Oregon Hatchery Research Center
2013 Annual Report

To:

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

By:

Oregon Hatchery Research Center Board

February 1, 2014

Executive Summary

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

- Formation of the new Board and appointment of members by the ODFW Director;
- Activities of the Board in 2013 and focus for the Board in 2014;
- Revised Mission Statement for the Oregon Hatchery Research Center (OHRC);
- Research activities conducted by the OHRC and collaborators in relationship to the mission and goals for the Center; and
- Three research proposals recommended by the OHRC Board for priority funding.

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 out lined 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 first 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 appointment of the new Board by the Director in September of 2013, the activities of the Board to date, and research findings and recommendations from research conducted at the OHRC in 2013.

Formation of the OHRC Board:

Per the direction in HB 3441 for establishing the OHRC Board, the 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

In August 2013, ODFW sought applications from qualified candidates to fill the 12 voting member positions on the Board. Twenty-three candidates applied for the 12 positions and in September 2013, the Director appointed the 12 voting members and the 3 non-voting members for the designated terms as outlined in Table 1.

The newly constituted Board met for the first time on October 17, 2013 at the Oregon Hatchery Research Center in Alsea, Oregon. The Board held subsequent meetings on December 9, 2013 and January 21, 2014. At the December 2013 meeting, the Board appointed 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	Darus Peake	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
Science	Jim Lichatowich	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 Activities in 2013:

The OHRC Board held its first meeting on October 17, 2013 at the Oregon Hatchery Research Center in Alsea, Oregon. At this board meeting, board members were welcomed by Roy Elicker, ODFW Director and Dr. Dan Edge, OSU Fisheries and Wildlife Department Head and thanked them for their willingness to serve. ODFW staff and the OHRC Director, Dr. David Noakes, made a series of presentations to the board, outlining the legislative direction for the OHRC and the board, the history of the OHRC, followed by a discussion of the next steps for the board. See the following link for board agenda and minutes (http://www.dfw.state.or.us/fish/OHRC/minutes.asp).

The board met again on December 9, 2013 at the ODFW District Office in Adair, Oregon. The board reviewed the current OHRC mission statement and strategic plan and made recommendations for revision, developed an outline for the OHRC 2013 Annual Report, reviewed and approved the OHRC budget and the Interagency Agreement between OSU and ODFW, reviewed and approved the ODFW Director's recommendation that Dr. David Noakes be re-appointed as the OHRC Director and selected a chair and 2 vice-chairs as noted above, and outlined the objectives for the January 21, 2014 board meeting. ODFW staff also updated the board on the new website hosted by ODFW for the OHRC and the board (http://www.dfw.state.or.us/fish/OHRC/). The website will be the on-line repository to access all information relevant to the OHRC and the board. Finally, the board solicited 3 research pre-proposals from OSU researchers along three lines of investigation as outlined by ODFW staff and OHRC Director Dr. David Noakes. See the following link for board agenda and minutes (http://www.dfw.state.or.us/fish/OHRC/minutes.asp).

On January 21, 2014, the board met at the ODFW District Office in Adair, Oregon. The focus of the meeting was review and approval of the revised OHRC mission statement (see Appendix 2), the 2013 OHRC Annual Report, the OHRC Board charter and ground rules. In addition, the board listened to presentations on the 3 research proposals solicited from Dr. Michael Banks, Dr. Michael Blouin, and Dr. David Noakes under a fast track for priority funding (see Appendix 3). The three proposals focus on high

priority research that have the most promise to advance the mission of the OHRC. The proposals focus on mate selection (Banks), the mechanisms driving domestication effects (Blouin) in the hatchery and factors that influence homing in salmon (Noakes). Based on the 3 pre-proposals and presentations, the board made recommendations to revise the proposals and forward for consideration by the Oregon Legislature and other funding entities.

OHRC Board Focus in 2014:

Based on discussions at the January 21, 2014 Board meeting, the OHRC Board will focus its efforts in 2014 in the following areas:

- Developing strategic direction and research priorities for the OHRC;
- Implement 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;
- Work with ODFW, OSU and other partners to expand the funding base in support of research at the OHRC; and
- Advising ODFW, OSU and the OHRC Director on priorities and research implementation at the OHRC.

OHRC Activity Report 2013:

Overview

The OHRC addresses our Mission, as approved by the OHRC Advisory Board through activities listed here, and provided in greater detail later in Appendix 4 to this Report. We address our Mission with a number of Research Projects, Research Workshops, Educational Projects and Outreach Activities. This has 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 attract about $1.6 million annually for educational and research activities 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 are reported to the OHRC Board, to ODFW, to local, regional, national and international meetings and are 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 2013:

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. Responses of wild and hatchery coho to engineered log jams – Tullos
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
1.c. Passive otolith marking of hatchery and wild salmon and steelhead – Gao, Noakes, Miller

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 2013:

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.a.1., 2.c. Steelhead smolt survival – Schreck, Noakes
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 continue activity in Education and Outreach, Research Workshops, based on both applied and basic Research at the OHRC. Together with Lincoln and Tillamook County School Districts we have brought $1.3 million to coastal schools over the past 5 years. We have just been notified that an application for significantly enhanced funding for our Oregon Coast STEM Hub has been approved by the Oregon Department of Education. We maintain active educational programs at every level from kindergarten to post graduate university students. We host Research Workshops for ODFW, university personnel, tribal band members, private consultants, stakeholders and members of the general public. We publish and distribute information about our activities on our website, through local newsletters and brochures, and in books and journals in the primary scientific literature. We attract 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 2013 at an increased pace over previous years. We host school visits to the OHRC, participate in teacher training, school visits and coordinate professional activities with students and teachers. We provide educational activities and opportunities at every level from kindergarten to postgraduate university students.

