Plenary Session Abstracts

WHY AQUACULTURE MATTERS

Jesse Trushenski

Riverence

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 the 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 review the history of aquaculture in North America, highlight important themes related to the purpose and practice of raising fish, and underscore the many reasons that aquaculture matters.

IDAHO'S AQUACULTURE INDUSTRY: FOOD, JOBS AND MORE

Gary Fornshell

Aquaculture Results LLC

Fish produced from commercial aquaculture in Idaho supply restaurants and grocery stores throughout the nation, are stocked into private ponds, contribute to aquatic resources, and supply the aquarium trade. Aquaculture farms are located throughout the state, but the industry is concentrated in the Magic Valley between Twin Falls and Hagerman. The Magic Valley produces about 70% of the food-size trout produced in the U.S. Other Idaho produced aquaculture species include tilapia, white sturgeon, catfish, and ornamental fish. Aquaculture farms are an intermediate link in the Magic Valley agricultural economy, with backward links to suppliers and service providers and forward links to fish processors. Commercial aquaculture is a valuable part of the Magic Valley's agricultural economy through food production and processing, job generation, and flow of new dollars into the region through exports. This presentation will describe the Idaho aquaculture industry, compare the aquaculture industry to other agricultural industries within the region and to aquaculture production in other states and highlight the "more" — the connection to conservation and science.

FISH HATCHERIES AND MANAGEMENT IN THE IDAHO DEPARTMENT OF FISH AND GAME: INNOVATION AND INTEGRATION AT EVERY STATION

Jim Fredericks

Idaho Department of Fish and Game

The Idaho Department of Fish and Game operates 21 fish hatcheries statewide that collectively spawn, raise, and release a total of nearly 37 million resident and anadromous fish of multiple species to meet a wide range of fishery management objectives. The history of the hatchery program is rich and long. The first state hatchery in Idaho was built in 1907. Over 100 years later, that facility (Hayspur Hatchery) is still operated by the IDFG. As facilities and functions of hatcheries have evolved and been modernized over the decades, so have policies and practices related to the use of hatchery fish. IDFG fishery managers use hatchery-reared fish to preserve, establish, or reestablish depleted fish populations and to provide angling opportunity to the public. Today, however, a key element of state policy is the emphasis on maintaining genetic integrity of native populations. To most effectively achieve management and policy objectives, the agency has endeavored to foster a culture of innovation and integration of hatcheries with research and management. Those collective efforts have resulted in several groundbreaking programs that have improved fishing opportunities, minimized or eliminated genetic risks, and even developed promising new methods for non-native fish control.

USING CONSERVATION AQUACULTURE TO RESTORE NATIVE SPECIES: A TALE OF TWO FISHES FROM THE KOOTENAI

Susan Ireland

Kootenai Tribe of Idaho

Kootenai River White Sturgeon and Burbot are unique keystone species in the Kootenai River and are of immeasurable cultural importance to the Kootenai Tribe of Idaho. These native fish once sustained an important Tribal subsistence fishery, as well as a recreational fishery. Due to largescale ecosystem changes over the last century, both Kootenai Sturgeon and Burbot populations have been severely limited due to a virtual lack of recruitment. Kootenai Sturgeon were subsequently listed as endangered in 1994 and Lower Kootenai River Burbot were considered functionally extinct by 1999. The Tribe has operated a successful Sturgeon conservation aquaculture facility since 1990. In 2014, construction of a second facility to produce sturgeon and burbot was completed and became fully operational in 2015. Without hatchery intervention, both species would have completely disappeared from the Kootenai River. The implementation of conservation aquaculture is integrated with a holistic transboundary program that includes habitat and nutrient restoration, innovative research, monitoring and evaluation, adaptive management, and outreach in collaboration with scientists, co-managers and the local community. There is still much to be done, but the conservation aquaculture program has restored Kootenai River White Sturgeon in numbers high enough to ward off extinction, and has restored the Burbot population in numbers high enough to provide a subsistence and recreational fishery in Idaho, contributing to the ecological health of the river and the cultural and social health of the Kootenai Tribe and the local community.

SOLUTIONS THROUGH SCIENCE: RESEARCH AS A CRITICAL COMPONENT TO ENHANCING FISH CULTURE AND FISHERIES

Ken Cain

University of Idaho

Aquaculture supports Idaho's economy and is an integral tool used to manage and conserve fish populations that are impacted by anthropogenic changes and ongoing human activities. As fisheries professionals we tend to focus on our "niche", be it fish management, fish culture, fish ecology and so forth; however, these fields are intertwined. I believe that we all share the common goal of wanting what is best for the resource we work with, but our fisheries resources face many challenges. Therefore, we must work together to effectively address these challenges and develop solutions based on good science. A scientific approach has been applied to fish culture and fisheries for decades. Whether working to recovery Redfish Lake Sockeye, addressing smolt to adult returns for salmon, estimating wild cutthroat populations, or managing around disease episodes in the hatchery, research aimed at answering critical questions is the foundation for success. Yes, aquaculture involves the "art and science" of fish culture to produce healthy animals but utilizing hatchery fish to meet goals such as enhancing fish populations, contributing to a sport fishery, or providing tribal harvest, requires more than just growing fish and releasing them into the water. You must use the "tool" that aquaculture represents in a way that meets these goals. Examples of research questions that address important problems for aquaculture and fisheries management will be discussed. Results from specific research studies and the implications they have for important fisheries resources in Idaho and elsewhere will be highlighted.

Invited Presentation Abstracts

MONITORING HATCHERY PROGRAMS WITH GENETIC TOOLS

Shawn Narum

Columbia River Inter-Tribal Fish Commission

Hatchery programs have been widely implemented to mitigate for impacts to anadromous salmonid populations throughout the Columbia River Basin. Widespread genetic sampling paired with cost-effective genotyping have enabled genetic tools to be effectively applied for monitoring hatchery programs. I review multiple applications of genetic monitoring for hatchery programs such as examining reproductive success of integrated hatchery supplementation programs, genetic tagging of hatchery produced fish with PBT to estimate stock specific escapement and return timing, and a new approaches for tracking underlying genes for traits such as run-timing and age-at-maturity in hatchery stocks. These genetic applications are intended to compliment traditional monitoring efforts for ongoing hatchery reform in the region.

THE WAFWA YY MALE CONSORTIUM: EXTENDING IDFG'S EXPERIMENTAL BROOK TROUT PROGRAM TO OTHER STATES AND SPECIES

Dan Schill, Elizabeth Mamer, Matthew Campbell, Katharine Coykendal, Gregg Anderson

Idaho Department of Fish and Game

Since 2008 the Idaho Department of Fish and Game (IDFG) has developed and researched field application of YY Male technology, a technique for potentially eradicating undesirable exotic fish populations. The basic approach involves the creation of a genetically YY Male broodstock whose progeny are released into specific populations in hopes of skewing the sex ratio to all males, thereby eradicating them upon stocking cessation. On July 1, 2018 a consortium of 13 western states comprising nearly all U.S. members of WAFWA (Western Association of Fish and Wildlife Agencies) including IDFG jointly funded and began a collaborative effort to expand the Brook Trout program regionally and also to begin laying the foundational science to enable the development of additional YY Male broodstocks. The invasive species being targeted in this program include the Common Carp, Lake Trout, Brown Trout, Walleye, and Northern Pike. This paper identifies members and intentions of the consortium and describes ongoing YY-related work in various collaborating state and federal entities. The status of YY Consortium work on two key elements in YY Male broodstock construction and subsequent field monitoring (sex reversal trials and sex marker development) will be reported for the above targeted species. IDFG's YY Male Brook Trout broodstock, housed and managed by IDFG staff at the Hayspur Hatchery is currently capable of producing 1-2 million eggs annually. Along with eggs for fish being reared for in-state IDFG evaluation, YY broodstock eggs are currently being provided free of charge to the states of NM, OR, WA, and a USFWS facility to enable broader field evaluation of the technique in terms of eradication success. Preliminary results of several of these efforts demonstrate exciting results in some scenarios. However, to date no eradications have occurred though such a result should not be anticipated this early. Remaining work and challenges to developing new species YY Male broodstocks including attainment of FDA approval will be discussed.

RECENT ADAPTATIONS OF THE KOOTENAI RIVER NATVIE FISH CONSERVATION AQUACULTURE PROGRAM TO RESTORE WHITE STURGEON AND BURBOT

Shawn Young, Nathan Jensen, Susan Ireland

Kootenai Tribe of Idaho

The Kootenai River White Sturgeon Acipenser transmontanus and Burbot Lota lota maculosa were once abundant in the Kootenai/ay River Basin in Idaho and Montana, USA, and British Columbia, Canada. Kootenai White Sturgeon remain listed as endangered in both countries, and Burbot natural recruitment remains very low despite recent successes meeting interim goals of warding of extinction / extirpation by filling recruitment gaps and re-building population structures via conservation aquaculture, and ecological restoration actions. The Kootenai Tribe of Idaho's (KTOI) Kootenai River Native Fish Conservation Aquaculture Program (KRNFCAP) goals are, avoid extirpation and rebuild abundance to jump-start natural recruitment, and support cultural and recreational harvest. Beyond rebuilding abundance, the conservation hatcheries also 1) spawn, rear, and release fish in a manner that supports monitoring, research, and evaluations of post-release performance of hatchery White Sturgeon and Burbot; and 2) release early life stages across habitat types/conditions in a manner that allows long-term evaluation of recruitment failure, and habitat restoration outcomes. By doing so, conservation aquaculture is an integral part of a large multi-strategy ecosystem restoration RM&E effort. The presentation will provide a summary of recent program adaptations implemented in response to recent RM&E results concerning the current status of the focal species and to the current ecological state of the Kootenai Basin.

DEMOGRAPHIC AND GENETIC CONSERVATION OF SNAKE RIVER SOCKEYE SALMON VIA EX SITU SPAWNING AND REARING

John Powell[1], Craig Steele[2], Dan Baker[1]

[1]Idaho Department of Fish and Game, [2]Pacific States Marine Fisheries Commission

Captive propagation is a tool managers can use to conserve genetic diversity and demographically support critically endangered species. A captive breeding program was established for Snake River Sockeye Salmon prior to their listing as endangered under the U.S. Endangered Species Act in 1991. This captive population is managed to maximize the retention of founding genetic diversity and minimize adaptation to the captive environment. To accomplish these goals broodstock selection is performed to minimize relatedness within the captive population. Effective population size is then maximized by maintaining nearly uniform spawner contributions to the next generation. The captive broodstock is integrated with the residual Sockeye Salmon population in Redfish Lake by incorporating natural-origin returns into spawning crosses and releasing captive-reared Sockeye Salmon into Redfish and Pettit lakes. The Snake River Sockeye Salmon Captive Brood program has been successful in preventing the extinction of the Snake River Sockeye Salmon evolutionarily significant unit and was estimated to have conserved 95% of the founding genetic diversity. In addition to successfully perpetuating this stock, more than 1.1 million eyed-eggs, 1.9 million parr, 6.1 million smolts and 16 thousand adults have been released to supplement the wild population over the program's 30-year history. Challenges to recovery persist despite increases in adult returns across the past quarter century. Therefore, captive propagation remains vital to the continued existence of this evolutionarily significant unit.

MITIGATION WASN'T BUILT IN A DAY: IDAHO'S AQUACULTURE HISTORY*

Eric Pankau

Pocatello High School

The year 2020 marked a historic milestone for the American Fisheries Society: 150 years of improving the conservation and sustainability of fishery resources. On December 20, 1870 a contingent of like-minded fish culturists convened in New York for what can be considered the formation the American Fisheries Society (Originally named American Fish Culturists' Association). The artificial propagation of fish in Idaho predates its statehood and formation of the state fish and wildlife management agency. This long and unique history is rich with the stories of fisheries professionals defining the craft of aquaculture for commercial, sport and conservation interests. A small handful of local historians have dedicated themselves to preserving this history and sharing it with the people of Idaho. In that spirit a new web based series of galleries are being created and maintained by the ICAFS to continue this effort. The purpose of this presentation is to highlight the significance of aquaculture in Idaho's fisheries history and to introduce the new online history galleries which can be found at the Aquaculture Committee section of the ICAFS website: https://www.idahoafs.org/committees/aquaculture.php

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Contributed Presentation Abstracts

Aquaculture Practices

INVESTIGATION OF WELL WATER REARING AS A MEANS OF BACTERIAL KIDNEY DISEASE CONTROL AT THE PAHSIMEROI HATCHERY

Douglas Engemann

Idaho Department of Fish and Game

Bacterial Kidney Disease (BKD) outbreaks and related mortality have been a problem at many hatcheries. Bacterial Kidney Disease outbreaks have consistently been the single largest source of juvenile summer Chinook salmon mortality at the Pahsimeroi Hatchery. Existing BKD treatment options are limited in both availability and efficacy. Consequently, a reduction of BKD infection rates will be critical in meeting Pahsimeroi Hatchery's mitigation and conservation targets. The BKD outbreaks at the Pahsimeroi Hatchery occur after the fish are transferred from the indoor nursery vats on well water to the outdoor rearing ponds on water supplied by the Pahsimeroi River. During Brood Year 2020 marking and tagging activities, the Pahsimeroi Hatchery staff will transfer approximately 60,000 summer Chinook salmon into three nursery vats supplied with well water. With the exception of a four week acclimation period at the conclusion of the investigation, these fish will be cultured throughout an entire production cycle on well water. The remaining 432,000 fish will be transferred to the outdoor rearing ponds and then cultured per normal hatchery protocol. A BKD causative agent baseline prevalence rate will be determined prior to pond transfer. During the subsequent course of the investigation, BKD prevalence will be compared between both groups of fish on a weekly basis. The primary objective of this investigation is to determine if BKD infection rates and associated mortality can be significantly reduced or eliminated by the use of well water rearing throughout the majority of a hatchery production cycle.

EVALUATION OF METHODS TO ESTIAMTE FISH PER POUND IN IDAHO HATCHERIES

Josh McCormick, **Daniel Dillon**

Idaho Department of Fish and Game

The purpose of this analysis is to evaluate two methods for estimating mean fish per pound in Idaho hatcheries. The first method, which is currently the most commonly used method, involves collecting multiple buckets of fish, weighing the bucket then counting the fish. The number of fish is then divided by the total weight of the fish to estimate fish per pound. The second method involves weighing individual fish and calculating the mean number of fish per pound based on individual weights. The evaluation is based on the relative bias and precision of each method, along with the sample size required to meet various levels of precision.

