ABSTRACTS FROM PRESENTATIONS AT THE 68TH NORTH WEST FISH CULTURE CONCEPTS (NWFCC) ANNUAL MEETING AND WORKSHOP

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In sequential order of appearance

Utilizing Conservation Aquaculture for Bonneville Cutthroat Trout in Idaho

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In 2007, the Idaho Department of Fish and Game implemented a conservation strategy to help restore native Bonneville Cutthroat Trout *Oncorhynchus clarkii utah* within the Thatcher Management Unit of the Bear River basin in southeast Idaho. The work was initiated because a primary objective described in the Idaho Department of Fish and Game's management plan for the conservation of Bonneville Cutthroat Trout is to supplement or reestablish populations in areas with low abundance or vacant habitat. Since 2007, approximately 1,800 wild, subadult Bonneville Cutthroat Trout have been collected for broodstock purposes. In 2010, conservation aquaculture operations were initiated at the Grace Fish Hatchery. These operations still continue and have resulted in the successful production and release of over 155,000 fish to assist with supplementation or reestablishment programs within the management unit. Post-release sampling events and angler reports indicate that Bonneville Cutthroat Trout abundance has increased in the Thatcher Management Unit. The

conservation aquaculture techniques developed for Bonneville Cutthroat Trout in this management unit provide a template for the development of similar techniques that can be utilized in other management units throughout the range of the subspecies in Idaho.

Livingston Stone National Fish Hatchery

Shasta Lake, California

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Oral Presentation

Abstract

Livingston Stone National Fish Hatchery is a conservation fish hatchery located at the base of Shasta Dam in California. Endangered Winter Run Chinook Salmon that run only in the Sacramento River are raised on site as well as a refugial population of endangered Delta Smelt which are endemic to the upper Sacramento-San Joaquin Estuary of California.

The hatchery is closed to the public due to its sensitive location at the base of Shasta dam so it is not widely known. The facilities will be discussed for both the chinook program and the delta smelt program. A rotifer and artemia rearing program is included with the Delta Smelt as the young require microscopic live feed in the early stages of life before they are transitioned to dry feed. Genetics play a large role in the spawning program for the Winter Run Chinook. It is a very intensively managed program to ensure the best pairings possible to reach release goals. This entire genetic evaluation process will be explained and questions are welcomed.

The goal of this presentation is to educate the public about Livingston Stone NFH as well as shed some light on the otherwise little known hatchery at the base of Shasta Dam.

Applied Conservation Genetics at the Lahontan National Fish Hatchery Complex

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Oral Presentation

The Lahontan National Fish Hatchery Complex maintains a broodstock of a unique genetic strain of Lahontan cutthroat trout. This important broodstock, which is the source for reintroduction and recovery in the western range of this species, represents the lacustrine strain originally present in ancient Lake Lahontan. These large, highly piscivorous cutthroat persisted in the Truckee River basin until their extirpation in the early 1900's. An out-transplanted population found in the late 1970's was determined through rigorous genetic testing to be directly descended from the Truckee basin fish. Over a fifteen year period the Complex has developed a genetically sound captive broodstock from this rediscovered population. In recent years we have partnered with University of Nevada, Reno to advance our techniques in preserving genetic integrity. Through this progression we have refined core protocols to maintain as well as improve brood and production fish genetic diversity. These protocols form the base of our current management program at the hatchery. Six years of implementation have resulted in increases in genetic diversity for each successive year class

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Topic: Lahontan Cutthroat Trout Conservation Hatchery: Building on success and improving fish culture efficiencies.

Presenter:

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Oral Presentation abstract

The Lahontan National Fish Hatchery Complex (LNFHC) house a critical broodstock for reintroduction and recovery of the lacustrine form of Lahontan cutthroat trout (LCT). LNFHC first brought the Pilot Peak strain of fish to Lahontan NFH in 1995 and has been refining methods throughout the last 20 years. Beginning in 2010 significant changes were made to broodstock protocols. Over the past year, a focus on refinement of the broodstock and production protocols improved operational efficiency by minimizing handling and feeding interactions. This broodstock population is a wild strain and the program effort is to reduce or eliminate impacts from culture in a hatchery environment. This presentation presents the improvements in operation that have occurred over the past year.

Colorado Parks and Wildlife's Salida Isolation Unit

Culturing Colorado's Native Greenback Cutthroat

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ORAL PRESENTATION – In 2007, new genetic research out of the University of Colorado was used to analyze the DNA of Colorado's native cutthroats to a sub-species level. The analysis determined that the cutthroats which were once thought to be pure greenbacks, native to the eastern slope, were in fact Colorado River cutthroats, native to the western slope. It also determined there was one remaining population of pure greenback cutthroats existing in Bear Creek, a small stream west of Colorado Springs.

In 2008, 66 adult greenback cutthroats were removed from Bear Creek and brought to the Salida Isolation Unit. These adults began the development of both wild and domestic brood stocks, used to begin reintroductions into their native range. The cutthroats are from a small population isolated for nearly 100 years and have proven challenging to rear in a hatchery setting. This presentation will cover a brief history, culture techniques used, and some of the future goals for the greenback cutthroat.

McCloud River Redband Trout Program

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Oral Presentation:

The McCloud River Redband trout was rescued out of three creeks; Edson, Moosehead, and Swamp and brought to Mt. Shasta Hatchery in August of 2014 because of drought conditions. These fish had been isolated in pools most of their lives not being able to move up and down the streams to find mates. This resulted in bad genetics. Hatchery personnel along with Wild Trout Foundation and geneticist Jeff Rodzen decided to cross spawn the streams for a better genetically diverse fish. In the springs of 2015 and 2016 we were successful in spawning two year classes of Redbands. Since doing so we have released hundreds of Redband back into Edson Swamp and Moosehead creeks and into the McCloud River. Certain numbers of fish were also set aside in RAS systems at Mt Shasta Hatchery for establishing a broodstock

My presentation will include the rescue efforts of 2014, the cross spawning of the streams for better genetics, the conservation efforts, and the establishment of a broodstock and production fish at Mt Shasta Hatchery.

Optimizing steelhead smolt production from natural-origin broodstock

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Oral Presentation

Hatchery programs designed to conserve and recover natural steelhead populations use natural-origin broodstocks to maintain natural spawn timing, minimize fitness loss, and reduce the genetic impacts of hatchery-produced fish interbreeding with natural-origin fish. However, challenges can sometimes arise when hatcheries attempt to produce yearling steelhead smolts from natural-origin broodstock, including selection for rapid growth, increased residualism, and poor post-release survival. We describe a series of hatchery and laboratory experiments that show how changes to hatchery rearing practices for steelhead smolts can facilitate use of natural origin broodstocks.

