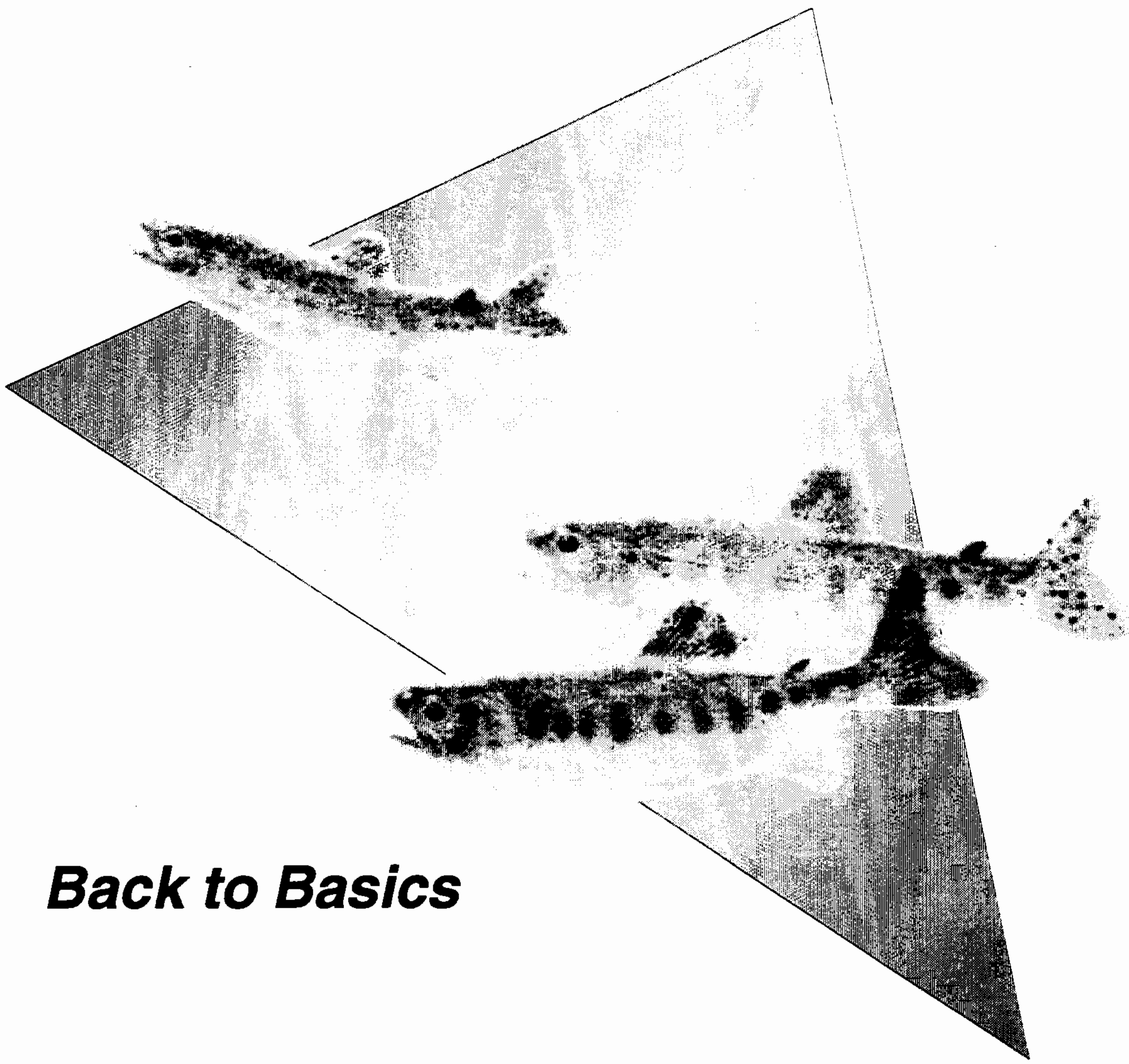
Proceedings of the
51st Annual Pacific Northwest Fish Culture Conference



Back to Basics

December 5-7, 2000
DoubleTree Hotel
Sacramento, California

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of the

Fifty-First

Northwest Fish

Culture Conference

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Judy Urrutia, Chair
California Department of Fish and Game

SPECIAL THANKS

To Christopher Dewees, who kindly donated the artwork used for the program logo and for the T-shirts.

To the feed companies BioOregon, EWOS, Nelson, Moore-Clark, and Rangen, for their continued support of the Northwest Fish Culture Conference through the hosting of the Social on Tuesday night.

To the Fisheries Foundation of California, for their generous donation in support of the meeting.

To all the Trade Show vendors (listed elsewhere), who have supported the NWFCC through the years. Your support is appreciated.

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DEDICATION

Memorial Tribute to Dr. G.W. "Bill" Klontz for 51st Annual Northwest Fish Culture Conference

The 51st Annual Northwest Fish Culture Conference is dedicated to the memory of Dr. G.W. "Bill" Klontz who died of complications from leukemia on March 22, just 2 days prior to his 71st birthday. Bill was internationally known for his contributions to aquaculture. He was well respected by his peers and his research and teaching in aquaculture and fish health improved the industry worldwide.

Bill was born March 24, 1929, in Tacoma, Washington. He grew up in the Tacoma area and attended area schools. He served in the Navy from 1948 to 1952, and re-enlisted in the Navy Reserve in 1954 and served until 1959. He married Martha Pryor in 1953. She survives him at the family home in Moscow, Idaho. He is also survived by two daughters and a son: Dani, of Kenosha, Wisconsin, Mary, of Moscow and, Bill, also of Moscow.

Bill earned a bachelor's degree in microbiology and a master's in immunology from the University of Washington in 1955 and 1959, respectively. He earned his doctor of veterinary medicine degree from Washington State University in 1963 and was a licensed veterinarian in the state of Washington.

He worked as a serologist for the U.S. Department of Interior Bureau of Commercial Fisheries in Seattle from 1955 to 1959. From 1961 to 1963, he was a serologist for the Department of Interior Bureau of Sport Fisheries and Wildlife in Seattle. For the next 6 years, he worked as a research immunopathologist for that Agency. In 1969, Bill took a position as an associate professor in the Department of Veterinary Microbiology at Texas A&M University, where he stayed until 1972. Bill left Texas A&M to become a professor of fishery resources at the University of Idaho in September 1972.

While at the University of Idaho, he served as Department Chair and served on the Faculty Council, the University Committee for General Education, the Experimental Animal Committee, and the Honorary Degrees Committee. Bill developed aquaculture and fish health programs at the University and wrote the text material for students to learn the concepts and techniques of fish culture and fish health management. He belonged to a variety of professional organizations including the American Fisheries Society, which awarded him the Snieszko Award in 1994 for his excellence in fish health research. He also belonged to the World Aquaculture Society, the American Institute of Fishery Research Biologists, the Aquaculture Association of South Africa, and the European Association of Fish Pathologists. At the time of his death, Bill was also a member of the Board of Directors of the U.S. Trout Farmers Association. He retired from the University of Idaho in 1994, but continued to work as a private consultant for Nelson & Sons, Inc., Sterling Silver Cup Fish Food in Murray, Utah.

One of Bill's greatest contributions to the industry was his masterful presentation of short courses. These workshops in fish health management and fish culture were taught in a number of states and foreign countries. The last workshop he taught was in the Arab middle east just a month before his death. His wife Martha – seafood chef and author of "To Cook a Trout" – joined Bill on many of these trips to teach cooking methods and techniques. Together, they had the industry covered from producing the animal to preparing it for human consumption!

After Bill's death, the University of Idaho received an astounding number of phone calls, cards, and emails from former students and colleagues. Among these communications are two that seem to sum up how we will always remember Bill:

"Bill had a great influence on hundreds of fisheries professionals around the world. He inspired faculty and students alike with fish health and culture. He was a real down to earth guy who always would stop to talk with the lowliest graduate students."

"There are only a few individuals who are truly unique, who are irreplaceable. Bill was such a person, a person who contributed more than he took from life, a person who made the world a better, warmer place for those of us who remain. We will treasure our memories of him and try to carry on the example he set as a scientist, a friend, and a unique and wonderful human being."

SESSION 1

PATHOLOGY/DISEASE/NUTRITION

Warm Springs Hatchery Spawning Methods and Fish Treatment Techniques as a Preventive Maintenance Tool for Controlling Bacterial Cold Water Disease in Steelhead Rainbow Trout

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At Warm Springs Hatchery, located on Dry Creek, a tributary to the Russian River, in the California Department of Fish and Game's Central Coast Region, we have methods and techniques we use as preventive maintenance tools to reduce mortalities in steelhead rainbow trout, due to bacterial cold water disease. These methods and techniques consist of an iodophor procedure during the spawning process and the timing of our fish treatments before and after the disease is detected.

One to three females are air spawned into a perforated colander lined with cheese cloth to drain off the ovarian fluid, which contains bacteria. The eggs are then rinsed in a 0.9% salt solution for 30 seconds to remove any remaining ovarian fluid or other matter that might interfere with fertilization. At this point, we transfer the eggs from the colander to a spawning pan and introduce the sperm from the males; the eggs now fertilize for 3 minutes. The eggs are transferred back to a colander and rinsed for 30 seconds in a new tub of 0.9% salt solution to remove sperm and other materials. The eggs are then rinsed in 100 ppm iodophor solution for 1 minute and finish disinfecting in the iodophor solution for 30 minutes. The rinsing of the eggs in either of the solutions is nothing more than moving the colander in an up and down motion. This allows the solution to make contact with all the eggs, preventing them from sticking to each other during this stage before water hardening. After the 30 minutes in the iodophor, the eggs are water hardened in fresh water.

Our Department pathologists have found that steelhead are most susceptible to bacterial cold water disease from swim-up to about 60/lb. We treat our fish in the hatchery building as soon as possible after swim-up and then again when the fish are about 300/lb, just before the fish are put out in the raceways. The treatment we use is a Penicillin G Potassium USP bath at 150 IU for 8 hours. In between these two treatments, if the fish do contact the disease, the same treatment will be used for 3 days in succession. The difficult part in using this treatment is finding a convenient way to re-circulate the water for the 8-hour bath without depleting the amount of dissolved oxygen. Through trial and error we have found a way that works well for us.

We started with 1/3 hp TEEL pump mounted to a custom bracket which was then mounted behind the last screen in our 18 ft by 3 ft deep tanks. A 2-inch PVC pipe was used for the intake and, for outflow, a garden hose was used, which ran overhead to the packed column. The packed column is filled with media to displace gasses and also aerate the water. We received our electricity from the nearest 110 outlet, and found that if we treated more than two deep tanks we would blow the circuit breaker; also, stretching a garden hose was very inconvenient.

To fix our electrical problem, we individually wired each deep tank coming off the power to our Nielsen automatic fish feeders, where we installed two outlets. This eliminated our circuit breaker problem, gave us an ideal place to plug in our pumps, and eliminated our need for extension cords.

To fix our problem with the water supply line to the packed column we decided to hardline 1-inch PVC pipe underneath the deep tanks and up to the top of the packed column. We also put quick disconnects on a 4-ft piece of flex hose, which ran from the discharge outlet on the pump to the beginning of the 1-inch PVC supply line, underneath the deep tanks. This way the supply line is permanent, out of the way, and not an eyesore. It also allows us to set up for treatment in a matter of minutes.

The wild stock of steelhead rainbow trout in the Russian River drainage are listed as threatened under the Endangered Species Act. To protect the wild stock, we do not release excess hatchery stock into the drainage. Therefore, it is important for us to keep our mortalities to a minimum and hatch only enough eggs to meet our mitigation goals. These treatments and techniques have helped tremendously in controlling bacterial cold water disease.

After implementing these fish treatments and spawning techniques, our mortalities due to bacterial cold water disease have dropped by 50%. We do not know whether it is one of these procedures that is helping us the most or a combination of the two.

Things to Consider Before Implementing These Procedures

1. The number of fish to be spawned. The iodophor procedure is time consuming. The most we will spawn in one session is 25 to 30 fish. If you are spawning large numbers of fish, perhaps additional modifications would have to be made.

