome of an attempted election. During this January 28th meeting, the Board held a brief discussion, then voted 5:4 in favor of electing Mr. Starkey as the new Board Chair. Minutes from the OHRC Board's January 28th, 2022 meeting can be found at: https://www.dfw.state.or.us/fish/OHRC/docs/2022/OHRC_BoardMinutes_01282022_Final.pdf

The second meeting of the OHRC Board in 2022 was held on March 8th. Chair Starkey welcomed the Board and minutes from the Board's last regular meeting, in December of 2021, were approved. New OHRC Board members, Seth Isenberg and Peter Gruendike, were introduced and briefly spoke about their backgrounds and interests. The Board then received a facility update from OHRC Manager, Jen Krajcik, who also highlighted some of the outreach and operational research being performed by and through the OHRC. Following Jen's report, the Board briefly discussed, then approved finalization of their Annual Report for 2021.

Dr. Shaun Clements offered a Legislative session update to the Board, and briefly described a number of bills relevant to fish and fisheries in Oregon. Dr. Marc Johnson followed Shaun's report with an OHRC research budget update, noting that spending by researchers had not exceeded ODFW's commitment for the biennium, and that a surplus of \$144,119 was available to allocate to candidate research proposals.

Drs. Michael Banks, Michael Blouin, and Carl Schreck then offered updates of their ongoing research. Members of the public offered comment and expressed both satisfaction with current projects and stricter compliance with Robert's Rules of Order during Board meetings.

Dr. Marc Johnson offered a review of the process to solicit, review and approve research for funding at the OHRC. Chair Starkey suggested that a separate meeting be held to review project proposals and decide upon them, and this approach was approved through a vote by the Board.

Minutes from the OHRC Board's March 8, 2022 meeting can be found at:
https://www.dfw.state.or.us/fish/OHRC/docs/2022/OHRC_BoardMinutes_03082022_Final.pdf

On March 23, 2022, the OHRC Board met virtually to review a number of research proposals received in 2021 and develop funding recommendations. The following researchers presented their proposals during this meeting, with proposal titles and budgets as listed below:

- Dr. Claire Couch - Optimizing rearing conditions of Pacific salmon for hatchery production and conservation. (\$138,788)
- Dr. Matt Falcy - Do strategies to manage differences between hatchery and wild populations optimally satisfy objectives? (\$191,360)
- Dr. Michael Banks - Automated Sampling of 1,000s of Salmon to Facilitate Hatchery Management (\$137,494)
- Dr. James Peterson - Integrating Socioecological Values and Decision Models for More Effective Salmon Fishery Management (\$244,104)
- Mr. Craig Lawson - Survey and Evaluation of ODFW's Angler-Caught Broodstock Programs for Coastal Steelhead (*Oncorhynchus mykiss*) (\$3,766)
- Dr. Carl Schreck - Elk River Olfactory Imprinting Project (additional \$20,000)
- Dr. Aimee Reed - Efficacy of injectable thiamine treatments to alleviate deficient thiamine levels in eggs of steelhead trout (*Oncorhynchus mykiss*) (\$13,000)

Brief descriptions of these project proposals are included with the meeting minutes, available online through the web address provided on the next page.

Following each presentation, Board members asked researchers about their proposed work. The Board then engaged in discussion of all research proposals and used an online poll to rank them according to favor. A motion was made and carried (8:0) to recommend funding for three projects, those proposed by Drs. Reed and Schreck, and Craig Lawson. This motion was followed by additional discussion and another motion carried (8:0) to offer support of \$50,000 to each of the projects proposed by Drs. Banks and Couch. Minutes from the OHRC Board's March 8, 2022 meeting can be found at:

https://www.dfw.state.or.us/fish/OHRC/docs/2022/OHRC_BoardMinutes_03232022_Final.pdf

On June 14, 2022, the OHRC Board held its fourth meeting of the year at the OHRC. Chair Starkey called the meeting to order and minutes from the previous meeting were approved by the Board. Manager Jen Krajcik offered a facilities update, reported on the OHRC's recent Free Fishing Day and other news from the center. Dr. Selina Heppell then thanked the Board for providing feedback during OHRC Director candidate interviews, introduced Dr. Seth White, and commented that the department was in process of developing an offer to Dr. White. Next, Dr. Marc Johnson provided a brief update on the status of the research budget and contracts.

The Board then received a presentation by Dr. Carl Schreck, detailing the work and progress of the Wild Surrogate Project, which has been studying differences between wild and hatchery Chinook Salmon and steelhead, and producing more wild-like fish through modified hatchery practices. The project, initiated by Dr. Schreck and Dr. David Noakes, has been operating for 14 years and has delivered tens of thousands of wild-like salmonids to researchers studying how dam passage and other experiences might affect threatened species.

Following Dr. Schreck's presentation, Dr. Marc Johnson presented a brief history of fisheries research in Oregon, the OHRC, and development of its research program. Marc reminded the Board that results from most OHRC projects were still pending the return of adult fish, but that it is the duty of the Board to deliver recommendations from those studies to management when results have been obtained. He encouraged the Board to identify a process to develop recommendations, which prompted discussion among Board members and a suggestion to use online tools to share draft recommendations.

Chair Starkey then initiated a conversation about future directions for the OHRC Board that focused on how the Board might review scientific information and develop recommendations for management. Board member Seth Isenberg offered to review relevant literature, and member Tom Alkire suggested that such a review might be an appropriate task for the new OHRC Director, once appointed.

The OHRC Board then discussed which business might be addressed during their next meeting, including appropriate speakers, review of priority research concepts to be included in the forthcoming request for proposals, and plans to engage with tribal fisheries managers.

Minutes from the OHRC Board's June 14, 2022 meeting can be found at:
https://www.dfw.state.or.us/fish/OHRC/docs/2022/OHRC_BoardMinutes_06142022_Final.pdf

The OHRC Board met again at the OHRC on September 13, 2022. Chair Starkey opened the meeting and past meeting minutes were approved by the Board. Jen Krajcik provided a facilities update, reporting that the OHRC's dam apron reconstruction was near complete, and that staff were preparing to rebuild the grizzlies (valves) for the Carnes Creek water intake system. Jen also reported on an aquaculture class that she had hosted at the OHRC, and several upcoming outreach opportunities.

Following Jen's report, Dr. Selina Heppell introduced Dr. Seth White as the new OHRC Director, with official start date of September 30, 2022. Dr. White spoke briefly about his 13 years of experience as a fisheries scientist with the Columbia River Inter-Tribal Fish Commission (CRITFC), and his recent engagement with ODFW hatchery managers at their biennial meeting in Elkton, Oregon.

Dr. Marc Johnson then provided a brief research budget report, which was followed by updates from researchers funded through the OHRC, including Drs. Aimee Reed, Marc Johnson, Michael Blouin, and Michael Banks. Full accounts of their research progress is included later in this Annual Report. Dr. Johnson and Chair Starkey also provide a brief synopsis of the ODFW Hatchery Managers Meeting, which they both attended in July at the Big K Ranch in Elkton, Oregon. At this meeting hatchery managers discussed the myriad challenges they face at their facilities, many brought on by a changing climate, staffing shortages, and aging infrastructure. Managers also engaged with OHRC researchers during a session led by Dr. Johnson, which included presentations and discussion with Drs. Banks and Blouin.

During this meeting the Board also briefly discussed the revenue sources supporting OHRC research, and whether additional reporting might be needed. The Board also received presentations by CRITFC fisheries researchers Dr. Ilana Koch and Hayley Nuetzel that described the hatchery fish management in the Columbia River and tribal perspectives, citing two case studies that highlighted the values of hatchery-produced salmon. The first study focused on supplementation of spring Chinook Salmon in Johnson Creek while the second study focused on reintroduction of spring Chinook Salmon to Lookingglass Creek, Oregon. Both studies presented evidence that first generation progeny of hatchery fish have lower relative reproductive success than their natural-origin counterparts, but this difference may diminish over generations as fish become naturalized to the receiving stream.

Following these presentations, Dr. Marc Johnson offered a brief overview of process and schedule for prioritization of research concepts to be included with the next OHRC request for proposals, emphasizing the current need for concept prioritization. However, the Board opted to table the discussion and postpone the prioritization process until a special meeting to be held in October. After several brief comments by members of the public, the meeting was adjourned.

Minutes from the OHRC Board's September 13, 2022 meeting can be found at: https://www.dfw.state.or.us/fish/OHRC/docs/2022/OHRC_BoardMinutes_09132022_Final.pdf

On October 7, 2022, the OHRC Board met virtually to identify priority research concepts to be included with the OHRC's request for proposals (RFP). After Chair Starkey opened the meeting, Dr. Seth White provided a brief review of the OHRC's Mission and definition of terms as they

relate to soliciting the RFP. The Board then engaged in discussion of candidate concepts, heard comments from Rep. Boomer Wright, then voted unanimously (9:0) to include the following nine concepts in the OHRC's 2022 RFP:

1. How might release strategies for hatchery salmonids be improved, especially for climate change adaptation?
2. How can rearing conditions and smolt release be modified to improve survival of hatchery salmonids?
3. What are alternative measures of risk to wild stocks from hatchery strays, and how might they be monitored over time?
4. Do hatchery traits pass to wild fish, and will they reverse over time?
5. How do different hatchery spawning practices (e.g., segregated vs. integrated broodstock management) affect the genetic and demographic characteristics of wild populations, and does the impact vary based on the health of wild populations?
6. Which traits are under selection in salmonid hatcheries that impact wild stocks, and how might fish culture techniques be modified to ameliorate selection?
7. How do hatchery operations effect the habitat of wild fish (positively and negatively)?
8. What are public perceptions of salmonid hatcheries, and how might outreach and education be effectively engaged to achieve a better understanding of their role in salmonid management?
9. How can communities effectively contribute to research and outreach through local conservation and supplementation programs?

Minutes from the OHRC Board's October 7, 2022, meeting can be found at:

https://www.dfw.state.or.us/fish/OHRC/docs/2022/OHRC_BoardMinutes_10072022_Final.pdf

The OHRC Board's final meeting of 2022 was held on December 6th, at ODFW's Adair Village office. Chair Starkey called the meeting to order and past meeting minutes were approved. OHRC Director, Dr. Seth White, then spoke briefly about his recent activities and plans, which included a visit to the Morgan Creek STEP facility, training and experience with the OHRC adult fish trap, and plans to refine methods to sample insulin-like growth factor 1 from small, juvenile fish. Dr. White also shared plans to attend the Northwest Fish Culture Conference and visit family and colleagues in the Czech Republic in January of 2023.

OHRC Technician and Outreach Specialist, Craig Lawson provided a facilities update for the OHRC, reported that OHRC Technician, Baylee Moser, had accepted a new position at Big Creek Hatchery. Craig also shared that he had accepted a position outside ODFW, and that recruiting to fill the two vacant positions was already in progress. Craig reported that Fall Creek had become very muddy, due to rains and the landslide upstream of the facility. Craig further reported on recent outreach and education activities at the OHRC, citing visits from a homeschooling group, Luckiamute Charter School, and the OSU Fish and Wildlife Club.

Dr. Marc Johnson provided a brief research budget update and indicated that, based on ODFW revenue forecasts, the agency would commit up to \$950,000 to support OHRC research projects during the 2023-25 biennium.

Following Dr. Johnson's financial report, researchers supported through the OHRC Dedicated Research Fund provided updates of their ongoing work. Presentations were made by or on behalf of Drs. Michael Banks, Andy Dittman, Aimee Reed, Michael Blouin, Claire Couch and Craig Lawson. Brief synopses of these presentations are provided in the meeting minutes and more detailed accounts of their research are provided elsewhere in this report.

Dr. Kathleen O'Malley then delivered a guest presentation, describing her work as the State Fisheries Geneticist, directing the State Fisheries Genomics Laboratory in Newport, Oregon. Dr. O'Malley described the broad scope of research conducted by her group in Oregon, and their collaborative efforts to advance genetic studies of marine and aquatic species along the Pacific coast, from Alaska to southern California. She also described her lab's establishment of a genetic sample repository at Hatfield Marine Science Center, which now includes over 130,000 tissue samples, most from Chinook Salmon or steelhead.

The OHRC Board then received 10-minute presentations from each of the following researchers that had submitted proposals in response to the OHRC's 2022 RFP:

- Dr. Andy Dittman - Olfactory and Imprinting
 - Improved homing of hatchery-reared salmon back to their natal hatchery through novel rearing strategies. Continuing to support this project will ensure the results of the work already completed will be fully realized.
- Dr. Jonathan Armstrong - Seasonal Timing of Hatchery Carcass Additions
 - Guidance on best timing to add carcasses for optimal salmonid growth, size, and survival of outmigrants.
- Dr. Kelly Biedenweg - Public Perceptions of Oregon Hatcheries for Outreach and Engagement
 - Findings are intended to inform the development of outreach and education efforts around hatcheries science and management targeted to different audiences.
- Joseph Feldhaus - Residualization and Reduced Smolt Abundance in a Production Hatchery
 - Guidance on improving hatchery management practices for summer steelhead released in the Pacific Northwest and informing fishing regulations.
- Dr. Michael Banks— Testing Wild-like Mate Choice in Hatcheries
 - Intended to increase viability of offspring and lessen impacts on wild fish. This proposal is to complete the work that has been started and champion the full study findings.
- Dr. Scott Heppell - Thermotolerance Differences Between Wild and Hatchery Steelhead
 - Provide baseline knowledge on different thermal tolerances of wild vs. hatchery stocks, as well as advanced methodology for determining those differences.

- Dr. Marc Johnson - Rearing and Release Strategy Impacts on Quality and Abundance of Returning Adult Hatchery Salmon
 - The researchers expect to generate actionable recommendations for juvenile salmon rearing and release strategies and potentially inform infrastructure needed to implement optimal strategies at ODFW hatcheries.
- Dr. Michael Kent - Effects of Hatchery Fish on Pre-Spawning Mortality
 - Inform short-term management changes and future studies on how hatchery rearing practices could be adjusted to reduce disease susceptibility and shedding when fish return to freshwater as adults.
- Ian Tattam - Mechanisms Driving Low Catchability of Hatchery Steelhead
 - Provide information for ameliorating low catchability of steelhead to ensure their support of the fishery and informing decision frameworks to ensure the fishery can be managed to conserve wild steelhead during low runs.

The Board discussed the merits and costs of proposed research, then decided unanimously (10:0) to support the ongoing Mate Choice and Olfactory Imprinting projects, with condition that they reduce their budgets by 8-10%. A second motion was made to support the research proposed by Dr. Biedenweg, but that motion failed to carry (3:7). Following additional discussion, the Board decided to postpone further decision on the seven remaining projects, but agreed to use a digital stack ranking tool to gauge overall support.

Chair Starkey then proposed meeting dates for the upcoming year, encouraged Board members to contribute toward development of the March 2023 meeting agenda, then adjourned.