Hatchery assessments conducted at the Winthrop National Fish Hatchery (WNFH, Methow River, WA) compared PIT tagged steelhead reared to smolt at age-1 (S1) and age-2 (S2). In some release years, the S1 steelhead showed strong size selection for migratory behavior and survival after release. S2 steelhead were not subject to size selection, but consistently exhibited higher levels of precocious male maturation than S1 steelhead. Residuals near WNFH were dominated by non-maturing S1 steelhead and sexually maturing male S2 steelhead.

Laboratory experiments were conducted at Manchester Research Station using natural-origin steelhead broodstock from the Methow River to produce S1 and S2 smolts. The first experiment found that S1 smolts were smaller and suffered higher mortality during a seawater challenge than S2 smolts. Body size positively and significantly correlated with survival. The second experiment found that body size of individual steelhead varied considerably within weeks of ponding and was predictive of body size at age-1. A third experiment found that sorting steelhead into groups based on size did not improve growth of small fish, suggesting that growth rate (and age at smoltification) was an individual characteristic and that growth suppression of smaller individuals was not a product of competition. An ongoing experiment is investigating whether metabolic phenotypes established at the embryonic stage are responsible for growth rate and age at smoltification.

The combined results from the hatchery and laboratory experiments suggests that production of steelhead smolts using natural-origin broodstock can be optimized by sorting slower growing individuals shortly after ponding and rearing them as S2 smolts. The faster growing individuals would have a high likelihood of smolting at age-1 using traditional S1 rearing procedures. We hypothesize this approach would reduce selection for rapid growth, increase the rate of smoltification, reduce the prevalence of precocious male maturation, and lower the potential for residualism. Other advantages would include reduced costs and rearing space requirements in comparison to an age-2 smolt rearing regime.

Rescuing California Golden Trout: Integrating Hatcheries into Climate Change Management Action and Policy

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Oral Presentation – Abstract

California Golden Trout (CaGT) (Oncorhynchus mykiss aguabonita), a subspecies of rainbow trout and the official state fish, are native to South Fork Kern and Golden Trout Creek watersheds located on the western slope of the Sierra Nevada in the Inyo National Forest's Golden Trout Wilderness. California Golden Trout (CaGT) inhabit waters at 7,000+ feet of elevation making them difficult to access. CaGT, formerly a candidate species for federal listing in the year 2000, did not merit listing due presence of a multi-agency conservation strategy and the fishery management protection actions it contained. CaGT are currently a State Species of Special Concern, and the waters they inhabit are designated wild and heritage trout fishery program management waters. This combination affords CaGT some regulatory protection intended to reduce threats and assist with restoration. Threats to CaGT include hybridization with stocked rainbow trout (Oncorhynchus mykiss), competition with non-native brown trout (*Salmo trutta*), and habitat degradation from cattle grazing. In 2012 an additional threat to CaGT returned, drought. In 2013, the Department selected a representative water, Volcanic Creek, to conduct intensive monitoring for purposes of evaluating drought persistent impacts. Volcanic Creek CaGT are one of the most genetically pure strains of CaGT, having very low introgression rates from genetic studies conducted in 2001. Volcanic Creek access is limited to foot or horse travel and is ~16 miles from the nearest trailhead. Visual encounter surveys (VES) were conducted from 2013 to 2016. During this time population abundance declined from >500 individuals to a low of <200, and wetted habitat declined by ~25%, triggering concern regarding population persistence. Summer dessication and winter anchor ice were believed to be the primary cause of population decline. In the fall of 2016 Volcanic Creek CaGT

were rescued to avoid extirpation. Rescued CaGT were to be returned to the wild and/or used for a founding population to provide stock for future year reintroduction(s). A total of 53 CaGT were removed from Volcanic Creek and two tributaries, Right and Left Stringer Creeks. CaGT were placed in burlap covered fish transport cans and transported from the field via horseback where they were transferred to a hatchery transport truck for eventual housing at CDFW's American River Hatchery (ARH). One fish was lost in transit to the ARH. At ARH the CaGT were PIT tagged, weighed and measured for length. The CaGT were reared in self-contained chiller units to control growth, to prevent both contamination with other trout species, and to preclude disease transmission. CaGT were held at the ARH for ~nine months, during which time feeding was suppressed to control growth so CaGT would not be too large to return when habitat conditions improved. Habitat conditions greatly improved in 2017 negating the need to spawn CaGT in captivity. Sexually mature female CaGT were not egg stripped while in captivity to minimize fish handling related mortality. In July 2017 48 CaGT were returned to the Volcanic Creek drainage. Fish and habitat monitoring will continue in the foreseeable to future track success.

Led Astray: The Impacts of Drought on Fall Chinook Salmon at Coleman National Fish Hatchery

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<u>Oral Presentation</u>

The U.S. Fish and Wildlife Service's Coleman National Fish Hatchery is one of the largest salmonid hatcheries on the West Coast. Fall Chinook Salmon are the hatchery's largest production program and contribute substantially to California's commercial and recreational fisheries. Standard operational practice at Coleman National Fish Hatchery is to release salmon smolts on-site, directly into Battle Creek, which typically achieves the hatchery's fishery contribution goals while providing a strong imprint to Battle Creek. Strong imprinting increases homing and reduces straying of hatchery-origin fall Chinook Salmon, thereby decreasing the potential for negative impacts to naturally spawning salmonids.

The severe drought experienced in California during 2014 and 2015 resulted in degraded conditions along the salmon emigration corridor, causing concern that on-site releases would not survive their emigration to the ocean and fail to achieve the hatchery's fishery contribution goals. In response to these concerns, the U.S. Fish and Wildlife Service transported a large percentage of the fall Chinook Salmon smolts more than 250 miles downstream by truck to the San Pablo Bay and the Sacramento- San Joaquin Delta for release off-site, which increases the survival of smolts by bypassing the deteriorated in-river conditions. A consequence of trucking smolts is reduced imprinting to the natal water source, resulting in increased straying. The effects of increased straying were expected to be most pronounced during 2016 and 2017, corresponding to an age-3 maturation of Central Valley fall Chinook Salmon.

