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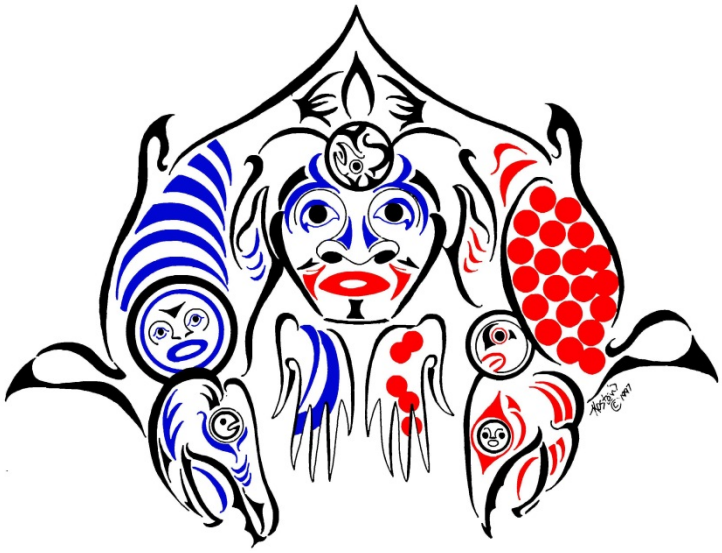

"Restoring Native Species in the Pacific Northwest"

DECEMBER 2-4, 2014

Wildhorse Resort and Casino
Pendleton, OR

Hosted by
Confederated Tribes of the Umatilla Indian Reservation and the Nez Perce Tribe

SESSION 1

Captive rearing environment effects bull trout phenotype: implications for recovery strategies

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The US Fish and Wildlife Service's National Fish Hatchery System is responsible for helping recover species listed under the Endangered Species Act. This is a difficult task considering the funding horizon, climate change predictions, and the status of imperiled populations. In addition, life in captivity has been linked to a suite of negative genetic, physiologic, morphologic and behavioral effects that may influence survival after release. The goal of our work is to develop a biologically sound conservation hatchery program through a better understanding of the effects of captivity on the bull trout phenotype and how that phenotype may effect post-release survival of captive reared individuals. From 2011 to 2013, we collected eyed bull trout eggs from the Metolius River Basin and reared fish in conventional and enhanced captive environments. We compared these fish with wild individuals and have documented differences in prey acquisition ability, "boldness" or exploratory behavior, stress response, and brain development. We are in the process of incorporating this information into a structured decision model with an adaptive framework that will evaluate all bull trout reintroduction strategies and is consistent with the goals and theory of Strategic Habitat Conservation.

Aquaculture developments for burbot *lota lota* intended for population restoration in the Kootenai River.

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Experimental culture of burbot *Lota lota* has been ongoing at the University of Idaho since 2003 as part of a larger population restoration project involving several regional stakeholders for the Kootenai River in Idaho. Since 2011, over 60,000 juveniles and 800,000 larvae have been successfully released as part of this recovery program. These efforts have culminated in the construction of a new burbot and white sturgeon *Acipenser transmontanus* hatchery outside of Bonners Ferry, ID, with juvenile production to begin in 2015 under the management of the Kootenai Tribe of Idaho. While many advances have been made, burbot culture still presents many challenges due to lengthy egg incubation and larval-rearing stages.

For the past three years, burbot eggs have been collected from wild stocks at Moyie Lake, BC. Fertilized eggs must be incubated below 4°C for approximately six weeks, before mass hatching is induced by spiking the temperature to over 9°C. Exogenous feeding commences 10-14 days after hatch, with larvae initially offered rotifers *Brachionus spp*.

After several days, larvae are large enough that artemia *Artemia spp*. becomes the primary live feed. Weaning begins once fish reach 15-20 mm by gradually transitioning from live to prepared feeds over 7-10 days. Dry feed acceptance is variable, and is responsible for continual issues with size differentiation and cannibalization. Regular grading is required until fish are fully weaned and reach 5 cm in length, after which cannibalization becomes less problematic.

From the beginning of egg incubation to the time weaned juveniles reach 5 cm in length, burbot remain a work-intensive species to culture. However, with the continued issues with the Atlantic cod *Gadus morhua* fishery, burbot may become a promising species for commercial culture. Once weaned onto dry feed they exhibit exceptional growth rates. Their flesh characteristics are desirable and they produce high quality caviar.

Determining juvenile burbot susceptibility to stress mediated pathogens

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To determine the susceptibility of burbot *Lota lota maculosa* to stress-mediated disease, a series of studies were conducted to determine the pathogenicity of select bacteria. Epizootics linked to water quality and density occurred in 2012 and 2013 at the University of Idaho's Aquaculture Research Institute. Initial clinical diagnostics and sampling resulted in the isolation of a number of bacterial pathogens. To determine which bacterial species were the most likely causative agents of these epizootics, juvenile burbot were intraperitoneally (IP) injected with bacteria in log phase growth. Mortality associated with specific bacterial species was recorded and more comprehensive challenges followed this initial screening. These challenges used IP and immersion methods for exposure of burbot to potential pathogens. This resulted in significantly higher mortalities in our IP groups compared to controls and no differences in mortality for immersion groups compared to controls. This indicates that both isolates used in the challenge, *Aeromonas* sp. and *Carnobacterium* sp., are pathogenic and potential burbot pathogens. The role of stress in relation to disease severity is being investigated as such additional stressors are likely responsible for the acute and chronic mortality observed during earlier clinical outbreaks during captive rearing. Additional work will focus on linking immersion exposure to specific stressors.

Evaluation of lipid sources in diets fed to the endangered Lost River sucker (*Deltistes luxatus*)

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The Lost River sucker (LRS, *Deltistes luxatus*) was listed as endangered in 1988 by the U.S. Fish and Wildlife Service. Declining LRS populations are the result of habitat loss, diminished water quality, overharvest and entrainment in water management structures. If artificial propagation is required to prevent extinction, information on nutritional requirements of this species will be essential. As a first step in developing nutritionally complete artificial diets for LRS we conducted a feeding trial to determine appropriate source(s) of dietary lipids for this species. Marine fish oil, linseed oil, soybean oil or a 50:50 mixture of these oils were added to a practical basal diet to obtain six dietary treatments. Diets were mixed and pelleted using a Hobart food mixer and pelleting attachment. Each dietary treatment was fed to triplicate groups of 100 juvenile LRS initially weighing 0.47 g/fish. Fish were maintained in 13.25 L circular tanks equipped with flow-through water supply and supplemental aeration. Water temperature was maintained at 18 ± 1°C throughout the experiment. Weight gain, survival, whole body proximate composition and whole body fatty acid data will be reported.

