

Oregon Hatchery Research Center 2021 Annual Report

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

By:
Oregon Hatchery Research Center Board

February 1, 2022



Executive Summary

This is the ninth 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. Highlights of the report include accounts of:

- Composition of the OHRC Board and appointment of an interim OHRC Director;
- An OHRC workshop to identify high-priority hatchery research concepts;
- Development of a new research proposal request and review process at OHRC;
- OHRC Board engagement with the OHRC Director search and hire process;
- Outreach and education activities, including a fall workshop designed to generate new hatchery research concepts;
- Research activities conducted in 2021 by OHRC researchers, students, and collaborators, with relationship to the Mission and Goals of the OHRC, including:
 - Continued implementation of the OHRC Research Plan which addresses three strategic research focus areas:
 1. If and how the differences in mate selection between hatchery and wild fish influences the reproductive success of hatchery fish in the wild, and how practices could be improved to increase the reproductive success of hatchery fish;
 2. If and how hatchery rearing practices alter the selection of traits with resultant fitness consequences, and how hatchery practices could be altered to minimize hatchery versus wild fitness differences related to selection in the hatchery;
 3. If and how manipulation of hatchery rearing and water can improve olfactory imprinting by juvenile salmonids and homing of adults to their hatchery of origin.
 - Continued implementation of operational research, including but not limited to:
 1. Evaluation of streamside incubators and in-stream hatchboxes as tools to increase production of artificially-spawned salmon
 2. 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>

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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 ninth 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 2021 calendar year, with reference to past activities, describe the funding and implementation of the Research Plan for the OHRC as adopted by the OHRC Board in 2014, and relate scientific information and recommendations produced through research conducted at the OHRC in 2021. This report also outlines the focus for the Board in 2022.

Directorship at OHRC

The tragic passing of OHRC's Director, Dr. David L.G. Noakes, which occurred in December of 2020, prompted several actions by ODFW and Oregon State University (OSU) in 2021.

First, ODFW Director, Curt Melcher, appointed Dr. Marc Johnson as interim Director of the OHRC on March 1, 2021. Dr. Johnson had previously served as ODFW Fish Division Liaison to the OHRC and continued in this role while fulfilling duties as OHRC Director. Throughout the course of 2021, Dr. Johnson assisted the OHRC Board with organization of quarterly meetings, organized and hosted a virtual workshop to identify priority hatchery research concepts for the OHRC, regularly met with OHRC staff to discuss center operations and safety, served as mentor for an OSU student conducting research at OHRC, and led with the development and implementation of new process to solicit and review research proposals at OHRC.

Second, OSU and ODFW formed a search committee to solicit applications and interview candidates for the OHRC Director position. This tenure-track OSU faculty position was advertised internationally and attracted many qualified applicants. Through a series of interviews, the search committee identified two top candidates for the position. The search committee invited these two candidates to participate in follow-up interviews and to deliver two seminars to the OSU community and public. These interviews and seminars occurred (virtually) in December of 2021. The OHRC Board was notified of candidate seminars and had ample opportunity to attend or view the recorded. OHRC Board members were encouraged to offer their recommendations regarding the selection of a new OHRC Director to ODFW Director, Curt Melcher. At the time of this report, Dr. Marc Johnson continues to serve as interim Director of the OHRC, while ODFW and OSU continue with process to appoint a permanent and full-time OHRC Director.

On October 15, 2021, the large meeting room at the OHRC was renamed to honor Dr. David L. G. Noakes through a dedication held during the ODFW Commission Meeting.

The 2021 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 2021

In January of 2021, OHRC Board member Kyle Smith (representing Wild Fish Advocacy) resigned from the OHRC Board. Dr. Shaun Clements was appointed to the vacant ODFW position on the Board in March of 2021. In June, ODFW Director Curt Melcher appointed Tom Alkire to the OHRC Board, filling the vacancy generated by Kyle Smith's resignation, and at the same time appointed Derek Wall and Travis Mackie to the positions representing Columbia River Gillnetters and Oregon Indian Tribes, thereby filling all OHRC Board seats. Director Melcher also reappointed several Board members in mid-2021, including members Dwight Collins, Steve Jacobs, and Andrew Dutterer.

Tragically, in September of 2021, Andrew Dutterer was involved in a fatal car accident. Andrew's calm demeanor and informed perspective were greatly appreciated, and his passing was a tremendous loss to the OHRC Board. At the time of this report, ODFW is working to identify a new OHRC Board member to represent Fish Habitat Restoration.

In November of 2021, OHRC Board member and chair, Brad Halverson, resigned from his positions on the Board. ODFW is now recruiting for the vacant Wild Fish Advocacy position.

OHRC Board composition, as of December 31, 2021, 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	vacant	
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	vacant	
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 2021

Overview

Public health and safety precautions, intended to limit the spread of COVID-19, precluded in-person meetings of the OHRC Board during 2021. Nevertheless, the OHRC Board used an online platform to conduct their regular meetings. As in the previous year, these virtual meetings were relatively brief (2-3 hours) and focused on critical OHRC matters, such as strategic direction, operations, finances, project evaluations and research prioritization.

Board Meeting Highlights

The OHRC Board met (virtually) on five occasions during 2021. Agendas and minutes for all Board meetings are posted on the web at <https://www.dfw.state.or.us/fish/OHRC/minutes.asp>. Virtual meetings provided opportunity for Board members to speak, interact and receive information from ODFW, OHRC researchers, faculty and staff.

The OHRC Board's first meeting of 2021 was held on March 9th. The Board approved minutes from their previous meeting and the annual report from the previous year. OHRC Facilities Manager, Jennifer (Jen) Krajcik, reported on planned upgrades to facility infrastructure, including repairs to the Center's chiller, water intake and improvements to the landslide alarm system. Jen also provided progress updates for OHRC operational research, including a project designed to evaluate the prevalence and cause of opercular deformities, and another study aimed to evaluate performance of streamside incubators and hatchboxes.

As occurs at all OHRC Board meetings, ODFW provided a financial update to the OHRC Board, describing revenue into and expenditures from the OHRC Dedicated Research Fund. Dr. Marc Johnson provided this information and reported that the latest ODFW budget forecast indicated a budget surplus that could be carried over into the next fiscal biennium.

Dr. Selina Heppell, Head of OSU's Department of Fisheries, Wildlife and Conservation Sciences, announced that Dr. Johnson would be serving as acting Director of the OHRC, while the university and ODFW conducted their search and recruitment for a new OHRC Director. Board chair, Brad Halverson, followed Dr. Heppell's update by introducing Dr. Shaun Clements, ODFW's [then acting] Assistant Administrator of Fish Division. Dr. Clements then offered his view of the OHRC Board's role – to provide strategic direction, define goals, and prioritize research aimed to understand mechanisms that create differences between hatchery and wild fish.

