The Oregon Hatchery Research Center: An experimental laboratory in a natural setting

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Discussions and debates about hatcheries and differences between hatchery and wild salmon have a high profile in the Pacific Northwest (Araki *et al*. 2007). Oregon has taken the lead to resolve these debates by establishing the Oregon Hatchery Research Center (OHRC). We will describe the OHRC (Figure 1), but first we will give a brief review of some history to put things in context. We apologize to readers for this brief summary of fish hatcheries and hatchery production. We risk belaboring the obvious because it is important for us to draw the distinctions we will make later in this article. Hatcheries and hatchery production of fishes have a long history in North America and elsewhere (Fishery Board of Scotland 1886, Maitland 1887, MacCrimmon 1965, Moring 2000). There are records of captive production and rearing of fishes in China from at least as early as 2,000 BCE. Hickling (1962) summarized the early history of aquaculture in China, Europe and elsewhere. Those earliest examples of captive breeding and rearing of fishes have continued their role in food production for direct human consumption, in what usually is described as intensive culture or fish farming. Fish farming, like other kinds of intensive production, is perhaps the most widely known form of aquaculture (Bardach *et al.* 1972, Huet 1970). Fish farming is one of the most rapidly growing forms of animal production, including a variety of marine and freshwater species (Leitritz and Lewis 1980, Pullin and Lowe-McConnell 1982, Smitherman *et al.* 1978, Usui 1991, FAO 2006). Fish farming is currently dominated by China, a consequence of its long history there and the large human population with a tradition of fish consumption (Figure 2).

Another form of aquaculture, usually described as extensive culture, involves the production of fishes under controlled conditions, but then stocking of them into open waters. Those fishes are intended for later harvest by humans, either by recreational or commercial harvest (Brannon *et al.* 2005).

The other major form of aquaculture is directed to conservation or restoration of fishes that are of concern. This type of aquaculture is much more variable, depending on the species in question, details of the location and the management needs. We repeat what must be the obvious here, because the distinctions and differences seem to be lost on many of the general public. We hasten to add that there can also be confusion because there may be hatcheries operated for intensive

Fig. 1. The Oregon Hatchery Research Center, Fall Creek, Oregon.

Fig. 2. Grass carp, Ctenopharyngodon idella*, served as part of a banquet at Huazhong Agricultural University, Wuhan, China.*

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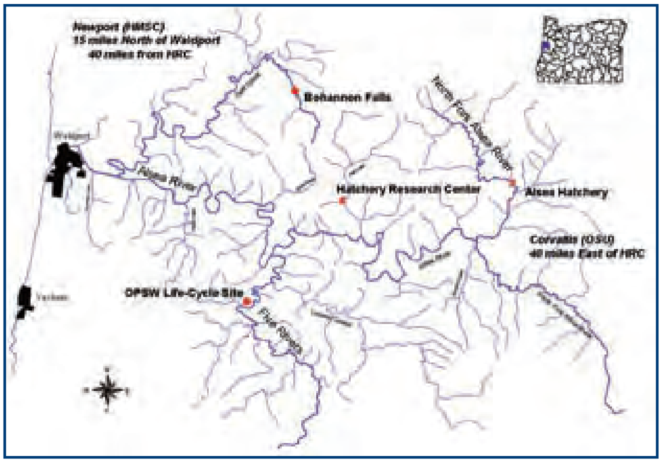

Fig. 3. Map to show location of the Oregon Hatchery Research Center in coastal Oregon.

production, extensive stocking and restoration or conservation in the same geographic area, perhaps with the same fish species (Waples 1999). The history of salmonid hatcheries in North America dates back to at least 1857 (MacCrimmon 1965). Salmonid hatcheries operated for extensive production, and for conservation and restoration, have grown and developed considerably since then. In North America, salmonid hatcheries are widespread, especially along the Pacific coast.