***Anodonta oregonensis*: restoration efforts for an at-risk species**

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The Oregon floater (*Anodonta oregonensis*) (Lea 1838), formerly widespread throughout the Pacific Northwest, has been declining in numbers throughout its historic range. In 2005, a mussel survey of the Umatilla River, Oregon indicated much of the historic mussel population had been eradicated. Freshwater mussels were once an important cultural resource for Tribal people. Today sustainable harvest of freshwater mussels remains a treaty right for the Confederated Tribes of the Umatilla Indian Reservation (CTUIR). The main focus of this research is to restore the once plentiful mussel population to the Umatilla River. We plan to use laboratory propagated mussels to test the feasibility of a reintroduction method without trans-locating adult animals, as well as to guide our restoration efforts. However, little was known about the life history of *A. oregonensis* and, in addition, there were no propagation techniques established for this species. Because freshwater mussels in their larval form are an obligate parasite on fish, conservation and restoration of existing mussel populations require understanding which fish species can serve as hosts. The first objective of this study was to identify host fish for *A. oregonensis*. Once the host fish were identified we were able to test various propagation techniques for *A. oregonensis*. In 2010 and 2014 laboratory experiments identified the redside shiner, speckled dace, margined sculpin, and Chinook salmon as host fish for *A. oregonensis*. The newly transformed juvenile mussels were then tested with various propagation techniques which included; no sediment, different sized sediment, flow through system, recirculating system, no flow system, and two types of feeding plans. Unfortunately, none of the propagation methods tested resulted in rearing juvenile mussels. We will continue to test rearing methods for this species, as well as continue to develop a broader understanding of host fish associations through laboratory studies.

SESSION 2

Innate and learned preferences for natural stream vs. ground water: implications for hatchery practices and natal imprinting in salmonids

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Many hatchery rearing and release practices can dramatically increase the rate of straying by adult salmon returning from the ocean to spawn. Homing is governed by the olfactory discrimination of home-stream water and exposure to the home stream (surface water) during appropriate juvenile stages is critical for olfactory imprinting and successful completion of the adult homing migration. In most hatcheries, the need to control embryonic development rate (temperature) and limit exposure to pathogens dictates that salmon are initially reared on ground water. Salmon often return to the vicinity of their natal site, suggesting that in the wild the period of hatching and emergence may be a critical time for olfactory imprinting. To explore whether exposure to surface water during these embryonic periods is also important for successful imprinting in a hatchery setting, we conducted a series of experiments to examine innate preferences of emergent salmon for surface water vs. ground water and whether prior exposure to these water sources influences these preferences. Embryonic learning studies were conducted with steelhead at the Oregon Hatchery Research Center (OHRC) and spring Chinook salmon at the OHRC and ODFW Leaburg Hatchery.

Embryos were reared in surface or ground water at the different facilities and then tested for attraction to different water sources in two-choice mazes. Both steelhead and Chinook salmon consistently demonstrated an innate preference for natural stream water over ground water. Initial incubation in ground water influenced these preference responses, however, suggesting that salmon are learning olfactory cues during these embryonic stages. These results are discussed in the context of olfactory imprinting and potential implications for hatchery rearing practices.

Characterization of dissolved free amino acids in salmon hatchery water

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Many salmon hatcheries utilize and rely on fishways to gather salmon that return annually to continue hatchery production. Unfortunately, this process is not perfect and many hatcheries observe variable return rates of hatchery-reared salmon to specific fishways, and this may cause varying ecological and genetic effects on wild and native populations. Within the last decade, considerable attention has been directed towards dissolved free amino acids (DFAA) as a set of molecules salmon use to navigate and identify their natal rivers. Research has shown that salmonids possess the ability to distinguish between certain water sources based on their DFAA compositions, correctly identify artificial natal river water based on DFAA composition, and that DFAA compositions often differ significantly between watersheds. The objective of this study was to identify whether the DFAA composition (types and percent composition) differed significantly between river water and water from the same river that has passed through a hatchery. By using ultra high performance liquid chromatography we analyzed DFAA compositions in 6 locations; 3 locations within a hatchery and 3 locations along the river running adjacent to the hatchery. Our results conclude that the composition of DFAA within this hatchery system do not differ significantly from the composition of DFAA in river water. These results might suggest that some of the variability observed in the returns of hatchery-reared salmon to hatchery fishways might be due to their inability to distinguish between hatchery water and river water based on its chemical components. If salmon do indeed utilize DFAA for homing to natal spawning sites, alteration of DFAA composition in hatchery system water during key imprinting and homing periods may be as a possible technique implemented to improve return rates of hatchery-reared salmon to their respective hatcheries.

Smolt quality and spring Chinook salmon survival: a hatchery scale experiment from the Hood River, Oregon.

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A hatchery scale experiment was designed to assess if smolt quality data collected from juvenile spring Chinook salmon could be used as a predictive measure of adult return rates (SARs). A single genetic stock of Hood River, Oregon, spring Chinook salmon, *Oncorhynchus tshawytscha,* was reared at three different hatchery facilities (Parkdale Hatchery, W.Fork Hood R., Round Butte/Pelton Ladder, Deschutes R., and Carson Hatchery, Wind R.) over three brood years (2008–2010) and then acclimated and released in the West Fork Hood River. Fish were monitored prior to release for size, gill Na^+,K^+ -ATPase activity, condition factor, whole body lipid, and plasma 11-ketotestosterone levels. These metrics were chosen because they are good indicators of smolt development, energetic status, and early male maturation (minijack rate) and would provide quantitative and qualitative indices to rank groups across years. Significant differences in smolt quality were found between the three different rearing groups in all three brood years. Based on those metrics, overall smolt quality rankings were: 1) Round Butte/Pelton 2) Parkdale 3) Carson, indicating that Round Butte/Pelton fish were predicted to have a higher SAR than Parkdale, which were predicted to have a higher SAR than Carson fish. Adult return rates nearly followed the predicted rank order in all three brood years for all three rearing groups. This data suggests that there are physiological indicators that can be measured in juvenile salmon that provide insights into adult return rates. Furthermore this study highlights the importance and benefits of releasing quality smolts in order to improve SARs from hatchery production programs.

The wild fish growth template improves smolt quality and survival in hatchery reared yearling summer Chinook salmon

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Smolt quality was monitored in several yearling summer Chinook salmon hatchery programs from the Upper Columbia River Basin over brood years 2006-2009. Fish for all programs were spawned and initially reared at Eastbank Hatchery near Wenatchee, Washington where they experienced similar rearing conditions up until their first fall. During the fall, fish from some programs were moved from Eastbank Hatchery to acclimation sites for over-winter rearing until release the following spring as yearling smolts (in-basin winter rearing). Other groups were overwintered at the Eastbank Hatchery and then transferred to their acclimation sites 1-2 months prior to spring release (out-of basin winter rearing). Thus, fish experienced two contrasting temperature profiles based on these two different rearing strategies. These temperature differences in turn affected winter growth, spring growth, minijack rates, and smolting (measured by gill Na+, K+ ATPase activity). Overall, in-basin winter rearing achieved more desirable smolting profiles, lower minijack rates, and despite smaller size at release, better overall return of age 4-5 adults. These results re-enforce previous studies demonstrating improved smolt quality for fish reared under a program that mimics the growth profiles experienced by wild fish: relatively high growth in the summer, low growth in the winter and a growth increase in the spring. The easiest way to develop this wild growth template is to rear fish in water that undergoes a natural seasonal cycle, with cold temperatures in the winter.

