Oregon Hatchery Research Center
2014 Annual Report

To:

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

By:

Oregon Hatchery Research Center Board

February 1, 2015

Executive Summary

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

- Adoption of an Oregon Hatchery Research Center (OHRC) Research Plan;
- Research activities conducted in 2014 by the OHRC and collaborators in relationship to the mission and goals for the OHRC;
- Activities of the Board in 2014 and the focus for the Board in 2015; and
- Appointment of replacement board members by the ODFW Director.

Introduction:

With the passage of House Bill 3441 (see Appendix 1) by the 2013 Oregon Legislative Assembly and the signature by Governor Kitzhaber, the Oregon Department of Fish and Wildlife and Oregon State University began a new chapter in the operation of the Oregon Hatchery Research Center (OHRC). As outlined in HB 3441, the newly formed Oregon Hatchery Research Center Board (Board) is directed to report to the Legislative Assembly, the State Fish and Wildlife Director (Director) and the State Fish and Wildlife Commission on or before February 1 of each calendar year on "the findings of research projects carried out by the Oregon Hatchery Research Center and any recommendations regarding current hatchery management practices based on the research projects."

This report constitutes the second 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 Board to date, provide the Research Plan for the OHRC adopted by the Board in 2014, and research findings and recommendations from research conducted at the OHRC in 2014.

Formation of the OHRC Board:

Per the direction in HB 3441 for establishing the OHRC Board, the Oregon Department of Fish and Wildlife 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

Table 1 identifies the current board members and their designated terms. The Board is currently led by Cam Parry as the Board chair and Scott Starkey and Lindsay Ball as the vice-chairs.

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

Position	Member	Term
Oregon Salmon Commission	Mark Newell	07/01/17
Columbia River Gillnet	Gary Soderstrom	07/01/16

Wild Fish	Peter Tronquet	07/01/15
Wild Fish	Kyle Smith	07/01/17
Sport Angler	Jack Smith	07/01/15
Sport Angler	Lindsay Ball	07/01/17
Agriculture	Les Perkins	07/01/16
Ports	Chuck Pavlik	07/01/16
Forestry	Scott Starkey	07/01/15
Independent Science	Vacant	07/01/17
Habitat Restoration	Cam Perry	07/01/15
Tribes	Stan van de Wetering	07/01/16
Federal	Craig Busack	Indefinite, non-voting
OSU	Carl Schreck	Indefinite, non-voting
ODFW	Bruce McIntosh	Indefinite, non-voting

OHRC Board Resignations:

At the November 19, 2014 OHRC Board meeting, the Board was informed of two board member's resignations. Jim Lichatowich and Darus Peake both resigned due to other commitments. The Oregon Salmon Commission nominated Mark Newell to replace their representative (Darus Peake). Mr. Newell began his board membership at the January 13, 2015 Board meeting.

Recruitment for a replacement to fill the independent scientific community position formerly held by Mr. Lichatowich was announced on November 24, 2014. The recruitment period was extended through January 20, 2015 in order to allow more candidates to apply. The ODFW Director is reviewing the applications received and will promptly appoint a replacement to complete this position's term.

OHRC Board Activities in 2014:

The OHRC Board chair and vice-chairs presented the Board's 2013 annual report to the Oregon House of Representatives Interim Committee on Agriculture and Natural Resources on February 27, 2014. The formation of the Board and revisions to the OHRC Mission Statement were presented along with a summary of activities conducted with OHRC participation during 2013. The Board chairs also presented the framework for an OHRC Research Plan which would focus on priority hatchery research for the OHRC to conduct.

The OHRC Board met by phone on March 11, 2014. The Board chair and vice-chairs briefed the Board on their presentation to the House Interim Committee on Agriculture and Natural Resources. The chairs conveyed that the presentation was well received and that there was general support for finding funding for the OHRC Research Plan. The chairs also announced that the Coastal Caucus was interested in touring the OHRC facility – possibly in May. The Board decided to go forward with their April meeting with a focus on program priorities and outreach efforts. See the following link for board meeting minutes (http://www.dfw.state.or.us/fish/OHRC/minutes.asp).

The OHRC Board met on April 22, 2014 at the ODFW Headquarters Office in Salem, Oregon. At this board meeting, the Board discussed refinements to the research proposals they plan to submit for funding consideration by the Oregon Legislature and other funding entities. Those three projects focus on mate selection (Dr. Michael Banks, OSU), the mechanisms driving domestication efforts (Dr. Michael

Blouin, OSU) in the hatchery, and factors that influence homing in salmon (Dr. David Noakes, OSU). The Board also discussed long term planning and identified timelines, benchmarks, and study direction that would advance the mission of the OHRC. Dr. David Noakes gave the Board an update on the Alsea River Steelhead Angler Harvest Program. The ODFW Western Oregon Research and Monitoring Program Manager presented to the Board an overview of ODFW's Western Oregon fish monitoring programs. ODFW staff and a representative of the Cow Creek Tribe gave a presentation on a project they are doing in the North and South Umpqua with imprinting of hatchery winter steelhead, and ODFW STEP staff from the North Coast Watershed gave a presentation on the North Fork Nehalem Winter Steelhead Telemetry project. See the following link for Board agenda and minutes (http://www.dfw.state.or.us/fish/OHRC/minutes.asp).

The Board met again on May 27, 2014 at the Oregon Hatchery Research Center in Alsea, Oregon. At this board meeting, the Board was given an overview of ODFW hatchery programs and an update on ODFW's budget process. The Board discussed a draft OHRC Research Plan which outlined priority research areas and how they apply to the goals of the OHRC mission. See the following link for board agenda and minutes (http://www.dfw.state.or.us/fish/OHRC/minutes.asp).

On June 27, 2014, the Coastal Caucus visited the OHRC, and several Board members along with Dr. David Noakes (OHRC Director) led a tour of the facility and provided a description of the OHRC Research Plan.

The Board met by conference call on July 8, 2014 to review and discuss revisions to the OHRC Research Plan. See the following link for board agenda and minutes (http://www.dfw.state.or.us/fish/OHRC/minutes.asp).

The Board met again on November 19, 2014 at the OHRC in Alsea, Oregon. The Board reviewed and approved the OHRC Research Plan and were provided an "Introduction to Fish Genetics" presentation by Dr. Marc Johnson of ODFW. ODFW staff updated the Board on the ODFW budget process and timeline. See the following link for board agenda and minutes (http://www.dfw.state.or.us/fish/OHRC/minutes.asp).

The final meeting of the Board prior to completion of this annual report occurred on January 13, 2015 at the OHRC. The Board reviewed and approved the draft of this report, as well as the flow charts describing the three proposed research projects within the Research Plan. The Board also discussed and approved the areas within which they would focus their efforts in 2015. The Board also heard a presentation from the Nature Conservancy and the Beaver Slough Drainage District on the process to develop a cooperative agreement to replace tidegates in the upper tidal area of the Coquille River and how to operate the tidegates to minimize negative impacts to landowners whose lands are influenced by the tidegates while also maximizing benefits to fish and wildlife.

OHRC Board Focus in 2015:

Based on discussions at the January 13, 2015 Board meeting, the OHRC Board will focus its efforts in 2015 in the following areas:

- Work with ODFW, OSU and the Oregon Legislature to secure funding for the OHRC Board's Research Plan (Appendix 2);
- Implement a focused outreach strategy to better inform the fishing community, the general public, public officials and other interested parties on how the OHRC is working to address their mission; and

- Advising ODFW, OSU and the OHRC Director on priorities and research implementation at the OHRC.

OHRC Activity Report 2014:

Overview

The OHRC addressed our Mission, as approved by the OHRC Advisory Board through activities listed here, and provided in greater detail later in Appendix 3 to this Report. We addressed our Mission in 2014 with a number of Research Projects, Research Workshops, Educational Projects and Outreach Activities. This involved active research collaboration with colleagues from the Oregon Department of Fish and Wildlife, the Oregon State University, the University of Oregon, the US Geological Survey, the US Fish and Wildlife Service, NOAA Fisheries, the University of Hawai'i, the University of North Carolina, the University of Washington – Seattle, the Makah Tribal Fisheries, and the University of California – Davis. Several postgraduate students, postdoctoral research scholars and technical staff, supported by external funding, have contributed to these efforts as well. Drs. Michael Banks, Michael Blouin, Kathleen O'Malley, Andy Dittman, Jessica Miller, Tom Quinn, Ken Lohmann, Kathleen Cole, Ben Clemens, Jason Dunham and Marc Johnson are the principal collaborators on these research projects. We attracted about $1.3 million for educational and research activities in 2014 with numerous collaborators at the OHRC from a variety of sources, including the National Science Foundation, the Bonneville Power Administration, the US Army Corp of Engineers, Oregon Sea Grant and international funding sources. Results of our activities were reported to the OHRC Board, to ODFW, to local, regional, national and international meetings and were published in the primary scientific literature.

OHRC Mission

The first goal in our Mission is 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.

We have addressed these questions with the following research projects in 2014:

1.a. Domestication selection (steelhead) – Blouin, Noakes
1.a., b. Non-genetic influences on early growth and development (Chinook, steelhead) – Schreck, Noakes
1.b. Effect of climate change on development and sex change (steelhead) – Cole, Schreck, Noakes, Blouin
1.b. Steelhead wild surrogates – Schreck, Noakes
1.b. Chinook wild surrogates – Schreck, Noakes
1.b. Behavior and survival of hatchery and wild steelhead smolts – Schreck, Noakes
1.c. Alsea steelhead population genetics – Banks, O'Malley, Noakes
1.c. Outplanting and angler harvest of Alsea River steelhead – OHRC, ODFW
1.c. Homing and straying in Chinook and steelhead – Noakes, Blouin, Quinn, Klimley, Schreck

The second goal in our Mission is:

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.

We have addressed these questions with the following research projects in 2014:

2.a.1. Predators and predation on hatchery and wild juveniles (steelhead, coho)– Dunham, Noakes
2.a.1.2., 2.b. Alsea steelhead angler harvest – ODFW, OHRC, Noakes, Alsea Steelhead Anglers
2.b. Mate choice – O'Malley, Banks
2.b., c. Behavior of triploid steelhead – spawning competition - OHRC
2.b.,d. Sterile triploids - homing and straying (steelhead) – Johnson, Dittman
2.d. Olfactory imprinting and homing (Chinook, steelhead)– Dittman, ODFW, OHRC, Noakes
2.d. Geomagnetic imprinting and navigation (Chinook, steelhead) – Noakes, Quinn, Klimley
2.d. Life cycle monitoring (steelhead) – Clemens, ODFW, Noakes, Schreck

The third goal in our Mission is to:

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 Oregonians 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.

We continued activity in Education and Outreach and Research Workshops based on both applied and basic Research at the OHRC. We maintained active educational programs at every level from kindergarten to post graduate university students. We hosted Research Workshops for ODFW, university personnel, tribal band members, private consultants, stakeholders and members of the general public. We published and distributed information about our activities on our website, through local newsletters and brochures, and in books and journals in the primary scientific literature. In particular, in 2014 we contributed a series of invited articles to the Alsea Valley Voice, a local newsletter, to describe our research, education and outreach activities. We attracted collaborators, including many students, from around Oregon, across the USA, Canada, China, Japan, Korea, Iceland, Norway, Sweden and the Netherlands.

The OHRC continued our activities during 2014 at an increased pace over previous years. We hosted school visits to the OHRC, participated in teacher training, school visits and coordinated professional activities with students and teachers. We provided educational activities and opportunities at every level from kindergarten to postgraduate university students.

OHRC personnel participated in numerous outreach activities with the local community, ODFW staff, and colleagues from universities and research organizations across Oregon, throughout the USA, Canada, Korea, China, Japan, Iceland, Norway, France and the Netherlands. We hosted visiting researchers, university and school groups, as well as making visits and invited presentations to services clubs, angler organizations and to educational institutions. We participated in local, regional, national and international research meetings where we presented results of OHRC educational and research activities.