Once approved by the OHRC Board, minutes from the December 6, 2022, meeting will be available at: <https://www.dfw.state.or.us/fish/OHRC/minutes.asp>

OHRC Board Focus for 2023

OHRC Board activities in 2023 shall include:

- Review OHRC research in progress;
- Review and evaluate the 2014 OHRC research plan;
- Develop and/or refine management recommendations based on OHRC research, as appropriate;
- Develop a workshop on a topic of critical importance to fish hatchery science and management (e.g., the utility of egg incubation boxes, recirculating aquaculture systems, best practices using artificial stream channels for research) in collaboration with the OHRC Director.

The OHRC Mission

The **Mission of the Oregon Hatchery Research Center (OHRC)** is “to be an internationally recognized leader in fisheries science, conducting research to define the mechanisms that may create differences between hatchery and wild salmonids, recommending strategies to manage those differences, and educating Oregonians about the benefits, risks, roles and performance of hatcheries in fisheries augmentation and conservation”.²

The three defined **Goals of the OHRC** are to:

1. **Understand mechanisms that may create differences between hatchery and wild fish.**
 - a. Determine the process and rate by which wild fish may change in the hatchery environment within and across generations.
 - b. Determine the process, rate and pattern by which hatchery-produced fish adapt to the natural environment at each life history stage.
 - c. Determine the possible genetic and ecological consequences of hatchery fish and their releases on native fish at each life history stage.
2. **Develop approaches to manage hatchery fish that conserve and protect native fish.**
 - a. Determine hatchery breeding, rearing and release practices that allow hatchery-propagated fish to both contribute to fisheries and facilitate the conservation and recovery of naturally produced native fish.
 1. Identify possible effects, both locally and on a landscape scale, to natural ecosystems associated with different types and levels of hatchery production and identify approaches to manage these effects.
 2. Identify hatchery practices that may need to be altered in response to changes in the natural environment and other external factors.
 - b. Identify breeding, rearing and release protocols that minimize possible adverse impacts on the natural ecosystem.
 - c. Evaluate the effectiveness of producing hatchery fish, relative to other strategies, as a means to achieve commercial, recreational, conservation and ecological objectives.
 - d. Determine the effects of hatchery operations (for example: flow alteration, effluent water quality, pathogens, migration and spawning distribution, etc.) on native fish, aquatic communities and their habitats.
3. **Educate and train students, fishery biologists, managers, and the public on the relationship between hatchery and wild fish, the connection between fish and watershed, estuarine and ocean systems, and the implications for fish management and stewardship.**
 - a. Train the next generation of biologists and managers, ODFW and OSU staff through undergraduate, graduate, and continuing education programs and classes at the facility.
 - b. Provide educational facilities and programs for K-12 students.
 - c. Design and manage the facility to provide an environment of passive and active learning for visitors.

² <https://www.dfw.state.or.us/fish/ohrc/mission.asp>

- d. Provide opportunities for educators and others to use the OHRC for meetings, workshops and programs that further public understanding of the relationship between fish and watershed health.
- e. Help facilitate and coordinate on the ground efforts of groups and individuals that have a key interest in our fisheries and fish management.
- f. Knowing that our wild and hatchery fish are a vital part of each Oregonian's heritage, we will develop critical hatchery science to be used as applied knowledge for creating policy and management goals that strengthen, support and conserve our fish.
- g. Conduct outreach in the communities impacted by wild fish or hatchery release issues.
- h. Share research results through both publications and presentations on the local, state and international level.

OHRC Activities in 2022

Overview

With reference to the **Mission** and **Goals** of the OHRC, the following activities and projects were developed or communicated at or through the OHRC in 2022:

Goal 1 - *Understand mechanisms that may create differences between hatchery and wild fish:*

- 1.a. Domestication selection project (steelhead) – Blouin et al.
- 1.a. Identifying hatchery rearing conditions that reduce stress and improve immunity – Couch et al.
- 1.b. Steelhead and Chinook Salmon wild surrogates project– Schreck et al.
- 1.c. Genetic propensity to be caught by anglers (“Biter Study”) – Johnson et al.

Goal 2 - *Develop approaches to manage hatchery fish that conserve and protect native fish:*

- 2a. Effects of thiamine supplementation on survival and performance of hatchery fish – Reed et al.
- 2.a., b. Identifying hatchery rearing conditions that reduce stress and improve immunity – Couch et al.
- 2.b. Mate choice –Banks, Auld, Jacobson
- 2.b., c. Effect of hatchery rearing conditions on steelhead behavior – Blouin
- 2.d. Olfactory imprinting and homing of Chinook Salmon – Schreck, Dittman, Johnson, Quinn, White, May, et al.

Goal 3 - *Educate and train students, fishery biologists, managers, and the public on the relationship between hatchery and wild fish, the connection between fish and watershed, estuarine and ocean systems, and the implications for fish management and stewardship:*

- 3.a. The OHRC re-opened to the public in May of 2022, and hosted student groups for classes on fish culture, pathology, anatomy, conservation, and ecology.

- 3.b.d. OHRC staff taught classes, hosted the ODFW Aquatic Inventories Annual Training, and held a Free Fishing Day Event.
- 3.c. OHRC reared fish for several OSU classes, including Introduction to Aquaculture.
- 3.e. OHRC staff engaged with the fishing public in outdoor areas of the OHRC.
- 3.f. Research conducted through the OHRC was published and presented at scientific workshops and symposia during 2022.
- 3.h. Results from OHRC research were disseminated through scientific publications, theses, and reports

Research

Throughout the course of 2022 the OHRC continued to implement its Strategic Research Plan³, which was developed and approved by the Board in 2014, with research funding sources secured in 2015. The OHRC Strategic Research Plan describes the OHRC's goals and several research focus areas aimed to meet those goals. The plan can be accessed online at: https://www.dfw.state.or.us/fish/OHRC/docs/2016/OHRC_Research_Plan.pdf.

To address research focus areas identified in the 2014 plan, three research projects were proposed, approved by the Board, and initiated. These three projects were designed to test 1) mechanisms of domestication selection in hatcheries, 2) effects of mate choice on fitness of hatchery salmon, and 3) the methods to improve homing by hatchery salmon, and were initiated by Drs. Michael Blouin, Michael Banks, and David Noakes, respectively. In 2021, Dr. Carl Schreck accepted duties as interim principal investigator (PI) for Dr. Noakes' project, then transferred these duties to Dr. Seth White in 2022. These three projects, all of which are described in the OHRC's Strategic Research Plan and initiated in 2016, continued through the course of 2022, per recommendations of the OHRC Board. Here, we briefly describe progress made by each of these projects in 2022 and offer more detailed accounts later in this report.

Research led by Dr. Michael Blouin (differences caused by hatchery rearing, or domestication selection) is motivated by the observation that hatcheries appear to select for improved performance in the hatchery, but at the cost of reproductive fitness in the wild (production of offspring that survive to adulthood). The researchers hypothesize that larger size of juvenile steelhead and salmon at time of release from hatcheries is favored (selected for) because it predicts greater survival at sea. Therefore, traits that promote fast growth in the novel environment of a hatchery are likely to be propagated by current hatchery practices, but those traits come at a cost to offspring survival in the wild. Dr. Blouin's lab is investigating how hatcheries might be changed to produce fish that are genetically more like wild fish. This involves testing whether various modifications to the hatchery environment can reduce the variance among families in size at release, which would reduce the opportunity for selection.

The project headed by Dr. Michael Banks (genetics and mate choice) progressed as planned in 2022. Marking completion of the first two phases of their project, Drs. Banks and Auld worked with a journalist from the United Kingdom to publish an article in *Hatchery International* about their work, describing how understanding of mate choice by wild salmon could be used to

³ https://www.dfw.state.or.us/fish/OHRC/docs/2016/OHRC_Research_Plan.pdf

improve hatchery production through genetically-informed crosses⁴. As this publication’s title suggests, it is the top industry newsletter serving hatchery professionals, with a broad global distribution and international readership.

Moving forward with Phase 3 of their project, 2022 marked the first year wherein all Coho Salmon returns to Sandy Hatchery were offspring from experimental spawns. Dr. Banks and Dave Jacobson worked with ODFW staff from Sandy Hatchery to sample all ~7,000 of these returns, which included adults from the 2019 spawn and jacks produced in 2020. Given the workload associated with sampling thousands of fish per day, they also worked extensively with the Hatfield Marine Science Center’s Innovation Laboratory to create a novel device dubbed the “VALUE TAGGER” to automate tissue and DNA sampling of salmon. These efforts yielded two prototypes with the second successfully sampling a fin-clip from the tails of all 2022 Sandy Hatchery Coho Salmon with minimal handling by hatchery staff.

Dr. Banks and Dave Jacobson also participated in the Coho Salmon spawn at Sandy Hatchery in 2022, keeping records of mating strategy and taking DNA samples from all broodstock. They also completed analysis of 1,300 jacks sampled in 2021 that were the first returns of the 2019 spawn.

Preliminary results indicate that ‘wild-like’ spawning strategies performed in the hatchery may create marginally higher yields (on average), because offspring from half of each female’s eggs bred with ‘wild-like-chosen’ males had more returns (52%) than those from an equal number of the same female’s eggs combined with randomly chosen males (48%). Ranking families by which father had the greatest number of returns provided additional evidence that evoking ‘wild-like’ mating strategies may hold promise to improve hatchery return numbers (Table 2). Eight of the top dozen alpha families were fathered by ‘wild-like-chosen’ males with only four random chosen males ranking among these top 12 alpha male families. Further, ‘wild-like-chosen’ males fathered 102 more returning jacks than the number returning from randomly chosen males, yet both started with an equal number of eggs. These preliminary results raise keen interest in forthcoming findings for the full three cohorts of jacks and adults that will return to Sandy Hatchery over the next three years.

Female	Alpha male	Alternate male	Differential	
F015	47	4	43	
F074	43	25	-18	
F018	35	4	31	
F105	27	20	7	
F044	25	13	12	
F033	22	15	-7	
F101	20	5	15	
F007	19	11	-8	Mate Choice
F008	19	6	-13	Random
F041	16	8	8	
F056	16	0	16	
F088	16	0	16	
			102	

⁴ <https://www.hatcheryinternational.com/choosing-a-mate-wild-vs-hatchery-coho-salmon/>

Table 2. 2021 Sandy Hatchery Coho Salmon jacks ranked by which father (‘wild-like’ mate choice or random) had greatest number of offspring returning. Eggs of each female we divided in half so that each male had equal opportunity for even numbers of offspring at fertilization.

As previously mentioned, Dr. Seth White accepted the position as the Director of the OHRC in 2022, and assumed the OSU Principal Investigator responsibilities for the Olfactory Imprinting Project from Dr. Carl Schreck. This project has and continues to benefit through participation from team members Dr. Andy Dittman (NOAA Fisheries; Seattle), Dr. Tom Quinn and Darraan May (University of Washington, Seattle), Dr. Marc Johnson, Ryan Gertken, and Jen Krajcik (ODFW), and Dr. Gabriel Singer (University of Innsbruck, Austria) and many more. Through this project, which aims to understand and alter the chemistry of water entering and leaving the Elk River Hatchery so as to improve olfactory imprinting and homing by hatchery salmon produced at the facility, river water samples have been analyzed, adult salmon movements have been tracked and described (Whitmore et al. 2021), candidate odorants have been tested and chosen, and juvenile salmon have been exposed to natural odorants at various developmental stages, and the first year of additions of imprinting odors to the hatchery ladder to attract returning adults was initiated. These accomplishments closely follow the plan and schedule presented by the researchers nearly six years ago, and the research team is now beginning to analyze coded wire tag data that will determine the effectiveness of the odorant treatments performed to date. Next, the Olfactory Imprinting Project will continue to collect, analyze and present these results, while testing the efficacy of alternative and less costly odorants and refining understanding of the physiological processes involved with olfactory imprinting. Pending final results, this project offers strong promise to identify a new and highly transferrable approach to improve homing by hatchery salmon.

In addition to these three projects, the OHRC’s Strategic Research Plan also states that other areas of research would be encouraged and supported by the Board,. Examples identified in the plan include investigations into effects of hatchery rearing on geomagnetic navigation by salmon, selection for harvest susceptibility in hatchery steelhead, and behavior of triploid steelhead. Each of these topics has been explored through research by the OHRC, generating numerous publications in scientific journals (e.g. Bellinger et al. 2022, Johnson et al. 2019, Johnson et al. 2020, Klimley et al. 2021, Naisbett-Jones et al. 2020, Putman et al. 2018, 2020, Scanlan et al. 2018) and numerous public presentations.

Beginning in 2021, the OHRC developed and implemented a new process to solicit, review, and prioritize research to be supported by the center (see OHRC Board Annual Report for 2021). The 2021 RFP attracted proposals for five new projects in addition to proposals for ongoing work. The OHRC Board worked diligently in late 2021 and early 2022 to deliberate and ultimately recommend support for all three ongoing projects and three of the newly proposed projects. This required the Board to advise researchers to revise their budgets, thereby allowing support for a greater number of projects, albeit with less financial support per project.

Among new projects recommended by the OHRC Board for funding in 2022 were studies led by Craig Lawson, Senior Technician at the OHRC, and Drs. Aimee Reed and Claire Couch. Their work began in mid-2022 and is expected to continue into 2023.

Craig Lawson's work follows upon a study led by Dr. Marc Johnson, which found that hatchery broodstock (adult Alsea River steelhead) collected by anglers produced far fewer adult returns than broodstock collected with hatchery fish traps. Craig's investigation aims to measure the success of angler-assisted broodstock collection programs for steelhead hatcheries along the Oregon Coast through surveys, site visits, and analysis of archival data. Mr. Lawson developed an online survey and contacted various ODFW hatchery managers, requesting their participation. However, a small number of responses were received, offering little information for analysis. Following, Craig met with several researchers at OSU to modify the survey approach, with expectation to collect data that will offer insights toward best practices for hatchery broodstock collection, holding, and spawning.

The focus of Dr. Aimee Reed's research is thiamine deficiency in hatchery-reared steelhead. Dr. Reed hypothesized that supplementing thiamine could resolve high early-rearing mortality experienced in some steelhead hatcheries in Oregon. Additional focus is on developing a diagnostic method for determining thiamine in fish eggs in Oregon at OSU's Linus Pauling Institute (LPI). To study thiamine supplementation in steelhead, researchers injected some broodstock with thiamine and compared progeny to non-injected hatchery stock steelhead. Three weeks later, in January and February 2022, eggs were collected at Alsea hatchery and brought to the OHRC for growout and data collection. Data were collected on mortality and growth on the fry at OHRC through May 2023, at which time all fish were transferred back to Alsea hatchery to contribute to their production. Results of this study are currently being published in the journal *Veterinary Sciences*. Progress is also being made on the assay conducted at LPI for High-performance liquid chromatography (HPLC) analysis of thiamine, and preliminary results are being assessed for quality and confidence.