Volitional release of steelhead removes age 1 and age 2 smolts with nonmigratory behavior

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Steelhead hatcheries that obtain broodstock from natural-origin spring spawners may be challenged to produce smolts in one year (S1), which is the approach adopted by nearly all existing programs. Wild summer-run steelhead in the Upper Columbia River exhibit a high degree of plasticity in age-at-smoltification, but predominantly smolt and emigrate at age-2 and age-3. We evaluated the effectiveness of two experimental approaches (age-2 smolt rearing (S2) and volitional release) in reducing the portion of hatchery steelhead that fails to migrate (hereafter 'residuals').

PIT tag interrogators installed in the weir boards of raceway outfalls detected volitional migrants (VM; those that left on their own) from April 15 to May 15. After May 15, all remaining PIT-tagged S1 and S2 steelhead were collected from the raceways and released (i.e., volitional-release nonmigrants, or VNM) from Winthrop National Fish Hatchery. Over three release years (2012-2014), we used pre-release demographic data and subsequent detection data collected from PIT tag interrogation systems at dams in the Columbia River to evaluate residuals.

The percentage of VNM was not different between S1 and S2 steelhead ($p = 1.00$), and ranged from 4.3% to 9.4% and 4.9% to 10.0%, respectively. Average migration rates, measured as percent of PIT-tagged fish detected at any location in the mainstem Columbia River, were significantly lower ($p < 0.001$) for VNM (9.2%) than VM (31.8%), and were not different for S1 and S2 steelhead ($p = 0.95$). In all release years, the pre-release fork length was significantly greater for S2 than S1 smolts ($p < 0.001$), and for VM than VNM ($p < 0.001$). Fish detected in the mainstem Columbia River were larger at release than non-detected fish ($p < 0.001$). We conclude that volitional migration is a useful hatchery management tool for reducing the number of residual steelhead in both S1 and S2 rearing programs, and that volitional release acts primarily by retaining steelhead that were below the size threshold for successful smoltification. As such, size grading to remove small steelhead prior to release may provide another management alternative for reducing the portion of hatchery steelhead most likely to residualize.

SESSION 3

New sockeye hatchery in British Columbia intends to expand range of sockeye in Upper Okanagan watershed; a case study on international collaboration

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The Public Utility Districts of Chelan and Grant Counties in Washington State (the Districts) and the Okanagan Nation Alliance in British Columbia, Canada (ONA), in 2004, embarked on a 12-Year Reintroduction of sockeye salmon program into Skaha Lake, British Columbia. The program is currently in its eleventh year of implementation and has culminated in the construction of a brand new sockeye hatchery in Penticton, B.C. The hatchery is outfitted to incubate five million eggs in a full gravity fed configuration, consistent with strict Alaska Sockeye Protocols. Fall 2014 marks the first year the facility will receive sockeye eggs and milt for on-station fertilization, disinfection, and hardening. Sockeye fry will be released into the adjacent Shingle Creek, a tributary of the Okanagan River, in spring 2015. Funding construction of a fish hatchery outside of the continental United States posed significant challenges for the Districts. These challenges, however, were overcome with diligence and partnership between the Districts, the ONA, and other Canadian agencies and organizations.

Changes in phenotypic and genetic characteristics of natural origin steelhead in a supplemented steelhead population.

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Integrated broodstock management plans have been proposed to minimize the potentially deleterious impacts of hatchery fish spawning with natural populations. The ability to determine a population's genetic characteristics has created an excellent management tool to help preserve populations that may be threatened or endangered. The question arises whether neutral genetic markers are sufficient to detect changes that may arise within stocks that are integrated with a hatchery broodstock program. As part of an ongoing project "Natural reproductive success and demographic effects of hatchery-origin steelhead in Abernathy Creek, Washington", phenotypic and genetic characteristics of the natural-origin winter steelhead population were monitored. Starting in 2005 returning adult steelhead were captured, genetic samples were taken for analysis with twelve microsatellite markers, and scale samples were used to determine saltwater age. During 2005-2008 the saltwater age structure of return years were averaging 53% two year olds and 41% three year olds. From 2009-2013 age structure shifted to an average of 86% two year olds and 12% three year olds. At the same time, microsatellite data did not reveal any changes to allele frequencies, linkage disequilibrium, or inbreeding effective population size. Changes in phenotypic characteristics in the supplemented population may reflect plasticity, or they may reflect genetic changes which were not revealed by the neutral markers.

Use of natural origin Chinook salmon for supplementation broodstock: the Johnson Creek story

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The Johnson Creek Artificial Propagation Enhancement (JCAPE) Project has utilized only Natural Origin Summer Chinook Salmon (*Oncorhynchus tshawytscha*) for brood stock since the project was initiated in 1998. Broodstock is collected over the entire spectrum of the run, based on run timing curves developed from previous returns to Johnson Creek. All returning Supplementation adults and Natural Origin adults in excess of broodstock needs are released above the weir for natural spawning purposes. Genetic sampling and analysis has been conducted on nearly all adult salmon trapped in Johnson Creek. Based on the genetic analysis, using only Natural Origin fish for brood stock has resulted in a demographic boost to the population, reproductive success of the Supplementation Adults was not different from Natural Adults, and there was no evidence of reduced fitness in Natural Adult spawners in the Johnson Creek population.

Captive broodstock program for Nooksack River spring chinook – we grow 'em big in ~~Texas~~ Washington

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In 2006, the Washington Department of Fish and Wildlife (WDFW), Lummi Tribe, Nooksack Tribe, and the Northwest Indian Fisheries Commission, in cooperation with NOAA Fisheries, established a cooperative 10 year captive brood stock program to aid in recovery of the South Fork Nooksack River spring Chinook listed as threatened in 1999 under the Endangered Species Act. Captive brood stocks are a form of artificial propagation in which fish are cultured in captivity for their entire life cycle. Increased survival in protective culture rapidly increases population size, accelerating recovery efforts by producing large numbers of offspring for return to the wild.
The South Fork Nooksack captive brood program employs a dual rearing strategy – half of the fish are reared from smolt to adult in freshwater and half are reared from smolt to adult in seawater. Wild parr (approximately 1000 per brood year), collected in the spring, are divided into the two rearing strategies and reared in captivity for 1 - 6 years, depending on age at maturation. Maturing adults are generally 5 and 6 year olds, reaching an unusually large size for Chinook in captive culture (10 – 20 lbs.). Mature adults are spawned in the hatchery and offspring are released as zero age smolts. Production has increased from 2,000 smolts released in 2011 to 750,000 smolts in 2013. The ultimate goal of the program is to produce a million smolts per year.

