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KEYNOTE SPEAKERS

Jesse Trushenski. *Telling Our Stories—Why We Raise Fish*

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Aquaculture is a modern imperative—for food security, economic development, and conservation and recovery of aquatic resources—but in the 'post-fact world', the public is inundated with mis- and disinformation about the fundamentals of fish propagation. Aquaculture is beset by 'fake news' that threatens our social license to operate and the essential services provided by hatcheries and fish farms. The public is largely unfamiliar with aquaculture and uncertain as to its economic and environmental sustainability, and many question the need for hatchery-origin fish and their conservation value. This presentation will articulate the need for better science communication in aquaculture, important themes related to the purpose and practice of raising fish, and strategies for better telling our stories.

George Iwama. *Aquaculture: a part of future food production*

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As the global population encroaches on 8 billion it is vital that we consider how we can meet the commensurate increase in food needs. We will need to produce 50% more food in 50 years. The greatest growth is in developing countries. The parallel trend of massive migration to urban areas, and an explosive growth of the middle-class, is resulting in consumption and disposal at alarming rates. These exacerbate greenhouse gas production and accelerate climate change. Of all uses of freshwater on earth, agriculture consumes over 70%. We do not have the resources to support the above growth and demands of water and land for food production. All of this is true for fish consumption and production. This talk will make a case for the positive role that recirculating land-based fish production systems can play in the context of food production needs today and into the future.

SESSION: EFFECTIVE REARING and RELEASE STRATEGIES

Gary Marston. *Assessing the Performance of Washington State Hatchery Chinook Salmon with Coded-Wire Tag data*

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Each year millions of Coded Wire Tagged (CWT) salmon are released from hatcheries operated by the Washington Department of Fish and Wildlife. These tagged salmon provide a useful tool for managing fisheries and gauging the performance of hatcheries based off of smolt to adult survival and contributions to specific fisheries. CWT recoveries were analyzed for Chinook salmon derived from harvest programs across three production regions in Washington State (Puget Sound, Coast and Lower Columbia River). This data was used to determine smolt-to-adult survival rates for each program, where fisheries benefits are achieved, the value of mark selective fisheries, and stray rates from the hatcheries. To investigate the effectiveness of mark

selective fisheries, three Puget Sound Fall Chinook double index tag (DIT) groups were used. Hatcheries across these regions contributed to fisheries in very different ways, with coastal hatcheries primarily benefiting northern fisheries, while Puget Sound and Columbia River hatcheries showed stronger contributions to sport and commercial fisheries within Washington and Oregon. The information provided by these tag recoveries is an important step in assuring that informed decisions are made regarding the management the State's hatchery system and this valuable resource.

Jessy Bokvist. *Multi-generational application of environmental enrichment increases escapement of Nitinat River Hatchery Coho Salmon (Oncorhynchus kisutch)*

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Robert Brouwer, Nitinat River Hatchery, Fisheries and Oceans Canada
Dr. Brad Anholt, Biological Sciences, University of Victoria
Dr. Sean Rogers, Biological Sciences, University of Calgary
Dr. Kristi Miller-Saunders, Pacific Biological Station, Fisheries and Oceans Canada

Environmental enrichment involves modifying rearing environments to imitate "wild" conditions and is used to promote the development of traits and genetic signatures associated with higher post-release survival in captive reared fish. This strategy may mitigate deleterious effects of captive rearing and limit differences in survival and fitness among hatchery and wild counterparts. We followed six generations of 250-300 coho salmon (*Oncorhynchus kisutch*) families reared under enriched semi-natural and non-enriched conventional treatments that were released as smolts at the Nitinat River Hatchery. We measured marine survival based on smolt release and adult escapement estimates and assessed the influence of year, sex and treatment. To explore potential molecular mechanisms behind differential survival, we characterized epigenetic signatures in the genome. These markers can modify gene expression in response to environment and may also lead to divergence between wild, enriched and conventional phenotypes. Salmon reared under semi-natural conditions had overall higher marine survival than conventional reared Salmon, although marine survival was variable across years. Males and females reared in the hatchery (semi-natural and conventional) survived equally well while semi-natural rearing led to decreased numbers of precocious males. Semi-natural smolts were half the size of conventional smolts at release yet had overall higher marine survival suggesting that enrichment methods are more predictive of survival than size at release in this system. Differential epigenetic marks associated with treatment demonstrate the environmental impact of hatchery enhancement practices at the genomic level and how enrichment may influence survival.

Mary Moser. *Use of olfactory cues to guide fish movement: a steelhead trout hatchery application*

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Andrew Dittman and Christopher Tatara, Northwest Fisheries Science Center, National Marine Fisheries Service

Michael Humling, Mid-Columbia Fish and Wildlife Conservation Office, Leavenworth Fisheries Complex, U.S. Fish and Wildlife Service

Juvenile hatchery steelhead trout typically migrate downstream after release from hatcheries; but, precociously mature males often remain. They can breed with wild females and thereby negatively affect wild populations. Hence, methods to differentially retain these males during volitional release are needed. During courtship and spawning, salmonids use olfaction to locate spawning habitat and identify mates. The presence of female odors might be sufficient to retain precocial males, while allowing immature males to volitionally exit hatchery raceways. Using experimental Y-mazes, we tested whether precociously-mature males were attracted to female odors, relative to immature males. Metrics assessed were both the number of entries into, and the time spent in the arm receiving female odors, compared to a control arm. We found that mature males were significantly more attracted to female odors than immature fish. We also tested whether presence of ovulated anadromous female steelhead in raceways would differentially retain sexually mature precocious male steelhead during a volitional release. In this hatchery application, we were not able to replicate results seen in the Y-maze trials. Further research is needed to understand why the results differed and to provide a viable protocol for hatchery use.

Philip R. Branigan. *Cost Effectiveness and Angler Return-To-Creel in Catchable-Sized Trout Stocking Programs: Does Size Matter?*

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Kevin. A Meyer and John D. Cassinelli, Idaho Department of Fish and Game

Catchable-sized hatchery trout (~250 mm TL; hereafter “standard” catchables) are an important component of cold water fisheries management programs, providing instantaneous fisheries once they are stocked in waters that cannot support wild trout populations or where catch rates are low. Recent investigations have indicated that the largest standard catchables in a raceway are caught by anglers at higher rates than smaller conspecifics, suggesting that increasing size at stocking (e.g., to 305 mm TL; hereafter “magnum” catchables) may substantially increase return-to-creel for anglers. However, costs of rearing catchables to larger size increase exponentially, thus balancing rearing costs and angler benefits can be challenging. We stocked “standard” and “magnum” catchable Rainbow Trout *Oncorhynchus mykiss* into 29 lakes and reservoirs and 19 streams across 3 years to evaluate size-at-stocking on angler catch, while monitoring rearing costs for each. Water bodies were stocked with equal numbers of magnums and standards that were marked with unique T-bar anchor tags. Magnums were returned by anglers at twice the frequency than standards, and the added cost of raising magnums was outweighed by the increase in catch by anglers, with the added benefit that anglers are presumably more satisfied catching larger fish.

Carol Schmitt. *Natural fresh water rearing program for chinook juveniles which significantly increases marine survivals resulting in greater numbers of adult fish for marine fisheries and escapements (spawner returns)*

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Juvenile Chinook salmon were raised at Omega Pacific Hatchery (Omega) in a freshwater program based on the “Fundamental Principles of Natural Biology” which more closely resembles the incubation and rearing cycle of wild fish. The naturally reared juveniles were raised as stream type fish (1+) and compared to the standard enhancement program accelerated ocean type (0+)

fish. Juveniles were adipose clipped and coded wire tagged prior release and assessed based on tags recovered from adult fish captured. The comparison included 0+ to 1+ juveniles released in Phillips River, which enters the Strait of Georgia (SOG) and 0+ to 1+ juveniles released in the Nahmint and Sarita Rivers, which enter West Coast Vancouver Island (WCVI). These releases were compared to the nearest federal production hatcheries 0+ chinook, being Quinsam for SOG and Robertson Creek for WCVI. On average the numbers of coded wire tags recovered from 0+ were 0.50% and Omega's 1+ at 3.0%. Since coded wire tags recovered represent 20 to 25% of the adult population, the marine survival for juvenile release to adults is extrapolated for 0+ at 2.5% and 1+ at 15%. The 1+ grown in a natural program resulted in few jacks, no straying and re-appearance of older, larger adult Chinook salmon. The majority of B.C.'s chinook stocks are extirpated and remain low level stocks despite being enhanced with thousands of 0+ juveniles, unable to increase numbers of adult spawning returns. Omega demonstrated with four releases of 45,000 1+ juveniles over a five year duration would increase the number of adult returns from a few hundred to 2800. Freshwater rearing greatly affects marine survivals and incorporating a more naturally grown 1+ juvenile for enhancement will re-build a stock to a large enough population more resilient to extirpation that leaves the majority of fish to naturally spawn with minimal hatchery intervention, and is the best solution to saving the remaining stocks of chinook salmon.

SESSION: ADVANCES in INFRASTRUCTURE and HATCHERY TECHNOLOGY

Catherine Willard. *Post-release performance of summer Chinook Salmon smolts reared in a partial reuse aquaculture system compared to cohorts reared in flow-through raceways*

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McLain Johnson and Alf Haukenes, Washington Department of Fish and Wildlife, 3515 Highway 97A, Wenatchee Washington 98801.