Brad Halverson then led a discussion of the OHRC Board's role, wherein several Board members expressed their views, which ranged from duties of research oversight to getting more fish to fishermen. Following this discussion, Board member Scott Starkey proposed a revision to the OHRC's Mission Statement, which was subsequently approved by Board vote.

Minutes from the OHRC Board's March 9, 2021, meeting are available at:

https://www.dfw.state.or.us/fish/OHRC/docs/2021/OHRC_BoardMinutes_03092021_Final.pdf

On March 29, 2021, the OHRC Board held their second meeting of the year. This meeting was specifically intended to provide researchers with opportunity to present project updates and identify how their findings had been or might be applied to fisheries management.

Dr. Michael Blouin was first to present, describing progress and potential applications of his project, which investigates which elements of hatchery rearing might contribute to domestication of hatchery fish and related fitness effects. Dr. Blouin emphasized that findings from his work could reduce risk from hatcheries by identifying and mitigating sources of domestication selection, thereby improving the fitness of hatchery fish that spawn in the wild. Dr. Blouin reviewed the goals, products, and schedule of his work, but noted that he was not yet prepared to make management recommendations to ODFW based on findings from his work.

Dr. Michael Banks provided the second research update to the OHRC Board, describing progress and applications of his project, which is designed to evaluate whether genetically-informed crosses (matings) can improve the fitness of salmon produced at hatcheries. Dr. Banks reported that his work is on schedule, and that genetic information from a previous study of wild-spawning coho is now being used to select mate pairs of coho salmon spawned at Sandy Hatchery. Production of adult salmon from informed crosses will be compared to that generated through conventional random mating. Dr. Banks indicated that, based on results from his study, he would be prepared to make management recommendations sometime in 2025 – 2027.

Dr. Marc Johnson delivered the final update of the day, describing the approach and progress of research being carried out with Chinook salmon at the Elk River Hatchery. Dr. Johnson noted that, unlike other strategic research projects at OHRC, this project was not designed to investigate methods to improve fitness of hatchery fish, but instead explored how chemical

manipulations of hatchery water might be used to improve olfactory imprinting and subsequent homing by hatchery salmon. High straying rates by hatchery Chinook salmon had been identified as a serious risk to the viability of wild salmon in the Elk River, and the olfactory imprinting project was designed to address this risk by identifying chemicals that could be added to hatchery water to make it more recognizable as “home” to returning adult salmon. Dr. Johnson reported that the project was on schedule and had produced several peer-reviewed publications that documented findings. He indicated that management recommendations from this project could be expected in 2026, after the last experimental release fish returned as adults.

Researchers then asked questions from the OHRC Board. Following questions, Brad Halverson requested that all Board members complete and submit a standardized evaluation of each project by March 31st. Synopses of project evaluation completed by the OHRC Board are provided in Appendix 2 of this report.

Minutes from the OHRC Board’s March 29, 2021, meeting are available at:

https://www.dfw.state.or.us/fish/OHRC/docs/2021/OHRC_BoardMinutes_03292021_Final.pdf

The OHRC Board held its third meeting of 2021 on June 8th. Prior to the meeting, three new members had been appointed to the OHRC Board. After opening the meeting, Brad Halverson (chair) introduced new members Derek Wall (Columbia River Gillnetters), Travis Mackie (Oregon Indian Tribes), and Tom Alkire (Wild Fish Advocacy).

OHRC Facilities Manager, Jen Krajcik, and Dr. Marc Johnson provided the Board with updates that covered OHRC operations, status of the nearby landslide, recent education and outreach activities, and finances. Dr. Shaun Clements provided an update on the OHRC Director search and addressed the recommended revision to the OHRC’s Mission Statement, citing language from several Oregon statutes.

Following these updates, Dr. Aimee Reed (ODFW Fish Pathologist) presented new information from her research at OHRC, which discovered thiamine deficiencies in hatchery steelhead, noting that thiamine (vitamin B) is critical for early development and survival of many organisms. Dr. Reed proposed that subsequent research could investigate whether thiamine treatments could be used to improve the survival and performance of hatchery salmon and steelhead.

Meghan Howell, an OSU student mentored by Dr. Johnson, then presented her research findings, which compared the operational costs and performance of streamside incubators and in-stream hatchboxes. Meghan had conducted her research at OHRC, throughout the winter and spring of 2021, and found that in-stream hatchboxes produced larger and more fry per eggs than streamside incubators, though perhaps at the cost of some tail deformities caused by the hatchboxes during embryo development.

Following these research presentations, Dr. Johnson discussed findings from research project evaluations with the OHRC Board (see Appendix 2), noting that in response to Board recommendations ODFW would continue funding all three strategic research projects, but with moderate and substantial reductions the budgets for Dr. Banks and Dr. Blouin, respectively. Dr.

Johnson then described process that he and others from ODFW and ODFW had developed to 1) host a virtual workshop in September to solicit new research concepts; 2) issue a request for research proposals; 3) provide the Board with technical reviews of research proposals; and 4) make project funding decisions based on reviews and recommendations by the OHRC Board. A copy of the announcement for OHRC'S fall 2021 workshop, Spawning Fresh Ideas, is provided in Appendix 3 of this report.

Minutes from the OHRC Board's June 8, 2021, meeting are available at:

https://www.dfw.state.or.us/fish/OHRC/docs/2021/OHRC_BoardMinutes_06082021_Final.pdf

After calling the OHRC Board's September 14th meeting to order, Board Chair Brad Halverson related how his experiences had shaped his views of hatchery and wild fish, and how the OHRC should work to understand differences between hatchery and wild fish, with the goal to produce an abundance of the best hatchery fish possible. The Board then received updates from OHRC Facilities Manager Jen Krajcik, who reported that the OHRC's meeting room would be officially renamed to memorialize the Center's former Director, Dr. David Noakes. Jen continued her report by noting that while COVID-19 restrictions had impacted public visitation to the OHRC in 2021, staff had provided education and outreach services through occasional classes and virtual tours of the Center.

Dr. Marc Johnson provided a brief financial update to the Board, reporting record-high revenue during the previous quarter, then briefly discussed a recent manuscript from Dr. Michael Blouin's lab. Dr. Johnson also described recent progress made with updates and improvements to the OHRC's webpages.

Dr. Johnson then reviewed the OHRC's new process to solicit, prioritize, and support research at OHRC. He reported that a list of research concepts had been developed during the OHRC's recent workshop, and that a request for proposals to address priority research concepts could be issued from the OHRC in late September or early October. According to the process outlined by Dr. Johnson, the OHRC Board would then have opportunity to review proposals and make funding recommendations during their December 14th meeting.