2. Penicillin G Potassium USG is expensive, $32 for 241 grams. We use 160 grams per treatment.

3. The type of additional aeration you will need during the bath treatment.

4. Water temperature during the bath treatment.

5. The amount of water to be re-circulated, to maintain proper oxygen levels, will determine the size of the pump.

6. The availability of an electrical source.

Acknowledgment

Research of the iodophor spawning procedure and penicillin bath treatment were conducted by Dr. Bill Cox, Senior Fish Pathologist, California Department of Fish and Game Fish Health Lab, Sacramento. I would like to thank Dr. Cox for helping the staff at Warm Springs Hatchery implement this procedure at our facility.

Attachment 1.

Iodophor Procedure

1. Spawn eggs into colander and separate from ovarian fluid. This removes ovarian fluids which often contain high levels of bacteria. These bacteria potentially could infect eggs during the fertilization and water hardening process. Also removed are proteins, blood cells, organics, etc., all of which can interfere with the fertilization process by blocking the micropyle. These substances can also combine with iodophor, effectively reducing the concentration during treatment.

2. Rinse eggs once with 0.9% saline (30 to 60 seconds). This rinse further removes products listed above, which are loosely bound on the egg surface.

3. Add sperm and fertilize for 5 minutes. Fertilization times vary at different facilities (1 to 10 minutes). Wet or dry spawning is okay.

4. Rinse once in 0.9% saline to remove excess sperm and other materials (30 to 60 seconds). Remove sperm and other organic products from the male (feces, mucus) so they don't use up iodophor during the disinfection process.

5. Rinse once in 100 ppm iodophor solution (1 minute). During a brief iodophor exposure, iodine will rapidly combine with the remaining organics, resulting in a rapid decline of iodine in this rinse solution. Use just enough iodophor solution to cover eggs. This solution is discarded.

6. Disinfect eggs for 30 minutes. Iodophor should retain near full activity due to pre-treatment in Step 5. Iodophor treatment should be done during the first stage of water hardening so that iodophor is drawn into the perivitelline space of the egg. The ratio of eggs to iodophor solution should be a minimum of 4:1. Recirculation of iodophor solution during the disinfection process is necessary to evenly distribute active iodine.

7. Rinse iodophor from eggs using clean or sterilized hatchery water (30 to 60 seconds). Eggs will continue to water harden for 90 minutes, so bacteria could be drawn into the perivitelline space of the egg at this time if contaminated water is used.

8. Finish water hardening in clean water or sterile hatchery water. Make sure water has adequate oxygen, pH, etc.

Control of Copepods Using Brook Trout Biofilter

Authors: Tresa Veek - Presenter, Fish Health Laboratory, 2111 Nimbus Rd., Rancho Cordova CA 95670, 916-358-2822 (W), tveek@dfg.ca.gov; John Modin, Fish Health Laboratory, 2111 Nimbus Rd., Rancho Cordova CA 95670, 916-358-2830 (W).

Abstract: In the early 1990's, a serious *Salmincola californiensis* (copepod) infestation developed in a large commercial rainbow trout, *Oncorhynchis mykiss*, farm near Merced, California. Mechanical and chemical measures to control the infestation were considered and rejected, and efforts to market copepod-resistant brook trout, *Salvelinus fontinalis*, reared as an alternative to rainbow trout, were unsuccessful. Laboratory trials demonstrated that brook trout held above rainbow trout, in experimental aquaria, effectively removed copepodid larvae from the water and substantially reduced infestation of the rainbow trout. Tests revealed an over 89% reduction in copepod infestation in rainbow trout held in water first passed over brook trout. These encouraging laboratory findings prompted a large-scale commercial hatchery application. A brook trout population was established in the incoming water supply and upper concrete production ponds of the hatchery, and all lower production ponds were depopulated for a 2-week period. Uninfested rainbow trout were then reintroduced into the hatchery production ponds. Monthly examinations of reintroduced rainbow trout by Fish Health pathologists and daily observations by commercial trout farm employees have not identified copepods in the facility, following 24 months of exposure to the copepod infested waters of the lower Merced River. These studies demonstrate one practical method for successfully rearing rainbow trout in copepod infested waters.

Importance of Thermal Refugia for Juvenile Chinook Health in the Klamath River

Authors: Rick Harmon, J. Scott Foott, Greg Bates, Ken Nichols, Jimmy Faukner, and Beth McCasland, US Fish & Wildlife Service, California - Nevada Fish Health Center, 24411 Coleman Hatchery Rd, Anderson CA 96007. Mr. Bates is with the Yurok Tribe Fisheries in Eureka California.

Abstract: Replicate groups of juvenile Iron Gate Hatchery Chinook were held in live boxes for 4 to12 days in either the mainstem Klamath River or within 2 thermal refugia (mouths of Cappel and Pecwan creeks). Control groups were held in Cappel Creek water. Mean water temperatures for the mainstem exposures ranged from 19 – 23 °C and were generally 4 °C higher than the thermal refugia. Mainstem exposure groups incurred significantly higher mortality than the thermal refugia cohorts. Mortality began at 4 days post-exposure and was associated with symptomatic *Flavobacterium columnare* infections. Gill Na-K-ATPase activities of mainstem fish tended to be lower than thermal refugia groups. Hemodilution, as indicated by low plasma osmolarity and hematocrits, was associated with stressed fish. Immune defense indicators, such as plasma globulin profile, leukocrit, and kidney phagocyte abundance, were influenced by exposure temperature and duration. Results from this initial study point out the health benefits for juvenile salmonids residing in thermal refugia along the Klamath River during the spring and summer months.

Release of IHNV Infected Chinook Smolts from Coleman NFH:
Risk Assessment of the Disease Impacts on Natural Chinook

Authors: J. Scott Foott, Rick Harmon, Ken Nichols, Dan Free **, and Kim True.
California - Nevada Fish Health Center, U.S. Fish & Wildlife Service

There is a on-going public debate on the merits of fish hatcheries and their effects on natural fish populations. The transmission of fish pathogens from hatchery to wild fish is one element of this debate. Coleman National Fish Hatchery (CNFH) has had a long history of disease in its juvenile chinook due to Infectious Hematopoietic Necrosis Virus (IHNV) dating back to the 1940's. Epizootics are common in the fall-run chinook (FCS) production with yearly losses in the hundreds of thousands. Even greater numbers of infected juveniles are released into the Sacramento River due to these IHNV outbreaks. For the last 7 years, concerns about these releases on natural chinook has prompted the CA - NV Fish Health Center to conduct studies on many aspects of IHNV, including distribution of infected fish in released CNFH smolts and natural FCS juveniles, virulence, and infectivity of the Sacramento River strain of IHNV, and factors which influence disease progression.

Infected hatchery smolts have been captured 183 rm down-river with the incidence of infection ranging from 9 to12 % over a 2- week period following release. Viral infection has not been detected in natural chinook juveniles ($\geq$ 500 fish over 4 years), but is commonly isolated in both wild and hatchery adults in the system. Moribund juveniles, showing clinical signs, shed approximately 10^3 PFU/mL and their mucus can contain up to10^6 PFU / mL. The high concentration of virus in mucus suggest that nipping behavior could be a mode of transmission. The Sacramento River strain of IHNV appears to be of low virulence. Brief 1-min. exposures to low concentrations of virus ($\leq 10^2$ PFU/mL) can infect chinook but rarely leads to a disease state unless the fish are under chronic stress.

Uninfected, natural chinook juveniles were co-habitated with different ratios of infected hatchery chinook (1:1, 1:10, 1:20) for either 5 minutes or 24 hours in a flow-through circular tank. Gill, liver, and kidney tissue from the natural fish were assayed for virus at 4 - 6 days post-exposure. No virus was detected in natural fish from any exposure group. Pilot studies with hatchery chinook showed that virus could be detected at 4 days following a 5 minute exposure to 10^3 PFU / mL of IHNV. The data indicates a low ecological risk to natural stocks from the release of IHNV infected hatchery chinook smolts.

** NMFS, Sacramento CA

Efficacy and Toxicity of Fumagillin & TNP-470, a Superanalog of Fumagillin, in Controlling Whirling Disease in Rainbow Trout.

Authors: Linda Staton-U.S Fish & Wildlife Service, Bozeman Fish Health Center, 920 Technology Blvd., Suite G, Bozeman, MT, 406-582-8656 (W), r6ffa_fhc@fws.gov, Charlie E. Smith-Presenter, Rangen Inc., 212 Story Hill Rd, Bozeman MT, 406-586-2856 (W), fishdoc1@mcn.net, and Dave Erdahl-U.S. Fish & Wildlife Service, Bozeman Fish Technology Center, 4050 Bridger Canyon Rd, Bozeman, MT, 405-587-9265 (W), Dave_Erdahl@fws.gov.

Abstract: Preliminary research investigations have indicated that the antibiotic fumagillin, a metabolite of the fungus, *Aspergillis fumigatus,* may provide a mechanism to reduce the presence and overall infectivity of *Myxobolus cerebralis* (Mc), the causative agent of whirling disease. TNP-470 was developed as a superanalog of fumagillin and is reported to have higher bioreactivity and lower toxicity than fumagillin when used at the same dosage. The purpose of this study was to determine the efficacy of fumagillin and TNP-470 in preventing/controlling experimentally induced whirling disease in rainbow trout by reducing the number of viable Mc spores. Also, to determine the safety of TNP-470 under controlled experimental conditions. Fingerling rainbow trout (about 2 g each) were fed fumagillin top-coated feed at concentrations of 3.75 and 7.5 mg/kg body weight (bw), or fumagillin or TPN-470 at 7.5 mg/kg bw incorporated into feed for 10 or 26 days post exposure to the Triactinomyxon (TAM) infective parasite stage of Mc. Fish fed fumagillin and TPN-470 incorporated into feed showed a significant reduction in Mc spore counts. There was no significant difference in spore counts between controls and fish fed feed top-dress with fumagillin. Limited examination of spores by electron microscopy demonstrated deformed spores. Fish fed TNP-470 for 26 days had a significantly higher mortality than controls and those fed fumagillin and TNP-470 for 10 days. Feeding TNP-470 for 26 days resulted in anemia. Hematocrits of fish sampled 30 days post exposure were 24.4% and 41.3% for treated and controls, respectively. The anemia that developed was classified as an aplastic anemia due to the severe destruction of lymphomyeloid tissue in hematopoietic tissue of the kidney and thymus, as well as the lack of immature erythrocyte and high percentage of degenerate erythrocytes observed in blood smears. Feeding fumagillin and TNP-470 reduces, but does not eliminate infection with Mc spores. Feeding TNP-470 for 26 days resulted in toxicity and mortality.

A Comparison of Bioproducts and Moore-Clark Starter Feeds

Author: Stephan D. Brightwell, Fish and Wildlife Technician (Range B), Feather River Hatchery, 5 Table Mountain Blvd., Oroville CA 95965, 530 538-2222(W), featrivr@dfg.ca.gov.

The study was designed to compare a #2 and #3 Bioflake (Bioproducts) food regimen with Mixed-flake Bioflake (Bioproducts), Biostarter (Bioproducts), and Nutra-plus starter (Moore-Clark).

Four 4 ft x 16 ft deep troughs (18 inches deep) were each stocked with 50,000 chinook salmon swim-up fry, taken from the same lot, to insure a consistent starting size. All four troughs were given a measured 10 gpm flow from a common line.

Dissolved oxygen and temperature were monitored daily, pH and ammonia weekly. No significant variance of these factors was noted at any time during the study.

All troughs were cleaned once daily, in the morning.

Any and all adjustments made to one trough were duplicated in all four (e.g., on 1-25-99, flow was increased to 20 gpm in all four troughs).

Study group 1 was fed #2 Bioflake until they reached 908/lb (9 days), then switched to #3 Bioflake until they reached 375/lb.

Study group 2 was fed #2 Bioflake until they reached 1000/lb (9 days), then switched to Mixed-flake Bioflake until they reached 375/lb. Note: Feed schedule for groups 1 and 2 was requested by Bioproducts for this study.

Study group 3 was fed #0 nutra-plus for 3 days, switched to #1 nutra-plus for 5 days (920/lb), switched to #2 nutra-plus at 5 weeks (592/lb), when they were switched to #3 nutra-plus. At the 9th week, many (300-500) stunted, non-eating fish were noticed, and the group was returned to #2 nutra-plus. At Week 12 (140/lb), they were again given #3 nutra-plus. At Week 15 (68/lb), they were switched to 1.5 mm Moore-Clark, on which they remained for the duration of the study.