OHRC personnel participate 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 host visiting researchers, university and school groups, as well as making visits and invited presentations to services clubs, angler organizations and to educational institutions. We participate in local, regional, national and international research meetings where we present results of OHRC educational and research activities.

We continue 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 attracts 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.

Funding

Operations: The OHRC receives a biennial operating budget of approximately $1.1 million from the Oregon Department of Fish and Wildlife. That is supplemented by funds provided by the Fisheries and Wildlife Department of Oregon State University, through a Memorandum of Understanding with the ODFW.

Research: We bring in about $1.6 million in research activity to the OHRC each year, from a variety of local, state, national and international sources. Much of that funding is leveraged by in kind support from the OHRC and OSU budget sources (personnel, facilities, operations). The number of research projects continues to grow, with 15 active projects in 2013 (listed in detail in the body of the Report). Funding for OHRC activities comes from a number of sources. The major operational funding is the biennial budget allocation from ODFW, with contributions from OSU. That funding supports a number of projects at the OHRC, including: Olfactory Imprinting, Temperature and Sex Change, Wild Broodstock, Steelhead Smolt Survival, and Otolith Marking. We also receive specific funding for individual projects: US Army Corps of Engineers (Chinook and steelhead surrogates), Noakes & Schreck – Steelhead surrogates ($187,000 year 1 of 3 years); Noakes & Schreck – Chinook surrogates - $320,000 year 2 of 3); Noakes – Oregon Sea Grant – geomagnetic orientation in salmonid fishes – year 2 of 2 - $87,000. In addition, a number of collaborators bring 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 support 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.

Education and Outreach: We are the principal partner with the Lincoln County and Tillamook County School Districts in the OCAMP and Oregon Coast STEM Project (5 year total funding $1.3 million). The Oregon Coast STEM Center project receives 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 total over most recent 5 years for OCAMP, STEM). Dr. Noakes and Ruth McDonald are 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).
We continue activity in Education and Outreach and Research Workshops based on both applied and basic Research at the OHRC. We maintain active educational programs at every level from kindergarten to post graduate university students. We host Research Workshops for ODFW, university personnel, tribal band members, private consultants, stakeholders and members of the general public. We publish and distribute information about our activities on our website, through local newsletters and brochures, and in books and journals in the primary scientific literature. We attract collaborators, including many

students, from around Oregon, across the USA, Canada, China, Japan, Korea, Iceland, Norway, Sweden and the Netherlands.

OHRC personnel participate 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 host visiting researchers, university and school groups, as well as making visits and invited presentations to services clubs, angler organizations and to educational institutions. We participate in local, regional, national and international research meetings where we present results of OHRC educational and research activities.
We continue 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 attracts 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.

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

Appendix 3: Priority Research Proposals for the OHRC

Oregon Hatchery Research Center
Dr. Michael Blouin, Dept. of Integrative Biology, Oregon State University
January 2014

Research Proposal – Domestication Studies
Cost Estimate: $210,000/year for 3 years

Background:
Evidence from multiple studies shows that even hatchery fish that are only one or few generations removed from the wild can have reduced fitness in the wild. In the case of Hood River steelhead, there is strong evidence that this reduced fitness results from extremely fast, genetic adaptation to hatchery conditions. Unfortunately, we do not know what traits are under selection in the hatchery, or what hatchery conditions tend to increase that selection. Answering those questions could point to ways to modify the hatchery environment to reduce the rate of domestication.

Proposed research directions
I. Experiments to identify traits under selection
We know that if we raise fish from multiple families (offspring of different pairs of broodstock) in a hatchery, there will be substantial variation among families in performance (growth and survival to release, survival to return). One approach to identifying traits under selection is to ask what traits differ between "winner" and "loser" families in the hatchery. For example, if high-performing families tend to have, say, higher metabolic rates than low-performing families, then that would identify metabolic rate as a potential trait under selection. A complimentary approach is to compare the offspring of wild (W) fish with the offspring of hatchery (H) fish under a common environment. For example, if offspring from HxH crosses have higher metabolic rates than offspring of WxW crosses, then that would suggest that fish with high metabolic rate were previously selected for in the hatchery.

Candidate trait approach: Here we predict in advance what traits might be important, and then design experiments to test those hypotheses. Candidate traits to study are chosen based on "common sense" and knowledge of basic salmonid biology. Candidate traits can also be identified using genome scan approaches.

Genome scan approach: We compare the genomes of "winner" and "loser" families, or the genomes of HxH versus WxW families. Here we look at genome-wide patterns of gene expression (mRNA transcription levels). Any consistent differences would point to genes that are potentially under selection.