We continued to host a regular series of OHRC Research Workshops on selected topics, ranging from fish genetics to fish nutrition, Chinook salmon conservation, lamprey management and otolith research. Each Workshop attracted a capacity attendance (55 people) from ODFW, tribal bands, private consultants, universities, commercial and recreational fishers and other stakeholder groups as well as the general public. Reports of our Workshops are submitted to ODFW, and distributed to all interested individuals electronically via the Oregon State University web site. Most Workshops lead to funding applications for new research projects. We remain active in publishing the results of our research in a number of international scientific journals and printed books as well as electronic reports. Dr. Noakes continues as Editor-in-Chief of the international journal, Environmental Biology of Fishes, and the monograph series, Fish and Fisheries, both published by Springer Academic Publishers.

Funding

Operations: The OHRC received a biennial operating budget of approximately $1 million from the Oregon Department of Fish and Wildlife for 2014. That was supplemented by funds provided by the Fisheries and Wildlife Department of Oregon State University, through a Memorandum of Understanding with the ODFW.

Research: We brought in about $1.3 million in research activity to the OHRC in 2014, 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 budget sources (personnel, facilities, operations). The number of research projects continued to grow, with 13 active projects in 2014 (listed in detail). Funding for OHRC activities came from a number of sources. The major operational funding was the biennial budget allocation from ODFW, with contributions from OSU. That funding supported a number of projects at the OHRC, including: Olfactory Imprinting, Temperature and Sex Change, Wild Broodstock, Steelhead Smolt Survival, and Otolith Marking. We also received specific funding for individual projects: US Army Corps of Engineers (Chinook and steelhead surrogates), Noakes & Schreck – Steelhead surrogates ($187,000 year 2 of 3 years); Noakes & Schreck – Chinook surrogates - $320,000 year 3 of 3); Noakes – Oregon Sea Grant – geomagnetic orientation in salmonid fishes – no cost extension (year 3) - $37,000. In addition, a number of collaborators brought their own funding for research projects at the OHRC: Dr. Desiree Tullos – NSF, Dr. Arimune Munakata – JSPS, Dr. Michael Blouin – BPA, Dr. Kathleen Cole – University of Hawaii, Dr. Michael Banks – COMES, Dr. Marc Johnson – ODFW. We also supported a number of our graduate students with individual awards to them as fellowships and scholarships. Many of our postgraduate students are supported by Graduate Teaching Assistantships from Oregon State University, and some have scholarships or other financial awards from a variety of sources.

Education and Outreach: We have been the principal partner with the Lincoln County and Tillamook County School Districts in the OCAMP and Oregon Coast STEM Project. The Oregon Coast STEM Center project received funding for Lincoln County & Tillamook County School Districts (Dr. Noakes is a Co-PI on this project with Ruth McDonald and others; $210,000 per year; 2 years; total awarded $1.3 million over most recent 6 years for OCAMP, STEM). Dr. Noakes and Ruth McDonald were Co-PIs for a recent successful submission to the Oregon Department of Education to fund the Oregon Coast STEM HUB Center (20 partners with the two School Districts; $644,000) for 2013 - 2014.

The OHRC also hosts an annual Free Fishing Day in June each year, and a Fall Festival in November. On those occasions we are open to the public and host 200 – 300 people, including many families. In 2014 we organized and hosted an international research conference (Ecology, Ethology and Evolution of Fishes) at Oregon State University that included delegates from across North America, Japan, Brazil, and Europe.

Management Recommendations in 2014 Based on OHRC Research Findings

Most of the research that the OHRC collaborated with in 2014 provided insights into the mechanisms that may be important for effective hatchery program management. While most of these insights suggested areas for further research, some results were shared with ODFW hatchery managers for their consideration.

The results from the olfactory imprinting study showing that juvenile salmon imprint on their natal water as they hatch and that young juveniles cannot imprint on well water was shared with hatchery managers. ODFW managers will consider this information and potentially modify incubation practices using well water to improve homing back to the hatchery. Research is identified in the OHRC Research Plan to determine how important this early imprinting is to the overall homing of returning adults.

Some of the results of the geomagnetism study were shared with hatchery managers for their consideration. While the results showed that fish raised in ponds with metal in the structure had difficulty orienting themselves to their current geographic location, more research is needed to

determine if the magnetic fields produced by the metal actually interfere with the fish's ability to home back to the hatchery. Changes to hatchery infrastructure are not planned at this time, pending the results of future research on this topic.

Appendix 1: Oregon House Bill 3441

Enrolled
House Bill 3441

Sponsored by Representative KRIEGER, Senator ROBLAN, Representative WITT; Representatives BARKER, BARTON, BENTZ, BERGER, BOONE, CAMERON, CLEM, CONGER, ESQUIVEL, FREEMAN, GARRETT, GILLIAM, GOMBERG, HANNA, HICKS, HOLVEY, HOYLE, HUFFMAN, JENSON, JOHNSON, KENNEMER, MATTHEWS, MCKEOWN, MCLANE, OLSON, PARRISH, RICHARDSON, SMITH, SPRENGER, THOMPSON, UNGER, WEIDNER, WHISNANT, WHITSETT, WILLIAMSON, Senators BAERTSCHIGER JR, BOQUIST, BURDICK, GEORGE, GIROD, HANSELL, JOHNSON, KRUSE, OLSEN, PROZANSKI, STARR, THOMSEN, WHITSETT

CHAPTER .....

AN ACT

Relating to the hatchery research center near Alsea; and declaring an emergency.

Be It Enacted by the People of the State of Oregon:

OREGON HATCHERY RESEARCH CENTER BOARD

SECTION 1. Establishment of Oregon Hatchery Research Center Board. (1) There is established the Oregon Hatchery Research Center Board within the State Department of Fish and Wildlife. The board shall consist of 15 members, including 12 voting members appointed by the State Fish and Wildlife Director under subsection (2) of this section and three non-voting members specified in subsection (3) of this section. Members of the board must be residents of this state who are well informed on matters related to fish management policy and scientific research and who demonstrate an interest in research related to the propagation of fish in hatcheries.

(2) The 12 voting members appointed by the director shall be representative of each of the following interests:

(a) One member shall represent the Oregon Salmon Commission established under ORS 576.062.

(b) One member shall represent the Columbia River gillnet salmon fishery established under ORS 508.775 to 508.796.

(c) Two members shall represent wild fish advocacy organizations.

(d) Two members shall represent statewide sport angling organizations.

(e) One member shall represent the agricultural industry.

(f) One member shall represent coastal ports.

(g) One member shall represent the forest products industry.

(h) One member shall represent the independent scientific community and have scientific background related to fish management and the propagation of fish in hatcheries.

(i) One member shall represent fish habitat restoration interests and have experience in the management or implementation of habitat restoration projects.

(j) One member shall represent Oregon Indian tribes, to be appointed by the director after consultation with the Commission on Indian Services.

(3) In addition to the members appointed under subsection (2) of this section, the director shall:

(a) Appoint the following two nonvoting members of the board who have a background in fish management and the propagation of fish in hatcheries:

(A) One member to represent the State Department of Fish and Wildlife.

(B) One member to represent Oregon State University.

(b) Invite a representative of agencies of the federal government related to fish management to serve as a nonvoting member of the board.

(4) The term of office of each member is four years, but a member serves at the pleasure of the director. Before the expiration of the term of a member, the director shall appoint a successor

whose term begins on July 1 next following. A member is eligible for reappointment. If there is a vacancy for any cause, the director shall make an appointment to become immediately effective for the unexpired term.

(5) A member of the board is not entitled to compensation under ORS 292.495. At the discretion of the board, board members may be reimbursed from funds available to the board for actual and necessary travel and other expenses incurred by members of the board in the performance of their official duties, subject to the limits described in ORS 292.495.

SECTION 2. Initial terms of office. (1) Notwithstanding the term of office specified in section 1 of this 2013 Act, of the members first appointed to the Oregon Hatchery Research Center Board pursuant to section 1 (2) of this 2013 Act:

(a) Four shall serve for a term ending July 1, 2015.

(b) Four shall serve for a term ending July 1, 2016.

(c) Four shall serve for a term ending July 1, 2017.

(2) The State Fish and Wildlife Director shall designate the positions of members first appointed to the Oregon Hatchery Research Center Board who are subject to the terms of office described in subsection (1) of this section.

SECTION 3. Duties of Oregon Hatchery Research Center Board. The Oregon Hatchery Research Center Board shall report to the Director of the Oregon Hatchery Research Center and shall:

(1) Establish strategic directions and operational objectives for the Oregon Hatchery Research Center located on Fall Creek, near Alsea, consistent with ORS 496.275.

(2) Develop, after consultation with the Director of the Oregon Hatchery Research Center, Oregon State University and the State Department of Fish and Wildlife, the proposed operating budget for the center.

(3) Recommend research projects for the Oregon Hatchery Research Center and issue requests for research proposals as needed to carry out the activities of the Oregon Hatchery Research Center specified in section 5 of this 2013 Act.

(4) Review and prioritize all research proposals submitted to the Oregon Hatchery Research Center before research takes place and prioritize the research according to whether the research is consistent with the strategic directions and operational objectives specified in subsection (1) of this section and with the activities of the Oregon Hatchery Research Center specified in section 5 of this 2013 Act.

(5) Make recommendations, as needed, regarding how the research projects at the Oregon Hatchery Research Center may be enhanced to meet the strategic directions and operational objectives specified in subsection (1) of this section and the activities specified in section 5 of this 2013 Act.

(6) On or before February 1 of each calendar year, report to the Legislative Assembly in the manner required by ORS 192.245, and to the State Fish and Wildlife Director and the State Fish and Wildlife Commission, regarding the findings of research projects carried out by the Oregon Hatchery Research Center and any recommendations regarding current hatchery management practices based on the research projects. The Director of the Oregon Hatchery Research Center shall post the report on the center's website for public access.

SECTION 4. Officers, quorum and meetings. (1) The Oregon Hatchery Research Center Board shall select one of its members as chairperson and another as vice-chairperson, for such terms and with duties and powers necessary for the performance of the functions of such offices as the board determines.

(2) A majority of the voting members of the board constitutes a quorum for the transaction of business.

(3) The board shall meet at least once every three months at a place, day and hour determined by the board. The board may also meet at other times and places specified by the call of the chairperson or of a majority of the members of the board.

OREGON HATCHERY RESEARCH CENTER

SECTION 5. (1) The hatchery research center located on Fall Creek, near Alsea, is named the Oregon Hatchery Research Center.

(2) Pursuant to the strategic directions and operation objectives established by the Oregon Hatchery Research Center Board under section 3 of this 2013 Act, the center shall carry out the following activities:

(a) Conduct research that assists in the implementation and advancement of native fish population recovery as well as viable fisheries.

(b) Conduct research on methods to minimize the genetic and ecological risks to naturally produced native fish when hatchery produced fish are released in the waters of this state for population recovery or consumptive fishery objectives.

(c) Conduct research to determine the genetic and ecological risk to naturally produced native fish when wild native broodstock hatchery produced native fish are released into the waters of this state.

(d) Conduct research to determine the effect of hatchery operations on naturally produced native fish and the habitat of naturally produced native fish.

(e) Provide educational and research opportunities for undergraduate students, graduate students and post-graduate students.

(f) Provide educational opportunities for the public and for students in grades 1 through 12.

(g) Consider any recommendations made by the Oregon Hatchery Research Center Board pursuant to section 3 of this 2013 Act.

(3) The Director of the Oregon Hatchery Research Center shall post information about the research specified in subsection (2) of this section on the center's website for public access.

(4) As used in this section, "waters of this state" has the meaning given that term in ORS 196.800.

SECTION 6. Director. The State Fish and Wildlife Director, after consultation with the chairperson of a department related to fish and wildlife at Oregon State University and the Oregon Hatchery Research Center Board established under section 1 of this 2013 Act, shall appoint a Director of the Oregon Hatchery Research Center.