Study group 4 was fed #3 Bio-starter for 9 days (970/lb), then switched to 1.0 mm Biodiet. They remained on 1.0 mm until Week 11(225/lb), at which time they were switched to 1.5 mm Biodiet, which they were fed for the remainder of the study.

The growth was fastest with the Nutra-plus throughout the study, with Bio-starter showing the next fastest growth. When the fish being fed Bio-starter were switched to 1.0 mm Biodiet, their growth rate slowed slightly and they were overtaken in about 2 ½ weeks by the fish eating Mixed-flake, although they remained within 96% of the size of these fish. The fish fed #2/#3 Bioflake showed the slowest growth throughout the study.

At 9 weeks, when both of the groups being fed Bioflake exceded 375/lb, the fish fed #2/#3 Bioflake were the smallest at 349/lb. The fish fed Bio-starter/Biodiet were next in size at 304/lb (10% larger). The next largest group was the fish fed Mixed-flake at 300/lb (1.3% larger than Bio-starter/Biodiet, 11.7% larger than #2/#3 Bioflake). The largest fish were the group fed Nutra-plus at 252/lb (25.9% larger than #2/#3 Bioflake, 17.1% larger than Bio-starter/Biodiet, and 16% larger than Mixed-flake).

We continued to compare growth between Biodiet and Nutra-plus as the fish grew to larger sizes. During Week 16, we ended the study with the fish fed Biodiet at 85/lb and the fish fed Nutra-plus 32.4% larger at 57.5/lb.

The only fish health problem encountered was the stunting (pinheads), which was corrected by returning to a smaller size food. It would seem that strict adherence to the manufacturer's size recommendation is important with this food, at least in sizes larger than #2.

Additionally, it was noted the feeding response was noticeably more aggressive with Nutra-plus from the beginning all the way through the study. It was also noticed that the Bioflake, both #2/#3 and Mixed-flake produced, more waste than the other feeds; however, it seemed easier and faster to clean.

Clean Raceways and Salt for Healthy Trout at Black Rock Hatchery

Authors: James Booth and Pat Brock

Abstract: Here at Black Rock we believe clean raceway's accompanied with weekly salt flushes keep stress and loss of our fish down . The process of cleaning and salting starts 2 weeks after the fish (fry) are set out in the deep tanks . The side walls and screens of the tank are cleaned thoroughly with a scrub brush. Cleaning should be done daily, while salting is weekly . Salt helps clean out the fishes gills , removes excess slime as well as restores electrolytes, which is crucial to have healthy fish. The salt is applied in small amounts, (about three pounds a week per deep tank) . The amount of salt is increased gradually. The purpose of gradually raising the salt level is to adjust the fish to the level of salt in the raceways.

Cleaning the raceways requires more labor and time . It starts with the cleaning of the head box and dam boards . This is done by scraping off algae that might have grown on the inside wall of the head box and dam boards . To clean this area , we use a straight edge scraper . This procedure helps to keep the screens at the top of the raceways clean . By doing this you have smoother water flow. Next, you will want to scrape the bottom and sidewalls of the raceways to push dirt, algae, and feces downstream . To do this, we use stainless steel scrapers and brushes . This process takes about 1 hour per 100 ft . The time span and distance is to ensure adequate water flow and oxygen to the fish . This also lessens the stress of the fish. It is extremely important to pay close attention to the screens and /or aerators when cleaning to be sure they **do not** become clogged with debris that is being cleaned . Once the raceways are cleaned, we add 500 lb. of salt at the head of each raceway and let it flow though. Again, we believe this helps reduce stress, clean out gills, removes excess slime, and restore electrolytes to the fish . Both steps of the processes give them a nice, healthy, debris-, and stress-free environment in which to develop. We believe that doing these processes weekly ensures the best success rate from eggs to release. Black Rock Hatchery is considered to be the most disease free installation within the State.

SESSION 2

HATCHERY PRACTICES

Validation of Existing Screen Criteria for Juvenile Bull Trout (*Salvelinus confluentus*)

Author: Gayle Barbin Zydlewski, Fisheries Biologist/ Behavioral Physiologist, U.S. Fish & Wildlife Service / Abernathy Fish Technology Center, 1440 Abernathy Creek Road; Longview, WA 98632, 360-575-1226 (W), 360-636-1855 (F), gayle_zydlewski@fws.gov, and Jeffrey R. Johnson, Smith-Root, Inc.

Abstract: Bull trout are currently listed as threatened in the Western United States. Entrainment at water diversion structures has been identified as one cause for the decline in bull trout populations in the West. The objective of this study was to evaluate whether existing screen criteria, based on tests using chinook, sockeye, and chum fry, are adequate in preventing juvenile bull trout fry from being impinged or entrained by screened water intakes at diversion structures in the Pacific Northwest. Bull trout were tested in a specially designed artificial stream. Test screens were those currently approved by NMFS and WDF&W: Perforated Plate (PP): opening not exceeding 0.24 cm (3/32 in.); Profile Bar (PB): narrowest dimension not exceeding 0.18 cm (0.069 in); and Woven Wire (WW): opening not exceeding 0.24 cm (3/32 in.). As a control, one experiment was conducted with no screen. Emergent bull trout, 24.0 mm TL, were tested in groups of 25 at 6°C. Only one bull trout was entrained during all experiments. Bull trout were regularly impinged on the screens but in most cases were able to escape impingement and survive for at least 24 hours. Therefore, at low temperatures and small sizes, bull trout exposed to the currently accepted screens are unlikely to be entrained or mortally damaged when impinged. This implies that currently specified screen regulations for salmonids do not need to be modified for bull trout fry. The potential bull trout population loss to entrainment at water diversion structures is adequately managed with the currently imposed screen criteria for juvenile salmonids.

Movable Fish Barrier at the Cedar Creek Fish Hatchery

Author: Charles W. (Bill) Cutting, HARZA Engineering Company, 2353 130th Avenue, N.E., Bellevue, WA, 425-602-4000(W), 425-602-4020 (F), ccutting@harza.com.

Abstract: In order to prevent hatchery origin salmon and steelhead trout from migrating above the Cedar Creek Hatchery site, the Oregon Department of Fish and Wildlife has maintained a fish barrier weir on Three Rivers since at least 1970. Previous barrier weirs included a fixed rack and two types of electric barriers. In 1998, the State hired an engineering consultant to design a replacement barrier weir. Several weir concepts were investigated and evaluated before the bottom-hinged, movable weir was selected for construction. Construction documents were prepared in the spring of 1998 and the weir was constructed later that year. The new barrier consists of a series of four rack panels that are independently raised to stop fish migration beyond the weir and lowered to clear debris or to allow fish migration. A hydraulic system independently raises and lowers each rack panel, avoiding the need for hatchery staff to enter the water to clear debris from the panels. The hydraulic system includes a "fail safe" setting that automatically lowers the weir when excessive debris accumulates on it.

THE CEDAR CREEK HATCHERY BARRIER

The Cedar Creek Hatchery is located on the Oregon Coast midway between Tillamook and Newport. It was initially constructed to raise trout and salmon for both sport and commercial harvest. Three Rivers is one of the premier steelhead fishing rivers in Oregon and the Hatchery contributes a significant portion of these fish. As part of the operation of the Hatchery, they "recycle" adult fish that are in excess of the Hatchery's needs back to the mouth of the river to give the fishermen a second opportunity to harvest them. The barrier weir across Three River and the adjacent adult fish facility contribute significantly to this activity by blocking these fish from migrating past the Hatchery and by providing a holding pond for collecting and sorting the returning fish.

Beginning in the 60's a number of different types of permanent weirs have been constructed across Three Rivers. The initial weir was a 2 by 4 rack type structure constructed on a concrete sill across the river. In the late 70's this weir was rebuilt into an electric barrier using the hanging probe design. This eliminated the need for hatchery personnel to manually clear debris from the rack to keep it from washing out, but created a potential safely problem and also fish health concerns as a result of the exposure to the electric current. In the early 80's, the hanging probe weir was converted to a Pulsed DC Barrier in one of the first applications of this design.

In the winter of 1996, a series of large floods occurred at the Cedar Creek Hatchery and the Pulsed DC Barrier was severely damaged. A large tree punched a hole in the wooden deck revealing significant deterioration to the supporting structure. Several of the electrodes were torn from the deck and the barrier was rendered inoperable.

A consultant was hired by the Oregon Department of Fish and Wildlife to plan and design a replacement fish barrier for Three Rivers. As part of the project the consultant was also to prepare a conceptual design for a new adult fish facility and pump intake to replace the existing facilities which were functionally obsolete and subject to flooding. The Department wanted a barrier that would effectively block the passage of returning adults under most river conditions, while requiring minimal maintenance and not damaging the returning fish. The Department's previous experience with a rack type barrier as well as two types of electrical barriers eliminated most of the conventional choices. A velocity barrier was not an option due to flooding of upstream property as well as low riverbanks and a broad floodplain. Conceptually, what the Department wanted was a barrier that could be put in place to block the fish, removed to allow debris to pass and didn't require anyone to get wet either installing or removing the barrier.

The consultant had developed a conceptual design for a finger weir in Alaska that used a low sheet pile dam with a pivoting finger weir mounted at the top of the sheetpiles. A lever and counterweight mechanism was intended to hold the fingers in the up position until ice or debris built up on the weir and forced fingers down, lifting the weight. Once the ice and debris cleared the fingers, the weight would return the weir to the fish blocking position. This design had never been constructed, but we were able to find some sketches in the files and used these as bait to help win the job.

One of the eastern Washington public utility districts had constructed a barrier weir that was hinged at one end and mounted on a concrete apron that spanned the river. This design used polyethylene racks to prevent icing in the winter and had hydraulic cylinders in the river to raise the rack. The utility district had experienced several problems with making the rack fish tight, primarily due to the flexibility of the polyethylene material. Additionally, the site in eastern Washington was on a much smaller river.

I had been involved in the planning of another fish barrier project for the US Fish and Wildlife Service in Idaho, where a hanging probe electric barrier had been converted to a floating weir to eliminate a safety concern at a site with lots of people around the barrier. The floating weir turned out to have bar spacing that was ideal for catching rocks moving down the creek and over the course of the winter, the rack accumulated enough rocks to overcome the buoyant force of the reaction board. For this project, we investigated a velocity barrier and eventually concluded that the flood issues were too difficult to overcome. We eventually settled on a weir using rack panels hinged off an overhead bridge. This stream was considerably narrower than Three Rivers and the watershed didn't have nearly as much potential to send large trees and debris downstream.

We eventually concluded that the most viable concept was a bottom-hinged rack with a hydraulic actuator located on the bank of the river. Putting the hydraulics on the bank would minimize the likelihood of damage to the hydraulic cylinders, keep the hydraulic oil away from the river and, in theory, make the whole thing easier to maintain. By putting a pressure relief valve in the hydraulic circuit, we could open the valve when enough leaves, trees, or other debris accumulated on the back of the weir to risk damaging the panels. As with the finger weir in Alaska, we wanted to use a pipe as a shaft to rotate the weir up and down and then use a level to convert the linear hydraulic cylinder motion into a rotary motion to raise the rack panels.

The old barrier at the hatchery was about 75 ft wide and we didn't want to change the hydrology of the river, so we decided to generally match the elevation and width of the original electric barrier. This barrier had been angled across the river to guide the fish toward the fish ladder and adult holding ponds. Doing this with the new barrier didn't appear feasible because it would result in gaps at the abutments when the weir rotated up into position. Additionally, the bars on the panels wouldn't align with the flow of the river and we were concerned that they wouldn't shed debris as easily as if they were parallel to the flow. The biologists agreed that the fish would find their way to the fish ladder without being led across the river and we had a concept that everyone was happy with. The biologists also told us that the openings in the rack couldn't be wider than 1 - inch to prevent the steelhead from sticking their heads through the openings and getting stuck. With openings this small, it became obvious that we couldn't use pipe fingers to form the barrier. The pipes would occupy too much of the flow area and this would result in an increased water surface and flooding upstream during high flow conditions. We decided to use 3/8 inch by 1-inch aluminum bars on their edges for the rack. This would provide a 75% open area for water small debris to pass the barrier.