Dr. Claire Couch received \$50,000 from the OHRC in 2022 to support her ongoing research on optimizing rearing conditions of Pacific salmon for hatchery production and conservation. Dr. Couch's central research question is: can alternative rearing strategies enhance disease resistance in hatchery-origin salmonids, thus increasing post-release survival and reducing the effects of hatcheries on natural-origin salmonids? By enhancing disease resistance, hatcheries would need to release fewer fish to achieve the same smolt-adult returns, thus reducing effects on hatchery releases on wild juveniles. Additionally, enhancing disease resistance in hatchery fish would reduce the risk of disease transmission to wild fish. Specifically, Dr. Couch's work focuses on how diet, rearing conditions, and stress relate to immune function, the microbiome (i.e. communities of bacteria and other microbes that live on and in fish), disease susceptibility, and ultimately, the health and survival of Pacific salmon.

In 2022, Dr. Couch completed and/or advanced several projects that are relevant to the OHRC mission. First, she collaborated with Dr. Carl Schreck and others to describe the stress physiology of adult Chinook Salmon as they approach spawning, thus laying the groundwork for understanding how hatchery-related stressors relate to pre-spawning mortality (Couch et al. 2022a). Second, she collaborated with Dr. Michael Kent to describe a novel parasite, *Enterocytozoon schreckii*, which could be an important indicator of immune status and mortality risk in adult Chinook Salmon (Couch et al. 2022b). Third, she completed a study on the effects of chronically elevated corticosteroids (i.e. stress hormones) on microbiome composition and

mortality risk, which has important implications for managing and monitoring juvenile fish in hatcheries as well as adult fish returning to spawn (Couch et al. 2023). Finally, Dr. Couch's team completed the experiment that was directly funded by OHRC and began analyzing data from this study. The purpose of the OHRC-funded experiment was to test the effects of diet on the microbiome, immune function, and disease resistance in juvenile Chinook Salmon. Preliminary data from this study suggests that low-lipid diets may enhance innate immunity relative to standard hatchery diets. This work will ultimately contribute to our understanding of post-release survival in hatchery-reared juveniles.

In late 2022, another RFP was issued by the OHRC, which generated a total of nine research proposals seeking support during the 2023-25 biennium, including proposals for continuation of research led by Dr. Michael Banks (Mate Choice study) and Dr. Seth White (Olfactory Imprinting study). The OHRC Board unanimously approved the work led by Drs. Banks and White for continuation, and deferred decisions on other proposals to 2023. This process is further detailed in the 'Funding of OHRC Operations and Activities' section below.

In addition to the projects supported through the Strategic Research Plan, OHRC staff continued work on other, shorter-term projects in 2022. In collaboration with the Wild Fish Surrogate Project, led by Drs. James Peterson and Carl Schreck, OHRC staff studied the timing of dorsal fin erosion in winter steelhead. This project was a continuation of work started in 2021 and determined that fin erosion is not caused by bacteria or skeletal deformities, and that it happens very early in the lifecycle of steelhead. The project will continue in 2023, looking for ways to extend the time before damage occurs through various environmental manipulations. OHRC staff also assisted Dr. Aimee Reed with her study of the effects of thiamine supplementation on the survival of winter steelhead fry, and evaluated alternative water temperature reduction measures, such as floating covers, shade cloth, and sprinklers.

In alignment with the goals of the OHRC, Oregon's State Fisheries Genomics Laboratory, led by Dr. Kathleen O'Malley, continues to support fisheries and hatchery research. In 2022, Dr. O'Malley's lab began to address critical information gaps regarding Oregon's coastal Chinook Salmon populations by analyzing genetic data for 1,188 Chinook Salmon sampled along the Oregon coast in 2020.

More information about research being conducted at the State Fisheries Genomics Laboratory is available at <https://agsci.oregonstate.edu/state-fisheries-genomics-lab>

Education and Outreach

The OHRC is a clearinghouse for information about hatchery management and coldwater fish culture. OHRC researchers regularly present their findings at conferences and symposia, and produce high-level publications in peer-reviewed scientific journals.

A selection of publications, reports and presentations produced by OHRC researchers is provided on the OHRC's website at <https://www.dfw.state.or.us/fish/OHRC/news.asp> and included here as Appendix 1.

OHRC staff and researchers provide education about fisheries and hatchery science to students of all levels. In 2022, OHRC Senior Technician, Craig Lawson, and OHRC Manager, Jen Krajcik, taught students from various schools and groups about fish anatomy and the salmon lifecycle through dissections and observations of spawning salmon. OHRC staff also provided numerous tours and hosted a free fishing day for the public in 2022. With public visitation now restored in 2022, the OHRC looks forward to planning expanded outreach and education opportunities in 2023.

Per its Mission, the OHRC shares information not only with the public and students, but also directly with fisheries managers and biologists. In July of 2022, ODFW researcher and agency liaison to the OHRC, Dr. Marc Johnson, hosted an OHRC-focused session during ODFW's biennial Hatchery Manager's Meeting in Elkton, Oregon. This session offered opportunity for OHRC manager, Jen Krajcik, and Drs. Michael Banks, Michael Blouin, and Aimee Reed to present and discuss their OHRC research directly with ODFW hatchery managers. OHRC Board Chair, Scott Starkey, also participated in this meeting and discussions. Water quality and availability issues, affected by increasingly warm, dry conditions, ranked high among concerns expressed by hatchery managers, along with aging hatchery infrastructures and fish health issues.

On several occasions in 2022, Dr. Aimee Reed presented and discussed her OHRC-based thiamine research with managers and colleagues, including at: the Western Fish Disease Workshop in Hood River, Oregon (May 19th), the American Fisheries Society Regional Meeting in Spokane, Washington (August 23rd), and the Pacific Northwest Fish Health Protection Committee (September 13th). Her work explores the effects of thiamine deficiency in salmonids, and methods for treatment.

In 2022, Dr. Andy Dittman presented and discussed findings from the Olfactory Imprinting Project with managers and colleagues at the Alaska Science Center in January, at the National American Fisheries Society meeting in Spokane, WA, in August, and at NOAA's Northwest Fisheries Science Center in October.

In November of 2022, OHRC Director Dr. Seth White presented an overview of current and future OHRC research, education, and outreach activities to the South Coast Anglers, followed by participating in the annual spawning event at the Morgan Creek STEP hatchery the next day.

Dr. Kathleen O'Malley developed an online exhibit for the State Fisheries Genomics Lab (SFGL) that attracted 2,000 visits during Hatfield Marine Science Center's virtual Marine Science Day, held on April 9, 2022. Dr. O'Malley also led tours of the SFGL on numerous occasions in 2022, including a tour for Oregon Institute of Marine Biology students on July 26th and a tour for researchers from the Sabah Wildlife Health, Genetic and Forensic Laboratory in Malaysia on July 27th.

These direct communications between OHRC researchers, managers, and the angling public are critical to both the refinement of research and application of findings toward improving Oregon's hatchery operations.

The OHRC's webpages were largely overhauled in 2021 and continue to be an important means of communicating the Center's purpose, capabilities, and activities to the public. OHRC staff continually work to update and improve the center's web-based material, offering news and information to OHRC Board members and public. The OHRC's homepage can be found at: <https://www.dfw.state.or.us/fish/ohrc/>

Funding of OHRC Operations and Activities

Operations, Education, and Outreach Funding

The OHRC received a 2021-2023 biennium operating budget of approximately \$1 million from the Oregon Department of Fish and Wildlife: \$553,039 for personal service, \$408,996 for service and supplies, and \$7,944 for housing maintenance.

Research Funding

During the 2015-2017 and 2017-2019 biennia, Strategic Research at the OHRC was conducted with financial support from ODFW of up to \$1.2 million per biennium. In 2019, renewed funding commitment was provided by ODFW to OHRC Research, albeit at a reduced level of \$800,000 for the 2019-2021 biennium, adjusted in response to ODFW's revenue projections through 2021. In 2021, ODFW's revenue forecast for the 2021-23 biennium indicated promise for support of research up to approximately \$1 million. Following recommendations made by the OHRC Board to ODFW in 2021, only \$635,000 of the projected available funds was committed to priority research projects at year's end. For the 2023-25 biennium, \$950,000 was made available to OHRC Research, and these funds were distributed in the manner described below.

Selection of projects to receive OHRC Research funding for the 2023-25 biennium was a multistep process. Based on discussions from prior workshops (including with angling groups), research questions generated during the 2021 *Spawning Fresh Ideas* conference (Appendix 2), and additional input by the OHRC Board Chair, nine research concepts were evaluated and recommended by the OHRC Board in October 2022. Soon after, a request for proposals (RFP) was announced, inviting researchers to submit projects that advanced existing OHRC research or addressed the new research concepts (Appendix 3). A total of nine proposals were received by the November 7, 2022 deadline requesting approximately \$1.9M (Appendix 4). Next, all nine proposals were evaluated by a panel of technical reviewers for their alignment with the OHRC mission, goals, and research concepts; value to the scientific community; feasibility; and likelihood of providing actionable management recommendations. The anonymous reviewers were selected based on their leadership in the fields of fish ecology, hatchery science and management, and the social sciences. Based on the technical reviews, all nine proposals were deemed satisfactory or better and so all responses to the RFP were presented to the OHRC Board for recommendation. At the December 2022 Board meeting, the OHRC Board recommended continuing funding for two pre-existing projects approved in the 2014 OHRC Research Plan: 1) Differences caused by mate selection and 2) the Olfactory Imprinting Project, with the stipulation that projects may be asked to reduce their budgets by approximately 8-10% to accommodate funding up to two additional projects. Discussion of awards for additional projects

was deferred to a special OHRC Board meeting in January, 2023, and so these will be discussed in the 2023 OHRC Annual Report.

All research budgets are formally approved through OSU-ODFW Intergovernmental Agreements and associated sub-awards. Research conducted at and through the OHRC is supported not only by the OHRC Dedicated Research Fund, but also by extramural funding. For example, the U.S. Army Corps of Engineers awarded Drs. Noakes & Schreck \$810,000 per year to carry out the Wild Surrogate Project through the OHRC, and that extramurally supported work is ongoing.

During 2022, the State Fisheries Genetics Laboratory⁵, headed by Dr. Kathleen O'Malley, continued multiple research projects developed in 2021 with significant relevance to the OHRC Mission. Many of these projects were supported through state and federal funding, as described below:

- 2021-2022. U.S. Army Corps of Engineers (O'Malley). Genetic pedigree analysis of North Santiam River spring Chinook salmon: \$95,354
- 2022. Oregon Department of Fish and Wildlife (O'Malley KG). Lostine River and Bear Creek Bull trout hybridization assessment: \$15,189
- 2021-2023. U.S. Army Corps of Engineers (O'Malley). Genetic pedigree analysis of South Santiam River spring Chinook salmon: \$175,155
- 2021-2023. U.S. Army Corps of Engineers (O'Malley). Genetic pedigree analysis of McKenzie River spring Chinook salmon: \$167,137
- 2021-2023. U.S. Army Corps of Engineers (O'Malley). Genetic pedigree analysis of Fall Creek spring Chinook salmon: \$152,797
- 2023-2025. Oregon Watershed Enhancement Board (O'Malley). Environmental DNA as an Improved Monitoring Technique for Bull Trout in the North Fork Malheur River: \$135,486

Management Applications of OHRC Research Findings

Research conducted by and through the OHRC in 2022 served to build upon the Center's record of producing actionable science in the field of fisheries management. Ongoing projects progressed toward delivering new tools to manage genetic and ecological risks from hatchery salmon and steelhead, and new projects identified practices to improve the health and survival of Oregon's salmon and steelhead.

Research being conducted by Drs. Michael Banks and Heather Auld, through their Mate Choice Project, has now completed the spawning components of its third phase (see OHRC Strategic Research Plan). These researchers have coordinated with hatchery managers to achieve production-scale generation of Coho Salmon to test their hypothesis of improved fitness through wild-like mate pairings, guided by molecular genetic information for three consecutive years (2019, 20 & 21). If results from the 2019 jacks provide an accurate forecast of future results, then "wild-like" breeding strategies at production hatcheries could greatly increase hatchery contributions to marine and inland fisheries. Offspring from 'wild-like' bred hatchery fish might

⁵ <https://agsci.oregonstate.edu/state-fisheries-genomics-lab>

also have closer reproductive success to wild fish, and thus reduce their potential impacts upon wild fish.

Research being conducted by Dr. Michael Blouin's lab is aimed at testing whether alterations to standard hatchery practice can produce fish that are genetically more similar to wild fish. This research is of primary concern to many people in the Pacific Northwest because a large body of research shows that hatchery fish generally have lower fitness (production of offspring that survive to adulthood) than wild fish when both spawn in the wild. As a consequence, managers must limit the proportion of hatchery-origin spawners (pHOS) in natural runs to mitigate concerns about negative genetic impact of hatchery fish on wild populations. Being able to raise hatchery fish that have genetic fitness that is more like that of wild fish would allow managers to increase pHOS, creating more opportunities for angling and harvest. This project originally came to Dr. Blouin from the Bonneville Power Administration, with some in-kind support provided by OHRC personnel and facilities, but is now funded solely by ODFW.

The Olfactory Imprinting Project, led by Drs. Carl Schreck and Seth White in 2022, has demonstrated that salmon can learn amino acid odorants as imprinting cues (Havey et al. 2017, Armstrong et al. 2021), and initiated the final phase (addition of imprinted odorants to the adult return ladder) of a multi-year study to demonstrate that additions of amino acid odorants to hatchery water can improve the homing fidelity of hatchery salmon. If successful, these odor addition strategies may be employed at most ODFW hatcheries that utilize river water for rearing to improve homing fidelity and minimize unwanted interactions of hatchery salmon with spawning wild fish.

However, salmon use more than olfactory cues to navigate the course of their marine and freshwater migrations, and the OHRC has led on the path to better understand their sensory capabilities. Research carried out at the OHRC has revealed that salmon can detect and use geomagnetic cues to navigate during the ocean phase of their migrations (Dittman et al. 2015, Putman et al. 2018, 2019, 2020). Colleagues from the University of North Carolina, and LGL Environmental Research subsequently conducted a study to measure the orientation responses of juvenile Chinook Salmon exposed to pulsed magnetic fields. Their results suggested that geomagnetic orientation in these fish relies upon magnetite crystals in receptor organs. These results have now been published (Naisbett-Jones et al. 2020), supported by related findings (Bellinger et al. 2022), and may have implications regarding magnetically charged materials used in hatchery construction, wave energy development projects, and other human activities (Klimley et al. 2021).