MISCELLANEOUS

SECTION 7. (1) Subject to subsection (2) of this section, no later than January 1, 2014, and in order to carry out the activities of the Oregon Hatchery Research Center specified in section 5 of this 2013 Act, the State Department of Fish and Wildlife shall, after consultation with the Oregon Hatchery Research Center Board established under section 1 of this 2013 Act, renegotiate any agreement entered into between the State Board of Higher Education and the State Department of Fish and Wildlife related to the Oregon Hatchery Research Center.

(2) Any agreement entered into between the State Board of Higher Education and the State Department of Fish and Wildlife related to advisory committees for the Oregon Hatchery Research Center is terminated on the effective date of this 2013 Act and any advisory committees cease to exist.

SECTION 8. The State Fish and Wildlife Director shall make the appointments, and extend the invitation, specified in section 1 of this 2013 Act related to members of the Oregon Hatchery Research Center Board no later than January 1, 2014.

SECTION 9. The unit and section captions used in this 2013 Act are provided only for the convenience of the reader and do not become part of the statutory law of this state or express any legislative intent in the enactment of this 2013 Act.

EMERGENCY CLAUSE

SECTION 10. This 2013 Act being necessary for the immediate preservation of the public peace, health and safety, an emergency is declared to exist, and this 2013 Act takes effect on its passage.

Appendix 2: OHRC Research Plan

OHRC Research Plan

November 2014

Introduction

The use of hatchery fish to provide fish for fisheries has been practiced in Oregon since the late 1800's. Hatchery salmon and steelhead programs in place today are vital to many Oregon fisheries and have helped restore and maintain natural production in some areas. Research over the last three decades has increasingly indicated that hatchery fish can also be detrimental to wild fish productivity. The challenge for today's fishery managers is how to appropriately manage hatchery salmon and steelhead programs to provide the benefits they provide while also ensuring they have minimal negative impact to the wild populations they interact with.

The Oregon Hatchery Research Center (OHRC) opened in October 2005 with the express purpose of helping fishery managers understand and manage the interactions between hatchery and wild fish. The current OHRC Mission 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." To achieve this mission, three goals guide the center's work:

1. Understand mechanisms that may create differences between hatchery and wild fish
2. Develop approaches to manage hatchery fish that conserve and protect native fish
3. 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.

The OHRC is an Oregon Department of Fish and Wildlife (ODFW) facility operated under a Memorandum of Understanding (MOU) between ODFW and the Fisheries and Wildlife Department of Oregon State University (OSU). The OHRC is intended to serve as a clearing house for all research in Oregon related to the interactions between hatchery and wild fish. The facilities at the OHRC have been, and will continue to be used to conduct such research, but may not be the primary location for other related research activities. The OHRC Advisory Board and the scientists associated with the Center will encourage researchers to use the OHRC as a sounding board for research proposals and will seek to collaborate with researchers addressing issues consistent with the OHRC Mission.

Addressing Goal 3 of the OHRC Mission

Information collected in the past from research conducted through the OHRC has been widely disseminated to the scientific community as well as the public, and has been applied to the management and conservation of hatchery and wild fish where appropriate. Numerous peer-reviewed, scientific papers related to research conducted through the OHRC have been published in journals and symposia, and news releases and displays at the OHRC have shared this information with the public. Several changes to hatchery operations have been implemented, or are being considered for implementation based on the outcome of previous OHRC research. These include:

- Changes in how broodstock are held for spawning
- New techniques for producing sterile trout for stocking
- Changes in how jack salmon should be incorporated into broodstocks
- Changes in how hatchery fish are released to avoid predation
- Use of moist air incubators to mark otoliths of young fish
- Confirmation of ODFW standard protocols for minimizing handling stress
- Water used for incubation and rearing salmon and steelhead

The findings of the research proposed in this plan, as with past research, will be shared with the scientific community and the public, as well as incorporated into fish management as appropriate

Proposed Research Plan

In order to address the Center's goals stated above, the OHRC Advisory Board has adopted a research plan focused on three important 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.

The proposed research projects in these three areas are described below. The phases of the research are described in a specific order so that the information gathered will build an understanding of what mechanisms influence the fish and which approaches show the most promise to test in a hatchery production setting.

The three research areas defined below are the areas that ODFW, OSU and the OHRC Advisory Board identified as being the most immediately informative and relevant to understanding and managing the interactions between wild and hatchery fish. This is not to suggest that these are the only areas of research surrounding the interactions of hatchery and wild salmon and steelhead that need to be explored. However, with limited funding, ODFW, OSU and the OHRC Advisory Board have identified the

research areas listed here as top priorities. The OHRC Advisory Board has identified and will encourage and support research into other important areas as proposals are received. Examples of other important research to be conducted include (in no particular order):

- Effects of hatchery rearing on geomagnetic orientation
- Comparative reproductive success (pedigree) study with Coastal Fall Chinook
- Selection for harvest susceptible adult hatchery steelhead
- Behavior of triploid (sterile) salmon and steelhead
- Imprinting fish to remote locations for supplementation

Focused Research Areas

The three areas are categorized based on which OHRC Mission goal it addresses and described in detail with each phase of research identified.

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

Focus Area 1: Differences caused by mate selection

Background

The Calapooya Creek coho pedigree study (Dr. Michael Banks and associates) found that male offspring from wild fish raised in a hatchery were much less successful producing offspring than wild males, even if the fish were released before feeding in the hatchery. Because this loss of reproductive success occurred with very little hatchery intervention (only spawning, egg incubation and fry emergence), the researchers hypothesized that this effect must be due to how spawning occurred in the hatchery versus in the wild. Initial investigations related to this hypothesis suggested that mate selection for disease resistance may play a role in reproductive success (see references 13, 16 below).

Relevance of Strategy

Hatcheries in Oregon randomly mate male and female fish to avoid bias. If offspring survival is tied to successful mate selection in the wild, then being able to understand that selection and mimic it in the hatchery could lead to hatchery fish (with better reproductive success) having a lower risk to wild populations from interbreeding.

This research will help determine if mate selection is important to offspring survival by genomic examination of pairings of wild coho salmon from Calapooya Creek whose success at producing offspring is known. If the analyses demonstrate that most successful matings can be associated with specific genetic combinations observed among most successful mate pairs, then gene markers for relevant traits will be identified and methods to rapidly identify them will be developed. These rapid identification methods will then be applied to mate wild and hatchery fish in a hatchery. Relative reproductive success in the wild of these fish will be compared with reproductive success of normal, random hatchery matings to determine if ‘wild-fish-like’ targeted mating in the hatchery

reduces the loss of reproductive success for hatchery fish, and the impact of current hatchery practice on wild populations. Thus results of this research may lead to new procedures for mating fish in a hatchery program that can reduce the risk hatchery fish have on wild populations.

Phase 1: Extensive Genetic Sampling and Analysis: The first step in this research will be re-sampling all of the successful mate pairings (1,387 total mate pairs) from the Calapooya Creek study and conducting an extensive analysis of the genetic composition of all pairings in the study and determining which genomic combinations were most successful in terms of production of young in the next generation (= reproductive fitness).
Timeline: 3 years, **Cost**: $700K

Phase 2: Application of Research Results: The information from the Phase 1 analyses will be used by ODFW and OSU collaborators to develop rapid, cost effective techniques to identify the important markers for mate selection.
Timeline: 1 year; **Cost**: $200K

Phase 3: Field Testing of 'Wild-like' Mating Practices in Hatcheries: The third step in this research program will be conducted at one or more ODFW hatcheries, in collaboration with the OHRC. The research and hatchery personnel will screen hatchery coho using markers to match fish and compare to normal hatchery mating practices. Smolts produced from mating those selected fish will be released following normal stocking procedures. We will use standard genetic pedigree techniques (as in the Banks study) to determine the reproductive success of the fish from the different mating procedures in the wild.
Timeline: 12 years; **Cost**: $3.7M

Focus Area 2: Differences caused by hatchery rearing

Background

Several studies have found that the offspring of wild salmon and steelhead brought into the hatchery were less successful at producing offspring in the wild than wild fish spawning in the wild (see references 1, 2, 3, 4, 5, 6, 10, 13, 15 below). In the Hood River study with steelhead, the reduced reproductive success was found to be inherited by the offspring, the result of strong trait selection occurring in the hatchery. Further research suggested that high rearing densities may be one factor that imposes strong selection, but the traits under selection and the particular rearing conditions that cause strong selection in hatcheries remain unknown.

Relevance of Strategy

Because the hatchery environment appears to select for traits that cause reduced reproductive success in the wild, it may be possible to alter certain rearing practices to reduce or eliminate the selection pressures, thereby producing hatchery fish that have traits that are more similar to wild fish.

Therefore, the goals are to identify which hatchery practices cause strong selection, and to identify what traits of the fish are under selection.

This research will attempt to determine: (1) the level of selection that occurs under different rearing conditions in the hatchery environment (e.g. different densities), and (2) the traits under selection, in order to better understand the mechanisms that may cause lower reproductive success in the wild.

The performance of offspring from the same set of full-sibling families will be compared when grown together under each environmental condition (families are tagged genetically, so individual identities are known). Here family performance is measured as average size and condition at release.

Firstly, environmental conditions that exacerbate differences among families in performance will be considered less desirable (i.e. because they cause stronger selection among families). Secondly, traits that distinguish high performance families ("winners") from low-performance families ("losers") under the high-selection environments will be examined to determine which traits are likely to be under selection. The genomes of "winners" and "losers" will also be compared to determine which genes appear to be under selection.

The various rearing conditions will be examined to find the most appropriate conditions that minimize selection, but maximize hatchery production. The revised rearing conditions would then be tested with wild steelhead in a production hatchery setting, and the reproductive success of the hatchery fish in the wild would be evaluated with a pedigree study. The results of this research may lead to new procedures for rearing fish in hatcheries that reduce the risk hatchery fish pose (due to lower reproductive success) to wild populations.

Phase 1: Investigation of Trait Selection: Multiple families of steelhead will be reared under different environmental conditions at the OHRC with the same goal for size at smolting. All fish will be associated with their parents/family genetically. At the end of the rearing period all fish will be assessed for size and condition factor. Siblings of those same families will be independently assayed for various candidate traits in order to determine which traits are associated with high *versus* low performance in the hatchery (i.e. "winner" *vs* "loser" families).
Timeline: 2 years; **Cost**: $350K

Phase 2: Identify Genes under Selection: The genomes of the "winner" and "loser" families will be analyzed to look for the genes that appear to be selected for under typical hatchery rearing conditions. These will be the genes that likely lead to lower reproductive success in the wild.
Timeline: 2 years; **Cost**: $250K

Phase 3: Field Testing: Once the traits under selection have been determined and the most appropriate rearing density is identified, researchers will release experimental groups of hatchery fish that have been reared under lower and standard densities. Researchers will then follow those fish with a pedigree study to determine if reproductive success in the wild is improved under the revised hatchery practices.

Timeline: 10 years; **Cost**: $3.1M

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

Focus Area 3: Methods to increase imprinting and homing back to the hatchery

Background

Efforts to reduce the number of hatchery fish that do not return to the hatchery or trap and instead spawn in the wild – defined here as straying – has been identified as a top priority in protecting wild fish (see references 7, 8, 9, 11, 12, 14, 17 below). This issue is a challenge for managing many hatchery programs in Oregon and throughout the Pacific Northwest. Oregon's Coastal Multi-Species Plan (CMP) recently identified a non-viable wild population that is affected by wild spawning hatchery fish, the Elk River Chinook population. The CMP's first priority is to address the non-viability of the wild Chinook population in the Elk River by taking actions to reduce the proportion of spawners that are hatchery fish, as well as addressing habitat improvement. Like most ODFW hatcheries, the Elk River Hatchery utilizes hatchery practices designed to maximize survival of hatchery-reared juveniles, minimize impacts of released juveniles on wild populations and ensure cost-effective operation. In some cases, these well-intentioned practices may contribute to excessive levels of straying, like those observed in the Elk River. Specifically, researchers have identified three hatchery practices at the Elk River Hatchery, commonly utilized at hatcheries throughout the Northwest that may contribute to elevated straying by hatchery fish:

1. Many hatcheries use river water for rearing hatchery Chinook, and it is this same water that is released from the hatchery to attract returning adults into the hatchery trap. This may make it difficult for the returning hatchery fish to differentiate the hatchery from the river itself. The CMP has proposed that the OHRC explore methods to attract more hatchery fish into Elk River Hatchery, including the use of an odorant in the water to give it a distinct scent that would attract more returning hatchery fish to the hatchery trap and keep them from spawning in the wild.
2. Modern hatchery programs are typically designed to attempt to minimize negative ecological interactions between juvenile hatchery and wild salmon. In an effort to minimize ecological overlap between wild and hatchery fall Chinook, the Elk River Hatchery, like several fall Chinook hatcheries in Oregon, typically releases their fish well after wild fish migrate out of the basin. The unintended consequence of these actions may be to increase straying by hatchery fish. The parr-smolt transformation has been identified as a critical period for successful olfactory imprinting and release from the hatchery at inappropriate developmental period before or after smolting can result in elevated stray rates. The third component of this research will

determine whether timing the releases of Elk River fall Chinook to coincide with the normal parr-smolt transformation will improve homing to the Elk River hatchery.