The subject of our research and management for this article is the design and operation of fish hatcheries for extensive production and for restoration or conservation. Most of our activities are directed toward salmonids in the Pacific Northwest, but as we shall discuss, the details are not critical. We do not consider intensive production hatcheries or fish farms. This distinction is important, since many people assume that hatcheries are equivalent to fish farming.

History of the Oregon Hatchery Research Center

The concept of a research center dedicated to studies of hatchery and wild salmonids originated with Lindsay Ball, the Director of the Oregon Department of Fish and Wildlife from 2001 to 2005. As the idea developed it gained broad support, from the Natural Resource Committee and the Ways and Means Committee of the Oregon Legislature, the Legislative Leadership, the Governor's Office, Oregon's Department of Fish and Wildlife, Oregon State University, and the Department of Fisheries and Wildlife of OSU. There has been broad public interest and support for the OHRC, especially from anglers, since its inception.

The proposal for the OHRC was reviewed and supported by the Independent Multidisciplinary Science Team (IMST). Members of the IMST are appointed by the Governor of Oregon to review science proposals or projects that are of general significance or have a high public profile. The IMST convened a Planning Workshop for the OHRC in October 2003. The Workshop brought together 40 scientists, managers and engineers from throughout the Pacific Northwest. They reviewed and discussed scientifically credible knowledge, data and publications to identify:

1. Unique research regarding hatchery and wild salmon issues.
2. The breadth and scope of potential experiments that would help resolve those questions.
3. Design plans for a facility that would maximize flexibility and accommodate a wide range of current and anticipated investigations.

The research goals of the OHRC are to use hatchery fish responsibly to support viable populations of wild fish and sustain sport, commercial and tribal fisheries; to understand biological processes and management implications on scales from individual fish to the landscape and to identify hatchery practices that minimize the impact of hatchery facilities on the natural environment.

The potential research questions to be addressed by the OHRC include:

1. Reproductive success of mating fish of hatchery and wild origins.
2. Influence of incubation, rearing and release strategies on behavior and survival.
3. Spawning success of hatchery fish in the wild.
4. Hatchery fish re-adaptation to the wild environment.
5. Relative importance of genetic and environmental influences on fish performance.
6. Balancing harvest of hatchery fish while minimizing impacts on wild fish population.
7. Inadvertent effects of domestication.

Funding Model

The OHRC facility is owned by the Oregon Department of Fish and Wildlife (ODFW), and is operated jointly under a Memorandum of Understanding between the ODFW and the Fisheries and Wildlife Department of Oregon State University. The OHRC receives one million dollars each biennium from the ODFW. In addition to salaries, that budget includes funding for student support, one-half of the Senior Scientist's salary and basic research and facility operations. Additional funding for operations, education, outreach and research comes from a variety of external sources. In particular, the Oregon Watershed Enhancement Board (OWEB) has provided substantial funding, both for initial construction and subsequently for research equipment such as video cameras and recorders, microscopes, field collecting equipment and analytical laboratory equipment.

Some Details of the OHRC

The Mission of the OHRC is to:

1. Understand mechanisms that may create differences between hatchery and wild fish.
2. Develop approaches to manage the differences to meet fishery and conservation goals.
3. Help Oregonians understand the relationships among wild fish, hatchery fish and the surrounding environment.

The OHRC is located on Fall Creek, a tributary of the Alsea River, in the Coast Range of Oregon (Figure 3). The facility was designed and constructed to accommodate the full range of experiments that might be required to address questions related to hatchery and wild fish. We take water for the OHRC, to a maximum permitted quantity of 0.68 cubic meters per second (cms), from Fall Creek (0.62 cms) and Carnes Creek (0.06

Fig. 4. Air-lift system to recirculate water in stream channels. Compressed air injected through smaller grey pipe lifts water up larger white pipe.