Potential management applications of research led by Dr. Claire Couch include development of novel biomarkers to monitor the health of fish in hatchery settings and in rivers, and the development of rearing practices that support healthy microbiomes, innate immunity, and post-release survival in juvenile salmonids. Specifically, one of Dr. Couch's recent publications (Couch et al. 2023) demonstrates that the microbiome predicts mortality in chronically stressed Chinook Salmon. These findings suggest that a nonlethal, microbiome-based biomarker could be used to monitor population health, especially during times when stress hormones are elevated (e.g. smolting, migration, sexual maturation). Additionally, Dr. Couch's current OHRC-funded research on diet, microbiome composition, and immunity has the potential to reveal new avenues

for mitigating disease susceptibility in hatchery-reared juveniles while minimizing the use of antibiotics. Overall, Dr. Couch's ongoing work will contribute to low-cost monitoring and sustainable management of both hatchery-origin and natural-origin salmon in the Pacific Northwest.

Research conducted by Dr. Aimee Reed and colleagues has determined that thiamine supplementation significantly improves survival of fry when administered via injection to broodstock as well as via bath to eggs; additionally, thiamine supplementation significantly increases condition factor of fry when administered via injection to broodstock prior to spawning. This practice is easily adapted to hatchery operations and can have significant influence on outcomes of fish. Adult broodstock are routinely handled upon intake in most programs, whether angler-caught or trap-caught, and a single injection of thiamine a few weeks prior to spawning is cheap, easy, and effective at promoting health of fish reared in Oregon hatcheries. If adult broodstock cannot be handled in a timely fashion prior to spawning, thiamine can still be effective if supplemented to the eggs at the time of spawn and improve survival of the fry. Additionally, having some progress in developing an assay to analyze thiamine in fish eggs can be the gateway to future studies of thiamine in Oregon's fish populations.

Hatchery salmon and steelhead make substantial contributions to fisheries in Oregon. Research led by Dr. Marc Johnson found that the way by which hatchery broodstock are collected can significantly affect production of the next generation (Johnson et al. 2020, in press). Their research initially set out to test whether the offspring of angler-caught broodstock would be more likely caught by anglers than offspring of trap-caught broodstock. They found little evidence to support that relationship, however a striking and consistent pattern unexpectedly emerged from their data: broodstock that were (passively) collected with traps produced nearly twice as many adult steelhead (per spawner) as broodstock that had been actively collected by anglers. Their findings, based on data from the Alsea Hatchery steelhead program, suggest that passive broodstock collection (with traps) better supported production of hatchery steelhead than active (angler assisted) broodstock collection methods.

The State Fisheries Genomics Laboratory, headed by Dr. Kathleen O'Malley at OSU, conducts fisheries genetics research that addresses the science and management needs of the Coastal Oregon Marine Experiment Station and the Oregon Department of Fish and Wildlife, often collaborating with OHRC researchers in support of OHRC goals. In August of 2021, NOAA Fisheries announced its findings related to two petitions to list populations of spring-run Chinook Salmon (*Oncorhynchus tshawytscha*) as threatened or endangered Evolutionarily Significant Units (ESUs) under the Endangered Species Act (ESA). NOAA Fisheries cited two reports generated by Dr. O'Malley's lab (O'Malley et al. 2020a, 2020b) and concluded that "the Oregon Coast and Southern Oregon and Northern California Coastal spring-run Chinook Salmon populations do not meet the ESU policy criteria to be considered ESUs separate from the Oregon Coast and Southern Oregon and Northern California Coastal fall-run Chinook Salmon populations". Findings from the 2021 workshop have now been published (Waples et al. 2022), illuminating how genetic diversity is structured among runs of salmon and steelhead, and how knowledge of this structure can inform management decisions.

These examples offer but a glimpse of how research at the OHRC and collaborating laboratories provide valuable information to fisheries managers in Oregon and around the world.

Acknowledgements

A draft of this report was prepared for the OHRC Board by Drs. Marc Johnson and Seth White, with significant contributions from OHRC staff Jen Krajcik and Craig Lawson, as well as Drs. Michael Banks, Michael Blouin, Andrew Dittman, Kathleen O'Malley, Claire Couch, Aimee Reed, and Carl Schreck.

Appendix 1: Detailed Activity Reports for the Oregon Hatchery Research Center

OHRC Mission Goals 1 and 2: Research Projects

Research Projects at the OHRC are reviewed, here, in context of our Mission Statement, current priorities, funding, and the availability of personnel and facilities⁶. All research projects are reviewed by ODFW, OHRC staff, the OHRC Director, and the OHRC Board. OHRC research projects can be linked to specific elements of the OHRC's mission and goals, as defined through statute and the OHRC Strategic Research Plan.

Research proposals, progress reports, completion reports and resulting publications are available on the OHRC website⁷. Many of those reports include recommendations that were made from the OHRC to ODFW or other agencies for consideration. Results from OHRC activities are reported to state fisheries managers and biologists at regularly-held meetings, such as the ODFW hatchery managers' and regional fish biologists' meetings.

Individual Research Projects

A variety of research projects were conducted at or by affiliates of the OHRC in 2022. A selection of those projects is described below, with reference to the OHRC's Mission and Goals, and a brief synopsis of each project's objectives and findings:

The Olfactory Imprinting Project (Mission Goals 1.c., 2.d)

This OHRC strategic research project addresses a high priority request from ODFW to provide recommendations for management of hatchery salmon and steelhead, that often stray and interact with wild fish on spawning grounds. Elevated straying by hatchery fish can result in increased proportions of hatchery-origin spawners (pHOS), with negative genetic and ecological consequences for wild salmon populations. This project is focused on developing techniques to improve the homing fidelity of salmon back to the hatchery they were released from to minimize these negative interactions.

This project has focused initially on Chinook Salmon released from the Elk River hatchery in southwestern Oregon, but research results should be transferable to other ODFW hatchery programs to reduce straying by other hatchery populations. The project began in 2012, with funding through the OHRC–OSU operating budget, and in-kind support provided by ODFW hatcheries, NOAA (NWFSC) and OSU, and expanded in 2016 with allocation of long-term research funds from the Oregon Legislature.

The Olfactory Imprinting Project was originally led by Dr. David Noakes (ODFW/OHRC). After Dr. Noakes' death in late 2020, Dr Carl Schreck accepted OSU Principal Investigator

⁶ <https://www.dfw.state.or.us/fish/OHRC/docs/2008/OHRC%20CallForResearch2008.pdf>

⁷ <https://www.dfw.state.or.us/fish/ohrc/>

responsibilities with participation from Dr. Andy Dittman (NOAA, NWFSC, Seattle), Dr. Tom Quinn (University of Washington), Dr. Marc Johnson (ODFW), Darran May (University of Washington), Dr. Gabriel Singer (University of Innsbruck), Brent Hinnert (ODFW), Ryan Gertken, (ODFW), and many more. In October, 2022, Dr Seth White became the OSU Principal Investigator for the Olfactory Imprinting Project.

Three central hypotheses are being tested through this project. First, it is hypothesized that the inability of salmon to effectively distinguish the olfactory cues of the hatchery from the river water that supplies the hatchery results in elevated levels of in-river straying. This hypothesis was supported by a radiotelemetry study published this year (Whitmore et al. 2021) that indicated that most returning hatchery and wild fish migrated close enough to the Elk River Hatchery to detect odors emanating from the facility, but some hatchery salmon still did not enter.

To address this issue, this project tests the idea that Chinook Salmon exposed to a unique bouquet of chemical odorants during select juvenile stages will home back to their natal hatchery (as adults) at higher rates than control fish (not exposed as juveniles), when the same chemicals are added to water leading into the hatchery (i.e. adult fishway). For practical purposes, candidate odorants should be neither innately attractive or repulsive to salmon, detectable, imprintable (i.e. learnable), safe and legal to add to hatchery water that enters the Elk River, and relatively inexpensive. Based on the results of these studies (May et al. in prep, Kamran et al. in prep), a cocktail of amino acids (L-arginine, L-threonine, L-glutamic acid) was determined to be the best candidate odors for scenting the hatchery water to improve imprinting. Extensive water chemistry analysis of hatchery and river water demonstrated that the addition of these amino acids would successfully alter the odor signature emanating from the hatchery (Dittman et al. manuscript in prep).

Beginning in 2020, Chinook Salmon were exposed to an amino acid cocktail during embryonic incubation (Jan.-March), and during the parr-smolt transformation (May June) and just prior to release (Sept-Oct.). All groups were given treatment- and raceway-specific coded wire tags and released into the Elk River in October 2020. This treatment and release design was repeated during 2021 and 2022. The first group of returning adults from this experiment returned to the Elk River hatchery in fall 2021 and in anticipation of these returning fish, an odor delivery system was established at the Elk River Hatchery adult return ladder and amino acid cocktails were constantly metered in the ladder during the entire adult return period Nov. 1, to Jan. 31 during the 2021-2022 and 2022-2023 return years. Approximately 700 returning mature adults from the experimental groups have been collected at the ERH and coded wiretags from approximately 500 fish have been read. Coded wire tags recovered from 2021-2022 and 2022-2023 spawning ground and creel surveys have not yet been read at the ODFW laboratory but these results should be available in 2023. Finally, water samples have been collected within and downstream from the hatchery to validate the amino exposure levels during experiments in 2022. All odor exposures, deliveries, and sample collections were completed as scheduled. The final juvenile exposure was completed in 2022 and adult returns will be monitored for the next several years as experimental fish return and while amino acids are delivered to the ladder. Improvements in homing fidelity will be assessed by comparing differences in hatchery returns between the exposure and un-exposed control groups.

In 2022, the Olfactory Imprinting Team initiated an extension of this work to identify more cost-effective but complex odors derived from inexpensive plant and animal materials that may be utilized as imprinting odors at the Elk River and other ODFW hatcheries. Initial studies utilized pure amino acids, potent salmon imprinting odorants, to test the theoretical applicability of this imprinting technique. However, supply chain challenges and dramatic price increases, may make the routine usage of these pure chemicals at ODFW hatcheries challenging. In 2022, experimental crosses of Elk River Chinook Salmon were fertilized and eyed embryos were transported to the OHRC for studies of responses to the new test odors. In 2023, experimental response metrics will include y-maze testing to determine innate responses, conditioning experiments to determine learning and discriminatory capabilities, and EOG analysis of olfactory sensitivity conducting at the NOAA facilities in Seattle. Finally, a subset of salmon will be exposed to test odors for gene expression studies to identify genes linked to the imprinting process that will facilitate future assessments of imprinting success.

The second hypothesis tested under this project is that rearing of salmon embryos in river water may be beneficial for improving olfactory development and homing fidelity. In most hatcheries, including the Elk River Hatchery, salmon are reared during embryonic stages in well water to minimize exposure to pathogens and control development rates. However, early studies at the OHRC demonstrated that salmon actively avoid well water and that olfactory development is altered in well water-reared fish (Dittman et al 2015). To test whether embryonic rearing water influences successful imprinting, we initiated a two-broodyear study in 2017 at the Elk River Hatchery, wherein embryos were incubated in either Elk River water or well water (per conventional hatchery practice). In June of their first year, juveniles were given treatment- and raceway-specific coded wire tags and released in the fall. Adults from these studies were recovered at the hatchery ladder and spawning grounds in 2019-2022 with the final experimental fish returning Fall 2023. Coded wire tag reading and analysis will be completed in 2024 and improvements in homing fidelity will be assessed by comparing differences in hatchery returns between the well water and river water exposure groups. Two manuscripts describing the results and management implications of this study will be completed in 2024.

Finally, the third hypothesis tested under this project is that the timing of odor exposure and release may be critical for successful olfactory imprinting. Wild Elk River Chinook Salmon typically migrate to sea in the late spring of their first year and the timing of olfactory imprinting is likely linked to these migratory events. In an effort to minimize ecological interactions between wild and hatchery fish and to improve hatchery fish survival, juvenile salmon are released from Elk River Hatchery much later than wild fish typically migrate seaward. However, this practice might impact successful imprinting and increase the rate of straying by adult hatchery salmon. As part of this project, we assessed imprint timing in Elk River Hatchery salmon by measuring several physiological and endocrine metrics associated with smolting and imprint timing. Laboratory analyses of these samples was completed in 2021 and suggest that two important periods for odor exposure are late spring and just prior to release. These findings have been incorporated into odor exposure experiments and final reports and publications on this work (Dittman et al. in prep) will be submitted in 2023.

COVID-19 travel restrictions continued to limit opportunities to present findings to peers and the public at meetings and conferences in 2022 but findings from the Olfactory Imprinting Project were presented at 1) the National AFS meeting in Spokane (Dittman, A.H. , Kamran, M., May, D., Johnson, M., Singer, G., Hinnens, B., Gertken, R., Quinn, T., Schreck, C., and D. Noakes. Creating a Unique Odor Bouquet to Improve Homing of Hatchery-Reared Salmon. Annual American Fisheries Society Meeting, Spokane, WA August 2022), aspects of this work was presented in a talk to scientists at the Alaska Dept. Fish and Wildlife, University Alaska, and the Alaska Science Center (Olfactory imprinting and homing in Pacific salmon: Mechanisms and controlling factors. Jan. 2022) and at other regional and OHRC meetings. Researcher in the Olfactory Imprinting team published two articles (one in press) on the role of amino acids in salmon homing (Dittman et al. 2022, Minkoff et al. in press) and are preparing a manuscript on the spatial and temporal patterns of amino acids in the Elk and Sizes Rivers. Additionally, the Olfactory Imprinting team will submit a manuscript on the olfactory sensitivity of Pacific salmon to potential imprinting odorants (May et al. in prep)

The Olfactory Imprinting Project contributes to the implementation of the OHRC Strategic Research Plan⁸.

Geomagnetic Imprinting by Salmon & Steelhead (Mission Goals 1.c, 2.d)

ODFW has a longstanding interest of factors that influence homing behavior in Pacific salmonids, motivated in part because the alternative to homing behavior (i.e. “straying”) can lead to negative and undesirable interactions between hatchery and wild fish on spawning grounds, but also because salmon homing behavior enables terminal (i.e. in-river) to benefit from local investments to fisheries enhancement. During his tenure as Director and Senior Scientist at OHRC, Dr. David Noakes led a series of research projects that investigated bases for homing behavior by Pacific salmonids. These included not only studies of olfactory guided behaviors, but also the ability of salmon to detect and use geomagnetic cues to orient and navigate. Several papers have been published from this research effort (Putman 2019, 2019, 2020), providing evidence that salmon have magnetite-based magnetoreception that they utilize for navigation (Naisbett-Jones et al. 2020). This research team has shown conclusively that Chinook Salmon, sockeye salmon, pink salmon, Atlantic salmon and steelhead use geomagnetic cues to orient their movements and marine navigation. This work continues to attract interest at regional and international levels and has raised important questions about possible anthropogenic impacts on the navigational capacity of hatchery salmon and other organisms (Klimley et al. 2021).