3. In most hatcheries, the need to control embryonic development rate (temperature) and limit exposure to pathogens dictates that salmon are initially reared on ground water. Salmon often return to the vicinity of their natal site, suggesting that in the wild the period of hatching and emergence may be a critical time for olfactory imprinting. Preliminary results from investigations at the OHRC indicated that salmon have an innate preference for stream water over ground water and development of the olfactory system is inhibited in salmon reared in ground water vs. surface water. This research will determine whether exposure to surface water during incubation and early rearing periods will improve homing to the Elk River Hatchery.

Relevance of Strategy

The research necessary to develop methods that may reduce the impact of hatchery fish spawning in the wild, as described in the first two focus areas, will require 15 to 20 years or more to translate into possible hatchery reform actions. In the meantime, short-term strategies need to be developed and tested that can reduce the impact of naturally spawning hatchery fish by removing hatchery fish that are not harvested in fisheries. Improving the ability to remove hatchery fish before spawning in the wild will allow hatchery programs, and the fisheries they support, to continue without jeopardizing the health of wild populations.

This research seeks to increase the homing of hatchery fish back to the hatchery to reduce the negative effects of excessive numbers spawning in the wild, and to better understand the imprinting and homing mechanisms in fish to allow for a broader application to other hatchery programs and situations. Salmon and steelhead use their sense of smell to find their way back to their natal streams which have unique scents. If research can determine how to improve the imprinting of the hatchery scent in juveniles, or create a unique scent for the water coming out of the Elk River Hatchery, and the outcome can significantly increase the number of hatchery fish that swim into the hatchery, the risk to the wild fall Chinook population can be reduced while allowing the same number of hatchery fish to be released if not increased. The results of this research may lead to new procedures for rearing fish in a hatchery program that can reduce the risk hatchery fish have (due to lower reproductive success) on wild populations.

Phase 1: Odorant Selection and Imprinting Effectiveness: Collaborate with NOAA scientist Andrew Dittman (an expert in homing science and fish olfactory systems) to identify the most likely effective scent(s) to incorporate into Elk River Hatchery water.

Researchers will identify and screen a variety of natural compounds released from aquatic plants and organisms and other known fish odorants for

their potential use as artificial imprinting/homing cues and identify the most likely effective scent(s) to incorporate into Elk River Hatchery water. Specifically, a panel of potential odorants will be screened using the criteria listed below:

1) safe for release into natural waters
2) inexpensive and readily available
3) stable for storage and after release into natural waters
4) detected by the salmon olfactory epithelium at relatively low concentrations
5) ideally does not elicit innate behavioral (attraction or avoidance)
6) embryo and juvenile salmon are able to learn and respond behaviorally to the compound.

During this phase, an initial analysis will involve:

1. Literature review, permitting procedures and cost analysis to identify safe and cost-effective candidate odorants for subsequent testing.
2. Complex odors will be chemically analyzed to identify candidate compounds.
3. Screening the pool of candidate odorants for neural response (electro-olfactogram) to establish that they are effective and stable olfactory stimulants for salmon.
4. Y-maze analysis for innate behavioral responses.
5. Odor conditioning experiments to establish odor discrimination and learning.

Timeline: 2 years; **Cost**: $300,000

Phase 2: Verification of Imprinting: Researchers will incubate and rear Chinook salmon at the Elk River Hatchery and OHRC under conditions that vary through:

a. Exposure to one or more water-soluble odorants (e.g. those meeting the criteria above) and;
b. The timing of exposure to the above (exposure beginning at incubation versus exposure beginning at ponding)

Researchers will measure the effect of these treatments on juvenile physiology at life history stages relevant to olfactory imprinting (e.g. post emergence, parr-smolt transformation). These experiments will involve two parallel experimental groups.

1. Elk River Fall Chinook will be reared at the OHRC hatchery under controlled conditions and exposed to specific, known imprinting odorants (e.g. arginine) to assess imprint success and timing using a targeted gene approach. Salmon will be exposed to odors at specific developmental periods and sampled for imprinting success using quantitative PCR assessment of odorant receptor expression and smolting-associated physiology (i.e. ATPase, T4). Fish will be reared and sampled through the normal time of release at Elk River hatchery.

This phase will inform managers about the appropriate times for odor exposure and release at Elk River hatchery (and other hatcheries) to ensure successful imprinting.

2. A second group of Fall Chinook will be reared and exposed to added odors at the Elk River hatchery. These experiments will generate fish that have experienced the normal hatchery water and procedures at Elk River but will not readily allow for a targeted gene approach. Salmon will be sampled less frequently and tissues will be collected for transcriptome and epigenetic analysis of imprinting-associated changes in olfactory function. These tools will also allow for assessing imprint in situ at the Elk River hatchery and development for new markers for imprinting success.
Timeline: 3 years; **Cost**: $700,000

Phase 3: Verification of Homing and Field Testing: Researchers will measure the effect of treatments on adult homing behavior to the hatchery. This will be accomplished by releasing smolts with coded-wire tag (CWT) codes that identify their treatment group for three years and subsequent monitoring of adult returns – through creel, surveys and trap collections. If feasible, the effect of juvenile release timing on adult homing behavior will be tested. Feasibility will be determined through statistical power analyses of appropriate release group sizes (in context of typical adult return rates) and hatchery infrastructure. This phase will inform whether the variables tested (see phase 2) can significantly affect adult homing behavior.
Timeline: 10 years; **Cost**: $2.35M

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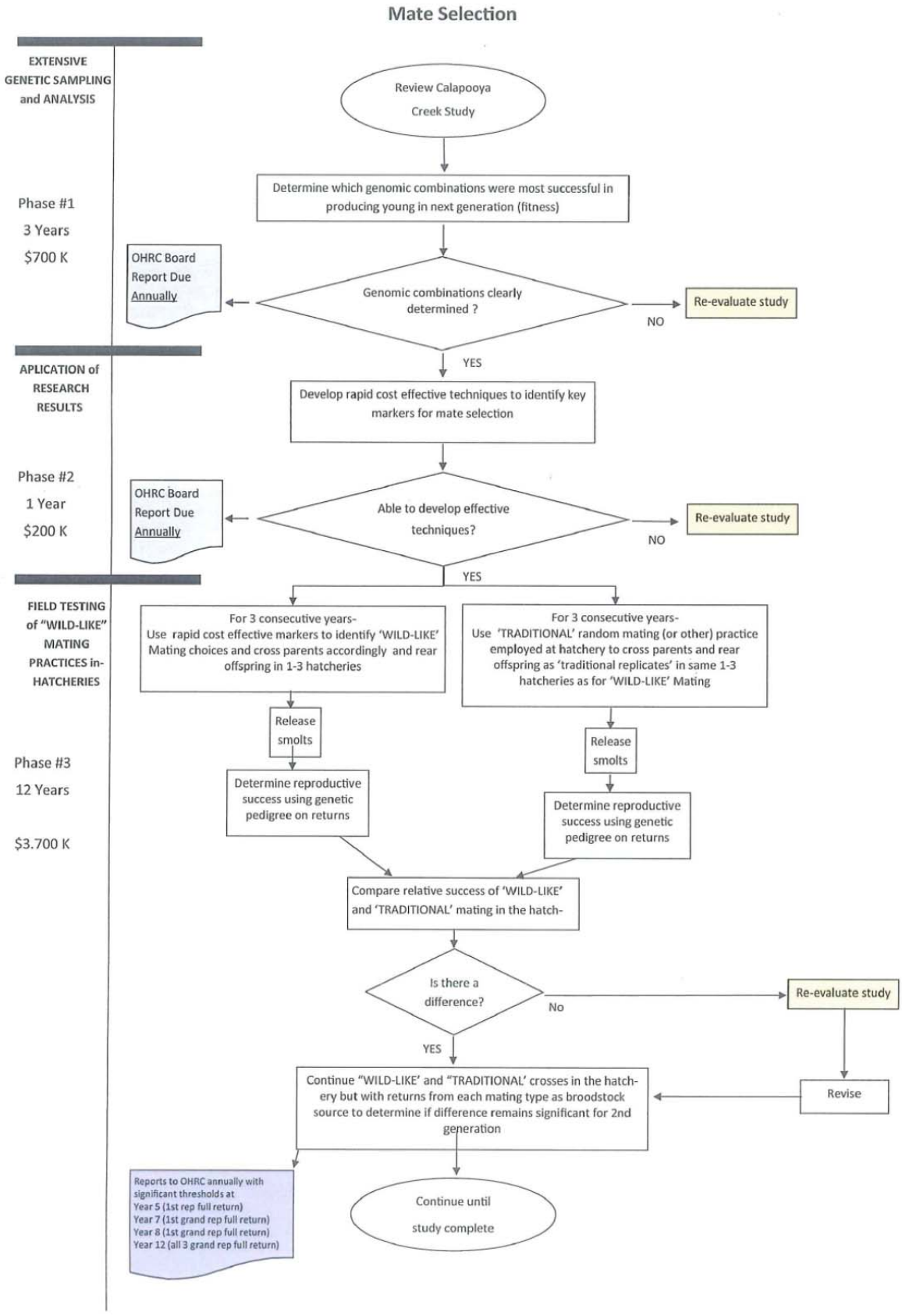
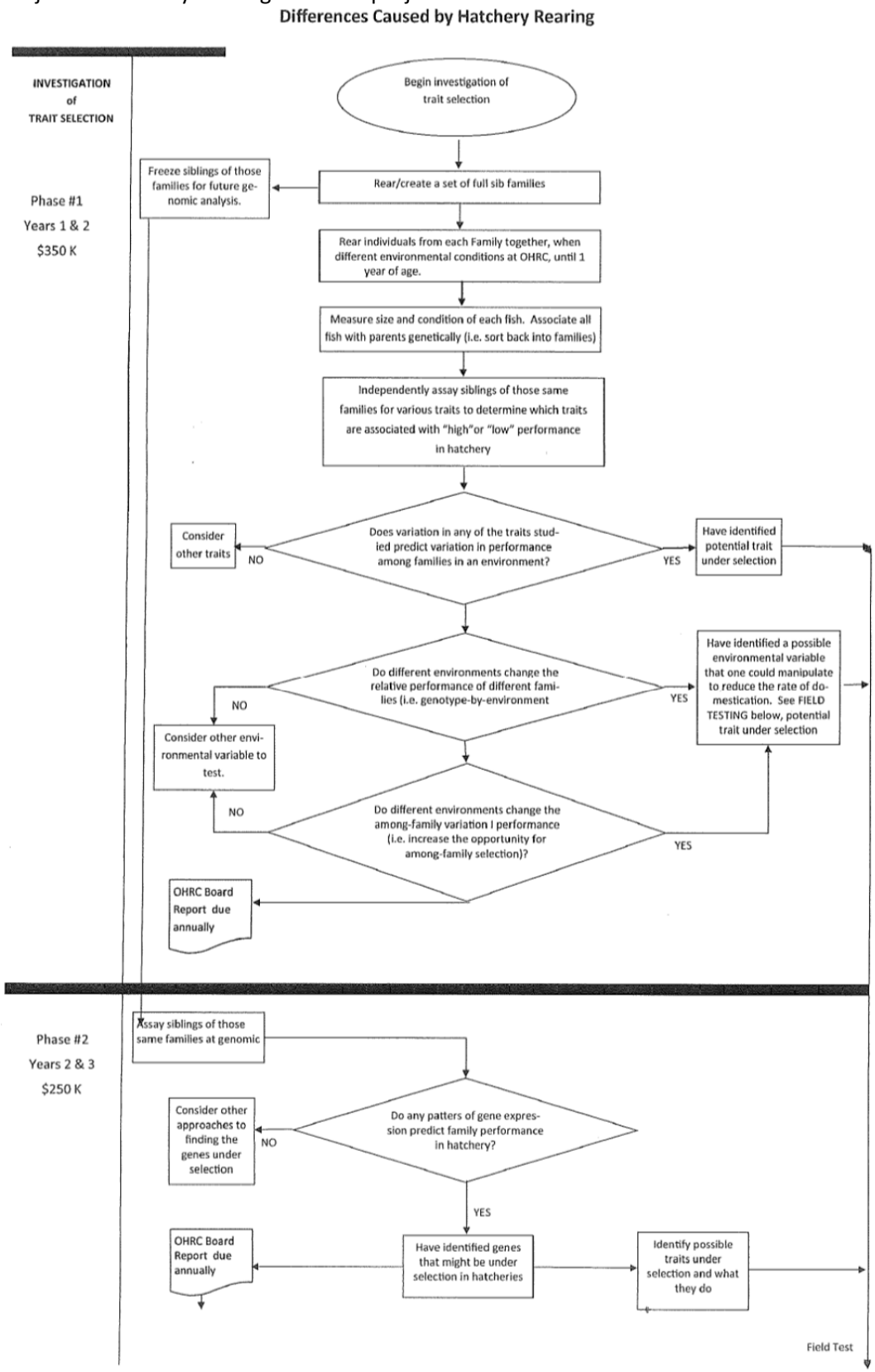
Annual and Biennial Budgets for Oregon Hatchery Research Center Priority Research Projects									
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	
Project 1: Mate Selection									
Phase 1: Genetic Sampling and Analysis	$233,333	$233,333	$233,333						
Phase 2: Application of Research Results				$200,000					
Phase 3: Field Testing					$308,000	$308,000	$308,000	$308,000	
Project 2: Hatchery Rearing Practices									
Phase 1: Trait Selection	$175,000	$175,000							
Phase 2: Identify Genes under Selection			$125,000	$125,000					
Phase 3: Field Testing					$310,000	$310,000	$310,000	$310,000	
Project 3: Imprinting and Homing									
Phase 1: Odorant Selection	$150,000	$150,000							
Phase 2: Verification of Imprinting			$233,333	$233,333	$233,333				
Phase 3: Field Testing						$235,000	$235,000	$235,000	
Annual Budget	$558,333	$558,333	$591,666	$558,333	$851,333	$853,000	$853,000	$853,000	
Biennial Budget	15-17	$1,116,666	17-19	$1,149,999	19-21	$1,704,333	21-23	$1,706,000	