Dr. Johnson presented the OHRC Board with a list of the top nine concepts identified during the OHRC's September workshop, those being:

1. How can we adapt hatchery rearing strategies to deal with climate change? Adjust hatchery release schedules?
2. Do strategies to manage differences between hatchery and wild fish optimally satisfy objectives? Could population viability analysis and other modeling be used to understand alternate outcomes.
3. What are the post-release effects of hatchery fish on wild population demographics and genetics?
4. What traits are under selection in hatcheries, and what aspects of hatchery culture could be modified to mitigate that selection?
5. What are the underlying drivers of public perceptions of hatcheries and what outreach/education strategies might affect those?

6. Do hatchery fish mated in ways that emulate wild-like mate choice pose less fitness risk?
7. Can genomics tell us how concerned we should be about hatchery-induced genetic change?
8. What factors most contribute to hatchery risk? and how do we define acceptable risk?
9. Can supportive breeding programs maintain/restore life history variation in populations?

The OHRC Board voted (8:1) to include the first seven of these research concepts as priorities identified in the OHRC's request for proposals.

The September OHRC Board meeting concluded with remarks from Board member Scott Starkey, who expressed dissatisfaction with changes made to the OHRC's Mission Statement, followed by an update from Dr. Selina Heppell regarding the status of the OHRC Director search, which had received eleven applications.

Minutes from the OHRC Board's September 14, 2021, meeting are available at:
https://www.dfw.state.or.us/fish/OHRC/docs/2021/OHRC_BoardMinutes_09142021_Final.pdf

The final OHRC Board meeting of 2021 was held on December 14th. Vice-chair of the OHRC Board, Chuck Pavlik, called the meeting to order, as Brad Halverson had resigned during the previous month. Following the call to order, interim OHRC Director, Dr. Marc Johnson, expressed appreciation for the former Chair's contributions to the OHRC and for the efforts of other Board members. The Board then received a facilities update from Jen Krajcik, who reported relatively low sediment loads in Fall Creek during recent rain events, and very strong returns of coho salmon recorded at the OHRC adult fish trap. Dr. Johnson then provided the Board with a financial report for the OHRC Dedicated Research Fund, noting a regular seasonal drop in revenue during the third quarter of the year.

Dr. Johnson provided an overview of meeting agenda items, which called for the Board to elect a new Chair and prioritize one or more of the research proposals that the Board had recently been provided. Dr. Johnson introduced Dr. Selina Heppell (OSU), who provided an update on the OHRC Director search and hire process, including instructions for OHRC Board members to offer recommendations regarding candidates. OHRC Board member Scott Starkey called attention to Oregon Revised Statute 498.833, which defines the OHRC Director hiring process, as it involves consultation with the OHRC Board and appointment by the ODFW Director.

In accordance with the meeting agenda, the OHRC Board then moved toward election of a new Chair. Board member Ted Simon nominated Scott Starkey for the position, and Scott accepted. Two other Board members declined nominations. After several minutes and some brief discussion, Dr. Johnson suggested that the Board move forward to elect a Chair and began asking each Board member to cast a vote. However, subsequent procedural issues with the election led to an uncertain result, and the Board decided to table [postpone] the motion to elect a Chair (6:4 decision to table).

The OHRC Board then engaged in a discussion of strategic direction, considering the costs and value of long-term research projects and the mission of the OHRC. The Board also discussed the merits of short-term, applied (i.e. operational) research, relative to longer-term projects, and how

proposals for such work might be obtained. Following this discussion, the OHRC Board focused on the ongoing OHRC project led by Dr. Michael Blouin, then voted unanimously to extend funding for his project through the end of the 2021-23 fiscal biennium. The Board received a brief project update from Dr. Michael Banks, discussed dates and format for upcoming meetings in 2022, and adjourned.

Pending approval by the OHRC Board, minutes from the December 14, 2021, meeting will be posted online at <https://www.dfw.state.or.us/fish/OHRC/minutes.asp>

OHRC Board Focus for 2022

Entering 2022, the OHRC Board will continue to solicit, review, and prioritize proposals for research at the OHRC. The Board will continue to work with interim OHRC Director, Dr. Marc Johnson, on this and other duties, but expects to welcome a new, full-time Director to the OHRC in 2022.

As in past years, the OHRC Board will review the progress of ongoing research projects, while working to expand the scope of projects conducted at OHRC. Importantly, the OHRC Board will continue to require that OHRC researchers demonstrate the potential applicability of their work toward improving hatchery and fisheries management within and beyond Oregon.

The OHRC Mission

The **Mission of the Oregon Hatchery Research Center (OHRC)** is “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.

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

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.
 - 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 2021

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 2021:

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

- 1.a. Domestication selection project (steelhead) – Blouin 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:*

- 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, May, et al.
- 2.a., b., c. Hatchbox research project (Johnson, Howell 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 developed online educational content made available to K-12 students, as a safe alternative to on-site tours that were restricted in 2021 due to COVID-19
- 3.b. OHRC staff hosted virtual tours and led dissection classes
- 3.c. Indoor areas of the OHRC remained closed to the public in 2021, but OHRC hosted a virtual workshop and offered online classes in 2021. OHRC reared fish for various OSU classes, including Introduction to Aquaculture.
- 3.d. The OHRC hosted a virtual research workshop
- 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 numerous scientific workshops and symposia during 2021
- 3.h. Results from OHRC research were disseminated through various publications
- 3.a., e., h. Hatchbox research project - Johnson, Howell et al.

Research

Perhaps the most important activities conducted by the OHRC Board in 2021 related to implementation of the OHRC Strategic Research Plan. The Plan, as approved in 2014, describes the OHRC’s goals and related research projects. It is available for viewing or download online at https://www.dfw.state.or.us/fish/OHRC/docs/2016/OHRC_Research_Plan.pdf. Funding to support the Research Plan was confirmed on July 1st, 2015, subject to formal agreements between ODFW and Oregon State University. Each of the three principal investigators identified through the Plan successfully completed international searches for Postdoctoral Research Scholars to assist with their respective research projects, and expenditure of research funds on personnel, supplies and operations began after approval by Oregon State University in January 2016. Re-authorization occurred in 2021, through approval of intergovernmental agreements between ODFW and OSU.

The research topic called for in the OHRC Research Plan and led by Dr. Michael Blouin (differences caused by hatchery rearing, or domestication selection) continued in 2021. This work 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). They 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 has adopted two approaches to investigate how hatcheries might be changed to produce genetically more wild-like fish. Firstly, they are 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 after release. They have tested, and continue to test, various modifications to standard practice, such as how and what the fish are fed, and the physical environment in the tanks. Secondly, they are measuring various behavioral traits of hatchery fish to investigate whether such variation predicts which families grow fastest. The idea is that identifying the traits under selection will help the researchers choose additional environmental manipulations to test.

The project headed by Dr. Michael Banks (genetics and mate choice) progressed as planned during 2021. Drs. Banks and Auld's full genome findings on differences in mate choice and reproductive success observed between hatchery and natural origin coho were published in *Integrative Organismal Biology* (Auld et al. 2021), meeting Phase 1 objectives.