A partial reuse aquaculture system (PRAS) was constructed in 2009 at Eastbank Hatchery in central Washington to decrease water use while maintaining satisfactory post-release performance of summer Chinook Salmon smolts relative to standard flow-through raceways. The PRAS comprises two 9.1 m-diameter dual-drain Cornell circular vessels for rearing smolts, whereas cohorts used for comparison were reared in a combination of standard raceways (30.5 m × 3.0 m and 61.0 m x 6.1 m). Passive integrated transponder (PIT) tags were utilized to estimate travel time, downstream survival, and minijack rates by rearing vessel across five brood years (2012 to 2016). Precocious maturation was also evaluated for the treatment and control fish by measurement of androgen 11-ketotestosterone (11-KT) for two brood years (2012 and 2013) by vessel type. After release into the Wenatchee River, summer Chinook Salmon reared in the PRAS had significantly faster travel times to downstream locations, significantly greater smolt survival rates, and significantly lower rates of precocious maturation relative to cohorts reared in traditional flow-through raceways. The results from these evaluations indicate that PRAS with circular rearing vessels can be an effective approach to reduce water consumption while improving post-release performance of hatchery-reared summer Chinook Salmon smolts.

McLain Johnson. *Survival of Adult Hatchery Summer Chinook Reared in a Partial Reuse Aquaculture System to Flow-Through Super Raceways*

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Hatchery managers seeking to maximize fish production must do so in the evolving framework of hatchery reform recommendations, while balancing environmental considerations (e.g. water use) of hatchery facilities. To meet program goals, evaluation of changing practices is necessary to inform adaptive management. In this investigation, we compared the adult survival of hatchery summer Chinook Salmon *Oncorhynchus tshawytscha* reared in a partial reuse aquaculture system (PRAS) to standard flow-through super raceways (SUPER). The study encompassed three brood years (2009, 2012, and 2013) and included approximately 280,000 and 1,240,000 smolts from PRAS and SUPER vessels, respectively. In all study years, smolt-to-adult survival rates were higher for smolts reared in PRAS, with significant differences observed in brood years 2009 and 2012. Age composition of returning adults was compared, with no significant difference in age-at-return observed. This study demonstrates PRAS systems can maintain (e.g., age structure) and may increase (e.g., increase in adult returns) hatchery performance metrics while conserving water.

Vincent Autier. *Planning for the Inevitable? Lake Water Filtration System to Prevent Zebra Mussel Infestation at the Gavins Point Hatchery*

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The United States Fish and Wildlife Service owns and operates the Gavins Point National Fish Hatchery near Yankton, South Dakota. Gavins Point NFH propagates a host of cool, cold and warm-water fish species including endangered Pallid Sturgeon *Scaphirhynchus albus*, Paddlefish *Polyodon spathula*, and Blue Sucker *Cycleptus elongatus*. The highly invasive zebra mussel *Dreissena polymorpha* was discovered in Lewis and Clark Lake in 2015, the primary water supply for the hatchery. Once established in a water body, zebra mussels can rapidly foul water intakes and other infrastructure. Fecundity of adult female zebra mussels can approach over 1 million eggs annually with planktonic (40-400 micron) larval phases settling in three to five weeks as juvenile mussels. Common control methods include the use of additives to water supplies, heating, dewatering, mechanical removal, and pipe coatings - management techniques that are not generally considered aquaculture-friendly. In order to safeguard the hatchery from these highly prolific invasive species, McMillen Jacobs teamed with USFWS staff to perform an alternative evaluation study that determined complete filtration of the hatchery lake water supply source was required, feasible, and then prepared the design of a screening facility using rotary drum filters. As zebra mussels and associated aquatic invasive species (AIS) continue a westward expansion with new detections now routine, protection of our surface water gravity sources will become paramount and hatchery managers should start planning for and evaluating their systems against the spread of AIS invasions.

SESSION: FISH HEALTH and NUTRITION

Timothy J. Bruce. *Live-attenuated bacterial Coldwater disease (BCWD) vaccine provides cross-protection against novel Flavobacteriaceae*

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Flavobacterium spp. infections remain a major concern for aquaculture causing major economic losses. Recent research has shown that a live-attenuated BCWD vaccine provides cross-protection from an array of *F. psychrophilum* strains. However, there are emerging bacterial pathogens in the family *Flavobacteriaceae* that have been identified and implicated in global fish health diagnostic cases. These virulent bacterial strains include representative *Flavobacterium* and *Chryseobacterium* isolates. In this study, we tested the cross-protective ability of our live-attenuated *F. psychrophilum* vaccine against novel *Flavobacteriaceae* infections in juvenile rainbow trout. It was found that fish developed high *F. psychrophilum*-specific antibody titers 8 weeks post-vaccination, as expected. Fish were then challenged with two *Chryseobacterium* spp. (S25 and T28), a *Flavobacterium* spp. (S21), a mixed combination of S21:S25:T28 strains, along with a standard virulent *F. psychrophilum* CSF259-93 strain. Results showed that vaccinated fish had a relative percent survival (RPS) of 94.44% when challenged with the CSF259-93 strain (259-93 V) when compared to the control (259-93 C) fish ($P<0.001$). Interestingly, vaccinated fish also had a high RPS (85.18%) following the mixed *Flavobacteriaceae* infection. Protection was not observed when fish were challenged with the single novel *Flavobacteriaceae* strains. Results indicate that the live-attenuated *F. psychrophilum* vaccine provides indirect protection against mixed infections with novel *Flavobacteriaceae,* but further work is needed to determine the synergistic virulence mechanisms for these emerging isolates.

Stacy Strickland. *Copepod-induced morbidity of spring Chinook smolts in the Upper Deschutes Basin: Implications for reintroduction success*

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Richard Stocking, Oregon Department of Fish and Wildlife, La Grande

Portland General Electric (PGE), the Confederated Tribes of the Warm Springs Reservation of Oregon (CTWSRO), and the Oregon Department of Fish and Wildlife (ODFW) are working together to reintroduce 3 anadromous salmonid species to the upper Deschutes Basin in central Oregon. A series of 3 dams have blocked migration between the upper and lower Deschutes River since the mid-1960s. Both smolt and fry releases have been used starting in 2008-2009. ODFW & PGE staff noticed after several years that the smolt-to-adult returns (SARs) were much lower for spring Chinook than they were for the summer steelhead. Pathogen possibilities were investigated and two parasites emerged as concerns: *Ceratonova shasta* and freshwater copepods. This presentation focuses on the investigation and results of the copepods on mortality and likely survival during outmigration to the ocean of juvenile spring Chinook. Freshwater copepods namely, *Salmincola californiensis*, attach to fish gills, fins, and skin.

Particularly vulnerable are migrating and smolting juveniles with gill infestations. The copepods cause epithelial damage which allows other pathogens to enter and proliferate as well as interferes with ionic exchange. We examine patterns of prevalence and extrapolate survival of the outmigrating population. Adaptive management practices are also described, including a possible solution to dramatically reduce copepod infestations.

Sarah J. Bjork PhD. *Innovative approaches to treating Columnaris in juvenile steelhead at an Oregon hatchery: what's old, what's new and what actually worked*

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Colby Gonzales, Rock Creek Hatchery, Oregon Department of Fish and Wildlife

Dan Meyer, Rock Creek Hatchery, Oregon Department of Fish and Wildlife

Juvenile salmonids at Rock Creek Hatchery, N. Umpqua River, OR, USA experience Columnaris outbreaks every summer. *Flavobacterium columnare* infections can be localized or systemic and disease severity increases with increasing water temperature. Drum filters and UV irradiation were installed to decrease pathogen viability, but Columnaris outbreaks continued to persist. At this site, oxytetracycline is the only effective oral antibiotic and repeated antibiotic courses have been required. In the past, topical Chloramine T treatments alone failed at eliminating the disease but treatment wasn't begun until loss had already escalated. It was hypothesized that early intervention with a topical treatment could prevent the need for oral antibiotics and/or reduce overall mortality. Additionally, there was interest in testing the efficacy of Diquat dibromide, a "new" topical treatment listed as an Investigational New Animal Drug in the USA (INAD). Once *F. columnare* was detected in gill cultures, two troughs of fingerling summer steelhead were each assigned to a treatment group: Chloramine T, Diquat or control (no topical treatment) and fish were treated 3 days/week. Regardless of topical treatment, daily mortality from Columnaris progressed and all three treatment groups were given oral oxytetracycline in conjunction with ongoing topical treatments. Conclusions are that neither Diquat or Chloramine T prevented progression of Columnaris, but loss in groups treated with either drug was lower than the control group. Combining topical treatment with oral antibiotics resulted in lower cumulative mortality. Additionally, it was determined that there were no apparent differences in efficacy between Chloramine T and Diquat.

Russell Hepburn. *Melting Fast and Furiously: Application of multiplexed melt analysis qPCR in Fish Health*

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Sherry Mead, Freshwater Fisheries Society of BC

The use of molecular techniques in fish health is well established with numerous protocols and assays available for bacterial, fungal and viral screening. Two primary advantages of using molecular methods to screen for fish pathogens are time savings and the ability to detect low level infection. There are, however, significant hurdles in terms of reagent, labour and time costs that can reduce the effectiveness of these molecular approaches. For example, the methodologies chosen to extract viral RNA, convert this RNA to cDNA and visualize the results affects the cost and throughput of the work flow. Here we give an overview how the FFSBC's fish health lab has used automated nucleic extraction, real time PCR (qPCR) and multiplexed melt

analysis to rapidly detect bacterial, fungal and viral pathogens, how we've reduced costs along the way and what we're working on now.

Laura Miceli. *Potential of black soldier fly larvae as a sustainable alternative source of protein for aquaculture diets – Supply, performance, and functionality*

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As the world population grows, global food production will need to increase far beyond current volumes without depleting resources. A possible solution is to utilize the power of insects paired with aquaculture which may alleviate some pressures on natural resources. This presentation discusses the capacity of a commercial insect producer: Enterra Feed Corporation, to supply a sustainable alternative source of protein to the aquaculture industry currently, and projections for the future. Insects as an alternative protein source for aquatic nutrition have a promising future based on their feed value, differentiation to end consumers, and functional benefits for efficient fish production. As an example of possible functional benefits, a recent multi-generational study with arctic charr will be discussed, which indicated that black soldier fly larvae may have significant benefits to survivability of fry as well as their condition factor, without compromising growth or efficiency.