	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Total
Project 1: Mate Selection									
Phase 1: Genetic Sampling and Analysis									
Phase 2: Application of Research Results									
Phase 3: Field Testing	$308,000	$308,000	$308,000	$308,000	$308,000	$308,000	$308,000	$308,000	
Project 2: Hatchery Rearing Practices									
Phase 1: Trait Selection									
Phase 2: Identify Genes under Selection									
Phase 3: Field Testing	$310,000	$310,000	$310,000	$310,000	$310,000	$310,000			
Project 3: Imprinting and Homing									
Phase 1: Odorant Selection									
Phase 2: Verification of Imprinting									
Phase 3: Field Testing	$235,000	$235,000	$235,000	$235,000	$235,000	$235,000	$235,000		
Annual Budget	$853,000	$853,000	$853,000	$853,000	$853,000	$853,000	$543,000	$308,000	$11,645,998
Biennial Budget	23-25	$1,706,000	25-27	$1,706,000	27-29	$1,706,000	29-31	$851,000	

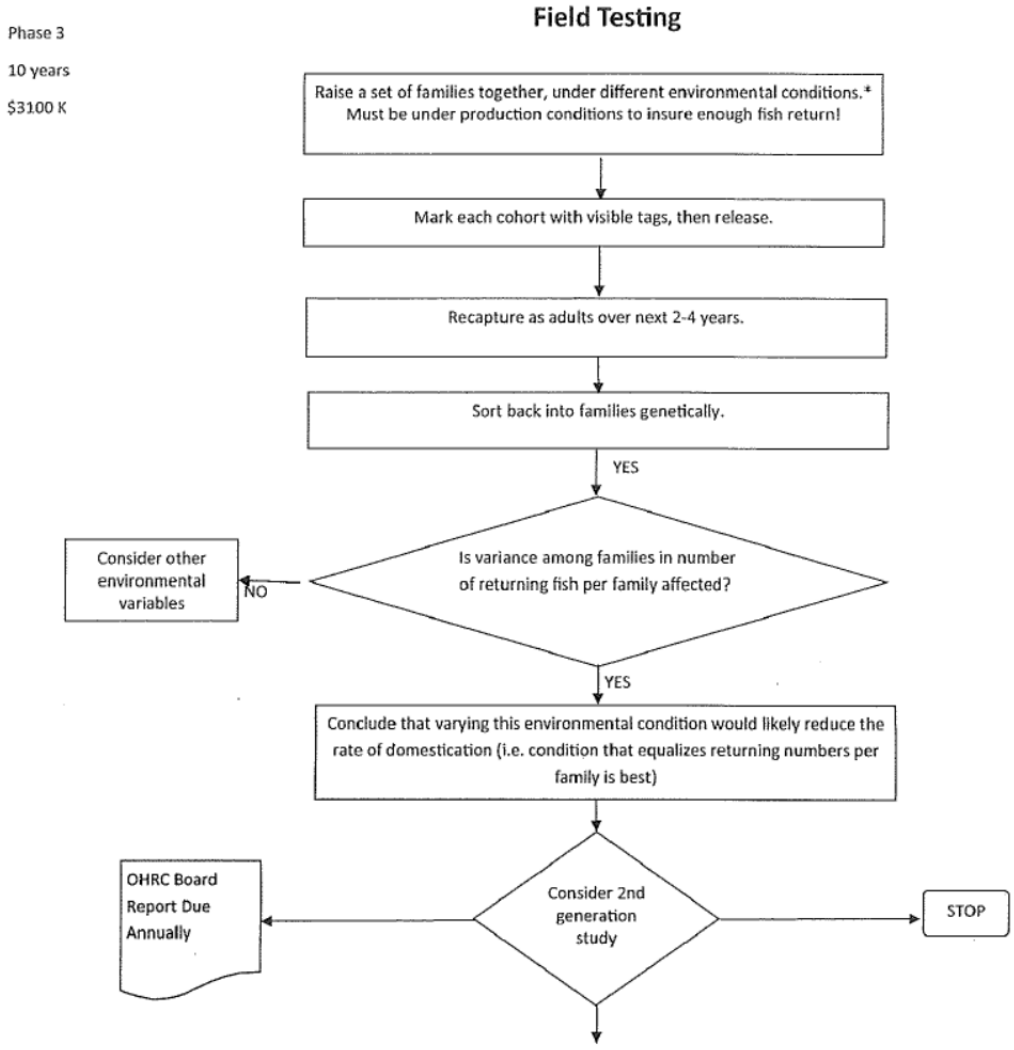
Project 1: Mate Selection project flow chart



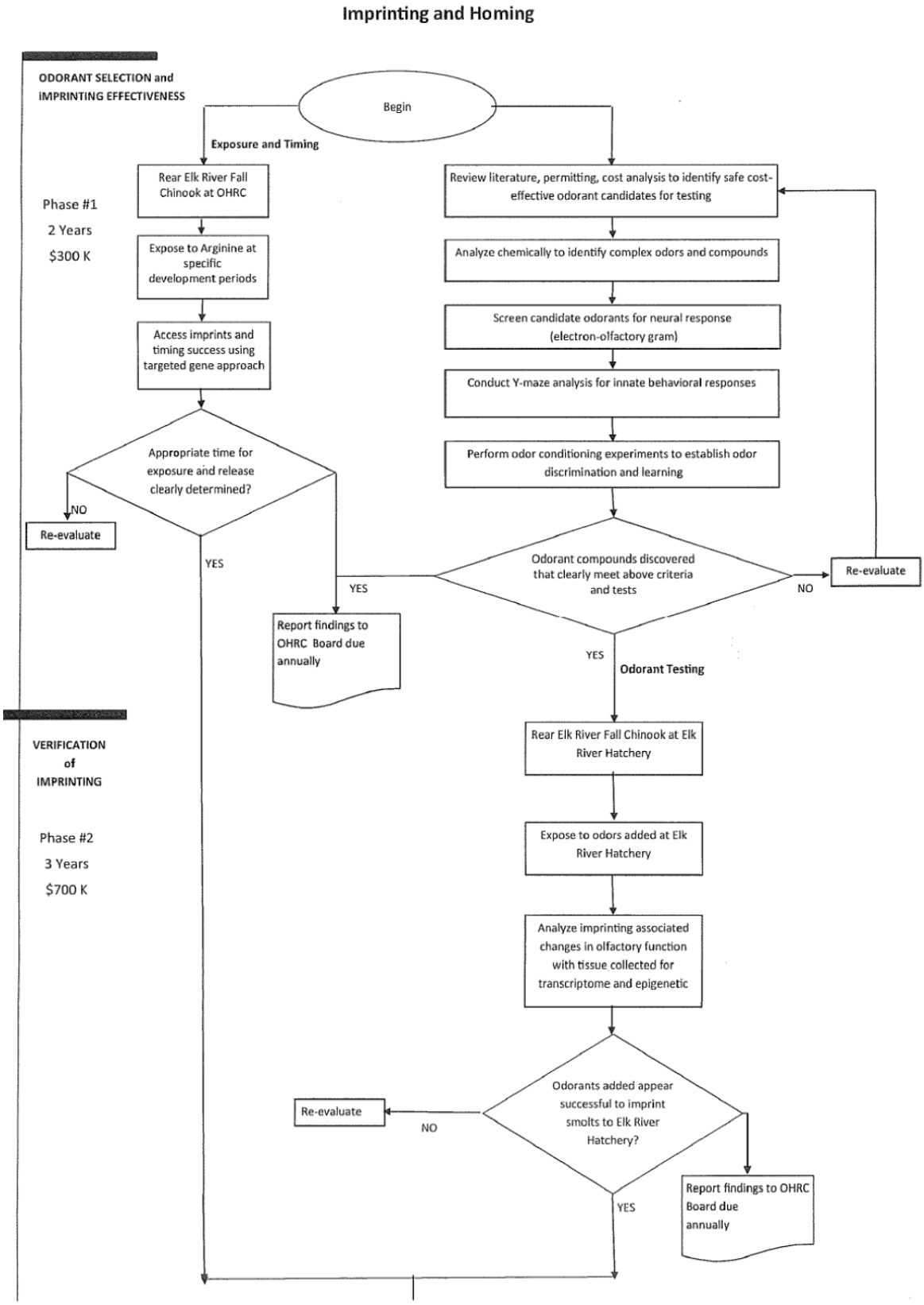
Project 2: Hatchery Rearing Practices project flow chart