The Grande Ronde basin spring Chinook salmon captive broodstock program: So, what worked and what didn't?

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The Grande Ronde Basin of Northeast Oregon historically supported multiple large populations of spring Chinook salmon *Oncorhynchus tshawytscha*. However, a steady decline from 1960 through the mid-1990s, when populations reached critically low levels, necessitated hatchery intervention. The Grande Ronde Basin Spring Chinook Salmon Captive Broodstock Program (CBS) was designed to prevent extirpation by quickly increasing the numbers of adults spawning in nature to the point where a Conventional Hatchery Program could take over and supplement the populations. The CBS was implemented in Catherine Creek, Lostine River, and Upper Grande Ronde River, beginning with collection of the 1994 cohort in August 1995 and it had four overarching gene conservation, management, and research objectives:

1) Prevent extinction of the target Chinook salmon populations.
2) Maintain the genetic diversity and identity of the target Chinook salmon populations, as well as those of unsupplemented wild Minam and Wenaha rivers populations.
3) Ensure a high probability of population persistence well into the future once the causes of basin-wide population declines have been addressed.
4) Provide methodologies to be used in the future to reverse the decline in abundance of endemic salmon populations.

The CBS also had specific targets for hatchery parameters (e.g., collection, growth, survival, fecundity). In October 2013, the last of the CBS salmon were spawned and the Program ended. This presentation provides a general overview of our results and will be an initial examination of our success in achieving those objectives and targets - what worked and what didn't.

The CBS generally met its parr collection and survival rate targets. Male age at maturation was much younger than expected, with the majority maturing at ages 2 or 3, while nearly all females matured at ages 4 or 5. Growth was slower than expected and adults were ~35% smaller (at age) than naturally-reared adults. Bacterial kidney disease (BKD) caused the majority of the mortalities in the program. Fecundity was less than half of that expected, and ~20% of all eggs collected were culled to prevent vertical transmission of BKD. As a result, effective fecundity was about one-third of that expected.

Mean fertility and eyed egg-to-smolt survival rates of the F1 generation were higher than expected but did not overcome the low fecundity and eggs lost to BKD culling, so production seldom attained the goal of 150,000 smolts. Mean smolt-to-adult return rate was higher than expected but well below the Northeast Oregon management goal of 0.65%, and adult escapement rarely exceeded the goal of 150 adults/stream. Age composition of the F1 generation was younger than expected but typical for Northeast Oregon spring Chinook hatchery programs.

The Captive Broodstock Program successfully contributed to increasing numbers of adults spawning in nature in the program streams. However, issues, such as disease and slow growth must be addressed for future captive broodstock programs. The ultimate measure of the success or failure of the CBS Program hinges on increases in natural production and escapement.

SESSION 4

A new concept in moving fish: the Whooshh Fish Transport System

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There's a new technology that's helping to transport fish in Washington. It's called the Whooshh fish transport system or salmon cannon. The system propels adult fish from one spot to another. A long, flexible tube is stretched out into the middle of the river where the trap box is located. At one end, crew members load adults into the tube. The fish are sucked up the 120-foot tube at about 22 miles per hour and then exit into a pond or truck. Small salmon may get stuck in the tube, which is designed to operate with fish from 15 to 30 pounds. Another larger salmon or a water-soaked sponge can be loaded into the tube to move smaller fish through the system. Fish are less stressed with the salmon cannon. WDFW has compared fish transported with the cannon to fish transported by hand or tote. Fish were held for six weeks and no differences in mortality or condition of fish were observed. The unit costs about $150,000.

A review of airlift water reuse technology at Vancouver Island Trout Hatchery

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The Freshwater Fisheries Society of BC (FFSBC) is an independent, non-profit organization with a mandate to provide fish stocking and other fisheries recreation services in British Columbia. FFSBC owns and operates six hatcheries and stocks about 800 lakes and streams in British Columbia each year.

Vancouver Island Trout located in Duncan, BC converted twenty concrete raceways and one fibreglass circular tank to an airlift water reuse system developed by FFSBC in June 2012. This presentation will discuss airlift system operations and optimization in both raceways and circular rearing tanks from a fish culturist's perspective. The benefits to fish and staff, water and energy reductions and our challenges and solutions to changed hatchery practices will also be presented.

FFSBC established 5 objectives at the outset of this project and all were realized as a result of this project:

1. Develop a low capital cost water reuse system that reduces raceway water consumption and its associated electrical energy costs by at least 50%.
2. Safely produce healthy, fast growing fish.
3. Realize reduced equipment maintenance costs.
4. Realize non-energy environmental benefits.
5. Water reuse technology to be accepted by hatchery staff.

Vancouver Island Trout Hatchery reduced water consumption in raceways by about 75% following installation of the airlift system resulting in an annual saving of 3.28 billion litres of water. Overall the hatchery achieved an annual electrical energy savings of about 438,000 kilowatt hours or about $27,000 savings each year. This annual water reduction is expected to significantly reduce pumping system maintenance costs over time although this cannot be quantified at this early date. Hatchery staff has also made additional improvements to the airlift system since the original installation benefiting fish, staff and fish culture operations.

Design improvements, marketing, manufacturing and product sales have since been licensed to a private aquaculture service company and this airlift system will be on display at the 2014 Northwest Fish Culture Conference in Pendleton, Oregon.

Reuse Aquaculture System (RAS) at Hagerman National Fish Hatchery

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Recent claims in circular tank reuse aquaculture systems (RAS) of faster downriver anadromous smolt migration compared to concrete raceways systems and higher number of adult returns, necessitates testing in Idaho fish hatcheries. Hagerman National Fish Hatchery was selected as a site to construct a RAS pilot project to investigate fish survival reared in circular RAS system for several reasons:

1) Southern Idaho, Eastern Snake River Plain Aquifer being depleted 200,000 acre feet annually.
2) Dedicated spring water supply for a RAS system.
3) Infrastructure already in place (i.e. electricity, effluent pipeline, influent pipeline).
4) A willing crew to develop and operate a RAS system.
5) Available funding.

This presentation will discuss what the Hagerman National Fish Hatchery's partial reuse aquaculture system (PRAS) consists of and how it operates. It will also describe considerations that were given to biosecurity, staffing, equipment, maintenance and value engineering.