Surrogates for Wild Chinook Salmon and Steelhead Trout (Mission Goals 1.b., 2.a.2., 2.b., 2.d.)

This project is a continuing, multi-year project led by Drs. Carl Schreck and Jim Peterson, supported by funding from the US Army Corps of Engineers since 2011. Many salmon and trout are listed as threatened or endangered under the Endangered Species Act. Research aims to understand factors contributing to population declines. This project is relevant to improving juvenile downstream passage through reservoirs and dams, particularly in the Willamette River basin in Oregon. Hatchery fish are not good models for assessing performance of wild fish, but wild fish are unavailable for study due to ESA restrictions. Researchers need artificially reared fish that act like wild fish when released into the watershed. The Wild Fish Surrogate Program

⁸ https://www.dfw.state.or.us/fish/OHRC/docs/2016/OHRC_Research_Plan.pdf

uses alternative rearing tactics to produce migrant-sized Chinook salmon and steelhead trout with wild fish-like behavior and performance for studies in the Willamette basin. This work is carried out at OHRC and Oregon State University's Fish Performance and Genetics Laboratory (FPGL). It also entails experiments conducted at several Willamette basin hatcheries. Rearing periods range from 9 to 24 months, depending on requirements of the researchers. The OHRC is primarily concerned with producing surrogate wild Winter steelhead trout originating from ESA-listed wild parents while Chinook Salmon are reared as well. The FPGL concentrates on Spring Chinook representing the various stocks in the basin. To date the project has provided nearly 500,000 to various agencies and a consulting company. This reporting period fish were produced and delivered to U.S. Army Corps of Engineers and Pacific Northwest National Laboratory. Juvenile Chinook salmon and steelhead trout from brood year 2022 are presently being reared.

This project provides research results to state hatchery personnel to assist with special fish culture needs at various hatcheries. The project also provides artificially raised Chinook with wild-like characteristics to ODFW to stock into watersheds to help reestablish populations of natural origin fish.

The research team accomplishes this by varying growth, feeding, density, cover, tank complexity, and diet. Special diet was formulated and produced for this project by the U.S. Fish and Wildlife Service's facility at Bozeman, Montana. The research team has also found that vertical location in a tank can influence similarity to different wild migrant phenotypes. To accomplish its objectives, the project has conducted research on all of the husbandry variables mentioned above at both facilities within rearing tanks, laboratory behavioral test chambers, and the artificial streams. Study variables include movement behavior, development (i.e., smolting and precocity) physiology, morphology, brain development, and gene expression. Tests have also included migratory performance of fish released into the McKenzie and the North Santiam Rivers.

Fish produced through this project are more like wild fish in morphology, fin condition, body composition, and behavior than typical hatchery fish. Over the course of nearly 12-years, this project has provided scientists, mainly from the USGS, ODFW, the Pacific Northwest National Labs, and the U.S. Army Corps of Engineers with surrogate wild Chinook salmon and steelhead. The overall success of this program is founded on numerous evaluations and the results of field studies. To date, over 400,000 wild Chinook salmon surrogates have been produced for researchers. In addition to nearly 50,000 wild Chinook salmon surrogates being provided to ODFW for stocking to restore a depleted population in the upper Molalla River, thousands of Willamette winter-run, threatened steelhead trout have been provided to researchers. All of these fish have been liberated into target watersheds in the Willamette basin. This research team has also conducted four release studies, two in the McKenzie and two in the North Santiam watersheds, of PIT-tagged surrogate wild Chinook Salmon to ascertain movement and survivorship of study fish. While not the direct aim of this research, some of these fish have contributed to adult returns.

Surrogate wild fish are provided at various times of the year and at several sizes that correspond to wild fish in study systems. This is done for genetically distinct populations. Our end users of the fish we supply have found that our fish have at least 95% the same movement behavior that they find in wild fish of the same stocks and times of year. The project has also produced

genetically marked Chinook to be studied in Willamette basin reservoirs at a size too small to be tagged by conventional means. This project has also created parasitic copepod-infected Chinook salmon for researchers studying fish bypass systems at Willamette dams. Huge numbers of fish in the reservoirs have severe infection rates. We conducted research to determine how to infect fish at naturally occurring severities with this parasite. We also found that survivorship of these fish is significantly reduced. We provided researchers with over 1,000 copepod-infected smolt-sized fish for their dam passage studies.

Hatchery Domestication Selection Project (Mission Goals 1.a, 1.b., 2.d.)

Substantial evidence shows that reduced fitness in the wild evolves simultaneously with greatly improved performance in the hatchery (Christie et al., 2012; Blouin et al., 2021). So it appears that fish are rapidly adapting to the hatchery (domestication) in ways that make them less well adapted to wild conditions. The Blouin lab is testing if it is possible to change hatchery rearing conditions to slow that process down. Their working hypothesis is that hatcheries inadvertently select for extreme values of heritable physiological or behavioral traits that allow some fish to grow quickly in the unnatural conditions of a hatchery, but at a cost to survival of their offspring in the wild. This is because the size of hatchery smolts at release is positively correlated with their probability of survival at sea (e.g. Thompson et al., 2018). So there is strong selection to grow as quickly as possible in the hatchery. Such selection might be especially intense on steelhead, which are typically raised to smolting in one year in hatcheries, versus the normal two years that they take in the wild. If those hatchery-favored traits are heritable and disfavored in the wild, then the wild-born offspring of hatchery fish that spawn in the wild would have low survival. This mechanism would explain why researchers consistently measure low fitness in hatchery fish that spawn in the wild. Blouin's group tested this hypothesis, showing that offspring of F1 hatchery broodstock do indeed grow faster in the hatchery than offspring of wild broodstock, while having poorer survival in the wild (Blouin et al., 2021). These are compelling data in favor of their hypothesis. This is promising news in that it shows that selection on traits of juvenile fish is very likely involved, meaning it might be possible to manipulate the hatchery environment to reduce those inadvertent selection pressures.

Dr. Blouin's group has been testing various modifications to standard hatchery practice in the hopes of finding modifications that will reduce the variation size at release. If that could be achieved, then there would be less intense selection on size at release. Thus, the gene pool that comes back from the sea would more closely mirror the gene pool that went into the hatchery (i.e., less rapid evolution). Their strategy is to try various manipulations of the hatchery environment on a small scale at the OHRC and OSU labs. If they find promising results, then we will test that manipulation on a production scale.

A hatchery is very different from the wild environment in that hatchery fish are crowded, in a featureless, predator-free environment, and fed large amounts of food that is nutritionally very different from the wild diet (e.g. high fat). The researchers hypothesize that variation in behavioral or physiological traits control which fish do well in that novel environment. So they are testing manipulations of the hatchery environment that they predict will favor the fish that don't normally thrive in the standard environment. In previous work at the OHRC, they found that raising fish at reduced densities had a small, but not statistically significant, effect in the desired direction (i.e. more narrow distribution of body sizes among families at release)

(Thompson and Blouin, 2015). They also experimented with manipulating the fat content of food to make it more like the high-protein wild diet, but that had minimal effect (Blouin et al., 2021).

One hypothesis is that fish that thrive and grow quickly in the hatchery may be “bolder”. Bolder fish seek out food more aggressively. In the wild that behavior exposes them to predation, but in the hatchery there is no cost to such behavior. Therefore, extreme boldness may be favored under hatchery conditions, but not under wild conditions. Some experimental data supports that hypothesis. Firstly, dominance and boldness tend to be correlated, and dominant families tended to grow more quickly (Thompson and Blouin, 2016). Another correlate of generalized boldness is willingness to feed at the surface. In two previous experiments, Blouin’s lab found substantial variation among steelhead families in propensity to feed at the surface. There was a positive correlation between family growth rate and surface feeding in one experiment (Wrey et al., 2020), although not in the other (unpublished data). So the lab has been testing whether environmental modifications of the hatchery that should favor shyer fish can reduce the variation in size at release.

Manipulations designed to favor the “shyer”, more skittish juveniles include changing the manner and timing in which food is delivered. They tested the effect of switching from hand feeding to automatic feeders. The hypothesis was that shyer juveniles might be less willing to feed in the presence of humans, but there was no effect (Wrey et al., 2020). Last year they tried a feeding schedule that involved alternate periods of feeding all the fish to complete satiation, followed by periods of fasting. The idea here was that if one satiates the more dominant fish, the less aggressive ones might be willing to eat more. However that treatment also had minimal impact on the distribution of sizes at the end of the experiment (unpublished data).

In 2022 they set up three experiments. In the first experiment they added physical structures in the tanks to give shyer fish places to hide from the more aggressive fish. The researchers hypothesize that this shelter may encourage the shyer fish to feed more readily, and so grow more quickly. The second experiment uses circulating water in the tanks to make all the fish swim constantly. This should prevent dominant fish from setting up territories, again releasing the subdominant fish from aggression. Thirdly, they are testing the effect of grading fish by size halfway through the growth period, and then raising the small ones separately (with more food and space, to see if they will catch up to the big ones). These experiments take about a year and half to complete, and so are still underway. At the end of this work, we should know whether or not simple modifications to hatchery rearing conditions, like those described above, are likely to substantially reduce the rate of inadvertent domestication that occurs in hatcheries. If one or more treatments appear to be promising, then we will undertake larger experiments to test the effect at a production scale. If not, then we will conclude that simple modifications to the hatchery environment are unlikely to overcome the strong family effects that are observed in such experiments. In that case, more extensive changes to hatchery culture might be required, but those will have to be balanced against the inevitable reduction in overall hatchery output that such changes would likely produce. Alternately, other approaches will need to be explored in order to mitigate genetic effects of hatchery fish spawning in the wild.

The Alsea Steelhead “Biter Study” (Mission Goals 1.c., 1.b., 1.c., 2.a.1., 2.a.2., 2.b., 2.c.)

Dr. Marc Johnson has led this project, which was initiated in response to a request from the Alsea Sportsmen’s Association, a local recreational angling group, together with other interested stakeholders. ODFW District Fish Biologist, John Spangler, obtained R & E funding to support the necessary creel census for this project. Funding for analyses of genetic samples of parental broodstock was provided by the OHRC and ODFW, and facilities for the genetic work provided by State Fisheries Geneticist, Dr. Kathleen O’Malley, at the Hatfield Marine Science Center in Newport, Oregon. This project depended on extensive in-kind and personnel support from ODFW, OHRC and OSU. Substantial efforts by collaborators on this project have helped to advertise the project, encourage angler participation and highlight the cooperative nature of this between ODFW and local anglers. The basic question for this project is whether the source and treatment of hatchery broodstock would affect the likelihood of their offspring to contribute to recreation catch (harvest). Conventional hatchery broodstock programs collect brood fish from traps, using fish that have not been taken by anglers. This study tested the hypothesis that the probability of a fish being caught by an angler would be affected by the source (angler vs. trap) of the parent fish; the prediction being that fish produced from conventional (trap caught) broodstock would be less likely to be caught by anglers than fish produced from broodstock that were caught by anglers. The question is straightforward and highly relevant to salmon and steelhead hatchery management, yet required considerable cooperation, collaboration and coordination among anglers, ODFW hatchery managers, the OHRC and researchers involved with the project. Collection of broodstock for this study occurred in 2015 and 2016, and their adult offspring returned and were sampled in the winters of 2017 and 2018. In 2019, Dr. Johnson presented preliminary results from this work at the annual meeting of Oregon Chapter of the American Fisheries Society, in Bend, Oregon. In 2020, Dr. Johnson and colleagues finalized and provided their results through an ODFW Information Series Report (Johnson et al. 2020)⁹. In brief, this research team found no compelling evidence that the offspring of angler-caught broodstock were more likely to be caught by anglers than steelhead produced with trap-caught broodstock. Surprisingly, and of great importance to hatchery managers, they found that trap-caught broodstock significantly and consistently produced more adult steelhead than angler-caught broodstock, as measured by the number of adult steelhead encountered in both the creel and hatchery trap. Dr. Johnson presented these results on March 16, 2021 at the Pacific Coast Steelhead Management meeting, hosted by Pacific States Marine Fisheries Commission. Meeting information available at <https://www.psmfc.org/steelhead/>.

Effect of Mate Choice on Fitness (Mission Goals 1.a., 1.b., 1.c., 2.a., 2.b.)

This project is identified in the OHRC Research Plan and is led by Dr. Michael Banks, with assistance from Dr. Heather Auld and lab manager Dave Jacobson. The premise of this research is that mate choice decisions made by wild salmon and steelhead under natural settings may involve genetic information that, ultimately boosts their individual fitness.

9

https://nrimp.dfw.state.or.us/web%20stores/data%20libraries/files/ODFW/ODFW_41981_2_ODFW%20Info%20Report%202020-05%20Alsea%20Steelhead%20Angler%20Vulnerability.pdf

In continuing Phase 3 of their work, Drs. Banks and Auld performed empirical tests to determine whether informed crosses that used their genomic and bioinformatic tools in 2019, 2020 and 2021 resulted in higher reproductive success of hatchery Coho Salmon.

Briefly, the overall experiment is designed as follows: First, hatchery Coho Salmon broodstock are collected and held at Sandy Hatchery as per standard hatchery practice. Once most of the brood is collected, genetic samples are taken from each male and female fish, by collecting a tissue sample from each individual in the form of a fin punch. Each fish is coincidentally marked with a unique floy tag number which allows the researchers to later identify individuals (and the associated mate choice relevant genotypes) on the spawning table. Fin punches are taken back to the lab where DNA is extracted and GTSeq is used to develop a genetic profile of each fish at markers identified in Phase 1 to have a role in mate choice. Within two weeks of brood collection and sampling, experimental spawning was carried out as per usual hatchery protocol with the exception that each female's batch of eggs were split into two equal volumes:

- One half of the eggs were fertilized by a male selected randomly (as per traditional hatchery process).
- The other half of the eggs being fertilized by a male selected based on the genetics of both the male and female at specific GTseq genetic markers.

This approach aimed to emulate genetic combinations observed among successful wild-like mating identified during Phase 1 of the project, and was implemented in the fall of 2019, 2020, and 2021. Final assessment of the relative fitness of these two mating approaches will occur when cohorts of offspring Coho Salmon return from the ocean in 2021 (as jacks from the 2019 spawn), 2022 (as adults from 2019 and jacks from 2020), 2023 (as adults from 2020 and jacks from 2021), 2024 (as adults from 2021). Due to the life history of salmon, it is impossible to conclude final results of this study until after these adult fish return from the ocean, at the end of their lifecycle. Also because 2021 adults will return through late fall, and it will take some time to extract DNA, and resolve pedigree, complete final results will not be possible before 2025.