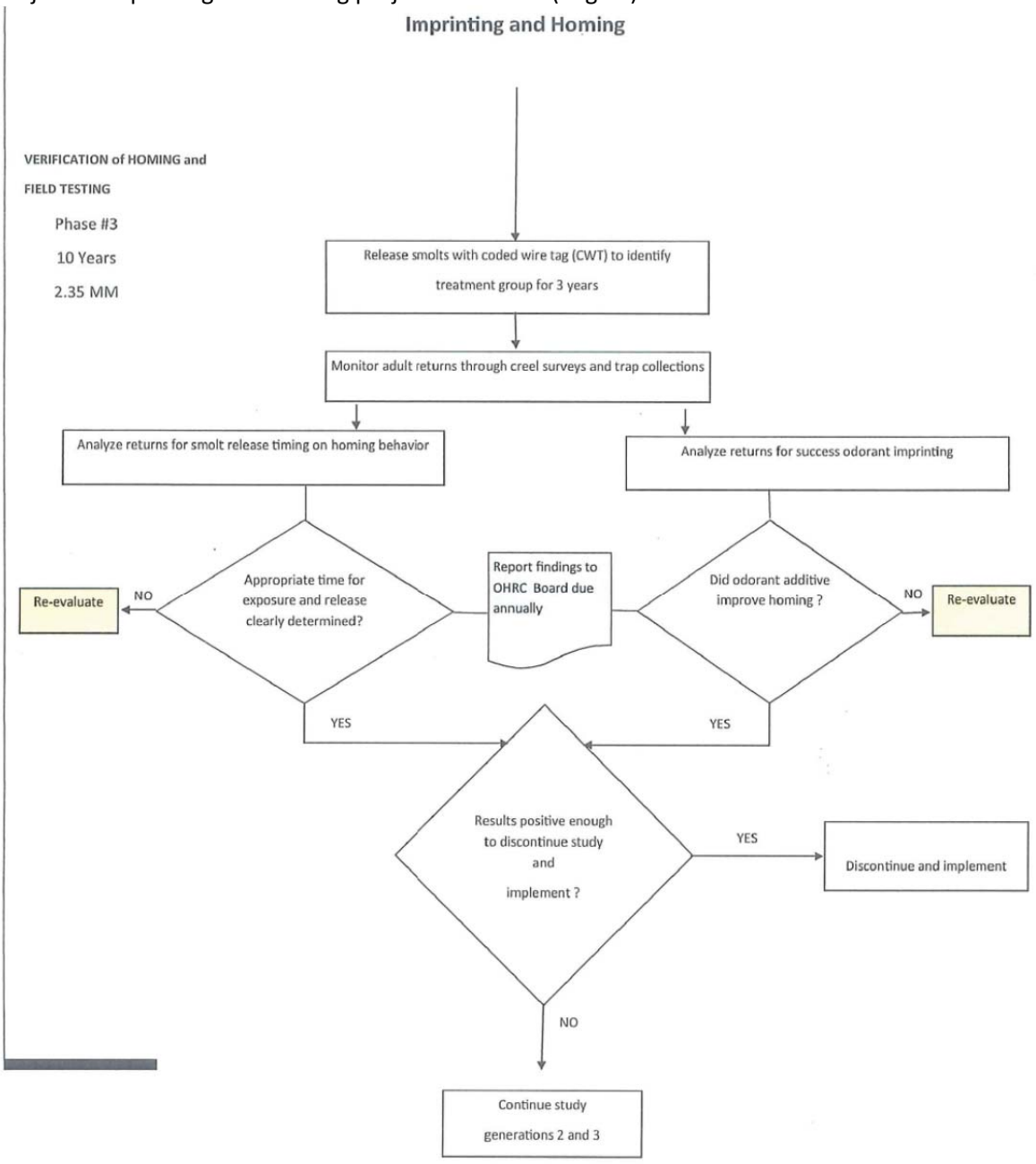
Project 2: Hatchery Rearing Practices project flow chart (Page 2)



Project 3: Imprinting and Homing project flow chart



Project 3: Imprinting and Homing project flow chart (Page 2)



Appendix 3: Detailed Activity Reports for the OHRC

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. All research projects are reviewed by ODFW, OHRC staff, the Director and the OHRC Board, and are required to provide updates and final reports. The current Research Projects can be grouped into major categories, related to the OHRC Mission and goals.

We have completed more than 50 research projects connected with the OHRC since opening in 2005. Details of the Proposals, Progress Reports, Completion Reports and resulting publications are available on the OHRC website, and in the records of the previous OHRC Advisory Committee. Many of those Reports include Recommendations that were made to the ODFW or other agencies for consideration or implementation. Results of our activities are reported to annual ODFW Meetings (hatchery managers and regional biologists in alternate years).

Individual Research Projects
During calendar year 2014 we had 13 research projects in various stages of activity at the OHRC. Those projects are listed below, with details for each as appropriate:

(1) Olfactory imprinting (Mission Goals 1.c., 2.d)
Our research on this topic is in response to a priority request from ODFW managers to provide recommendations for their management of homing and straying in wild and hatchery salmon and steelhead. We began by hosting a Research Workshop on Homing and Straying at the OHRC 8 – 9 February 2011 to bring together people from state and federal agencies, universities and other institutions in Oregon, Washington, California and North Carolina. That Workshop provided a Written Summary report to ODFW, and lead to this project. We began research on this project in 2012. Funding is provided from the OHRC – OSU operating budget, with support in kind provided by ODFW hatcheries. Our collaborators include Dr. Andy Dittman (NOAA, Seattle), OHRC, ODFW and OSU personnel. All of whom provide support directly and in kind for time, equipment and personnel. A continuing postgraduate student, Joseph Lemanski, supported by a McNair Scholarship and a scholarship from NSF – JSPS, is conducting his M. Sc. research with this group (completion expected 2015). He spent summer 2014 working with collaborators at Hokkaido University, Japan on part of his research project. We have presented progress reports at local, regional and national research meetings, and at invited presentations to university classes, school groups, angler clubs, and ODFW Hatchery Managers. The first manuscript from this project has been accepted for publication in Fisheries (Dittman et al.). Oral papers from this project were presented during 2014 at the Oregon Chapter of the American Fisheries Society, the International Fish Biology Congress (Scotland), the Annual Meeting of the American Fisheries Society, and the International Conference on Ecology, Ethology and Evolution of Fishes. We have shown that both Chinook salmon and steelhead imprint on the water in which they incubated, from fertilization to swim up stage. The fish imprint strongly on river water, but not on well water. We have verified our findings at both the OHRC and at the ODFW Leaburg Hatchery. Our results have resulted in significant re-evaluation of ODFW hatchery practices for the use of water during incubation. Our colleagues in Vermont have tested our predictions with Atlantic salmon (*Salmo salar*) and have found that fish incubated in river water return at four times the number incubated in well water (their standard procedure) – a result that is likely to change their hatchery management practices. The next step in our research will be to rear large numbers of salmon and steelhead at a selected ODFW hatchery in the two sources of water, mark them accordingly and release them as production smolts. The homing/straying of the returning adults will determine whether ODFW (and probably other agencies) changes their

hatchery practices. This forms part of the proposed Research Plan activity for the OHRC (details elsewhere in this Report).

(2) Geomagnetic imprinting (Mission Goals 1.c, 2.d)

Our research on this topic is also 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. We hosted a Research Workshop on Homing and Straying at the OHRC 8 – 9 February 2011 to bring together people from state and federal agencies, universities and other institutions in Oregon, Washington, California and North Carolina. That Workshop provided a Written Summary report to ODFW, and lead to a successful proposal to Oregon Sea Grant for research funding. Dr. Noakes was awarded $186,000 from Oregon Sea Grant for 2012 – 2013 (extended for year 3 in 2014) to investigate this subject. Together with matching funds and in-kind support from OSU and the OHRC, this project hired Dr. Nathan Putman as a Postdoctoral Research Scholar for this research, beginning in summer 2012 to spring 2014. We were granted a "No Cost Extension" for this project until December 2014, to allow us to complete the experiments currently in progress. 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 major papers has been published from this research and at least two more are in progress (Putman et al.). We have shown conclusively that Chinook salmon, sockeye salmon, pink salmon and steelhead use geomagnetic cues to orient their movements and navigation from the time of hatching until their return as adults. Our publications have attracted a considerable level of interest because we are the first to demonstrate that salmon and steelhead use geomagnetic orientation (several hundred web sites list our research papers already). Michelle Scanlan is currently engaged as a postgraduate student for her M. Sc. research on this project (graduation projected for 2015). She is supported by a combination of Oregon Sea Grant funding and OSU Graduate Teaching Assistantship funding awarded to Dr. Noakes. Our findings have very significant implications for both wild and hatchery salmon and steelhead. We have shown experimentally that rearing young fish in a hatchery environment with conventional equipment and facilities impairs their ability to use geomagnetic cues to orient and navigate. We predict that any interference or disruption of the geomagnetic cues would potentially cause significant impairment of homing in both wild and hatchery fish. Sources of such disruption would include iron reinforcement bars in concrete buildings or raceways, transport of smolts inside steel barges, passage of smolts or adults through hydroelectric dams or operation of wave energy structures or undersea electrical cables. In a similar manner, wild fish could be affected by any disruption of their magnetic environment during their migrations as smolt or adults (e.g., passage through hydroelectric dams, proximity to wave energy structures or electrical cables). We are continuing these experiments to compare a life cycle testing of the homing and straying of fish reared under normal and disrupted magnetic fields. This will require cooperation with ODFW production hatcheries, to produce the numbers of fish for life cycle testing, and will have to extend over at least one life cycle of the fish to determine the effects on returning adults. Michelle Scanlan's research is investigating the effects of coded wire tags on the magnetic responses of juvenile salmon and steelhead. Coded wire tags are strongly magnetic, and they are inserted into the nasal region of the fish, where the magnetic receptors are probably located. Results from her study will certainly have very significant implications for the large scale marking of hatchery fish with coded wire tags.

(3) Chinook wild surrogates (Mission Goals 1.b., 2.a.2., 2.b., 2.d.)

This project is being conducted by Drs. Carl Schreck and David Noakes, supported by funding from the US Army Corps of Engineers (Willamette River BiOp), initiated in 2011. We have been assisted by Dr. Eric Billman, a postdoctoral research associate (2011 – 2014; replaced by Dr. Karen Cogliati summer 2014), one graduate student (Julia Unrein, completion December 2014), two part-time research assistants and

two student work-study students. We receive about $360,000 each year for this project, with significant leverage from OHRC, OSU and USGS in-kind support. The first of a series of publications from this study are currently in press (Billman et al., Putman et al.). This project, together with the steelhead wild surrogate project, are examples of studies to determine what rearing mechanisms produce differences between wild and hatchery fish, and how to manage those differences to meet fishery and conservation needs. Both the wild surrogate projects also included OHRC Research Workshops on fish genetics, fish nutrition, and Chinook management. Reports of those Workshops are available from the ODFW and are posted on the OSU web site. Our primary task is to provide juvenile fish of specified qualities, to research collaborators from the ODFW, the Corps and others, to be used in their field studies required by the Willamette BiOp. Those fish must emulate wild fish as closely as possible in terms of genetic origin, size, growth history, morphology, physiology and behavior. They are used by our research collaborators in tagging and tracking telemetry studies of juvenile fish through reservoirs, through dams and fishways and down the Willamette River to Willamette Falls. We provide thousands of such fish, at different times of the year, to specifications from our collaborators. In order to produce those fish we are conducting extensive studies at the OHRC and the Fish Genetics and Performance Laboratory in Corvallis to determine the effects of genetic origin, diet, density, rearing substrate, rearing conditions and handling on the final performance of those fish in the Willamette River. We have been successful with this project in providing thousands of fish that perform almost the same as wild conspecifics, in contrast to conventional hatchery fish, for the studies in which they have been used. We have presented our results in Progress Reports each year. We have also given oral presentations on this project to ODFW, OSU, Oregon AFS, and other regional, national and international meetings. Our results from this and the steelhead wild surrogate project have implications and potential applications for ODFW and other management agencies. Our results inform management personnel on the practices and procedures to follow that can minimize (or maximize) the phenotypic and behavioral differences between wild fish and those produced in their hatcheries. Funding for both the Chinook and steelhead wild surrogate projects is in place from the Corps until 2016. Thus far the numbers of our wild surrogate fish that have been released in the wild have been deliberately kept limited, to avoid any potential genetic or ecological interactions with wild fish.