II. Identify hatchery practices that exacerbate domestication selection
Here we are testing which hatchery rearing practices tend to *increase* differences among families in performance (without having to know the actual traits under selection). Conditions that increase variation among families will increase the opportunity for selection, and so are undesirable. For example, we suspect that raising fish at higher densities (crowding) increases the difference between "winner" and "loser" families. Other environmental conditions that might be worth studying include varying feeding protocols or the physical complexity in the rearing tanks. For example, although NATURES rearing conditions (e.g. woody debris in tanks) do not seem to increase overall fish production, no one has ever tested whether using such conditions could reduce the rate of domestication.

Budget Estimate (Assumes 3-year project – annual cost estimates)

(1) Without the gene expression work: $120,000/year

Personnel	
Post-doctoral Student	$74,000
Materials & Supplies	
Molecular Biology supplies	$20,000
OHRC Support	$25,000

(2) Add the gene expression $90,000/year

Personnel:	
Molecular biology technician	$60,000
Materials & Supplies	
Molecular Biology supplies	$30,000
ANNUAL TOTAL (estimate)	**$210,000**
PROJECT TOTAL (estimate)	**$630,000**

Oregon Hatchery Research Center
Dr. David L. G. Noakes, OHRC Director, Oregon State University
January 2014

Research Proposal – Homing in Pacific Salmon
Cost Estimate: $104,000/year for 5 years

Homing behavior is a striking feature of the biology of Pacific salmon, and is the basis for most salmon management. Homing by wild fish is a critical feature of stock identification and conservation. Any disruption of homing behavior of wild fish will have negative consequences. Failure to show successful homing behavior (= straying) is frequently shown by hatchery fish and causes negative interactions of wild and hatchery fish. Stray hatchery fish are in the wrong places at the wrong times so that they are not available for designated harvest, they compete with wild fish and can interbreed with wild fish and cause reduced reproductive fitness for the wild fish. I propose an integrated research project that would extend over one life cycle (maximum of 5 years) for Chinook salmon and steelhead to measure the effects of chemical and magnetic imprinting on homing behavior of adults. Our results thus far have shown that the fish imprint upon the water in which they are incubated, with a strong preference for river water over well water. We predict that this imprinting is responsible for the homing behavior of adults to their spawning sites. Disruption of that early imprinting, by incubating fish in well water, or by transferring them to different water sources during early development, produces increased straying by hatchery fish. We have also shown that salmon and steelhead respond to geomagnetic cues throughout their lives, that they learn the geomagnetic coordinates of their freshwater rearing habitat, and that they use geomagnetism to direct their ocean migration and return to their spawning streams. Disruption of geomagnetic imprinting, by rearing fish in areas with electromagnetic influences or exposing them to electromagnetic influences during their freshwater migration will also produce increased stray rates in hatchery fish.

We will rear Chinook and steelhead under controlled conditions at the OHRC to determine the timing and strength of their chemical and magnetic imprinting (ongoing, each year). We will use a designated ODFW production hatchery (hatcheries) to rear test groups of fish exposed to experimental conditions, and then monitor returns of those returning adults to compare stray rates of control and test fish (one life cycle). We will compare fish reared in well water and river water at the same hatchery – fish reared in well water will have higher stray rates. Production hatcheries could then decide on water sources, timing of exposure of fish to different water and consider the possibility of exposure of fish to selected water to direct returning adults to designated spawning areas. We will compare fish reared in natural and experimentally altered magnetic fields at the same hatchery. Magnetic fields are readily altered by the presence of electrical wires near rearing tanks, the presence of iron reinforcing bars in tanks or raceways, or the presence of altered magnetic fields from low voltage electrical fields around rearing tanks. Fish reared in disrupted magnetic will have higher stray rates. These results will allow hatchery managers to judge the best design and operation to minimize (or maximize) geomagnetic imprinting, to control homing (or straying).

Background Justification

Pacific salmon and steelhead are characterized by the high degree of philopatry – adults typically return to spawn at the very specific location where they began life (the spawning grounds of their parents). This "textbook" view of their behavior is the basis of much of the management practices for both wild and hatchery salmon and steelhead. The precise homing of wild fish is the basis for the multitude of local populations of wild salmon and steelhead, and it is a critical feature of conservation and management of those stocks. The converse of homing, straying, almost certainly occurs to some degree in some wild salmon and steelhead, when returning adults spawn in locations other than their natal sites, but it is not a significant concern. Straying is a serious and significant concern for hatchery fish. By definition hatchery fish are produced with the intention that they will restrict their movements, whether as juveniles or spawning adults, to very specific times and locations. Straying by hatchery fish is a disaster for fishery managers, by definition. Straying results in hatchery fish being in the wrong places at the wrong times. That will likely make them inaccessible to intended harvest, for example. More significantly, it will bring them into negative interactions with wild fish that will create major concerns. Those concerns include genetic interactions between wild and hatchery fish, including interbreeding, competition for spawning sites and depression of reproductive fitness of the wild fish. The negative interactions can also be ecological, including competition for feeding sites by juveniles, predation by hatchery fish on wild juveniles, mixed stock harvest, and competition during freshwater or marine migrations. The critical need is to understand the factors that determine homing behavior (= "success") in wild fish, and consequently straying behavior (= "failure") in hatchery fish. This requires a research program to investigate the development of orientation responses by young fish, both wild and hatchery, in natural and hatchery situations. Some of these can be accomplished by retrospective analyses of existing data on homing and straying by wild and hatchery fish – but that approach will be very limited at best and can only lead to hypotheses that must be tested by controlled experiments.