In addition to the aforementioned activities, in 2022, Drs. Banks and Auld continued to carry out a study on Chinook Salmon pedigree, involving natural and hatchery origin Chinook that spawned in a natural context above Cougar Dam in the McKenzie River, similar to the Coho Salmon pedigree from Calapooya Creek on the Umpqua River. A manuscript for their Chinook research is currently in preparation. Drs. Banks and Auld also continue to prepare a manuscript describing different hatchery spawning practices throughout the state, which began in 2019 when they hosted an NSF funded undergraduate student through the Research Experience for Undergraduates (REU) program. With release of COVID-19 restrictions Dr. Banks was able to present this work to the public, stakeholders and peers at 5 meetings with OHRC Board, with ~40 OR Hatchery Managers and associated ODFW Leadership at the ODFW Hatchery Managers Meeting, in July, and with ~300 Hatchery managers, staff, NOAA, state (e.g. ODFW), Tribal and private representations from throughout US and Canada, at the 71st meeting of the Fish Culture Society (AFS) in December.

Hatchery rearing practices that reduce stress and improve immunity system of hatchery salmon (Mission Goals 1.a., 2.a., 2.b.)

In 2022, Dr. Couch completed three research projects that are relevant to the OHRC mission, and made significant progress on a fourth project that is directly funded by the OHRC. The first three projects are summarized briefly below, but more details can be found in the associated publications (Couch et al. 2022a, 2022b, and 2023).

First, Dr. Couch and colleagues completed a study characterizing the cortisol dynamics of adult Chinook Salmon during the three months prior to spawning (Couch et al. 2022a). This study is relevant to the OHRC mission because it clarified the susceptibility of adult fish to external stressors, including those related to hatchery operations. In this study, adult Chinook Salmon were obtained from the ODFW Minto Fish Facility on the North Santiam River. Fish were held in cool, pathogen-free water at the Fish Performance and Genetics Laboratory (FPGL) from early June through September. Each month, cortisol levels were measured before and the application of a mild stressor. Results showed that both resting and stressed cortisol levels begin to rise in adult Chinook Salmon as they mature, beginning at least three months prior to spawning. Chronically elevated cortisol may result in increased susceptibility to disease and external stressors such as passage, handling, and predator pursuit. Our finding that resting and stressed cortisol become elevated at least three months prior to spawning suggests that early freshwater phase adults may be more susceptible to stressors than previously believed.

Dr. Couch and colleagues also completed two studies that identified potential biomarkers of stress and immunosuppression. The first of these potential biomarkers is a novel microsporidian parasite, *Enterocytozoon schreckii*, which was described by Couch et al. (2022b), and which has only been found in senescent adult fish. The second set of biomarkers is a set of gut microbes that become more abundant (or less abundant) in fish that are chronically stressed, and some of these microbes predict mortality in stressed or senescent fish (Couch et al. 2023). These biomarkers could be leveraged for the development of nonlethal tests to monitor population health in hatcheries and in natural settings. Developing tractable indicators of stress and immunosuppression could significantly reduce costs and enhance the effectiveness of fish health monitoring programs and could contribute to the OHRC goal of defining the factors that contribute to hatchery risk.

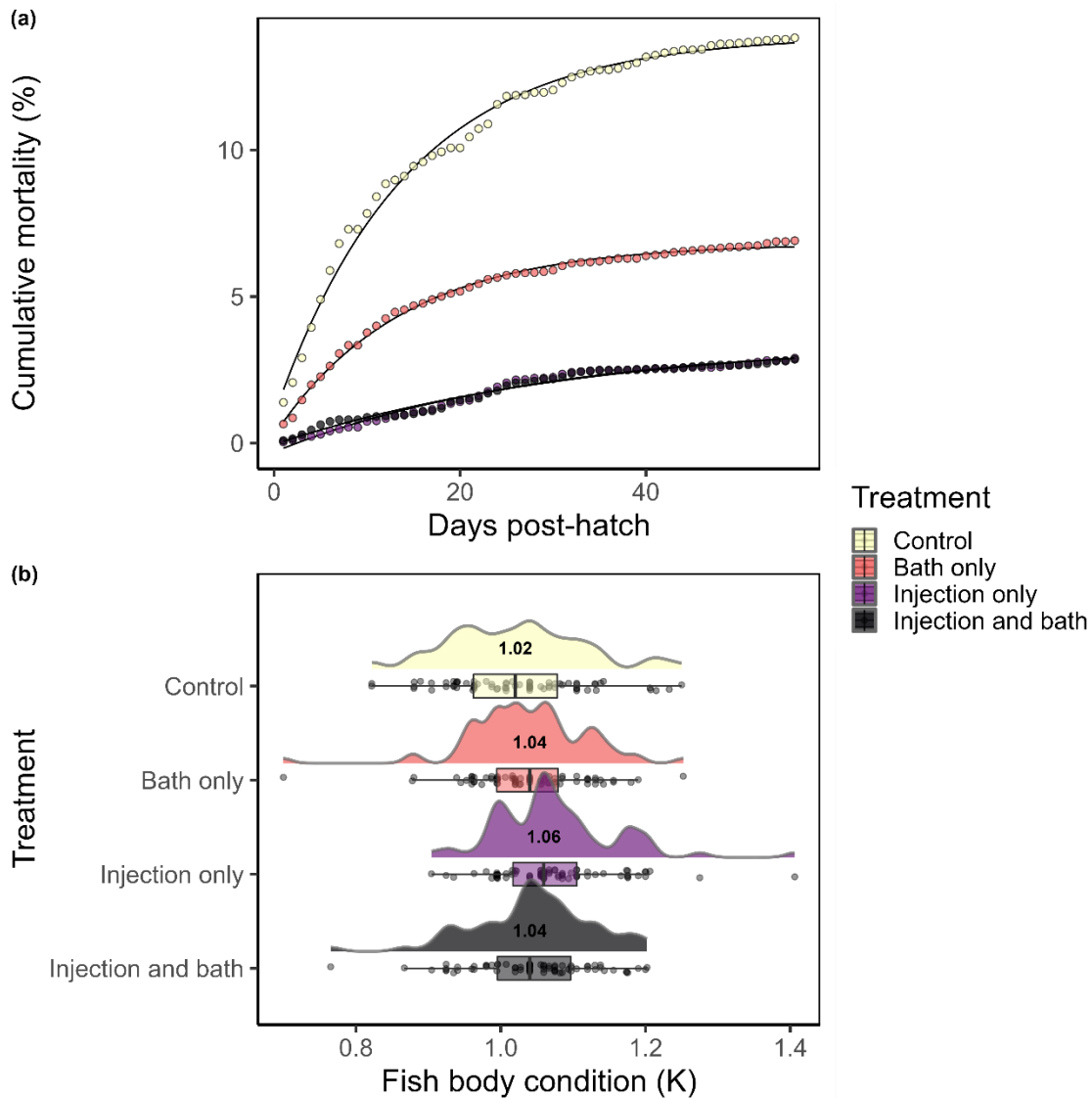
Finally, significant progress was made on Dr. Couch's OHRC-funded research project. This project, which was funded in 2022, seeks to define the effects of diet on microbiome communities, immune function, and disease in captive-reared fish. For this experiment, we held juvenile Chinook Salmon on two different diets: (1) a standard hatchery diet, or (2) a low-lipid diet designed for wild-like growth and development. We reared fish for eight weeks on either of these two diets, with a subset of fish switching between diets midway through the study. We collected gut microbiome swabs biweekly throughout the study and collected tissue and blood samples for immune assays at the end of the study. We have completed all sample processing for the microbiome samples, and these samples are currently being sequenced at Oregon State University. We anticipate microbiome results will be available by the end of 2022. Preliminary immune assays have been completed, with early results indicating that the low-lipid diet enhances innate immune function relative to the standard hatchery diet. We await the results of

additional immune assays in order to confirm these results. Future studies will directly assess the effects of diet on disease resistance by conducting experimental infections of fish reared on different diets. These studies will clarify whether any microbiome/immune differences associated with feed type are sufficient to significantly alter disease susceptibility. In addition to diet, future studies will assess the effects of other important rearing parameters (e.g. density, tank design, probiotic/antibiotic treatment) on microbiome communities, immune function, and disease susceptibility in Pacific salmon. Ultimately, results from Dr. Couch's ongoing work could contribute significantly to optimizing post-release survival of hatchery fish and reducing the risk of hatchery operations (including disease transmission) to wild fish.

Effect of thiamine supplementation on the health and survival of hatchery steelhead (Mission Goals 2.a)

Dr. Reed's research on thiamine deficiency in Oregon hatchery steelhead is exquisitely applicable to Oregon hatcheries, and it highlights a larger and more complicated issue if applied to wild fish populations, both steelhead and other salmonids. This project is being conducted by Aimee Reed, Senior Fish Health Specialist for ODFW's Fish Health Services. She is working with Jennifer Krajcik and the staff at Alsea hatchery for steelhead supplementation work. Thiamine egg analysis via HPLC is being adapted at OSU's Linus Pauling Institute analytical chemistry laboratory staff. Early rearing of steelhead in Oregon hatcheries is often problematic; fry can become emaciated and die during the period between hatch and first feed. This has been a problem for a long time but was dismissed as either poor breeding, poor environment, or just an inability for steelhead to survive early life in hatcheries, and adjustments for program needs are accommodated for by increasing number of fish spawned and by increasing egg takes to meet production goals. Thiamine (vitamin B1) deficiency has caused early mortality in other salmonids but it was unknown if the thiamine status of Oregon's steelhead populations is contributing to early rearing successes. Previous analysis of 26 egg samples from three Oregon hatcheries in 2019, 20 (77%) had thiamine levels < 10 nmol/g, and 13 of those samples (50%) had levels < 6.5 nmol/g, suggesting the thiamine deficiency of adult, female steelhead.

In this study, to investigate if thiamine deficiency was causally related to fry survival, females were injected with buffered thiamine HCl 50 mg/kg prior to spawning; additionally, a subset of eggs were supplemented via bath treatment with thiamine mononitrate (1000 ppm) at spawning. A third group of fry was reared from injected-females that also received thiamine as a bath, and the control group was fish from non-supplemented females that received no thiamine. Cumulative fry mortality at 8 weeks post-hatch from thiamine-injected females was 2.9% compared to 13.8% mortality of fry without thiamine supplementation. Fry treated only with the thiamine via bath as eggs had a mortality rate of 6.9%. There were no additional improvements for the survival of fry from injected females that also received a thiamine bath. Furthermore, condition factors (K) were greater in thiamine-supplemented fry that came from injected females than in those that received no thiamine.



If the hatchery steelhead sampled in this study are representative of wild steelhead populations in Oregon, thiamine deficiency may be an important and underappreciated limiting factor for their survival. Providing supplemental thiamine can profoundly increase the survival, growth, and health of steelhead fry in Oregon hatcheries. This is the first description of the thiamine deficiency of steelhead populations in Oregon.

In efforts to adopt methods to analyze egg thiamine via HPLC at OSU's Linus Pauling Institute (LPI), eggs from supplemented and non-supplemented broodstock were supplied to LPI's analytical chemists. Fish eggs are notoriously difficult to use as substrate for HPLC; additionally, thiamine is exquisitely sensitive to degradation by light, temperature, and pH. Results of the initial analysis have been analyzed by the leading laboratory that conducts this test (SUNY) for comparison. Three vitamers of thiamine are reported and total thiamine is estimated using these values. The laboratories are currently comparing results to check for quality of runs as well as comparisons of known samples. Next steps are to submit additional samples for analysis and provide feedback in order to continue to develop and troubleshoot this assay.

Impact of Research

Findings from research conducted at and through the OHRC are disseminated through peer-reviewed publications, technical reports, as well as presentations at conferences and symposia. Management applications of OHRC research are discussed in a previous section of this report. Listed here are papers, reports, and presentations developed by OHRC-supported researchers. **Works completed or submitted in 2022 are indicated in bold:**

Technical Reports, Theses and Peer-reviewed Journal Publications

Armstrong, M., Minkoff, D., Dittman, A.H., May, D., Moody, E, Quinn, T.P. and W.R. Ardren. 2021. Evidence of an olfactory imprinting window in embryonic Atlantic salmon. *Ecology of Freshwater Fish*. DOI: 10.1111/eff.12628

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Presentations at Research Conferences and Meetings

- Auld, H.L., D.P. Jacobson, A.C. Rhodes, M.A. Banks. 2019. Mate choice of hatchery and wild coho salmon. Behaviour. Chicago, Illinois, USA.
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- Bohn S, Whitman L, Cannon B, Hart S, Lewis M, O'Malley KG. American Fisheries Society, "Use of neutral and adaptive (Greb1L) genetic markers to discriminate spring and fall Chinook salmon across time and space in the Sandy River, Oregon, USA," Reno, Nevada. (2019). Oral Presentation.
- Cogliati, K.M. Friesen, T.A., Johnson, M.A., Olmsted, P., Schreck, C., and Noakes, D.L.G. 2021. Migration and survival of juvenile winter steelhead above and below high-head dams. Pacific Coast Steelhead Management Meeting, March 16-18, 2021. Abstract and presentation available at: <https://www.psmfc.org/steelhead/past-2021.html>
- Couch CE. Monitoring, management, and microbes: the role of commensal bacteria in fish health. Invited lecture at the Continuing Education Session of the Western Fish Disease Workshop, Hood River, OR, 2022.**
- Dittman, A.H. Remembrance of things past: Strategies to reduce straying in hatchery-reared salmon. Presentation to NWFSC, NOAA. October 2022**
- Dittman, A.H. Olfactory imprinting and homing in Pacific salmon: Mechanisms and controlling factors. Presentation to Alaska Dept. Fish and Wildlife, University Alaska, Alaska Science Center. January 2022**
- Hakason, O., Cogliati, K.M., Noakes, D.L.G., Schreck, C.B. 2020. Conceptual decision making model for artificial rearing of fish intended for use in passage studies. OR Chapter American Fisheries Society, Bend, OR.
- Johnson, M. A. Fishing for the next generation: the value of angler-assisted broodstock collection programs. Presentation to the ODFW Restoration and Enhancement Board. Newport, OR, December 2, 2022.**
- Johnson, M. A. An Introduction to the Oregon Hatchery Research Center. 2022. Presentation at the ODFW Hatchery Managers' Meeting. July 28th, Elkton, OR.**
- Johnson, M. A. 2022. The Olfactory Imprinting Project. Presentation at the ODFW Hatchery Managers' Meeting. July 28th, Elkton, OR.**
- Johnson, M. A. Fishing for the next generation: the value of angler-assisted broodstock collection programs. Webinar presentation to ODFW managers and staff, December 2, 2020.