Evaluation of the 2016 fishery contributions showed off-site released salmon produced greater contributions to the ocean fishery but lower catch rates in the freshwater fishery than on-site released salmon. Additionally, the number of fall Chinook Salmon returning to Battle Creek was one of the lowest seen in 20 years. The U.S Fish and Wildlife Service anticipated that even lower adult returns to the hatchery in 2017 could compromise the ability to satisfy broodstock needs. Based on these concerns, the hatchery partnered with the California Department of Fish and Wildlife to collect eggs at the Nimbus Fish Hatchery near Sacramento. Coded-wire tags were read in real-time to target broodstock originating from Coleman National Fish Hatchery. Additionally, the hatchery has begun experimental releases to gather data on the survival of fall Chinook Salmon released at an earlier date or smaller size. Information from this study will inform future adaptive management decisions and enable managers to consider alternative actions in response to future periods of drought.

Environmental and fish health assessment of Lahontan cutthroat trout (*Oncorhynchus clarkii henshawi*) from Walker River basin

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Oral presentation

Abstract

In July 2017, Lahontan cutthroat trout (*Oncorhynchus clarkii henshawi*) **(**n=60) were collected from Walker River basin, CA and submitted for diagnosis. Additionally, water (n=6) and sediment (n=6) samples from same site were collected and used to investigate the presence of environmental DNA (eDNA) of known fish and amphibian pathogens. Upon necropsy, all fish appeared normal and only few pathological changes were observed, including cataract in one of the fish eyes. Sub-samples of spleen, kidney, and gonad were pooled for virus isolation on Epithelioma Papulosum Cyprini and Chinook salmon (*Oncorhynchus tshawytscha*) embryo cell lines. Three weeks post-inoculation, neither cell lines presented cytophatic effect. Extracted DNA from water and sediment samples was used as a template in previously described TaqMan probe real-time polymerase chain reaction (qPCR) assays, specific for the detection of *Ceratanova shasta*, *Myxobolus cerebralis*, *Batrachochytrium dendrobatidis*, Ranavirus, *Flavobacterium columnare*, *Flavobacterium psychrophilum*, *Renibacterium salmoninarum* and *Veronaea botryosa.* Only *F. psychrophilum* was detected in one of the soil samples. The preliminary results obtained in our study suggest that eDNA can be used as a non-invasive, rapid, specific and sensitive method for establishing risk of infection in wild populations.

Monitoring the Impacts of Pathogens at Increasing Water Temperatures in Chinook Salmon in the Sacramento-San Joaquin Delta

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Water temperatures in the Sacramento-San Joaquin River Delta (SSJRD) are predicted to rise over the next decades as a result of global climate change, potentially altering the processes of pathogen infection, fish physiological responses to infection, and the spread of infectious diseases. Altered timing of migration in some populations of juvenile Chinook salmon (CS) coincided with elevated water temperatures, potentially exposing populations to different pathogen communities. In this study, wild, out-migrating winter run CS were collected from rotary screw traps deployed in the Sacramento River at the Red Bluff Diversion Dam between October and November in 2015. Pathogen presence and abundance, as well as the expression of immune-response and general stress genes, were assessed from gill tissue to determine the relative impact of infections on fish. We discovered 8 different pathogens in our sampled population, and nearly all fish tested (with the exception of one) were positive for *Parvicapsula minibicornis, Candidatus branchiomonas cysticola*, and *Ceratonova shasta*. Multiple infections (up to 7 simultaneous pathogen infections) were detected in each fish. Although qPCR assessments suggested potential viral infections based on responses of specific genes (e.g. Mx protein) that were differentially regulated across many individuals involved in the immune response to viral infection, no specific viral infections were detected. Immune responses did not always match general stress responses suggesting that other environmental variables, in addition to the pathogen, are likely impacting the overall physiological health of out-migrating Chinook salmon. Experiments are in progress to assess the presence of pathogens and the physiological responses of fish to pathogens among fish held at increasing water temperatures (12°C, 15°C, 18°C, and 20°C) in the laboratory following sentinel exposures in the SSJRD for 2 weeks. Data analyses and modeling will help predict the potential environmental risks to address effective management of smolt migration and rearing survival during periods of high water temperatures associated with extreme drought.

Ceratonova shasta and _Parvicapsula minibicornis_ infection in Sacramento and Feather River juvenile Chinook salmon: Spatial, temporal, and river condition influence on disease severity.

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Ceratonova (previously *Ceratomyxa*) *shasta* and *Parvicapsula minibicornis* are endemic myxozoan parasites of salmonid fish in the Pacific Northwest and can have significant impacts on juvenile health. Survey and sentinel fish exposure data from 2014 – 2017 in both the Feather and Sacramento River will be discussed in context of seasonality, zones of infectivity, and river conditions influence on disease severity.

Maintaining the Health of Endangered White Abalone *(Haliotis sorenseni)* in a Captive Breeding Program

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White abalone *(Haliotis sorenseni*), one of seven abalone species native to California, was once a sought-after delicacy, prized for its tender meat and beautiful shells. An upsurge of the commercial white abalone fishery in the 1970s caused the population of this marine snail species to decline significantly. Despite the closure of the commercial fishery in 1993, the fragmented population has only continued to decline in the wild and now exist at merely 1% of its historic estimated size. As a result of the decline and facing extinction, they were the first marine invertebrate to be federally listed as an endangered species in 2001.

The White Abalone Recovery Program, a NOAA-sponsored project led by UC Davis' Bodega Marine Laboratory in collaboration with the California Department of Fish and Wildlife (CDFW), is dedicated to restoring the species through its native range. The core of the project is the captive breeding program, through which white abalone progeny of wild-caught individuals are produced for outplanting and research. The CDFW Shellfish Health Laboratory (SHL) is responsible for maintaining the health of both the wild individuals and their offspring in captivity, as well as engaging in research to better understand the disease threats that await outplanted individuals in the wild.

Arguably the biggest threat to the abalone's health in captivity is the susceptibility of the species to the Rickettsiales-like prokaryote *Candidatus* Xenohaliotis californiensis (Xc), the causative agent of a degenerative disease called Withering Syndrome (WS). To treat the disease in captivity, the SHL has developed an oxytetracycline antibiotic bath, which has been shown to not only eliminate the Xc infection, but also protect treated abalone from subsequent Xc reinfection for several months post-treatment. Shell-boring organisms, including bivalves, sponges, and polychaetes, are commonly found in wild abalone and, unfortunately, can also infest captively-reared individuals; these organisms compromise their abalone host's biological fitness and may facilitate opportunistic microbes that cause shell lesions. A shell waxing protocol was developed to rid the affected abalone of these pests and it has been effective in reducing deleterious health impacts, including mortality, caused by the lesions while presenting minimal risk to the animals. Both treatments have proven to be essential in maintaining healthy abalone broodstock and aid the efforts to bring the species back from the brink of extinction.