Jason Mann. *Fish Nutrition – New Ingredient Innovations for fish feed*

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With the continued growth in demand for fish feed, new sources of protein, oil and novel additives are being developed by start-up and industrial companies to meet the future requirements of aquaculture and enhancement hatcheries.

A practical presentation will be made about new ingredient sources for fish feed from an industry perspective. Merits and challenges of each innovation will be described.

SESSION: CONSERVATION and NEW SPECIES AQUACULTURE

Christopher Tatara. *Sorting for growth potential improves smoltification in steelhead (Oncorhynchus mykiss) conservation hatcheries*

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Jeff Atkins and Barry Berejikian, NOAA, Northwest Fisheries Science Center

Conservation hatcheries for steelhead trout use local natural-origin (NO) broodstock to maintain natural spawn timing and minimize genetic differences with supplemented natural populations. Rearing all juveniles for release as yearlings (S1) can result in undersized fish that fail to smolt. Rearing all juveniles for release at age-2 (S2) reduces the incidence of smolt failure due to inadequate growth opportunity, but can increase the proportion of males that mature

precociously. We discuss experiments conducted at laboratory and production hatchery scales designed to maximize size at release and minimize precocious male maturation. The approach requires sorting the fish according to length at 9 weeks post-ponding into large and small groups. Rations for the large fish were increased to promote rapid growth and produce S1 smolts, and rations for the small fish were restricted to produce S2 smolts. Our initial results indicate that the approach is practicable in hatcheries with the use of automated marking and tagging trailers. Hatchery fish automatically sorted by median total length resulted in 46.5% reared as S1 and 53.5% as S2. Post-sorting subsampling indicated accuracy ranged from 97.4% to 100% for S1 and from 75.4% to 85% for S2. Rates of smoltification and seawater challenge survival were higher, while rates of precocious maturation and size variation were lower in sorted S1 and S2 groups compared to unsorted controls. Outmigration survival of PIT tagged fish was higher despite slower migration speed for sorted S1 steelhead compared to unsorted S2 controls. Experiments are underway to determine the percentages reared as S1 or S2 given spawning date and juvenile rearing temperature.

Madison L. Earhart. *Early-rearing effects on larval White Sturgeon (Acipenser transmontanus) physiology, growth, and survival*

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White Sturgeon (Acipenser transmontanus) are listed as endangered or threatened throughout their range in British Columbia. As such, this species is of high conservation concern and population supplementation, through conservation hatcheries, is prevalent throughout the region. Conservation hatcheries aim to release “wild-type” individuals that will survive and ultimately reproduce with wild populations; but most hatchery practices deviate from the natural life-history of the sturgeon. In the wild, sturgeon spawn in fast-flowing rivers where adhesive eggs stick to a rocky substrate until hatch. However, most conservation hatcheries use tumbling jars, colloquially referred to as McDonald jars, which constantly roll clay-covered embryos in a water column throughout embryogenesis. In this study, we investigated the effects of this rearing technique, compared to embryos allowed to adhere to an egg mat, throughout embryogenesis and in post-hatch larvae. Embryos that were adhered to an egg mat had a higher mass ($P < 0.001$) than tumbled embryos within one day post fertilization (DPF). The tumbled embryos were shorter in length and smaller in mass over a month post-hatch ($P<0.01$). Further, the larvae that had been tumbled had 201% more mortality ($P<0.00001$) over the two-month period, particularly during the transition from endogenous to exogenous feeding. Analyses of endogenous cortisol production and stress-related gene expression in embryos and larvae are currently underway. We predict the tumbling jar will also have deleterious effects on the development of both cortisol production and related gene expression.

Mike Manky. *Nechako White Sturgeon Conservation Centre*

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The Nechako White Sturgeon Conservation Centre (NWSCC) is a facility that houses a conservation fish culture program for the unique population of Nechako White Sturgeon

(*Acipenser transmontanus*). This facility is operated by the Freshwater Fisheries Society of BC (FFSBC) and uses modern Recirculating Aquaculture System (RAS) technology. The facility incorporates 3 independent culture modules; a recirculating juvenile rearing module, an adult holding module, and an adult spawning module.

Due to changes in habitat, the Nechako White Sturgeon have experienced recruitment failure for over 50 years. Nechako White Sturgeon are listed as Critically Imperiled by the British Columbia Conservation Data Centre and as an Endangered Species under the Species at Risk Act (SARA).

The hatchery program began in 2014 with the objective of maintaining genetic diversity and returning the Nechako White Sturgeon to a self-sustaining population. In addition, FFSBC staff carry out research and monitoring activities on the Nechako River including spawning habitat assessments, wild egg collection, and juvenile indexing and adult monitoring through Passive Integrated Transponder (PIT) tagging and radio telemetry.

Anja Huff. *Continuing the Journey: Southern Resident Killer Whales*

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The Southern Resident Killer Whale (SKRW) population has been declining since 1995 with only a slight increase in the early 2000's before continuing its steady decline. The SKRW population was listed as endangered under the Endangered Species Act in 2005 when the SRKW count was at 88 whales. With an increase of chemicals of concern in the environment, and a decrease in survival of their preferred prey species, Chinook salmon, the Residents face an uphill battle for survival. In 2018, Governor Inslee issued an executive order to pursue ways to increase the likelihood of survival of the species. The Governor's Task force listed key threats to the species and recommendations for correcting or mitigating those issues. For Washington State hatcheries, the goal is to increase production of salmon to boost populations and survival to provide additional forage for SRKW. This would mean implementing and evaluating changes in operations, release-timing strategies, spawning practices, and optimizing existing infrastructure. The agency is looking toward future production increases and implications associated with that increase. While the hatcheries increase production and introduce new release strategies and brood stocking strategies, agencies are attempting to hedge predation on salmon, reduce boat traffic noise, and increase habitat.

Gary Marston and ***Beata Dymowska.** *Hatchery Release Timing Studies*

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Based on long-term smolt-to-adult survival rate (SAR) trends there has been a reduction in SAR for Chinook salmon in Puget Sound since the late-1980s as well as a consolidation of hatchery releases into a short period of several weeks between mid-May and early-June. This has resulted in reduced Chinook salmon prey base, which is affecting the survival of Southern Resident Killer Whales (SRKW). To aid SRKW the Washington Department of Fish and Wildlife (WDFW) is planning to increase hatchery production as a means of supplementing the prey supply as well as to implement studies to improve the survival and age at return of hatchery Chinook in Puget Sound. One of the approaches WDFW is exploring is alternative release strategies to improve

SAR and the size and age of Chinook salmon at return to freshwater at four hatchery facilities across the Puget Sound. Here we discuss plans for the upcoming release time studies as well as the results from a pilot study that occurred between brood years 2004 – 2007 in the Chambers Creek watershed in South Puget Sound.

SESSION: PHYSIOLOGY and GENOMICS

Anita Mueller. *Role of Genomics in Advancing BC's Fisheries and Aquaculture Sector*

*Genome BC

Lisey Mascarenhas, Genome BC

Climate change and environmental impacts on fish health and habitat, lack of a reliable supply of sustainable fish feed, as well as the role and effect of hatcheries in enhancing and restoring wild stocks are key challenges and uncertainties facing the fisheries and aquaculture sector in BC. At the same time, opportunities exist, including diversification of aquaculture species and production systems, as well as development of alternative feed ingredients (https://www.genomebc.ca/wp-content/uploads/2019/08/0112.001.002_Fisheries-Aquaculture-Sector-Strategy_FINAL.pdf). Research supported through past and current Genome BC projects and initiatives shows that the application of genomics can be part of the solutions to address challenges in hatcheries, aquaculture and fisheries management, including recreational fisheries. Ongoing and future effort will focus on addressing sector challenges such as restoring and maintaining healthy wild stocks, increasing socially and environmentally responsible aquaculture production and developing sustainable fish feed.

Patricia M. Schulte. *Applications of genomics in Rainbow Trout culture – an overview*

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Sara L. Northrup, Freshwater Fisheries Society of BC

Rainbow Trout are an important natural resource supporting a recreational fishery that results in economic impacts exceeding $120 billion annually in North America. Genomic approaches hold substantial promise for providing relevant information to fish culturists to help maintain the success of Rainbow Trout stocking programs in the face of environmental change. As part of a large-scale project funded by Genome Canada, in collaboration with the Freshwater Fisheries Society of British Columbia, we have developed a single nucleotide polymorphism (SNP) chip containing over 200,000 SNPs derived from comparisons of whole-genome sequence from multiple natural populations of Rainbow Trout from across the species range. We are currently using this chip to identify variants that are associated with differences in vulnerability to a range of climate-change relevant stressors. With hatchery-reared fish, we are also using RNA-seq approaches to identify variation among strains in gene expression responses to environmental stressors. Together, these approaches provide useful information that aids in identifying appropriate strains of Rainbow Trout for stocking into the future.