The hatchery manager had experienced many floods on Three Rivers and because we were going to retain the same general cross section at the new barrier, we were able to rely on his recollection of typical high water elevations. During most high water events the migrating fish will seek out low velocity areas in the river and take refuge until the water level drops. Because of this we didn't need to design the barrier to stop fish during an extreme flood event. We decided that a typical high flow event was about 5 ft of water depth across the channel. At this flow depth the electric barrier had been ineffective and the water was usually too dirty to see if any fish were getting by anyway.

After running some preliminary calculations on the forces generated by 5 feet of water passing though a bar rack and then factoring in what would happen when leaves started to accumulate on the rack, we rapidly came to the conclusion that we needed to divide the barrier into sections. The end result of this was the decision to go with four 20-ft sections, each with its own shaft and hydraulic cylinder to operate it. By using pipes for the shafts and nesting one pipe inside the next we developed the final concept for the movable barrier.

We wanted to be sure that we designed the barrier so that it was unlikely to be totally destroyed by a single large tree hitting it during a large flood. In order to do this, we designed the mechanism to become stronger as the forces were transferred from the rack panels, to the arms, to the shaft, to the lever arm and finally to the hydraulic cylinder. The idea was to set the hydraulics so the barrier panel would stay up as leaves accumulated on the panels, but at the same time we wanted the hydraulics to give way if a log hit the panel. We designed the racks in sections, three per weir section. Each rack section is attached to a support frame that fit into a socket welded to the pipe shaft. The support frames bolt together to increase their rigidity, yet they were intended to be light enough to allow them to be removed manually if they got damaged.

Because the shafts are located below the river level, they are constantly submerged. This meant that the lever arms and hydraulics had to be mounted in a pit behind the abutment on each bank. We wanted the pits to remain dry so we developed a shaft seal system similar to a mechanical seal on a pump or gearbox. The shafts only rotate about 50 degrees and the speed is slow so we invented our own design using Teflon impregnated packing and a follower ring to squeeze the packing against a stop welded to the shaft. This seal was used at two places on each side of the river. One seals the annular space between the two nesting shafts and the second seals the shaft penetration into the hydraulic cylinder pit. Where the shafts enter the hydraulic cylinder pit we used a steel plate to form a portion of the pit wall. The steel plate forms the top half of the seal and can be unbolted and removed to allow the entire shaft assembly to be removed for maintenance or repair. We also had to design a bearing to support the shaft across the sill. The bearings consist of steel weldments with a replaceable Teflon bearing material. As with the seals, the shaft rotates slowly so a precision machining job was not needed.

We wrote a performance specification for the hydraulic system that described the required operation of the overall system and left the details of the equipment selection and design up to the supplier. The specification outlined the basic requirements for the hydraulic power pack, the hydraulic cylinder capacity and the operating pressure. It required that the system be capable of raising or lowering each rack panel in no more than 30 seconds and described a pendant mounted control station to allow the operators to walk around and view the racks as they moved. The system uses a counterbalance valve to hold the rack panels in the raised position and automatically lower them when the force on the cylinder exceeds a preset value. The counterbalance valves are capable of either lowering the panels fully or lowering them until the force on the cylinder is below the set point. An alarm function is also built into the system to alert the hatchery staff when an event occurs that lowers one of the panels. For safety reasons, it was decided that automatic operation of the system to lower and raise the panels would not be allowed. While it would be desirable to lower and raise the panels periodically to clear leaves and other debris, there is a high risk of damaging the panels if they automatically rise with a log or large debris between two of the panels. Also if a rafter or kayaker caused the panel to lower and became trapper on the weir, they could be injured as the panels automatically raised.

BIDDING AND CONSTRUCTION

Construction bids were solicited in May 1998 and a contract awarded in early June. Although the contractor encountered a number of problems and was several months late in completing the project, it has operated successfully to date. The operational problems that have occurred have been primarily due to poor construction quality. There were numerous "fit and finish" problems and often the contractor's attempt to fix one problem created two or three new ones. Ultimately the State just wanted him off the site and left several items incomplete rather than put up with the collateral damages that occurred as he tried to fix things.

One major problem was that the contractor did not align the hydraulic cylinders so they were square to the shaft. This caused the shafts and rack panels to move longitudinally relative to each other and eventually bind up. The problem was solved by trimming one of the panels and by readjusting the shaft guides that were intended to keep the shafts from moving relative to each other.

Operationally, the hydraulic system was deliberately set to lower the rack panels at a very low force initially. This resulted in rack panels lowering themselves automatically on a frequent basis. The hatchery staff was instructed on how to set the hydraulic system to increase the force required to lower the panel and, over time, they increased the set point to prevent the barrier from lowering unnecessarily. The objective is to allow some debris to accumulate without lowering the panel, while being sure that a log or tree impact will cause the barrier to lower without damaging the rack panels.

A final problem relates to the bar spacing selected to keep the fish from gilling themselves in the rack panels. The spacing retained gravel moving down the river during high flow events. There probably isn't a solution to this problem,;however, it should be accounted for in the design because the gravel will add to the weight of the panels and to the hydraulic forces that act on the panels as the water flows through them. The conservative design of the hydraulic system allowed it to be adjusted to accommodate the extra loads and the hatchery staff will have to manually remove the gravel on an annual basis.

The Success of Fish Egg Hatching Jars at Hot Creek Hatchery

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Abstract: At Hot Creek Hatchery, we put about 18 million trout eggs through hatching jars every year. This paper will focus on a brief description of the history of Hot Creek Hatchery, egg take and fertility from four strains of broodstock maintained at the hatchery, discussion of four sizes of hatching jars used on seven strains of trout, for green and eyed eggs, and sac fry, cost savings from the use of hatchery jars compared to the use of incubation trays and chemical treatments, and design plans of the hatching jars to assist in their construction. A slide show will accompany the presentation of the paper.

Hot Creek Hatchery is located 38 miles north of Bishop, California at an elevation of 7,100 feet. The Hatchery, with 11 employees, is multifunctional, raising fingerlings, subcatchables, catchables, and broodstock. It provides 17 million trout eggs to the state-wide hatchery system.

Operating since 1931, the facility sits atop a volcanic cauldera. The water supplying the Hatchery comes from spring sources, and the temperatures from the geothermal aquifers are fairly constant, ranging from 52 to 60 degrees F. The combined water flow of the four major springs is approximately 16to 25 cfs, depending on the season and the snow content of the surrounding mountains. After the water leaves the Hatchery, it becomes the headwaters for Hot Creek, a well-known wild trout fishery.

The Hatchery maintains four different strains of rainbow trout broodstock. Our Coleman's spawn in the early winter; Kamloops, a wild stock spawner, in the spring. Hot Creek strain in the summer and Hot Creek Wyoming crosses in the beginning of fall. Hatching jars are now used for all the eggs taken, approximately 18million. The Hatchery also uses jars for the eggs that are imported into the Hatchery, specifically golden trout, brown trout, and Lahontan cutthroat trout. The average overall egg take fertilities from our 1999-2000 season as follows:

RTC 2 year & 3 year:	76%	RTH 2 year & 3 year:	52%
RTKJ 2-5 years:	80%	RTH X WY 2 year	58%

Our water supply for the hatchery buildings is captured by a small check dam, which gives us about 8 feet of head pressure. The constant flow of 53 degree F water with adequate pressure has made the use of hatching jars a cost effective and reliable method for egg incubation.

Upwelling incubators are commercially available in several different models or can easily be constructed from PVC or other materials. The majority of our hatching jars are made from PVC. They range in size from 6 inches wide by 18 inches tall to 12 inches wide by 2 feet tall. We use the largest ones the majority of the time for storing domestic broodstock spawns of green eggs, numbering ¼ million to 2 million eggs each spawning. They are easy and quick to fill, holding up to 750 ounces a jar. Our smallest jars, which hold up to 110 ounces, are functional for smaller lots of wild trout eggs.

HATCHING JAR SIZES AND MAXIMUM HOLDING CAPACITIES

	Width	Height	Capacities
Small	6"	18"	110 oz.
Clear	8"	20"	300 oz.
Medium	8"	22"	350 oz.
Large	12"	24"	750 oz.

All of our fish allotments are set out to hatch as eyed eggs in hatching jars. Upwelling incubators maintain adequate circulation by using the water flow to suspend the eggs. The jars work well in California troughs as well as fiberglass deep tanks. In deep tanks, we lower the water level and set out a maximum of 40,000 per trough. We turn the water flow up for sac fry, as compared to the slow moving flow we use for green eggs. One of the major benefits of jars as compared to incubation trays are the ease by which the dead eggs float to the surface, which can then be easily siphoned off. We have found a substantial savings by eliminating the formalin and iodine treatments that were used with incubation trays. And overall, we find a major decrease in the fungus (Saprolegnia parasitica) clumps or balls because the eggs are suspended in constant movement, which make it hard for fungus to grow from egg to egg.

The use of hatching jars has improved the cost effectiveness of our broodstock program. By the elimination of picking dead eggs out of Heath incubation trays and the costly use of fungicides and chemicals. Upwelling incubators are a better environment for eggs, which improves overall fertility. Jars hold as many eggs as incubation stacks but require less workspace and labor. The biggest benefit to hatching jars, once you become familiar with them, is the ease of use and the quality results they produce.

Acknowledgement: John Modin, fish pathologist for California's Department of Fish and Game, must be commended for his foresight in the implementation of hatching jars in the California State Hatchery System. His enthusiasm and constant design modifications lead the way for the success of this incubation method throughout the state hatchery system.

12″ PVC Tube Egg Jars

For 12-inch jars, we made a sleeve to seat the plates on a 12 inch 100 PSI-PIP PVC 1120 will slide tightly into a 12" Class 80 PVC with the use of PVC Glue. The sleeves on the smaller jars were made from the same size PVC as the jar, with a slot cut out.

There are two plates per jar; the top plate has 3/8-inch holes on ¾-inch centers. Under the top plate, we install a nylon mesh cloth (3/32 inch) held on with silicone to keep the eggs from falling through. This may not work if you have a lot of debris in your water supply. We bolt the plates together with a ¼ inch stainless slot head bolt with a wing nut. On the supply line we use a 1-inch threaded hose barb with clear soft plastic hose from a 2-inch PVC ball valve.

The PVC Plates are from:

Precision Plastics
827 Jefferson Ave.
Clovis, CA 93612
(209) 323-9595

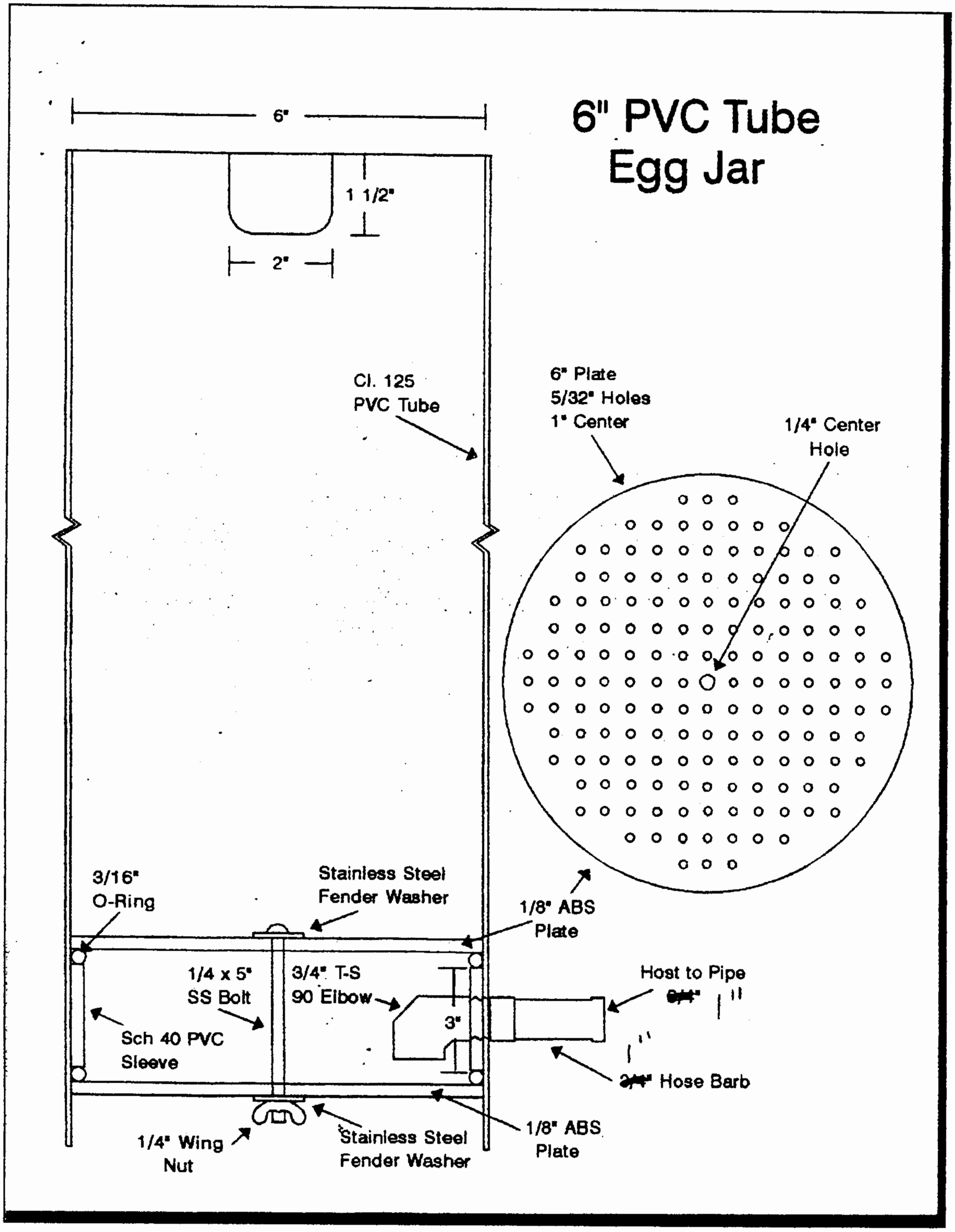
Commercially Available Upwelling Incubators:

Eagar, INC.

6-inch diameter by 18-inch height	$137.00
9-inch diameter by 18-inch height	$186.00
12-inch diameter by 26-inch height	$222.00

Eagar, Inc.
P.O. Box 540476
North Salt Lake, UT 84054
(800) 423-6249

6" PVC Tube Egg Jar



The Benefits of Hatching Jars When Raising Salmon, Steelhead, and Trout Eggs

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In California, as in many other states, it is becoming increasingly difficult to use chemicals in the treatment of salmon, steelhead ,and trout eggs during incubation. Most hatcheries in California currently use incubator stacks. Incubating eggs in stacks requires the use of chemical treatments to help prevent and treat the growth of fungus on the eggs. As environmental restrictions on chemical output tighten, hatcheries will need to focus on more environmentally friendly methods. Hatching jars are the answer to this problem.

Many different chemicals are currently being used to treat eggs while developing in incubators. Hatching jars reduce or eliminate the use of chemicals to treat fungus by keeping the eggs constantly moving in the water of the hatching jar. This movement helps greatly reduce the fungus from growing on the eggs, and more closely resembles the natural movement of the eggs when found in their natural habitat.

Eggs developing in hatching jars require a minimum amount of human contact as compared to eggs in incubator stacks. When eggs are left to develop in hatching jars, the flow of water in the hatching jar keeps the eggs constantly moving; the dead eggs float to the top of the jar and can be removed without touching the healthy, developing eggs. This saves employees the time of picking bad eggs out of each incubator tray in the incubator stacks.

A proper understanding of how hatching jars work is important when installing the jars in hatchery troughs. Hatching jars can be placed right into a trough, and the outflow of water from the jar to the trough will allow sac-fry to swim up out of the jar into the hatchery trough where they will continue to grow and develop. After hatching is complete, the remaining sac-fry can be dumped into the trough.

Future environmental restrictions may prove it necessary for hatcheries to raise eggs without the ability to treat them with any chemicals. Hatching jars allow the incubation of eggs without the use of chemicals, allow less contact with the eggs for picking, and can fit right into existing troughs.

Electro-Anesthesia at Iron Gate Hatchery

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Abstract: Introduction and video will explain why Iron Gate Hatchery switched from CO_2 to electro-anesthesia to subdue returning adult salmon and steelhead in preparation for spawning. How the system was designed, how it operates, and what it has meant for our operation and personnel will also be discussed.

The current trapping and spawning facilities below Iron Gate Dam on the Klamath River, were completed in February 1962. Iron Gate Hatchery traps and spawns chinook and coho salmon and steelhead. Our current mitigation goals are 6 million chinook (4,920,000 smolts and 1,080,000 yearlings), 75,000 yearling coho, and 200,000 yearling steelhead. Another current goal is for the Hatchery to count all fish attempting to enter the Hatchery's two fish ladders, which remain open to the fish at all times. No fish are to be returned to the River. Fish are spawned as needed to get eggs from all parts of the runs. Spawned and excess fish are given to food banks and various other charities.

In order to handle large numbers of fish and to make handling easier and safer for personnel, an alternative to CO_2 for subduing adult fish had been discussed for several years. As early as 1994, hatchery personnel started looking into the possibility of using electro-anesthesia instead of CO_2 as a means to subdue adult fish for sorting and spawning purposes. A new electro-anesthesia system was in use at Cole River Hatchery (ODF&W) on the Rogue River and was working well for them. Similar systems were also in use in Washington and Alaska. After investigating Cole River's system and talking with the manufacturer, Coffelt Manufacturing from Flagstaff, AZ (phone 520 774-8829), we felt such a system would make fish handling and sorting easier for our crew.

Pacific Power and Light Company (PP&L) pays for 80% of Iron Gate Hatchery's operation. We obtained $20,000 of capital improvement monies from PP&L in spring 1998 to install an electro-anesthesia system. Our staff worked closely with Coffelt employees during the design and installation of the new system. The original brail used for our CO_2 system was modified the first year. The controls and wiring were installed and hooked up by Coffelt employees, with our assistance. This system worked well, but not as well as we had hoped. We knew we could make the system work better than the initial installation, so in the spring and summer of 1999, we removed the large brail that had been modified and constructed a much smaller one. It was constructed mostly from fiberglass (angle, channel, flat stock ,and grating) with an aluminum framework attached to the top of the brail. A hydraulic ram was attached to the center of this aluminum frame for lifting and lowering the brail. Two stainless steel plates (anode and cathode) were mounted at opposite ends of the brail that are wired to the electrical control box. This smaller brail also required other modifications inside the spawning building. We are currently using this modified system and it is working very well for us.

The system is activated by a foot switch on the floor where the fish sorter operates. A safety switch is incorporated into the system that disconnects the electrical power when the brail is lifted. The unit has controls for voltage output, wave form, and shock time. There are many variables that determine what settings to use for fish sorting or spawning. These variables are conductivity of the water used (salt may be added if conductivity is low), number of fish in the brail, species of the fish, and whether the fish being sorted are spawned and/or saved. We use various settings depending on what type of fish handling mode we are in. The maximum length of shock time for our system is about 30 seconds for one brail of fish.

With our old CO_2 system, fish used to thrash around for a considerable length of time before they were subdued enough for handling. This thrashing by the fish also concerned by visiting public. With the new electro-anesthesia system there is virtually no thrashing when the fish are shocked. Our crew has been able to handle larger numbers of fish with less strain on the personnel doing the sorting and spawning.

Our adult chinook salmon run for this year is more than 71,000, a record at Iron Gate Hatchery. We could not have efficiently handled and counted this volume of fish had it not been for the electro-anesthesia system.

An electro-anesthesia system may or may not work well at any given facility. If the facility handles a large number of salmon, it is definitely worth looking into the feasibility of installing an electro-anesthesia system.

Spawning Procedures at Feather River Hatchery

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The Feather River Hatchery is located 70 miles north of Sacramento in Oroville. It is considered one of largest salmon and steelhead hatcheries in the State. The following presentation will explain the spawning procedures at this installation.

Salmon enter and proceed up the ladder to the main gathering tank, at which time they are crowded into the CO_2-injected anesthetizing tank. Once they are subdued, they are sorted according to their sex and stage of ripeness. If not ready to spawn, they are counted into one of our four holding tanks. These holding tanks are approximately 40 ft in diameter with a water depth of 4 ft and will hold approximately 1,500 fish.. If ready to be spawned, both male and female are killed using an air knife to sever the spinal cord and the main artery. Both males and females are hosed off to prevent blood accumulation.

The individual taking eggs places three males and three females per tub and checks for marked fish.

Marked fish lack an adipose fin and have a coded wire tag implanted in their snout . Fish are measured in length, by sex, and date of capture. Their heads are removed and bagged . All information is recorded .

Quality fish are distributed to charitable organizations, others are sent to a rendering plant..

After the eggs have been taken, two tubs of three fish each are combined to uphold genetic diversity. A 6 oz. sample is then taken from every combined tub of six fish to determine egg size and percent of increase from flaccid stage to water hardened stage; 100 oz. is then measured in their flaccid state into each incubator tray which contains 6 oz. of PVP iodine, which is used for disinfection.

Eggs that remain in each of the tubs are then measured and recorded when flaccid. The eggs are again measured after water hardening, this also helps in determining the percentage of growth of the egg and the approximate amount of total eggs per female.

At the end of the day, 2 oz. counts are taken and an average egg size per ounce is determined, along with the number of ounces and total eggs taken for the day and the accumulated egg totals. The water hardened sample represents at least a 1-oz. sample from each female.

On a daily basis, incubating eggs are treated with 6 oz PVP iodine at the top and middle of each stack morning and afternoon, up until they have become eyed, at which time treatment stops. The iodine is used to prevent fungal growth.

Sample eggs are put in an incubator tray at the end of each day .These samples are then labeled as to the number of ounces (normally no more than 100 ounces). The sample is kept separate from all other eggs in that lot. By doing this, we should be able to determine a percentage of loss to eggs put away flaccid compared to water hardened eggs.

Eyed eggs are addled 24 hours prior to being bounced. After bouncing, eggs are re-measured and the following information recorded: eggs per ounce, number per ounce, total number of eggs per lot, accumulated total, and percentage of losses.

At this time, The Feather River Hatchery mitigation production is as follows:

Spring Run: Seven million green eggs for mitigation must be obtained prior to 10/7.

Production Goals: Five million fish of 60 lb or larger.
Ocean Enhancement: Two million fish of 50 lb or larger.

Inland Chinook: Up to 2 million eyed eggs from the earliest trapped salmon, on the approval of the Fish Health Lab.

Restoration: Fingerlings are planted in appropriate tributary streams identified by Regional Fisheries Management biologists and approved by the Chief, Central Valley Bay Delta Branch.

If by early November, Mokelumne Hatchery is not be able to reach their production goals, up to four million eggs may be taken for transfer to Mokelumne Hatchery for rearing. Eggs transferred must represent the full spectrum of the run.

Steelhead

Up to 1 million eggs, which must represent the entire run.

If by late June, Mokelumne River Hatchery is unable to reach its mitigation goals, up to 250,000 eggs may be taken for transfer.

Mitigation Production - Department of Water Resources (DWR):

400,000 released Jan-Feb for DWR mitigation of which will be marked with adipose fin clip and coded wire tag.

Mitigation Delta Pumps Fish Protection Agreement (4 pumps):

Up to 50,000 yearlings of which will be marked with an adipose fin clip and coded wire tag.

Steelhead release site is at Gridley or further downstream to avoid predation.

At present, the goals spring run have not been met. The goals for the fall run have been met for the last 15 years. Steelhead goals fluctuate year to year.

Heenan Lake Air Spawning

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Abstract: This paper will discuss the area and habitat around Heenan Lake, the spawning facilities, the history of the Lake and the broodstock, spawning techniques, spawning equipment, and egg allotment numbers and stocking.