Presentation Title: Managing Precocious Maturation in Chinook Salmon (*Oncorhynchus tshawytscha*) Captive Broodstock

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Oral Presentation

Abstract

The San Joaquin River Restoration Program (Program) is working to reintroduce a self-sustaining population of spring-run Chinook salmon. However, the threatened status of the Central Valley population limits the availability of fish for restoration purposes. Therefore, a captive breeding program was developed to allow collection of small numbers of individuals from the wild without negatively impacting these populations. The modest collections are then amplified by rearing the donor stock in captivity to adulthood, spawned and their offspring are used for restoration.

Chinook salmon can be challenging to rear in captivity and early efforts by the Program resulted up to 84% early maturing age-two males. Research has shown that slowing the growth rates of juveniles at particular times of the year can reduce the incidence of early maturation.

The Mac & Jack study: Size and domestication effects on minijack rates of summer Chinook salmon from McCall Fish Hatchery, Idaho.

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Oral presentation

Previous studies have found age-2 male maturation (minijack) rates in Chinook salmon to vary across hatcheries in the Columbia River and Snake River basins. Also, segregated (more domesticated) brood lines have been found to have lower minijack rates than integrated (incorporate some wild fish in broodstock) brood lines. This physiological “decision” to mature early is influenced by size and energy stores, as well as genotype. This decision has been described as a threshold trait where individuals that surpass a genetically determined size or energy threshold during specific seasonal windows are more likely to initiate maturation. In this study we examined the effect of High and Low feed ration on both an integrated and segregated brood line of summer Chinook salmon from the McCall Hatchery in Idaho to test whether these lines have different size thresholds for minijack maturation under variable rearing conditions. Eyed eggs were obtained from each brood line and reared separately on a moderate growth rate. All fish were then PIT tagged at the end of their first summer after which equal numbers of fish from each brood line were intermixed in each of four tanks. Replicate tanks were then reared on either a High or Low ration treatment throughout the fall and winter. This experimental design allowed us to track the effect of brood line, size, growth rate and resource competition on minijack maturation of individual fish throughout the experiment. By tracking size across seasons we found further evidence that the decision to mature as a minijack is based on size of individual males and is initiated in fall/winter of their first year. Feed treatment had the greatest influence on minijack rate with High ration males exhibiting 2-3 times as many minijacks (47%) compared to low ration males (18%). The level of domestication had a milder effect on rate of minijack maturation with the integrated line producing more minijacks (34%) than the segregated line (28%). Finally, the integrated line had higher growth rates than the segregated line in the Low feed treatment suggesting they may be better

able to compete for food when resources are limited and that there are other genetic or phenotypic factors affecting growth rates.

Effect of Broodstock Age on Precocial Maturation of Male Chinook Salmon Smolts - Minijacks

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Sexual maturation of male Chinook salmon typically occurs at age 3 (jacks), 4, or 5, although maturation may also occur precocially at age 1 (microjacks) or 2 (minijacks). Natural rates of precocious maturation are very low, however, rates may be very high among hatchery juveniles - averaging 40% (and as high as 71%) among spring Chinook smolts at the Cle Elum Supplementation Research Facility (CESRF), Cle Elum WA. Minijacks contribute minimally to natural spawning and do not reach a size to provide fishery benefits. Therefore, high incidence of minijacks represents a substantial biological and economic loss to supplementation hatchery programs.

Minijack production among hatchery smolts is strongly influenced by environmental factors associated with increased growth and lipid levels relative to naturally rearing fish. Additionally, heritability for age at adult male maturation (age 3, 4 or 5) has been indicated by an observed positive correlation between age of Chinook broodstock and age of their returning adult male progeny. Large variation in minijack rate across Columbia River basin hatchery stocks provides further evidence of a potential genetic component.

We are conducting a three broodyear (2014 to 2016) study at CESRF to assess whether the age of natural origin spring Chinook broodstock also correlates positively with minijack rate, for which results are available for 2014 and 2015. Factorial matings were performed among age 4 and/or 5 females crossed to age 1 (2015 only), 3, 4 and/or 5 males. At swim-up, 50 fry per mating were pooled into a common raceway for rearing to the smolt stage (age-1+). The fish were then sacrificed, dissected and identified to sex, and males were measured (length and weight), and blood and tissue sampled. The blood plasma was assayed for 11-ketotestosterone to characterize each juvenile as non-maturing or as a maturing minijack. Tissue samples were genotyped for a panel of 293 SNP markers, and parentage analysis assigned each juvenile to its parental pair. The proportion of minijacks per full-sib male progeny group was calculated and the data analyzed for an effect of parent age on minijack rate across parental cross types

Variation in minijack rate among progeny groups was unexpectedly large within all parental cross types (<10% to >80%), and contrary to results cited above for broodstock and their returning adult male progeny, average minijack rate was not significantly different across parental cross types ($P>0.05$).

However, progeny groups produced in 2015 with precocial parr (microjack) males, did show a significantly higher rate ($p<0.01$) of minijacks relative to age 3 jacks crossed to age 4 females, although not to progeny of age 4 male broodfish. Therefore, while an effect of was sometimes observed among crosses made with microjack male parents, altering the age composition of adult (age 3, 4 and 5) male Chinook salmon hatchery broodstock did not affect minijack rate overall. These results provide evidence that production of minijacks is affected by genetic influences, albeit not directly related to adult broodstock age, in concert with environmental influences of hatchery rearing conditions.

Photoperiod: A potentially underappreciated phenonomenon in salmon physiology and culture?

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Oral Presentation

Growth rate and size are often a focus of hatchery and aquaculture production. Maturation schedules are also a significant concern as shifts in maturation toward younger ages and smaller size may result in reduced production of full-size fish. While manipulation of temperature, ration, and photoperiod, have all been shown to affect one or more of these parameters, current growth models tend to focus on temperature and ration suggesting that the role of photoperiod in modulating fish physiology may be under-appreciated in cultured fish populations.

In this study Yakima River, Washington spring Chinook Salmon (*Oncorhynchus tshawytscha*) alevins of the same age and average size were ponded into tanks experiencing different seasonal photoperiods (early, middle, late) that spanned the natural seasonal range of emergence for this population. Temperature and feed ration were similar for all treatments, thus, providing a unique opportunity to investigate the effects of photoperiod alone on condition factor and whole body lipid levels. Photoperiod was found to have a significant effect on lipid levels and condition factor and both followed a similar seasonal

pattern that was inversely related to day length. These results have implications for salmonids reared for both aquaculture and hatchery supplementation as physiological shifts may affect proximate composition, product quality and maturation size schedules. Fish culturists may optimize feeding regimes by incorporating the influence of seasonal changes in photoperiod on lipid levels, especially in the fall and winter.

