Oregon Hatchery Research Center
2020 Annual Report

To:

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

By:

Oregon Hatchery Research Center Board

February 1, 2021

Executive Summary

This is the eighth annual report by the Oregon Hatchery Research Center (OHRC) Board to the Oregon Legislature, Oregon Department of Fish and Wildlife Director and the State Fish and Wildlife Commission. Highlights of the report include:

- Appointment of Board members by the ODFW Director;
- Activities and focus of the Board in 2020;
- Continued development and implementation of the OHRC Communications Plan;
- Outreach and Education Activities;
- Research activities conducted in 2020 by OHRC researchers and collaborators, with relationship to the Mission and Goals of the OHRC, including:
    - Continued implementation of the OHRC Research Plan which addresses three 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 at the OHRC, including but not limited to:
        1. Evaluation of hatchery broodstock collection methods on the vulnerability to angling of Alsea River hatchery steelhead;
        2. Evaluation of streamside incubators and in-stream hatchboxes as tools to increase production of artificially-spawned salmon

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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 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 eighth report of the OHRC Board to the Legislative Assembly, the State Fish and Wildlife Director and the State Fish and Wildlife Commission. In this report, we detail the activities of the OHRC Board during the 2020 calendar year, with reference to past activities, describe the funding and implementation of the Research Plan for the OHRC as originally adopted by the OHRC Board in 2014, and relate scientific information and recommendations produced through research conducted at the OHRC in 2020. This report also outlines the focus for the Board in 2021.

In Memoriam of our Center's Director

It is with great sadness to report that the OHRC's Director passed away in early December of 2020. Dr. David Noakes is recognized internationally as a true scholar, an exceptional scientist, and a beloved teacher and mentor. Simply stated, he was a giant in the field of biology and fishery science. He has won the highest awards in his profession in recognition of his research and his teaching. It is easy to think of David as a man of the world. He was born and raised in Canada, receiving his undergraduate and Master's degrees from the University of Western Ontario. This was followed by a Ph.D. from the University of California, Berkeley, and an assistant professorship for over two years at the University of Edinburgh. He then became a professor at the University of Guelph and Director of the Institute of Ichthyology, doing two separate sabbatical years study in Japan. He has also worked in China, Europe, Scandinavia, Africa, and Iceland on many occasions. He was a visiting professor at over a dozen international universities. His research was broad and varied with a focus on diversity amongst the fishes. His background, education and experience made him a perfect fit for the mission of the OHRC, for he had a strong focus on how individuals of a single species of salmonid residing in different environments within a watershed had vastly different shapes and behaviors. David was an equally perfect fit for a professorship at OSU. He was a prolific writer, publishing over 200 papers and books. He was also the Editor-in-Chief of *Environmental Biology of Fishes* for decades. He was also editor of the book series Fish and Fisheries. David really enjoyed teaching and interacting with students. In addition, he had experience at hatcheries, had interacted extensively with staff from various agencies, strongly believed in the importance of outreach, and was an outspoken advocate for diversity.

And, there was so much more that made David the truly exceptional person that he was. He was extremely generous, in all aspects of the word, to entering students, staff, colleagues, and others. We all benefitted by the hospitality that his wife Pat showed us as well as guests that came from near and far and who often stayed at his house. He loved the OHRC and his life revolved around

making it a success. He brought countless colleagues, individual students, whole classes and others to work at the OHRC and to marvel at what a wonderful institution it is. He really cared for people. He continued a tradition that he started at Guelph; he baked yummy goodies that he served at OSU's Fisheries and Wildlife Friday morning get-togethers. Anyone on campus was welcome. David's memory was amazing; he was able to speak about anything, with anyone. How David kept track of everyone's birthdays is beyond us. He helped celebrate these often with singing cards, be it with a student, David Attenborough, the former President of Iceland, or the Emperor of Japan. We will miss his great sense of humor, disarming smile and the ways in which he could bring out the best in us. He was greatly loved by so many. We were very fortunate to have David as OHRC Director and as part of our lives, immeasurably enriched in so many ways.

The 2020 OHRC Board

Per the direction in HB 3441[1] for establishing the OHRC Board, the Oregon Department of Fish and Wildlife (ODFW) Director 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 Appointments and Resignations

Lance Kruzic was appointed to the OHRC Board in 2020 as representative of Federal Agency, filling the seat previously held by Craig Busack. In the last quarter of 2020, ODFW representative Bruce McIntosh and Oregon Indian Tribes representative Maureen Hess both resigned from their respective positions on the OHRC Board. ODFW will work to fill these vacancies and the vacant Columbia River gillnetters position in 2021.

[1] https://www.dfw.state.or.us/fish/OHRC/docs/2013/HB_3441.pdf

Table 1 identifies the current OHRC Board members as of December 31, 2020, their position descriptions (group representation) and their designated terms. The 2020 OHRC Board was led by Co-Chairs Brad Halverson and Kyle Smith.

Table 1: OHRC Board members by interest group and term of appointment.

Position	Member	Term
Oregon Salmon Commission	Dwight Collins	06/30/21
Columbia River Gillnet	Vacant	
Wild Fish Advocacy	Brad Halverson	06/30/21
Wild Fish Advocacy	Kyle Smith	06/30/21
Sport Angler	Jack Smith	06/30/21
Sport Angler	Lindsay Ball	06/30/21
Agriculture	Ted Simon	06/30/20
Coastal Ports	Chuck Pavlik	06/30/20
Forestry	Scott Starkey	06/30/21
Independent Science	Steve Jacobs	06/30/21
Habitat Restoration	Andrew Dutterer	06/30/21
Oregon Indian Tribes	Vacant	06/30/20
Federal Agency	Lance Kruzic	Indefinite, non-voting
OSU	Carl Schreck	Indefinite, non-voting
ODFW	Vacant	Indefinite, non-voting

OHRC Board Activities in 2020

Overview

The OHRC Board oversaw the implementation of the OHRC Research Plan throughout 2020 with periodic updates provided by researchers to the Board at their meetings. Health and safety precautions related to the COVID-19 pandemic prohibited regular in-person meetings of the OHRC Board in 2020. Instead, the Board held shorter (two hour) online meetings to conduct their business. The Board continued work on their communications and outreach plan, and appointed Lindsay Ball, Andrew Dutterer, Chuck Pavlik, Scott Starkey, Kyle Smith and Brad Halverson as subcommittee members to lead this effort.

Board Meeting Highlights

In response to health and safety restrictions brought on by the COVID-19 pandemic, in-person Board meetings were cancelled in 2020 and replaced by online "virtual" meetings. The OHRC Board met virtually on three occasions during 2020, as indicated on the OHRC webpage at https://www.dfw.state.or.us/fish/OHRC/minutes.asp. Virtual meetings provided opportunity for

Board members to interact and receive updates from ODFW, OHRC researchers and staff, and attend presentations by guest speakers.

The Board's first regularly scheduled meeting was set for March 24th, but was cancelled due to COVID-19 safety measures. The Board met virtually, for the first time in 2020, on May 14th. At this meeting the Board approved their annual report from 2019 and reviewed brief written research updates from Drs. Banks, Blouin and Noakes, as included in the minutes from that meeting.

Drs. Bruce McIntosh and Marc Johnson (both ODFW) provided the Board with an account of new Operational Research being developed at several ODFW hatcheries, aimed to boost production and genetic diversity of hatchery salmon. Dr. Johnson and Scott Patterson (ODFW) also reported on plans to release a group of fall Chinook salmon smolts at a larger size in the Coos River, and track performance of adult returns through coded-wire tag analyses of that experimental release group. The expected result from this experimental release is greater juvenile survivorship and improved harvest opportunity. Board members Scott Starkey and Chuck Pavlik both commented on the effects that predation by cormorants can have on juvenile salmon.