Fig. 6. Water intake from Fall Creek at the OHRC.

cms). With two exceptions, all water flow through the OHRC is by gravity through a network of approximately 10 km of (mostly) underground plastic (HDPE) pipes and valves. The two exceptions to gravity water flow are a water re-use system for the stream channels, and a water treatment facility inside the research building. The water re-use system for the stream channels injects compressed air from turbines (Figure 4) into the water outlet from each stream. This operates as an airlift to recirculate water back to the head of the stream channel, and to increase water flow in each channel by up to 50 percent to a design maximum flow of 1.4 cms.

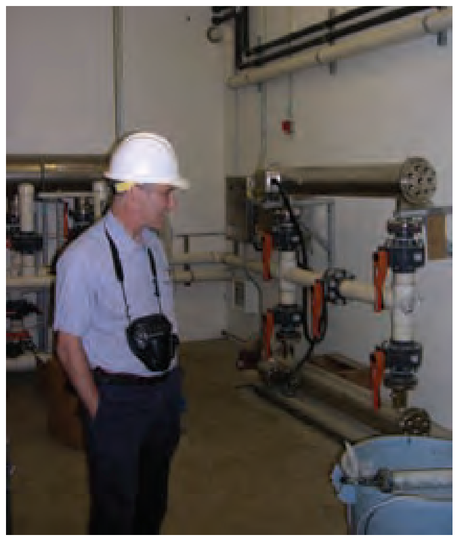

Fig. 5. Dr. Dan Edge, Head of Fisheries and Wildlife Department at Oregon State University, inspects the water treatment facility at the OHRC.

The water treatment facility is located inside the main research building (Figure 5). We take intake water from Fall Creek, Carnes Creek or a combination of the two, put it through a micron filter, sterilize it with ultraviolet light and then adjust the temperature (cold, ambient, or warm) with counter-current heat exchangers. This water is then available for controlled experiments in the wet lab. Water is put through an abatement pond it is returned to Fall Creek.

Water is taken from Fall Creek through an automated intake (Figure 6). The intake meets current NOAA standards, including screens. An innovative system was designed and installed to clean these intake screens. When activated by an automated programming system, the series of electrically driven brushes rotate against the intake screens to loosen debris that is moved away by the sweeping water flow. Water can be directed to a number of locations and functions, depending on research needs.

The stream channels are a key feature of the OHRC (Figure 7). Water from the intake flows through a settling pond, to allow large silt and sand particles to drop out before it passes through the four replicate channels, each 65 m long, 6.5 m wide and 2 m deep. River gravel, large wood, root wads and stones can be arranged within each channel as required in each experiment. Automated PIT tag detectors in the channels can be used to record positions and movements of fish in the channel. A series of television cameras, mounted about 3 m above the channels, can be remotely controlled from the dry lab, and used to record the behavior of fish in the channels. We have had steelhead, coho and Chinook salmon spawn successfully in the channels, and we have subsequently reared hundreds of juveniles resulting from those spawning events. The juveniles feed solely on natural benthic invertebrate production in the channels

Fig. 7. Experimental stream channels at the Oregon Hatchery Research Center.

Fig. 8. Juvenile steelhead, Oncorhynchus mykiss*, reared on natural prey in stream channels.*

Fig. 9. OHRC main building, with tank farm in the foreground.

Fig. 10. Assistant Manager Joseph O'Neil (left), Facility Manager Ryan Couture (center) and Technician Joyce Mahr (right) at the Oregon Hatchery Research Center.

and grow as well as fish from the same cohorts reared on formulated diets on our Tank Farm (Figure 8).

The heart of the OHRC is the 1672 m^2 building (Figure 9), with wet and dry labs, meeting rooms, research offices, water treatment facilities, and dormitory space. We can accommodate up to 24 visiting scientists living on site and working on a wide range of research projects. We have wireless connections outside the main building, and high speed Ethernet within the building. All water and electrical systems have alarms in the main building. Our resident staff of three professional ODFW personnel monitors and maintains the OHRC. We typically have resident volunteer hosts, student interns and temporary research assistants working at the OHRC, in addition to the visiting researchers and OSU faculty and students.