Year-round availability of genetic material through cryopreservation of milt in salmonids

Presenters:

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-Tiersch, T.; Professor, LSU AgCenter, 227 School of Renewable Natural Resources Bldg, Baton Rouge, LA, USA, 70803225-578-4131, TTiersch@agcenter.lsu.edu

Oral Presentation

While artificial insemination in domestic animals has been documented since 1784, the history of long-term preservation (cryopreservation) of bull semen in the US is documented since the 1950s.

The techniques used to cryopreserve bull spermatozoa, including the selection of qualified samples through sperm evaluation; the extension of ejaculates as a means to protect the spermatozoa from damage during the cryopreservation and thawing processes; the planning and implementation of controlled cooling and freezing rates customized to the cryoprotectants and extenders used; and the long-term storage and handling of frozen semen samples are well accepted and used routinely in the production of semen for nine million dairy cows in the US.

The equipment and inputs used in bull semen cryopreservation, including semen packaging materials, freezing equipment and storage infrastructure, as well as all other accessories, have been applied successfully in the cryopreservation of sperm of multiple species of fishes. Semen extenders and cryoprotectants have been customized for use in fish.

Cryopreservation of fish sperm has enhanced hatchery and aquaculture operation by providing flexibility in spawning of females, greater control in breeding programs and the ability to store favorable genes for extended periods[1]. Sanitary considerations to the movement of live animals can be relieved when gamete samples are transported without deterioration and without consideration for time. The ability to preserve and store fish sperm provides a reliable source of fish genetic material for scientific and aquaculture purposes, conservation of biodiversity as well as for routine production in the modern aquaculture industry.

In particular for the North American fish industry, the cryopreservation of salmonid sperm benefits from the protocols and commercial infrastructure institutionalized by the bull semen industry.

[1] Tiersch, Terrence; Cryopreservation of Aquatic Species; Advances in World Aquaculture, Vol. 7; World Aquaculture Society; XXI.

A Decade of Parentage-Based Tagging: What Have We Learned from Salmon and Steelhead Hatchery Programs

John Carlos Garza*, David Vendrami, Hayley Nuetzel, Hilary Starks, Anthony Clemento, Eric Anderson and Devon Pearse

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*Presenter

Parentage-based tagging is a type of pedigree analysis that uses the principles of inheritance to provide intergenerational monitoring and evaluation. Molecular genetic data are collected from parents and provide individual-specific tags for all of their progeny. It was developed to study salmon and steelhead, and was first implemented in California in 2006 at the Feather River Hatchery with spring-run Chinook salmon and has subsequently been implemented broadly for salmon and steelhead. It is particularly useful for iteroparous steelhead, as carcasses are rarely encountered, they are usually released alive from hatcheries after spawning, and are generally not coded wire tagged.

We have collected genetic data from more than 50,000 steelhead, Chinook salmon and coho salmon used as broodstock in California's anadromous fish hatchery programs to understand salmonid biology and hatchery operations.

These data were used in parentage analysis and allowed us to estimate age structure, family size and the fraction of spawning pairs that contribute to the next generation for all three species. Investigation of the spawn timing of related individuals revealed a strong genetic component of date of reproduction in steelhead. In addition, the use of the genetic data as DNA fingerprints allowed the estimation of rates of iteroparity of steelhead, as well as migration rates between Central Valley basins.

The pedigree and DNA fingerprint data further identified several aspects of hatchery operations. First, we found a high proportion of age 2 spawners in multiple steelhead programs, as well as multiple instances of reuse of males as spawners, at rates that were not concordant with program goals. We further found that some designated natural-origin spawners were actually hatchery-origin fish for which a mark was either not applied or recognized. Finally, we found that many hatchery programs unintentionally mate related pairs of fish and that this inbreeding leads to a measurable decrease in adult returns. This work shows the power of parentage-based genetic tagging analysis to elucidate details of key life history traits of salmon and steelhead, and, as a consequence, its utility in formulating effective management strategies for hatchery programs.

Evidence for Genetic Adaptation to Captivity and a Potential Mechanism to Account for Domestication in Hatchery-Reared Steelhead

Neil F. Thompson[a*], Benjamin J. Clemens[b], Lindsay L. Ketchum[b], Philip C. Simpson[c], Robert E. Reagan[c] and Michael S. Blouin[a]

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Oral presentation

Abstract; Genetic adaptation to captivity (domestication) influences the reproductive success of hatchery-reared steelhead (*Oncorhynchus mykiss*) spawning in the wild, but the mechanism by which domestication occurs is not well understood. Because body size at release is positively correlated with survival, one hypothesis is that hatcheries select for physiological and/or behavioral traits that promote fast growth in captivity. If those traits are maladaptive in the wild, then that could explain why hatchery fish quickly evolve to have lower reproductive success than natural-origin fish in the wild environment. First-generation hatchery steelhead from the Hood River, (Oregon) have lower reproductive success in the wild than do natural-origin fish, and substantial evidence suggests the fitness difference is genetically based and due to domestication. Here we ask whether the 'selection on size at release' hypothesis could explain the rapid domestication observed in this well-studied steelhead population. Using scale analysis, we back-calculated length at ocean entrance to test whether size-selective survival occurred in two cohorts (brood year 1997 and 2009). In BY 2009, we found evidence of weak size-selective survival (difference of 9 mm between pre-release average length and back-calculated length from surviving adults), but in BY 1997, strong (37 mm difference) size-selective survival was observed. Family identity explained 33 percent of the variance in fork length before release, so the requisite genetic variation for response to selection on size at release likely exists in this population. Our results support the hypothesis that size-selective survival does occur after release, and that selection for traits promoting fast growth in the hatchery could be a mechanism by which rapid domestication has occurred in the Hood River winter steelhead hatchery program.

Chinook Salmon Gamete tracking

Author and Presenter: Stephen Brightwell

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Oral presentation using Powerpoint.

This presentation will detail the reason (identifying spring run fish in our fall run), the process and procedures used, and the results (being able to discard only those crosses containing Spring Run instead of whole lots) of the gamete tracking efforts at Feather River Hatchery. Presentation will also cover Genetic tracking of Spring Run crosses which started because of the San Joaquin Project but was expanded to include our entire Spring Run.