Dr. David Noakes reported that he had received a research proposal from Dr. Johnson and (OSU student) Meghan Erickson, aimed to evaluate salmon egg incubation devices at the OHRC: streamside incubators and in-stream hatch boxes. Scott Starkey commented that there is strong support for this research from the Coos Bay area. Minutes from the May 14th OHRC Board meeting are available at:
https://www.dfw.state.or.us/fish/OHRC/docs/2021/OHRC_BoardMinutes_05142020_Final.pdf

The OHRC Board's regularly scheduled June 9th meeting was cancelled due to COVID-19 restrictions. Instead, the Board met virtually on September 9th. OHRC Director, Dr. David Noakes, and Board Co-chairs, Brad Halverson and Kyle Smith, opened the meeting and acknowledged the challenges posed by COVID-19 and the need to conduct online meetings.

Wildfires and smoke severely impacted much of Oregon during the late summer of 2020. During their September meeting, OHRC Board members heard from OHRC Facilities Manager, Jen Krajcik, about thick smoke that had descended on the OHRC. Scott Patterson reported on the devastating impacts that wildfires were currently having on Rock Creek (Umpqua), Klamath and Leaburg hatcheries, and that ODFW staff had been evacuated from McKenzie, Marion Forks, Minto, Clackamas, Sandy, and Salmon River hatcheries.

Drs. David Noakes and Michael Blouin provided research updates to the Board at the September 9th meeting. Dr. Banks was unable to attend the meeting due to a power outage caused by a nearby wildfire.

Briefly, Dr. Noakes reviewed the overarching hypothesis of his research, that hatchery origin adult Chinook salmon fail to return to their hatchery (i.e. stray) because they did not successfully imprint on chemical cues in the water during their early development. He further stated that the prediction is that if young salmon could be exposed to selected chemicals during early incubation

and smolt life stages, then those same chemicals could later be released into the hatchery entrance water to attract returning adults. Dr. Noakes described how his research is testing this hypothesis, and that the end goal would be to reduce stray rates of hatchery salmon, reduce risk to wild fish, and improve harvest opportunities for anglers.

Dr. Blouin stated that his hypothesis is that generalized boldness is favored in hatcheries, but selected against in the wild, and that different selection regimes might explain fitness differences between hatchery and wild salmon. Dr. Blouin reported that his results have shown that families of fish that surface feed or express boldness grow faster and may, therefore, have greater survivorship during transition to saltwater, but that he had not yet identified a mechanism to normalize growth rates among families. Dr. Blouin reported that, with assistance from post-doctoral researcher, Dr. Maryam Kamran, he is investigating effects from different diets, feeding approaches and tank environments.

Dr. Marc Johnson provided updates on operational research being conducted at the OHRC, including the development of the hatch box project and completion of the Alsea "biter study" that evaluated the effects of steelhead broodstock collection methods on the survivorship and fate of their offspring. Dr. Johnson related that while the biter study had not found evidence to suggest that the offspring of broodstock collected by anglers were more likely to be harvested than enter hatchery fish traps, the study had produced some remarkable results. Specifically, he reported that broodstock collected by hatchery traps consistently produced twice as many returning adult offspring as broodstock collected by anglers. He emphasized that the study's results offer clear guidance to improve hatchery production and angler opportunity, through use of broodstock collected by traps, and not by anglers.

Following these research updates, the Board engaged in a lively discussion of the applicability of the research, and the merits of hatchery fish. Discussion comments from Board members are paraphrased in the minutes from this meeting, available at:
https://www.dfw.state.or.us/fish/OHRC/docs/2020/OHRC_BoardMinutes_09092020_Final.pdf

The December 9th meeting of the OHRC Board opened on a deeply somber note, following the unexpected death of the Center's Director, Dr. David L. G. Noakes, which occurred on December 1st. Co-chair Brad Halverson sorrowfully acknowledged that David's passing was a great loss to the OHRC, and introduced Prof. Selina Heppell (OSU Department of Fisheries and Wildlife Head), who related that she and her department had been receiving condolences from across the country and around the world, reflecting the scope of David's influence. Prof. Heppell recognized the importance of the work conducted at the OHRC and affirmed OSU's commitment to the Center's continued success. She indicated that the University would work to identify and support a new OHRC Director that would help to meet Oregon's needs in hatchery management.

Following these opening remarks, Jen Krajcik provided a facility update, including reports on replacement of the OHRC's water chillers and the recently completed water intake gate at the Center. Jen also reported on an operational research project that she and others at the OHRC had developed to evaluate the effects of different feeding approaches on steelhead fin erosion. She provided updates on projects aimed to identify causes of operculum deformities in hatchery steelhead and new approaches to sort hatchery fish eggs by size, perhaps alleviating need for

time-consuming size sorting that typically occurs at later stages. Jen also reported on efforts by OHRC technician, Craig Lawson, to construct platforms to be used during the hatch box research being conducted at the OHRC. Jen reported that the Center had recorded a record high 613 Chinook salmon entering the facility's trap, which were passed upstream to spawn in Fall Creek. The previous record for Chinook salmon at the OHRC was 161, with an annual average of 80.

Dr. Marc Johnson expressed sorrow for having lost a colleague and friend, with the passing of Dr. Noakes. He then provided an update from ODFW, reporting on the retirements of both Drs. Ed Bowles and Bruce McIntosh from ODFW Fish Division. Marc reported that Cedric Cooney and Dr. Shaun Clements, both present at the meeting, had been appointed to interim positions to fill the vacancies left by Ed and Bruce, respectively. Dr. Johnson reported that the OHRC Research budget was in good standing, in part due to strong license sales in the second quarter of the year. He also provided updates on the report for the Alsea steelhead "biter study" (now available online) and progress of the OHRC hatch box research project.

Scott Patterson provided an update on impacts from wildfires to ODFW hatchery facilities, noting the nearly complete loss of Klamath and Rock Creek hatcheries. Scott noted that these losses could impact fish production in the near near, and that there will be a significant amount of work needed to clean up and rebuild.

Following Scott's report, OHRC Board member, Dr. Carl Schreck, introduced OSU professor, Dr. James (Jim) Peterson, who presented information about the relationships between monitoring, research and management. Dr. Peterson advocated for using model-based decision support in management and encouraged Board members to evaluate the models they adopt when evaluating program or project success. He offered perspective on how adaptive management can be informed through model outputs and related how this approach has been used for salmon recovery efforts in California.

Dr. Peterson's presentation was followed by a discussion of the relevance of relative reproductive success (RRS) to salmon management, with perspectives offered by Board member Scott Starkey, Brad Halverson, Carl Schreck, and Drs. Peterson and Johnson. Board members Steve Jacobs and Jack Smith offered words of appreciation for Dr. Peterson's presentation, and offered their perspectives about assumptions used in models. Minutes from this meeting will be posted to the OHRC's website following approval by the Board. All OHRC Board meeting minutes can be found at: https://www.dfw.state.or.us/fish/OHRC/minutes.asp

OHRC Board Focus for 2021

The OHRC Board will continue to refine and expand its outreach and education efforts in 2021, to be spearheaded by the Outreach and Education Subcommittee formed in 2020. Pending reductions in risk presented by COVID-19, the Board anticipates a return to in-person meetings and expanded outreach opportunities.

The Board will also continue to advise ODFW, OSU and the OHRC Director on research priorities and opportunities to implement technologies developed through the OHRC. The

OHRC Board will actively exercise its role in reviewing research proposals submitted to the OHRC, through actions of the OHRC Board Research Subcommittee formed in 2020.

The OHRC Mission

The **Mission of the Oregon Hatchery Research Center** (OHRC) is "to be an internationally-recognized leader in fisheries science, specializing in defining the mechanisms that may create differences between hatchery and wild salmonids, recommending management strategies to manage those differences while meeting fishery and conservation objectives, and educating Oregonians on the role and performance of hatcheries in supporting and protecting Oregon's native fish and fisheries".[2]

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

1. **Understand mechanisms that may create differences between hatchery and wild fish.**
    a. Determine the process and rate by which wild fish may change in the hatchery environment within and across generations.
    b. Determine the process, rate and pattern by which hatchery-produced fish adapt to the natural environment at each life history stage.
    c. Determine the possible genetic and ecological consequences of hatchery fish and their releases on native fish at each life history stage.