In further development of Phase 2, Drs. Banks and Auld worked with Dana Gibbon, a bioinformatician from OSU's Center for Quantitative Life Sciences, to develop and provide a Shiny front end user interface for MultifacetedCHOICE so that this tool could be more easily applied in a hatchery context where users may not be familiar with how to run programs in R. The outcome goal was to create simple interface to allow users to enter fish ID from tags among fish on the spawning table, associate these with genotypes and 'wild-like' mating preferences to efficiently determine choice partnering among hatchery broodstock that best emulate productive 'wild-like' mating strategies.

Moving forward with Phase 3 of their project, 2021 marked the third consecutive year of testing a new way of forming mate pairs in a hatchery context that better emulate 'wild-like' matings, which have been found to be more productive. Ongoing pedigree characterization of coho returns to Sandy Hatchery through 2025 will determine if such a strategy yields offspring that survive and return in greater numbers than their 'randomly-bred' half-siblings. Dr. Banks and Dave Jacobson worked with ODFW staff from Sandy Hatchery to select and spawn coho in October and November of 2021. Excitingly, coho jack returns in 2021 to Sandy Hatchery are the first returns from the project's experimental spawn of 2019, and there were many of them! Ryan Queen (Sandy Hatchery Manager) suggested they appeared larger than usual as well. Dr. Banks' team took fin-clips from all identified jacks during visits to Sandy Hatchery (in total sampling just short of 1,300), and also tagged and genetically sampled broodstock that were subsequently spawned on November 3rd, 2021. Dana Gibbon joined on Nov. 3rd to help test the new Shiny frontend of MultifacetedCHOICE, which proved very efficient: eggs from 107 females were successfully halved to form 214 half-sibling families, all within one normal spawning day.

Briefly, experimental design applied in 2021 followed that of previous years. Two weeks prior to spawning, and with the help of hatchery staff, male and female coho were selected, tagged, fin

clipped and held as per normal hatchery protocol. DNA from each tagged fish was extracted and genotyped at the markers developed using GT-Seq (Phase 2). 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 practice). The other half of the eggs were fertilized by a male selected based on the genetics of both the male and female at specific GT-seq genetic markers, to better emulate allelic combinations observed among wild-like mating in Phase 1. Final assessment of the relative fitness of these two mating types for the 2021 experimental spawn will occur when offspring from this cohort return from the ocean as adults, ready for spawning in fall 2024, and perhaps early 2025.

In early 2021, Dr. Carl Schreck accepted OSU Principal Investigator responsibilities for the Olfactory Imprinting Project, previously led by Dr. David Noakes. This project has and continues to benefit through participation from team members Dr. Andy Dittman (NOAA Fisheries; Seattle), Dr. Tom Quinn and Darran May (University of Washington, Seattle), Dr. Marc Johnson (ODFW), and Dr. Gabriel Singer (Leipzig Institute, Germany) 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. 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 they've 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.

Study plans and schedules for the projects led by Drs. Banks, Blouin and Schreck are provided in the OHRC Strategic Research Plan³. In 2021, OHRC Board members received updates for each of these projects during their March 29th meeting, then evaluated each project in context of its goals, schedule, and alignment with the OHRC's Mission (see Appendix 2).

In addition to Strategic Research Projects, several Operational Research Projects have been and continue to be developed at and through the OHRC. These projects include a hatchbox study that was completed in 2021 (Howell 2021), study of opercular deformities conducted by OHRC staff, investigations into the source and timing of fin erosion in hatchery steelhead, evaluation of atomizers as a means to reduce predation and cool hatchery raceways, and a genetically-informed performance evaluation of hatchery broodstock that were collected actively by anglers or passively with hatchery traps (Johnson et al. 2020).

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

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 2021, Dr. O'Malley's lab used "startup funds" to process nearly 2,000 samples in support of research to:

- Evaluate neutral and adaptive genetic diversity among Oregon coastal Chinook salmon
- Test for population genetic structure among Oregon coastal chum salmon
- Evaluate the genetics of naturally produced Chinook salmon captured in the Lower Rogue River (OR) in 2020
- Test for population genetic structure among hatchery and wild steelhead in the North Fork and South Fork Coquille Rivers

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 journals. Drs. Michael Banks and Heather Auld worked with OSU science writing staff in 2021 to develop a press announcement associated with their recent publication (Auld et al. 2021), which elicited broad readership interest in *Hatchery Feed and Management*, *ScienceDaily*, *Science Magazine*, *Seafood News*, *Reddit*, and *Sciences Café*. 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. For instance, on April 8, 2021, Dr. Michael Blouin delivered OSU's College of Science F. A. Memorial Gilfillan Lecture, presenting findings from his ongoing studies of hatchery steelhead fitness in context of broader genetic concepts. A recording of his lecture can be viewed at: <https://www.youtube.com/watch?v=BbhUIiKdco>. Also in 2021, OHRC Senior Technician, Craig Lawson, visited several Oregon schools, including Luckiamute Charter School, Alsea School, and Mary's River Watershed Outdoor School, where he taught students about fish anatomy through dissections and shared thoughts about his career experiences in fish culture and research. OHRC Facilities Manager, Jen Krajcik, delivered an online presentation from the OHRC to Oregon Coast Community College in 2021.

In past years, the OHRC accomplished a great deal of public outreach through facility tours and demonstrations, as well as through Free Fishing Days and a Fall Festival. However, COVID-19 safety measures again restricted these activities in 2021. However, outdoor grounds at OHRC reopened to visitors in June of 2021, and staff again had opportunity to directly engage with the public. As indoor areas of the OHRC have remained closed to the public during the COVID-19 pandemic, the OHRC's staff worked to deliver outreach in 2021 by designing new outdoor signage and through construction of an outdoor kiosk, stocked with information about the center, its research activities, and ODFW fishing and hunting regulations.

Per its Mission, the OHRC shares information not only with the public and students, but also directly with fisheries managers and biologists. On September 9th and 10th, 2021, the OHRC hosted a (virtual) workshop that involved participation from over 30 attendees, representing a variety of state and federal agencies, tribal organizations, universities, and non-governmental organizations (Table 2). The purpose of this two-day workshop was to generate new research concepts for the OHRC (which were presented to the OHRC Board at their September 14th meeting), but also provided an opportunity to showcase ongoing OHRC research to a diverse group of managers, researchers and biologists. During the workshop, OHRC staff presented a “virtual tour” of the OHRC that they had prepared, and which has now been posted to the OHRC’s website at: <https://www.dfw.state.or.us/fish/ohrc/scientists.asp>

The OHRC’s webpages continue to be an important means of communicating the Center’s purpose, capabilities, and activities to the public, particularly as COVID-19 restrictions have limited in-person visitation. Significant improvements and updates were made to the OHRC’s website in 2021, which now offers a more intuitive and organized structure for online visitors to explore. The OHRC’s homepage can be found at: <https://www.dfw.state.or.us/fish/ohrc/>

Funding of OHRC Operations and Activities

Operations

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, Education and Outreach

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 on recommendations made by the OHRC Board to ODFW in 2021 (Appendix 2), only \$635,000 of the projected available funds had been committed to priority research projects at year’s end. In 2022, the OHRC Board will continue to identify and prioritize additional hatchery research and deliver funding recommendations to ODFW.