(4) Steelhead wild surrogates (Mission Goals 1.b., 2.a.2., 2.b., 2.d.)
This project, also funded by the US Army Corps of Engineers ($187,000 annually), was initiated in 2013. A postgraduate student, Kate Self, is working on this for her M. Sc. degree, supported by Corps funding (2014, expected completion 2015). This project is exactly comparable to the Chinook wild surrogate project, and was requested by the Corps as result of our success with the Chinook salmon. The objectives, procedures and evaluation are the same as for the Chinook project. As with the Chinook wild surrogate project, progress on this project is very well received by the Corps and other collaborators.

(5) Engineered logjams (Mission Goals 1.b., 2.d.)
This research project was conducted by Drs. Desiree Tullos (OSU, Biological and Ecological Engineering) and Jason Dunham (USGS) at the OHRC during 2013 with funding from NSF and the USFS. The first publication from that study has now been published (Tullos et al.in press). Details of the project were provided in the 2013 OHRC Report.

(6) Temperature and sex change (Mission Goals 1.a., 1.b., 2.d.)
This project was initiated in response to concerns brought to ODFW and OSU about possible effects of climate change on wild salmon and steelhead, and the potential for hatchery rearing effects at ODFW production hatcheries. This project was initiated in 2011 and was completed in 2014. The report from this project is in preparation for publication (Cole et al.). Details were provided in the 2013 Report. We

have presented our results at a number of national and international scientific meetings here in Oregon, Hawai'i, Scotland and Canada. Our results are of considerable significance to hatchery managers, since we have no reason to believe that the range of temperatures used to rear fish are likely to produce sex change. Wild fish are also not likely to change sex as a result of the projected temperature changes forecast by climate models. Our results are important because of our conclusions, and because they resolve some uncertainty about the potential impacts of climate or habitat changes.

(7) Domestication selection (Mission Goals 1.a, 1.b., 2.d.)

This project is conducted by Dr. Michael Blouin, his postgraduate student, Neil Thompson and their laboratory collaborators. The project is a continuation of early 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 for 2015 (details elsewhere in this Report). Neil Thompson recently completed his Ph. D. program as part of this project (2014). He and Dr. Blouin have a continuing series of publications from this work. Funding for this project comes to Dr. Blouin from the BPA, with some in kind provided by OHRC personnel and facilities. This research is of primary concern to many people in the Pacific Northwest, as Dr. Blouin's earlier research is the basis for ongoing concerns about negative genetic effects of hatchery steelhead on wild counterparts. This project is the latest in a series of tests of specific predictions by Dr. Blouin from his hypothesis for the mechanism of the reduced fitness of hatchery fish. He is rearing genetically identified fish from both hatchery and wild parents, under a number of different density conditions. His prediction is that hatchery fish will do well at high rearing densities (= hatchery conditions) while wild fish will do well at low rearing densities (= wild conditions). If the results confirm his predictions then he will be able to screen the hatchery and wild fish for the genes (or sets of genes) that are responsible for producing those differences. That would allow hatchery managers to control the rearing conditions (e.g., density) to minimize differences in growth, survival and reproductive fitness between hatchery and wild fish.

(8) Temperature and migration (Mission Goals 1.b., 1.c., 2.a.2., 2.d)

This project is being carried out in collaboration with Japanese colleagues, Professor Arimune Munakata, from Miyagi University in Sendai, Japan and his associates. He has come to the OHRC over a number of years to collaborate with Drs. Carl Schreck and David Noakes in this research. He has presented results of his research in both oral and published papers since he began this study. Funding for this research comes from Japanese awards to Professor Munakata, with some in kind support of facilities from the OHRC. This project was initiated because of interest in the factors that initiate the downstream movements of juvenile smolts of salmon and steelhead. The behavior and survival of salmon and steelhead smolts is of critical importance, since we have shown in other projects that only about 40% of smolts survive to reach the Pacific Ocean. The timing of downstream migration is obviously a major part of this phenomenon. Furthermore, there is the complexity that while some fish move downstream to the Pacific Ocean and complete their life cycle as anadromous steelhead, a significant but variable number of individual fish remain in freshwater as non-migratory rainbow trout. Those rainbow trout can have a significant effect on reproductive fitness of hatchery fish, and so it is important to learn what regulates this difference in migratory behavior of steelhead and rainbow trout. Professor Munakata's research has been remarkable because it shows that very small (perhaps less than 1^{o} C changes) in temperature can trigger downstream movement. Most remarkably, however, that downstream movement response is shown only by steelhead, rainbow trout show no such movement. Professor Munakata is now continuing his studies in Japan to determine what internal (physiological) mechanism produces this difference between steelhead and rainbow. That difference is part of a much larger concern, because of the major differences in life history and management of rainbow and steelhead, as

well as the influences on reproductive success than can result for hatchery fish. Dr. Munakata was here in 2014 and carried out tests on the effects of temperature change on migration of Chinook salmon. He has presented those results at meetings in Japan and has a manuscript in preparation for publication from this work.

(9) Alsea steelhead population genetics (Mission Goals 1.c., 2.a.1.2.b.)

This project has been conducted by a graduate student, William Heemstrom, supervised by Drs. Michael Banks and David Noakes, with very considerable cooperation from ODFW hatchery personnel and fishery biologists. Funding support came from OHRC, OSU, and COMES. The request for this project came from ODFW fish biologists, hatchery managers and program managers. ODFW biologists and program managers have a need to know the detailed genetic structure of hatchery and wild steelhead in the Alsea River basin. This project is supported by funding to Drs. Banks and Noakes from several external sources, with considerable in kind and personnel support from ODFW and OHRC for field collections. The ODFW North Fork Alsea Hatchery produces hatchery steelhead to support recreational angling harvest, a matter of continuing interest and concern to local anglers and other stakeholders. ODFW has been considering alternative hatchery procedures at the North Fork Alsea Hatchery for broodstock management, rearing and release, outplanting and angler surveys. The critical primary need for all these considerations is a detailed survey of the population genetics of Alsea River steelhead. We have worked with ODFW and OHRC personnel to collect genetic samples from as many locations as possible in the Alsea and adjacent watersheds. Dr. Banks and his postgraduate student, Will Heemstra (graduation expected 2015), have analyzed those samples in their lab at HMSC. They have presented progress reports and a preliminary written draft of their results to the OHRC Advisory Committee and to ODFW hatchery and program managers. The final written report is being prepared for publication in the primary scientific literature (Heemstrom et al.). The results of this study have been incorporated in hatchery practices at the ODFW North Fork Alsea Hatchery already. The detailed knowledge of genetic identity of wild and hatchery steelhead in different locations within the Alsea River watershed was used to determine the location of outplanting releases of steelhead smolts from the hatchery, and was used as part of the decision on locations to sample fish for hatchery broodstock.

(10) Wild broodstock (Mission Goals 1.c., 1.b., 1.c., 2.a.1., 2.a.2., 2.b., 2.c.)

This project was initiated in 2012 in response to a request from the Alsea Anglers Association, a local recreational angling group, together with other interested stakeholders. Derek Wilson, ODFW Fish Biologist in Newport has taken the lead and has already obtained R & E funding to provide for the necessary creel census for this project. This project depends on extensive in kind and personnel support from ODFW, OHRC and OSU. There has also been a lot of effort by a number of collaborators on this project to advertise the project, to encourage angler participation and to highlight the cooperative nature of this between ODFW and local anglers. This project has also involved very extensive outreach with the local anglers and other stakeholders, numerous public presentations and continued close cooperation with the general public. This project is of much broader interest to ODFW hatchery personnel and program managers. The basic question in this project is whether the source and treatment of hatchery broodstock will change the success rate of anglers on returning fish. Conventional broodstock programs take their fish from traps, using fish that have not been taken by anglers. The hypothesis we are testing is that the probability of being caught by anglers is affected by the source and handling of the parent fish. The prediction we are testing is that fish produced from conventional (trap caught) broodstock will be less likely to be caught by anglers than will fish produced from broodstock fish that were caught by anglers. The question is simple, obvious and very significant. The test requires very considerable cooperation, collaboration and coordination among the anglers, the ODFW hatchery managers and personnel, the OHRC personnel and the OSU scientists in the project. We now have all the

elements of the project in place, and we are awaiting delivery of angler-caught wild steelhead to use as broodstock in this project. The project will have to extend over at least one life cycle of the fish, to measure angler harvest of the returning fish from the two sources of broodstock. The results of this project will be of considerable interest and importance to anglers, ODFW fish hatchery managers, ODFW fish biologists and ODFW program managers, as well as the research scientists. If we find the predicted difference in angler harvest there will undoubtedly have to be significant changes in broodstock management practices and procedures. If there is no difference in angler harvest of returning steelhead, then angler groups and other interest groups, as well as research scientists, will be assured broodstock collection is not responsible for the level of contribution of these fish to the fishery. This will resolve a long-standing concern about hatchery management, and it will also demonstrate a contrast in the situation between the original example of angler catch of bass in Illinois, and angler catch of steelhead in Oregon. This project has been widely discussed in the local and regional communities, and has been the subject of feature stories in The Oregonian and has been presented by us a number of times to meetings of the OHRC Advisory Committee and other groups. The project will be initiated with wild broodstock at the Alsea North Fork Hatchery during this brood year (2014 – 2015).

(11) Steelhead smolt survival (Mission Goals 1.a., 1.b., 2.a.2., 2.b., 2.c.)

This project was initiated in response to requests from ODFW fish biologists and program managers because of the importance of understanding the factors affecting survival of juvenile smolts during their migration from freshwater to the Pacific Ocean. The research was incorporated into the graduate research projects of Camille Leblanc (Ph. D.) and Jeremy Romer (M. Sc.) (both completed). Details were provided in our 2013 Report and an earlier publication. Funding support came to Drs. Carl Schreck and David Noakes from the Pacific Ocean Shelf Tracking Network (POST), collaboration with the Vancouver Aquarium, ODFW and the USGS. We continue to analyze our data, and this has resulted in further publications (Thompson et al.) documenting significant sex bias in migrating smolt populations and significant annual variations in the survival of smolts.

(12) Triploid steelhead (Mission Goals 1.c., 2.a.1., 2.a.2., 2.b., 2.d.)

This project is a continuation by Dr. Marc Johnson (ODFW) of an earlier project initiated by requests from ODFW program managers. Our initial work on this project was the M. Sc. graduate thesis research by Eva Schemmel (now a Ph.D. student at Hawai'i). Eva tagged and tracked intact and surgically castrated hatchery adult steelhead in the Clackamas River. The results from her research are being published in several papers in the primary scientific literature. Her research was supported by funds from the OHRC, ODFW and OSU with considerable logistic and personnel support from ODFW. Her research showed that reproductively sterilized adult steelhead remained in the river, occupied the same locations as intact fish, and were caught by anglers at the same rate as intact (control) fish. This immediately led us to investigate practical alternatives for producing reproductively sterile hatchery steelhead. Subsequent work on this project has been supported by OHRC and ODFW funding, personnel and facilities. Of several options tested, we learned that using triploid fish was likely the best option. Ryan Couture, Joseph O'Neil and ODFW hatchery personnel worked to develop the detailed protocol to produce triploid steelhead and other salmonids in subsequent research at the OHRC. Triploid fish are reproductively sterile, and can be reared in large numbers using conventional production hatchery techniques. Ryan, Joseph and ODFW hatchery personnel tested the behavior of triploid fish in the experimental stream channels at the OHRC to confirm that they are reproductively sterile. This project has moved to the production scale testing necessary to determine if these fish can be produced by ODFW hatcheries and stocked as smolts with Dr. Marc Johnson as the research lead. We will follow those marked fish to estimate subsequent return rates as adults and angler harvest rates. This has been a multi-year project, involving collaboration and cooperation with many people. The immediate need is

for external funding to provide the unique marking required for these fish and the creel census procedures to monitor angler harvest in the rivers where they are stocked. The results of this project are of major interest to ODFW program managers, fish biologists and hatchery personnel. If reproductively sterile hatchery fish can be stocked in selective watersheds to support recreational angling harvest then a major concern of hatchery – wild interactions will be resolved.