Heenan Lake spawning station is located in Alpine County California on the east side of the Sierra Nevada Mountains. The elevation is 7,100 feet. Terrestrial habitat consists of sagebrush and mixed conifers. Ponderosa and pinion pine, aspen, and juniper are the major species represented. Construction of a dam in 1924 to1925 formed the Lake, which comprises a surface area of 139 acres, with a maximum depth of 35 feet. Snowmelt and a single creek, spring fed, are the only water sources for the lake. Temperature profiles range from 30 to 60 degrees Fahrenheit during spawning season. A federally listed threatened species; the Lahontan cutthroat trout, is the indigenous species for east slope Sierra waters. Heenan Lake provides the only source of Lahontan cutthroat eggs for production in California. The original strain of Lahontons came from the upper West Fork of the Carson River in the Blue Lakes area. These were placed in Heenan Lake during the mid 1940's. Through genetic testing, this strain was found to be less pure than hoped. A replacement broodstock was found in Independence Lake near Truckee, California. This strain, marked with an adipose fin clip, is the only fish spawned at Heenan Lake

The original wood spawning shed was replaced with a metal structure in the late 1980's. During spawning season, water from Heenan Creek is diverted into a series of three ponds and down a fish ladder. A permanent barrier prevents any natural spawning in the upper creek. Once fish enter the trap they are sorted and held until sufficient numbers are present to warrant spawning. As water temperatures rise above 50 degrees Fahrenheit, floating jump screens, become necessary to prevent fish from changing ponds. These screens are constructed of 1-inch nylon bird netting secured to a PVC pipe frame.

During spawning, a collapsible metal ironing board is used to secure spawning pans and numerical recorders. Sodium bicarbonate (baking soda) is the anesthetic of choice as some fish are stocked into local waters and must adhere to FDA regulations. Bottled oxygen is the air source for spawning due to its availability on stocking trucks. A standard regulator is placed on the tank along with a small brass gate valve. This is connected by tigon tubing to a thumb actuated air valve and a number 18 needle. A cork or rubber stop is placed over the needle to maintain depth of needle insertion. The oxygen regulator is set for approximately 2 to 3 psi and fine-tuned with the gate valve. Needle insertion is to one side of cartilage surrounding the ventral fin. As the hand valve is actuated and the abdominal cavity fills with air, eggs are gently expelled into the spawning pan and fertilized. Eggs are then rinsed before disinfection in a dilute solution of iodophor. Spawning is done using a ratio of one male to one female on a random selection from the total population to maintain the greatest genetic diversity. After spawning the female is held by the caudal peduncle, head down, as hand pressure expels excess air from the body. In other words, the fish must be "burped." On completion of this process, they are placed in a recovery area of the station to await either return to the Lake or stocking into local waters.

Approximately 800,000 to 1,000,000 eggs are taken in this manner. Spawning is a cooperative effort between California Department of Fish and Game and Nevada Division of Wildlife. After egg allotments are met, all remaining fish are returned to Heenan Lake and the station is closed.

Fishery Foundation of California Net Pen Acclamation Project

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The Fishery Foundation of California (FFC) is a 501(c)3 nonprofit corporation. Our purpose is to enhance fisheries and their habitat through innovative techniques, for commercial, sport, and non-game species. In 1992, FFC began rearing striped bass in floating net pens. That project has been very successful and continues into its 9th year. Last year production included 498,677 yearling striped bass, with 54,000 yearlings to be held over for release as 2-year fish in 2001.Currently these bass are 1.3 fish/lb.

In 1993, the Executive Director of United Anglers of California asked me to research the possibility of using a net pen to acclimate salmon smolts being released by the California Department of Fish and Game (CDFG) into the Carquinez Straits.

The 1993 the season consisted of only four releases at three different sites to demonstrate the feasibility. The full project began in 1994. A 3-year contract was negotiated with CDFG to acclimate up to 25% of the Central Valley production. The acclamation process is extremely simple. Semi tractor-trailer trucks are backed up to an 80-foot long, 12-inch diameter pipe that is coupled to the truck, and the fish are unloaded into a floating net pen. Each float has three compartments. One truck-load is unloaded into each compartment. For the last couple of years, we have had two floating pens available, giving us the capacity of six trucks a day. The average load of a semi is 2200 lb. @ 42 fish/lb. or 92,400 fish x six trucks equals 554,400 fish total float capacity. The outside dimensions of an individual float are 38 ft x 29 ft: two floats rafted together are 76`x 29`. Each compartment within a float is 10 ft 8 inches width x 22 ft length, 12 inches in depth.

An average density of 33 fish per cubic foot or .78 lb. of fish per cubic foot is high when compared to culture densities, but considerably lower than transportation densities in the trucks.

After all fish are transferred from the truck to the pens, the float is untied from the pier and drifts with the tidal current. A tow boat is attached and directs the floating cage with the current, to prevent collisions with boats, piers, and other obstacles . The Carquinez Straits have extreme currents, winds, waves, and generally foul weather and sea conditions.

Two hours after unloading the trucks , the fish are released in the same order that they were loaded. This process is accomplished by removing the weights from the bottom corners of the net . Two weights are then tied to the two top corners on the same end of the net. The two weights are dropped into the water and the net is pulled up on the float at the opposite end of the float . This releases the salmon yearlings without additional handling.

At the planting sites, as the planting season wears on, predators congregate waiting the trucks to arrive. Stressed fish are less able to avoid these predators. As these small fish enter their new environment, they are stressed from handling, from trucking, from unloading, and the shock of entering the salt water environment. Fish are instantaneously subjected to temperature and salinity differentials of 9.3 C. and 19 ppt, respectively. Salmon yearlings can survive this shock, but they need a little time to adjust and protection from becoming striped bass food during the adjustment period. Holding salmon yearlings for a 2-hour period has shown positive benefits.

CDFG started trucking salmon yearlings in the early 80`s in an effort to reduce out-migration loses. Many factors contribute to out-migrant losses, including diversions, predation, poor habitat, pollution, and others. Trucking young salmon around these dangers has proven beneficial. Accessible planting sites in the Carquinez Straits area are limited in number and quality. Potential sites have been narrowed down to three. The Bennett Marina in Rodeo offers good access and is fairly private. Shallow water surrounds the marina for miles parallel to shore and deep water is over a half mile from shore. The Benicia Ninth Street Boat Launch Ramp has shallow waters, which surround the ramp for a mile in both directions and the deep channel is a half-mile off shore. This site is open to public, who often interfere with operations. The Wickland Oil property in Selby is far and away the best release site. Deep water comes up to within 40 feet of the shore. This is a Super Fund clean up site with acres of pavement for five or six trucks to turn, back up, and maneuver. There is also an abandoned pier to support the unloading pipes and tie the float. This site is also secure from the general public.

A coded wire tagging study was undertaken to prove the claimed benefits of this project. The Department of Water Resources funded a 3-year study. Starting in 1994, a total of 300,000 fingerlings was tagged. Two separate groups of 150,000 fish each were tagged with different tag codes at the Feather River Hatchery. The control group was released without the benefit of the net pen acclamation. The study group was acclimated as described above. In 1995 and 1996, similar numbers of fish were tagged and released. The average benefit over the study period was 236 % better return of the study group than the control. In the current season FFC acclimated over 10 million fall run chinook yearlings . At the rates indicated in this study, an additional 95,200 adult salmon will be available for harvest in a couple years. This puts an adult salmon in the ocean for less than a quarter.

This year, the FFC pen acclamation project handled 10,128,675 fall run chinook salmon yearlings. The fish were between 68 fish/lb. and 19 fish/lb. All three hatcheries participated fully. The cost to the Commercial Salmon Trollers Stamp Fund was $24,469. The cost per yearling was $.0024.

Acknowledgments

Our appreciation to Mr. Bruce Barngrover, recently retired Supervisor of Hatcheries in Region 2 (CDFG). This has been a simple, common sense type of project you don't need a Ph.D. degree to understand. Bruce helped me fight through the bureaucracy. We would also like to thank the hatchery managers and their staffs. We know it would be a lot easier not to have to deal with us. The hatchery staffs are committed to doing the best possible job for the resource under constantly increasing restrictions. Our thanks, also, to the Commercial Salmon Trollers Stamp Committee for their continuing funding.

SESSION 3

HATCHERY PRACTICES (CON'T)

Giving Salmon a Head Start in the Ocean – Net Pen Rearing

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Abstract: For the past 15 years, Central Coast Salmon Enhancement, a non-profit organization, has been operating a successful ocean net-pen program in Avila Beach, California, for the enhancement of salmon fisheries. The purpose of the program is to annually give 70,000 chinook salmon a "head start" in the ocean. The fish (at 50-70 fish to the pound) are acclimated to saltwater in Avila Bay. After acclimation, the pens are moved to a summer mooring location in the Bay, where they remain for approximately 100 days. When the fish reach an average size of an 1/8 of a pound, they are released into the open ocean. The program is supported by California Department of Fish and Game, the Commercial Salmon Stamp Committee, and the local community. The success of the program is reflected in a high survival rate to release and a high recovery rate of coded wire tags.

Steelhead Kelt Reconditioning: A Fish Culture Tool for Conservation

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Abstract: Declining numbers of returning adult steelhead in the streams along the East Coast of Vancouver Island have compelled fishery managers to initiate population rebuilding plans. One fish culture tool that may aid in the rebuilding of depressed steelhead stocks is kelt reconditioning. An informal kelt reconditioning trial succeeded in reconditioning 2 of 8 female kelts, however, egg viability was poor. In an attempt to fully monitor kelt recovery and egg production, we held 14 post-spawn steelhead in freshwater holding tanks. No males and six of 10 females survived. Two of the six females did not recondition (produce eggs) after one year in captivity. Eggs produced by the reconditioned females averaged 95.5 % survival to the eyed stage. Egg size and fecundity increased at second spawning versus initial spawning. Growth, physical condition, feeding and diets are discussed.

The British Columbia (BC) hatchery program has been in existence for 63 years. This program produces over 10 million anadromous and non-anadromous trout, kokanee, and char for stocking into roughly 1000 streams and lakes annually. Recent conservation initiatives, such as rebuilding depressed steelhead (*Oncorhynchus mykiss*) and white sturgeon (*Acipenser transmontanous*) stocks, have taken the BC hatchery program in a new direction. As part of larger population rebuilding plans, conservation hatcheries for East Coast Vancouver Island steelhead and Kootenai River sturgeon are now in operation in BC. The BC hatchery program expects to continue playing a role in future population rebuilding initiatives. We have been experimenting with steelhead kelt reconditioning in order to assess it's utility as a population rebuilding initiative.

Kelt reconditioning in Atlantic salmon (*Salmo salar*) is well documented in the scientific literature (White, 1942; Gray et al., 1987; Johnston et al., 1987; Dumas et al., 1991). However, only recently has the reconditioning of Atlantic salmon and wild sea trout (*Salmo trutta*) kelts and their resulting progeny been considered as a tool to rebuild depressed wild populations (Poole et al., 1994; Moffett et al., 1994).

The well-documented declines in returns of wild Atlantic salmon in western Europe and eastern North America forced fishery managers to explore all available tools for population rebuilding. On the westcoast of North America, a relatively recent downturn in adult returns has encouraged fishery managers to research and develop population rebuilding tools for the Pacific salmon, including steelhead. Reconditioning of kelts is not an option for the semelparous Pacific salmon, but it may be for the iteroparous steelhead. To our knowledge, the scientific literature does not contain any references to the reconditioning of steelhead kelts.

In response to a trend of all-time low adult return levels and dire predictions for future ocean survival, preparations for population rebuilding of East Coast Vancouver Island steelhead were initiated in 1997. These initiatives included fishery closures, regulation changes, the capture of wild smolts for experimental captive brood programs and an informal kelt reconditioning trial. The kelts for this trial were wild captured adult winter-run steelhead taken from the Quinsam River (depressed stock, near Campbell River, B.C.). A total of nine (eight females and one male) Quinsam River steelhead kelts were transported to the Vancouver Island Trout Hatchery for reconditioning. Fifty percent of the kelts survived for the 1-year trial and two females produced gametes. However, detailed growth and feeding data were not formally recorded and egg viability at second spawning was very low (<10(%) survival to eyed stage).

A more formal study was planned with the objective of monitoring: growth, feeding, and survival of the kelts during reconditioning and egg production and viability at second spawning. To fully document the reconditioning of steelhead kelts, we utilized adult steelhead from non-depressed mainland Fraser River tributary stocks.