2. **Develop approaches to manage hatchery fish that conserve and protect native fish.**
    a. Determine hatchery breeding, rearing and release practices that allow hatchery-propagated fish to both contribute to fisheries and facilitate the conservation and recovery of naturally produced native fish.
        1. Identify possible effects, both locally and on a landscape scale, to natural ecosystems associated with different types and levels of hatchery production and identify approaches to manage these effects.
        2. Identify hatchery practices that may need to be altered in response to changes in the natural environment and other external factors.
    b. Identify breeding, rearing and release protocols that minimize possible adverse impacts on the natural ecosystem.
    c. Evaluate the effectiveness of producing hatchery fish, relative to other strategies, as a means to achieve commercial, recreational, conservation and ecological objectives.
    d. Determine the effects of hatchery operations (for example: flow alteration, effluent water quality, pathogens, migration and spawning distribution, etc.) on native fish, aquatic communities and their habitats.

3. **Educate and train students, fishery biologists, managers and the public on the relationship between hatchery and wild fish, the connection between fish and**

[2] https://www.dfw.state.or.us/fish/ohrc/mission.asp

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 2020

Overview

With reference to the **Mission** and **Goals** of the OHRC, the following activities and projects were developed at or through the OHRC in 2020:

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 wild surrogates project– Schreck, Noakes
1.c. Genetic propensity to be caught by anglers ("Biter Study") – Johnson, Noakes et al.
1.c. Chinook salmon telemetry study– Noakes, Dittman, Johnson, Kamran et al.

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

2.b. Mate choice –Banks, Auld, Noakes
2.b., c. Effect of hatchery rearing conditions on steelhead behavior – Blouin, Holland
2.b.,d. Performance of sterile triploid steelhead – Johnson, Dittman, Noakes et al.
2.d. Olfactory imprinting and homing (Chinook, steelhead)– Dittman, Johnson, Noakes, Kamran et al.
2.d. Geomagnetic imprinting and navigation (Chinook, steelhead) – Noakes, Putman, Scanlan, Pollock

2.a., d. Radio telemetry study of wild- and hatchery-origin Chinook salmon in the Elk River
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 2020 due to COVID-19
3.b. OHRC staff hosted tours for K-12 students and provide education both onsite and through outreach activities in Oregon
3.c. hosted visiting student groups.
3.d. Workshop.
3.e. seminars.
3.f. Research conducted through the OHRC was published and presented at numerous scientific workshops and symposia during 2020.
3.g. OHRC researchers and ODFW staff gave regular presentations to various stakeholders, community organizations and local residents in Port Orford twice each year related to Dr. Noakes' Olfactory Imprinting Study and management of Chinook salmon in the ODFW Elk River, Oregon.
3.h. Results from OHRC-based research were disseminated through various publications, as
3.a., e., h. Hatchbox research project - Johnson, Howell et al.

Research

Perhaps the most important activities conducted by the OHRC Board in 2020 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 (Drs. Banks, Blouin, and Noakes) 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 2019, 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 to be addressed in 2020. The premise of this work is that larger size of juvenile steelhead and salmon at time of release from hatcheries is favored (selected for) because it predicts greater survival during transition to saltwater. Therefore, traits that allow fast growth in the novel environment of a hatchery are likely to be propagated by current hatchery practices. Dr. Blouin's lab has adopted two approaches to investigate sources of growth variation and mechanisms of selection. First,

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. So far, they have rejected the hypothesis that raising fish under low density would achieve that goal. They are testing various other environmental manipulations, such as feeding conditions and water current (flow). Secondly, they are measuring various behavioral traits of hatchery fish that are grown in the hatchery to investigate whether variation can predict which families grow fastest. Results from that work could identify which traits might be subject to domestication selection. Their current hypothesis is that hatcheries select for excessively bold behavior.

The project headed by Dr. Michael Banks (genetics and mate choice) progressed as planned during 2020. *In completion of phase 1*: Drs. Banks and Auld used the information obtained from having successfully analyzed a 10-year genetic pedigree to identify genetic markers significantly associated with differences in mate choice between hatchery and natural origin coho salmon from the Umpqua River. They co-authored a review of mate choice studies in salmon that is now published in *Reviews in Fish Biology and Fisheries*. A second manuscript detailing findings from the coho salmon pedigree (phase 1) was submitted for review to the journal *Animal Behaviour* in 2019, but has not yet been accepted for publication. This manuscript has been revised with plans to submit for peer review publication in a different journal, February 2020. Their findings were presented at the Canadian Conference for Fisheries Research, the joint meeting of the 56th Annual Conference of the Animal Behavior Society and the 36th International Ethological Conference and at the meeting of the Oregon Chapter of the American Fisheries Society. *In completion of phase 2*: Drs. Banks and Auld worked with the company GT-Seek to develop a method for genotyping fish at markers that evidence from the pedigree suggests are important to mate choice differences observed between natural origin and hatchery coho in phase 1 on this project. *Commencing the third phase of the project*: they designed an experiment to test whether mating hatchery fish in a non-random way, as informed from phase one (to emulate 'wild-like' mating), compared to methods traditionally used in hatcheries, had any effect on the relative fitness of offspring. The experiment was carried out using coho salmon returning to the Sandy hatchery in fall 2019 and fall of 2020 as follows: Males and females were selected for broodstock by hatchery staff and held as per normal protocol. Two weeks prior to spawning, broodstock fish were tagged, fin clipped, 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 haphazardly (as per traditional hatchery process). 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, as best means to emulate combinations observed among wild-like mating in phase 1 of this project. Final assessment of the relative fitness of these two mating types will occur when this cohort of offspring coho return from the ocean as adults ready for spawning in fall 2023.

The project led by Dr. David Noakes involved collaborations with colleagues from the University of Washington (Seattle), NOAA Fisheries (Seattle), the Leipzig Institute (Berlin, Germany), Hokkaido University (Japan) and ODFW. River water samples from the Elk and Sixes rivers have been and continue to be analyzed (amino acids, dissolved organic matter, dissolved carbon compounds) in the laboratories in Germany and Japan to characterize the

various river tributaries where variable stray rates of Chinook salmon are observed. Testing of behavioral responses by young Chinook salmon in response to candidate odorants was completed at the OHRC. This research team also measured the olfactory receptor responses of salmon to selected chemicals in the NOAA Fisheries (Seattle) laboratory, using electro-olfactogram analyses. Chinook salmon embryos from the ODFW Elk River Hatchery were reared at the OHRC under controlled conditions prior to testing their behavioral responses to test chemicals. Juvenile Chinook salmon were reared at the ODFW Elk River Hatchery and under comparable conditions at the OHRC. Fish at both localities were sampled at regular intervals to measure the development of olfactory receptors. In addition, some fish at the OHRC were exposed to a candidate odorant chemical (arginine) during development to provide comparisons of olfactory organ development in control fish. Several manuscripts from the first phases of this project are in preparation or published in 2019.

Detailed schedules, timelines and activities for all three Research Projects are provided in the OHRC Research Plan[3]. Progress reports for these projects were presented to the OHRC Board before and during their meetings in 2020.

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 the hatchbox research project that was initiated in 2020, a recently completed evaluation of induced triploidy effects on the performance of hatchery steelhead (Johnson et al. 2019), and a study to the performance of hatchery broodstock that were actively collected by anglers with that of broodstock collected passively by hatchery traps (Johnson et al. 2020). Performance, in the last case, was measured as the relative catch contributions of adult returns from the two broodstock sources. This research involved significant hatchery and angler coordination in the Alsea River, a two-year creel survey staged from the OHRC with financial support from ODFW's Restoration and Enhancement Program, and genetic laboratory services provided by the State Fisheries Geneticist (see below). Initial findings from this research were presented in 2019 by Dr. Johnson at the annual meeting of the Oregon Chapter of the American Fisheries Society, and final results were included in an ODFW Information report by Johnson et al. (2020).