EFFECTS OF INTIAL FEEDING TIMING ON EARLY SURVIVAL OF BONNEVILLE CUTTHROAT TROUT

Steve Stowell, Wayne Fowler, Wyatt Tropea

Idaho Department of Fish and Game

Since 2010, the Grace Fish Hatchery has been responsible for managing a conservation aquaculture program to help supplement and reestablish populations of Bonneville Cutthroat Trout Oncorhynchus clarkii utah within the Bear River basin in southeast Idaho. The timing of initial feeding is an important element in fish culture and can have a significant impact on the survival and growth of larval fish. Historically, the initial feeding phase of Bonneville Cutthroat Trout rearing is where the highest mortality is experienced at Grace Fish Hatchery. The purpose of this evaluation was to determine if there is an initial feed timing that can be implemented to maximize survival of Bonneville Cutthroat Trout. Treatment groups were fed for 30 days with initial feeding times of 858, 924, 968 and 1012 TU's. Average percent direct survival ranged from 83% - 88% across the treatment groups with no significant difference detected.

EARLY WEANING OF BURBOT (LOTA LOTA MACULOSA) LARVAE ONTO ARTIFICIAL ARTEMIA (EZ ARTEMIA) AND GEMMA MICRO DIET

Moureen Matuha**, Luke Oliver, Joseph Evavold, Kenneth Cain

University of Idaho, Aquaculture Research Institute

This research builds on the 2019 (trial 1) burbot preliminary weaning trial results that showed that artificial artemia (EZ artemia) could be a potential substitute for live feeds by reducing live feeding time by 17 days when compared with the standard rearing protocol. The present study, therefore, aims to further identify feeding regimes that could reduce the use of live feeds by maximizing growth and survival during the early phase of burbot production. Burbot larvae were reared with green water, live food (rotifers, San Francisco Artemia, Salt Lake Artemia), artificial artemia, and Gemma micro diets) and the effect of weaning on growth and survival of the larvae under controlled conditions were investigated. The experiment lasted 70days (8-77 days post hatch [DPH]). The fish (BW 0.001 g; TL 5.0 mm) were divided into five feeding regimes: a standard control (fed live feeds), treatments 1 (fed San Francisco artemia and artificial artemia), 2 (fed rotifers and artificial artemia), 3 (exclusively fed artificial artemia) and 4 (fed Great Salt artemia) that were weaned to Gemma micro diet on 60, 50, 8, and 25 DPH, respectively. Standard production protocol had a better survival (~30.9%), treatment 1 larvae (20.7%), treatment 2 larvae (17.5%) and treatment 4 (~15.2%). Treatment 4 had a better growth (~58mm), standard production protocol (~55mm), treatment 1 (~44mm), treatment 2 (~38mm). Only one larva survived in treatment 3 by 77dph. Use of artificial artemia in treat 1 and 2 reduced the period and amount of using live feeds by 19 days and 24days, respectively. Early use of Gemma micro diet in treatment 4 helped reduce on live feed use by 19 days when compared with the standard production protocol. The results further represent a potential cost saving and labor reduction since the period of using live feeds can be reduced.

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VOLITIONAL SPAWNIGN AND EGG INCUBATION PRACTICES USED IN THE RECOVERY OF KOOTENAI RIVER BURBOT

Riley Jones, Nathan Jensen, Shawn Young

Kootenai Tribe of Idaho

Burbot Lota lota maculosa were once abundant in the Kootenai/ay River Basin; Idaho USA and British Columbia Canada, where they provided important cultural, recreational, and commercial fisheries. Beginning in the 1970's, cumulative effects of habitat loss and hydro-power operations lead to an extirpation of Burbot populations. A multi-agency cooperative program lead by the Kootenai Tribe of Idaho (KTOI), the University of Idaho Aquaculture Research Institute (UIARI), the British Columbia Ministry (BCM) and Idaho Department of Fish and Game (IDFG) has resulted in development of a program to conserve, restore and monitor a native strain of Burbot now being used to rebuild and restore populations on a basin-wide scale. From 2009 to present, the program transitioned from UIARI laboratory-scale production to larger-scale production at a new KTOI Tribal fish hatchery. The Kootenai Tribe of Idaho Native Fish Conservation Aquaculture Program now operates the hatchery to support Kootenai River Burbot conservation aquaculture and IDFG and BCM complement the program by means of in-river post-release monitoring and evaluation. Current population estimates of adult Burbot in the basin exceed 50,000, which has led to the implementation of Kootenai River Burbot as a source of brood stock for the program. This new brood stock source has produced more than 59 million eggs over the course of four years of the program. The eggs collected from the Kootenai River Burbot have been used for multiple research projects, experimental larval releases, and to bolster juvenile production for Idaho and Canadian releases. This presentation will go in depth on the aquaculture practices that have led to the success of the Kootenai River Burbot as a brood stock source, including aquaculture system design, volitional spawning, and egg incubation practices.

CONTROL OF BURBOT (LOTA LOTA) SPAWNING INDEPENDENT OF NATURAL SEASON USING PHOTOTHERMAL MANIPULATION

Luke Oliver**, Joseph Evavold, Kenneth Cain

University of Idaho

Intensive commercial production of burbot fingerlings will depend on genesis of eggs and larvae independent of season, however, no information on out of season burbot spawning exists and it is unknown how out of season spawning may affect egg and larval quality. Using one burbot broodstock, sexual maturation was shifted six months from the natural spawning season by manipulation of the photothermal period. Out of season data was compared to randomly selected in-season broodstock to assess differences between the two production regimes. For both treatments, broodstock was sampled for condition factor and egg production, eggs were monitored for development, viability, and survival, and larvae were reared to report growth and survival. Pre-spawn condition factor for in-season fish did not statistically differ from the out of season fish, 0.81 and 0.89, respectively. However, the out of season broodstock did have a significantly higher post-spawn condition factor, 0.83, when compared to the in-season fish, 0.64. Eggs produced per weight of pre-spawn female did not differ significantly between in -season and out of season production, 328.5 and 213 eggs/g, respectively. Fertilization did not differ

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significantly between treatments, averaging 90% for both in and out of season production. Survival of eggs through incubation did not differ between treatments, except in the last week of incubation where the out of season eggs had significantly higher survival. Finally, larvae did not significantly differ in growth or survival between the two treatments at any instance up to the 35dph termination point. Production of burbot eggs outside of natural spawning season appears to be an effective way to enhance annual production of burbot fingerlings and mitigate the risk of relying on a single annual spawning season occurring on a natural cycle.

XX ALL-FEMALE RAINBOW TROUT – SEX REVERSAL

Jared Riemenschneider, Thomas Lindenmuth, Gregg Anderson

Idaho Department of Fish and Game

At Hayspur Fish Hatchery, we have a recirculating aquaculture system (RAS) that has 24 tanks (four rows of six tanks each) and the RAS allows us to feed hormone treated feed to our diploid rainbow trout. The RAS consists of multiple components such as the biofilter, sand filter, degassing tower, a pump, and water chillers. Abbreviations for hormones are as follows: MT - 17a-methyltestosterone, OHA - 11β-hydroxyandrostenedione. Brood year 2018 (BY18) at Hayspur Fish Hatchery consisted of three treatment groups: MT 1 PPM, MT 3 PPM, and OHA 3 PPM. BY19 consisted of six treatment groups: MT 1 PPM, MT 3 PPM, OHA 3 PPM, MT immersion and 0.5 PPM MT, OHA immersion and 3 PPM OHA , and MT immersion and fed untreated feed. Two groups for BY19 were placed in the pots. BY20 consisted of three treatment groups: MT 1 PPM, MT 3 PPM, and OHA 3 PPM. BY18 is our only mature group of XX All-Female rainbow trout. We know how many males we had produce milt when squeezed, from what treatment groups those fish came from, which treatment group was the most and least successful in sex reversal, and what treatment group produced the highest percentage of expressing males. We spawned our expressing males and we injected the XX All-Female rainbow trout with LHRHa hormone to ripen the fish. I will discuss our spawning procedures for those events.

HOW TO CREATE A SEXUALLY REVERSED BROOK TROUT BROODSTOCK IN A HATCHERY SETTING

Thomas Lindenmuth, Jared Riemenschneider, Gregg Anderson

Idaho Department of Fish and Game

The presentation will cover many different aspects of how to create a sexually reversed broodstock in a hatchery setting. For example: Goals of the program, Treatment Process, Egg Incubation, Genetics/PIT Tagging, Spawning Process and equipment used to build the Recirculating Aquaculture System. The ability to sex reverse Brook Trout to create a broodstock for Idaho Department of Fish and Game has been very beneficial to control invasive Brook Trout populations. This allows the department to remove Brook Trout from lakes and streams without having to kill the entire system.

USING LIGHT MANIPULATION TO SPAWN RAINBOW TROUT YEAR-ROUND

Thomas Lindenmuth, Jared Riemenschneider, Gregg Anderson, Marc Garst

Idaho Department of Fish and Game

The presentation will cover many different aspects of using light manipulation to spawn rainbow trout year-round. For example: Why Idaho Department of Fish and Game is using this technique, the time frame required for light manipulation to work on rainbow trout, LED light blubs over CFL light bulbs, the length of a spawn period, egg eye-up percent, the number of females spawned per spawning event over the length of the spawn period, egg size over the length of the spawn period, and average fecundity per fish, and the number of fish that do not produce eggs in a spawning period. There will also be comparisons made between several different age groups of Rainbow Trout that are on light manipulation schedules to groups that are on natural spawning schedules. The comparisons that will be made between the different groups are as follows; the length of a spawn period, egg eye-up percent, the number of females spawned per spawning event over the length of the spawn period, increasing egg size over the length of the spawn period, average fecundity per fish, and the number of fish that do not produce eggs in a spawning period. Using light manipulation has proven to be very beneficial to Idaho Department of Fish and Game and their state stocking program. Using light manipulation has also benefited other Idaho Fish and Game programs with the ability to have eggs year-round. Taking eggs throughout the year has helped spread out receiving hatcheries workloads. Taking 20 million eggs a year and shipping out 8 million eggs throughout the year has a greater benefit to the program than taking all of those eggs at one time.

USING AN ALL-INSECT BASED FEED SUPPLEMENT TO ACTIVATE AN IMMUNE RESPONSE IN RAINBOW TROUT*

Joseph Wannemuehler

Idaho Department of Fish and Game

Since the Idaho Department of Fish and Game obtain the Nampa Fish Hatchery in 1982, the early rearing ponds have been a hotbed for disease outbreaks. Within the last several years, the addition of Quonset structures has provided much needed stress relief for the fish and cleanliness within the concrete ponds, but move-out events continue to result in stress-induced disease outbreaks in the grow-out ponds. To combat these issues, the introduction of an all-insect-based feed supplement was added to the daily feed rations of two early rearing ponds. The supplement was added at an 8% inclusion rate and matched with its corresponding bulk feed size; #0-#3 crumb. Each raceway was monitored monthly for growth and health along with bi-monthly condition factor exams. The presentation will discuss the results and subsequent implications of the feed study.

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THREE YEARS OF POST-PROJECT EFFECTIVENESS MONITORING AND ADAPTIVE MANAGEMENT ON TWO PROJECTS IN THE UPPER LEMHI RIVER WATERSHED

Katie Salsbury[1], Jeff Diluccia[2], Breann Green[3], Stacey Feeken[2], Jeff Fealko[4], Rob Richardson[4]

[1]Intermountain Aquatics, [2]Idaho Department of Fish and Game, [3]Lemhi Regional Land Trust, [4]Rio Applied Sciences & Engineering

Collaborative partners of Idaho's Office of Species Conservation are implementing habitat conservation actions in the Upper Salmon Basin to address limiting factors to ESA listed Chinook salmon (Oncorhynchus tshawytscha), steelhead (Oncorhynchus mykiss), and bull trout (Salvelinus confluentus). In 2017, the Lemhi Regional Land Trust completed the construction of the Big Springs Phase 1 and Lemhi River - Fayle reach habitat enhancement projects to increase aquatic habitat complexity and restore floodplain and riparian zone function. To meet BPA HIP III high-risk project monitoring requirements for Endangered Species Act Section 7 Consultation, 3 years of post-project effectiveness monitoring and adaptive management actions were completed. Project effectiveness monitoring included: 1) individual work element performance criteria, effectiveness and stability monitoring, 2) plant establishment and survival, and 3) annual fish presence and spawning surveys conducted by the Idaho Department of Fish & Game. Adaptive management actions included plant skydd applications to discourage ungulate browse, additional willow plantings and the installation of a post-line willow weave fence to discourage a chute cut-off. This presentation will highlight the habitat enhancement techniques employed, their effectiveness, adaptive management actions and pre and post project reach fish data.

EXPLORING STREAM CONNECTIVITY OUTCOMES FOR STAKEHOLDERS AND YELLOWSTONE CUTTHROAT TROUT IN THE TETON RIVER DRAINAGE

Lizzie Jossie**[1], Travis Seaborn[2], Colden Baxter[1], Morey Burnham[1]

[1]Idaho State University, [2]University of Idaho

Two primary threats to native fishes worldwide are habitat degradation and invasive species. Stream habitat fragmentation divides metapopulations and may lead to local extinction. In many systems, including the Teton River drainage in eastern Idaho, fish passage barriers block migratory pathways for native salmonids. However, these same barriers may also prevent invasion from non-native fish species that have negative interactions with native species. In the Teton River drainage, invasion of non-native salmonids, including rainbow trout (Oncorhynchus mykiss), brook trout (Salvelinus fontinalis), and brown trout (Salmo trutta), is patchy and dependent on the connectivity of individual streams to the rest of the network. Managers and conservation groups in the Teton River drainage prioritize native Yellowstone cutthroat trout (Oncorhynchus clarkii bouvieri), but decisions that change connectivity and stream flow or address non-native species have uncertain ecological and social outcomes, and affect not only streams and fish but also irrigation, angling, and other stakeholder interests. In this project, I use a combination of qualitative mental modeling and quantitative agent-based modeling to examine 1) the suite of plausible

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connectivity scenarios in the Teton River drainage; 2) stakeholder perceptions of the outcomes of restoring connectivity across a variety of ecosystem services; and 3) the impacts of the different identified scenarios on Yellowstone cutthroat trout populations and their interactions with non-native species. The results from this project may help inform management of water resources, in-stream barriers, and trout fisheries in the Teton River drainage, as well as contribute to our understanding of connectivity conservation broadly.