Jessica L. McKenzie. *Effects of acclimation temperature on gene expression in two strains of Rainbow trout*

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Patricia M. Schulte and Nicholas R. Strowbridge, Department of Zoology, University of British Columbia

Rainbow trout (*Oncorhynchus mykiss*) is a socioeconomically important species that is stocked widely around the world. In the current climate crisis, understanding the thermal limits of a species is crucial to predicting how organisms may respond to future conditions and can provide insight into hatchery rearing conditions that may help protect fish against elevated temperatures on release. We used RNA-sequencing to investigate the effect of temperature acclimation on cardiac gene expression of fish acclimated to 12°C, 18°C, and 24°C, for both Coleman and Shasta strains of rainbow trout. For the Coleman 12°C and 18°C comparison, 626 transcripts were differentially expressed and this list included genes enriched in GO categories associated with regulation of cardiac muscle cell membrane potential and smooth muscle contraction. Also for the Coleman strain, 2,006 transcripts showed significantly different expression in the 18°C versus 24°C comparison and represented GO terms including glial cell proliferation and mitochondrial electron transport. For Shasta fish acclimated to 12°C compared to 18, 9294 genes were differentially expressed and significant enrichment was observed for GO terms representing genes involved in mRNA splicing and protein targeting to the mitochondrion. The 18°C versus 24°C comparison for this strain yielded differential expression of 7933 genes, and these differentially expressed genes were enriched for terms describing biological process including regulation of DNA-templated transcription in response to stress. Thus, thermal acclimation resulted in remodelling of the cardiac transcriptome, with cardiac gene expression patterns reflecting a cellular stress response in fish acclimated to elevated but environmentally relevant temperatures.

Don Larsen. *Is out-of-basin rearing an underappreciated problem? Stress, acute mortality and long-term survival of Chinook Salmon reared in different water chemistries and released in the Yankee Fork of the Salmon River*

*NOAA Fisheries, Northwest Fisheries Science Center, 2725 Montlake Blvd. NE, Seattle, WA 98112. Tel: 206-860-3462. Email: don.larsen@noaa.gov

Jonathan Ebel, Shoshone-Bannock Tribes' Fish and Wildlife Department, Fort Hall, ID

Mollie Middleton, NOAA Fisheries, Northwest Fisheries Science Center, Seattle, WA

Keats Conley, Shoshone-Bannock Tribes' Fish and Wildlife Department, Fort Hall, ID

In 2008, the Shoshone-Bannock Tribes (SBT) initiated the development process for the Crystal Springs Hatchery to aid in recovery of Chinook salmon in the Yankee Fork (YF) of the upper Salmon River Basin, Idaho (ID). The proposed site is proximate to the Idaho Department of Fish and Game's Springfield Fish Hatchery (FH) in southeast ID, and would use the same ground water source. Springfield FH, completed in 2013, is the primary smolt rearing hatchery for endangered Snake River Sockeye Salmon. The first two brood years of Springfield FH reared Sockeye Salmon suffered extensive acute mortality upon release into Redfish Lake Creek and had low survival to Lower Granite Dam (LGD) (mean = 16–31%) relative to previous hatchery releases (>80%). In 2017,

co-managers determined that the difference in hardness and alkalinity between the rearing and release water was the primary source of stress and mortality, but 1-2 week acclimation in intermediate hardness water could mitigate these effects. This raised concerns regarding the efficacy of rearing YF Chinook salmon on water from the same source and releasing them in the YF of the Salmon River. To answer this question, 100,000 juvenile Chinook Salmon were reared at each of two hatcheries — Sawtooth FH (control group; water hardness = 40-80 mg $CaCO_3$/L) and Springfield FH (treatment group; water hardness = 250-270 mg $CaCO_3$/L) — for release into the YF. We conducted a series of evaluations to test whether survival and stress differed between the two groups at the parr and smolt life stages in October 2018 and April 2019, respectively. At the parr stage, we observed low acute mortality rates during the 48 hrs after release, but the treatment group survival rate to LGD was an order of magnitude lower than the control group. At the smolt stage, the treatment group showed evidence of extreme physiological stress that persisted for at least 48 hrs (high plasma cortisol and glucose, high blood lactate and hematocrit and impaired blood ion balance), experienced acute mortality rates of 40-80%, and had immeasurably low survival to LGD. Meanwhile, the control group recovered from the stress of transport, had zero acute mortality, and survived to LGD at a rate comparable to previous years' releases. Results from both these programs demonstrate the challenges associated with rapid transfer of salmonids from very hard to soft water and the possibility for substantial interspecific differences in tolerance. Fisheries management programs should take these considerations in to account when designing out of basin rearing facilities for supplementation and recovery efforts for Sockeye, Chinook, and potentially other salmonid species.

William S. Bugg. *Thermal Physiology of age-0 Lake Sturgeon from geographically different populations*

*University of Manitoba, Department of Biological Sciences, 50 Sifton Road, Winnipeg, Manitoba, R3T 2N2.

Gwangseok Rex Yoon, Department of Biological Sciences, University of Manitoba

Andrew Laluk, Department of Biological Sciences, University of Manitoba

Gary Anderson, Department of Biological Sciences, University of Manitoba

Kenneth Jeffries, Department of Biological Sciences, University of Manitoba

This study examined the response to chronic and acute changes in environmental temperature of two populations of Lake Sturgeon, *Acipenser fulvescens.* The northern population from the Burntwood river and southern population from the Winnipeg river were separated by 3.5° latitudinally and are considered two distinct sub-populations in the province of Manitoba. Lake Sturgeon, at 30 days post fertilization, from northern and southern populations, were acclimated to one of 16, 20, and 24°C treatments for 30 days. Critical thermal maxima (CT_{max}) trials were then conducted by raising water temperatures by 0.3°C $minute^{-1}$ until a loss of equilibrium in individual fish was reached. Rearing temperature had significant effects on CT_{max} in the northern population: 16°C (32.2°C), 20°C (33.9°C), and 24°C (34.9°C) as well as in the southern population: 16°C (32.3°C), 20°C (34.6°C) and 24°C (35.3°C) ($P < 0.001$). Comparison of CT_{max} between populations indicated significant differences in the 20°C ($P < 0.001$) and 24°C ($P < 0.05$) acclimation treatments with the southern population having higher CT_{max} compared to the northern population. Further, hepatosomatic index was elevated in the northern population relative to the southern population in each acclimation treatment, with significant effects of both acclimation and population ($P < 0.001$) across treatments. Routine metabolic rate was impacted by both

acclimation temperature and population ($P < 0.05$) while maximum metabolic rate was affected by only acclimation temperature ($P < 0.001$). In addition, significant differences in growth, mRNA expression patterns, and mortality were also observed between treatments.

Nicholas R. Strowbridge. *Intraspecific variation in thermal and hypoxia tolerance across populations and life-stages of Rainbow Trout*

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Patricia M. Schulte, Department of Zoology, University of British Columbia

Jessica L. McKenzie, Department of Zoology, University of British Columbia

Sara L. Northrup, Freshwater Fisheries Society of British Columbia

Anthropogenic climate change threatens to reduce habitat for freshwater fish species such as Rainbow Trout. Increased water temperatures, a direct result of global warming, are also leading to markedly increased catch-and-release mortality in Rainbow Trout. In response, stocking managers continue to develop strategies to help preserve recreational fisheries into the future. One such strategy includes identifying populations that are resilient to the predicted future environmental conditions associated with climate change. In this study, we examined thermal and hypoxia tolerance in various strains of Rainbow Trout across multiple brood years (2017 and 2018) and at two life-stages (fry and yearling). We found significant differences ($p < 0.05$) in thermal tolerance (Critical thermal maximum; CT_{max}) across strains, and across life-stage. We also found significant differences ($p < 0.05$) in hypoxia tolerance (ILOS) across strains and across life-stage. In the 2017 brood year, we found a significant correlation ($p < 0.05$) between thermal and hypoxia tolerance at the yearling stage, such that thermally tolerant individuals tended to be hypoxia tolerant. However, we were unable to detect such relationships in the 2018 brood year at either life stage. Strains also differed in their post-trial mortality rates, with one particular strain sustaining significantly higher post-thermal tolerance trial mortality than the other strains. These results suggest that there are differences in strain/life-stage responses to high temperatures and hypoxia. Our findings may help inform managers on optimal strains and life-stage to use when stocking lakes that are susceptible to large changes in temperature and hypoxia.

SESSION: HATCHERY INNOVATIONS (short snappers – 10 minutes in length)

Jamie Deupree. *Wild Stock Enhancement Programs Support Systems and Infrastructure*

*Innovasea Systems, Inc., 425 Ericksen Ave. NE, Suite 101, Bainbridge Island, WA 98110. Tel: 206-866-9800. Email: jdeupree@innovasea.com

Tim Gregg, Innovasea Systems, Inc.

A warming climate in the Pacific Northwest is altering both the freshwater and saltwater habitat for all Pacific salmon species. This coupled with human infrastructure altering access and habitat degradation, is imperiling all coastal and Salish Sea salmon species. All populations need help to survive the warmer waters, changing seasonal streamflow patterns, and our impact on their

environment. Maintaining any existing salmon population will require a significant effort on our part.

Many programs throughout the Puget Sound are helping the Pacific salmon species through wild stock enhancement programs. Some of these programs have also benefited from the use of acclimation pens. The acclimation pens are beneficial because the salmon can continue to grow in a protected environment prior to release. The larger salmon have better odds of survivability. The positive effect on the survival and return percentage of enhancement fish with the use of acclimation pens has been proven over many years by multiple programs. Some programs have seen up to twice the return rates compared to when acclimation pens are not used. If the use of acclimation pens was adapted by more programs, there is a strong potential for improved survivability of the local Pacific salmon species.

To help our salmon species, it will take a combination of habitat restoration, upgraded hatchery systems, and improving the survivability of juvenile salmonids. The use of acclimation pens is a proven method which can positively assist survivability of juvenile salmonids benefitting stock enhancement programs throughout the Pacific Northwest.