Razorback sucker, Rio Grande silvery minnow, and considerations on the supplementation of wild populations

Evan W. Carson, Bay-Delta Fish and Wildlife Office, USFWS

For threatened and endangered fishes that are at acute risk of extinction, management efforts often include supplementation of wild populations, whereby fish produced or reared in captivity are released to the wild. Supplementation is appealing as a management tool because it has the potential to quickly bolster populations that are in steep decline. Yet supplementation also can exacerbate the risk of extinction because captive populations are prone to inbreeding, genetic drift, domestication selection, and other influences that can reduce the current and future fitness of the species in the wild. Further, supplementation does not diminish the need to mitigate the underlying causes of decline.

This presentation considers ‘lessons learned’ from two of the longer-running supplementation programs for non-salmonid fishes, the endangered razorback sucker *Xyrauchen texanus* (RBS) and Rio Grande silvery minnow *Hybognathus amarus* (RGSM). The RBS is a large-bodied, long-lived, iteroparous fish that is at risk of extinction from predation by non-native fishes and from nutrient limitations associated with habitat change. Supplementation of RBS is managed through a traditional hatchery-origin program (Upper Colorado River basin) and through a repatriation program (Lower Colorado River basin), in which wild-caught larvae are reared to adults in hatcheries and protected off-channel habitats and then released back to the wild (repatriated). The RGSM is a short-lived (~ annual) fish that is endangered as a result of fragmentation and loss of habitat and from insufficient river flow. The supplementation program for RGSM is based supportive and captive breeding.

Supplementation programs for RBS and RGSM have maintained genetic diversity and thus far prevented extinction of these species. Yet both remain dependent on supplementation because their habitats remain insufficient to support self-sustaining populations. Discussion will focus on lessons to draw from the successes, shortcomings, and challenges of these programs.

Development of a Hatchery and Genetic Management Plan for Delta Smelt (*Hypomesus transpacificus*)

Daphne Gille [*,1], Melinda Baerwald [2], Ted Sommer [2], Tien-Chieh Hung [3], and Amanda Finger [1]

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As abundance indices continue to decline, there is growing concern that Delta Smelt may become extinct in the wild before habitat restoration programs can be completed to aid in recovery. One management option to prevent species extinction in the short term is to reinforce the wild population using cultured Delta Smelt that are reared in a conservation hatchery. However, the release of cultured fish into the wild for reintroduction or supplementation will inevitably alter the genetic composition of the existing population. Here, we describe the intensive management strategy that is currently in place to maintain genetic diversity and minimize inbreeding within the refugial population of Delta Smelt housed at the UC Davis Fish Conservation and Culture Laboratory. We also discuss the genetic risks associated with reintroduction and supplementation using cultured fish such as domestication selection and founder effects and best practices to mitigate these potential issues. Finally, we outline how parentage-based tagging and genetic monitoring can be used to evaluate the success of population reinforcement and as part of an adaptive management plan.

Title: Recommendations for Conservation Hatchery Programs for Inland Trout

Jeff Rodzen*, Mark Clifford, and Michael Lacy.

CA Dept of Fish and Wildlife, Fisheries Branch, Sacramento CA

California is poised to begin several conservation hatchery programs using native trout species and subspecies. In preparation, we developed guidelines and recommendations for operation of conservation hatchery programs for inland trout. It further provides recommendations to inland trout hatchery managers and Regional biologists who are responsible for implementing such programs. The need for conservation hatcheries in modern trout production stems from the requirement, by legislative directive or appropriate stewardship of natural resources, to produce native species.

The decision to start a conservation hatchery program should be based on an evaluation of the trade-off between the risk of extinction or extirpation and the possible accumulation of negative genetic and ecological effects that may accompany a hatchery program. Another way to consider this is an evaluation of the risk of bringing the fish into a captive environment versus the risks of leaving them in the wild. Managing these effects (e.g. fitness loss, domestication selection, inbreeding depression) is crucial for the long-term success of a conservation hatchery program.

A hatchery program that produces fish for conservation and restoration efforts in addition to fish for recreational sportfishing is inherently more complex than a traditional hatchery program that focuses solely on production of fish for commercial and recreational harvest. Several variables must be considered prior to starting a conservation hatchery program. Diligent planning coupled with real-time evaluation and annual scrutiny and review is imperative for conservation programs to be successful.

Current status and future management directions of the Devils Hole pupfish

Michael R. Schwemm* (US Fish and Wildlife Service)

Kevin P. Wilson, Jeffrey A. Goldstein, Ambre L. Chaudoin, and John Wullschleger (National Park Service),

Corey Lee, Olin Feurerbacher, and Javier Linares (US Fish and Wildlife Service), and

Brandon Senger (Nevada Department of Wildlife)

The Devils Hole pupfish (*Cyprinodon diabolis*) of southern Nevada occurs in likely the smallest habitat of a vertebrate taxon, and as such exhibits a precarious and complex history of conservation management. This report updates the current status and future management of the species. The most recent census at Devils Hole (a semi-annual estimate by direct count) was 115 fish on September 16 and 17, 2017. This count was lower than fall counts of immediately prior years 2016 or 2015 (144 and 131 fish, respectively). Nonetheless, because life-history attributes, seasonality and stochastic impacts on habitat strongly influence short-term demography, 2017 results are not extraordinary in this system over the past three years. Instead, the relative stability at a population size far below historic levels represents an ongoing management concern. The sole refuge population outside of Devils Hole at the Ash Meadows Fish Conservation Facility houses approximately 60 additional animals in the refuge tank, and 25 animals collected as eggs from Devils Hole over the preceding fall (2016) and spring (2017). Animals housed in the refuge tank consists of all life-stages, indicating natural recruitment. Similar to the Devils Hole population, the level of recruitment and population size in the refuge tank is lower than expected given habitat size and productivity. Potential explanations for observed population sizes and ongoing research objectives will be discussed.

Umatilla Coho Program – A Study On Adaptive Management Strategies For Success

Jon Lovrak*

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ORAL

The Umatilla Tribe began collecting local broodstock on the Umatilla River in 2010 for its Coho program. Collection timing and associated water temperatures are the primary factor in determining survivals of both adults during holding and green egg viability. The CTUIR and ODFW coordinated a study in Brood Year 2014 to compare “early” and “late” Coho collections and spawning. There were increased survivals in both prespawning mortality and egg viability for the latter group collected after water temperatures decreased. This information has been used to guide management decisions for current and future broodstock collection and spawn planning.
The presentation will outline the comparisons in survival of the two groups and provide information on the effects of temperatures and timing on early and late broodstock collections related to pre-spawn mortality and egg viabilities.