DESCRIPTION OF JUVENILE ANADROMOUS SALMONID HABITAT DENSITY RELATIONSHIPS USING LARGE INTERAGENCY DATABASES AND SPATIAL STREAM NETWORK (SSN) MODELS

Dan Isaak[1], Erin Peterson[2], Jay Ver Hoef[3], Dave Nagel[1], Gwynne Chandler[1], Sherry Wollrab[1]

[1]US Forest Service, [2]Erin Peterson Consulting, [3]NOAA

Significant investments have been made by numerous agencies to monitor anadromous salmonids by conducting thousands of density surveys within streams across the Columbia River Basin. We aggregated these surveys from CRITFC, ODFW, IDFG, USFS, CHaMP, and BioMark for the period of 2000–2018 for Idaho and northeastern Oregon streams into a single database and applied spatial stream network (SSN) models to describe habitat relationships of juvenile Chinook salmon (n = 6,757) and steelhead (n = 7,436). Twenty-eight covariates were assessed, but only seven were statistically significant for Chinook salmon (reach slope, mean summer flow, mean August temperature, baseflow index, riparian canopy density, brook trout density, and inter-annual variation in juvenile densities) and these explained 57% of the variation in densities at the survey sites. The final model for steelhead accounted for 48% of the variation in densities and included six of the same seven covariates as the Chinook salmon model. Response curves describing habitat relationships indicated Chinook salmon densities were highest in medium sized streams with low reach slopes, cool temperatures, higher brook trout densities, and intermediate levels of riparian canopy and baseflows. Conversely, steelhead densities were highest in small streams with greater slopes, warmer temperatures, low brook trout densities, high proportions of watershed conifers, and intermediate levels of riparian canopy. The SSN models were used to create 24 prediction scenarios of juvenile densities for all reaches in the study area networks, and included baseline composite scenarios of average densities for 2000-2018, annual density scenarios, and three future scenarios indicative of climate warming
(scenarios available online as ArcGIS shapefile at the StreamNet Data Store: https://app.streamnet.org/datastore_search_classic.cfm). Our results highlight the utility of existing fish density survey data for creating new information when integrated to a consistent database and used with SSN models and other publicly available geospatial resources.

DISTRIBUTION, ABUNDANCE, AND HABITAT ASSOCIATIONS OF WARRIOR BASS (MICROPTERUS WARRIORENSIS) IN THE BLACK WARRIOR WATERSHED, ALABAMA

Amber Young**, Steve Sammons

Auburn University

The Southeastern United States possesses the richest diversity of freshwater fishes on the North American continent. Black bass Micropterus spp. follow this diversity trend. In fact, nine of the 14 described species and subspecies of black bass are endemic to the Southeastern United States. Some species of black bass in the Southeastern United States (e.g., Warrior Bass Micropterus warriorensis) were elevated to species status in 2013 and little is known about their distribution, life-history, and status. Therefore, resource managers need a better understanding of Warrior Bass distribution and habitat use before management actions can be implemented. The goal of this study was to estimate the distribution and abundance of Warrior Bass and to evaluate the influence of various factors on their presence and abundance. Warrior Bass distribution and abundance was assessed by conducting electrofishing (backpack and canoe) surveys in 49 streams from May – August 2020. During electrofishing surveys, all black bass were captured and identified to species. Habitat surveys were then conducted within the same section of stream as the electrofishing survey to characterize the habitat of each stream reach. Warrior Bass were detected in 16% of streams sampled. In total, 696 black bass were collected during sampling, of which 172 were Warrior Bass. Preliminary results are pending; however, results of this study will allow resource managers to identify areas within the watershed that should be prioritized for Warrior Bass conservation and management.

CHARACTERIZING SPATIOTEMPORAL VARIABILITY IN WATER TEMPERATURE AND HABITAT TO INFORM RESTORATION FOR COLD-WATER FISHES

Eric Berntsen[1], Francine Meija[2], Christian Torgersen[2], Todd Anderson[1], Jason Connor[1], Mark Lorang[3]

[1]Kalispel Tribe Natural Resources Department, [2]USGS Forest and Rangeland Ecosystems Science Center, [3]Freshwater Map

Aquatic organisms are exposed to multiple stressors due to habitat modification and climate change. Restoring degraded lotic systems requires initial assessment of the ecohydraulic landscape to identify stressors and determine riverine features that can be enhanced. The Lower Priest River in northern Idaho has had recent declines in bull trout (Salvelinus confluentus) and westslope cutthroat trout (Oncorhynchus clarkii lewisi), potentially due to changes in flow, temperature, and channel morphology. We identified cold-water refuges and characterized channel morphology by floating the lower 70 km of the river in a Lagrangian fashion with temperature probes and acoustic doppler current profiling (ADCP) to produce longitudinal profiles of thermal patterns, water velocity, and depth. We complemented these spatially continuous data with in-situ thermographs placed every 2 km and at selected pools and tributary junctions, and with physical measurements of channel morphology, and instream and riparian cover. Preliminary results revealed that, in general, water temperature decreased in a downstream direction due to groundwater and surface water exchange and tributary inflows. Localized downstream warming was observed in low-velocity reaches where travel time was

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greater and net solar radiation was relatively high, whereas high velocity reaches showed less warming in a downstream direction. Cover for fish (e.g. overhanging vegetation, brush, large woody debris, and undercut banks), large woody debris, and large, deep pools were limited, and cold-water areas associated with tributary junctions were localized. Restoration efforts can be focused on restoring and enhancing these riverine features at specific locations. These findings highlight the importance of high-resolution, spatially extensive assessments of the ecohydraulic landscape to help prioritize the selection of sites for restoration

TRIBUTATRY SCALE FISH RESPONSE FOLLOWING IMPLEMENTATION OF HABITAT CONSERVATION ACTIONS IN THE LEMHI RIVER SUB-BASIN, IDAHO

Jeffrey Diluccia, Stacey Feeken

Idaho Department of Fish and Game

The Idaho Department of Fish and Game monitored the effectiveness of habitat actions that were implemented to re-establish connectivity between the Lemhi River and its tributaries. Multiple limiting factors, such as stream dewatering and fish migration barriers, resulted in the isolation of tributary habitat that was historically important for Chinook salmon (Oncorhynchus tshawytscha), steelhead (Oncorhynchus mykiss), and bull trout (Salvelinus confluentus). Using a collaborative approach, projects were implemented from 2007 – 2012 to enhance stream flow, replace road culverts and irrigation diversions, and rehabilitate degraded stream habitat in Big Timber and Lemhi Little Springs creeks. Monitoring and evaluation studies also commenced during this time to determine tributary specific response among the different life stages of anadromous and resident fish species. Using a combination of stream reach electrofishing, aggressive Passive Integrated Transponder (PIT) tagging, and redd counts, we documented post treatment utilization of both tributaries. Juvenile response was seen mainly with Chinook salmon and O. mykiss parr life stages, with observed migration into Little Springs and Big Timber creeks presumably for summer rearing. Juveniles resided in these tributaries for extended periods of time. Furthermore, typical outmigration patterns were evident in the fall in both tributaries, and in the case of O. mykiss, anadromous forms were observed. Annual juvenile abundance estimates were variable, and were likely influenced by Lemhi basin adult escapement. Juvenile survival benefits are also discussed. Tributary use by adult life stages was documented, but to a lesser extent. PIT tagging documented adult Chinook salmon and steelhead escapement into Lemhi Little Springs, however, only steelhead were observed spawning. PIT tagged adult steelhead also entered Big Timber Creek, but spawning has not been documented. Results of this study results suggest that conservation actions aimed at reestablishing watershed connectivity were successful in providing conditions necessary for multiple life stages of anadromous fish.

WHITE STURGEON REPATRIATION IN THE MIDDLE SNAKE RIVER

Phil Bates

Idaho Power Company

The historical distribution of White Sturgeon in the Snake River extends upstream to Shoshone Falls, near Twin Falls, Idaho. White sturgeon habitat in the middle Snake River is fragmented into multiple segments by hydroelectric dams and is heavily influenced by managed flows from storage reservoirs in the upper Snake River Basin designed for flood control and irrigated agriculture. Only one of these middle Snake River populations, between Bliss and C.J. Strike dams, produces natural recruitment when inflows are favorable and has shown 30 years of increasing abundance. For populations without natural recruitment, managers have relied on small collections of wild reproductive White Sturgeon for hatchery broodstock to supplement abundance. Broodstock gametes were mixed using a factorial design to maximize diversity while culturing, but still failed to meet genetic diversity targets and produced unexpected levels of triploidy. As a result, the conservation program has switched to using a "repatriation" strategy where wild embryos are captured from the Bliss Reach then incubated and reared in a hatchery facility. Repatriation methods have met or exceeded genetic diversity targets, reduced triploidy, and allowed managers to develop a more robust stocking program for rebuilding White Sturgeon populations in the middle Snake River. However, a significant challenge is the consistent capture of a sufficient number of diverse embryos to support the program. In order to secure the long-term benefits of repatriation, continuing efforts to improve the collection of wild embryos will be a significant research component moving forward.

NIAGRA SPRINGS WHITE STURGEON HATCHERY CONSTRUCTION COMPLETEION

Daniela Ruiz

Idaho Department of Fish and Game

The aim of the new Niagara Springs White Sturgeon Fish Hatchery (NSWSH) is to successfully rear 2,500 juvenile White Sturgeon (Acipenser transmontanus), to be stocked into various segments of the Mid-Snake River, annually. The new facility features 30 new fiberglass circular tanks, a heated water system, and an aeration tower. White Sturgeon (WS) eggs, sourced from the Snake River will arrive Mid-April and go through Mid-June. These eggs will be sorted and placed in 2L upwelling incubation jars within sixteen, 2-ft circular tanks. Throughout the early rearing, WS will be graded and moved accordingly amongst the remaining tanks: eight, 4-ft tanks and six, 8-ft tanks. The water source for the new facility (1 CFS) comes from Niagara Springs, which is a constant water temperature of 14.4°C (58°F). The heated water system will allow us to increase the water temperature to 16-18°C (60-64°F) at the inflow of each tank. This will allow us to mimic natural incubation and rearing temperatures within the hatchery setting. WS are known to be sensitive to elevated levels of total dissolved gasses, so the addition of the aeration tower will strip gases and oxygenate the spring water before entering the rearing containers. In collaboration with other sturgeon rearing facilities, including the College of Southern Idaho, we hope to achieve the overall conservation goal of increasing WS abundance between Shoshone Falls and Brownlee Dam, and allow WS to reproduce naturally. A test group of Hayspur Fish Hatchery rainbow trout eggs will be reared in the facility to test the new components of the building, prior to WS egg arrival in April of 2021.

WHITE STURGEON CONSERVATION AQUACULTURE IN THE MIDDLE SNAKE RIVER; THE BENEFITS AND CHALLENGES OF REPATRIATION

Riley Brown

Idaho Power Company

While examining best management practices for White Sturgeon conservation aquaculture in the Middle Snake River, repatriation has shown clear benefits over traditional broodstock spawning. With higher genetic representation of the wild population, repatriation allows managers to increase annual stocking to predicted levels that recover Conservation populations in reaches between Shoshone Falls and Brownlee Dam. However, the repatriation method comes with challenges. The success of embryo collection is dependent on the ability to sample throughout the variable spring freshet in the Bliss Reach as White Sturgeon are spawning. Once in the hatchery, the adhesive embryos are usually encased in filamentous macrophytes, gravel and other debris. Much of this debris is difficult to remove and can aid in the onset of fungal growth. New techniques and knowledge have been applied annually to more efficiently sort and enumerate White Sturgeon embryos at the College of Southern Idaho Fish Hatchery. Due to the nature of their collection and life history, these embryos vary in developmental age and hatch within in a week or less. However, because of the sensitivity of late-stage embryos to chemical treatments, hatchery personnel have few tools to prevent losses due to fungal inoculation. And because of parental diversity, the variance in age amongst the cohorts has also presented challenges in terms of hatching dates, feed training, and size grading throughout the rearing cycle at the hatchery. With increased rearing needs and limited space and resources at the College of Southern Idaho, Idaho Power Company constructed the new Niagara Springs Sturgeon Hatchery in Wendell, ID. Although methods continue to evolve, knowledge gathered in recent years of culturing wild-source White Sturgeon from embryo to age-1 at the College of Southern Idaho Fish Hatchery will be applied at the new Niagara Springs Sturgeon Hatchery.

KOOTENAI RIVER WHITE STURGEON NATURAL SUBSTRATE AND FUNGAL CONTROL DURING EGG INCUBATION EXPERIMENT

Brian R. Michaels Jr., Nathan R. Jensen, Daniel Craig, Daniel Aitken, David Weaselhead, Mark. E. Elliston Jr.

Kootenai Tribe of Idaho

In 1988 the Kootenai Tribe of Idaho (KTOI) recognized the lack of Kootenai River White Sturgeon Acipenser transmontanus natural recruitment and started an experimental aquaculture facility to reverse population decline. The Kootenai River Native Fish Conservation Aquaculture Program (KRNFCAP) began rearing fish in 1990; shortly thereafter, the Kootenai River White Sturgeon were

listed as endangered in 1994. Using standard procedures (e.g. hormone injection, de-adhesion of eggs, and using McDonald jars for incubation), the KRNFCAP has been successful in raising juvenile White Sturgeon. Although standard practices have been successful, recent studies suggest there may be potential negative effects of hatchery practices (e.g. potential to exacerbate spontaneous polyploidy). During 2019, KTOI initiated new natural incubation techniques; and during 2020, amended protocols for fungal control to improve incubation, hatch, and early larval survival. The 2019 natural incubation techniques, used natural river rock substrate. Each substrate tank was setup with the same placement and size of substrate; and included spray bars introducing water below the surface directly upstream of the substrate. Fertilized eggs were not de-adheased and broadcast directly onto substrate beds <2 min post fertilization. Typically, fertilized eggs are de-adhesed to prevent adhesiveness/clumping and to allow tumbling in McDonald-Jars for 10 days; McDonald-Jars were also included in the experiment following standard incubation procedures (e.g. eggs de-adhesed). Four tanks were set up with substrate and four tanks were set up with McDonald Jars. Two substrate tanks and two McDonald-Jars received hydrogen peroxide (500mg/L) for fungal control. In general, this presentation will highlight survival results comparing McDonald-Jar vs. natural substrate incubation; fungal control vs. no treatment for the various incubation methods.