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.

Table 2. Participants in the OHRC’s two-day virtual workshop, *Spawning Fresh Ideas*, held September 9-10, 2021. Workshop facilitators indicated by asterisk (*).

Participant	Organization
Michael Banks	Oregon State University
Brian Beckman	National Marine Fisheries Service - NOAA
Mike Blouin	Oregon State University
Chris Caudill	University of Idaho
Shaun Clements*	Oregon Department of Fish and Wildlife
Ryan Couture	Oregon Department of Fish and Wildlife
Rob Dietrichs	Oregon Department of Fish and Wildlife
Andy Dittman	National Marine Fisheries Service - NOAA
Matt Falcy	University of Idaho
Mike Ford	National Marine Fisheries Service - NOAA
Carlos Garza	National Marine Fisheries Service - NOAA
Brad Halverson*	OHRC Board Chair
Selina Heppell	Oregon State University
Brent Hinnners	Oregon Department of Fish and Wildlife
Dave Jacobson	Oregon State University
Marc Johnson*	Oregon Department of Fish and Wildlife
Jen Krajcik	Oregon Hatchery Research Center
Craig Lawson	Oregon Hatchery Research Center
Ross McDorman	Oregon Department of Fish and Wildlife
Shawn Narum	Columbia River Intertribal Fish Commission
Hayley Nuetzel	Columbia River Intertribal Fish Commission
Kathleen O'Malley	Oregon State University
Scott Patterson	Oregon Department of Fish and Wildlife
Jim Peterson	Oregon Department of Fish and Wildlife
Tom Quinn	University of Washington
Megan Sabal	University of California, Santa Cruz
Carl Schreck*	Oregon State University
Christian Smith	US Fish and Wildlife Service
Adrian Spidle	Northwest Indian Fisheries Commission
Peter Stevens	Oregon Department of Fish and Wildlife
Kerrie Tarkinton*	Oregon Department of Fish and Wildlife
Matt Weeber	Oregon Department of Fish and Wildlife
Seth White	Columbia River Intertribal Fish Commission
Jacques White	Long Live the Kings

During 2021, the State Fisheries Genetics Laboratory⁴, headed by Dr. Kathleen O'Malley, developed multiple research projects 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. Genetic pedigree analysis of North Santiam River spring Chinook salmon: \$95,354
- 2021-2022. U.S. Army Corps of Engineers. Genetic pedigree analysis of South Santiam River spring Chinook salmon: \$175,155
- 2021-2022. U.S. Army Corps of Engineers. Genetic pedigree analysis of McKenzie River spring Chinook salmon: \$167,137
- 2021-2022. U.S. Army Corps of Engineers. Genetic pedigree analysis of Fall Creek spring Chinook salmon: \$152,797
- 2021. Bureau of Land Management Genetic analysis of *Oncorhynchus mykiss* in the Deschutes River: \$4,263
- 2021. Oregon Department of Fish and Wildlife. Identification of “late” run alleles in Chinook salmon (*Oncorhynchus tshawytscha*) returning to Cole Rivers Hatchery on the Rogue River (OR): \$1,183

Management Applications of OHRC Research Findings

Research conducted at the OHRC in 2021 served to build upon the Center's record of producing actionable science in the field of fisheries management. Ongoing Strategic Research projects continued progress toward delivering new tools to manage genetic and ecological risks from hatchery salmon and steelhead, in support of the OHRC's Mission and sustainable fisheries management.

Research being conducted by Drs. Michael Banks and Heather Auld, through their Mate Choice Project, has now entered its third phase (see OHRC Strategic Research Plan), wherein these researchers now coordinate with production-scale hatchery managers to test their hypothesis of improved fitness through wild-like mate pairings, guided by molecular genetic information. Dr. Banks contends that if fitness of offspring from ‘wild-like’ bred hatchery fish is increased anything close to the average observed across life (40-50%), then implementation of new “wild-like” breeding strategies within hatcheries could have the potential to near double hatchery contribution to ocean and river fisheries. Offspring from ‘wild-like’ bred hatchery fish might also have closer reproductive success to wild fish, and thus reduce their potential impacts upon wild fish.

Recent work published by Dr. Michael Blouin and his team (Blouin et al. 2021) revealed that while offspring of hatchery steelhead may grow faster in captivity than offspring of their wild counterparts, they tend to suffer higher mortality in the wild. Their finding alludes to a possible mechanism for widely observed fitness differences between hatchery and wild fish, whereby hatcheries select for bolder, faster-growing fish, whose offspring suffer higher predation in the wild, due to expression of these heritable traits (i.e. growth and boldness). Dr. Blouin's team

⁴ <https://agsci.oregonstate.edu/state-fisheries-genomics-lab>

now aims to identify ways to reduce among-family variation for these traits, and thereby limit the influence of artificial selection that could reduce fitness of hatchery salmon and steelhead.

The Olfactory Imprinting Project, led by Dr. Carl Schreck in 2021, has demonstrated that salmon can learn the chemical nature of their natal water during incubation and hatching, and that young salmon incubated in well water may not adequately develop “olfactory memories” of their source hatchery, which could contribute to adult straying behavior. These findings were published in the journal *Fisheries* (Dittman et al. 2015)⁵ and shared with ODFW managers, which prompted several hatchery managers to modify their practices, switching to use river water to incubate salmon eggs at their facilities instead of well water to improve homing rates. At the Elk River Hatchery, ODFW incubated a portion of its 2017 and 2018 Chinook salmon production in river water. These fish and control groups (incubated in well water) were differentially tagged as juveniles before being released. Researchers are now collecting and analyzing coded-wire tag data from adult treatment and control salmon, sampled at both the hatchery and on spawning grounds, to evaluate the effect of river water incubation on adult homing rates.

But 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).

Hatchery salmon and steelhead make tremendous 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). Their research, dubbed the “Biter Study”, 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. At very least, they identified potential for improvements to some angler assisted broodstock collection programs, and ODFW is currently researching how to effectively improve its programs.