Oroville Dam Spillway Crisis Response at Feather River Hatchery

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Presenter: David Lunsford

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Oral presentation using Powerpoint.

This presentation will detail the effect of the spillway failure on the Feather River Hatchery and the Hatchery response to the unprecedented siltation.

Microscreen Filtration and UV Disinfection in Fish Culture

Presenter – "Terry McCarthy", co-owner / Managing Member Water Management Technologies, Inc.

Presentation Type - Oral

Microscreens are mechanical gravity flow filters that remove particles down to 10 microns. They are widely accepted in the aquaculture industry because they are scalable, energy efficient and require very little water to backwash compared to most forms of depth filtration.

Typical microscreen applications include intake, recycle and effluent polishing within aquaculture. The author explains why one type of microscreen is better for one application versus another and details the main guidelines for applying microscreens.

UV disinfection is a proven technology for treating bacteria and viruses in fish culture. The presentation details how UV works and the different applications where it is used within the hatchery.

Microscreens enhance UV effectiveness by removing particles which influence UVT. UVT is the measurement of the clarity of the water to be disinfected. The higher the UVT the less UV energy one has to apply to achieve a given dose rate. This presentation describes the criteria required for sizing a UV system for an aquaculture application and a list of common fish diseases are listed with the corresponding UV dose rate required to render the bacteria or viruses harmless.

Use of RAS Technology in Serial Re-Use Fish Culture and Lessons Learned

Steve Sharon, Fish Culture Supervisor
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The Wyoming Game and Fish Department presently operates ten fish culture facilities to manage diverse salmonid sport fisheries as well as restoration efforts for four sub-species of native cutthroat. Prior to the introduction and spread of *Myxobolus cerebralis*, the causative agent of whirling disease, the department managed fish culture facilities with a mixture of surface and closed water systems. Traditional water supplies drastically dropped as the parasite infected four hatchery water supplies from 2000 to 2012. To counter this loss, recirculating aquaculture system (RAS) technology has been incorporated within serial re-use systems statewide to improve fish quality and meet production requirements. After over ten years of operation, this presentation provides an

updated overview of the types of RAS technology employed at six facilities and the resulting benefits from the addition of this technology as well as the lessoned learned.

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aquaManager Hatchery Database Software

Author:

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Presentation type: Oral

Abstract:

At the core of any well-functioning organization, public or private, are one or more technology based processes or solutions, and the California Department of Fish and Wildlife is no exception. CDFW’s hatcheries are a complex machine, with many moving parts and hundreds of pieces of information to collect and analyze each day. In a modern, technology-based society, it is more important than ever before to have the ability to quickly and efficiently collect and share crucial data.

Faced with the unavoidable expiration of our prior hatchery database solution, CDFW has recently acquired and customized an incredible new tool called aquaManager. Developed in Greece for commercial European hatcheries, the aquaManager software is a modern database tool which has been tailored to fit CDFW’s specific business and data needs. Hatcheries can use it to collect, analyze, and report on a variety of information utilized by our department. Covering the full life cycle of fish from spawning, growing and hatching eggs to planting fish out to public waters, aquaManager has the capability to collect and share data for dozens of different daily hatchery transactions. While in use for only a short amount of time to date, this software is already changing CDFW’s data collection process for the better by offering an easier way to share records

in real-time across the department, optimizing data collection to require less employee data entry time, and automating processes where possible to learn from data trends and help predict and calculate fish feeding and growth patterns. CDFW would like to share this discovery with other entities who may wish to explore using aquaManager for their hatcheries.

Improve Production Efficiency and Fish Management Using Data Mining and Machine Learning

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Aquaculture companies and organizations are drowning in data, but starving for knowledge. Data can tell a lot about the parameters influencing the success of the production from **environmental parameters**, to **feed types, feed composition, feeding rates** and **practices, production management strategies** and many others. They can also be used to identify patterns, trends, problem causes and also to develop models. Unfortunately the data are currently unexploited. It is difficult to transform them into knowledge in order to support **smarter decisions**, **better production** and **efficient management**

Data mining and machine learning can help to convert data into to knowledge, which can be used to dramatically improve performance. Whether is used to drive new business, reduce current costs or gain the competitive edge, data mining can be seen as a highly transformational asset for every fish farming organization, be it large or small. This secure and unobtrusive collation of data enables **analysis of huge volumes of historical data** to **deliver informed business** driven **knowledge** from **models** built for **prediction**, **estimation**, and other **inferences** involving uncertainty.

A **cloud-based machine learning and analytics platform** is presented that promotes more informed and precise strategic business decisions, previously not possible, thus enabling a competitive edge to manifest. The platform provides features for **data management, descriptive statistics, machine learning model building, predictive data mining and development of growth and feeding tables**. All the provided tools are adapted to the needs and requirements of aquaculture producers and speak their language. The platform is offered as a cloud-based system in order to provide the necessary computer resources for descriptive and predictive datamining, which are resource-intensive tasks.

The benefits for the sector are more knowledgeable methods for production and management and richer decision making capabilities based in a holistic data framework.

The platform is open to any non-profit organization who can use it and experiment with their data for free.

Title: Sockeye Over Cle Elum Dam – A 2017 Fish Passage Pilot

Type: Oral Presentation

Presenter: Todd Deligan; Whooshh Innovations; todd.deligan@whooshh.com

At the 67th NWFCC held at the Great Wolf Lodge in Washington State, Whooshh Innovations presented findings of several Whooshh Fish Transport System (WFTS) tests that occurred in 2016. The first was a CRITFC conducted return to river Sockeye migration study that was undertaken on the main-stem of the Columbia River at the Off-ladder Adult Fish Trap (OLAFT) at Priest Rapids dam. The second involved the testing of a 1,100 ft WFTS to transport Chinook adjacent to Roza Dam in Washington State and was conducted in partnership with the U.S. Bureau of Reclamation (USBR) and the Yakama Nation Department of Fisheries.

The 2016 successes set the stage to allow for a USBR contract for a summer 2017 pilot utilizing a WFTS to enable fish passage over one of its owned and operated high head dams. Specifically, an observational feasibility pilot was conducted at the USBR's Cle Elum Dam in Washington State with an installed system length of 1,700 feet and spanning 180 feet of height. The pilot established safe and efficient size-sorting and passage of Sockeye salmon from a location at the tailrace of the dam through a WFTS up and over the dam structure with fish exiting into Lake Cle Elum – for the first time in 90 years. The USBR engaged the Yakama Nation and U.S. Geological Survey (USGS) to facilitate sockeye sampling, tagging and tracking throughout the pilot.