SPONTANEOUS AUTOPOLYPLOIDY TESTING PROTOCOL FOR THREE-MONTH-OLD KOOTENAI RIVER WHITE STURGEON

Mark E. Elliston Jr., Brian R. Michaels, Nathan R. Jensen, Shawn P. Young

Kootenai Tribe of Idaho

Kootenai River White sturgeon (KRWS) Acipenser transmontanus, at Kootenai tribal hatcheries are typically tested for Spontaneous Auto-polyploidy (SA) at 10 months at average lengths and weights >200 mm and >50 g. SA means that a fish has 12 sets of chromosomes (12N) which is abnormal. Normal ploidy for KRWS is 8N. The Kootenai Tribe of Idaho uses a Z2 Coulter Particle Count size Analyzer to determine if juveniles are positive for SA. Sample analyses are consistent to normal practices and protocols developed in collaboration with University of California-Davis. Briefly the Analyzer is equipped with a 100-micron aperture tube with lower threshold at 3 microns and upper threshold at 9 microns, with channelizers set to observe particle sizes between 3.695 microns and 6.664 microns. The purpose of this study was to develop methods to safely test smaller juvenile fish for SA by modifying standards and procedures. The test group (n=120) was part of an experimental incubation experiment with four distinct groups/treatments of fish (n=30) included 1.) H_2O_2 Treated McDonald Jars, 2.) Untreated McDonald Jars, 3.) H_2O_2 Treated substraight and 4.) Untreated Substraight. Average length and weights of test fish were 121mm and 8 g. The smallest fish tested was 82mm and 2.6 g. This presentation will overview the protocol used, rationale for protocol modifications and the resulting survival post testing as well as whether accurate SA results were obtained. The modified protocols may allow for pre-release screening to occur at earlier developmental life stages, and allow for year-class evaluation earlier in the hatchery production cycles.

SUBMERSIBLE PIT-TAG ANTENNA – ANOTEHR TOOL TO SUPPORT POST-RELEASE EVALUATIONS OF WHITE STURGEON IN THE SNAKE RIVER

Brandon Bentz

Idaho Power Company

Idaho Power Company (IPC) owns and operates eight hydroelectric dams in the Snake River between Lower Granite Dam (US Army Corps of Engineers) and Shoshone Falls (natural barrier), which after their construction created nine fragmented river segments with semi-isolated populations of White Sturgeon Acipenser transmontanus. Consistent recruitment failure, low genetic diversity, skewed size distributions, and low White Sturgeon abundance plague all but two of these population segments. Beginning in 2014, IPC collaborated with IDFG and CSI to augment depressed population segments between Brownlee Dam and Shoshone Falls using conservation aquaculture as part of project license requirements in the Middle Snake River. An essential component to conservation aquaculture and rebuilding populations is post-release monitoring of stocked White Sturgeon. Those monitoring efforts include an understanding of post-release metrics such as growth, condition, movement, habitat use, abundance and survival. Obtaining precise estimates of post-release survival rates require recapturing substantial numbers of tagged White Sturgeon which can be inefficient with traditional sampling gear such as gillnets or setlines. Therefore, to increase detection efficiency of stocked White Sturgeon, IPC employed the use of Biomark submersible PIT-tag antennas in the Snake River between C.J. Strike and Swan Falls dams from 2017-2020. Detections from baited PIT-tag antennas and physical recapture data from two year classes of stocked White Sturgeon were used to produce apparent survival rates first and second year post-release. Of the 297 juveniles stocked during 2016 and 2017, we detected a total of 215 (72.4%) individuals with antennas. Survival rates were estimated at 0.820 (95% CI 0.773-0.858) across both first and second year post-release. Baited PIT-tag antennas proved effective and efficiently increased detections of stocked fish which in turn provided for precise estimates of survival that are used to inform stocking numbers and project population growth.

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POPULATION DYNAMICS OF BONNEVILLE CUTTHROAT TROUT IN BEAR LAKE

Megan Heller[1,2], Michael Quist[1 2,3], Jeffrey Dillon[4], Carson Watkins[4], Arnold Brimmer[4] Scott Tolentino[5]

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Land-use disturbances and associated losses in habitat quantity and quality have negatively affected the Bonneville Cutthroat Trout (BCT) Oncorhynchus clarkii utah population in the Bear Lake system. Bear Lake BCT follow an adfluvial life history strategy and without access to suitable spawning habitat, the population of wild BCT was nearly extinct by the early 1950s. In response to this decline, supplementation of the population with hatchery BCT began in 1973. Production of wild BCT was minimal until conservation efforts shifted towards improving fish habitat. In 2002, only 5% of the population was wild fish; by 2017, nearly 70% of BCT in annual population surveys were wild fish. As a result, rule changes have been considered to allow for harvest of wild BCT. However, gaining a comprehensive understanding of the population dynamics of BCT in Bear Lake is critical before changes are made to management of the fishery. The objectives of this study were to evaluate the population dynamics of BCT and develop age-structured population models to investigate potential management scenarios (e.g., bag limits, length restrictions). Population age-structure, growth rates, mortality, and recruitment were estimated using sagittal otoliths from 562 fish collected during annual gillnetting surveys in 2017-2020. Total length of BCT collected in Bear Lake varied from 169-702 mm and age varied from 1-12 years. Because knowledge of population rate functions of BCT is limited, future management efforts in Bear Lake will benefit from this study.

POPULATION DYNAMICS AND TEMPORAL TRENDS OF BULL TROUT IN THE EAST FORK SALMON RIVER, IDAHO

Curtis Roth[1], **Eric Stark**[1], Lucas Koenig[1], Brian Ayers[2], Kevin Meyer[1]

[1]Idaho Department of Fish and Game, [2]Pacific States Marine Fisheries Commision

Because of their long-term listing under the Endangered Species Act, much interest has been placed on estimating population vital rates for Bull Trout Salvelinus confluentus, but the biotic and abiotic factors that influence the interannual variability in those vital rates have rarely been evaluated. We used mark-recapture data to estimate fish growth, survival, and trends in abundance for fluvial adult Bull Trout in the East Fork Salmon River, Idaho. Over an eight-year period, a total of 1,205 individual Bull Trout were collected at a weir 29 km upstream of the confluence of the East Fork Salmon River during June – September, of which 420 were recaptures from prior years. Bull Trout varied in length from 215 - 756 mm, and achieved a slightly larger asymptotic length (L_∞) and a slightly lower rate of growth (K) relative to other fluvial and adfluvial Bull Trout populations. Apparent survival ($\hat{\Phi}$) averaged 0.42 across all years, which was similar to previous studies estimating $\hat{\Phi}$ for Bull Trout. The number of emigrating anadromous salmonid smolts in the upper Salmon River basin positively influenced East Fork Salmon River Bull Trout growth and

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survival, and survival was higher in years with lower annual discharge. Assessment of population growth via linear regression analysis indicated that the Bull Trout population was increasing during the study period (λ = 1.08; 95% confidence interval = 1.03 – 1.14). Our findings highlight the ecological link between abundance of wild and hatchery salmon and steelhead and growth and survival of Bull Trout in systems where these species occur in sympatry.

SALMONID POPULATION TRENDS IN IDAHO'S SOUTH FOR BOISE RIVER

Timothy D'Amico, John Cassinelli

Idaho Department of Fish and Game

The South Fork Boise River (SFBR) downstream of Anderson Ranch Dam is a nationally-renowned tailwater trout fishery. Idaho Department of Fish and Game (IDFG) fisheries staff has utilized various sampling techniques to monitor trends in Rainbow Trout Oncorhynchus mykiss populations in the SFBR triennially since 1994. In the early 2010s, multiple landscape-level disturbances occurred in the SFBR drainage, including wildfire and subsequent debris flows. Almost a decade removed from these disturbances, IDFG staff are beginning to understand the implications these largescale events had on trends in the trout population. Inferences drawn will help guide management of one of Idaho's premier trout fisheries.

DEMOGRAPHICS OF IDAHO BROOK TROUT POPULATIONS

Curtis J. Roth, **Patrick A. Kennedy**, Kevin A. Meyer

Idaho Department of Fish and Game

In western North American waters, nonnative Brook Trout frequently threaten native salmonids, so fisheries managers often implement suppression or eradication programs for conservation purposes. In conjunction with such programs, managers often construct population models to evaluate the effects of different management strategies on the undesirable population, but such models require demographic data (e.g., age, growth, sex ratios, and survival), which is lacking for western Brook Trout populations. Brook Trout were sampled from 12 alpine lakes and two streams in Idaho, with total length varying from 80 – 380 mm and age varying from 1 – 11 yrs. Across all waters, the von Bertalanffy growth parameters L_∞varied from 231 – 490 mm (mean = 345 mm) and K varied from 0.15 – 0.76 (mean = 0.37). Survival estimates, constructed from age-length keys, were corrected for streams with mark-recapture data; for alpine lakes, corrections were made via gill net selectivity data, which was modeled as a log-normal function averaging 0.84 across size classes and ranging from 0.49 for 80-100 mm fish length bin to a high of 1.00 for 280-300 mm fish. Survival varied from 0.30 - 0.56 (mean = 0.45) and except for one water, estimates were minimally affected by correcting for capture efficiency. The proportion of the population that was male varied from 0.34 – 0.75 (mean = 0.53). Our results indicate that Brook Trout population vital rates in Idaho were similar to those that have been observed in their native range, and were surprisingly similar between alpine lake and stream environments.

ELEVATED STREAM TEMPERATURE, ORIGIN, AND INDIVIDUAL SIZE INFLUENCE CHINOOK SALMON PRESPAWN MORTALITY ACROSS THE COLUMBIA RIVER BASIN

Christopher Caudill[1], Tracy Bowerman[2], Matthew Keefer[1]

[1]University of Idaho, [2]Changing Arc Environmental

Conservation and restoration efforts for Pacific salmon (Oncorhynchus spp.) can be hampered by prespawn mortality, when adult fish reach reproductive sites but die before spawning. We examined annual estimates of female Chinook salmon (O. tshawytscha) prespawn mortality relative to individual fish traits (77,707 individual females) and reach-scale variables in 49 study reaches in 41 streams throughout the interior Columbia River Basin. Mean annual prespawn mortality estimates across 14 years ranged from 0% to 65%. For spring-run Chinook salmon, the probability of prespawn mortality decreased over the spawning period, was positively associated with mean August stream temperature and individual fish length, and was higher for hatchery-origin than natural-origin fish. Based on the basin-wide statistical model and future stream temperature predictions, average spring-run Chinook salmon prespawn mortality rates in 2040 were predicted to increase 0-17% for fish of natural origin and 1-17% for fish of hatchery origin. Climate change is likely to exacerbate conditions that lead to prespawn mortality, particularly in low elevation stream reaches, for larger fish, and for those of hatchery origin.

LIFE HISTORY DIVERSITY OF A RECOVERYING SALMON RIVER CHINOOK SALMON POPULATION

Brian Kennedy[1], Jens Hegg[1], Lytle Denny[2]

[1]University of Idaho, [2]Shoshone-Bannock Tribes

Successful recovery of a migratory population requires an understanding of the strategies adopted by individuals that are reproductively successful and how they map onto features of the landscape they occupy. Salmon populations in the Panther Creek basin have suffered the same challenges as those throughout the Snake River with the added challenge of an extensive mining legacy over the last 60 - 80 years. Intensive rehabilitation of the habitat and water quality occurred in the late 1990's and spring Chinook salmon have naturally recolonized. The Shoshone-Bannock Tribes have begun an intensive monitoring effort with a weir for adult collection and PIT antennas for juvenile tracking. Additionally, the tribes' redd surveys have improved our understanding of spawning distributions while providing tissues of spawned adults. We have been improving our understanding of the behaviors of juvenile fish and the fates of these different life histories using Sr isotope records in the otoliths of those successfully returning fish. Based upon the unique geology of the basin, Sr isotopes alone provide a spatially explicit record of locations and emigration from Panther Creek as well as outmigration timing and behavior through the Snake River. Water samples were collected to expand out our map of Sr isotopic variation in the Salmon River basin. Juveniles were collected from 6 sites within the basin to confirm stable and consistent signatures with water Sr isotope signatures. Seventy-five natural-origin adults were collected from across 3 return years. Natal origins of adults were precise to within 4 regions of Panther Creek that each shared between 20 and 40% of the successful adult returns in the basin. Most individual represented a single overyearling outmigration strategy with little use of downstream habitats other than Panther Creek. The implication for this in comparison to other Salmon River populations will be discussed.

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DNA-METHYLATION PROFILES OF REDBAND TROUT FROM DESERT AND MONTANE ENVIRONMENTS

Benjamen Kline[**1], Janet Loxterman[1], Ernest Keeley[1], Shawn Narum[3]

[1]Idaho State University, [2] Columbia River Inter-Tribal Fish Commission

Epigenetic variation is a potential pathway for rapid response to environmental change and has been shown to influence local adaptation at the population level through population-environment interactions. The most well-understood mechanism of epigenetic variation is DNA-methylation, a form of gene regulation that acts in response to environmental stress. Previous studies have shown ecotypic variation in DNA-methylation, but few have attempted to quantify epigenetic variation in natural populations. As such, we developed a study to compare levels of DNA-methylation in Rainbow Trout (Oncorhynchus mykiss) from contrasting environments. For this study we sampled populations from cold montane and warm desert streams on repeated intervals and tissue samples were collected for epigenetic analysis. Levels of DNA-methylation (percent methylation) will be quantified using targeted bisulfite sequencing of promotor regions of three candidate genes (Heat Shock Protein 70, 90, and 47) that have previously been shown to be important to thermal stress response in coldwater fishes. Subsequent transcriptomic analyses will also be performed to evaluate the potential relationship between methylation level and gene expression in these regions. We hypothesize that percent methylation will be different between desert and montane populations, with desert populations expressing lower overall methylation patterns resulting in upregulation of genes favorable to survival. Since the fitness cost of maladaptive epigenetic variation is relatively low when compared to the cost of maladaptive genetic variation, we predict that epigenetic variation may be favored in environments where thermal regimes are less stable.