Duaine Hardie. *Redesign and custom-built fish transport tanks*

*Freshwater Fisheries Society of BC, Vancouver Island Trout Hatchery, 1080 Wharncliffe Rd, Duncan BC. Tel: 250-746-5180. Email: duaine.hardie@gofishbc.com

In 2018 Freshwater Fisheries Society of BC redesigned and custom-built fish transport tanks for mounting onto a 5-ton truck chassis. The project objectives were to build better designed tanks for the fish transport and release and better structural integrity of the tanks and frame. Tank design consists of three inline stainless-steel tanks enveloped with aluminum storage cabinet. The combination of Stainless steel and aluminum allow for strength for the transport tanks while still maintaining the additional attributes of lightweight aluminum for the storage cabinets. This presentation will present the pros and cons of the first generation of the new tanks.

Derek Ingram. *Feeding eFISHently, one meal at a time*

*Freshwater Fisheries Society of BC, 34345 Vye Rd., Abbotsford, BC, V2S 7P6.
Tel: 604-504-5409. Email: derek.ingram@gofishbc.com

Erin Wright, Chris Casey, and Steve Olson, Freshwater Fisheries Society of BC

All Freshwater Fisheries Society of B.C. hatcheries are continuing to transition their feed systems from Digital Direct Controls (DDC) to Programmable Logic Controllers (PLC). Initial purchases of off the shelf feeder software worked in the short term. With the help of fish culturists and facilities personnel, changes to software resulted in improvements to feeding strategies and streamlined implementation for our specific needs. FFSBC staff have developed and continue to maintain software for fish culture activities.

The goal of this presentation is to outline the process of implementing feeder control software. It will cover user challenges, troubleshooting, benefits, and outline a plan for all our facilities.

Steve M. Atamanchuk. *Bug Attractor - Mutilator - Killer Bug Zapper*

*volunteer Goldstream Hatchery, Langford BC. Cell: 250-882-9903.

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I was first introduced to the Bug Zapper when our Technical Advisor, Peter McCully, asked me if could fix this, I said what is it, OK. I fixed the unit and after which he said can you make one. The original device was made in the USA, years ago. The Zapper consists of a photo cell, lamp and ballast, an AC motor, with a wire attached to the motor shaft. The components are housed in a 12" cake plate and covered with a 12" pie plate. The unit is hung from the ceiling above each tank of our ponding shed. The basic function of the unit is that the photo cell detects darkness and turns on the light and motor. Light attracts flying bugs, like moths, bugs and such. The wire attached to the shaft is situated such that the bugs pass it and hence are killed or injured and they fall into the tanks. Units are installed above each tank once the fry are big enough to eat bugs and the outside temperate is warm enough for bugs. We have done some analysis on the effectiveness of the units, but not a comparison of fish size in a tank with and without Zappers. We have installed a Zapper above a tank filled with water and then took pictures of the amount of bugs it had attracted and identified them. I can provide a complete list of all parts and my source. The approximate cost of one unit is between $150.00 to $180.00. Each unit consumes 68 watts.

SESSION: POTPOURRI

Erin Rechisky. *The Coast-wide Collapse in Northeast Pacific Chinook and Steelhead Survival*

*Kintama Research Services

David Welch and Aswea Porter, Kintama Research Services

Accelerating decreases in survival are evident for a wide range of Northern Hemisphere salmon populations. We collated data on: (1) smolt survival during downstream freshwater migration and (2) coded wire tag-based and PIT tagged-based smolt-to-adult survival for all regions of the Pacific coast of North America excluding California to examine the forces determining salmon returns. A total of 3,055 years of annual survival estimates were available for Chinook (*Oncorhynchus tshawytscha*) and steelhead (*O. mykiss*). We found that over the past half century marine survival collapsed by a factor of at least 4-5 fold to similar low levels (~1%) for most regions of the Pacific coast. The size of the decline is too large to be compensated by freshwater habitat remediation or cessation of harvest, and too large-scale to be attributable to specific anthropogenic impacts such as dams in the Columbia River or open net-pen salmon farming in British Columbia. Survival declines later in the marine phase may help explain why Chinook survival has fallen so drastically across the entire west coast of North America.

Projected rates of climate warming are likely to increase in the near future, further reducing marine survival of many salmon populations. Managers need to correctly identify the drivers of salmon collapse and to respond appropriately.

Bob Robinson. *Things I have learned during my 35+ years within the industry*

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Accumulated knowledge basically starts at birth. If you would have told me 35 years ago upon graduation from the University of Wisconsin - Stevens Point with a fisheries degree that I would have taken the path I have, I would have told you, you are crazy. Having placed my feet on more

than 1,000 aquaculture farms all over the world has blessed me with friends, experiences, challenges and knowledge that I will take to my grave. My experiences include selling equipment, selling feed, working within the channel catfish industry and currently for the last 20 years using my accumulated knowledge to help farmers with their aeration challenges. This industry has faced challenges from the regulatory community, inconsistent quality fry, fingerling availability, financing, risk management, NGO use of fiction over facts and a basic lack of understanding that fish farmers by their inherent nature are typically excellent environmental stewards. Using my experiences this talk will focus on facts, successes and failures, combined with a bit of humor. I will offer where I think the industry is headed along with what is needed to take it there.

Douglas Engemann. *Fertilization of Chinook Salmon and Steelhead Eggs Using a Saline Solution for Sperm Activation*

*Idaho Department of Fish and Game, Pahsimeroi Hatchery, 71 Fish Hatchery Lane, May, ID 83253 Tel: (208) 876-4330. Email: douglas.engemann@idfg.idaho.gov

Steeve Pomerleau, Jacob Rook, and Morgan Fife, Idaho Department of Fish and Game

The Sawtooth and Pahsimeroi Fish Hatcheries have commonly used regular well-water to activate sperm for Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead trout (*Oncorhynchus mykiss*) eggs fertilization. However, literature suggests that the use of a saline solution for sperm activation can improve fertilization rates in numerous salmonid species. A total of four separate studies were conducted to evaluate the effect of a 0.85% saline sperm activating solution on eye-up rates of Chinook salmon and steelhead trout eggs. The saline sperm activating solution was compared to common well water during one steelhead spawning season (Sawtooth 2014) and three Chinook spawning seasons (Sawtooth 2014, 2015, and Pahsimeroi 2018). The eye-up rate of steelhead trout eggs fertilized in a saline solution (93.9%) was significantly greater ($P<0.001$) than the eye-up rate of eggs fertilized in regular well water (90.5%). However, there were no significant differences ($P > 0.05$) in eye-up rates of Chinook salmon eggs between the saline and no-salt treatments on any of the three years tested. Despite observing between 0.4 and 0.6% improvements in the mean eye-up rates of Chinook salmon eggs fertilized in a saline solution on the three years tested, the differences were not statistically significant. However, the statistical power of those analyses was very low (18-44%).

Soledad Francke. *The Importance of Extending Quality Salmonid Sperm*

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By 2018, 2.3 million tons of Atlantic salmon were shipped worldwide, with almost 90% corresponding to farmed salmon.

The constant productive challenges are related to the appearance of disease, productive seasonality, and growth, among others. These challenges are increasingly faced with greater technology that allows acceleration of results such as genomic selection, QTLs, etc. This allows for accurate identification of individuals carrying genes that translate into specific resistance to disease, greater growth, and organoleptic characteristics among others.
However, crossing fish that contain ideal characteristics becomes complicated since it is not always possible to have valuable males and females available at the same time.

By extending semen longevity, monitoring quality, and utilizing cryopreservation, it is possible, today, to perform all required combinations at production level.
The following work shows the effect of extending salmon semen longevity, evaluating its quality, as well as the use of cryopreservation as a production management tool, all to increase the effectiveness and speed of obtaining a new generation in the program's genetics.

Nuri Fisher. *Mysis shrimp: An invasive species in the interior lakes of British Columbia, Canada and the pioneering of a sustainable freshwater fishery*

*Piscine Energetics, Tel: 250-800-1540, nuri@mysis.com

Mysis diluviana was introduced into Okanagan Lake in 1966 to provide an additional food source for rainbow trout and kokanee salmon, but this theory has proven to be largely incorrect and the introductions caused competition between mysids and kokanee for the same food source. In the deep lake, the Kokanee eat few of the shrimp, and instead, the shrimp compete with juvenile Kokanee for selective macrozooplanktors such as Daphnia sp. Invasive, Mysis shrimp have decreased the quantity of food available to Kokanee. The experimental harvest of mysids began on Okanagan Lake with the long erm objective of removing enough mysids to provide kokanee with a competitive advantage. Under the auspices of the British Columbia Ministry of Environment, Forests, Lands and Natural Resource Operations, Piscine Energetics pioneered and invented fishing technology for environmentally sustainable harvesting and removal of the invasive Mysis shrimp from Lake Okanagan. The technology enables the simultaneous live harvesting of Mysis Shrimp and facilitates the live reintroduction of non-target species (i.e. Kokanee fry) unharmed and in pristine condition back to the lake.

Jennifer Krajcik. *Salmon Research at the Oregon Hatchery Research Center*

*Oregon Department of Fish and Wildlife, 2457 East Fall Creek Road, Alsea, OR, 97324. Tel: 541-487-5510. Email: jennifer.a.krajcik@state.or.us

The Oregon Hatchery Research Center is a unique research facility, owned by the Oregon Department of Fish and Wildlife and operated jointly with the Fisheries and Wildlife Department of Oregon State University. We have living space for visiting researchers, wet and dry labs, incubation and rearing facilities, multiple sizes of tanks both indoors and in an outdoor tank farm, and four simulated streams. The OHRC professional staff work with researchers on a wide range of projects with wild and hatchery salmon and steelhead. Our Mission is to study the mechanisms creating differences between wild and hatchery fish, and to develop ways to manage these differences while meeting fishery and conservation goals. Operational research is directed to practical questions from hatchery rearing, including the production of sterile triploids, the effects of rearing structures on fish growth and health and the use of different fish brood stocks for hatchery production. Strategic research ranges from molecular genetics to landscape ecology, including studies of olfactory imprinting and homing, geomagnetic ocean navigation, effects of rearing temperature on sexual development, life history consequences of egg size and mating success of individual males and females. We have access to wild Chinook, coho, cutthroat and steelhead, as well as hatchery Chinook and steelhead. We are actively engaged in education and outreach at all levels from pre-school students to senior citizens. We encourage those interested in research collaborations to contact us to develop productive projects that take advantage of our unique facilities.