Ten wild post-spawn steelhead, captured for the purposes of providing gametes for the hatchery steelhead program, were the source of kelts for this experiment. Four hatchery origin, post-spawn steelhead were also used in the experiment (Table 1).

All females were anesthetized with clove oil and live spawned (air-spawning method). Weight and length (pre-spawn and post-spawn), fecundity, and physical condition for each female were recorded. Similar data for each male was also recorded. Every fish was marked with a PIT tag (Biomark. Boise, Idaho) and an external tag. The external tags facilitated sorting and reduced reliance on the pit tag reader. Ovarian fluid samples from each female and sperm samples from each male were taken for disease screening purposes.

The kelts were placed into two 6-foot circular holding tanks at the Fraser Valley Trout Hatchery "old site" for recovery and reconditioning. One tank housed the male and female summer-run kelts and the other tank housed the male and female winter-run kelts. All fish were held in 9.5^{O} C single-pass ground water and exposed to natural photoperiod for the full duration of the study.

During the reconditioning period, growth (length and weight) and overall condition were monitored. Sampling occurred at the most frequent interval that did not impede recovery (every 4 months). Daily feed ration (% body weight feed) was readjusted after each sample period. Each kelt was photographed during sampling to provide a visual record of recovery.

The reconditioned females were anesthetized, checked for ripeness and live spawned upon ovulation. Weight and length (pre and post-spawn), fecundity, and physical condition were recorded. Ovarian fluid samples were also taken for disease screening. Eggs from reconditioned females were crossed with motile steelhead sperm (wild source). Eggs from each female were incubated separately in vertical tray incubators and mortalities were recorded to the eyed stage.

This experiment began with five winter-run steelhead (three males, two females) and six summer-run steelhead (one male, five females). Within 4 weeks of the start of reconditioning all of the winter-run steelhead died. As a result, another three winter-runs were added to the experiment. Unfortunately, weight and length data from first spawning was not available for these fish. The only summer-run male also died.

At 1-week post spawning, the kelts were introduced to palatable natural feeds in an attempt to stimulate an initial feeding response. The natural feeds consisted mostly of fresh, frozen salmon eggs and frozen krill but also included dew worms. The eggs and krill were frozen in paper cups in an attempt to minimize the disturbance of the kelts during feeding. To do so, the paper cup was torn away from the frozen eggs or krill and the remaining frozen mass was discreetly placed into the holding tank. As the frozen mass thawed, pieces of the eggs or krill would separate and become available to the fish. At 11 weeks post-spawn, an artificial semi-moist brood diet was introduced in combination with the natural feed. The fish were weaned off natural source feeds at 15 weeks post-spawn. At this point, the semi-moist brood diet composed 100% of the diet. The fish were fed at a rate of 0.8 % of body weight. The feed was administered via automatic belt feeders. The feeding rate was reduced by 50 % at 6 weeks prior to second spawning in response to maturation testing. The fish were taken off feed 2 weeks prior to second spawning.

Growth data for the four reconditioned (produced eggs) fish are presented (Graph 1). Growth data from first spawning to second spawning was available for only one fish (Tag # 128). All four females gained weight in the August and December sampling periods. Three of four females decreased in weight in the March sample. Increases in length were minimal (Graph 2).

Six female steelhead survived in captivity to second spawning. Four of these six females underwent sexual maturation and produced eggs at second spawning. Two females did not produce eggs and remained silver in coloration with relatively poor condition factors. Survival to the eyed egg stage for the progeny of the four fish averaged 95.5% (Table 2). There was a slight but not significant increase in % survival to the eyed stage between initial and second spawning. An increase in egg size (# eggs/Kg), and fecundity was observed for all four females at second spawning, when compared to initial spawning. At one week post second spawning, the wild reconditioned females were returned to their natal streams. The hatchery reconditioned female was terminated.

This experiment shows that wild and hatchery steelhead kelts can be reconditioned after one year in captivity, producing progeny with a high % survival to the eyed stage. The 95.5 % survival to eyed stage at second spawning obtained for this experiment was much greater than the <10% survival to the eyed stage obtained for the Quinsam River kelts. Other than site specific differences, the only major difference between the two studies that may have effected egg viability was the type of natural and artificial diets used. The Quinsam River kelts were reconditioned on frozen krill and eventually a dry (7 % moisture) salmon brood diet. Whereas, the kelts in the present study were reconditioned on a combination of fresh, frozen salmonid eggs, frozen krill, dew worms, and eventually a semi-moist (20.5 % moisture) salmon and trout brood diet.

It is well known that survival to second spawning in the wild for steelhead ranges from 5-20 percent (Behnke, 1992). Zero of four males (0 %) and six of ten females (40 %) survived to second spawning in this study. In B.C., we commonly observe much higher post-spawn mortality rates of male rainbow trout relative to female rainbow trout. As a result, it was not unexpected that no males survived to second spawning. Dumas et. al (1991) also observed higher mortality rates in reconditioned Atlantic salmon males than in females. The fish that died during reconditioning were negative for viral pathogens. Therefore, we speculate they succumbed to the stress of spawning and/or lack of nutrition from not feeding after initial spawning.

Significant energy is required for oogenesis (egg production), therefore it was expected that some females would not produce eggs after one year of reconditioning. Of the six females that survived to second spawning, only two did not produce eggs. These results are similar with those of Dumas, et al. (1991) where 15% of reconditioned Atlantic salmon did not produce eggs at second spawning. The two females that did not produce eggs are currently being held and will be monitored for egg production after two years of in captivity.

Complete growth data, from initial to second spawning, was available for only one kelt. However, all four reconditioned females exhibited similar trends in weight gain (Graph 1). The four reconditioned females exhibited weight increases during the August and December sampling periods. However, three of the four fish experienced a decrease in weight in the March sampling period. It is assumed the loss in weight is due to a decrease in observed appetite as the fish sexually matured.

All six females that survived to second spawning regained a silver-bright coloration by the August sample period. However, only the four reconditioned females exhibited spawning coloration. The two females that did not recondition (produce eggs) remained silver in coloration. Within 3 weeks of initial spawning, parasitic copepods (*Salmincola* spp.) appeared in the gills of both summer and winter-run steelhead. These copepods were observed on the body and fins at approximately 5 weeks after initial spawning. We decided to not treat the fish or pick the copepods to minimize handling of the fish and the infestations became quite heavy (especially in the gills). As the fish neared second spawning, it appeared that the number of copepods per fish was reduced.

The observed increase in egg size (# eggs/Kg) and fecundity at second spawning (Table 2) is consistent with wild rainbow trout populations in BC and elsewhere (Behnke, 1992). Interestingly, fecundity in reconditioned Atlantic salmon decreased at second spawning contrary to our observations (Dumas et al., 1991).

In summary, we successfully reconditioned female steelhead kelts in a 1-year period. The reconditioned kelts produced viable eggs that exhibited excellent survival to the eyed stage. As a result, steelhead kelt reconditioning has good potential as a population rebuilding tool. Reconditioned kelts can supplement a depressed population in a number of ways. They can be released back into their natal streams in pre-spawning condition or their progeny could be planted as eyed eggs, fry, or smolts. Finally, it must be noted that kelt reconditioning should be only one component involved in a population rebuilding initiative. Large numbers of progeny produced from reconditioned kelts can not help to bolster a depressed population if other bottlenecks to production are not addressed and mitigated.

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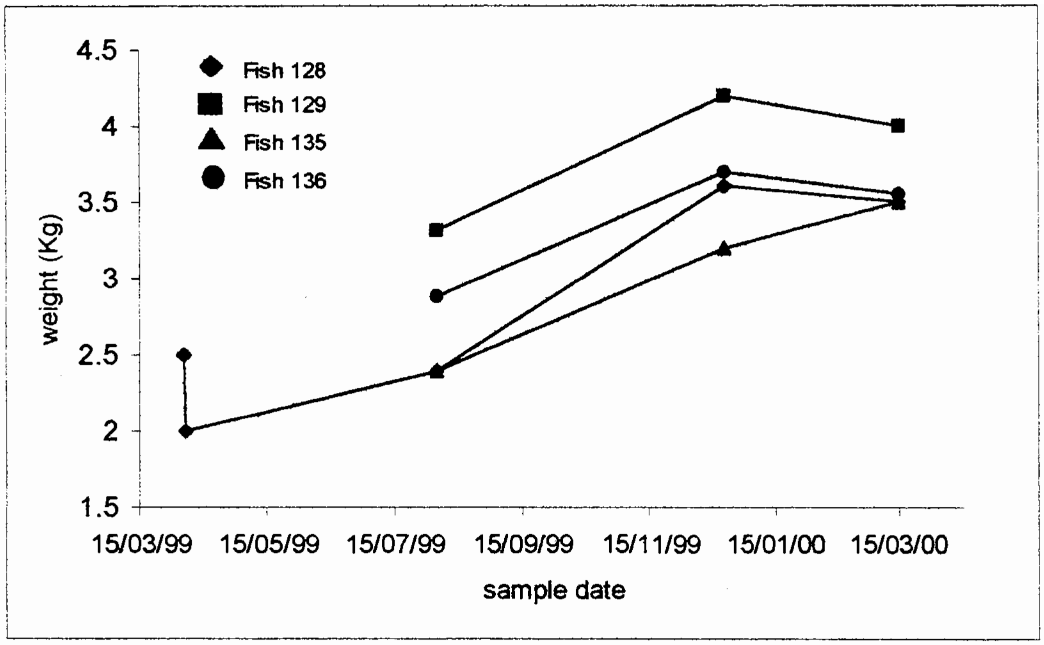
Natal Stream	Winter/Summer run	Wild/Hatchery	# females	# males
Alouette River	Winter	Wild	1	0
Big Silver Creek	Winter	Wild	3 (2)	0
Chehalis River	Winter	Wild	0	3
Chehalis River	Summer	Hatchery	3 *	0
Chilliwack River	Winter	Hatchery	1 (1)	0
Coquihalla River	Summer	Wild	2 (1)*	1

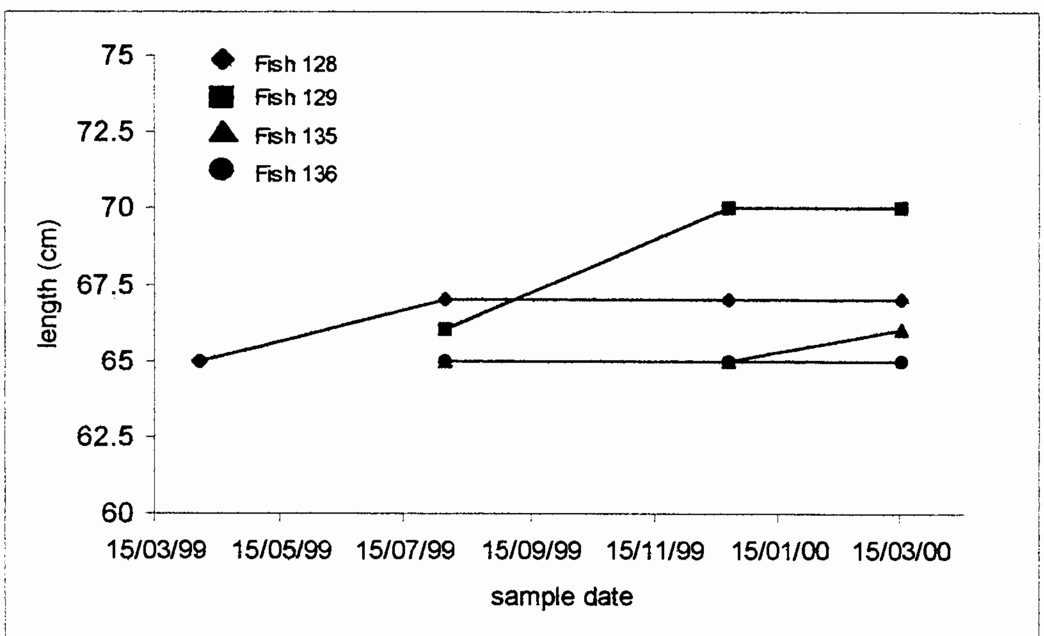
Table 1: Origin of steelhead kelts. Number in parentheses indicates number of reconditioned females. * denotes one fish that survived to second spawning but did not produce eggs.