GENETIC AND MORPHOMETRIC TOOLS TO IDENTIFY SPECIES DIVERSITY OF CATOSTOMID FISHES IN THE INTERMOUNTAIN WESTERN UNITED STATES

Brandy Smith**, Janet Loxterman, Ernest Keeley

Idaho State University

Effective monitoring and conservation plans of natural populations require an understanding of species distributions and abundance. For poorly-studied and morphologically similar species, there is often uncertainty in identifying which species are observed and enumerated in the wild. Catostomid fishes of the Intermountain western United States have been a subject of taxonomic debate for decades due to overlapping ranges, similar morphology between species, and limited sampling efforts. Recent studies have investigated the taxonomy and classification of the bluehead sucker (Catostomus discobolus), previously described from the upper Snake River, Bonneville basin, and Colorado River drainages. Molecular data indicate that populations of bluehead sucker in the upper Snake River and Bonneville basin should be reclassified as a different species, the green sucker (Pantosteus virescens). However, range overlap with the morphologically similar mountain sucker (Catostomus platyrhynchus) across the entire range of the proposed green sucker has created uncertainty in establishing which species occupy

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adjacent watersheds and how to distinguish them. Efforts to disentangle these issues are made urgent by marked declines in range and abundance in both species. In this study, we examine variability in morphology and genetic structure of bluehead and mountain sucker populations across watersheds to determine the range, extent, and morphological characteristics of catostomid fishes. Digital landmarks, linear-based measurements of morphological characters, and meristic counts will be used to quantify differences among species and populations. We will also apply molecular techniques, including analysis of mitochondrial DNA loci and single nucleotide polymorphisms (SNPs), to evaluate evolutionary relationships and contemporary patterns of genetic diversity. This project will provide management relevant information by evaluating the appropriateness of the proposed species reclassification, investigating potential distinguishing characteristics, and clarifying species range boundaries.

VALIDATION AND ASSOCIATION OF CANDIDATE MARKERS FOR ADULT MIGRATION TIMING AND FITNESS IN CHINOOK SALMON

Ilana Koch, Shawn Narum

Columbia River Inter-Tribal Fish Commission

Recent studies have begun to elucidate the genetic basis for phenotypic traits in salmonid species, but many questions remain before these candidate genes can be directly incorporated into conservation management. In Chinook Salmon (Oncorhynchus tshawytscha), a region of major effect for migration timing has been discovered that harbors two adjacent candidate genes (greb1L, rock1), but there has been limited work to examine the association between these genes and migratory phenotypes at the individual, compared to the population, level. To provide a more thorough test of individual phenotypic association within lineages of Chinook Salmon, 33 candidate markers were developed across a 220 Kb region on chromosome 28 previously associated with migration timing. Candidate and neutral markers were genotyped in individuals from representative collections that exhibit phenotypic variation in timing of arrival to spawning grounds from each of three lineages of Chinook Salmon. Association tests confirmed the majority of markers on chromosome 28 were significantly associated with arrival timing and the strongest association was consistently observed for markers within the rock1 gene and the intergenic region between greb1L and rock1. Candidate markers alone explained a wide range of phenotypic variation for Lower Columbia and Interior ocean-type lineages (29% and 78%, respectively), but less for the Interior stream-type lineage (5%). Individuals that were heterozygous at markers within or upstream of rock1 had phenotypes that suggested a pattern of dominant inheritance for early arrival across populations. Finally, previously published fitness estimates from the Interior stream-type lineage enabled tests of association with arrival timing and two candidate markers, which revealed that fish with homozygous mature genotypes had slightly higher fitness than fish with premature genotypes, while heterozygous fish were intermediate. Overall, these results provide additional information for individual-level genetic variation associated with arrival timing that may assist with conservation management of this species.

SEASONAL DISTRIBUTION AND FOOD HABITS OF WALLEYES IN LAKE PEND OREILLE

Susan Frawley[**1,2], Michael Quist[1,2,3], Matthey Corsi[4], Jeffrey Dillon[4]

[1]Department of Fish and Wildlife Sciences, University of Idaho, [2]Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho, [3]U.S. Geological Survey, [4]Idaho Department of Fish and Game

Invasive species continue to threaten aquatic ecosystems in the United States. Silver Carp Hypophthalmichthys molitrix have successfully infiltrated much of the Mississippi River Basin, including Kentucky Lake – a large mainstem reservoir of the Tennessee River in western Kentucky. Although Silver Carp have been present in Kentucky Lake for at least two decades, until recently, very little was known about the population. This makes it difficult to predict the potential impact of Silver Carp on native species. Silver Carp were sampled from Kentucky Lake using gill nets, cast nets, boat electrofishing, and commercial fishing. We examined population demographic data for Silver Carp within Kentucky Lake by measuring total length, weight, and gonad weight. Additionally, we removed a pectoral fin ray for aging. Of the sampled Silver Carp, 83% were between 700-1000 mm and 90% of aged carp were from the 2010, 2011, 2012, or 2015 year-classes. Furthermore, Silver Carp in Kentucky Lake grew quickly to large sizes and were in excellent condition. The capture of young-of-the-year Silver Carp suggests that natural reproduction is occurring in Kentucky Lake. In conclusion, we found Silver Carp in Kentucky Lake to be larger sized, faster growing, in similar condition, and similarly aged to Silver Carp in other populations within the Mississippi River Basin. These data are among the first to examine population characteristics of Silver Carp in a large reservoir and may serve as a model for other large ecosystems such as the embayments of the Great Lakes.

SEASONAL MOVEMENTS AND HABITAT USE OF WALLEYE IN LAKE PEND OREILLE DURING 2019 AND 2020

Pete Rust, Matthew P. Corsi

Idaho Department of Fish and Game

Walleyes were illegally introduced into reservoirs upstream of Lake Pend Oreille in the early 1990's and subsequently became established in Lake Pend Oreille by 2006. Based on index netting, walleye densities are approximately doubling every three years since 2007. Idaho Fish and Game is concerned that increasing walleye densities will jeopardize native fish populations and the recently recovered kokanee prey base which supports important predatory species including Bull Trout, Rainbow Trout, and Bass. Beginning in 2018, we implemented an acoustic telemetry array to begin answering key research questions about walleye life history components including seasonal movements, habitat use, and spawning migrations. To facilitate more detailed analysis, we stratified the lake and rivers into five sections and evaluated metrics by season. Results from this research provide a spatial and temporal baseline understanding of the effectiveness of our telemetry array in detecting walleye in 2019 and 2020. Results also provide a baseline

understanding of spatial and temporal habitat use, movement rates, and depth use in 2019 and 2020. Telemetry results have contributed to improved sampling and have helped us understand gaps in our pilot suppression program.

EVALUATION OF A PILOT WALLEYE SUPPRESSION PROGRAM IN LAKE PEND OREILLE, IDAHO

Matthew Corsi, Rob Ryan, Pete Rust, Andy Dux, Ken Bouwens

Idaho Department of Fish and Game

An illegally introduced Walleye (Sander vitreus) population threatens the management and conservation of sport fisheries and native fish assemblages in Lake Pend Oreille, Idaho. Indices of Walleye abundance in Lake Pend Oreille indicated a pattern of exponential population growth from 2011 – 2017. In 2018, we convened a panel of North American Walleye experts who unanimously concluded we should begin testing manual suppression and evaluating angler exploitation. We began suppression with gillnets in the spring of 2018 and began an angler incentive program in 2019. Since the initiation of these programs, 3170 Walleyes have been removed via suppression netting and 1645 Walleyes have been removed by anglers participating in the incentive program. An additional 706 Walleyes have been removed as part of other surveys or suppression activities targeting Lake Trout (Salvelinus namaycush). In 2019, we evaluated the sex and maturity of all fish during suppression netting and mature female Walleyes made up 49% of the catch. Median length of Walleyes in suppression netting was 560mm for females and 485mm for males. Catches in suppression netting declined each year of the program and the Walleye abundance index declined by 48% from 2017 to 2020. Taken together, these metrics suggest the combination of gillnetting and incentivized angling may constitute an effective strategy for preventing Walleye population expansion.

INFLUENCE OF PARASITIC COPEPODS ON VULNERABILITY TO ANGLING AND SHOT-TERM SURVIVAL OF RAINBOW TROUT

Hannah Bluth**, Eric Billman

Brigham Young University-Idaho

The parasitic copepod Salmincola californiensis infect trout and salmon of the genus Oncorhynchus and have lethal effects on populations at high prevalence and intensities. Lethal effects may impact population abundance and angling satisfaction. Little is known about sublethal effects and whether infection influences vulnerability to angling. Our objective was to determine the effects of S. californiensis on angling and short-term survival after catch and release of Rainbow Trout (Oncorhynchus mykiss) in Birch Creek, Idaho. We compared infected Rainbow Trout between fish captured by recreational angling and backpack electrofishing in May and October 2020. Additionally, we evaluated the effects of catch and release on short term survival of infected Rainbow Trout. Within the population (electrofishing sample), prevalence of infection in Rainbow Trout did not differ between May (37.4%) and October (34.8%). Intensity of infection ranged from 1-27 copepods in May (mean = 3 copepods; median= 2 copepods) and ranged from 1-18 copepods in October (mean= 3 copepods; median= 2 copepods). In May, we captured a higher proportion of infected fish while recreational fishing (49.3%) compared to the proportion of fish in the population (37.4%). In October, the proportion of infected fish caught while recreational fishing (41.2%) did not differ from the proportion of infected fish in the population (34.8%). In the short-term survival study, we recaptured 22 uninfected Rainbow Trout (36.7%) and 25 infected Rainbow Trout (59.5%); however, the difference was not significant. Copepods either did not influence or increased the vulnerability of Rainbow Trout to recreational fishing. Infection with copepods did not influence short-term survival of Rainbow Trout after angling. We did not detect any negative sublethal effects of copepod infection on Rainbow Trout. Angler perception of parasitic copepods may be accentuated if they are catching a higher proportion of infected fish compared to actual prevalence of infection.

FLOATER USE OF THE BIG SPRINGS NATIONAL RECREATION WATER TRAIL: ASSESSING CONFLICTING PUBLIC OPINIONS

Kamberlee Allison, Rob Van Kirk

Henry's Fork Foundation

Anglers have reported declines in various aspects of the fishery and their experience on the Big Springs Water Trail located on the upper Henry's Fork, especially related to the number of non-angling floaters on the river. Information regarding angler and floater attitudes, in addition to vehicle and floater use on the Big Springs, can inform management efforts and identify specific areas of conflict. Conducted May 25 to September 2, 2019, this study quantified floater use, determined whether use was exceeding capacity of facilities, and assessed angler and floater satisfaction with experience. We estimated total use at 37,187 floaters, and found the capacity of the launch parking lot was exceeded around one-third of the time. Over 90% of floaters interviewed were satisfied or very satisfied with all aspects of their recreational experience. Only 58% of anglers surveyed rated their fishing experience as better than "fair". Relative to their expectations, anglers were significantly dissatisfied with size of fish caught, quality of fish habitat, and number of non-anglers they encountered on the river. Quality of angling experience did not depend on number of non-anglers seen on the river, but it was negatively correlated with the number of years anglers had fished the upper Henry's Fork. Also, angler support for management changes such as implementing wild-trout regulations was at least as high as those aimed at limiting floater use. The decision to increase parking or limit the number of floaters lies fully within the management authority of the Forest Service. Ultimately, addressing the larger issue of declining fishing quality on the upper Henry's Fork will require a collaborative effort involving government agencies at all levels, NGOs, private fishing clubs, and other stakeholders.

ENCOUNTER RATES AND CATCH-AND-RELEASE MORTALITY OF WILD STEELHEAD IN IDAHO

William Lubenau[**1,2], Michael Quist[1,2,3], Timothy Copeland[4], Brett Bowersox[4], Josh McCormick[4]

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Steelhead Oncorhynchus mykiss are ecologically, economically, culturally, and recreationally important in the Pacific Northwest and Idaho. Due to a decline in wild steelhead abundance that has resulted in federal protection, recreational fisheries are supported by hatchery-supplemented fish. In the mark-selective steelhead fisheries of Idaho, adipose-clipped steelhead may be harvested, but adipose-intact fish must be immediately released. Nevertheless, the potential influence of recreational fisheries on wild fish is poorly understood and is a function of the abundance of wild fish, how many are encountered by anglers (i.e., encounter rate), and the mortality of fish that are caught and released. Historical estimates of wild steelhead encounter rates were derived from a series of calculations using the number of wild and hatchery steelhead passing Lower Granite Dam, the number of hatchery steelhead harvested, and the number of hatchery steelhead caught and released. Currently, managers assume hatchery fish and wild fish have equal encounter rates and apply a 5% catch-and-release mortality rate to the portion of the wild steelhead population encountered by anglers. We sampled, tagged, and released 1,284 spawn-year 2020 and 2,065 spawn-year 2021 adult steelhead at Lower Granite Dam with T-bar anchor tags to apply novel methods to estimate hatchery and wild steelhead encounter rates in Idaho. Tagged fish moved upstream into fisheries where some were caught and reported by anglers. The tags were labeled with US$0, $25, $50, $100, and $200 to estimate non-reporting. Tagged fish were reported from the Clearwater, Snake, Salmon, Little Salmon, Grande Ronde, and Imnaha rivers. Catch-and-release mortality estimates stemmed from comparing passive integrated transponder (PIT) tag detections of caught and uncaught fish at remote PIT arrays located in many spawning tributaries in the Snake River basin.