In alignment with the work and Mission of the OHRC, research conducted by the State Fisheries Genomics Laboratory, led by Dr. Kathleen O'Malley, contributed to a number of projects carried out by OHRC researchers. For example, Dr. O'Malley's lab provided microsatellite data used to perform parentage analyses that were critical to the success of the Alsea steelhead "biter study", led by Dr. Marc Johnson. Dr. O'Malley's lab also continues to conduct genetic pedigree studies that inform reintroduction of Chinook salmon above dams in the upper Willamette River. Her lab has also conducted research to elucidate genetic connectivity in marine species (including Dungeness crab, albacore tuna and Deacon rockfish). Additional activities of the State Fisheries Geneticist in 2020 include:

- Presented our albacore tuna genomics research to the American Fishermen's Research Foundation and the Director of NOAA's Southwest Fisheries Science Center. GoToMeeting [~25 attendees]

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

- Presented research findings of Chinook salmon run-timing markers at a Genomics Workshop (Feb 2020) in Seattle, WA
- Continued genetic monitoring and research of Oncorhynchus mykiss in the Rogue and Klamath rivers

More information about the research being conducted through the State Fisheries Genetics Laboratory can be obtained through the lab's website at https://agsci.oregonstate.edu/state-fisheries-genetics-lab/research-areas.

Education and Outreach

The OHRC is a clearinghouse for, and helps facilitate, research in Oregon related to the management of hatchery fish. Through publications and presentations, OHRC research findings are shared with hatchery and fisheries managers, biologists, fish culturists, scientists and the general public. ODFW and other fisheries managers consider the information provided by the OHRC in their decisions, and in some cases apply new techniques and technologies to hatchery operations. A list of publications, reports and presentations delivered by OHRC researchers in 2020 is provided in Appendix 1.

The OHRC normally meets much of its public education and outreach responsibilities through facility tours and demonstrations, as well as through an annual Free Fishing Day in June and Fall Festival in November. However, these activities were almost entirely restricted during 2020, due to COVID-19 safety measures that closed the facility to the public. The OHRC staff and Board anticipate a return to these activities as restrictions ease pending lower risk from COVID-19 in 2021.

Board members also typically provide outreach and education services for the OHRC. To the extent allowed amid COVID-19 safety restrictions , OHRC Board members continued these activities in 2020 to highlight the work and Mission of the OHRC to diverse stakeholder groups. These meetings allowed opportunities for groups to ask questions and otherwise engage with OHRC Board members.

In accordance with its Mission, the OHRC delivers new information bot to the public and directly to ODFW managers, biologists and staff. In December of 2020, Dr. Marc Johnson (ODFW Fish Division liaison to the OHRC) presented results from the Alsea steelhead "biter study" (see report by Johnson et al. 2020)[4] to a large group of ODFW managers and staff. The group subsequently engaged in a 30 minute discussion of the study's results, and its implications for management and research. In brief, ODFW managers agreed that the study had identified an aspect of hatchery management that could be improved, and that more research was needed to identify broodstock collection methods that minimize fish stress and bolster smolt-to-adult return rates of hatchery steelhead and salmon.

[4] 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

Importantly, the activities described above and in Appendix 1 of this report occurred in 2020, but additional reports, papers and descriptions of outreach and education activities from previous years can be found on the OHRC website at: http://www.dfw.state.or.us/fish/OHRC/news.asp. Earlier reports hosted on this website illustrate the progress of research activities at the OHRC, as well as development and funding of the OHRC Research Plan.

Funding of OHRC Operations and Activities

Operations

The OHRC received a biennial operating budget of approximately $1 million from the Oregon Department of Fish and Wildlife for 2019-2021. That support was supplemented by funds provided by the Fisheries and Wildlife Department of Oregon State University, through a Memorandum of Understanding with ODFW.

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, though at a reduced level of $800,000 for the 2019-2021 biennium, adjusted in response to ODFW's revenue projections through 2021. This research budget was formally approved through OSU-ODFW Intergovernmental Agreements, and OHRC researchers accommodated by making necessary adjustments to their individual research budgets.

During 2020, the OHRC attracted significant extramural funding from a variety of local, state, national and international sources. Much of that funding was leveraged by in-kind support from the OHRC and OSU (personnel, facilities, operations, etc.). A new research project being developed at the OHRC to gather information about in-stream hatchboxes and streamside incubators benefitted from a generous donation from the Alsea Sportsman's Association, which purchased and provided 15 hatchboxes (at $50 per unit) for the study. Milk crates, also used by this study, were provided by OHRC Board member Ted Simon. Other ongoing projects at the OHRC continued to support Center operations. 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 work continued into 2020.

During 2020, the State Fisheries Genetics Laboratory, 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:

- O'Malley KG. Principal, "Alsea Biter Study: Parentage-based tagging of steelhead," Sponsored by Oregon Department of Fish and Wildlife, Total $20,264 (2019).
- O'Malley KG. Principal, "Estimating the proportion of Rogue River winter and summer steelhead exhibiting the half-pounder life history in the 2018," Sponsored by Oregon Department of Fish and Wildlife, Total $14,212 (2019).

- O'Malley KG. Principal, "Genetic analysis of Chinook salmon returning to the Rogue River in 2019," Sponsored by Oregon Department of Fish and Wildlife, Total $5,210 (2019).
- O'Malley KG. Principal, "Informed marker selection for the study and monitoring of genetic introgression among native upper Willamette River steelhead *Oncorhynchus mykiss* populations," Sponsored by Oregon Department of Fish and Wildlife, Total $9,002, (2018-2019).
- O'Malley KG. Principal, "Testing for neutral and adaptive genetic differentiation between fall and spring run Chinook salmon in the Sandy and Clackamas Rivers," Sponsored by Oregon Department of Fish and Wildlife, Total $29,972, (2018-2019).
- O'Malley KG. Principal, "Adult salmonids trap and transport success above dams," Sponsored by U.S. Army Corps of Engineers, Total $320,722, Share $271,128, (2019-2020).
- O'Malley KG, Principal, "Testing for neutral and adaptive genetic differentiation between fall and spring run Chinook salmon in the Rogue River," Sponsored by U.S. Army Corps of Engineers, Total $32,651, (2018-2019).

Management Applications of OHRC Research Findings

Research conducted at the OHRC in 2020 expanded knowledge of tools that could be used by ODFW to improve culture and manage risk from hatchery salmon and steelhead. Although COVID-19 safety measures limited opportunities for in-person meetings during 2020, OHRC researchers shared their results with the OHRC Board and with ODFW managers on numerous occasions, offering suggestions for the implementation of new information that could prove useful to hatchery management.

Notably, ODFW staff, including Bruce McIntosh, Marc Johnson, Scott Patterson, Jen Krajcik and others, regularly attend OHRC Board meetings, where they learn about OHRC research findings that they can then share with colleagues and other ODFW staff. As described earlier in this report, Dr. Marc Johnson first published (Johnson et al. 2020) then presented findings from the Alsea steelhead "Biter Study" to a large audience of ODFW managers and staff on December 2nd, 2020. His presentation prompted a discussion of best management practices for the collection of hatchery broodstock, with considerations of improved hatchery efficiency and wild fish protection. A work group was formed within ODFW shortly after the presentation, and has met to develop an approach to improve broodstock collection techniques through a survey of current techniques, targeted research and identification of measures to reduce adult fish stress during and after collection.

Research being conducted by Drs. Banks and 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. Pending results from this work, Drs. Banks and Auld will issue recommendations to ODFW, as to whether genetic marker informed crosses can improve the fitness of hatchery salmon and steelhead. These results are dependent upon the adult returns of experimental fish produced in 2019 and 2020, as described in Appendix 1 of this report.

Research led by Dr. Noakes through the Olfactory Imprinting Project discovered that fish 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 by using river water to incubate salmon eggs at their facilities, so as to improve homing to the hatchery by the fish they produce. In a production-scale test of this experimental practice, ODFW incubated a portion of the Chinook salmon it produced at Elk River Hatchery in 2017 and 2018 in river water, to compare homing and straying rates of these fish to those of fish incubated in well water. Experimental fish were tagged as juveniles before being released and can therefore be assigned to treatment and control groups once they return to the Elk River as adults. Results from this work are expected provide empirical evidence to support a recommendation to ODFW, as to whether or not embryo incubation in river water can improve the homing of hatchery salmon.