Homing and straying of wild and hatchery salmon and steelhead has been identified by ODFW as one of their key management concerns. I was a Co-Editor on a major international publication that summarized the current state of knowledge for the ecological interactions of wild and hatchery salmonids. In addition, we convened a Research Workshop on that topic, held at the OHRC (8 – 9 February 2011), to address both the management concerns of ODFW and other agencies, and the research questions associated with that behavior of salmon and steelhead. That Research Workshop produced a Report and Recommendations to ODFW, a Report to the OHRC Advisory Committee and a request for research funding to Oregon Sea Grant (David Noakes, PI). That research proposal was funded by Oregon Sea Grant (2012 – 2014) and has supported an active research program by Dr. Nathan Putman, working with Dr. Noakes and other collaborators (Oregon, California, Washington, North Carolina) at the OHRC. That research has produced a series of presentations at various international scientific meetings and high profile publications in the primary scientific literature with immediate implications for both basic science and practical management applications. We have established for the first time that salmon and steelhead can detect geomagnetic cues and use that information to direct their ocean migration. The fish have that ability from shortly after hatching, while they are still in the gravel redd. That ability persists and is used throughout their life, including spawning migration and homing of adults. Rearing fish inside a hatchery, or in hatchery raceways seriously disrupts their navigational responses. The implications of our research findings are immediate and obvious for both wild and hatchery fish. Anything that disrupts the magnetic environment of the fish at any time during their life history can result in decreased homing (increased straying). Examples of disruptive magnetic influences would include rearing fish inside hatcheries with electrical or magnetic (= iron) influences, transporting fish down river inside metal tanks or barges, constructing large metal structures in nearshore areas (wave generating structures), laying electrical transmission cables near hatcheries or migration routes, or

passing fish through hydroelectric dams. Our hypothesis is that fish develop their geomagnetic sense at a very early age, and use that ability to characterize their "home" location, and subsequently imprint on the geomagnetic coordinates of the location where they move from fresh to salt water as juveniles. They use geomagnetic cues for their ocean navigation and to return to the area of their freshwater home river. Our predictions are that if we rear fish in conditions with simulated geomagnetic conditions we can control the return migration of those fish as adults to specified locations. Continuation of this research will require at least one generation of the test species (Chinook and steelhead).

The second approach we have taken to study homing and straying has been directed to olfactory imprinting. Fishery managers rely extensively on the assumption that the homing of wild and hatchery fish depends critically on their exposure to particular water sources around the time when juveniles move from freshwater to the ocean as smolts. The smolts imprint on that water, and selectively return to that chemical signal when they return from the ocean to their natal freshwater habitat for spawning. However, the management of this homing response of the fish is less than perfect, and consequently there is often a high stray rate of hatchery fish to areas other than their desired release sites. We are testing the hypothesis that the fish develop sequential imprinting during early life history, first to the water they experience during incubation in the spawning gravel before they imprint on the water they experience as smolts. We have initiated a series of experiments with collaborators from NOAA, Washington and ODFW to test this hypothesis. We have discovered that fish selectively imprint on surface (= river or stream water) during incubation, but not well water. This has very important consequences for management of hatchery fish, because some hatcheries operate on well water, some on river water, and others transfer fish between the two sources of water at different times during development. Our prediction is that this will result in increased stray rates in those hatchery fish, with all the negative consequences listed above. The need for continuation of this research is to test our predictions at a production hatchery, with one group of fish incubated in well water and matched groups reared in surface (river) water. The fish will be identified by appropriate tagging methods, released as smolts and the behavior (homing or straying) of returning adults will be monitored. This will require at least one generation of the test species (Chinook and steelhead).

References

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Rand, P. S., B. A. Berejikian, T. N. Pearsons, D. L. G. Noakes (editors). 2012. Ecological interactions between wild and hatchery salmonids. Springer Academic Publishers, Dordrecht. 361 pp.

Budget Estimate (Assumes 5-year project – annual cost estimates)

Personnel	
1 postgraduate student	$30,000
2 seasonal student assistants	$24,000
Transportation	
Vehicle rental – OSU Motor Pool	$12,000
Local – between Corvallis and OHRC	
Local – between OHRC and ODFW hatcheries	
Fish tagging, marking, tracking, monitoring	$10,000
Feed and Rearing Expenses	$16,000
OSU Indirect, communications, computer	$12,000
ANNUAL TOTAL (estimate)	**$104,000**
PROJECT TOTAL (estimate)	**$520,000**

(NOTE: budget estimate ASSUMES significant contributions "in kind" from ODFW fish hatcheries, OSU personnel)

Oregon Hatchery Research Center
Dr. Michael Banks, Director, Cooperative Institute for Marine Resources Studies Director
Oregon State University
January 2014