- Johnson, M. A. Managing genetic risk from hatchery salmon. Oral presentation at Public Outreach Event, Port Orford, October 24, 2019
- Johnson, M.A., Spangler, J.J., Jones, M. Couture, R.B., Noakes, D.L.G. Can angler-caught broodstock programs improve catch rate of hatchery steelhead? Oral presentation at the Pacific Coast Steelhead Management Meeting, March 16-18, 2021. Abstract and presentation available at: <https://www.psmfc.org/steelhead/past-2021.html>
- Johnson, M.A., Spangler, J.J., Couture, R.B., Noakes, D.L.G. Can angler-caught brood improve catch rates in steelhead fisheries? Results from a genetic tagging study on Oregon's Alsea River. Oral presentation at the Annual Meeting for the Oregon Chapter of American Fisheries Society, Bend, Oregon, March 4-8, 2019
- Kamran, M. "Olfactory imprinting". Oral presentation at Public Outreach Event, Port Orford, October 24, 2019.
- Kamran, M. "Olfactory imprinting and homing in Pacific salmon". Oral presentation for the Confederated Tribes of Warm Springs at the Warm Springs National Fish Hatchery, May 22-23, 2019.
- Kamran, M., M. M. Pollock, A. H. Dittman, M. A. Johnson, and D. L. G. Noakes. "Use of olfactory learning and conditioning assays to select odorants for olfactory imprinting to improve homing in Pacific salmon". Oral Presentation at the Gordon Research Seminar, Movement Ecology of Animals, March 2-3, 2019 in Lucca, Italy.
- Kamran, M., M. M. Pollock, A. H. Dittman, M. A. Johnson, and D. L. G. Noakes. "Using behavioral assays to select odorants for olfactory imprinting to improve homing in Pacific salmon". Poster Presentation at the Gordon Research Conference, Movement Ecology of Animals, March 3-8, 2019 in Lucca, Italy.
- Kamran, M., M. M. Pollock, A. H. Dittman, M. A. Johnson, and D. L. G. Noakes. "Smells like home: Use of behavioral assays to select odorants for olfactory imprinting to improve homing in Pacific salmon". Oral Presentation at the Society of Integrative and Biology Annual meeting, January 3-7, 2019 in Tampa, Florida.
- Krajcik, J. "Salmon research at the Oregon Hatchery Research Center". Northwest Fish Culture Concepts Meeting, held December 4th, 2019 in Victoria, British Columbia.
- O'Malley, K.G. 2020. *Greb1L* variation in Chinook salmon from the Sandy and Rogue Rivers. Genomics Workshop: Reviewing and synthesizing the state of the science regarding associations between adult run timing and specific genotypes in Chinook salmon and steelhead. NOAA Northwest Fisheries Science Center. Seattle, Washington.

O'Malley KG, Dayan DI, Mazur S, Green LJ, Bohn S, Johnson MA, Van Dyke DJ, Samarin P, Wells A, Battleson RD (2022) Genetic diversity within late-summer and half-pounder steelhead (*Oncorhynchus mykiss*) in the Rogue River, Oregon. American Fisheries Society Meeting, Spokane, WA. Oral Presentation.

Piotrowski, S.J., O'Malley, K.G., Hereford, M.E., Pearse, D.E., Armstrong, J.B., Tinniswood, W.R., and Ramirez, B.S. 2020. Genomic diversity of Klamath Redband Trout. Oregon American Fisheries Society Meeting. Bend, Oregon.

OHRC Workshops

Although the OHRC re-opened to the public and hosted numerous classes and tours in 2022, the center did not host focused workshops in this year.

OHRC Mission Goal 3: Education and Outreach

The OHRC re-opened to public visitation in May of 2022, following an extended closure in response to COVID-19 safety measures. OHRC staff, Jen Krajcik and Craig Lawson, led tours of the facility for several groups in 2022, including a group of retired OSU staff, a group from the Tillamook Estuaries Partnership, and the OSU Fish and Wildlife Club. The OHRC also hosted a Free Fishing Day in June. OHRC staff also maintained the center's outdoor kiosk with OHRC information and ODFW regulations, taught students about fish anatomy and the salmon lifecycle, through dissections and spawning observations.

In late July, 2022, OHRC researchers shared and discussed their work with ODFW hatchery managers during a 3-hour session of the agency's biennial Hatchery Manager's Meeting, regularly held in Elkton, Oregon. Presentations by Drs. Aimee Reed, Marc Johnson, Michael Banks, Michael Blouin and Jen Krajcik were followed by a question-and-answer session with a strong representation of Oregon's hatchery managers. OHRC Board Chair, Scott Starkey, also participated in this meeting and discussions, then shared his perspective with other OHRC Board members during their September meeting. As in past years, the Hatchery Manager's Meeting proved to be a productive forum for researchers and hatchery managers to exchange ideas, and gain appreciation of new tools and challenges in the fields of hatchery management and native fish conservation.



Environment

OSU researchers look to raise more "shy" hatchery steelhead

Karen Richards, January 18, 2022

A professor at Oregon State University is leading a series of studies to breed hatchery-raised steelhead that are more like wild fish.

▶ LISTEN • 0:58

OHRC outreach was also achieved through news releases in the popular press. Examples here include an article in *Hatchery International*, describing OHRC-funded research being conducted

in Michael Banks' lab¹¹, and an OSU news release of Dr. Michael Blouin's OHRC work¹² that was subsequently covered by a variety of news outlets, including ScienceDaily¹³, KTVZ news¹⁴, KOIN news¹⁵, and which led to radio interviews on KLCC¹⁶ and Jefferson Public Radio¹⁷.

More education and outreach services provided by OHRC-affiliated researchers and staff are described on pages 20-21 of this report.

¹¹ <https://www.hatcheryinternational.com/choosing-a-mate-wild-vs-hatchery-coho-salmon/>

¹² <https://today.oregonstate.edu/news/oregon-state-researchers-explore-ways-make-hatchery-steelhead-more-wild-fish>

¹³ <https://today.oregonstate.edu/news/oregon-state-researchers-explore-ways-make-hatchery-steelhead-more-wild-fish>

¹⁴ <https://ktvz.com/news/wildlife/2022/01/18/osu-researchers-explore-ways-to-make-hatchery-steelhead-more-like-wild-fish/>

¹⁵ <https://www.koin.com/news/environment/osu-researcher-wants-to-make-hatchery-steelhead-more-like-wild-fish/>

¹⁶ <https://www.klcc.org/2022-01-18/osu-researchers-look-to-raise-more-shy-hatchery-steelhead>

¹⁷ <https://www.ijpr.org/show/the-jefferson-exchange/2022-01-25/wed-8-am-fish-experts-look-for-ways-to-make-hatchery-fish-more-like-the-wild-ones>

Appendix 2: Announcement for the OHRC's 2021 fall workshop,
Spawning Fresh Ideas

Spawning Fresh Ideas

The Oregon Hatchery Research Center (OHRC) announces its fall workshop **Spawning Fresh Ideas**, to be hosted virtually from 9 a.m. until noon on **September 9th and 10th, 2021**. The purpose of this workshop is to showcase ongoing research at the OHRC and identify new research concepts that address the OHRC's research mission. The number of participants for this event will be limited, so please **register by August 20th** by contacting OHRC's acting Director at Marc.Johnson@oregonstate.edu.



The OHRC Mission

Recognizing that wild and hatchery fish runs are a vital part of each Oregonian's heritage, and that hatchery fish play a key role in meeting both fisheries and conservation objectives, the mission of the Oregon Hatchery Research Center (OHRC) is to be an internationally recognized leader in fisheries science, conducting research to define the mechanisms that may create differences between hatchery and wild salmonids, recommending strategies to manage those differences, and educating Oregonians about the benefits, risks, roles and performance of hatcheries in fisheries augmentation and conservation. The OHRC will foster and support a wide range of research and education projects, and provide unique state-of-the-art facilities.

How to participate

First, share your fresh ideas! Hatchery and wild salmon can differ in many important ways – through adult return timing, size, age at maturity, fitness in the wild, and much more. The OHRC is tasked with developing and supporting research that investigates how such differences arise, and how they might be managed to benefit fisheries and limit risk to wild fish. In preparation for our workshop, we're asking that you kindly consider submitting new ideas to help us fulfill our mission. New research concepts should be presented in the form of a question that addresses how differences between hatchery and wild salmon develop, or how differences could be managed.

For example: Could leaner hatchery diets influence the age at maturity of returning hatchery salmon to more closely resemble demographics of wild counterparts?

Research concepts should be sent by August 27th to Marc.Johnson@oregonstate.edu

Second, register! Simply email Marc.Johnson@oregonstate.edu by August 20th to confirm your interest to participate in **Spawning Fresh Ideas**. You'll then receive an agenda and connection information for the workshop.

Can't attend the workshop? No problem. We understand that these are busy times for many, but we still want to hear from you! Whether or not you can join us in September, please consider submitting research concepts. Your ideas will be presented, discussed, and help to shape the future of OHRC's research program!

Questions or comments? Contact Marc Johnson at Marc.Johnson@oregonstate.edu or by phone at 541-224-4063. Visit us at <https://www.dfw.state.or.us/fish/ohrc/>



Appendix 3: The OHRC's 2022 fall Request for Proposals

OHRC Request for Proposals 2023-25



The Oregon Hatchery Research Center (OHRC) is a cooperative undertaking between the Oregon Department of Fish and Wildlife and Oregon State University's Department of Fisheries, Wildlife, and Conservation Sciences. Recognizing that wild and hatchery fish runs are a vital part of each Oregonian's heritage, and that hatchery fish play a key role in meeting both fisheries and conservation objectives, the mission of the OHRC is to be an internationally recognized leader in fisheries science, conducting research to define the mechanisms that may create differences between hatchery and wild salmonids, recommending strategies to manage those differences, and educating Oregonians about the benefits, risks, roles and performance of hatcheries in fisheries augmentation and conservation. The OHRC will foster and support a wide range of research and education projects, and provide unique state-of-the-art facilities.

The OHRC is now soliciting proposals for research to be conducted in 2023-25.

By statute, the OHRC is to conduct the following activities pursuant to the strategic direction established by the OHRC Board:

- a) Conduct research that assists in the implementation and advancement of native fish population recovery as well as viable fisheries.
- b) Conduct research on methods to minimize the genetic and ecological risks to naturally produced native fish when hatchery produced fish are released in the waters of this state for population recovery or consumptive fishery objectives.
- c) Conduct research to determine the genetic and ecological risk to naturally produced native fish when wild native broodstock hatchery produced native fish are released into the waters of this state.
- d) Conduct research to determine the effect of hatchery operations on naturally produced native fish and the habitat of naturally produced native fish.

- e) Provide educational and research opportunities for undergraduate students, graduate students and post-graduate students.
- f) Provide educational opportunities for the public and for students in grades 1 through 12.

The Oregon Hatchery Research Center is now accepting proposals for research to be conducted July 1, 2023 through June 30, 2025, with possibility for no-cost extension pending approval. Proposals may request funding for continuation of previously approved studies, or address new questions. Regional scientists, ODFW, and the OHRC Board have identified the following priority research concepts to contribute to the OHRC's strategic direction:

1. How might release strategies for hatchery salmonids be improved, especially for climate change adaptation?
2. How can rearing conditions and smolt release be modified to improve survival of hatchery salmonids?
3. What are alternative measures of risk to wild stocks from hatchery strays, and how might they be monitored over time?
4. Do traits of hatchery fish pass to wild fish, and will they reverse over time?
5. How do different hatchery spawning practices (e.g., segregated vs. integrated broodstock management) affect the genetic and demographic characteristics of wild populations, and does the impact vary based on the health of wild populations?
6. Which traits are under selection in salmonid hatcheries that impact wild stocks, and how might fish culture techniques be modified to ameliorate selection?
7. How do hatchery operations affect the habitat of wild fish (positively and negatively)?
8. What are public perceptions of salmonid hatcheries, and how might outreach and education be effectively engaged to achieve a better understanding of their role in salmonid management?
9. How can communities effectively contribute to research and outreach through local conservation and supplementation programs?

See **Table 1** below for examples of research that could be conducted under these priority concepts.

Proposals should be prepared in the following format:

- A brief, not more than three (3) page study description, indicating the purpose and background for the proposed research, experimental design, study area, species, analytical methods, and expected results and products.
 - For funding requests to continue research projects that were approved in previous years, explain how the continued funding is needed to complete or enhance the research, and what new products will be provided.
- **Research proposals should explicitly connect to the OHRC mission, address one or more of the OHRC activities (a-f), and address one or more priority research concepts (1-9) or describe the need for continuation of an existing OHRC-funded project.**
- Up to one (1) page documentation of consultation with a hatchery manager on study design and value of the research for improved hatchery practices to meet management objectives.

- One (1) page communication plan for disseminating results to different audiences, including the OHRC Board.
- One (1) page study timeline, indicating expected delivery times for research and communication products (i.e. preliminary results, reports, etc.). For projects that require evaluation of progeny returns or multiple generations, indicate the extended timeline, work, and funding that would be needed to complete the research.
- One (1) page budget proposal, including indication of cost sharing or matching funding if applicable.
- A short (4-page maximum) *curriculum vitae* of Principal Investigator(s) highlighting previous collaborative work, products, and outreach that are relevant to salmonid management, hatchery practices, or other actionable science.

The OHRC plans to support multiple research projects, with estimated total support of \$900,000 offered through this RFP and award period (see below). Amounts awarded to projects for the previous 2021-23 are shown in **Table 2**.

Project proposals must be submitted as PDF, Word, or similar word processor files.

How proposals will be evaluated and selected for funding:

Proposals will be evaluated for scientific merit and feasibility by external science reviewers selected by the OHRC Director. Proposals and scientific evaluations will then be reviewed by the OHRC Director and Board to make recommendations to ODFW for funding.

<https://www.dfw.state.or.us/fish/OHRC/board.asp>

Awards will be based on project merit, including alignment with the OHRC mission, strategic actions, and priority research concepts listed above or the continuation of existing OHRC-funded research; feasibility of delivering timely and actionable science for ODFW hatchery management; demonstration of a collaborative and interdisciplinary approach; a record of previous success and products by the investigator(s); and budget viability.

Proposals for research located at the Center that enhance the OHRC's activities and outreach will receive additional consideration. Information regarding the facility and research capabilities is available at <https://www.dfw.state.or.us/fish/OHRC/> and further details can be obtained from the OHRC Director, Dr. Seth White (Seth.White@oregonstate.edu).

Submission deadline and award period:

Research proposals must be received by **midnight of November 7th, 2022 (PST)**. Award period to begin on or after July 1, 2023; period ends June 30, 2025, with possibility of no-cost extension.

How to submit:

Please submit your research proposal to the OHRC Director **by email** at: Seth.White@oregonstate.edu, using subject line **"OHRC Research Proposal"**

Table 1. The descriptions below are provided only as examples of research that could be conducted under the priority research concepts 1-9; proposals can be submitted that address other aspects of these concepts.