Dr. Brian Riddell. *The Pacific Salmon Foundation's analyses of Hatchery Effectiveness in BC*

*Pacific Salmon Foundation (PSF)

The Pacific Salmon Foundation (PSF) will undertake a science-based review of hatchery results in the Pacific Region including community hatcheries and major facilities operated by DFO. The findings will be designed to guide and improve program effectiveness, as well as provide factual data that will aid in dealing with requests for new or different production.

The aim of this project is to examine the effectiveness of current production, identify scientific advancements in recent years that may be applied to increase effectiveness, and ultimately inform the joint production of hatchery-based and wild Pacific salmon for BC communities and ecosystems.

The project will include the following components:

1. PSF will carry out an analysis of current scientific methods that may be applied to the examination of hatchery-produced salmon ids with an objective to explain changes over time which could be applied to future production and to improve effectiveness, where appropriate. This will include an assessment of genetic stock identification, parentage-based tagging (PBT), and genomics.
2. PSF will collate existing data for major facilities and community facilities into an analytical framework that allows for analysis of juvenile production, analysis of survival rates by release groups, and production of adults by release group, facility, and return years. These analyses will include examination of changes in biological characteristics.
3. PSF will carry out a review of past programs (both in Canada and the US) and a review of findings to date around release strategies and other experimental programs. These analyses and review of findings will be summarized in a review paper.
4. On the basis of components 1 through 3, PSF will complete an independent peer review of hatchery effectiveness in BC and provide recommendations. PSF will organize an independent panel (experts in science, analyses, and enhancement practices) and conduct a review workshop before finalizing their report.
5. The final report will provide recommendations to assist SEP programming, infrastructure investments and future methodologies, strategies and tools to increase effectiveness in major and community hatcheries in B.C.

POSTERS

Kari Alex. *Okanagan River Restoration Initiatives*

*OKANAGAN NATION ALLIANCE - HABITAT GROUP

Starting in 2009 the Okanagan Nation Alliance began the task of reconnecting Okanagan River habitat that was lost from the historic floodplain due to river reconstruction to prevent flooding. The Okanagan River Restoration Initiative (ORRI) continues as an ongoing project to restore aquatic habitat and reactivate rearing areas for salmon and other aquatic species.

Kylie Anderson. *Delayed Release Strategy for Juvenile Coho Impacts on Survival and Size at Spawn*

*Fisheries and Oceans Canada.

Edward Walls, Eric Fortkamp, and Shawn Kerr DFO, Fisheries and Oceans Canada.

Juvenile coho salmon (*Oncorhynchus kisutch*) are released in multiple areas at various times of year in a myriad of conditions by government and volunteer agencies in Campbell River, BC. Quinsam River Salmon Hatchery (Quinsam Hatchery) operated by Fisheries and Oceans Canada, located in Campbell River, is a major contributor to coho enhancement on the east coast of Vancouver Island. Quinsam Hatchery conducts volitional releases of nearly 400,000 juvenile coho annually after rearing within the facility over the course of an average of 19 months. As part of a site specific study, delayed juvenile releases have been conducted since the 2014 brood year in order to collect conclusive data on whether a delayed release would directly result in improved spawner recruitment in the Quinsam River watershed. A normal release for juvenile coho at Quinsam Hatchery occurs in early to mid-May, whereas delayed release occurs in mid to late June. Results indicated an improved relative survival of late release when compared to 'normal' release timing; however, length at return has been noted to be lower in the late release group.

Ryan Benson. *Sockeye Smolt Out of Basin Survival: Pit tagging*

*OKANAGAN NATION ALLIANCE - STOCK ASSESSMENT

The Okanagan River Sockeye salmon population is one of the last remaining viable fisheries in the Columbia River basin. Since 2003 the ONA has conducted reintroduction of hatchery reared sockeye into the Okanagan River system (Osoyoos Lake, Skaha Lake and Okanagan Lake). Out of basin survival of both hatchery and natural sockeye remains an important yet unanswered question.

Randall Bock. *Humane Percussive stun/killing of Salmon using the Bock Industries Zephyr-F*

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Email: randall@bock-industries.com

Mark Cylwik, FHS3, Hoodsport Hatchery, WDFW

The conventional method of stun/killing salmon is to apply a mechanical percussive stun from which the fish will not recover (FAWC 2014). Salmon are usually also bled for quality purposes, but this would also cause death if the percussive stun did not already achieve this. Percussive stunning requires sufficient force to cause instantaneous unconsciousness and/or death. The generalised use of automated percussive stunning for salmon and large trout has become common practice. Manual percussive stunning becomes less efficient particularly over time due to operator fatigue. The use of a portable Zephyr-F allows salmon farmers an alternative to the fixed automated systems currently in use.
For percussive stun/killing of salmon, the blow must be delivered to the top of the head, just behind the eyes. The blow should be of sufficient force to induce immediate, non-recoverable unconsciousness (Kestin et al., 2002; Robb and Kestin, 2002; Roth et al., 2007). Research by Lambooij et al. (2010), showed that when salmon are hit on the head with sufficient force, brain function is instantaneously lost. The Zephyr-F fitted with an adjustable shaped adaptor, enables the energy developed by the pneumatically powered bolt (27 Joules) to be delivered accurately to adult salmon of all sizes. This tool has been proven for the euthanasia of all poultry species and neonate livestock on-farm.

Don Chamberlain. *Puntledge River Summer Chinook Conservation – Annual DNA Sampling and Analysis*

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Laurent Frisson, Esther Guimond, James Amos, Jacob Melville, Anabel Cairns, Heather Braun, Fisheries and Oceans Canada

The Puntledge River system is one of a few rivers on the east coast of Vancouver Island in British Columbia that supports both a summer and a fall-run of Chinook salmon (*Oncorhynchus tshawytscha*). Summer-run Chinook enter the river from May to August while fall-run Chinook enter from September to October, but both stocks spawn at the same time, primarily in October.

Maintenance of the genetic integrity of the summer-run stock has been an ongoing objective of Fisheries and Oceans Canada's (DFO) Puntledge River Hatchery since enhancement activities to restore the population began in the watershed in 1965. Summer-run Chinook are genetically distinct from the fall-run population. By annually collecting Chinook that arrive to the hatchery early, before August 1st, and holding these fish for use as broodstock, the genetics of the Puntledge summer-run Chinook stock have been preserved.
With recent advances in genetic analysis techniques at the DFO Molecular Genetics Laboratory, at the Pacific Biological Station, Puntledge Hatchery is now able to identify individual fish based on stock origin (summer versus fall-run Chinook) as well as family relationships. Since 2013, the use of cutting-edge DNA sampling techniques has also provided information on the survival of different spawning groups based on disease status, and the heritability of adult migration time. This new information supports better management actions focused on improving wild and hatchery summer Chinook productivity and safeguards the genetic integrity of the population which is of high conservation concern for DFO, local First Nations and Community stakeholders.

Curt Edmondson. *Applications and Results of Moist Air Salmonid Incubation Systems*

*Jensorter, 3699 NE John Olsen Ave., Hillsboro, OR 97124. Tel: 503-701-9719

Moist Air Incubators (aka "fog incubators") offer technical advantages and challenges for the incubation of salmonid eggs. Advantages include extremely low water requirements and the ability to accurate control incubation temperatures. Disadvantages include additional infrastructure and operational costs. This presentation will review field use of these new types of incubators during the past few years.

Chad Fuller. *Building Capacity for Basin Management*

*OKANAGAN NATION ALLIANCE - AQUATIC LABORATORY

The ONA operates an Aquatic Health lab that services the traditional territory of the Syilx people. Additional work is done on contract to other organizations within BC and across Canada. The lab currently is able to utilize tissue culture, qPCR and Elisa for disease diagnostics. Furthermore, they are able to age fish, analyze stomach contents and test water quality.

Kevin Hall. *Adult Salmon Handling at Inch Creek Hatchery: Electro-Anaesthesia System*

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Inch Creek Hatchery which is located in the Fraser Valley had a goal to update their adult chum and coho handling procedures in order to meet their animal care obligations and improve staff health and safety. Until 2017, fish used in eggtakes were killed individually in a labour intensive procedure that often left staff suffering from repetitive motion injuries. Fish taken in Excess Salmon to Spawning Requirement fisheries were killed through suffocation and a more humane method of handling the fish was needed. The solution to these problems was to try something new: electro-anaesthesia. Electro-anaesthesia uses electricity as a means of immobilizing or euthanizing adult salmon. The electro-anaesthesia system at Inch Creek was built using Halltech's HT-2000 Battery Backup Electrofisher. This unit in combination with a pescalator, flumes and a new adult handling building has greatly improved the efficiency and safety of adult handling operations. Improvements continue to be made to ensure that fish are being killed in the most humane manner possible.