System components include volitional entry, an optical scan and sort unit, chilled water misting throughout to limit thermal shock, and a system exit configuration capable of handling a highly fluctuating reservoir. Sockeye were collected in multiple manners and either radio and/or PIT tagged for tracking and spawning analysis.

An exceptionally low run of returning Sockeye came back to the Columbia/Yakima basin in 2017, but the pilot successfully demonstrated the ability to transport 125 fish a third of a mile up and over the dam. Final results of the radio tag analysis and PIT-tag carcass survey will be compiled by the USGS and published in the winter of 2018.

A detailed discussion of the system configuration and the short timeline from contract signing through installation and operation to dismantle will be covered.

Also discussed will be an update regarding a U.S. Department of Energy funded fall 2017 study conducted by the Pacific Northwest National Laboratory at Ringold Hatchery on volitional entry and optical scanning and sorting of species.

Title: Optimizing Aeration Tower Design for Salmon Hatcheries

Presenter:

Don MacKinlay,

Salmonid Enhancement Program, Fisheries and Oceans Canada

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Oral Presentation

Abstract:

Fish hatcheries throughout the world have been looking for the ideal aerator to equilibrate gas pressures (nitrogen, oxygen and carbon dioxide) in pumped well water for decades. This talk will cover the journey toward and conclusion of investigations in Canada that have led to an optimal design for the conditions that we encounter in our salmon hatcheries.

TRC Triploid Machine Repair/Rebuild

Bill Branch

California Department of Fish and Wildlife

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Oral Presentation:

This presentation will be regarding proper care and maintenance of TRC triploid machines. Topics covered will be the contents of a rebuild kit, a video showing how to replace gaskets, seals and springs, and proper care of the motor and hydraulic systems.

The video portion of the presentation is under 10 minutes, however will be paused at certain points to illustrate possible difficulties or tips and tricks.

Triploid trout eggs account for millions of eggs reared at California hatcheries every year. Neglect of the triploid machines can be detrimental not only to egg production, but our pocketbooks. A rebuild kit is significantly cheaper than a new machine.

OVERVIEW OF PRIVATE AQUACULTURE IN CALIFORNIA
68th Annual NWFCC Workshop December 5-7 2017

Presenter:
Tony S. Vaught
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Oral Presentation (requested time is 20 minutes plus 15minutes for questions.)

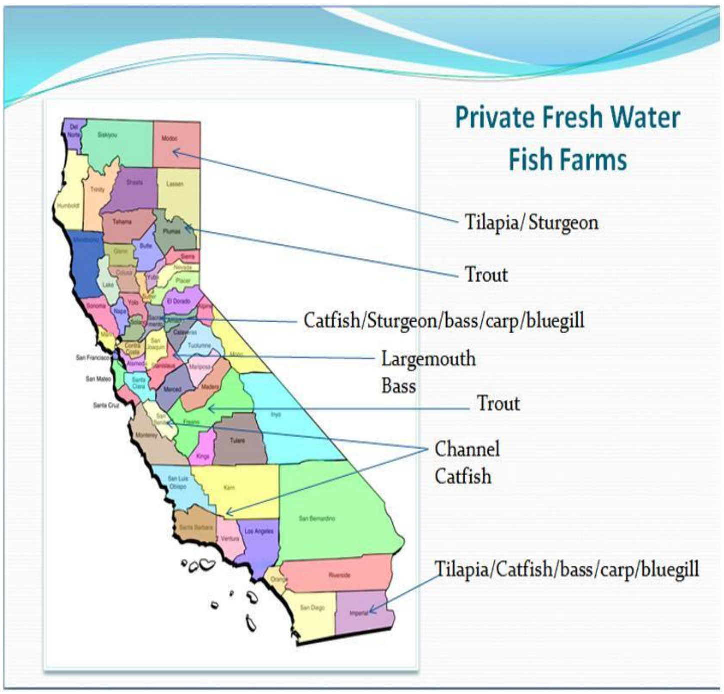
Abstract

California has a long history in aquaculture, with over two dozen species grown for food recreation and research. Private aquaculture is diverse due to California's rich natural resources, climate and species.

Public and private aquaculture overlap in many ways such as recreation, research, nutrition, husbandry practices, fish pathology, water treatment and discharge, transportation, broodstock and hatchery production.

This overview of California will identify species grown, areas of production, new technologies and the direction and growth of aquaculture in California.

The goal is to identify those areas of commonality so as to increase collaboration and to solve problems related to production and quality, while at the same time enhance and protect the environment.



A PowerPoint presentation will clearly show key elements of production methods, geographical areas of private aquaculture and species diversity.

CDFW Hatcheries: Fulfilling a Commitment

Cody Leonard

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Oral Presentation.

This presentation will provide an overview of CDFW hatchery operations and objectives for both anadromous and inland fish hatcheries. This presentation will detail 10 year average production numbers and pounds for both anadromous and inland salmonid species, and list broodstock and fish production programs. The location of each facility will be presented on a map with some history of CDFW hatcheries in CA. Some emphasis will be placed on conservation programs for listed species and the momentum toward more native salmonids for inland fishing, such as McCloud River Redband, Kern River Rainbow, Eagle Lake and Lahontan Cutthroat trout.

We will also describe the public service provided by the Kids Fishing Day at the Mount Shasta Fish Hatchery. This was a very popular event for the community and surrounding communities. Each even would host upwards of 1,000 kids and allow them to fish the settling ponds for trophy trout. Each registered participant is allowed to keep 2 fish each. Families plan their vacations around these events. Since discovering Whirling Disease in fish transported to the facility, the events had were subsequently shut down, and alternative sites hosted the Kids Fishing Day events. My presentation will be on the history of the events and the public relations. I will discuss the reaction of the public when the event was cancelled and the other options that were made available. Also, on the actions that we are taking to try to get the event back to the hatchery. I will talk about the testing of fish that has been done and a dredging project that is scheduled for the ponds; that will be done prior to opening the facility for Kids Fishing Day events.

We have placed fish in the ponds for a drafting study and those fish are also going to be tested for whirling disease to see if the ponds are infected in a hope to get a clear result and be able to proceed with the dredging out of the ponds and restocking of the fish. We are in the beginning stages of developing a new protocol for this event and the ponds; such as to plant whirling Disease resistant fish in these ponds such as Brown Trout and the Hofer strain of Rainbow Trout.