Research Proposal - Wild-like Mate Choice Pairing in Hatcheries
Cost Estimate: Varies depending on research focus

WILD-LIKE MATE CHOICE PAIRING IN HATCHERIES

A. Apply cutting edge genomic and bioinformatic tools to study mate choice among coho salmon observed in a natural spawning context (Calapooya Creek, Umpqua River Valley). A previous ten-year genetic pedigree studied here provided conclusive proof that wild origin fish had greater total life-time fitness than their hatchery origin counterparts (Thériault et al 2011). Our goal would be to direct a new research program led by an assistant professor to characterize, compare and analyze aspects of the genomes among alternate pairs (WxW, HxH as well HxW mate pairs from the Umpqua River coho study) in sufficient detail so as to elucidate which genomic choice combinations resulted in offspring of greater fitness.

Timeframe: 3 years, cost: $1.3 million (assuming 10% overhead)

B. Develop cost effective, rapid turnaround assays to characterize these discriminatory genomic features among putative hatchery broodstock determined from step 1 (i.e. characterize them using the same markers hypothesized that wild fish use to select most compatible - and thus fit - mating partners).

Timeframe: 1 year, cost: $350K (assuming 10% overhead)

C. Experiment with hatcheries (including OHRC) to modify hatchery spawning practice so that pairs mated in hatcheries better match choices made by wild fish in a natural context. Broodstock will be assayed immediately after collection to determine their status regarding mate choice discriminatory genomic features (using findings from phases 1 and 2). Hatchery spawns can then be conducted to emulate “wild-like mate choice pairs”. Experiment goals would be to construct replicate study cases: some replicates would employ the artificial wild-like mate choice as determined from 1 and 2, other replicates would mate pairs selected at random, yet others would mate pairs using traditional methods applied in current hatchery practice (perhaps both 1-1 or 2-5 male-female bucket type mating strategies). Offspring for all replicates would be released using consistent methods across all mate types and ultimate proof of concept would be pedigree assay and fitness analysis among returns identified back to mating type (as in Thériault et al 2011). Three consecutive years would be required (to control for confounding forces of variable survival under different environmental conditions) and relative fitness of offspring from these alternate crosses should be followed for three generations (to assess deeper importance of fitness differences observed).

Timeframe: 12 years, cost: $5,760K (assuming 10% overhead)

Overall timeframe: 17 years and grand total cost: around $ 7.5 million

Thériault, V., G.R. Moyer, L.S. Jackson, M.S. Blouin, and M.A. Banks**.** 2011. Reduced reproductive success of hatchery coho salmon in the wild: insights into most likely mechanisms. *Molecular Ecology* 20(9):1860–1869.

Appendix 4: 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 Advisory 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 2013 we had 15 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 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 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 in include Dr. Andy Dittman (NOAA, Seattle), OHRC, ODFW and OSU personnel. A new postgraduate student, Joseph Lemanski, supported by a McNair Scholarship has begun his M. Sc. research with this group. 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 submitted for publication in Fisheries. Oral papers from this project will be presented 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 (Corvallis). 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 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 one selected 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.

(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 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. We have been 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. Two major papers have been published from this research and three more are in progress. We have shown conclusively that both Chinook 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 spectacular 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. She is supported by 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 will continue these experiments as funding is available, 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 are assisted by Dr. Eric Billman, a postdoctoral research associate, one graduate student (Julia Unrein), 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. This project, together with the steelhead wild surrogate project, are perhaps the clearest examples of studies to determine what 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, 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 extremely successful with this project. We have provided thousands of fish that perform in almost every way the same as wild conspecifics, in contrast to conventional hatchery fish. We have made numerous oral and written presentations of our results to the Corps, in the form of 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. For example, three of our papers from this project were key presentations at the International Smolting Conference in Iceland in 2013, and all are now in publication in the primary scientific literature. Our results from this and the steelhead wild surrogate project have immediate and significant implications and potential applications for ODFW and other management agencies. Our results inform management personnel on the practices and procedures to follow if they wish to minimize (or maximize) the 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. However, the logical completion of this project would be a production scale test of our rearing procedures with hatchery Chinook salmon and steelhead. The test will be a matched comparison of survival, reproductive fitness and life cycle completion of fish reared under our protocols, compared to conventional hatchery fish and naturally-produced 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, was initiated in 2013. A new postgraduate student, Kate Self, is working on this for her M. Sc. degree, supported by Corps funding. 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. As with the Chinook wild surrogate project the ultimate test will be a production scale field experiment to determine reproductive fitness of fish reared according to our specifications, compared to conventional hatchery fish and naturally-produced fish.