Maureen A. Hess. *Monitoring salmonid hatchery stocks with Parentage Based Tagging (PBT) in the Columbia River basin*

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Parentage-based tagging (PBT) and genetic stock identification (GSI) are two approaches, that when used in combination, can provide critical stock-specific information for both hatchery- and natural-origin salmon and steelhead. In this presentation, we focus on PBT, a large-scale tagging technology for salmonid hatchery stocks. This approach assigns unknown hatchery-origin fish to a baseline of candidate parents from known hatchery broodstock, thereby inferring age, origin and hatchery source of the offspring. The PBT program was initiated with broodstock collections in the Snake River but have been expanded throughout the Columbia River Basin since 2012. Several applications of PBT have been demonstrated for Chinook salmon and steelhead to characterize stock composition in fisheries, estimate stock-specific abundance and run-timing at dams, identify physically unmarked hatchery fish, estimate the proportion of hatchery fish on spawning grounds, and identify stocks using thermal refugia during migration. These applications are now possible on a basin-wide level, as PBT allows the ability to track millions of hatchery fish and the opportunity to address a variety of parentage-based research and management questions.

Norm Johnson. *Increasing Survival of Cultured Sockeye*

*OKANAGAN NATION ALLIANCE - HATCHERY

As a part of the Okanagan Basin Sockeye Reintroduction Program the ONA collects broodstock yearly from the Okanagan River system. This program has been producing sockeye fry for 16 years. Construction of an ONA wholly owned hatchery in 2014 has allowed sockeye fry releases as high as 5.2 million per year. Survival from green egg to release are consistently 90-96% and are due to a customized Okanagan Nation Sockeye Rearing Protocol that is specific to the hatchery. The hatchery also has a Chinook rearing program and is currently licensing to raise Sturgeon.

Tod Jones. *Advances in Oxygen Supplementation for Hatcheries*

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The role of oxygen in fish metabolism is well established in its ameliorating effects on fish health and on improved conversion rates of fed fry/smolts. Three factors control the concentration of oxygen in water bodies, temperature, salinity and total gas pressure. The latter is usually dictated by altitude, however, artificial enhancement of atmospheric pressure can be achieved and has been shown to allow for increased absorption of dissolved oxygen in a hatchery's water supply. Redd Zone has developed a novel device that allows for using existing source water pressure to exceed normal atmospheric pressure and to achieve up to 300% concentration of oxygen while ex-gassing nitrogen. In cases where little existing head pressure exists, the "Water Spike" can be fitted to a pump that will provide the desired continuous pressure and volume needed to achieve hyper-saturation.

Tod Jones. *Instant Hatchery In a Box*

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Roger Warren, Vice President Redd Zone, LLC

Hatchery costs continue to accelerate and new facilities are often designed with old technology. Redd Zone has developed the "Instant Hatchery" concept by using new shipping containers and turning them into a "plug-and-play" hatch house. Using the Redd Zone "Best Fry", "Swim-Out" incubators the system, allows for single pass or re-cycled incubation to control incubation temperatures, provide for UV depuration and conserve on water use. Often the cost of a complete unit, which can be from ten feet in length to fifty feet, is less than the engineering costs of standard hatchery construction.

Lori Kishimoto. *Assessing the Fisheries Contributions of Washington State Hatchery Chinook Salmon with Coded-Wire Tag data*

*Washington Department of Fish and Wildlife, Natural Resources Building, 1111 Washington St. SE, Olympia, WA 98501.

Each year millions of Coded Wire Tagged (CWT) salmon are released from hatcheries operated by the Washington Department of Fish and Wildlife. CWT recoveries for Chinook Salmon released in the Columbia and Snake River Basins were analyzed for brood years 2000 to 2011. This data was used to determine fisheries contribution per 100,000 fish released, to account for differences in smolt-to-adult survival (SAR). Hatcheries across this region contributed to fisheries

in very different ways, Lower Columbia has a higher proportion of adults contribute to hatchery returns, Upper Columbia tended toward spawning ground, whereas Middle Columbia and Snake River had higher commercial catch. All regions had similar proportions of adults caught in sport fisheries. Although more expensive to raise to release size, yearling programs showed a SAR benefit over sub-yearling Chinook, as well as a potential increased benefit to sport fisheries.

Jacob Knight and Lyndy Vroom. *The Benefits of Using Aerial Drones for Scouting and Estimating Salmon Abundance*

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At the Conuma hatchery it is important to have timely information on the location and size of salmon runs in order to successfully collect brood stock for egg-takes and bio-sampling requirements. An unmanned aerial vehicle, also known as a drone, is used to identify and quantify salmon escapement in the rivers in which brood stock capture takes place. The use of a drone provides improved data for more accurate and timely observations of river populations and their locations which improve escapement estimates and the ability of hatchery crew to target fish for brood purposes. The use of a drone also aids in finding salmon in locations that are not easily accessed by foot that may have otherwise been missed. The drone and drone pilot training are a minimal cost to SEP. The procedure is significantly less resource intensive and much quicker than typical count methods such as manned aircraft flights, observations from boats, snorkeling and stream-side counts. Videos and photos can be saved, filed and evaluated at a later date if the information is needed. Flight plans and procedures are carried out in accordance with Transport Canada Policy and Procedures.

Robert Konrad. *Capilano Watershed Trap and Truck Program*

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The Capilano River was dammed in 1954 by the Cleveland dam creating the water supply for metro Vancouver. As a result, Salmon could not migrate to the upper capilano river to spawn naturally. Populations of native species such as coho salmon (*Oncorhynchus kisutch*) and Steelhead (*Oncorhynchus mykiss*) dwindled. The numbers of native species improved when the Capilano Hatchery was built to mitigate the dams' negative impacts. In order to provide the upper watershed with salmon and steelhead hatchery staff must capture and transport fish so they can spawn naturally in the upper reaches. Once the progeny of those adults emerges from the gravel and are ready to migrate to the ocean metro Vancouver captures the juveniles and transports them safely below the dam as they would not survive a 200-foot drop. This program has provided an increase in unmarked fish returning to the system.

Alexa N. Maine. *Polyculture increases growth and survival of larval Pacific Lamprey*

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In an effort to increase growth and survival for lab propagated larval Pacific lamprey (*Entosphenus tridentatus*), a preliminary polyculture experiment used speckled dace (*Rhinichthys osculus*) to increase the microbial community in a recirculating system. Laboratory environments are largely homogenous, providing little habitat complexity and few interspecies interactions; and are generally maintained in a semi-sterile state to prevent the development of harmful microorganisms. For the purposes of population supplementation and research, larval Pacific Lamprey (*Entosphenus tridentatus*) have been propagated and reared at Confederated Tribes of the Umatilla Indian Reservation (CTUIR) facilities since 2012, mainly in monoculture systems (containing only lamprey). As larval lamprey are closely associated with the benthic environment in the river, they likely have an important relationship with the microbial community existing on the river bottom. Average instantaneous growth rates for larvae reared in polyculture in 2018 were higher ($7.2x10^{-3}$ mm/day) than those of monoculture larvae reared in 2016 and 2017 (2.1×10^{-3} mm/day). Laboratory monoculture of larval lamprey in 2016 resulted in a 29.0% survival rate, adjusted to survival at 90 days post-fertilization, while polyculture resulted in a 57.1% adjusted survival rate. These results suggest that the presence of dace as a co-reared organism provides some improvement in the growth and survival of lab-propagated larval lamprey. Potential mechanisms for these results include direct consumption by lamprey of microorganisms or increased ecosystem services provided by the microbial community; however further research is needed to clarify the factors affecting growth and survival in larval lamprey.

Doug Olson. *10-years of Chinook salmon contribution to Pacific Ocean and Columbia River fisheries from our Columbia River Gorge National Fish Hatcheries*

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Todd Gilmore, David Hines, Steve Pastor (retired), Brook Silver, David Hand, and Jesse Rivera, U.S. Fish and Wildlife Service, Columbia River Fish and Wildlife Conservation Office, Vancouver, Washington.

Contribution to fisheries was determined by summarizing code-wire tag recoveries of adult Chinook salmon released as juvenile fish (brood years 2001 through 2010) from four National Fish Hatcheries (NFH) located in the Columbia River Gorge, including tule fall Chinook from Spring Creek NFH, upriver bright fall Chinook from Little White Salmon NFH, and spring Chinook from Carson NFH, Little White Salmon NFH, and Warm Springs NFH. During this 10-year period, these hatcheries contributed over one million adult Chinook salmon to the Pacific Ocean and Columbia

River, including harvest (sport, commercial and tribal fisheries), hatchery returns, and spawn ground tag recoveries. For ocean fisheries, tule fall Chinook were harvested in British Columbia (45%), Washington (38%), Oregon (16%), and California (1%), with a 10-year total contribution > 200,000 adult Chinook salmon. For the Columbia River, tule fall Chinook contributed > 540,000 adult salmon over 10-years, where 49% were harvested in freshwater, 49% returned to hatcheries, and 2% were recovered on spawning grounds. Upriver bright fall Chinook ocean fisheries (> 50,000 adults over 10-years) contributed to Alaska (48%), British Columbia (37%), Washington (10%), Oregon (4%), and California (1%). Within the Columbia River, upriver bright fall Chinook contributed > 170,000 adults over 10-years, with 33% harvested in freshwater, 53% returned to hatcheries, and 14% were recovered on spawning grounds. For spring Chinook returning to the Columbia River (> 130,000 adults over 10-years), 51% of adult fish were harvested, 47% returned to hatcheries, 2% were recovered on spawning grounds, and < 1% in ocean fisheries.

Jeremy Pike. *Salmon in Idaho: Dworshak NFH Hurdles Challenges in the Race to Beat the Effects of Climate Change*

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Changes in climate have affected survival of Salmonids from the Clearwater River Basin during ocean rearing. Warmer river temperatures downstream during migration creates a thermal barrier to fish movement. As a result, returns of Salmonids to the Clearwater River has declined, compared to historical averages.