(13) Passive Otolith Marking (water, food) (Mission Goals 1.a., 1.b., 1.c., 2.a.1., 2.a.2., 2.d.)
We have pioneered the use of microstructural and microchemical analyses of otoliths to interpret a good deal about the history of individual salmon and steelhead. This research project has a high priority for application by ODFW fish biologists and program managers. Our results have the potential to replace active marking (tagging, fin clips) of fish to identify them as hatchery or wild origin, or even to assign them to natal watersheds. We held a Research Workshop on Otoliths at the OHRC (October 2012) with reports to ODFW, the OHRC Advisory Committee and posted on the OSU web site. We followed up on that Workshop with continued collaboration with Dr. Yongwen Gao, of the Makah Tribal Fisheries band in Washington and Dr. Jessica Miller of OSU Fisheries and Wildlife Department. In our publications from that collaboration we have shown that we can discriminate hatchery and wild salmon from the same watershed, and discriminate fish from different watersheds, based upon stable isotope analyses (carbon, nitrogen) of their otoliths. We have extended that collaboration at the OHRC, using OHRC and OSU funds and substantial contributions in kind, personnel and resources from Dr. Gao. We have reared steelhead in different water sources at the OHRC and fed them on different commercial diets. We have analyzed water, feed and tissue samples from the fish to determine what correlations exist among these independent measures. This will be the first case where fish will come from known water and known feed for this kind of analysis. The results are in preparation for publication, and will determine whether we will be able to assign fish to their watershed of origin, based upon isotopic composition of the water, and to identify wild and hatchery fish as a consequence of different diets (commercial hatchery feed, natural prey).

Impact of Research:

Reports and Publications
Results of our research are given in numerous oral presentations and publications, selected examples are listed below. Presentations to the former OHRC Advisory Committee and the current Board at regular meetings are available on the OHRC website.

Billman, E. J., L. Whitman, K. Schroeder, C. S. Sharpe, D. L. G. Noakes, and C. B. Schreck. 2014. Body morphology differs in wild juvenile Chinook salmon *Oncorhynchus tshawytscha* that express different migratory phenotypes in the Willamette River, Oregon, U. S. A. Journal of Fish Biology DOI: 10.1111/jfb.12482

Cole, K. S., Thompson, D. L. N. N., Blouin, M., & Morrison, B. 2014. Effects of early exposure to elevated temperature on sexual development in *Oncorhynchus mykiss*. (in preparation)

Dittman, A. H. T. N. Pearsons, D. May, R. B. Couture and D. L. G. Noakes. 2014. Imprinting of hatchery-reared salmon to targeted spawning locations: A new embryonic imprinting paradigm for hatchery programs. Fisheries (in press).

Gao, Y. R. Conrad, D. Bean, D. L. G. Noakes. 2013. Statistical analysis on otolith data of anadromous fishes. Environmental Biology of Fishes 96: 799 – 810.

Miura, G., Munakata, A., Yada, T., Schreck, C. B., Noakes, D. L., & Matsuda. 2013. Effect of short-term decrease in water temperature on body temperature and involvement of testosterone in

steelhead and rainbow trout, *Oncorhynchus mykiss*. Comparative Biochemistry & Physiology A 166: 112 – 118.

Noakes, D. L. G. 2014. Behavior and genetics of salmon. pp. 195 - 222, In: P. T. Woo & D. J. Noakes (editors) Salmon: Biology, ecological impacts and economic importance. Nova Science, USA.

Noakes, D. L. G., E. Billman, C. Schreck, C. Schreck, R. B. Couture, J. O'Neil and J. Unrein. 2014. Born to be wild? Development patterns on Chinook salmon, *Oncorhynchus tshawytscha*, and steelhead, *O. mykiss*. 144th Annual Meeting, American Fisheries Society, Quebec City, Canada.

Noakes, D. L. G., C. Cole, N. Thompson, M. S. Blouin, B. Morrison and C. Schreck. 2014. Temperature, development and sexual differentiation in steelhead (*Oncorhynchus mykiss*). 144th Annual AFS Meeting, Quebec City, Canada.

Noakes, D. L. G., A. Dittman, R. Couture, J. O'Neil. 2014. Innate and Learned Preferences for Natural Stream Vs. Ground Water; Implications for Hatchery Practices and Natal Imprinting in Salmonids. 144th AFS Annual Meeting, Quebec City, August 2014.

Piccolo, J., D. L. G. Noakes and J. W. Hayes. 2014. Preface to the special drift foraging issue of Environmental Biology of Fishes 97: 449 – 451.

Putman, N. F., E. S. Jenkins, C. G. J. Michielsens and D. L. G. Noakes. 2014. Geomagnetic imprinting predicts spatio-temporal variation in homing migration of pink and sockeye salmon. Royal Society Interface DOI 10.1098/rsif.2014.0542

Putman, N. F., K. J. Lohmann, E. M. Putman, T. P. Quinn, Thomas, A. P. Klimley, D. L. G. Noakes. 2013. Evidence for Geomagnetic Imprinting as a Homing Mechanism in Pacific Salmon. North Pacific Anadromous Fish Commission Technical Report No. 9: 64.

Putman, N. F., K. J. Lohmann, E. M. Putman, T. P. Quinn, Thomas, A. P. Klimley, D. L. G. Noakes. 2013. Evidence for geomagnetic Imprinting as a homing mechanism in Pacific salmon. Current Biology 23: 312 – 316.

Putman, N. F., A. M. Meinke and D. L. G. Noakes. 2014. Rearing in a distorted magnetic field disrupts the 'map sense' of juvenile steelhead trout. Royal Society Biology Letters DOI: 10.1098/rsbl.2014.0169

Putman, N. F., M. M. Scanlan, E. J. Billman, J. P. O'Neil, R. B. Couture, T. P. Quinn, K. J. Lohmann and D. L. G. Noakes. 2014. An inherited magnetic map guides ocean navigation in juvenile Pacific salmon. Current Biology 24: 446 – 450.

Romer, J. D., Leblanc, C. A., Clements, S., Ferguson, J. A., Kent, M. L., Noakes, D., & Schreck, C. B. 2013. Survival and behavior of juvenile steelhead trout (*Oncorhynchus mykiss*) in two estuaries in Oregon, USA. Environmental Biology of Fishes 96: 849 – 863.

Thompson, N. F., K. S. Cole, L. A. McMahon, M. L. Marine, L. D. Curtis and M. D. Blouin. 2015. Sex reversal, selection against hatchery females or wild males does not explain differences in sex ratio between first generation hatchery and wild steelhead, Oncorhynchus mykiss. Environmental Biology of Fishes DOI: 10.1007/s10641-014-0240-0

Tullos, D. and C. Walter. 2014. Fish use turbulence around wood in winter: physical experiments on hydraulic stability and habitat selection by juvenile coho salmon, *Oncorhynchus kisutch*. Environmental Biology of Fishes, DOI 10.1007/s10641-014-0362-4

Our research attracts attention, collaborators and joint research proposals. The impact of our research can be estimated by conventional methods, perhaps the clearest examples are from our recent publications on sockeye, Chinook and steelhead. Our research on geomagnetic orientation and navigation in Chinook, sockeye and steelhead has attracted considerable attention to the OHRC, with numerous requests for information and proposals for funding applications and research collaborations.

Research Workshops

We continued our series of Research Workshops at the OHRC on a range of topics to meet the OHRC Mission. The Workshops are funded by cost recovery for meals and accommodation from attendees. These Workshops attract people from ODFW, state and federal agencies, tribal bands, universities and colleges, stakeholder groups and the general public. We held an Otolith Research Workshop (October 2012) that produced a written Report to ODFW, a video recording posted on the OSU website and an ongoing series of research publications in the primary scientific literature (see list below). We organized a Lamprey Research Workshop (October 2013) that produced a Report to ODFW, a video to be posted on the OSU website and a number of presentations that were given at the meetings of the Oregon Chapter of the American Fisheries Society, the International Fish Biology Congress (Edinburgh, Scotland) and the Annual Meeting of the American Fisheries Society. We also hosted an OHRC Research Workshop (July 2013) that produced a written summary and report to Rep. Krieger and other members of the Oregon Legislature. We participate actively in local, regional, national and international scientific meetings where we present the results of our research. We organized and hosted the International Conference on Behavior, Ecology and Evolution of Fishes in June 2014, and the annual meeting of the Gilbert Ichthyological Society in October 2014.

OHRC Mission Goal 3: Education and Outreach

Joseph O'Neil continued his activities at the OHRC and during visits to a number of schools in Lincoln County during 2014 as the lead person responsible the Education and Outreach activities at the OHRC. He was a key person in the OCAMP Science Education Project, and he continues as an active member of the Oregon Coast STEM project. He is responsible for organizing and hosting school visits and school tours at the OHRC as well as taking presentations to schools and meetings away from the OHRC. We have made presentations and hosted visits of more than 1,000 elementary and secondary school students in this program. In addition, we travel to schools throughout Lincoln, Benton and Tillamook counties to provide organized science exercises to classes from kindergarten to Grade 12 students. We also provide science classes and science exercises to meetings of Scouts and other service groups. Joseph has been selected to represent the Oregon Coast STEM HUB Center on a scientific visit to Russia in March 2015.

David Noakes continues as one of the Co-PI personnel for the Oregon Coast STEM (budget details listed elsewhere). He provides invited seminars, leads science colloquia and makes school visits to judge science fairs and to advise students at all levels. He is also responsible for teaching duties in the Fisheries and Wildlife Department at OSU, including senior undergraduate courses in Fish Ecology (classroom and Distance Education) and a postgraduate class in Fish Ecology & Conservation (classroom and Distance Education). He continues to give invited lectures and seminars at OSU on Scientific Publishing, and on salmon biology and conservation (Steelhead Class). He regularly supervises postgraduate students who conduct their research at the OHRC, and serves on the Advisory Committees for other postgraduate students at OSU. His activities in the Oregon Coast STEM project include visits and presentations to classrooms, advising on student projects and coordinating school visits and presentations by visiting scientists. He also presents invited lectures on OHRC research, scientific editing and publishing at regional, national and international meetings. One of our elementary teachers, Sean Beddell, at Eddyville School received $20,000 award for tsunami project with his class that included a school visit by Dr. Arimune Munakata of Miyagi University in Sendai, Japan (the location of the 2011 earthquake and tsunami).

A number of postgraduate students conduct part or all of their research at the OHRC, with support in kind from our personnel and facilities. Their research topics include subjects as diverse as studies of the impact of dams and fish passage on steelhead in the Umpqua River, responses of juvenile salmon to avian predators, domestic selection on wild and hatchery fish, experimental production of hatchery salmon and steelhead to behave and perform as wild fish, olfactory imprinting in salmon and steelhead and the use of geomagnetic cues for navigation by juvenile and adult salmon and steelhead.

Appendix 4: Oregon Hatchery Research Center Mission Statement

The Oregon Hatchery Research Center Mission

Realizing that healthy wild and hatchery fish runs are a vital part of each Oregonian's heritage, 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. The OHRC will foster and support a wide range of research and education projects and provide unique state-of-the-art facilities. The OHRC is strategically located in the Alsea Basin, surrounded by streams and close to coastal fisheries that offer natural laboratories to study the life cycle and interactions of wild and hatchery fish and their management on a broad "basin-to-landscape" scale. The site also is close to other scientific institutions such as the Hatfield Marine Science Center and Oregon State University. 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 conserves and protects 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.
    e. Work with ODFW to integrate key findings from research at the OHRC into ODFW fish and hatchery management programs.
    f. Conduct research that assists in the implementation and advancement of native fish population recovery as well as viable fisheries.

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 Oregonians 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.

Share research results through both publications and presentations on the local, state and international level.