Over the course of several years, research carried out at the OHRC has elucidated the remarkable ability of salmon to detect and use geomagnetic cues to navigate during the ocean phase of their migrations[6]. 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) and may have implications over materials used in hatchery construction, wave energy development and other human activities.

A list of hatchery management recommendations and practices developed through past and ongoing research at the OHRC has been developed and is provided on the Center's website[7].

[5] https://www.dfw.state.or.us/fish/OHRC/docs/2015/Dittman_et_al%20_2015_Fisheries.pdf
[6] https://today.oregonstate.edu/archives/2014/feb/study-confirms-link-between-salmon-migration-and-magnetic-field
[7] https://www.dfw.state.or.us/fish/ohrc/docs/projects/ongoing_research.pdf

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 facilities[8]. 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 website[9], and in the records of the previous 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 our activities are reported at annual ODFW meetings (hatchery managers' and regional fish biologists' meetings, occurring in alternate years).

Individual Research Projects

A variety of research projects were conducted at or by affiliates of the OHRC in 2020. A selection of those projects is described below, with reference to OHRC 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, which occasionally stray and interact with wild fish on spawning grounds. 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 has been led by Dr. David Noakes (ODFW/OHRC) and benefits through participation from Dr. Maryam Kamran (OSU), Margi Whitmore (OSU alum), Dr. Andy Dittman (NOAA, NWFSC, Seattle), Dr. Tom Quinn (University of Washington), Dr. Marc Johnson (ODFW), Darran May (University of Washington), Dr. Gabriel Singer (University of Innsbruck, formerly at Leipzig Institute, Berlin, Germany), Amanda Pollock (OSU), Brent Hinners, Shannon Richardson and Austin Huff (all ODFW), and many more.

The central hypothesis being tested by this study is 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.

[8] https://www.dfw.state.or.us/fish/OHRC/docs/2008/OHRCCallForResearch2008.pdf
[9] https://www.dfw.state.or.us/fish/ohrc/

During phase 1 of this project, Dr. Noakes and his team demonstrated through a series of experiments that both Chinook salmon and steelhead imprint on the water in which they are incubated, from fertilization to swim up stage. These findings were published in the journal *Fisheries* (Dittman et al. 2015)[10], and challenged conventional belief that olfactory imprinting by salmon may be restricted to the parr-smolt transformation developmental stage. To identify candidate odorants that could be detected by salmon, the research team then conducted electro-olfactogram (EOG) analyses in Dr. Andy Dittmann's laboratory. These tests aimed to measure the responsiveness of salmon olfactory epithelium to various concentrations of various candidate odorants, including phenylethyl alcohol, morpholine, algal cultures, watercress, lignite, cyprinid odors, salmon ovarian fluid, bile acids, geosmin, cyprinol sulfate, taurolithocholic acid-3a sulafate, arginine, kynurenine, threonine, glutamate and several others. Detailed methods and results from their work were provided in a report developed by Dittman et al. (2019), distributed to the OHRC Board. Therein, the authors reported that bile acids elicited the strongest olfactory neural responses in juvenile salmon, followed by several amino acids, including arginine.

Parallel to EOG phase 1 work, Dr. Maryam Kamran and other team members used a series of y-maze and similar behavioral assays to screen candidate imprinting odorants, evaluating whether (or not) juvenile fish might be attracted (or repulsed) by select compounds, and whether (or not) fish can detect, learn and respond to candidate odorants. Results from that work have been presented at a variety of meetings and conferences, including a public outreach meeting in Port Orford in 2019, at the Warm Springs National Fish Hatchery, and at the Gordon Research Conference in Lucca, Italy.

While most Phase 1 work for this project has been completed, some Phase 2 tasks, such as a transcriptomic analysis of fish exposed to top candidate odorants, remain incomplete. Nevertheless, the research team has already initiated Phase 3 of their project, exposing Chinook salmon to a weak arginine solution – their chosen candidate odorant – during embryonic incubation (treatment 1) and during parr-smolt transformation (treatment 2) during February and May of 2020, respectively. Odorant exposed treatment fish and unexposed control fish were tagged in June of 2020 with coded wire tags, with codes that were unique to treatment or control groups and raceways. These tagged treatment and control fish were released on October 12, 2020, from the Elk River Hatchery. This treatment and release design is being repeated in 2021 and again in 2022. Analysis of tagged adults that return and are collected at the hatchery or from wild spawning grounds will soon determine whether or not odorant treatments significantly affected hatchery salmon stray rates.

COVID-19 travel restrictions limited opportunities to present findings to peers and the public at meetings and conferences in 2020. However, reporting and publishing continued. In 2020, the Olfactory Imprinting Project team published their finding from an analysis of 34 years of coded-wire tag data from adult Chinook salmon that returned to the Elk River. In their paper, published in *Canadian Journal of Fisheries and Aquatic Science*, Pollock et al. (2020)[11] demonstrated that both size and sex influenced the probability of straying by hatchery Chinook salmon, with older fish and female fish being more likely to stray onto natural spawning grounds. Most recently, project participants authored and submitted a new manuscript to the *North American Journal of*

[10] https://www.tandfonline.com/doi/pdf/10.1080/03632415.2015.1007206?needAccess=true
[11] https://cdnsciencepub.com/doi/pdf/10.1139/cjfas-2018-0384

Fisheries Management, which prompted favorable reviews. This latest manuscript 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 arginine that will be added to the Elk River Hatchery water, and will have an opportunity to respond by entering the hatchery, or not.

The Olfactory Imprinting Project contributes to the implementation of the OHRC Strategic Research Plan[12].

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

Research on this topic is in response to a priority request from ODFW to provide recommendations for their management of homing and straying in wild and hatchery salmon and steelhead. This research has produced the first evidence that salmon and steelhead use geomagnetic cues for their orientation and navigation, from embryos to adults. A series of papers has been published from this research, most recently those of Putman et al. (2018) [13] and Scanlan et al. (2018)[14]. In this year, these researchers published new results that demonstrated that salmon have magnetite-based magnetoreception that they utilize for navigation (Naisbett-Jones et al. 2020)[15]. Results from this work has been and continues to be presented at regional, national and international research conferences. 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 navigation from the time of hatching until their return as adults. The novel results from this work have attracted considerable interest, from regional to international levels, and raised important questions about possible effects from magnetic fields at hatchery rearing facilities on salmonid navigational capacity.

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 David Noakes, supported by funding from the US Army Corps of Engineers, initiated in 2011. Many salmon and trout are listed as threatened or endangered under the Endangered Species Act. Research aims to understand factors contributing to population declines. This project is relevant to improving juvenile downstream passage through reservoirs and dams. 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. Our Wild Fish Surrogate Project 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 River basin. This work is carried out at Oregon Hatchery Research Center and Oregon State University's Fish Performance and Genetics Laboratory. It also entails

[12] https://www.dfw.state.or.us/fish/OHRC/docs/2016/OHRC_Research_Plan.pdf
[13] https://royalsocietypublishing.org/doi/full/10.1098/rsbl.2017.0752
[14] https://www.pnas.org/content/115/43/10995.short
[15] https://jeb.biologists.org/content/223/10/jeb222091.abstract

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 the FPGL concentrates on spring Chinook salmon that represent various stocks in the basin.

The research team accomplishes its project objectives by varying growth, feeding, density, cover, complexity, and diet. Their experimental diet was formulated by and produced for them by the U.S. Fish and Wildlife Service's facility at Bozeman, Montana. They also conduct research to figure out how to best produce a wild-like fish under culture conditions. This research has focused on simulating growth rates found in the wild, experimental diets, adaptive feeding tactics, cover providing shade and in-tank complexity of structure, fish density, and temperature. They have also found that vertical location in a tank can influence similarity to different wild migrant phenotypes. To meet 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, developmental (smolting and precocity) physiology, morphology, and brain development and gene expression. Tests have also included migratory performance of test fish released into the McKenzie and the North Santiam Rivers.