(5) Engineered log jams (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. Planning for this project took more than 1 year because of the complexity, the need for permits to collect wild coho salmon, and the schedule for use of the experimental stream channels at the OHRC. Funding came from NSF awards to Dr. Tullos, with support in kind from the USFS, and the OHRC. All personnel, supplies and equipment were provided by NSF funds to Dr. Tullos. Her NSF funds also paid for the use of the stream channels, and all modifications to the channels for her observations. This was undoubtedly the most complex technical project conducted thus far at the OHRC. Drs. Tullos and Dunham have made several oral reports and

presentations already, and they are preparing several manuscripts for publication in the primary scientific literature. The project required significant physical restructuring of the stream channels, placement of large logs and woody debris, and extremely detailed physical measurements of water flow and fish behavior. For example, they took about 17,000,000 measurements of water flow alone during this experiment. The project was motivated by long-standing concerns with stream habitat, habitat restoration and fish production in Oregon streams. Very considerable efforts are devoted each year, in fact often required by legislation, to placement of large woody structures or debris in Oregon streams and rivers – with no measurement or monitoring of the consequences for fish production. This project will provide definitive information on the effects of wood placement on habitat structure and water flow, and most importantly on behavior, survival and growth of fish. The implications and applications of the results from this project are numerous, obvious and highly significant – hence the NSF funding for the project. Undoubtedly the results will change the "common sense" approximation that most people apply to wood, rivers and fish in Oregon and elsewhere in the Pacific Northwest. The results might even change legislation in this area, much of which is based on suppositions and estimations, rather than scientific data.

(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 will be completed in 2014. The project involves detailed collaboration with colleagues at the OHRC, OSU, University of Hawaii, and the Sea Lamprey Control Branch of Fisheries and Oceans Canada. The expertise of our collaborators includes genetics, life history, ecology, history, development and statistical analysis. Funding has been provided by the collaborators, supplemented by some operating funds from the OHRC. The concern derives from two publications that suggested sex change might occur in salmon as result of differences in early rearing temperatures. Those publications relied on estimates of population sex ratios, and while suggestive are not definitive. We carried out an extensive, controlled study to provide a definitive answer to this question. We reared steelhead under three different temperatures (ambient = normal rearing conditions at the OHRC; chilled, and heated). We determined the genetic and phenotypic sex of individual fish, so we can state with certainty whether individual fish change sex. We compared fish from hatchery and wild parents, over two successive years, to strengthen our conclusions. With a sample size of about 10,000 fish we are quite confident of our results. While there may be differences in sex ratios in different groups, there is no evidence of sex change of any individual fish at any rearing temperature. We have presented our results at a number of scientific meetings here in Oregon, in Hawai'i and elsewhere, and we are preparing the report for publication in the scientific literature. 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.

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

This project is conducted by Dr. Michael Blouin and his postgraduate student, Neil Thompson. 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. His funding for this project comes 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 by a Japanese colleague, Professor Arimune Munakata, from Miyagi University in Sendai, Japan (the location of the 2011 earthquake and tsunami). 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} 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.

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

This project has been conducted by Drs. Michael Banks and David Noakes, with very considerable cooperation from ODFW hatchery personnel and fishery biologists. 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. 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 new postgraduate student, Will Heemstra, 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. 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 is being used to determine the location of outplanting releases of steelhead smolts from the hatchery, and will be 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, it was the subject of a feature story in The Oregonian and has been presented by us a number of times to meetings of the OHRC Advisory Committee and other groups.

(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 conventional management procedure is to estimate smolt production, and hence freshwater productivity based upon estimates of the numbers of juvenile smolts trapped on their downstream migration to the Pacific Ocean. The techniques and technology for sampling the juvenile smolts, and for interpreting the smolt numbers as part of the larger life cycle monitoring and management of the species are well known and widely accepted by ODFW and other

management agencies. The project is being led by Drs. Carl Schreck and David Noakes, with assistance from ODFW and OHRC personnel, and OSU postgraduate students. Initial funding was an operating research grant from the Pacific Ocean Shelf Tracking network (POST) that has deployed acoustic receivers along the coast from California to Alaska, and has put active acoustic transmitting tags into large numbers of salmon and other marine invertebrates throughout that range. We tagged and tracked wild steelhead smolts in the Alsea and Nehalem rivers over 2 years (2009, 2010), and compared our results to a similar tagging and tracking program by ODFW on hatchery steelhead smolts in the Alsea River. The first papers from our study have been published and widely distributed, and all the participants in this project have given many presentations on this project. The research was incorporated into the graduate research projects of Camille Leblanc (Ph. D.) and Jeremy Romer (M. Sc.). Among our many significant findings the one that drew the most immediate attention was our discovery that only about 50% of the steelhead smolts enumerated at the standard counting traps actually survived to the Pacific Ocean. Our finding immediately resulted in a change in management by ODFW, to include predator hazing of cormorants on selected Oregon coastal rivers. We have continued our analyses of these data, with ongoing support from OHRC and OSU budget contributions and in kind services from personnel now at OSU, ODFW and Holar University College in Iceland. We are now assessing the features of each smolt in relation to behavior and survival during migration. We have discovered that the sex ratio of smolts moving downstream is significantly female-biased. Furthermore, in at least some years there are also significant male-biased mortality rates. We are also looking at effects of the size of smolts, river and weather conditions and health of fish as they might relate to survival. We regularly present updates on this project to the OHRC Advisory Committee/Board, at scientific meetings and to interested citizen groups.

(12) Barriers and fish passage (Mission Goals 1.b., 1.c., 2.a.1., 2.c.)