A case study comparison of modern water use strategies for sport fish and enhancement rearing

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Enhancement and sport fish rearing facilities are faced with the challenges of meeting growing production needs, improving sustainability, and maintaining economic viability through minimizing costs. Addressing these challenges today and in the future requires careful management of increasing limited water resources.

Water reuse technologies, originally developed for commercial aquaculture, are now being employed successfully in enhancement and sport fish rearing facilities. Water reuse systems use water treatment technologies to allow a portion of the culture discharge flows to be used again, significantly reducing new water demand. Water reuse systems may be deployed with either centralized or decentralized treatment solutions.

In centralized reuse systems, water from the culture tank is collected, piped to a common water treatment plant, and then redistributed to the culture tanks. The treatment system consists of a series of unit treatment processes aligned to sequentially improve the water quality. Such systems have been used successfully at the Eastbank Hatchery in Washington and, more recently at the Hagerman National Fish Hatchery in Idaho.

In decentralized reuse systems, treatment of water occurs at each individual culture tank and, in some cases, is integrated directly into the culture tank. One such approach to decentralized treatment has been developed and successfully employed by The Freshwater Fisheries Society of British Columbia (FFSBC) and is now being built under license as the AeroBoost^{TM} Airlift Pump. This system utilizes specifically designed airlift pumps within each rearing vessel to simultaneously improve circulation, improve solids removal, and aerate the water.

A case study approach will be used to compare the application of centralized and decentralized treatment approaches to water reuse for fish rearing systems. The case study will include both a qualitative and quantitative comparison, and will explore the sensitivity of factors affecting selection of one technology over the other.

Post-release performance evaluation of Chinook salmon and steelhead reared in partial water reuse circular vessels compared to traditional flow-through raceways

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Partial water reuse in circular vessels were evaluated as a means to decrease water use while maintaining or enhancing the performance of yearling summer run Chinook salmon and steelhead relative to standard flow-through raceways. Test fish were reared in 9.1 m-diameter dual-drain Cornell circular vessels and control fish were reared in 30.5 m × 3.0 m raceways located at Chelan County PUD owned hatchery facilities near Wenatchee, Washington. Passive integrated transponder (PIT) tags were utilized to evaluate travel time and survival to McNary Dam (> 260 km downstream) of juveniles by rearing vessel type for each release year. PIT tags were utilized to evaluate smolt-to-adult survival (SAR) and corresponding age structure by rearing vessel type for each release year. Additionally, SARs and age structure of adults from release groups were evaluated by length at juvenile tagging and rearing vessel type for each release year. Collectively, the results from these evaluations indicated that partial water reuse with circular rearing vessels can be an effective approach to minimize water use while improving performance of hatchery-reared smolts and adults.

SESSION 5

Yakama Nation Sturgeon Management Project

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The Yakama Nation Fisheries Management Program (FRMP) has been exploring sturgeon culture requirements by rearing small numbers of white sturgeon in tribal hatchery facilities since the 1990s. Fish were obtained from various sources including the private Pelfrey sturgeon hatchery operating downstream from Bonneville Dam and mid-Columbia hatchery research by CRITFC and the USFWS.

The FRMP has constructed a sturgeon hatchery at the Marion Drain Facility which operates under Yakama Nation tribal funding, Fish Accord and mitigation contracts from the Mid-Columbia Public Utility Districts (PUD) of Grant, Chelan and Douglas Counties. The Yakama Nation hatchery program has successfully spawned broodstock in 2007, 2008 and 2010-2014. In 2014 the FRMP has successfully spawned wild brood and is currently rearing juvenile fish for release into the PUD project areas in 2015, which includes the Priest Rapids, Wanapum, Rocky Reach and Wells reservoirs.

The long-term goal of the Yakama Sturgeon Management Project is to facilitate restoration of viable populations and fisheries for white sturgeon in mid-Columbia River and Lower Snake reservoirs. Specific objectives to address near term needs in the first phase of this project include:

1. Assist in the development of a recovery, research and monitoring strategy, and hatchery Master Plan for depleted sturgeon populations in FCRPS portions of the mid-Columbia and lower Snake rivers (facilitated by the CRITFC).
2. Continue to develop critical expertise and refine effective sturgeon culture methodology for spawning and rearing of white sturgeon using tribal staff, facilities and resources, and captive broodstock currently maintained on the Yakama Reservation at the Marion Drain Hatchery.
3. Identify facility and staff requirements and costs of hatchery alternatives for use in research/monitoring and hatchery Master Plan considerations (based on #2 and #3 above).
4. Develop a detailed implementation plan for production and rearing of juvenile sturgeon as appropriate for use in experimental research and hatchery feasibility evaluations (as identified in #1 above).
5. Assist in the development and implementation of effective experimental research and hatchery feasibility evaluations (as identified in #1 above).

This work will be implemented in a collaborative manner with other regional and local fisheries managers and interests in Federal and non-Federal portions of the system to produce coordinated, complementary, and cost effective outcomes. This project will provide dedicated resources to enhance substantive participation and contributions as sturgeon efforts continue to transition from research to restoration activities. The resulting information and expertise will inform the overarching strategic and master planning efforts and expedite subsequent experimental implementation and evaluation of restoration actions.

An overview of white sturgeon collection, sampling and population indexing in the Rocky Reach Reservoir

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Chelan County Public Utility District's (Chelan PUD) program to promote white sturgeon population growth in the Rocky Reach Reservoir of the mid-Columbia River is underway. Under the Chelan PUD Rocky Reach Dam relicensing agreement, white sturgeon brood stock collection, spawning, rearing, and extensive monitoring and evaluation is conducted to support Chelan PUD's sturgeon hatchery production program. In 2014, a total of nine ripe females and 11 ripe males were transported to the Yakama Nation's Marion Drain Sturgeon Hatchery, which resulted in successful M:F spawning matrices (5x5 and 3x5), representing the most successful brood collection and spawning matrix since the initiation of brood collection in 2011. In 2012, acoustic telemetry gear was deployed throughout the Rocky Reach Reservoir as part of a three-year study to monitor movements, habitat use, and survival of the hatchery reared white sturgeon. In 2013, a three-year indexing study using PIT tags for mark and recapture analysis was initiated, as well as habitat typing. Catch per unit effort in 2013 was highest in the upper reservoir, and habitat models suggested that fish released in 2013 were more likely to be caught in areas of lower river velocity. To date, data has shown that fish movement has been predominantly upstream of the release sites in the Rocky Reach Reservoir, especially soon after release. Indexing data from 2013 were also combined with data from the Chelan and Douglas PUD Northern Pikeminnow Removal Program, wherein white sturgeon were incidentally recaptured, to estimate survival of white sturgeon from release to six months (2011 and 2013 releases) and from six months to a year and a half (2011 release). These ongoing efforts will continue to inform Chelan PUD fisheries staff and other fish managers how to best achieve program goals.