Fish produced by the Wild Surrogate Project are more like wild fish in morphology, fin condition, body composition, and behavior than are typical hatchery fish. Over the nearly 10-year course of the project researchers have provided scientists, mainly from the USGS, Oregon Department of Fish and Wildlife, the Pacific Northwest National Labs, and the U.S. Army Corps of Engineers with several hundred thousand surrogate wild Chinook and tens of thousands of surrogate steelhead. These fish are provided at various times of the year and at various sizes that correspond to wild fish in the system. This work is done for various genetically-distinct populations. The various end users of the fish supplied through the project have found 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. In addition, over the last two project years the Wild Surrogate Project has produced for ODFW 20,000 and 25,000 wild-like Chinook, respectively, for reestablishment of natural origin fish in the Molalla River system where the native population has been largely extirpated. Over the last two reporting periods the project has also created parasitic copepod infected Chinook for researchers studying fish bypass systems at Willamette River dams. Huge numbers of fish in the reservoirs have severe infection rates. This project has conducted research to determine how to infect fish at naturally occurring severities with this parasite. Researchers also found that survivorship of these fish is significantly reduced, and the Surrogate Wild Project has provided researchers with over a 1,000 copepod infected smolt-sized fish for their dam passage studies and associated evaluations.

To date the Surrogate Wild Project has trained three post-doctoral students, four Masters students, and numerous undergraduate students. During 2020, the project also had four full-time faculty research assistants working as staff. The project provides funding that goes directly to the OHRC for its operation.

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

This Strategic Research Project is led by Dr. Michael Blouin, his postdoctoral research assistants and their laboratory collaborators. The project is a continuation of earlier work by Dr. Blouin at the OHRC, carried out as part of his long-term study of the factors producing lifetime differences in reproductive fitness of hatchery and wild salmon and steelhead. This project is another part of the OHRC Research Plan (details elsewhere in this Report). Dr. Blouin's lab has a continuing series of publications from this work. Funding for this project originally came to Dr. Blouin from the BPA, with some in-kind support provided by OHRC personnel and facilities. This research is of primary concern to many people in the Pacific Northwest because a large body of research shows that even first-generation hatchery fish have lower fitness than wild fish when both spawn in the wild which raises concerns about negative genetic effects of hatchery steelhead on wild counterparts. This project is the latest in a series of tests of specific predictions about the mechanisms causing reduced fitness of hatchery fish, and how one might change hatchery rearing conditions to make hatchery fish more like wild fish. In previous work at the OHRC, his lab showed that raising fish at reduced densities did *not* reduce the opportunity for selection on size at release. This result failed to support a hypothesis that raising fish at high density exacerbates differences among families in size at release (of interest because size predicts survival after release). The lab has subsequently manipulated other aspects of hatchery rearing, such as feeding method, feed composition, and how water flows in tanks, in order to find conditions that would reduce the selection pressures. So far, it appears that neither manipulating the fat content of the feed, nor altering the feeding methods (automatic feeders vs. hand fed, or feeding on the surface vs. under water) has an appreciable effect on the variation among families in growth rate under hatchery conditions. In other words, they have repeatedly found that the winners (fast growing families) are the winners, and the losers are losers, under all conditions.

So, the overall conclusion to date is that the among-family variation in growth rate is so large that extensive modifications of the way fish are raised may be required to overcome it. Furthermore, the choice of modifications may need to be based on a better understanding of the traits under selection, which is still a major area of uncertainty.

Dr. Blouin's lab also recently found that families created by crossing wild broodstock grew more slowly under hatchery conditions than families created by crossing first-generation hatchery broodstock. The siblings of these families were simultaneously grown in the artificial streams at the OHRC. Although the families created using hatchery parents grew faster in the hatchery, they had poorer survival in the streams than did the families created using wild broodstock. This tradeoff in performance mirrors data from adult steelhead in which families that performed well in the hatchery (produced many returning offspring) produced offspring that had low relative reproductive success in the wild. So again, we see evidence that adaptation to captivity can happen rapidly (detectable after a single generation of selection in the hatchery). More importantly, these results are consistent with their working hypothesis that hatcheries select for traits that enhance the ability to grow to a large release size in one year. Thus, we still believe

that identifying the traits under selection may allow us to more rationally target environmental conditions that can be changed in the hatchery.

In order to identify those traits under selection, Blouin's lab has been testing hypotheses about specific behavioral traits that may be favored under hatchery conditions. They are currently testing the hypothesis 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. Excessive boldness can be maladaptive in the predator-filled and low-food natural environment, so selection on this trait could also explain the fitness tradeoff: hatchery fish have lower fitness in the wild, but perform better than wild fish in captivity. The three components of boldness they have studied include (1) propensity to feed at the surface during the first week of feeding, (2) preference for position in the water column immediately after ponding, and (3) dominance in defending a feeding site as juveniles. These traits were interesting to study because surface feeding, preference for a higher position in the water column, and being dominant are all correlates of generalized boldness. The researchers found that juvenile dominance and propensity to feed at the surface both correlate positively with the growth rate of those same families when raised in mixed-family tanks. The data on propensity to feed at the surface are particularly striking, in that they observed substantial variation among families (some families readily rise to the surface to feed, while at the other extreme, some families never come to the surface. These experiments were replicated in 2020 using families from a different population of steelhead, and the researchers found equally striking variation. So this seems to be a general result. In ongoing work they will test whether the siblings of these putatively "bolder" families also grew fastest in mixed-family tanks.

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)[16]. 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 steelhead enumerated in both the creel and hatchery trap. Dr. Johnson presented these results to over 80 ODFW staff, including managers and policy makers, during an online presentation in early December, 2020.

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. The premise of their 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 completed a reduced representation full genome study 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 reduce 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 currently under review by the journal *Integrative Organismal Biology*.

In Phase 2 of their work, Drs. Banks and Auld have begun to apply the 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

16 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

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. This program, called multifacetedCHOICE, facilitates selection of appropriate mate pairs from candidates on the spawning table. This tool was used to quickly identify appropriate coho mate pairs from genomic data during spawning at Sandy River Hatchery in November of 2020, improving efficiency of process used to select mate pairs in 2019.

In Phase 3, Drs. Banks and Auld will perform an empirical test to determine whether informed crosse that used their genomic and bioinformatic tools in 2019, 2020 and 2021 resulted in higher reproductive success of hatchery coho salmon. The experiment is designed as follows:

First, the hatchery coho brood stock is 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 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, 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 will be repeated in 2021. Final assessment of the relative fitness of these two mating approaches will occur when cohorts of offspring coho return from the ocean as adults in 2021 (jacks), 2022, 2023, and 2024. Due to the life history of salmon, it is impossible to get the final results of this study until after these adult fish return from the ocean, at the end of their lifecycle.

In addition to the aforementioned activities, in 2020, Drs. Banks and Auld have continued to carry out a study on Chinook salmon pedigree, involving natural and hatchery origin Chinook that spawned in a natural context above Cougar Dan 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 program (REU).

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 an OHRC Board meeting, they did not present their work in 2020 due to COVID-19 restrictions. Their plans to present their results to an international audience at the meeting for International Society for Behavioural Ecology in Melbourne, Australia have been postponed until 2022.

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

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

During their first meeting of the year, the OHRC Board was presented with a proposal to conduct research in the OHRC stream channels with intent to evaluate the effectiveness of two salmon egg incubation devices: in-stream hatchboxes and streamside incubators. Both of these devices are designed to incubate artificially fertilized salmon eggs (embryos) in the field, with less influence from the hatchery environment over development. Consequently, salmon and steelhead produced with in-stream hatchboxes or streamside incubators could be expected to exhibit more "wild-like" characteristics than fish produced with traditional hatchery methods. The research proposal received favorable reviews from OHRC Board members and was subsequently approved by the Center Director and ODFW Fish Division. The project was designed by and is led by Dr. Marc Johnson and Meghan Howell (OSU BioResource Research student), with collaboration from Drs. David Noakes and James Peterson. OHRC staff actively assisted with preparation and setup of the study in all four OHRC stream channels, allowing evaluation of each device in two replicate channels. In 2021, researchers will record the amount of time and cost necessary to produce fish with each device, while testing for the effects of environmental variables (temperature, dissolved oxygen, current flow rate) on hatch success. Results from this research will be presented to ODFW to inform decisions on field applications.