Use of artificial “hatchboxes” has been proposed as a means to increase the abundance of salmon in select river systems, and these devices could hold potential to produce more “wild-like”

⁵ https://www.dfw.state.or.us/fish/OHRC/docs/2015/Dittman_et_al%202015_Fisheries.pdf

salmon than conventional hatchery rearing, due to limited time and exposure to domestication selection. In 2021, Meghan Howell (OSU) conducted research at the OHRC to investigate costs and effectiveness of hatchboxes and streamside incubators for production of Chinook salmon. Her work benefitted from generous donations provided by OHRC Board members Chuck Pavlik and Ted Simon, mentorship by Drs. Marc Johnson and James Peterson, and the tireless efforts of OHRC staff (Jen Krajcik, Craig Lawson and Brian Willett), who assisted with project setup, oversaw animal husbandry, and maintained artificial stream channels. This study, described in detail by Howell (2021), provided new information regarding the use of hatchboxes and streamside incubators for hatchery salmon production. Foremost among findings were that hatchboxes produced more fry per eggs than streamside incubators, though the size and configuration of the commercially produced hatchboxes used in her study were difficult to load, prevented many fry from escaping the device, and appeared to generate tail deformities. Results from this OHRC study offer an important note of caution to fisheries managers that might consider the use of hatchboxes or streamside incubators in their programs.

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"⁶.

These examples offer but a glimpse of how research at the OHRC and collaborating laboratories continues to 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 Dr. Marc Johnson, with significant contributions from OHRC staff members Jen Krajcik and Craig Lawson, as well as Drs. Michael Banks, Michael Blouin, Andrew Dittman, Kathleen O'Malley and Carl Schreck.

⁶ NOAA White Paper NMFS-NWFSC-WP-2021-01 <https://doi.org/10.25923/jqxf-2m34>

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 according to our Mission Statement, current priorities, funding and the availability of personnel and facilities⁷. All research projects are reviewed by ODFW, OHRC staff, the Director and the OHRC Board, and are required to provide updates and final reports. Current research projects can be grouped by categories related to the OHRC's mission and goals.

Research proposals, progress reports, completion reports and resulting publications are available on the OHRC website⁸, and in the records of the [decommissioned] OHRC Advisory Committee. Many of those reports include recommendations that were made from the OHRC to ODFW or other agencies for consideration or implementation. Results from OHRC activities are reported at annual ODFW meetings (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 2021. 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 responsibilities with participation from Dr. Andy Dittman (NOAA, NWFSC, Seattle), Dr. Tom

⁷ <https://www.dfw.state.or.us/fish/OHRC/docs/2008/OHRCForResearch2008.pdf>

⁸ <https://www.dfw.state.or.us/fish/ohrc/>

Quinn (University of Washington), Dr. Marc Johnson (ODFW), Darran May (University of Washington), Dr. Gabriel Singer (University of Innsbruck), Brent Hinnert (ODFW), Ryan Gertkin, (ODFW), and many more.

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 has been initiated again in 2022. The first group of returning adults from the 2020 exposure returned to the Elk River hatchery in fall 2021. 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 from Nov. 1, 2021 (when the ladder was first opened) to Jan. 31, 2022 (when the ladder was closed). Approximately 100 returning mature 2-year old males from the experimental groups were collected at the ERH. Coded wire tags have been collected and will be read and interpreted in 2022. At the same time, extensive creel and spawning ground surveys were also conducted to identify experimental fish and recover tags. Finally, water samples have been collected within and downstream from the hatchery to validate the amino exposure levels during experiments in 2021.

Despite severe constraints on the ability to maintain the research program due to COVID-19, all odor exposures and deliveries, and sample collections were completed as scheduled. The final juvenile exposure will be 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.

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, 2020, and 2021. Improvements in homing fidelity will be assessed by comparing differences in hatchery returns between the well water and river water exposure groups.

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 2022.

COVID-19 travel restrictions limited opportunities to present findings to peers and the public at meetings and conferences in 2021, although findings have been presented regionally and at OHRC meetings. As mentioned earlier, the Olfactory Imprinting Project team published a new manuscript in 2021 in the *North American Journal of Fisheries Management*, that describes the movements of hatchery and wild adult Chinook salmon in the Elk River, as measured through radio telemetry analyses. Findings suggest that of the adult hatchery and wild Chinook salmon that enter the Elk River during spawning migrations, most typically enter, pass, or at least reach the vicinity of the hatchery. These results offer promise that in future years, returning adult study fish will likely enter detection range of the amino acids added to the Elk River Hatchery water.

The Olfactory Imprinting Project contributes to the implementation of the OHRC Strategic Research Plan⁹.

⁹ https://www.dfw.state.or.us/fish/OHRC/docs/2016/OHRC_Research_Plan.pdf

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 by Drs. Carl Schreck and Jim Peterson supported by funding from the US Army Corps of Engineers, initiated in 2011. With the unfortunate passing of Dr. Noakes, Dr. Peterson of the Oregon Cooperative Fish and Wildlife Research Unit at OSU is the principal investigator. 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 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.

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. Over the last two reporting periods the 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.

To date the Wild Surrogate Program has trained four post-doctoral students, four masters students, and numerous undergraduate students. During this reporting period (2021) the project also had three full-time faculty research assistants and several undergraduate students as staff. The project provides funding that goes directly to the OHRC for its operation. In addition, a related course on research is being taught in the Department of Fish, Wildlife, and Conservation Sciences at OSU. The Wild Surrogate Program and OHRC staff are part of this teaching effort.

[Hatchery Domestication Selection Project \(Mission Goals 1.a, 1.b., 2.d.\)](#)

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 more like that of wild fish would allow managers to increase PHOS, creating more opportunities for angling and harvest. This Strategic Research Project is part of the OHRC Research Plan (details elsewhere in this Report), and is led by Dr. Michael Blouin of Oregon State University. Funding for this project originally came to Dr. Blouin from the BPA, with some in-kind support provided by OHRC personnel and facilities, but is now funded solely by ODFW.

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 conducting tests of specific predictions about the mechanisms causing rapid domestication of hatchery fish, and how one might 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. 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 grow faster in the hatchery than offspring of wild broodstock, but have poorer survival in the wild (Blouin et al., 2021). These are compelling data in favor of their hypothesis. This is also promising news in that it shows that selection on traits of juvenile fish is indeed 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 ones that will even out the distribution of size at release. If that could be achieved, then there would be less intense selection on size at release (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 very 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 even distribution of body sizes at release) (Thompson and Blouin,

2015). So that work needs to be repeated, but on a larger scale. They 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 idea is that fish that thrive in the hatchery may be “bolder”, more willing to aggressively feed. 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 on the hypothesis that shy 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.

The conclusion to date is that the among-family variation in growth rate is so large that more extensive modifications of the way fish are raised may be required to overcome it. However, the researchers still have other manipulations to try, and they remain hopeful that some combination of treatments will have the desired effect. Experiments planned for the future include adding physical structures in the tanks to give shy fish places to hide, circulating the water to make all the fish swim constantly (prevents dominant fish from setting up territories, and improves body condition), and grading the fish part way through growth to separate fast and slow-growing fish to give the small ones a chance to catch up.