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LAKE TROUT REMOVAL IN A CENTRAL IDAHO LAKE*

Taylor Morlan, Kayden Estep, Greg Schoby

Idaho Department of Fish and Game

Historically, Lake Trout Salvelinus namaycush have been introduced across the Western U.S. for angling opportunities and as a biological control for fish populations. However, unintended expansion and colonization has led to instances of increased predation and crashes of several native fish stocks. Stanley Lake, in Central Idaho, is one of five lakes in the Upper Salmon that once supported Sockeye Salmon Oncorhynchus nerka. After a toxaphene treatment and outlet barrier construction in 1954 to eradicate non-game species, fish managers attempted several introductions of various sportfish species into Stanley Lake. Lake Trout were introduced to Stanley Lake in 1975 to increase size structure of the kokanee population. However, Lake Trout pose a threat to Sockeye Salmon recovery in the Upper Salmon via possible expansion and colonization of recovering Sockeye Salmon lakes. Idaho Department of Fish and Game as well as stakeholders developed a management plan to address this threat via removals of fertile Lake Trout and restocking of sterile (triploid) Lake Trout. In June 2020 Idaho Fish and Game contracted with Hickey Brothers Research LLC. and deployed gillnets in Stanley Lake to remove Lake Trout and again in August. An additional removal event was conducted by IDFG in October. A total of 91,348.6 m of gill net, ranging in mesh size from 38mm to 114mm, were set in those three events. Cumulative catch from three netting events was 563 Lake Trout. Sterile Lake Trout were stocked on September 28th 2020 with the hopes to reestablish the trophy Lake Trout fishery. Future plans for Stanley Lake include, the continuation of commercial Lake Trout removals until 2022 and stocking juvenile hatchery reared Lake Trout and adult triploid Lake Trout from Bear Lake, Idaho, to reestablish a sterile trophy Lake Trout fishery.

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EVALUATION OF NATURAL AND HATCHERY-PRODUCED KOKANEE IN FLAMING GORGE RESERVOIR

Aaron Black[**1,2], Michael Quist[1,2,3], Mark Smith[4], John Walrath[4]

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Kokanee Oncorhynchus nerka were first stocked in Flaming Gorge Reservoir (FGR), Wyoming-Utah, in 1963. In a system that uses supplemental stocking to enhance a popular sport fishery, an understanding of the contributions from natural and hatchery-produced fish is critically important so that hatchery resources can be appropriately allocated. Identifying contributions to FGR was accomplished using otolith microchemistry. Otoliths were analyzed for the strontium isotope ratio (i.e., 87Sr/86Sr) using laser ablation and a multi-collector inductively coupled plasma mass spectrometer. Flaming Gorge Reservoir has a unique strontium signature compared to the hatcheries that produce kokanee for FGR. Kokanee were sampled from June-July throughout the reservoir using suspended gill nets and creel surveys. Kokanee from spawning aggregates were collected from September-October in the reservoir using sinking gill nets and in spawning tributaries using weirs. We collected and analyzed 1,655 otoliths from 2018-2020. Line scans of 87Sr/86Sr were visually inspected to identify kokanee origin. Hatchery-produced kokanee were identified by a shift in the Sr signature from the primordium to the edge. Naturally produced kokanee had no shift in their Sr signature across the otolith. In our preliminary results we were able to identify origin of 1,385 kokanee: 592 as hatchery origin and 793 as natural origin. Fish that were identified as hatchery origin were 41% of the sample in 2018, 62% in 2019, and 23% in 2020. Natural origin fish were 59% of the sample in 2018, 38% in 2019, and 77% in 2020. Water samples collected from FGR, spawning tributaries, and hatcheries will be analyzed for their unique Sr signature. Water samples will be used to assign kokanee to a specific hatchery or FGR and help with classifying the remaining unknown fish that could not be classified during the visual examination.

COLLECTING KOOTENAI RIVER ADAPTED, HATCHERY PRODUCED BURBOT FOR BROODSTOCK AT THE KOOTENAI TRIBE OF IDAHO'S - TWIN RIVERS HATCHERY

Brycen Lunger, Nathan Jensen, Shawn Young, Riley Jones, Mason Mcginnis

Kootenai Tribe of Idaho

Burbot Lota lota maculosa were once abundant in the Kootenai/ay River Basin; Idaho USA and British Columbia Canada, where they provided important cultural, recreational, and commercial fisheries. Beginning in the 1970's, cumulative effects of habitat loss and hydro-power operations lead to an extirpation of Burbot populations. A multi-agency cooperative program lead by the Kootenai Tribe of Idaho (KTOI), the University of Idaho Aquaculture Research Institute (UIARI), the British Columbia Ministry (BCM) and Idaho Department of Fish and Game (IDFG) has resulted in development of a program to conserve, restore, and monitor a native strain of Burbot now being used to rebuild populations on a basin-wide scale. From 2009 to 2020, the program has used a within-basin lake populations brood to seed the Kootenai River Burbot Conservation Aquaculture

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Program. While the genetic variability of the "founder" Lake has been successfully captured, KTOI is now turning to hatchery produced fish in-river for broodstock. The pre-determined restoration goal of 17,500 spawning adults has been achieved, which now allows the program to collect pre-spawn river-adapted adults from the Kootenai River to supply the Burbot program with gametes KTOI in Co-operation with IDFG, collect adults in January and February using shallow (<=10m) hoop nets as part of the IDFG annual M&E efforts. In general, KTOI transports adult Burbot (>300mm) to Twin Rivers Hatchery, where they are sorted by size (small<550mm>large) and gender using ultra-sound. Adults are held in ambient river water and water temperatures are maintained to mimic the Kootenai River. Adults are not fed in-hatchery prior to spawning. The target spawning population per year is 200-300 burbot (>300mm), Seasonal weather conditions and the narrow window of time to collect pre-spawn burbot during annual migrations make collecting adult burbot difficult and unpredictable. This presentation will highlight the methods used to collect Kootenai River Burbot for use as broodstock at the Kootenai Tribe of Idaho's – Twin Rivers Hatchery.

STRATEGIC USE OF KOOTENAI RIVER BURBOT EMBRYOS RELEASED DUE TO COVID-19 RELATED FORCED HATCHERY SHUTDOWN

Nathan Jensen, Riley Jones, Brycen Lunger, Mason McGinnis, Shawn Young, Susan Ireland

Kootenai Tribe of Idaho

The Kootenai River Burbot Lota lota maculosa were once abundant in the Kootenai/y River Basin in Idaho and Montana, USA, and British Columbia, Canada. Historically, they provided important cultural resources for indigenous peoples and local fisheries. Cumulative effects of habitat loss, overfishing and hydro-power operations caused widespread population declines in this region and these effects have persisted for decades. In 2003, a Burbot conservation aquaculture program was initiated with the University of Idaho-Aquaculture Research Institute. Since 2003, conservation aquaculture methods have been developing and a large-scale Kootenai Tribal Burbot hatchery began production in 2015. The Kootenai Tribal Burbot program objectives are to: 1) rebuild species abundance to support cultural and recreational harvest; 2) spawn, rear, and release multiple life stages of Burbot across different habitat types to determine optimal conditions for survival; 3) support post-release research, monitoring and evaluation. Prior to 2003, Burbot abundance estimates in the Kootenai/y River were estimated to be <50 adults (Age 3+), now through the success of the program's population rebuilding efforts adult abundance is estimated near 50,000 and supports a sport fishery. In addition, all broodstock used in the program now come from the in-river augmented population. This presentation will provide a brief summary of what happened in 2020 regarding spawning and incubation and actions taken following a forced hatchery shut down due to the COVID-19 Pandemic. Over 25,000,000 Burbot embryos were released in <48 hours in 11 different tributaries that flow into the Kootenai River. Methods and results of post-release monitoring and evaluation will also be discussed.

COMPARISON OF HARD STRUCTURES USED TO ESTIMATE AGE OF YELLOWSTONE CUTTHROAT TROUT FROM HENRYS LAKE, IDAHO

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Understanding age and growth of fish populations is critical for making meaningful management decisions. In some populations aging structures have been collected for decades, providing important insight on long-term trends in growth. Unfortunately, the structure used by biologists may have changed through time. For example, Yellowstone Cutthroat Trout Oncorhynchus clarkii bouvieri (YCT) have been monitored in Henrys Lake since the 1970s. Historically scales were the primary structure used for age estimates, but otoliths have been used more recently. Understanding differences among structures is critical to making meaningful conclusions about population dynamics. The objectives of this study were to evaluate between-reader precision and reader confidence in age estimates from sagittal otoliths and scales for YCT collected from Henrys Lake, Idaho. Yellowstone Cutthroat Trout were collected during annual gill net surveys in May 2019 and 2020. Sagittal otoliths and scales were removed from captured YCT. Four hundred and thirty-three YCT were sampled in 2019 and 2020. Scales, whole otoliths, and sectioned otoliths were aged independently by two readers without prior knowledge of fish length. Each reader also provided a confidence rating of 0 (not confident) to 3 (completely confident). The percent exact reader agreement (PA) was highest for sectioned sagittal otoliths (PA = 85%), followed by scales (PA = 68%), and whole sagittal otoliths (PA = 64%). Average confidence rating (CR) was highest for sectioned sagittal otoliths (CR = 2), whole sagittal otoliths were next (CR = 1), lastly scales (CR = 1). Although sectioned otoliths are more time consuming to process than scales or whole otoliths, they produce the most precise age estimates for YCT with the highest reader confidence.

FACTORS INFLUENCING YELLOWSTONE CUTTHROAT TROUT GROWTH IN HENRYS LAKE, IDAHO

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Yellowstone Cutthroat Trout (YCT) Oncorhynchus clarkii bouvieri is a species with high ecological and recreational value. In many YCT fisheries, managers are tasked with balancing angler satisfaction and fish conservation. Trying to balance these two needs is typified at Henrys Lake, Idaho. Henrys Lake supports a popular trophy trout fishery, but recent surveys have suggested changes in the YCT population. A variety of factors have been hypothesized to explain these patterns, including warming temperatures, density dependence, and direct and indirect effects of introduced Utah Chub (UTC) Gila atraria. Understanding the population dynamics of both nonnative UTC and native YCT in Henrys Lake is important, particularly as the environment shifts to

unfavorable conditions for YCT (i.e., climate change). Fortunately, biologists have monitored fish populations in Henrys Lake since 1950 and these historical data provide valuable insight into long-term changes in population dynamics. Archived hard structures were reexamined to provide a comprehensive evaluation of changes in age structure and growth of YCT in the system. Scales were collected from fish sampled in 1977, 1984, 1987, 1988, 1991, and 1992 with a variety of sampling gears. Sagittal otoliths were collected from 2002 to 2020 during annual gill net surveys. Air temperature, snowpack, reservoir volume, discharge, stocking records, and catch rates of UTC and trout in Henrys Lake will be used as covariates to explain changes in YCT growth. In total, 3,030 YCT otoliths and 229 YCT scales was aged. Yellowstone Cutthroat Trout age varied between 1 and 11 years; YCT from the most recent decade were the oldest. Results from this research will identify factors influencing YCT growth in Henrys Lake and are expected to guide management of Henrys Lake.

COMPARISON OF METHODS USED TO ESTIMATE AGE COMPOSITION OF CHINOOK SALMON POPULATIONS WHEN THE BEARS BEAT YOU TO THE CARCASSES

Eli Felts

Idaho Department of Fish and Game

Quantification of reproductive rate requires estimates of the number of individuals which spawned in a given year, and the number produced in that year which eventually returned to spawn. In practice, estimating the return from a given age class requires age composition estimates. Abundance of 27 extant populations of Spring-Summer Chinook Salmon in Idaho is indexed annually by redd counts, but age composition estimates are more difficult to obtain and are often lacking at the population scale. Estimates based on assumptions are used when direct estimates are lacking. The objective of this study was to quantify the effect of estimated age compositions on resulting estimates of reproductive rate. Age composition was estimated by three methods: assuming all fish returned at age 4, assuming that aggregate age composition from a broader spatial scale was representative for a given population, or simulating age composition from a distribution generated by empirical data. Analysis compared estimates of reproductive rate generated from estimated age composition to a reference data set consisting of 187 brood years across 22 populations for which sufficient samples were available to directly estimate age composition at the population scale across return years. Assuming aggregate age composition from a broader spatial scale resulted in more accurate estimates of reproductive rate (RMSE = 0.43) than simulated age compositions (RMSE = 1.38) or assuming that all fish matured at age 4 (RMSE = 1.76). Results suggest that aggregate age compositions from a broader spatial scale produces accurate and unbiased estimates of reproductive rate, and may be preferable to the other methods considered.

MOVEMENT AND HABITAT USE OF YELLOWSTONE CUTTHROAT TROUT AND UTAH CHUB IN HENRYS LAKE, IDAHO

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Henrys Lake is a popular trophy trout fishery, but recent surveys have revealed changes in catch rates and body condition of Yellowstone Cutthroat Trout (YCT) Oncorhynchus clarkii bouvieri. Various factors have been hypothesized to explain these patterns, including direct and indirect effects of introduced Utah Chub (UTC) Gila atraria. The influence of UTC on YCT is largely unknown, but UTC typically have negative effects on salmonids in systems where they have been introduced. To better understand YCT and UTC interactions, 94 YCT and 95 UTC were radio-tagged in spring 2019 and 2020 to describe their movement and habitat use in Henrys Lake. Fish were located via mobile tracking and fixed receivers from June to December 2019 and 2020. In June, YCT and UTC were concentrated in nearshore habitats. As water temperatures increased in July, UTC were documented in deeper water and YCT became more concentrated in areas with cold water (e.g., mouth of Targhee Creek, Staley Springs). Utah Chubs that were relocated in July and August seemed to be in large congregations. We visually observed large congregations of UTC near the Idaho Department of Fish and Game (IDFG) hatchery, Henrys Lake State Park, and most frequently in the 3.5 km above the dam. In 2019, YCT were detected in Duck and Howard creeks from June to July and Targhee Creek in August. In 2020, YCT were detected in Duck, Howard, and Timber creeks in June and in Targhee Creek from June to August. Temperature sensors on the radio tags revealed that the majority of fish were in water temperatures that were similar to the rest of the lake. These data provide insight about movement patterns and habitat use of YCT and UTC in Henrys Lake and can be used to inform management decisions for fishery improvement and YCT conservation.