Developing techniques for artificial propagation and early rearing of Pacific lamprey (*Entosphenus tridentatus*)

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Pacific lamprey, an important subsistence, ceremonial and medicinal food source for Columbia River Basin (CRB) tribes, is a prehistoric anadromous fish species from the Pacific Coast of North America and Asia. Lamprey abundance is at a fraction of historical numbers and distribution is increasingly limited to the lower portions of the CRB. To prevent further decline and local extirpations, the CRB tribes and a consortium of partnering agencies began developing artificial propagation and early rearing techniques for Pacific lamprey in 2012. Work to date has focused on developing the best methods and techniques associated with gamete holding, gamete fertilization, egg incubation and prolarvae holding, transportation of gametes and larvae, disinfection (adult broodstock, eggs, and larvae), and larval culture. The transition from prolarvae to burrowing and first-feeding larvae appears to be a survival bottleneck with high mortality of early life stages in hatchery settings. Our laboratory work provides important insights into lamprey early life history. For example, early survival bottlenecks may occur in nature as well. Although our methods and techniques are continuously being refined, there is enough knowledge in the Pacific Northwest region to begin a supplementation program to reintroduce and supplement locally extinct and functionally extinct populations. New monitoring associated with supplementation programs, in concert with ongoing hatchery research, will likely reveal other new discoveries about the early life history of lamprey, such as critical food resources and feeding strategies, survival and growth rates, optimal density levels, environmental sex determination, demographics, and migration behavior. In addition, genetic typing of both hatchery-reared and wild larvae holds great promise for assigning parentage, examining mating systems, and identifying genetic traits that have allowed lamprey to persist for millennia.

Effects of ammocoete stocking density and ration size on the growth and survival of Pacific lamprey (*Entosphenus tridentatus*)

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After decades of decline in wild populations, efforts to determine culture methods for the Pacific Lamprey (*Entosphenus tridentatus*) have begun. This experiment investigated the effects of two factors, ammocoete stocking density (ASD) and ration size (RS), on length, weight and survival of 41 days post hatch Pacific lamprey ammocoetes over a 63 day trial. The diet consisted of a 4:1 mixture of active dry yeast and Otohime A. Four levels of ASD (152, 303, 1,515, and 3,030 ammocoetes/m^2) were tested along with two levels of RS (125 mg/L, and 250 mg/L) in a 4x2 factorial with three replicates per treatment level. The interaction of ASD and RS significantly effected survival. Survival was higher only at the lowest ASD paired with the highest RS. The interactive effect of ASD and RS on mean length was significant. Fish fed at the high ration at any ASD were significantly longer than those fed low ration at ASDs of 1,515 and 3,030 ammocoetes/m^2. Mean weight was not affected by the interaction. However, weight gain was significantly affected by the main effects ASD and RS. Fish fed high ration were roughly double the weight of those fed the low ration, which equals the magnitude of the ration increase. Weight was highest at the lowest ASDs of 152 and 303 ammocoetes/m^2, and dropped significantly as ASD increased to 1,515 ammocoetes/m^2. Weight was the lowest at the highest ASD of 3,030 ammocoetes/m^2. When culturing ammocoetes careful consideration must be paid to ration size and stocking density as both factors effect growth and survival. Densities above 303 ammocoetes/m^2 reduce weight, whereas density induced reductions in length were minimized by feeding a high ration. Of the ration sizes tested, it is recommended that 250 mg/L be fed regardless of the density of ammocoetes. Further testing of ration size may indicate that even higher rations are needed.

History and Results of Lamprey Health Monitoring by
Oregon Department of Fish and Wildlife – Fish Health Services

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Oregon Department of Fish and Wildlife Fish Health Services (La Grande, OR) personnel have examined 218 Pacific lampreys (*Entosphenus tridentatus*) since 1999. Monitoring efforts have coincided with increased focus on restoration of this species regionally for the last 15 years.

Most examinations have been from adults (N=159) associated with the Confederated Tribes of the Umatilla Indian Reservation translocation project. Exceptions to this include larvae submitted from the middle fork of the John Day River (N=21), lower Grande Ronde River (N=1) and larvae lampreys submitted from the Water and Environmental Center in Walla Walla (N=10) and Mukilteo Research Station (N=27) in western Washington. Standard Fish Health diagnostic methods, including bacterial culture, virology and enzyme-linked immunosorbent assay (ELISA), were used to test for pathogens. Additionally, blood hematocrit and leukocrit was examined for grab-sampled normal healthy appearing lampreys to determine baseline normal values and see if anemia was present in the population.

To date the primary pathogen of concern is a bacterium, *Aeromonas salmonicida*, the causative agent of furunculosis. Thirty-four of 84 (40.5%) mort/moribund adult lampreys were found to have systemic *A. salmonicida* infections. No *A. salmonicida* detections have been made in larvae (N=59) or in grab-sampled adults (N=74). Hematocrit values from grab-sampled lampreys have typically ranged from the lower 30's to 60% packed red blood cells, though there were six with hematocrits ≤ 24. No substantial levels of *Renibacterium salmoninarum* antigen have been detected by ELISA. All samples tested for virus have been negative.

These results support the need for a better understanding of pathogen impacts and future research into disease prevention measures for culture of this species.

SESSION 6

Evaluation of alternative feeds for Pacific salmon

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Feeds used in the hatcheries of the Pacific Northwest were developed more for commercially raised fish which will be used for immediate human consumption. The challenge for hatchery personnel are to find a feeds that meet the nutritional needs of the fish they raise and produce fish that are physiologically competent to survive after release. An eight week feeding trial tested two formulated experimental diets against a commercial feed using coho salmon *Oncorhynchus kisutch*. Variables in the diets include increased level of chitin and an increased level of moisture. Information presented will include feed formulations, growth, composition of gain, and blood chemistry.

Fish health management in a captive and endangered Chinook salmon broodstock

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From July 2008 to February 2014, Little White Salmon National Fish Hatchery raised five year classes (brood years) of an endangered run of spring Chinook salmon originating from the White River in the upper Columbia River watershed. As part of their recovery plan, captive broodstock were received at the hatchery as adults, post-smolts, juveniles or redd- pumped eggs and fry. Broodstock were reared on river water in outdoor raceways with low densities, predator control, and biosecurity measures. Adult captive broodstock were spawned as they matured, their progeny were raised at the hatchery, and those progeny were transferred back to the White River for acclimation and release.