Impact of Research:

Research findings generated through the OHRC and by collaborators are disseminated through peer-reviewed publications in scientific journals, presentations at conferences and symposia and technical reports. Provided, here, is a list of such papers, reports and presentations. Reports and papers published or submitted to peer-reviewed journals in 2020 are indicated in **bold**:

Reports and Journal Publications

Auld H.L., Jacobson D.P., and Banks M.A. Genome wide marker patterns of mate choice in wild and hatchery coho salmon. In revision for *Integrated Organismal Biology*.

Auld, H.L. D.L.G. Noakes & M.A. Banks. 2019. Advancing mate choice studies in salmonids. *Reviews in Fish Biology and Fisheries*. https://link.springer.com/article/10.1007/s11160-019-09551-5

Cogliati, K. M., J. R. Unrein, W. M. Sealey, F. T. Barrows, O. Hakanson, R. Chitwood, D. L. G. Noakes, C. B. Schreck. 2019. Low-Lipid Diets Fed at Reduced Ration: Effects on Growth, Body Composition, and Survival of Juvenile Chinook Salmon. *Journal of Fish & Wildlife Management* 10: 500-509. DOI: 10.3996/062018-JFWM-059.

Cogliati K.M., Herron C.L., Noakes D.L.G., Schreck C.B. 2019. Reduced stress response in juvenile Chinook Salmon reared with structure. *Aquaculture* 504:96-101.

Cogliati, K.M., J. R. Unrein, H. A. Stewart, C. B. Schreck, D. L. G. Noakes. 2018. Egg size and emergence timing affect morphology and behavior in juvenile Chinook Salmon, *Oncorhynchus tshawytscha*. *Ecology and Evolution* 8(1): 778-789.

Cogliati, K. M., Unrein, J.R., Schreck, C.B. and Noakes, D.L., 2019. Rearing environment affects spatial learning in juvenile Chinook salmon *Oncorhynchus tshawytscha*. *Journal of Fish Biology* 95: 870-880.

Cole, K.S., Noakes, D.L., Thompson, N., Blouin, M., Morrison, B., Couture, R.B., O'Neil, J. and Schreck, C.B., 2021. Effects of temperature on sexual development in steelhead, *Oncorhynchus mykiss*. *Environmental Biology of Fishes*, pp. 1-10.

Evans ML, Hard JJ, Black AN, Sard NM, O'Malley KG. 2019. A quantitative genetic analysis of life-history traits and lifetime reproductive success in reintroduced Chinook salmon. *Conservation Genetics* 20, 781-799.

Ford, M., Nichols, K., Waples, R., Anderson, E., Kardos, M., Koch, I., McKinney, G., Miller, M., Myers, J., Naish, K,, Narum, S., O'Malley, K.G., Pearse, D., Seamons, T., Spidle, A., Swanson, P., Thompson, T., Warheit, K., Willis, S. (2020) Reviewing and synthesizing the state of the science regarding associations between adult run timing

and specific genotypes in Chinook salmon and steelhead. Report of a workshop held in Seattle, WA. 27-28 February 2020. 42 pp

Herron C.L., Cogliati K.M., Dolan B., Munakata A., Schreck CB. 2018. Stress up-regulates oxidative burst in juvenile Chinook salmon leukocytes. *Fish & Shellfish Immunology* 80:655-659.

Jensen A., Schreck C.B., Hess J., North J., Bohn S., O'Malley K.G., Peterson J. 2020. Application of genetic stock identification and parentage-based tagging in a mixed-stock recreational Chinook salmon fishery. *North American Journal of Fisheries Management* 41(1): 130-141 https://doi.org/10.1002/nafm.10542

Johnson M.A., Noakes D.L.G., Friesen TA, Dittman AH, Couture RB, Schreck CB, Banner C, May D, Quinn TP. 2019. Growth, survivorship, and juvenile physiology of triploid steelhead (*Oncorhynchus mykiss*). *Fisheries Research* 220. https://doi.org/10.1016/j.fishres.2019.105350

Johnson, M. A., Friesen, T. A., Van Doornik, D. M., Teel, D. J. and Myers, J. M. 2021. Genetic interactions among native and introduced stocks of *Oncorhynchus mykiss* in the upper Willamette River, Oregon. *Conservation Genetics* 22:111-124 https://link.springer.com/article/10.1007/s10592-020-01322-1

Johnson M.A., Friesen T.A., VanDoornik D.M., Teel D.J., Myers J.M.. 2018. Genetic influence from hatchery stocks on upper Willamette River steelhead *Oncorhynchus mykiss*. ODFW Information Report 2018-03, 20 pp.[17]

Johnson, M. A., Spangler, J. Jones, M., Couture, R. B., Noakes, L. G. 2020. Angler harvest of Alsea River hatchery winter steelhead: An evaluation of wild broodstock collection techniques. ODFW Information Report no. 2020-05. 43 pp.

Koeberle, A. L., I. Arismendi, W. Crittenden, D. Leer, D. L. G. Noakes. 2020. Fluctuating asymmetry of adult Chinook salmon (*Oncorhynchus tshawytscha*) otoliths from wild and hatchery origins. *Aquatic Ecology* 54:431-446. https://doi.org/10.1007/s10452-019-09733-0

Munakata, A., E. Ogihara, C. B. Schreck, D. L. G. Noakes. 2017. Effects of short term acclimation in cool and warm water and influent water temperatures on temperature selection behavior in juvenile steelhead trout, *Oncorhynchus mykiss*. *Aquaculture 467*: 219 - 224.

[17] All ODFW Information Reports are publicly accessible by query at https://nrimp.dfw.state.or.us/DataClearinghouse/default.aspx?p=149

Naisbett-Jones, L. C., Putman, N. F., Scanlan, M. M., Noakes, D. L., & Lohmann, K. J. (2020). Magnetoreception in fishes: the effect of magnetic pulses on orientation of juvenile Pacific salmon. *Journal of Experimental Biology*, *223*(10)

O Malley KG, Van Dyke D, Samarin PA, Bohn S. 2019. Evaluating the genetics of Rogue River Chinook salmon. Technical Report to the U.S. Army Corps of Engineers.

O'Malley, K.G., Bohn, S., Whitman, L., Lewis, M. 2020. Genetic analysis of Chinook salmon in the Clackamas Basin, 2015-2018. Information Report 2020-04. Oregon Department of Fish and Wildlife, Salem. 20pp.

O'Malley, K.G., Mazur, S., Green, L.J., Bohn, S., Wells, A. 2020. Evaluating the genetics of naturally produced Chinook salmon in the lower Rogue River fishery. Information Report 2020-02. Oregon Department of Fish and Wildlife, Salem. 11 pp.

O'Malley, K.G., Van Dyke, D., Samarin, P.A., Bohn, S., Clements, S. 2020. An evaluation of "early" and "late" run alleles in Rogue River Chinook salmon (*Oncorhynchus tshawytscha*). Information Report 2020-06. Oregon Department of Fish and Wildlife, Salem. 24 pp.

Pollock, A. M., Kamran, M., Dittman, A. H., Johnson, M. A., & Noakes, D. L. 2020. Within-river straying: sex and size influence recovery location of hatchery Chinook salmon (*Oncorhynchus tshawytscha*). Canadian Journal of Fisheries and Aquatic Sciences 77(2), 226-235. https://cdnsciencepub.com/doi/pdf/10.1139/cjfas-2018-0384

Putman, N. F., H. Ueda, D. L. G. Noakes. 2019. The current status of research on geomagnetic navigation in Pacific salmon. *North Pacific Anadromous Fish Commission Technical Report* 15: 1–5.