DEVELOPING A FRAMEWORK FOR ASSESSING ADAPTIVE CAPACITY IN STREAM NETWORKS USING AGENT-BASED MODELS FOR REDBAND TROUT

Travis Seaborn, Christopher Caudill

Univeristy of Idaho

Adaptive capacity is an important emerging concept for predicting impacts of environmental change, but the factors of systems conferring adaptive capacity are poorly known. The Idaho EPSCoR GEM3 project is using a combination of landscape genomics to assess local adaptation, common garden experiments, physiological ecology, field studies, remote sensing and modeling to evaluate the impact of changing socio-ecological systems on populations of redband trout (Oncorhynchus mykiss gairdneri) in Idaho, with the goal to identify factors associated with population adaptive capacity. A key area of uncertainty is the role of 'plastic rescue' through

the expression of phenotypic plasticity as populations encounter extreme and/or novel environmental conditions under rapid environmental change. We created a model of redband trout using CDMetaPOP in Jacks Creek in southern Idaho. The location was selected for initial model simulations because average August temperatures exceed those known to induce physiological stress in O. mykiss gairdneri (20 °C) in parts of the stream network, and local genetic adaptation to thermal stress has been demonstrated. The goal of the simulations is to understand how individual-level variation in genetics and plasticity affect the adaptive capacity of a species in stream environments at the landscape scale as the regional climate warms. We ran models using projected stream temperature data through 2099 under four broad scenarios: 1) historic environmental conditions; 2) warming climate 3) warming climate with adaptive loci ("genetic rescue"); and 4) including genetically-based phenotypic plastic traits for thermal tolerance and movement ("plastic rescue"). Inclusion of an adaptive allele prevented decline in population sizes regardless of climate in early simulations, although this effect was dependent on the amount of dispersal in model. Similarly, the rates of homozygosity and counts of the adaptive allele were heavily influenced by the amount of movement of individuals, highlighting the potential roles of movement behavior, connectivity, and habitat heterogeneity within the landscape. Future efforts will use refined parameter estimates obtained from the common garden and field experiments, and locations with differing thermal regimes. The ABM simulations will provide insight into the relative importance of genetic and phenotypically plastic traits and the spatial arrangement of habitat elements in dendritic networks in demogenetic population dynamics. More broadly, application of ABM simulations can be used to identify key components and metrics of adaptive capacity and to evaluate conservation and management options such as assisted migration and land use planning.

OCCURRENCE, ABUNDANCE, MOVEMENT, AND HABITAT ASSOCIATIONS OF BONNEVILLE CUTTHROAT TROUT IN THREE TRIBUTARIES TO BEAR LAKE

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Bonneville Cutthroat Trout (BCT) Oncorhynchus clarkii utah in Bear Lake, Idaho-Utah, are an important species both ecologically and recreationally. Although the distribution and abundance of BCT have declined due to anthropogenic disturbances, production of wild BCT has increased over the last decade. The objective of this study was to assess the occurrence, distribution, and movement of BCT in tributaries of Bear Lake. Stream surveys were conducted at 75 sample sites across three study streams (i.e., St. Charles, Fish Haven, and Swan creeks). Logistic regression models indicated that the presence of BCT in St. Charles Creek was positively associated with distance to Bear Lake, gradient, variability in depth, canopy cover, and cover area, but negatively associated with elevation and width. In Fish Haven Creek, the presence of BCT was positively associated with temperature and variability in current velocity, but negatively associated with elevation, distance to lake, and fine substrate composition. The abundance of BCT was not predicted by biotic or abiotic characteristics in St. Charles and Swan creeks. In Fish Haven Creek, abundance of BCT was negatively associated with elevation and distance to Bear Lake. A total of 869 BCT was tagged during stream surveys. Of those fish tagged, 5.5% of BCT outmigrated from St. Charles Creek, 50.2% from Fish Haven Creek, and 16.3% from Swan Creek.

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Logistic regression models indicated that outmigration of BCT was positively associated with fish length for St. Charles and Fish Haven creeks, and negatively associated with distance to Bear Lake for St. Charles Creek and the number of downstream irrigation diversions for Fish Haven Creek. In Swan Creek, movement of BCT was positively associated with age and negatively associated with distance to Bear Lake. Results from this study provides critical information on the ecology of BCT that can be used to guide conservation and management efforts.

FACTORS RELATED TO THE DISTRIBUTION AND ABUNDANCE OF RESIDENT SALMONIDS IN CENTRAL IDAHO

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Native resident salmonids throughout North America have experienced population declines, and understanding factors that influence their current distribution and abundance may help conserve and manage such species. We examined the influence of several environmental factors on the current distribution and abundance of Westslope Cutthroat Trout Oncorhynchus clarkii lewisi, Bull Trout Salvelinus confluentus, and Mountain Whitefish Prosopium williamsoni in central Idaho. Because nonnative Brook Trout S. fontinalis often negatively influence native salmonids in the Pacific Northwest, they were also included in these analyses. Current fish distribution and abundance was based on snorkel survey data collected from 2007 – 2018. Generalized linear modeling results indicated that the distribution of Westslope Cutthroat Trout and Bull Trout was negatively influenced by Brook Trout abundance. Elevation negatively influenced Westslope Cutthroat distribution and density, but positively influenced Bull Trout, Mountain Whitefish, and Brook Trout distribution and density. Modeling results also indicated that predominant underlying bedrock type affected species distribution more than their abundance, with occupancy rate highest when the predominant underlying bedrock type was acid volcanic rock for Westslope Cutthroat Trout, carbonate for Bull Trout, shale for Brook Trout, and sedimentary for Mountain Whitefish. Stream width negatively influenced the density of Westslope Cutthroat Trout, Bull Trout and Brook Trout, and road density negatively influenced the occupancy of Westslope Cutthroat Trout and Mountain Whitefish. Results of this study suggest that the effects of landscape-level factors on sympatric salmonid species in central Idaho vary dramatically among taxa, highlighting that conditions appearing to benefit one species may concurrently hinder another. This makes multi-species ecosystem-based management and conservation steps more difficult to prioritize and implement.

FACTORS CONTRIBUTING TO THE PRESENT AND FUTURE OCCURRENCE OF RELICT HEADWATER BULL TROUT POPULATIONS IN THE NORTHERN ROCKY MOUNTAINS

Dan Isaak, Mike Young, Dave Nagel, Dona Horan, Kevin McKelvey, Mike Schwartz

US Forest Service

Bull trout declined significantly during the 20th century as populations were exploited, non-native trout species expanded geographically, and stream habitats were degraded—leading to federal protections under ESA in 1997. Although the species remains widespread in patchily distributed headwater populations across the Pacific Northwest, climate change is gradually reducing and fragmenting the remaining habitats. Using an extensive new dataset of species occurrence results from 9,908 eDNA and electrofishing site samples in 991bull trout patches throughout most non-wilderness basins in Idaho, Montana, and northeastern Oregon, we developed bull trout occupancy models to assess the relative importance of 24 covariates that represented patch size, connectivity among patches, thermal and hydrologic regimes, internal patch refugia, geomorphic attributes, wildfire prevalence, road densities, occurrence of adfluvial bull trout, and brook trout prevalence. The best model correctly predicted bull trout occupancy status in 82.6% of the patches and included statistically significant effects for (in decreasing order of importance): patch volume, length of patch reaches below 9 °C mean August temperature, distance to nearest occupied patch, road density, brook trout prevalence, and frequency of high flows during winter. Subsequent analyses are using the model with climate projections to create probabilistic scenarios of bull trout occurrence in the study streams and to perform sensitivity analyses for understanding where and why occurrence probabilities are most likely to change. In particular, we are interested in determining the degree to which habitat geometry (i.e., patch size and connectivity) might buffer or worsen the deleterious effects of climate change, and whether realistic assumptions about habitat restoration and management interventions could effect meaningful climate mitigation that would enhance the long-term persistence of some populations or bull trout as a species in the northern Rocky Mountains.

SPECIES TRAITS AND LANDSCAPE RESISTANCE MEDIATE NATIVE FISH DISRIBUTION SHIFTS AND VULNERABILITY TO CLIMATE CHANGE IN A ROCKY MOUNTAIN RIVERSCAPE

Dan Isaak, Mike Young, Dave Nagel, Dona Horan, Kevin McKelvey, Mike Schwartz

US Forest Service

Climate change poses a substantial risk to freshwater biodiversity, but most studies focus on understanding impacts to popular cold-water fishes (e.g., salmon, trout, and char) that have relatively large body sizes, are often highly mobile, and may be adept at tracking habitat shifts or dealing with natural disturbances. Small, less mobile fish species often constitute significant portions of aquatic communities and could be more vulnerable to environmental change, so a broader understanding of how species traits and landscape resistance influence climate change vulnerability is needed. By revisiting 280 sites over a 20 year interval throughout a warming riverscape in western Montana, we described changes in species site occupancy and assessed the environmental conditions associated with those changes for four fishes spanning a range of body sizes, thermal niches, and habitat preferences. Two larger-bodied trout species exhibited small changes in site occupancy, with bull trout showing a statistically significant 9.2% reduction, mostly in warm, low elevation stream reaches, while westslope cutthroat trout showed a nonsignificant 1% increase. The small-bodied slimy sculpin that prefers cold temperatures was originally distributed broadly throughout the network but experienced a 48.0% reduction in site occupancy with declines common in warmer stream reaches and areas subject to wildfire disturbances. The small-bodied longnose dace which prefers warmer temperatures was originally constrained to reaches at low elevations but expanded its distribution upstream in many areas. Distribution shifts for sculpin and dace were often constrained by barriers, which included anthropogenic water diversions at low elevations and natural step-pools and cascades in steeper upstream reaches. Our results suggest that aquatic communities exhibit a range of responses to climate warming, that effects on non-salmonids may be underappreciated, and that improving passage and fluvial connectivity will be important climate adaptation tactics for conserving aquatic biodiversity. This study was published in Global Change Biology and is available for download from TreeSearch (https://www.fs.usda.gov/treesearch/pubs/61372).

POSTER ABSTRACTS

DO DIFFERENCE IN BEHAVIORAL PLASTICITY AMONG REDBAND TROUT (ONCORHYNCHUS MYKISS GAIRDNERI) POPULATIONS CONTRIBUTE TO ADAPTIVE CAPACITY?

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University of Idaho

Temperature is a crucial environmental factor that governs movement, dispersal, and physiology in ectotherms. Under thermal stress, ectotherms exhibit behaviors such as movement and habitat selection to maintain optimum physiological performance. As stream temperatures increase across the intermountain west, fluvial ectothermic species like redband trout (Oncorhynchus mykiss gairdneri) are especially vulnerable because dispersal is limited to the extent of stream networks. Our research aims to predict adaptive capacity among redband trout populations by determining the influence of genetics and past selective regimes on plastic traits. To study these differences, we collected newly hatched redband trout from three distinct ecotypes (desert, cool montane forest, and cold montane forest). Individual fish from all ecotypes were reared in a common garden experiment using three temperature regimes that ranged from optimum to stressful (15, 18, and 21°C). Thermal preference data will be collected using a Loligo® Shuttlebox System, which uses video tracking software to allow a fish to determine its preferred temperature. To test for potential movement cues resulting from environmental changes in temperature, turbulence, and velocity, we will conduct behavioral assays to quantify patterns of directional movement (upstream or downstream) using a recirculating system with unidirectional flow. Because physiological limitations and habitat use play a role in population persistence, understanding how these variables interact enables us to predict occupancy in response to land use and climate change. The data collected from these experiments will inform modeling efforts to predict redband trout population persistence across space and time.

SWIMMING IN 'THIN AIR': EVALUATING THE COMBINATION OF HYPOXIC AND THERMAL STRESS AN ADDITIVE OR SYNERGISTIC EFFECT (ONCORHYNCHUS MYKISS GAIRDNERI)

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Aquatic hypoxia, or dissolved oxygen (DO) deficiency, has increased in frequency with rising water temperatures as a result of anthropogenic climate change. Temperature and DO concentration are two important factors that can affect many biotic processes for salmonids. Fish can adjust to environmental variables such as temperature change and hypoxia via acclimation, a form of phenotypic plasticity. In Idaho, there are 3 ecotypes of redband trout (Oncorhynchus mykiss gairdneri) from either desert, cool montane, or cold montane habitats. This research analyzed the effects of hypoxia and thermal stress, both in combined and isolated tests, on age-0 redband trout. The redband trout have been acclimated in a common garden at 21°C, 18°C, and 15°C, to model desert, cool montane, and cold montane habitats, respectively. The experiment examined cardiac phenotypic response using an electrocardiogram (ECG) to measure the heart rate of individuals when exposed to hypoxic conditions and acute thermal stress. The treatment started with each fish at their acclimation temperature and 100% DO saturation. Hypoxia was initiated by bubbling N2 gas into the water at a constant rate while

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reducing dissolved oxygen (DO) levels from 100% saturation until there is 50% oxygen saturation. The redband trout then experienced an acute temperature increase until the ECG displays arrhythmia, which marks the endpoint of the study. The results will show the heart rate at cardiac arrhythmia for individuals from each ecotype and acclimation temperature. These results may display that phenotypic plasticity could be possible for redband trout when it comes to hypoxia and acute temperature tolerance. This could have positive implications for the persistence of the species. However, if the combination of hypoxic and thermal stress has a synergistic effect, climate change could have worse consequences for fish than previously understood.

GENETIC ANALYSIS OF NATIVE REDBAND TROUT LEGACY SAMPLES IN IDAHO

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Redband Trout (Oncorhynchus mykiss) are native to many drainages in western Idaho, inhabiting diverse ecotypes including desert and montane streams. Native Redband Trout populations in Idaho have been shown to be phenotypically, and in some cases genetically, differentiated. However, because of the properties of aquatic connections, geographic proximity may not predict relationships and interconnectedness of aquatic taxa. (I would put a knowledge gap sentence here). (could also add a rationale sentence). Using samples collected by multiple organizations over a 20-year period, single nucleotide polymorphism (SNP) data was generated for twelve populations of native Redband Trout and one hatchery strain of Rainbow Trout. Using this SNP data, we aimed to quantify population structure, isolation by distance, diversity, and effective population size of native Redband Trout across Idaho to investigate intraspecific variation and connectivity among populations.