Dworshak National Fish Hatchery (DNFH) is located below Dworshak Dam at the confluence of the mainstem and the North Fork Clearwater Rivers. The facility operates to mitigate losses of steelhead trout (*Oncorhynchus mykiss*) and Chinook salmon (*Oncorhynchus tshawytscha*). Dworshak Dam regulates water outflow through three hydroelectric generators and as “spill” for downstream water temperature, flood management, and seasonal needs. Water travels through spillways on the face of the dam into the North Fork Clearwater River, the primary water source for the facility. Releases of reservoir water for downstream temperature augmentation creates cold water temperatures for holding adults. The cold temperatures create challenges for growth in early rearing of juveniles.

Obtaining enough eggs to meet broodstock needs is another hurdle. The fish ladder runs continuously and in some years, basin coordinators implement hook and line supplementation. Egg transfers from other facilities are more frequent. The number of spawning events in a season increased from an average of four to an average of seven. Managing temperature units of so many groups is a new challenge faced at DNFH. There is constant refinement and adaptation with the times for methods of meeting brood, egg incubation, rearing juveniles, and overall success of the hatchery’s programs.

Ravinder Sappal. *Substituting fish meal with freshwater mysid shrimp in the formulation of fish feed: effects on the performance of juvenile rainbow trout (Oncorhynchus mykiss) reared in hatchery*

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The aquaculture industry is threatened by rapid growth and dwindling marine fish stocks that conventionally serve as a source of fishmeal in the formulation of commercial aquafeeds. Consequently, there has been increased interest in finding alternative, environmentally-friendly sources of these critical aquafeed ingredients, wherein a variety of sources ranging from aquatic insects to vegetable material have been explored. We tested the effectiveness of *Mysis diluviana*, a freshwater invasive crustacean, as a replacement for fishmeal in salmonid food. Blackwater and Pennask strains of juvenile (parr) rainbow trout were reared for 60 days with a commercial feed (control) or one of two experimental diets in which 25% or 50% of fishmeal was replaced with Mysis in the formulation of the aquafeed. Feed analysis revealed higher lipid content and comparable fatty acid profile in experimental food relative to the commercial food. Importantly, the 50% Mysis feed improved survival, growth performance and body lipid content of the fish without altering their fatty acid profile. The 50% Mysis feed provided dietary protein and energy at levels sufficient to enhance growth, and lipid at a level that maintained normal body fatty acid composition. Interestingly, the fish fatty acid profile mirrored that of the food indicating that fatty acids are primarily derived from dietary sources. These results suggest that Mysis can be used effectively to replace 50% of fishmeal in salmonid food for parr stage rainbow trout.

Carol Schmitt. *Natural fresh water rearing program for chinook juveniles which significantly increases marine survivals resulting in greater numbers of adult fish for marine fisheries and escapements (spawner returns)*

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Rupert Gale, Gillard Pass Fisheries Association

Juvenile Chinook salmon were raised at Omega Pacific Hatchery (Omega) in a freshwater program based on the “Fundamental Principles of Natural Biology” which more closely resembles the incubation and rearing cycle of wild fish. The naturally reared juveniles were raised as stream type fish (1+) and compared to the standard enhancement program accelerated ocean type (0+) fish. Juveniles were adipose clipped and coded wire tagged prior release and assessed based on tags recovered from adult fish captured. The comparison included 0+ to 1+ juveniles released in Phillips River, which enters the Strait of Georgia (SOG) and 0+ to 1+ juveniles released in the Nahmint and Sarita Rivers, which enter West Coast Vancouver Island (WCVI). These releases were compared to the nearest federal production hatcheries 0+ chinook, being Quinsam for SOG and Robertson Creek for WCVI. On average the numbers of coded wire tags recovered from 0+ were 0.50% and Omega’s 1+ at 3.0%. Since coded wire tags recovered represent 20 to 25% of the adult population, the marine survival for juvenile release to adults is extrapolated for 0+ at

2.5% and 1+ at 15%. The 1+ grown in a natural program resulted in few jacks, no straying and re-appearance of older, larger adult Chinook salmon. The majority of B.C.'s chinook stocks are extirpated and remain low level stocks despite being enhanced with thousands of 0+ juveniles, unable to increase numbers of adult spawning returns. Omega demonstrated with four releases of 45,000 1+ juveniles over a five-year duration would increase the number of adult returns from a few hundred to 2800. Freshwater rearing greatly affects marine survivals and incorporating a more naturally grown 1+ juvenile for enhancement will re-build a stock to a large enough population more resilient to extirpation that leaves the majority of fish to naturally spawn with minimal hatchery intervention, and is the best solution to saving the remaining stocks of chinook salmon.

Tristan Shonat. *Developing culture methods for larval Pacific lamprey: energetic demands*

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Alexa Maine, Fisheries Program, Department of Natural Resource, Confederated Tribes of the Umatilla Indian Reservation

Aaron Jackson, Fisheries Program, Department of Natural Resource, Confederated Tribes of the Umatilla Indian Reservation

As a First Food for the Confederated Tribes of the Umatilla Indian Reservation, Pacific lamprey holds a deep cultural significance. Artificial propagation is a tribal restoration focus, both to replenish declining wild populations and gain a greater understanding of this species. In culture, oxygen availability can be limiting, especially after larvae are fed oxygen-consuming yeast and fish food. Therefore, it is crucial to understand oxygen consumption rates in conditions with or without food. A goal for artificial propagation is release into the wild, so it is also important to understand how energy demands and fitness of propagated larvae compare to wild-caught larvae. Oxygen consumption was measured in static chambers with optical oxygen probes. The resulting data were compared between age classes, between fed and unfed groups, and between lab-propagated and wild-caught larvae. We hypothesized that oxygen uptake would increase with larval size and with feeding due to specific dynamic action (SDA) and yeast consumption and would drop back down after feeding. We also hypothesized that the energy demands of wild lamprey and lab-propagated lamprey would be similar. Larvae from 2019 had low respiration rates; however, upon feeding oxygen consumption increased due to yeast respiration and SDA. Larvae returned to their normal respiration rate within 24 h. Yearling larvae (from 2018) had higher weight-adjusted respiration rates even before feeding. Wild and propagated lamprey had similar oxygen demands. This suggests that propagated lamprey larvae may be adequate surrogates for wild fish.

Geraldine Vander Haegen. *How to tag 278,000 fish in an hour, and why do we need to?*

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Dave Knutzen and Lee Blankenship, Northwest Marine Technology Inc.

In the Pacific Northwest of the United States and Canada, hundreds of millions of salmon are reared and released from hatcheries every year. Over 250 million of these fish are either coded-wire tagged or mass marked by an adipose fin clip before release. A similar program in the mid-west of the United States releases all 20 million trout and salmon stocked into the Great Lakes with a coded wire tag and adipose fin clip. Coded wire tags are mainly used to identify stocks for fishery allocation and population assessment. Mass marking allows visual distinction of hatchery fish from wild fish in selective fisheries, for broodstock management and in limiting stray fish. Implementation of these marking and tagging programs has been a significant logistical and technological accomplishment. State, tribal, and federal fish and wildlife management agencies in these regions use a combination of manual processing and the fully automated marking and tagging technology of AutoFish System. We describe how it is possible to process this huge number of fish within the limited time they can be handled.

Jeremy van Woerden. *Tenderfoot Creek Hatchery: The re-introduction of Chinook and Coho to the upper Elaho River*

*Fisheries and Oceans Canada

Joshua Retallick, Fisheries and Oceans Canada

The Elaho river holds significant importance to the Squamish Nation as a summer fishing location. However, since the 1970's, fish passage, specifically that of Coho (*Oncorhynchus kisutch*) and Chinook salmon (*Oncorhynchus tshawytscha*), into the upper Elaho river has been hindered by a large boulder that sits in the middle of the river. The velocity of the water moving downstream around the boulder has acted as a barrier preventing the migration of spawning salmon to the upper Elaho.
As a result of logging activity in the area, the boulder fell into a narrow canyon section of the river making it extremely difficult to access. Beginning in November 2017, blasting of the rock overseen by the Department of Fisheries and Oceans Resource Restoration Unit has helped break the boulder into smaller pieces, allowing for freshet to remove rock fragments more easily. This has reduced the velocity around the rock enough that it is believed fish movement past the barrier is possible. Ongoing monitoring and blasting will continue as required.
In an attempt to reintroduce Coho and Chinook species back into the Upper Elaho river, DFO's Tenderfoot Creek Hatchery (Squamish, BC) has been collecting broodstock from tributaries of the Elaho and Squamish. The second year of Chinook capture and rearing for the Elaho project is underway, with 15,000 Chinook planned to be reared and released as yearlings into the upper Elaho. In coordination with Squamish First Nation and Squamish River Watershed Society, DFO's Tenderfoot Creek Hatchery was able to conduct the first release of Chinook fry in May of 2019. An attempt to re-introduce Coho will commence in November and December of 2019. Coho will be re-introduced by transporting adult Coho from the upper Squamish and lower Elaho up past the barrier rock and into the upper reaches of the Elaho River.
In upcoming years eDNA data collected pre blasting will be used as a baseline to determine if fish migration around the barrier is possible. Once positive fish passage is determined new targets for successful reintroduction will be determined.

Kayla P. Warden. *Comparison of dissolved oxygen and the cost of using the O2 generator*

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The Kooskia National Fish Hatchery has operated our O2 generator for the past two years. During the summer months, we have low dissolved oxygen concentration due to the use of well water and growth of our fish. The O2 generator is successful in adding oxygen to the water; the hatchery production could increase without increasing the water flows. Currently in a research phase, the most effective way to inject oxygen is to have it go through air stones near the bottom of the aerator area near the pumps that send water to the burrows ponds. This would be a comparison of dissolved oxygen going to the burrow's ponds compared to the last two years dissolved oxygen data and the cost of using the O2 generator during the summer months.