1. <i>How might release strategies for hatchery salmonids be improved, especially for climate change adaptation?</i> This could relate to timing of (or volitional) release in relation to river hydrograph or ocean conditions, or in response to competitor or predator densities or other environmental conditions impacted by climate change.
2. <i>How can rearing conditions and smolt release be modified to improve survival of hatchery salmonids?</i> This could relate to identifying rearing and release conditions that improve survival, such as more temperature resilient smolts, smolts that are better at avoiding predators, finding food in natural environment, etc.
3. <i>What are alternative measures of risk to wild stocks from hatchery strays, and how might they be monitored over time?</i> This could relate to developing or evaluating alternative risk-reward measures for fish hatchery management strategies. Conventional measures of risk include the proportion of hatchery-origin fish on spawning grounds (PHOS), proportionate natural influence (PNI), and measures that incorporate habitat carrying capacity.
4. <i>Do traits of hatchery fish pass to wild fish, and will they reverse over time?</i> This could relate to domestication selection and transmission of traits to wild fish through gene flow, as well as the potential for natural selection to reverse domestication over time.
5. <i>How do different hatchery spawning practices (e.g., segregated vs. integrated broodstock management) affect the genetic and demographic characteristics of wild populations, and does the impact vary based on the health of wild populations?</i> This could relate to whether—and under which circumstances—segregated or integrated hatchery programs are a more appropriate tool for increasing abundance of harvestable fish while minimizing risk to wild populations. The choice of which management strategy to use may depend on the conservation status of associated wild populations.
6. <i>Which traits are under selection in salmonid hatcheries that impact wild stocks, and how might fish culture techniques be modified to ameliorate selection?</i> This could relate to domestication selection similar to the first part of Concept #4, but explores in more detail the mechanisms of how hatchery practices might reduce domestication selection, perhaps by adding structure to tanks, increasing flow, removing dominance hierarchies, reducing size variance of fish, using circular tanks, etc.

<i>7. How do hatchery operations affect the habitat of wild fish (positively and negatively)?</i> This concept addresses how hatchery operations can be modified to minimize potential negative effects and maximize positive effects of hatchery operations on wild fish habitat. Examples could include a novel method or technology to minimize effluent outputs and reduce carbon emissions at hatcheries and/or focus placement of carcasses for nutrient enrichment in areas of greatest benefit to wild fish.
<i>8. What are public perceptions of salmonid hatcheries, and how might outreach and education be effectively engaged to achieve a better understanding of their role in salmonid management?</i> OHRC has been involved in education and outreach in the past, but this concept marks a shift towards acknowledging existing scientific approaches to studying human dimensions and social dynamics of fisheries. What insights can we draw from the social sciences to help with communicating the value and risks of hatcheries, and how can we measure whether that messaging is effective?
<i>9. How can communities effectively contribute to research and outreach through local conservation and supplementation programs?</i> This focuses on community science, also known as citizen science. For example, are there some activities the public can take that may or may not be viable at a production-level scale, but may have significant value in increasing public awareness and providing a way to engage the public such as the use of instream egg incubation boxes (hatch boxes). The term “public” means the angling public but could also target youth or other less-represented demographics.

Table 2. Level of support for OHRC-funded projects during the 2021-23 biennium.

Project title	Award amount
Automated sampling of 1,000s of salmon	\$280,000
Reducing domestication in hatchery salmon	\$310,881
Elk River olfactory imprinting	\$335,000
Efficacy of injectable thiamine treatments to alleviate deficient thiamine levels in eggs of steelhead trout	\$13,000
Optimizing rearing conditions of Pacific salmon for hatchery production and conservation	\$50,000
Survey and evaluation of ODFW’s angler-caught broodstock programs for coastal steelhead	\$3,766
TOTAL	\$992,647

Appendix 4: Summary of Proposals Submitted to the OHRC for 2023-25 Funding

Projects approved in the 2014 OHRC Research Plan

1. Differences caused by mate selection

Principle investigator: Michael Banks, Oregon State University

Species: Coho Salmon

Location(s): Sandy Hatchery, OR

Synopsis: This project evaluates whether mimicking ‘wild-like’ mate selection in hatcheries leads to greater reproductive success. This is Phase III of a long-term project that already evaluated genotypes of mate pairings (Phase I) and efficient methods for selecting wild-like mates in hatcheries (Phase II). Wild-like mate pairings are compared with random fathers in terms of number of fish successfully returning from the ocean to spawn. Most fish are still returning from sea and will continue through 2024. Results of this research may lead to new procedures for mating fish across hatchery programs to produce a better hatchery fish that will reduce impacts when interacting with wild populations. This project is being developed complementarily with the Value Tagger fin-clip sampler project, funded by OHRC and other sources.

Amount requested: \$332,686

2. Improved homing of hatchery salmon through novel rearing strategies: The Olfactory Imprinting Project

Principle investigators: Seth White, Oregon State University; Marc Johnson, ODFW; Andrew Dittman, Northwest Fisheries Science Center (NOAA), Thomas Quinn, University of Washington

Species: Fall Chinook Salmon

Location(s): Elk River, OR; OHRC; NOAA lab, WA

Synopsis: This project’s goal is to minimize hatchery straying by developing olfactory imprinting techniques that improve homing by hatchery-produced salmon. The project previously identified safe chemical odorants that can be added to hatchery water during periods of juvenile rearing and adult return (Phase I), employed physiological and genetic methods to identify the most appropriate odors and stages of juvenile rearing for odorant exposures (Phase II), and is currently conducting field tests to measure the effectiveness of odorant treatments for adult homing (Phase III). The current proposal advances work in progress by evaluating straying and homing rates in surface vs. well water and creating distinct chemical imprinting signature in hatchery water. Most control and treatment fish are still at sea and returning through 2027. The current proposal builds on this work by exploring affordable alternatives for production-scale applications and investigating the transferability of findings to other geographic regions and other hatcheries in context of climate change through mapping of environmental conditions and workshops with hatchery managers.

Amount requested: \$416,494

New proposals

3. How does seasonal timing mediate the effectiveness of hatchery carcass additions?

Quantifying benefits to the growth and survival of juvenile Chinook salmon in the Upper Grande Ronde Basin

Principle investigators: Jonny Armstrong, OSU; Ian Tattam, ODFW; Matt Kaylor, OSU; Joseph Feldhaus, ODFW; Joe Lemanski, ODFW, and Kyle Bratcher, ODFW

Species: Spring Chinook Salmon (focal species) and steelhead (carcasses)

Location(s): Upper Grande Ronde River basin, OR

Synopsis: This project builds on existing studies by the investigators that found supplementing food webs with hatchery carcasses increases size, growth, and survival of juvenile salmonids through transfer of energy and nutrients. The major unanswered question addressed is the *timing* of carcass addition to evaluate the greatest benefit to juvenile fish—which depends on optimizing time of growth with temperature and whether fish direct energy to somatic growth vs. fat stores, and when food is available seasonally. Carcasses will be added to treatment reaches at various times Aug-Dec and juvenile salmon consumption, growth, and survival will be evaluated in comparison to control reaches both empirically and using bioenergetic models. The investigators purport the study would provide the first *in situ* experimental evidence to guide decision-making on the timing of carcass addition, an increasingly important management tool.

Amount requested: \$190,455

4. Tribal and Non-Tribal Public Perceptions of Oregon Hatcheries for Future Hatcheries Outreach and Engagement

Principle investigators: Kelly Biedenweg, OSU; Samantha Chisholm Hatfield, OSU (enrolled Confederated Tribes of Siletz; Cherokee); Megan Jones, OSU

Species: Humans

Location(s): Oregon, including OHRC

Synopsis: Hatchery salmon and steelhead are an integral part of Oregon's ecosystem and culture, yet almost no research has been done on perceptions of hatcheries as a tool for salmonid management. Misconceptions about hatcheries and their role in relation to Oregon Tribes are common in the public arena. This is a human dimensions study of public perceptions of salmonid hatcheries, with a focus on two primary audiences: 1) Tribal communities, including Tribal fishermen, and 2) non-Tribal fishing communities, including anglers, guides, commercial fishermen, and their families. Methods include interviews, workshops, and Traditional Ecological Knowledge methods. Findings are intended to inform the development of outreach and education efforts around hatcheries science and management targeted to different audiences. Products include a manual developed for OHRC and informational workshops to share lessons learned, among others.

Amount requested: \$174,338

5. Does Reduced Winter Growth of Hatchery Summer Steelhead Increase Residualization and Reduce Smolt Abundance in a Production Hatchery?

Principle investigators: Joseph Feldhaus, ODFW; Michael Greiner, ODFW; Ian Tattam, ODFW

Species: Summer steelhead

Location(s): Grande Ronde basin, OR

Synopsis: An unknown portion of the hatchery summer steelhead smolts released into the Grande Ronde Basin residualize (remain in freshwater) and may be broadly distributed. Monitoring is a high priority for ODFW, yet the proportion of residuals is unknown as is their impact on wild salmonids. The development of parentage-based tagging (PBT) methods can now directly link individual residual fish with specific hatchery rearing practices (e.g., mate pairings, in-hatchery growth profiles, spawning date) not previously possible and could be used to monitor residual populations. The three main study objectives are to 1) compare the proportion of residual hatchery steelhead among three different release strategies; 2) determine if hatchery practices like mate pairings, spawning date, growth profiles, or release strategy disproportionately contribute to the residual population; and 3) map the current spatial and temporal distribution of residual hatchery steelhead and compare these results with previous distribution and abundance data.

Amount requested: \$168,500

6. Assessment of Individual Variability in Thermotolerance Between Wild-Origin and ODFW Hatchery Stock Steelhead (*Oncorhynchus mykiss*) of the Alsea River

Principle investigators: Scott Heppell, OSU and David Craig Lawson, ODFW-OHRC

Species: Winter steelhead

Location(s): Alsea River basin, OR & OHRC

Synopsis: Climate change is expected to have major impacts on Oregon rivers including alterations in the timing and magnitude of seasonal air and water temperatures, precipitation levels, and runoff which impact the thermal environment of aquatic species such as steelhead. Elevated water temperatures lead to physiological stress in fish and can be indexed using heat shock proteins (HSPs) that protect cellular processes. This study aims to compare HSP responses in ODFW hatchery-produced vs. wild steelhead stocks as well as evaluate the individual range of variability in HSP response to understand the adaptive capacity of steelhead to climate change. Hatchery vs. wild steelhead growth, survival, length/weight, body composition (protein and fat), and HSPs will be monitored at various temperature regimes at OHRC including those expected with climate change. A novel mRNA approach would advance the field by providing a technique to quickly and accurately assess thermal stress in lab and field studies. Products include outreach projects at OHRC, among other communications.

Amount requested: \$198,138

7. Evaluating effects of smolt size, condition, and season of release on the quality and abundance of returning adult hatchery salmon

Principle investigators: Marc Johnson, ODFW; Brian Beckman, Northwest Fisheries Center (NOAA); Jessica Miller, OSU

Species: Fall Chinook Salmon

Location(s): Klaskinine, Trask, Coos, and Elk rivers, OR

Synopsis: Size and season for release of fall Chinook produced by ODFW hatcheries largely mimic the subyearling outmigration strategy. However, additional release strategies could more accurately reflect the diversity of wild populations and buffer against increasing variability of environmental conditions. The investigators propose to study the performance of hatchery fall Chinook released as 1) subyearlings in spring, 2) subyearlings in the late summer, or as 3) yearlings in the following spring. Performance will be measured through estimates of age-structured smolt-to-adult recoveries (SARs) of coded-wire tagged fish sampled in fisheries, at hatcheries, and on spawning grounds. In addition, a semi-quantitative smolt assessment will be conducted prior to release for all groups to account for potential differences in the condition of stocks and release conditions. The researchers expect to generate actionable recommendations for juvenile salmon rearing and release strategies and potentially inform infrastructure needed to implement optimal strategies at ODFW hatcheries.

Amount requested: \$107,949

8. Understanding and mitigating the effects of hatchery fish on pre-spawning mortality

Principle investigators: Michael Kent, OSU; James Peterson, USGS-OSU; Claire Couch, OSU; Luke Whitman, ODFW

Species: Spring Chinook Salmon

Location(s): South Santiam and McKenzie Rivers; North Santiam and McKenzie Hatcheries; OSU Fish Performance and Genetics Laboratory

Synopsis: Pre-spawn mortality (PSM) occurs at high rates (up to 50% or more) and is higher in hatchery-origin (HO) than natural-origin (NO) fish. PSM is higher in warmer water and is expected to increase with climate change. Investigators hypothesize that HO fish have more degraded intestines and are more susceptible to infections than NO fish, and that HO fish shed more pathogens into the environment than NO fish. To answer these questions, investigators build on an existing OHRC-funded study to determine whether gut deterioration and pathogen infection are more severe in HO adults than in NO adults from the same environment and evaluate differences in pathogen shedding rates between HO and NO fish under controlled conditions. Study design includes histopathological assays of carcasses in two streams; histopathology and gut microbiome analysis along with collection of gill samples to evaluate immune gene expression and oxidative stress at two hatcheries; and a laboratory study using environmental DNA (eDNA) to measure concentrations of pathogens of HO only, NO only, and cohabitating HO-NO fish in addition to other histopathological assays. In addition to informing short-term management changes,

this work aims to inform future studies assessing how hatchery rearing practices could be adjusted to reduce long-term disease susceptibility and shedding when fish return to freshwater as adults.

Amount requested: \$184,082

9. Investigating Mechanisms Driving Low Catchability of Deschutes River Hatchery Steelhead

Principle investigator: Ian Tattam, ODFW

Species: Summer steelhead

Location(s): Lower Deschutes River, OR

Synopsis: The Deschutes River has a popular and historically productive summer steelhead fishery consisting of Deschutes natural-origin (NO), Deschutes hatchery-origin (HO), and Columbia basin strays. ODFW operates Round Butte hatchery (RBH) for augmenting this sport fishery. However, analysis of creel data indicates NO steelhead are captured at 2-3 times the rate of HO steelhead despite HO fish vastly outnumbering NO. The investigator proposes to concurrently investigate two potential mechanisms for lower catchability of RBH steelhead: 1) mandatory release of wild steelhead allows aggressive wild biters to be captured multiple times, whereas the aggressive biters in the RBH population are mostly harvested and removed on their first capture and 2) selection against “biters” in the RBH broodstock creates genetic propensity for less aggressive HO steelhead. Methods to address the first mechanism include collaboration with fishing guides to mark steelhead; angler outreach; expanded creel surveys, and riverscape stock composition models. Methods addressing the second mechanism involve passing known HO “biters” through the fishery, spawning known-biters with known-biters for comparison with standard pairings, and tracking return of progeny using parentage-based tagging (PBT). Monitoring of fish returns through 2028 are proposed to be funded by other sources. The two objectives proposed would provide critical data for understanding and ameliorating low catchability of RBH steelhead to ensure their support of the Deschutes steelhead fishery. Secondly, these data are critical for informing decision frameworks to ensure the fishery can be managed to conserve wild steelhead during low runs.

Amount requested: \$167,650



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