PHENOTYPIC PLASTICITY IN THERMAL TOLERANCE AND PERFORMANCE WITHIN AND AMONG REDBAND TROUT POPULATIONS

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Fishes respond to environmental changes using phenotypic plasticity and evolutionary adaptation. Phenotypic plasticity can buffer organisms from diel and seasonal environmental fluctuations within a lifetime, while evolutionary adaptation occurs over a longer timescale across generations. To understand the role of phenotypic plasticity in thermal adaptation, we reared redband trout (Oncorhynchus mykiss gairdneri) from contrasting climates in Idaho (i.e., ecotypes of the desert, cool montane and cold montane) under 15°C, 18°C and 21°C in a common garden setting, and examined several ecological important traits including critical thermal maximum (CTMAX), maximum growth rate, critical swimming speed and cardiac performance. We found plasticity existed in all traits, but it was trait-specific and varied among ecotypes. Although CTMAX showed limited variation among ecotypes, it is plastic and positively correlated with acclimation temperature. Maximum growth rate, in contrast, had a strong genetic-by-environment interaction whereby acclimation and rearing in warmer environments may lead to a slower growth rate in desert redband trout than in montane trout populations. Critical swimming speed showed less phenotypic plasticity, at least at the population level. However, the swimming performance of cold montane fish was severely impaired at 21°C acclimation. In addition to the whole organism performance, we also investigated the organ-level performance by examining cardiac function. It is not surprising that warm acclimation right-shifted the response curve of heart rate to warming. Interestingly, we found ecotype level variation in cardiac function, but not at the warmest acclimation. These findings indicate that plastic responses differed by trait and ecotype; further niche modeling that integrates phenotypic plasticity needs to consider its complexity for a better predictive power for population-level adaptive capacity under future climate change scenarios.

LEADING INNOVATION IN IDAHO AQUACULTURE THROUGH RESEARCH, TEACHING AND OUTREACH

Brian Small, Madison Powell

University of Idaho

Established in 1988, the Aquaculture Research Institute (ARI; @UIdahoAquaculture) is an interdisciplinary entity at the University of Idaho designed to provide a focus for aquaculture research by faculty and students throughout the University and to elevate Idaho aquaculture. The institute was founded on the understanding that aquaculture is a highly diverse activity involving food production, fisheries enhancement, and fisheries stock restoration, and involves application of an array of scientific disciplines, including fish nutrition, genetics, physiology, immunology, and water quality. Research involves not only fish rearing studies but also basic research into the molecular, cellular, and organismal regulation of phenotypic responses to environment, diet, and pathogens. Reducing the environmental impacts of aquaculture and understanding how genome and environment drive phenotypic expression are among the focuses of ARI research. As such, ARI facilitates basic and applied research in aquaculture and covers a broad portfolio of native and non-native species, such as rainbow, cutthroat and redband trout, white sturgeon, burbot, tilapia, catfish, and freshwater ornamental species. With the recent addition of new recirculating aquaculture systems and through collaboration with partners, ARI research now extends to Atlantic salmon, marine fish species, shrimp and other important farmed species. Within the University of Idaho, ARI leads and facilitates research and education across several Departments and Colleges, but ARI's impact does not stop there. ARI-affiliated faculty and students work closely with the commercial sector, and federal, state, and tribal agencies to collaborate on research, conduct training workshops, and provide extension support. In short, ARI is committed to the advancement of environmentally sustainable aquaculture through transformative research and by training tomorrow's leaders in the aquaculture and fisheries fields.

MANAGING DURING THE FALL: IMPROVING ESTIMATES OF HATCHERY ADULT SNAKE RIVER SPING-SUMMER CHINOOK SALMON DURING RECORD LOW RETURNS

Katharine Coykendall[1], Thomas Delomas[1,2], Matthew Belnap[1], Brian Leth[1], Bill Schrader[1], Matthew Campbell[1]

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One of the more challenging fisheries to manage in the Columbia River basin is the spring-summer Chinook Salmon run that returns to the Snake River drainage of Idaho, Oregon and Washington. Historically, the run was one of the more productive throughout the Columbia River Basin. Snake River spring-summer Chinook Salmon experienced declines in abundance due to over-fishing, habitat degradation, and dams. They are listed as threatened under the ESA and supported by mitigation hatcheries funded by Idaho Power Company and the Lower Snake River Compensation Plan. To maximize tribal and state harvest of returning hatchery adults, minimize impacts on wild fish, and ensure that enough hatchery fish return to meet broodstock needs, careful fisheries management is required. Since 2008, managers have used hatchery adults, PIT-tagged as juveniles and detected at Lower Granite Dam (LGD), to generate adult abundance escapement estimates. In-season, these estimates help manage state and tribal harvest shares and ensure broodstock needs are met. Post-season, they provide smolt-to-adult survival and return rates. This methodology underestimates abundance, with undetected tag shedding and differential survival post-release, suspected as causes. Since 2008, Parentage Based Tagging (PBT) has provided an alternative method to estimate stock- and age specific returns at LGD, since returning hatchery adults sampled at LGD can be assigned to their parents. We compared stock-specific abundance estimates between PIT- and PBT-derived methodologies for return years 2016 - 2019. Across all years, in-season PIT tag estimates accounted for 65% of the PBT-based estimates at LGD across all age groups and release sites combined. The 65% underrepresentation across all groups equated to 49,712 PIT tagged fish that went unrepresented in abundance estimates. Moving forward, we suggest that PBT-based estimates should aide in-season harvest management and post-season run reconstruction, especially during years of low returns, when increased accuracy is critical.

MONITORING HATCHERY PRODUCTION, BROODSTOCK COMPOSITION, AND GENETIC VARIATION OF SPRING/SUMMER CHINOOK SALMON IN THE SNAKE RIVER BASIN WITH MULTI-GENERATINO PEDIGREES

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Hatchery production of Chinook salmon (Oncorhynchus tshawytscha) in the Snake River basin is responsible for a large number of anadromous salmonid production, with the goal of increasing the number of returning adults to mitigate for declining abundance and extirpated populations. A genetic based method referred to as parentage-based tagging (PBT) enables highly reliable detection of hatchery reared offspring but also allows tracking of multi-generation pedigrees. This study compiles 11 years' worth of PBT data from over 87,000 fish for spring/summer-run Chinook salmon from 9 hatchery programs located in the Salmon and Clearwater Rivers. These multi-

generational pedigrees allowed investigation of several characteristics of each hatchery program including: the proportion of hatchery fish that return each year as adults, the proportion of natural and hatchery origin fish incorporated as broodstock, age class proportions of broodstock, number of strays among hatcheries, and genetic diversity and divergence in relation to various breeding practices. We were able to assign over 91% of hatchery broodstock back to their hatchery of origin and found a wide range of offspring produced by females (0-41) with the most frequent values of zero adult offspring per female followed by 1-2 returning fish. There was an overall rate of straying of less than 1% among hatchery stocks. Hatcheries spawned predominately 4 year old fish and nearly all programs incorporated broodstock across the three ages classes observed (3-5 years old). This study demonstrates the utility of the PBT as a monitoring tool for hatchery stocks and results suggest that segregated and integrated types of programs have tradeoffs that generally align with their intended purposes of mitigation or supplementation.

TRANSLOCATION OF WESTERN PEARLSHELL MUSSELS IN TINCUP CREEK, IDAHO

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Freshwater mussels can be negatively affected by heavy machinery during stream habitat enhancement projects. The objective of this project was to determine the success of translocating Western Pearlshell (*Margaritifera falcata*) within Tincup Creek, Idaho, prior to a stream restoration project. From 2018 – 2020, we used plexiglass bottom buckets to survey restoration sites for Western Pearlshell prior to project initiation. After collection, each mussel was measured and double-tagged with vinyl tags, and relocated to previously restored reaches. Additionally, in 2019 and 2020 we surveyed for mussels that had been translocated in previous years. From 2018 – 2020, we surveyed a total of 4,359 m of Tincup Creek and translocated 1,213 Western Pearlshell. We released mussels at 6 sites in 2018 (n = 408 mussels), 3 sites in 2019 (n = 184 mussels) and 1 site in 2020 (n = 621 mussels). Mussels ranged from 19 – 84 mm with 83% of the mussels ≥ 50 mm. In each year, we found a greater proportion of mussels in run habitat (>45%) compared to riffle and pool habitats. We recaptured mussels at five of the nine relocation sites; at these five sites, we recaptured 43 – 57% of released mussels. The probability of recapturing mussels was positively affected by mussel size. Tag retention was higher for mussels tagged and released in 2018 (88.2%) than those tagged and released in 2019 (78.1%). Estimated survival of mussels at two sites was 66.3% (95% CI = 55.4 – 88.0%) and 84.6% (95% CI = 72.6 – 100%). We demonstrated that Western Pearlshells can be successfully translocated with high survival of the mussels. Relocation sites should primarily consist of run and riffle habitats.

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EVIDENCE FOR INCREASING SUMMER TEMPERATURES IN HENRYS LAKE, IDAHO USING REMOTE SENSING

Mitchell Tree**, Eric Billman, Julie Willis

Brigham Young University – Idaho

Henrys Lake has a large surface area and a very shallow depth which makes it particularly vulnerable to shifts in climate. The objective of this study was to determine if climate change is influencing surface water temperatures of Henrys Lake. We used remote sensing techniques to extract lake surface temperature from satellite images (Landsat 8 and Landsat 5 Satellites) over 35 years (1984-2019). We analyzed temperature by month during ice-free portions of each year (i.e. May – October) to determine if surface water temperatures have increased over time. Mean surface temperature of Henrys Lake was positively correlated with time for the months of July, August, and September. For May, June, and October, mean surface temperature was not significantly correlated with time. Between 1984 – 2019, mean surface temperature during the months of July, August, and September increased by an average of 1.2°C per decade. The most drastic increase in surface temperature was in September which increase by 1.63°C per decade. Under the current rate of temperature change in Henrys Lake, trout in the lake will have to become more dependent on thermal refugia to survive through summer months as water temperatures approach and potentially exceed thermal limits for these fish. Consequently, fisheries managers will face additional challenges in managing this important fishery as effects of climate change are manifested in the lake.

ESTIMATING GROWTH AND BODY CONDITION OF MYY BROOK TROUT

James Sage Unsworth, Curtis J. Roth, Kevin A. Meyer

Idaho Department of Fish and Game

For decades biologists have theorized that the stocking of Myy fish (i.e., fish with two Y chromosomes) could be used as a tool to eradicate fish populations by shifting the sex ratio of the wild population to all male. Successful eradication using this tool likely increases as fitness of Myy increases relative to wild populations. Although fitness can be difficult to quantify, other more easily obtained metrics such as growth and body condition can provide insight into fitness because these metrics are often highly correlated with vital rates such as fecundity, recruitment, and survival. In an effort to eradicate unwanted Brook Trout populations, the Idaho Department of Fish and Game implemented the first Myy program by stocking Brook Trout Salvelinus fontinalis into four waterbodies in 2015. The objective of this study was to evaluate growth and body condition of Myy Brook Trout relative to wild fish. We used electrofishing and gill nets to capture 179 fish (n = 74 Myy Brook Trout and n = 105 wild Brook Trout) in three Idaho waterbodies (i.e., Dry Creek, Tripod Creek, and Seafoam Lake #4). Growth was compared between Myy and wild Brook Trout using von Bertalanffy growth models, and fish condition was compared using relative weight. Results of this study will provide managers with valuable insight when evaluating the likelihood of Myy Brook Trout successfully eradicating unwanted Brook Trout populations.

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EVALUATING THE PRECISION OF AGE ESTIMATES FROM LAKE CASCADE YELLOW PERCH HARD STRUCTURES

Isaac Fournier, Mike Thomas, Jordan Messner

Idaho Department of Fish and Game

Sagittal otoliths are widely used to estimate the age of Yellow Perch Perca flavescens and previous studies have verified age estimates from otoliths against non-lethal (scales, dorsal, and anal spines) and lethal (opercula) hard structures. However, these studies did not include Yellow Perch beyond age-12 or 340 mm TL. Lake Cascade, Idaho consistently produces Yellow Perch greater than 340 mm TL and fisheries managers have used multiple hard structures (sectioned otoliths and opercula) to document Yellow Perch up to age-16. Therefore, we verified age estimates obtained from sectioned otoliths, whole view otoliths, and opercula of Yellow Perch (n = 143) collected from Lake Cascade by evaluating between-reader precision, readability, and differences in age estimates among structures. Preliminary analyses suggested that between-reader agreement (PA) was highest and coefficient of variation (CV) was lowest for sectioned otoliths (PA = 70%, CV = 5) compared to opercula (PA = 47%, CV = 10.5) and whole view otoliths (PA = 43%, CV = 11.4). Opercula and whole view otoliths had lower mean reader confidence levels and underestimated ages ($P < 0.001$, $P = 0.04$, respectively) compared to sectioned otoliths. Our results both corroborate and build upon the results of previous studies by including larger and older Yellow Perch. Based on these findings, we recommend fisheries managers use sectioned otoliths for age estimation.

ASSESSMENT OF HARD STRUCTURES USED TO ESTIMATE AGE OF SMALLMOUTH BASS IN LAKE CASCADE, IDAHO

Steve Hughes, Mike Thomas, Jordan Messner

Idaho Department of Fish and Game

The Smallmouth Bass Micropterus dolomieu is one of the most popular freshwater sportfish in North America. To manage Smallmouth Bass populations, fisheries managers rely on age estimates that can be obtained from different hard structures. Although scales and sectioned sagittal otoliths are the most common structures used for estimating the age of Smallmouth Bass, scales have been shown to lack precision, and sectioned otoliths require extensive processing time. Previous research has identified opercula as a possible alternative to sectioned otoliths for estimating ages of Smallmouth Bass that requires less effort. In Lake Cascade, Idaho, fisheries managers have used opercula to estimate ages and have documented Smallmouth Bass up to age 20. This study compared age estimates obtained from sectioned otoliths, whole view otoliths, and opercula of Smallmouth Bass (n = 74) collected from Lake Cascade to compare between-reader precision, readability, and differences in age estimates. Preliminary analyses suggested that percent agreement (PA) was highest and coefficient of variation (CV) was lowest among sectioned otoliths (PA = 50%, CV = 6.7) and opercula (PA = 63%, CV = 7.3) compared to whole view otoliths (PA = 32%, CV = 15.9). For opercula, percent agreement within 1 year (PA-1) was similar to sectioned otoliths (PA-1 = 90%, PA-1 = 93%, respectively), and mean reader confidence was higher. However, opercula significantly underestimated the ages of Smallmouth Bass ($P < 0.001$) when compared to sectioned otoliths. Based on these findings, we recommend fisheries managers use sectioned otoliths to estimate ages of Smallmouth Bass.

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