It would help in choosing manipulations to experiment with if we better understood what traits are under selection. Therefore, Blouin’s lab has been testing hypotheses about specific traits that may be favored under hatchery conditions. As mentioned above, one hypothesis is that hatcheries select for excessively bold behaviors, most likely those associated with propensity to feed very early in the lifecycle. The idea is that genotypes that more readily feed on artificial food as fry get an early growth advantage that they maintain through the rest of the growth cycle. However, excessive boldness can be maladaptive in the predator- filled and low-food natural environment, so selection on this trait could partly explain the fitness tradeoff in which hatchery fish have lower fitness in the wild, but perform better than wild fish in captivity. In a previous study, Blouin’s lab showed that more dominant families tended to grow more quickly (Thompson and Blouin, 2016). More recently they showed, using Wilson River steelhead, that there is large variation among families in propensity to feed at the surface (a correlate of generalized boldness), and that surface-feeding predicted fast growth (Wrey et al., 2020). Last year they replicated that study using Siletz River families in order to see if the results were repeatable. They observed the same large variation among families in propensity to feed at the surface, but no correlation with growth rate. It remains to be seen whether there is some difference between these two populations, or if something about the experimental set up differed between the two experiments. The researchers are in the process of adding more behavioral data to the dataset (e.g. propensity to explore novel environments), and then plan to summarize both datasets together.

The Hatchery Domestication Selection Project contributes to the implementation of the OHRC Research Plan.

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)¹⁰. 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.

During Phase 1 of their research, Drs. Banks and Auld first performed and published a review of extant scientific literature documenting mate choice in salmonids (Auld et al. 2019). They then

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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

completed a reduced representation full genome study (Auld et al. 2021) of Umpqua River coho salmon, previously described through several genetic pedigree analyses (Whitcomb et al. 2014, Thériault et al. 2011, 2010, Moyer et al. 2007). Because natural origin fish had greater reproductive success than hatchery origin fish in those and other studies (Thériault et al. 2011, Araki et al. 2008, Christie et al. 2014), Drs. Banks and Auld posited that applying ‘wild-like’ mating practices in a hatchery setting could lead to greater reproductive success and survival of hatchery fish, thus leading to greater harvest opportunity and potentially reducing impacts to wild salmon. Accordingly, they mined the enhanced, higher-resolution genetic pedigree (15,451 SNPs considered) to identify genetic combinations, formed through matings, that resulted in higher average parental fitness. This work employed the resources of the OHRC, Oregon State University’s Center for Genetic Resources for Biotechnology (CGRB) and the Hatfield Marine Science Center. In 2018, these researchers identified a suite of genetic markers that pair at unexpectedly high frequencies in successful wild salmon mating pairs. In total, they identified 2,485 markers associated with mate choice among natural- and hatchery-origin coho, and a manuscript describing their approach and results is published in the journal *Integrative Organismal Biology*.

In Phase 2 of their work, Drs. Banks and Auld applied results from Phase 1 of their work, to devise a test of improved coho salmon fitness (achieved through genetically informed crosses) at the Sandy River Hatchery. To quickly and effectively identify appropriate mate pairs, they collaborated with Dana Gibbon at Oregon State University’s Center for Genome Research and Biocomputing to develop a computer program (R package) that would allow users to identify males and females in the hatchery that match expected mate pairs in the wild. In 2021, this program, called MultifacetedCHOICE, was enhanced with a Shiny interface to facilitate selection of appropriate mate pairs from candidates on the spawning table. As follow-up, the tool was used to quickly identify appropriate coho mate pairs from genomic data during experimental spawning at Sandy Hatchery in November of 2021. Improvements including the Shiny frontend markedly increased efficiency of the process used previously to select mate pairs in 2019 and 2020.

In continuing Phase 3, Drs. Banks and Auld will perform an empirical test 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 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 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 2021, 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 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. While Drs. Banks and Auld have presented this work to the public, stakeholders and their peers more than 20 times since 2017, with the exception of several OHRC Board meetings, and the Spawning New Ideas workshop of September 2021, they did not present their work at other venues during 2021 due to COVID-19 restrictions.

The Mate Choice Project contributes to the implementation of OHRC's Strategic Research Plan.

[The OHRC Hatchbox Research Project \(Mission Goals 2.a., 2.b., 2.c., 3.a., 3.e., 3.h.\)](#)

Previously, in 2020, the OHRC Board approved a proposal to conduct research at the OHRC to evaluate the effectiveness of two salmon egg incubation devices: in-stream hatchboxes and streamside incubators. Both devices are designed to incubate artificially fertilized salmon eggs (embryos) in the field, with potential to produce more "wild-like" salmon, through reduced exposure to selection from a hatchery environment. The project was designed and conducted by OSU BioResource Research student Meghan Howell, mentored by Drs. Marc Johnson (ODFW) and James Peterson (OSU). OHRC staff were instrumental with care of embryos, study setup, and maintenance of the OHRC's artificial stream channels, which were used in the project. Throughout the late winter and spring of 2021, Meghan conducted her research at the OHRC, regularly collecting and analyzing data, which she presented to the OHRC Board during its June 8, 2021 meeting. Meghan successfully completed her project and earned her degree from OSU

in 2021. The abstract from her thesis (Howell 2021)¹¹ offers a brief summary of her project's objectives and findings, as follows:

“Hatcheries are used to produce salmon to augment the number of fish available for harvest, and to supplement wild populations that may be threatened with extinction. Although traditional hatchery rearing methods can produce many fish, they can pose risk to wild populations because they tend to produce salmon with lower fitness than wild counterparts. As wild salmon populations continue to decline, researchers and managers continue to explore alternative methods with potential to affordably produce large quantities of salmon with higher fitness and survival to adulthood. In this study, we evaluated two devices designed to artificially boost juvenile salmon abundance with limited rearing cost: instream hatchboxes and streamside incubators. We installed these devices into four artificial stream channels at the Oregon Hatchery Research Center, then supplied them with a total 30,000 fertilized Chinook salmon (*Oncorhynchus tshawytscha*) eggs. We compared egg-to-fry survival rates, cost per fry and fry size for the two methods. Our results suggest that hatchboxes delivered higher egg-to-fry survival (79.8%) than incubators (68.1%). We also found that hatchboxes and incubators produced fry at similar costs (\$0.064 and \$0.056 per fry, respectively). Finally, we found that fry produced with hatchboxes were 21.4% heavier than those produced with incubators. We suggest that managers and conservationists consider benefits and limitations to the application of these methods as tools for conservation or fisheries augmentation” (Howell 2021).

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 **2021 are indicated in bold**:

Technical Reports, Theses and Peer-reviewed Journal Publications

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¹¹ https://ir.library.oregonstate.edu/concern/undergraduate_thesis_or_projects/kd17d1275

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¹² ODFW Information Reports are publicly accessible by query at <https://nrimp.dfw.state.or.us/DataClearinghouse/default.aspx?p=149>

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OHRC Workshops

On September 9-10, 2021, the OHRC hosted a virtual workshop with 35 participants representing a variety of state and federal management agencies, tribal organizations, universities, and non-governmental organizations (Table 2). This workshop allowed OHRC researchers to showcase their work to fellow scientists and regional managers, and participants generated a ranked list of hatchery research concepts that were then presented to the OHRC Board.