The captive broodstock presented several challenges as a result of spending their entire lives in freshwater and had four predominant causes of mortality during the captive broodstock lifecycle: smolting in freshwater, post-spawn male die-off, *Renibacterium salmoninarum* and *Salmincola californiensis*. During smolting (from 18 to 25 months old), losses were low and ranged from 0-3.4% (median = 0.2%) monthly mortality. The males were live-spawned and returned to a raceway to die naturally; there were no males which recovered to spawn a second year. Intensive fish health management was required to control the *Renibacterium salmoninarum* and *Salmincola californiensis* infections. The copepod's presence on resident trout in the watershed was apparently enough to infect the captive broodstock at around 3 years of age. *Salmincola californiensis* was resistant to hydrogen peroxide treatments; however, SLICE® (emamectin benzoate) was very effective. We anticipated the *R. salmoninarum* infection and implemented an aggressive control plan. A combination of azithromycin injections and oral treatments 2-4 times per year, in combination with biosecurity at the hatchery, was successful in controlling *R. salmoninarum* until the final year class.

Reproductive development in reconditioned female Yakima River steelhead kelts: evidence for consecutive and skip repeat spawning life histories

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Columbia River Basin steelhead are capable of iteroparity, however, repeat spawning rates are low. Projects to capture and recondition ESA-listed downstream migrating kelts are underway, with the goal of releasing rematuring fish into rivers to spawn naturally. Ocean-reconditioned repeat spawners may return after a single summer in the ocean (consecutive spawners), or after two summers (skip spawners). To determine whether the consecutive and skip spawning life histories are found in captive-reconditioned steelhead, we measured blood levels of vitellogenin and estradiol in kelts in the reconditioning program at Prosser, Washington, 2009-2013. Estradiol and vitellogenin levels separated rematuring and non-rematuring females at release in October. On average, 57% of fish were rematuring at release. Vitellogenin was elevated in rematuring fish by mid-August, whereas estradiol was elevated by mid-July. Rematuring fish grew more rapidly over the reconditioning period and had higher muscle lipid levels at release than non-rematuring fish, suggesting that rematuration is associated with positive energetic status. In samples taken in the fall at Prosser dam, rematuring reconditioned kelts had similar plasma estradiol and vitellogenin levels to maiden spawners, but tended to have greater muscle lipid levels and condition factors, suggesting that reconditioned kelts have sufficient energy reserves to spawn successfully. This study shows that the consecutive and skip spawning life histories are found in reconditioned steelhead kelts. Strategies to allow skip spawners to contribute to target populations should be developed.

A production-level hatchery experiment using diet manipulation to reduce minijack rates in Umatilla River fall Chinook salmon

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The Umatilla River hatchery program currently produces 900,000 yearling Fall Chinook salmon smolts. An estimated 35% to 80% of the males released in the spring return that same autumn as sexually mature minijacks. This abstract is part of a co-presentation with Don Larson of NOAA Fisheries (see the following abstract) on a production scale experiment to identify a rearing regime that reduces minijack numbers while maintaining acceptable adult production characteristics. In this 2x2 factorial experiment, conducted at Bonneville Hatchery from release years 2012 to 2015, fish were fed High (18%) or Low (12%) fat diets at High (7 days/wk) or Low (4 days/wk) ration levels from April through November, then all groups received the High Fat-High Ration diet until release in March into the Umatilla River. The normal feed is the High Fat-High Ration diet. During hatchery rearing fish length, weight, *K*, body lipid, gill Na^+/K^+-ATPase activity (smolt index), mortality rate, and pre-release microjack and minijack rates were routinely monitored. To evaluate performance upon release to the river all smolts were coded-wire-tagged (CWT) and a sample from each experimental group received PIT tags. Upon release to the river, smolts fed a High Fat-High Ration diet migrated downriver past John Day Dam on the Columbia River more quickly and had higher migration survival rates than the other treatment groups. Based on CWT recoveries an estimated 895 minijacks from this study returned to the Umatilla River in 2012 and 2013, of which 84% were from groups fed a High Fat – High Ration diet. Only two minijacks came from groups fed a Low Fat – Low Ration diet. An estimated 282 jack (1-ocean) salmon from the 2012 release groups returned in 2013, of which 52% were from the High Fat – Low Ration group and 40% were from the High Fat – High Ration group. Two-ocean adults from the 2012 releases returned to freshwater in autumn of 2014. Preliminary results derived from PIT tag recoveries at Bonneville Dam on the lower Columbia River suggest that the High Fat – High Ration group produced 17% more two-ocean adults than the Low Fat – Low Ration group, followed by the Low Fat – High Ration and High Fat – Low Ration groups. Adults from this study will return through year 2019; however, these preliminary data demonstrate the efficacy of diet manipulation for reducing minijack rates and suggest that a feeding regime may be identified which also maintains acceptable returns of older aged adults.

The effect of modulating ration and dietary lipid on growth, smolting, and early male maturation in yearling Umatilla River fall Chinook salmon

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This talk is part of a co-presentation with Lance Clarke of ODFW (see previous abstract) presenting an update on a multi-brood year hatchery production scale study designed to optimize rearing regimes for yearling Fall Chinook salmon. In the Columbia and Snake River basins a significant number of Fall Chinook salmon hatchery programs use yearling, as opposed to sub-yearling, rearing regimes for smolt production. This strategy produces large smolts capable of avoiding predation, but mounting evidence suggests that these programs experience high rates of early male maturation (age-1 microjacks, age-2 minijacks and age-3 jacks). High rates of early male maturation may have negative ecological impacts, reduce the number of full size adults and are a waste of program resources. Several studies have confirmed that age of maturation in Chinook salmon is influenced by dietary lipid and autumn growth rate. This multi-year production scale 2x2 factorial experiment is being conducted with Umatilla River Fall Chinook salmon at Bonneville Hatchery, Oregon examining the effect of High (18%) and Low (12%) lipid diet and High (7 days/wk) and Low (4 days/wk) ration on growth, smolting, age of maturation and adult return rates. We monitored bi-monthly length, weight, *K*, body lipid, gill Na^+/K^+-ATPase activity (smolt index), and pre-release microjack and minijack rates. After completing the monitoring of 3 of 4 brood years the following general conclusions can be made: treatments successfully altered growth rate and body lipid levels. Based on gill ATPase activity all treatments, except LoFat-LoRation, smolted in the first fall and then again in the spring with spring levels being highest in the LoFat-LoRation and lowest in the HiFat-HiRation (a.k.a. Controls). Early male maturation rates varied significantly among brood years and treatments (microjacks + minijacks) ranging from 55-65% of all males in HiFat-HiRation, 5-70% in the HiFat-LoRation, 32-60% in the LoFat-HiRation and 7-36% in the LoFat-LoRation. Taken together, these data suggest that reducing growth rates and lipid accumulation through autumn reduced precocious male maturation and improved smolt development.