This project came to the OHRC originally from ODFW program managers who have an ongoing need to understand the performance of fish passage structures in relation to fish behavior. Fish barriers and fish passage, whether at natural barriers such as waterfalls, or at dams and other constructions, have very high priority throughout the Pacific Northwest. The fish ladder at the OHRC was designed to be flexible in terms of operations for exactly this purpose. Funding is provided by external agents (typically commercial suppliers) who are developing alternative passage structures or operations. OHRC support is provided in the form of in kind personnel effort and some facilities. This work has been ongoing since the first year of operation of the OHRC, with one or two approaches to us each year. Typically we conduct pilot scale tests of equipment, most often using the OHRC raceways. Progress reports are made on a regular basis to the OHRC Advisory Committee/Board. Unfortunately we have yet to find any of these designs to offer any significant advantages over existing procedures and policies. Operation of the equipment is often unpredictable and unreliable and if fish are tested with the installation the results are inconsistent at best. While this remains a high priority for us at the OHRC we do not anticipate any significant advances that would affect installations or operations by ODFW or any other agencies. Our own work on this subject takes place in detailed field studies of tagging and tracking wild and hatchery Chinook and steelhead. Those studies, supported by the USFS, the US ACOE and ODFW take place in the Umpqua River basin and at a number of dams and reservoirs in the Willamette River basin. Our studies include both juveniles (smolts) and adults of both species, with direct (telemetry) observations of movements, survival and spawning (adults) of tagged fish. Sierra Lewis carried out her studies of wild and hatchery steelhead at Soda Springs Dam, using both tagging of adult fish and studies of marine-derived nutrients in forest vegetation above the dam. Her thesis has been completed and two manuscripts are in preparation for publication in the primary scientific literature. Our studies of juvenile Chinook and steelhead use fish that we rear under controlled conditions at the OHRC to produce hatchery fish that are as similar as possible to wild individuals. In our studies thus far we have identified

key features of early rearing that produce hatchery fish much more like wild fish than does conventional hatchery production.

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

This project is a continuation 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 have been published in several papers in the primary scientific literature. Her research was supported by funds from the OHRC and OSU. 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 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 is now moving to the production scale testing necessary to determine if these fish can be produced by ODFW hatcheries and stocked as smolts. 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.

(14) Moist Air Incubator (MAI) – Otolith marking (Mission Goals 2.a.2, 2.d.)

This project was initiated by requests from ODFW hatchery managers in response to requests from local anglers, STEP personnel and other local stakeholders. The Moist Air Incubator is a new device from Alaska that has attracted a lot of attention from STEP volunteers and local fish biologists, as well as anglers and other stakeholder groups. The advantage of the MAI is that it requires much smaller volumes of water for holding and incubating developing embryos from the time of fertilization until hatching. It also provides much better temperature and water quality control, with much less energy input and therefore lower operating costs. This project has been supported by OHRC funds, OHRC personnel and OHRC facilities, together with significant in kind and other support from ODFW. The project began in 2012 and continues over successive steelhead, rainbow and Chinook year classes. We obtained one of the devices from the supplier (Alaska) – and discovered catastrophic operational problems – that were eventually remedied by the manufacturer (details in earlier reports to the OHRC Advisory Committee). We found that indeed the MAI does require less water, has better temperature control and uses less energy than conventional incubation procedures. There are important and significant species differences in the suitability of the MAI. In general, smaller eggs pack more tightly and have much higher mortality rates than larger eggs. This would be a major consideration for installation and operation in Oregon. However, fish of any species must be moved from the MAI to conventional trays or trays as soon as they hatch. This is a major limitation of the MAI and our recommendation to the ODFW hatchery managers was that unless they had special circumstances we would not recommend acquisition or operation of MAI units. The only circumstance that we anticipate as useful for MAI is the

precise temperature control to create thermal marks on otoliths of fish between the time of fertilization and hatching. With collaboration of Dr. Yongwen Gao of the Makah Tribal Fisheries we have carried out such temperature experiments with the MAI. Otoliths from those fish are now being processed to determine if thermal marks were created and if the MAI could be useful for that purpose in production hatcheries. Currently production hatcheries rely on heating and chilling huge volumes of single-pass water to create thermal marks on fish during development. The control of temperature in those situations is not precise, and it requires very significant expenditures of energy (= money) to heat or chill hatchery water. The results of our thermal marking project with the MAI are of considerable interest to ODFW hatchery personnel and ODFW program managers. At present if hatchery fish are to be marked by thermal treatment it requires installation and operation of very expensive heating and circulation equipment. If thermal marks can be created in otoliths with the MAI that could represent a considerable saving for hatchery operations. The large unknown that we have yet to resolve is whether thermal marks will be formed in the MAI, since fish are held there only for a short time early in their development.

(15) 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. 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 are in the process of analyzing 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. If the results are positive it means that 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 Advisory Board at regular meetings are available on the OHRC website.

Billman, E. J., Noakes, D. L. G., C. B. Schreck, C. Sharpe, J. Unrein, O. Hakanson, R. Chitwood, and R. Couture. 2013. Raising the wild child: wild fish surrogates for UWR spring Chinook salmon, *Oncorhynchus tshawytscha*. Oregon Chapter of the American Fisheries Society Annual Meeting. February 2013.