During its September 14, 2021, meeting, the OHRC Board prioritized seven of the research concepts from the workshop for inclusion in the OHRC’s fall 2021 request for research proposals (see Appendix 4). Proposals were received by the interim OHRC Director, peer reviewed, and distributed to the OHRC Board on December 2, 2021.

Noteworthy, here, is that even amid travel and meeting restrictions imposed during the ongoing COVID-19 pandemic, the OHRC successfully convened meetings with regional experts to generate new research in support of the OHRC’s Mission. As in past years, the OHRC will continue to coordinate and host workshops to identify new ways to improve management and understanding of Oregon’s salmon hatcheries.

OHRC Mission Goal 3: Education and Outreach

In-person outreach and education opportunities were limited in 2021 due to COVID-19 safety measures. Indoor areas of the OHRC were mandatorily closed to the public and staff did not host regular tours as done in past years. However, OHRC staff did visit numerous elementary schools in 2021, offering education through fish dissection classes and talks about fish culture and hatchery operations in Oregon. OHRC Facilities Manager, Jen Kracik, also delivered an online presentation to the Oregon Coast Community College.

In 2021, OHRC staff also developed a video tour of the OHRC’s research facilities, which they presented at the OHRC’s virtual workshop, *Spawning Fresh Ideas*, (September 9-10, 2021). OHRC staff also used the outdoor kiosk, installed along the road passing by the OHRC in 2020, to deliver OHRC outreach information and fishing regulation to the public.

OHRC researchers presented their research findings in 2021 through a variety of publications and presentations, including project overviews delivered to hatchery managers, fisheries biologists, university professors and other participants of the OHRC's fall workshop (see Table 2). This two day workshop offered an opportunity for OHRC researchers to discuss applicability of their work directly with ODFW staff and regional managers.

Appendix 2: Synopses of Project Evaluations Completed by the OHRC Board in 2021

Synopsis of OHRC Board evaluations for the Mate Choice Research Project (led by Dr. Michael Banks)

Summary of scores: The number of OHRC Board members that expressed various levels of agreement (from **strongly disagree** to **strongly agree**) that this project has satisfactorily met the evaluation criteria listed at left. Cells with zero counts are left blank.

Evaluation criteria	Strongly disagree	Disagree	Uncertain	Agree	Strongly Agree
The project serves the Mission of OHRC			1	5	1
Project has achieved objectives in Research Plan			2	3	2
The project is on schedule per Plan				6	1
Results have been clearly presented to the OHRC Board				7	
Results have been published & presented to ODFW			3	4	
Project has provided educational opportunities			1	6	
Project is likely to generate useful management recommendations			3	4	

Synopsis of OHRC Board evaluations for the Hatchery Domestication Research Project (led by Dr. Michael Blouin)

Summary of scores: The number of OHRC Board members that expressed various levels of agreement (from **strongly disagree** to **strongly agree**) that this project has satisfactorily met the evaluation criteria listed at left. Cells with zero counts are left blank.

Evaluation criteria	Strongly disagree	Disagree	Uncertain	Agree	Strongly Agree
The project serves the Mission of OHRC			1	5	1
Project has achieved objectives in Research Plan		3	1	2	1
The project is on schedule per Plan	1	2	2	2	
Results have been clearly presented to the OHRC Board	1	2		2	2
Results have been published & presented to ODFW		2	3	1	1
Project has provided educational opportunities		1	2	4	
Project is likely to generate useful management recommendations	1	1	3	2	

Synopsis of OHRC Board evaluations for the Olfactory Imprinting Research Project (led by Dr. Carl Schreck)

Summary of scores: The number of OHRC Board members that expressed various levels of agreement (from **strongly disagree** to **strongly agree**) that this project has satisfactorily met the evaluation criteria listed at left. Cells with zero counts are left blank.

Evaluation criteria	Strongly disagree	Disagree	Uncertain	Agree	Strongly Agree
The project serves the Mission of OHRC			2	3	2
Project has achieved objectives in Research Plan			1	4	2
The project is on schedule per Plan				5	2
Results have been clearly presented to the OHRC Board				5	2
Results have been published & presented to ODFW			2	5	
Project has provided educational opportunities			1	4	2
Project is likely to generate useful management recommendations			2	3	2

Appendix 3: 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/>



Photo credit: Eric Bailey (ODFW)

Appendix 4: The OHRC's 2021 fall Request for Proposals

OHRC Request for Proposals 2021-23



The Oregon Hatchery Research Center is now accepting proposals for research to address one or more of the following priority research concepts:

Understanding and adapting hatchery practices to improve performance and lessen risk

1. How might rearing and release strategies for hatchery salmonids be adapted to meet program objectives amid climate change?
2. How might hatchery salmonids affect the genetic and demographic characteristics of wild populations?
3. Which traits are under selection in salmonid hatcheries, and how might fish culture techniques be modified to ameliorate selection?
4. Can hatchery practices be modified to emulate natural mate choice and improve fitness?

Improving and communicating fisheries science and management

5. Do strategies intended to manage differences between hatchery and wild salmonids optimally satisfy management objectives?
6. What drives public perceptions of salmonid hatcheries, and how might outreach and education be effectively engaged?
7. Can genomic approaches improve our understanding of risk from hatchery-induced genetic change in cultured salmonids?

How to prepare?

Research proposals should be prepared in the following format:

- A brief, not more than three (3) page study description, indicating research concept(s) and question(s) to be addressed, experimental design, study area, species, analytical methods, expected results and products
- 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 and work that would be needed to complete the research.
- One (1) page budget proposal
- *Curriculum vitae* of Principal Investigator(s)

Successful proposals will employ a collaborative and multidisciplinary approach with promise to deliver actionable science for ODFW hatchery and fisheries management.

Awards will be based on project merit, including alignment with the OHRC mission, promise to deliver timely and actionable science for ODFW hatchery management, demonstration of a collaborative and interdisciplinary approach, and budget viability.

	The OHRC plans to support multiple research projects, with estimated total support of \$400,000 offered through this RFP and award period (see below). Applicants are encouraged to indicate cost sharing or match funding in their budget proposals. Project proposals must be submitted as PDF, Word, or similar word processor files.
When to submit?	Research proposals must be received by midnight of October 31st, 2021 (PST) Award period to begin on or after January 31, 2022; period ends June 30, 2023, with possibility of extension and additional funding, pending approval.
How to submit	Please submit your research proposal to the OHRC Interim Director by email at: Marc.Johnson@oregonstate.edu , using subject line “OHRC Research Proposal”



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.



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