Putman, N.F., M. M. Scanlan, A. M. Pollock, J. P. O'Neil, R. B. Couture, J. S. Stoner, T. P. Quinn, K. J. Lohmann, D. L. G. Noakes. 2018. Geomagnetic field influences upward movement of young Chinook salmon emerging from nests. *Biology Letters 14*(2): 20170752

Scanlan, M., N. F. Putman, A. M. Pollock, D. L. G. Noakes 2018. Magnetic map in nonanadromous Atlantic salmon. *Proc. Nat. Acad. Sci.* www.pnas.org/cgi/doi/10.1073/pnas.1807705115

Self, K. E., C. B. Schreck, K. M. Cogliati, E. J. Billman, D. L. G. Noakes. 2018. Egg size and growth in steelhead *Oncorhynchus mykiss*. *Journal of Fish Biology* 93(3): 465 – 468.

Self, K. E., C. B. Schreck, K. M. Cogliati, E. J. Billman, D. L. G. Noakes. 2018. The effect of rearing structures on behaviour and movement of juvenile steelhead *Oncorhynchus mykiss*. *Journal of Fish Biology* 93(3): 449 – 454.

Stewart, H.A., K. M. Cogliati, E. J. Billman, R. Chitwood, J. R. Unrein, D. L. G. Noakes, C. B. Schreck. 2017. Effects of transportation timing on osmoregulation and survival in yearling hatchery Chinook salmon (*Oncorhynchus tshawytscha*). *Journal of Applied Aquaculture 29*(3-4): 277-290.

Thompson N.F., Blouin M.S. 2016. Family dominance level measured during the fry stage weakly influences family length at smolting in hatchery reared steelhead (*Oncorhynchus mykiss*). *Transactions of the American Fisheries Society* 145: 1282-1289.

Thompson, N.F., M.S. Blouin. 2015. The effects of high rearing density on the potential for domestication selection in hatchery culture of steelhead (*Oncorhynchus mykiss*). *Canadian Journal of Fisheries and Aquatic Sciences* 72:1-6.

Thompson, N.F., B.Clemens, L.Ketchum, P.Simpson, R. Reagan, and M.S. Blouin. 2018. Family influence on length at release and size-biased survival post release in hatchery-reared steelhead: a mechanism to explain how domestication occurs. *Aquaculture* 491:135-146

Unrein, J.R., E. J. Billman, K. M. Cogliati, R. Chitwood, D. L. G. Noakes, C. B. Schreck. 2018. Vertical self-sorting behavior in juvenile Chinook salmon (*Oncorhynchus tshawytscha*): evidence for family differences and variation in growth and morphology. *Environmental Biology of Fishes*, 101(2): 341-353.

Vaux, F., Bohn, S., Hyde, J.R., O'Malley, K.G. 2021. Adaptive markers distinguish North and South Pacific Albacore amid low population differentiation. *Evolutionary Applications*. https://doi.org/10.1111/eva.13202

Whitmore, M., Richardson, S., Huff, A., Goodson, K., Quinn, T. P., Dittman, A. H., Johnson, M. A., Kamran, M., Noakes, D. L. G. *In Review*. Homeward bound: In-river movements of adult hatchery- and natural-origin Chinook Salmon in the Elk River, Oregon. *North American Journal of Fisheries Management*

Presentations at Research Conferences and Meetings

Auld, H.L., D.P. Jacobson, A.C. Rhodes, M.A. Banks. 2019. Mate choice of hatchery and wild coho salmon. Behaviour. Chicago, Illinois, USA.

Auld, H.L., D.P. Jacobson, A.C. Rhodes, M.A. Banks. 2019. Mate choice of hatchery and wild coho salmon. Oregon Chapter of the American Fisheries Society. Bend, Oregon, USA.

Auld, H.L., D.P. Jacobson, M.A. Banks. 2019. Mate choice of hatchery and wild coho salmon. Canadian Conference for Fisheries Research. London, Ontario, Canada.

Bohn S, Whitman L, Cannon B, Hart S, Lewis M, O'Malley KG. American Fisheries Society, "Use of neutral and adaptive (Greb1L) genetic markers to discriminate spring and fall

Chinook salmon across time and space in the Sandy River, Oregon, USA," Reno, Nevada. (2019). Oral Presentation.

Hakason, O., Cogliati, K.M., Noakes, D.L.G., Schreck, C.B. 2020. Conceptual decision making model for artificial rearing of fish intended for use in passage studies. OR Chapter American Fisheries Society, Bend, OR.

Johnson, M. A. Fishing for the next generation: the value of angler-assisted broodstock collection programs. Webinar presentation to ODFW managers and staff, December 2, 2020.

Johnson, M. A. Managing genetic risk from hatchery salmon. Oral presentation at Public Outreach Event, Port Orford, October 24, 2019

Johnson, M.A., Spangler, J.J., Couture, R.B., Noakes, D.L.G. Can angler-caught brood improve catch rates in steelhead fisheries? Results from a genetic tagging study on Oregon's Alsea River. Oral presentation at the Annual Meeting for the Oregon Chapter of American Fisheries Society, Bend, Oregon, March 4-8, 2019

Kamran, M. "Olfactory imprinting". Oral presentation at Public Outreach Event, Port Orford, October 24, 2019.

Kamran, M. "Olfactory imprinting and homing in Pacific salmon". Oral presentation for the Confederated Tribes of Warm Springs at the Warm Springs National Fish Hatchery, May 22-23, 2019.

Kamran, M., M. M. Pollock, A. H. Dittman, M. A. Johnson, and D. L. G. Noakes. "Use of olfactory learning and conditioning assays to select odorants for olfactory imprinting to improve homing in Pacific salmon". Oral Presentation at the Gordon Research Seminar, Movement Ecology of Animals, March 2-3, 2019 in Lucca, Italy.

Kamran, M., M. M. Pollock, A. H. Dittman, M. A. Johnson, and D. L. G. Noakes. "Using behavioral assays to select odorants for olfactory imprinting to improve homing in Pacific salmon". Poster Presentation at the Gordon Research Conference, Movement Ecology of Animals, March 3-8, 2019 in Lucca, Italy.

Kamran, M., M. M. Pollock, A. H. Dittman, M. A. Johnson, and D. L. G. Noakes. "Smells like home: Use of behavioral assays to select odorants for olfactory imprinting to improve homing in Pacific salmon". Oral Presentation at the Society of Integrative and Biology Annual meeting, January 3-7, 2019 in Tampa, Florida.

Krajcik, J. "Salmon research at the Oregon Hatchery Research Center". Nortwest Fish Culture Concepts Meeting, held December 4th, 2019 in Victoria, British Columbia.

O'Malley, K.G. 2020. *Greb1L* variation in Chinook salmon from the Sandy and Rogue Rivers. Genomics Workshop: Reviewing and synthesizing the state of the science regarding associations between adult run timing and specific genotypes in Chinook salmon and steelhead. NOAA Northwest Fisheries Science Center. Seattle, Washington.

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

Research Workshops

In 2020, the OHRC suspended its series of Research Workshops due to challenges and restrictions associated with the COVID-19 pandemic. Prior to this year, OHRC researchers and staff have regularly participated in local, regional, national and international scientific meetings, and there is every expectation that these activities will resume when travel and meeting restrictions are safely lifted.

OHRC Mission Goal 3: Education and Outreach

In-person outreach and education opportunities were restricted in 2020 due to COVID-19 safety measures. The OHRC facility was mandatorily closed to the public and staff did not host tours or offer onsite classes as done in past years. The 2020 Fall Festival was also canceled due to COVID-19 safety measures.

In 2020, OHRC staff worked to develop video content that could be shared with local schools and teachers. They developed a dissection tutorial, a spawning lesson, and a virtual facility tour. OHRC Facilities Manager, Jen Krajcik, delivered presentations to the Oregon Coast Community College's Aquarium Science program, and to Hatfield Marine Science Center's "Growing in Engineering, Math and Science" webinar series. The OHRC staff also built and installed a small kiosk along the road passing by the OHRC, where the public could safely receive copies of fishing regulations, pamphlets and other informational material. The OHRC anticipates a return to in-person education and outreach with reductions to COVID-19 risk.


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