Billman, E. J., Noakes, D. L. G., C. Sharpe, and C. B. Schreck. 2013. Wild fish surrogate project for Upper Willamette River Chinook and steelhead. Annual Coordinating Committee Meeting for the Oregon Cooperative Fish and Wildlife Research Unit, November 2013.

Billman, E. J., L. Whitman, K. Schroeder, C. S. Sharpe, D. L. G. Noakes, and C. B. Schreck. 2013. Body shape predicts life history tactic in juvenile Chinook salmon. Journal of Fish Biology (in review).

Chitwood, R, E. J. Billman, C. Sharpe, D. L. G. Noakes, and C. B. Schreck. 2013. Tactics to produce wild movement phenotypes in artificially reared spring Chinook salmon. August 2013. The 9th International Workshop on Salmonid Smoltification, Reykjavík and Hólar, Iceland.

Cole, K. S., Thompson, D. L. N. N., Blouin, M., & Morrison, B. 2013. Does Exposure to Elevated Temperature During Early Development Affect Sexual Development in *Oncorhynchus mykiss*. North Pacific Anadromous Fish Commission Technical Report No. 9: 101 – 103.

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.

Ismail, G., D. L. G. Noakes & D. Sampson 2013. Current status and conservation of Lake Lanao endemic fishes. Environmental Biology of Fishes 97:1 – 10.

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., Dittman, A. H., Couture, R. B., J. O'Neil & T. P. Quinn. 2013. Imprinting of hatchery-reared salmon to targeted spawning locations: A new embryonic imprinting paradigm for hatchery programs. Nagasaki University, Faculty of Fisheries. June 2013.

Noakes, D. L. G. & N. F. Putman 2013. Geomagnetic imprinting and navigation. Nagasaki University, Faculty of Fisheries. June 2013.

Noakes, D. L. G. & N. F. Putman. 2013. How salmon find their way home. Carleton University, Biology Department. October 2013.

Noakes, D. L. G. & N. F. Putman. 2013. Animal magnetism: how salmon find their way home. McMaster University, Psychology Department. October 2013.

Noakes, D. L. G., A. Dittman, R. Couture, J. O'Neil, T. Quinn & C. Schreck. 2013. Olfactory imprinting in salmon and steelhead. International Ethological Congress, Newcastle, England. August 2013.

Noakes, D. L. G. & N. F. Putman. 2013. Geomagnetic imprinting and navigation by Pacific salmon. University of Western Ontario, Advanced Facility for Avian Research. September 2013.

Noakes, D. L. G., A. Dittman, R. Couture, J. O'Neil, T. Quinn & C. Schreck. 2013.Olfactory and geomagnetic imprinting of salmon and steelhead. August 2013. The 9th International Workshop on Salmonid Smoltification, Reykjavík and Hólar, Iceland.

Noakes, D. L. G., L. Bouvier. 2013. Threatened fishes of the world: the end of the series. Environmental Biology of Fishes 96: 1139 – 1149.

Noakes, D. L. G., C. Sharpe, E. J. Billman, and C. B. Schreck. Development of a wild fish surrogate for UWR spring Chinook salmon *Oncorhynchus tshawytscha*. Willamette Fisheries Science Review, February 2013

Pearsons, T.N., Murauskas, J.G., Larsen, D.A., Beckman, B.R. & A.H. Dittman. 2013. Hitting the right target; six rearing strategies to optimize salmon conservation objectives. Hatchery International. 14: 26-28.

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.

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.

Schreck, C. B., E. J. Billman, J. Unrein, R. Chitwood, C. Sharpe, and D. L. G. Noakes. Determinants of juvenile downstream movement behavior. August 2013. The 9th International Workshop on Salmonid Smoltification, Reykjavík and Hólar, Iceland.

Unrein, J., E. J. Billman, Chitwood, C. Sharpe, R. Couture, Noakes, D. L. G., and C. B. Schreck. Assessing downstream movement behavior of spring Chinook salmon reared under various experimental and conventional conditions. Oregon Chapter of the American Fisheries Society Annual Meeting. February 2013.

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. The two publications by Putman have resulted in more than 200 media articles throughout Oregon, across the USA and internationally.

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., M. M. Scanlan, E. J. Billman, J. P. O'Neil, R. B. Couture, T. P. Quinn, K. JH. Lohmann & D. L. G. Noakes. 2014. An inherited magnetic map guides ocean navigation in juvenile Pacific salmon. Current Biology 24: 153 – 165.

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http://green.blogs.nytimes.com/2013/02/07/the-sockeyes-secret-compass/
BBC, Sockeye salmon 'sense magnetic field of home'
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http://www.nytimes.com/2013/02/21/opinion/how-salmon-follow-the-compass-home.html?_r=0
Wall Street Journal, For Salmon, Magnetic Fields Point the Way
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NPR, Animal Magnetism: How Salmon Find Their Way Back Home
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National Geographic, Mystery Solved: Salmon Navigate Using Magnetic Field
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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 will be given at the annual meeting of the Oregon Chapter 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 will host 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 2013 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.

David Noakes continues as one of the Co-PI personnel for the Oregon Coast STEM (budget details listed below). 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.