Some Ongoing Research, Education and Outreach, and Operations

Three ODFW staff members operate and manage the facility; Ryan Couture, Facility Manager, Joseph O'Neil, Assistant Manager and Joyce Mahr, Technician (Figure 10). There is an Advisory Committee of 15 members from watershed councils, federal, state and Tribal governments, scientists, representatives of commercial and recreational fishers, landowners, farming and logging interests and representatives from educational organizations who advise and assist the Senior Scientist. Regular meetings of the Committee are held quarterly and the agendas and minutes of our meetings are posted on the ODFW website.[3]

During our first year of operation, 2005 – 2006, we had to test all systems and operations at the OHRC. We had to test and verify all systems, including water supplies and drains, flows and water chemistry, electronics systems and ensure that we had uniform characteristics among tanks and replicate stream channels. We had to verify fish performance in tanks and replicate stream channels. We carried out all our testing and verification with wild and hatchery fish, from spawning behavior of adults to development, growth and survival of young fish. During our first year the OHRC received both state and national engineering awards for planning and construction, namely the ACEC Oregon Engineering Excellence 2006 Grand Award, and the Carl V. Andersen Conservation Project Award 2006 from the Association of Conservation Engineers.

Education and Outreach

The OHRC has education and outreach as an important part of our mandate. We assist undergraduate students with requirements for internships. We provide a facility and opportunity for graduate research at the M.S. and Ph.D. level. We provide a venue for professional development programs for staff from Oregon as well as nationally and internationally.

We have an extensive education program with the Lincoln County School Board (Figure 11). The OHRC is also a focal point for the community (Figure 12). We host meetings of local service groups, the Alsea Watershed Council, ODFW and OSU workshops, and other local groups. In November 2007, we celebrated our first Fall Festival, and welcomed more

Fig. 11. Lincoln County School Board class visits at the OHRC.

Fig. 12. Community use of OHRC — dedication of memorial for Ernie Walters Nov. 2, 2007.

than 150 local residents to the OHRC. Our guests ranged from young children to folks well into their 80s and we had something for all of them. We presented a series of hands-on arts workshops, including subjects as diverse as digital photography and fish printing (Figure 13). A wonderful lunch, catered by our neighbors at the Thyme Garden and a tour to see returning adult Chinook and coho salmon rounded out the day. Television (OPB – Oregon and Iowa Public Broadcasting, KATU), radio (Eugene, Oregon KLCC), newspapers, ODFW Newsletter and OSU bulletins help us to spread the word about the OHRC and our programs.

Fig. 13. Fall Creek Salmon Festival at the OHRC, November 2007.

Research

We take the research in our name very seriously. Everything we do, whether conventional research or education outreach to elementary school students, is based on research. With all the facilities at our disposal, we have taken advantage of our location in the natural environment to carry out a diversity of research projects in our first two years. Together with our collaborators and colleagues, we have studied the effects of climate change on benthic invertebrates, the effects of hatchery practices on stress physiology, mate choice and spawning success in Chinook, coho and steelhead, optimal techniques for holding wild broodstock, and the use of stable isotopes to track feeding and growth in juvenile salmonids. Our research has focused on a wide range of techniques, ranging from molecular genetics, through stomach contents analysis, to detailed studies of growth chronology, regulatory physiology and watershed movements of steelhead smolts (Figure 14).

Fig. 14. One OHRC research project involves the study of stable isotopes and fish diets.

Conclusions

Controversies about hatchery and wild salmonids continue, often in the form of strongly held opinions in the absence of experimental scientific evidence. We firmly believe that the resolution of these controversies lies in experimental research. With a clearly defined mission, we continue to invite and welcome research collaborators from around the Pacific Northwest and across the world to join with us in the research needed to resolve these important issues.

Notes

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[3]http://www.dfw.state.or.us/OHRC/

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