SESSION 7

Niagara Springs Hatchery renovations and innovations

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Niagara Springs Fish Hatchery (NSFH) was constructed in 1966 by Idaho Power Company (IPC) to partially mitigate for fisheries impacts of Brownlee, Oxbow and Hells Canyon dams on the Snake River. NSFH is owned and funded by IPC and operated under contract by the Idaho Department of Fish and Game. In the years since the facility was initially constructed, IPC has made several renovations to the hatchery. This presentation will describe historical steelhead survival at the hatchery and how renovations and innovations have affected that survival.

The first major renovation occurred in 1993-94. The project entailed the addition of five raceways, two settling ponds, a movable bridge work platform for the new raceways, new air-cleaning technology, and the construction of a water chiller and storage building.

The second major renovation was just completed in 2013. The centerpiece of this project was the construction of a new hatchery building containing thirty-eight 50' fiberglass vats for early rearing, and improvements to biosecurity and water filtration. The new building has biosecure boot and egg rooms, a feed room, visitor center, office area and conference room. A series of water filters and an ultraviolet light disinfection system were installed to treat the water supplied to the building. The presentation will detail many additional hatchery innovations intended to improve fish health and hatchery efficiency, including the facility's new alarm system, a raceway floor scrubber, traveling cleaning screens, incubator stands and belt feeder supports, catwalks, and bolt-on keyways.

NWFCC 2014: Retrofitting older hatchery infrastructure to accommodate a changing program at Lookingglass Hatchery

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Modifying vertical stack incubators to accommodate increased production through minimal hatch house infrastructure changes. In an effort to conserve space and increase incubation capacity vertical stack incubators were modified and mounted inside double deep Canadian troughs. Flexible tubing was plumbed into three individual existing trough water supply sources in order to manipulate egg development. During ponding the troughs can be filled with water and the fry can be gently released while under complete submersion. Further trials will determine if this technique of gentle emersion ponding will result in higher survival by eliminating the traumatic incubation to trough transfer. The incubation stacks can easily be removed from the troughs after ponding and flexible tubing is removed for conventional trough rearing.

Conventional style circular raceways were retrofitted to function as dual drain circular raceways. A design flaw in the circular raceways at Lookingglass Hatchery resulted in poor performance and the inability to utilize available water inflow. The original design was prone to cavitation and overflow issues. Juvenile fish could not be reared in these containers due to risk of escape from overflow and standpipe failure. The circulars were retrofitted with a side drain and the center standpipe was removed and replaced with an external standpipe. The water inflow pipe was also modified to allow proper circulation for holding juvenile and brood fish.

Boundary Native Salmonid Conservation Facility: developing a conservation program in the Pend Oreille River Watershed

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As part of its Boundary Hydroelectric Project Federal Energy Regulatory Commission (FERC) operating license, Seattle City Light (SCL) is required to design, construct and operate a Native Salmonid Conservation Facility. Westslope Cutthroat Trout will be the initial target species for propagation, but the facility must be designed to propagate a second species of native salmonid as well. Locally adapted, multiple age-class broodstock will be used to maintain long-term fitness traits and the facility will be operated to minimize genetic divergence from local, naturally spawning stocks.
SCL has taken a phased approach to project development and commenced the first phase of planning and design activities in fall 2013. Phase I was implemented as a parallel process of assessing a potential site for the facility, developing biological program objectives, evaluating permitting requirements, and developing an initial concept design. The initial concept design, informed from the biological objectives, was then evaluated against the site characteristics. The final task during Phase I was to assess the feasibility of constructing the initial concept design at the potential site. The project is being implemented in collaboration with federal, state, and tribal stakeholders.

Improving Return-to-Creel of Hatchery Catchable Rainbow Trout in Idaho: Catchable Size at Release

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Idaho Department of Fish and Game (IDFG) hatcheries are integral to managing coldwater sport fishing opportunities in Idaho. Current hatchery production capacity and funding are not increasing, while demand for hatchery catchable trout remains steady or is increasing. Given the current economic climate for IDFG hatchery funding, efforts must be made to ensure that hatchery programs remain efficient while producing a quality product for Idaho anglers. Since 2011, IDFG has released over 140,000 T-bar anchor-tagged hatchery rainbow trout across 135 water bodies statewide, as part of a multi-year evaluation of exploitation rates. All tagged fish are measured for length (mm) with the goal of releasing catchable trout that average 254 mm (10 inches). Average total length of all standard catchable rainbow trout tagged since 2011 has been 256.1 ± 0.3 mm. We evaluated returns-to-creel based on length-at-release and from 200 mm to 305 mm there was roughly a 7% increase in catch rates for each 25 mm increase in length at release. A pilot study showed that the relationship between return rates and size appears to be static and is not dependent on the rank of fish within a given release. Therefore, IDFG has increased the average target size at release for a subset of catchables destined for larger, lotic water bodies from 10 inches to 12 inches. Without an increased budget or expanded rearing space, this size increase results in a roughly 40% decrease in production (quantity), but results in an overall increase in return to creel numbers, a higher percentage of the release being caught by anglers, and a better product for anglers. Future work will further evaluate the relationship between length-at-release and catch rates, and continue to explore rearing options that result in maximizing the rearing cost/return-to-creel relationship.

Poster Abstracts:

Oxbow Fish Hatchery's intake screening project, 2013

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Is Ringold Springs Hatchery spring water suitable for holding and spawning fall Chinook salmon and incubating their eggs?

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Collection and assessment of emigrating Snake River steelhead (*Oncorhynchus mykiss*) kelts at Lower Granite Dam

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Reproductive viability assessment of reconditioned Upper-Snake River tributary 'B-Run' female steelhead (*Oncorhynchus mykiss*) kelts

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From Elwha River to a 20 foot pool: raising a captive population of Elwha pink salmon

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Vacuum degassing vs. packed column: a Dworshak Hatchery comparison

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All for one and one for all

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Gamete storage limits for Pacific lamprey

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Methods and accuracy of sexing Sockeye salmon *Oncorhynchus nerka* using ultrasound for captive broodstock management

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Ease-of-use: methods for Pacific lamprey (*Entosphenus tridentatus*) egg incubation

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Evaluation of short term saltwater immersion to alleviate handling stress in steelhead trout (*Oncorhynchus mykiss*)

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Energy saving comparison of single-pass incubation vs. recirculation

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Coho returns to Kooskia National Fish Hatchery

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Shade cloth covering/BY-13 spring Chinook raceways: with and without

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Clearwater Coho Restoration Project

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Comparison of long term retention rates of coded wire tags vs visual implant elastomer tags in summer Chinook salmon

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A non-salmonid propagation laboratory: a student's perspective

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Feeding and growth of wild-caught sculpin in a captive environment

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The Chief Joseph Hatchery Science Program: **Hatchery Reform's Emphasis on Data Collection, Analysis and Reporting**
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Controlling fish specific fungus on incubating salmon eggs, using copper pot scrubbers
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Northwest Fish Culture Conference Hall of Fame Plaque
*Jerry McGehee and Tim Yesaki