		First Spawn				Second Spawn			
Stream	Tag #	Kg eggs	#eggs/Kg	# of eggs	% eyed	Kg eggs	#eggs/Kg	# of eggs	% eyed
Coquihalla	128	0.5185	7795	4042	84.0	0.7082	7520	5325	97.3
Big Silver	129	0.3940	9852	3822	95.4	0.6680	6943	4637	93.3
Big Silver	135	0.3780	6447	2434	97.4	0.5650	6045	3406	96.7
Chilliwack	136	0.4715	8604	4557	97.5	0.6707	8218	5512	94.6
Averages		0.4405	8175	3714	93.6	0.6530	7182	4720	95.5

Table 2: Initial and second spawning details for reconditioned steelhead kelts.



Graph 1: Weight of reconditioned steelhead kelts during captivity.



Graph 2: Length of reconditioned steelhead kelts during captivity.

Multi-Compartment Fish Planting Tanks

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In my presentation, I'll discuss the use of a multi-compartment tank for the use of fish planting. At Fish Springs Hatchery, we have been utilizing multi-compartment tanks since 1984. We have added more tanks to our fleet of vehicles over the last 16 years. The use of multi - compartment tanks have streamlined our labor tremendously.

In terms of efficiency, a multi-compartment tank allows employees to separate total fish allotments in different tanks. With a single tank, employees must net out fish for each body of water. In doing so a single compartment can take more time per plant and increase the chance of error in calculating numbers of fish per planting site. The chance for injury to an employee is also increased because of the necessity to net off the fish at each body of water. It is also required to send a single compartment vehicle out more frequently than with a multi-compartment tank because of the maximum allowable pounds each vehicle tank can haul safely, This, in turn, elevates the cost of fish and results in more frequent maintenance to the vehicles.

Safe hauling capacity of the multi-compartment tank in the 1200-gallon size is 3300 pounds, while a single compartment 1200 is 2400 pounds, although altitude can have an effect on those figures. Factors in hauling capacity include the use of two primary fresh flows and two secondary or back up fresh flows. An example, in a multi-compartment tank of three 400-gallon compartments with two 75 G.P.M fresh flows, the fresh flows turn the entire amount of water over in 2.7 minutes, as opposed to the same fresh flows in a single 1200-gallon tank, which requires 8 minutes. The use of wilfley weber stone instead of carbon stones also helps in hauling fish safely. Other features of the mult-compartment tank include the use of separate discharge tubes for each compartment instead of a single discharge. Also, with a multi-compartment tank you have the flexibility to load and haul different sub-species or different sizes of fish on the same vehicle.

With the use of a multi-compartment tank you can lessen planting times, lessen chance of error, and create a safer environment for employees, all of which can result in less expense, less maintenance, and more efficiency at your installation.

In conclusion, it is up to all of us to find the most efficient, safe, and responsible way of doing our job. It is my opinion that converting to multi-compartment tanks is one way to be more efficient and responsible to our Department, our employees, and, most of all, our fishing public.

Incubation and Rearing of Chinook X Pink Salmon Hybrids

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Abstract: Alaska Department of Fish and Game, Sport Fish Division, has an extensive lake stocking program that includes lakes in Southeast, Interior, and Southcentral Alaska. In systems or lakes where fish may escape and interact with local wild fish populations, the department's Genetics Policy mandates the use of sterile fish. In many landlocked lakes where escape is not possible we stock catchable-sized chinook salmon, specifically to enhance ice fishing; however the chinook salmon are fecund. Many of the males mature sexually during the first year, becoming discolored and deformed, making them an unattractive product for sport anglers, or they die and are unavailable for the fishery. Our primary objective in creating these chinook X pink salmon hybrids was to have a sterile salmonid alternative whose performance is comparable to the chinook currently stocked.

In 1998, we created our first chinook X pink salmon hybrids using males and females of both species. Chinook salmon female X pink salmon male crosses were the most successful cross, meeting or exceeding the incubation and rearing survival of chinook salmon. Growth rates in the hybrids during early rearing were almost twice that of chinook salmon. Within 2 months of rearing, the chinook female X pink male hybrid cross began to show a bimodal distribution in length. Approximately 90% of the larger-sized fish were female and 90% of the smaller-sized fish were male. These fish have been stocked in a few experimental lakes to compare performance against chinook salmon catchable fish. This evaluation will be done this winter during the ice fishery.

Temperature Control Water Heating andChilling
Done Easily...Done Cheaply

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From 1973 through 1996, I was the Fish Hatchery Manager at the Washington State Department of Game's Reiter Ponds on the Skykomish River. When it opened in 1973, it had two 2.5-acre earthen rearing ponds, one for summer steelhead and the other for winter steelhead.

1977 was the first return of adult steelhead. The following year, we constructed a small wooden trap in the outlet stream and started collecting the returning summer steelhead that were eventually shipped to the South Tacoma Fish Hatchery, where they were spawned. At that time the South Tacoma Fish Hatchery was the "mother" hatchery for all the Puget Sound steelhead programs operated by the Dept.of Game.

In the mid1980's, it was decided to construct an adult collection trap and a holding tank, as well as a small incubation building. During the planning stages I tried, unsuccessfully, to get the Dept. of Wildlife (formerly the Dept. of Game) to build some type of a temperature control system to speed the development of the green steelhead eggs.

A spawning target of 600,000 to 1,000,000 eyed summer steelhead eggs was to be delivered to the South Tacoma Fish Hatchery. The plan was to be able to supply all of the summer steelhead fingerlings for the Puget Sound summer steelhead programs.

The main water source for the Reiter Rearing Ponds is Austin Creek. The water from Austin Creek is plentiful and well aerated. One of the problems with the Austin Creek water is very fine silt. This silt can plug an incubator bucket if the floating filters aren't changed and washed on a regular basis. The biggest problem with this water is that from January to mid March, the water temperatures run from 37 to 42 degrees Fahrenheit. During freezing periods, the water temperature can drop to minus 33 degrees Fahrenheit for 2 or 3 days.

The problems caused by this cold water were many, but among them was the fact that it takes from 6 to 7 weeks to eye the eggs so they could be safely transported. Another problem was the size of the fingerlings that were returned from South Tacoma Fish Hatchery for the next year's spring release. This was caused by several things. The eggs takes were usually small, from 14,000 eggs to 120,000. This meant many small lots of fish at the South Tacoma Fish Hatchery, where pond space was at a premium. Many of these small lots had to be combined, causing a size disparity and uneven growth.

I was still interested in doing some temperature control work to try to lessen some of these problems. When I asked for permission to do this, I was given approval just as long as I didn't go over my budget. So I started to look around and see what was available. After talking with many people from all over the place, I settled on the idea of recirculating heated water using incubator stacks.

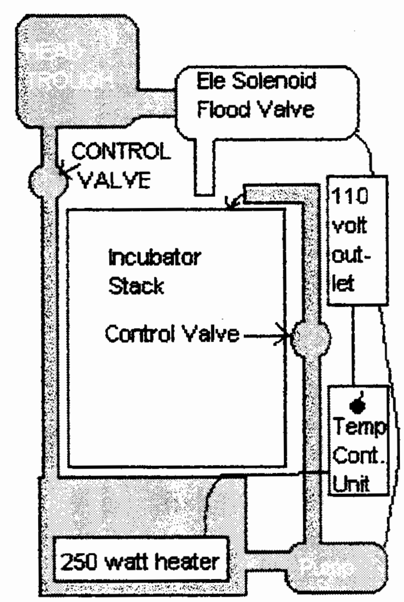
First, I had to get an incubator stack and at that time the Dept of Wildlife was only incubated fish eggs in baskets suspended in shallow troughs. I finally was able to borrow an incubator stack from a defunct fish hatchery in the area.

I then talked to the sponsor of my soccer team who installs water systems and I explained that I needed a pump that would pump from 6 to 12 gallons of water and lift that water from 6 to 8 feet. The pump would have to run for weeks with no chance to shut it down for maintenance. He suggested using a fountain pump.

I purchased on a Little Giant Pump, Model 3 E-12NR that could lift about 16 gallons of water up to10 feet. This pump cost a little over $ 100.00 dollars.

The next problem was a heat source, I settled on a 250 watt aquarium heater. The problem with this heater was that it was designed to get to warm. The lowest setting on the temperature control was 72 degrees

I then purchased a Honeywell, model # T675A 1516, temperature control unit for around $ 250 dollars. This control was wired so that it controlled the power that fed the water heater and it is accurate to one degree Fahrenheit.



I cut up an old formaldehyde barrel for a water reservoir and, with about $15.00 dollars worth of plastic pipe, fittings, and valves, I was in business.

I set the incubator stack on a bench over the water reservoir. Water was heated in the reservoir and pumped to the top of the incubator stack. From the bottom of the incubator stack the water dropped back into the reservoir. I added about 2 gallons of fresh water per hour to the reservoir.

Another problem I was concerned about was the lack of a backup or alarm system in case of power failure. I used an ASCO Model # 8210B57 electric solenoid controlled flood valve that would open if the power went off. We plumbed the new valve into the hatchery water supply. That way if there had been a power failure, raw water would be delivered into the top of the incubator stack. This water would continue to run until power was restored and the recirculating pump resumed its work. This cost a little over $ 500 dollars.

The way I tried to operate the system was that the first egg take was kept on raw water. As the second and third takes eyed, they were picked and put in the heated incubated stack at 50 degrees Fahrenheit. The temperature units were tracked on all three egg takes and the eggs were removed from the incubator stack when their temperature units matched those of the first egg take. Then all three of these egg takes were delivered to South Tacoma where they all hatched within a 1- to 2-day period, instead of being spread over a 4-week period. Egg takes five and six were also treated in the same manner.

The result was that when I received fish from the South Tacoma Fish Hatchery the next summer, they were uniform in size and came in about 3 weeks earlier than in the past.

I successfully operated this water heating system until I moved to the Arlington Fish Hatchery in February 1996.

After I moved to Arlington, all of the steelhead eggs spawned at Reiter Ponds were hatched at another hatchery. The system was dismantled and put away.

At this time we started to incubate winter steelhead eggs for the Whitehorse Rearing Ponds about 15 miles farther up the North Fork of the Stillaguamish River. I suggested using the same method at the Arlington Fish Hatchery and was allowed to set it up.

I was able to use the equipment from the Reiter Ponds and most of it is still in use here at the Arlington Fish Hatchery.

One of the programs here at the Arlington Fish Hatchery is the Alpine Lake Program. This program stocks alpine lakes in the summer and fall. These lakes are in the Cascade Mountains and most of them are over 3,500 feet. These lakes are either aircraft or backpack planted. This program seems to have the most success when the fish that are planted range from 400 to 600 FPP. The biggest problem with this program is that the Mount Whitney Rainbow that make up about 70% of this program are spawned in January and February and the can easily grow too big.

My dilemma as a Hatchery Manager was how to keep these fish from growing to big and still have a healthy product. In the past, growth was controlled by withholding feed and overcrowding.

I was able to borrow a chiller unit, a unit normally used to otolith mark chinook. This time, I re-circulated chilled, 40 degree water through the incubator stack.

I was able to pick up unfertilized eggs and sperm, instead of eyed eggs. These eggs were fertilized, hatched, and kept to swim-up in the "chilled"incubator stack. At the time these fish were at the swim-up stage, other Mt. Whitney Rainbow (reared at the Tokul Creek Hatchery, with water about the same temperature as ours) were at 1100 FPP.

The only alarm on this system was a float switch on the head trough that feeds water into the chiller. Two days before we were scheduled to move the Mount Whitney Rainbow into rearing troughs, the electric plug-in on the re-circulation motor came loose and we lost all of the

100,000+ fish for this program.

I figured the program was over, but the idea had proved itself. We installed a flow switch on the outlet of the re-circulation pump that will tell us if the water stops.

The following fall, I talked the Trailblazers Sports Club into buying a $2000 chiller unit like the one I had been borrowing. This is the sports club that does most of our Alpine Lakes backpack plants and they could see the advantage in "chilling".

The past 2 years we have been trying to improve both of these systems. We felt that the recirculating pump was probably the weak link and we've been trying to design a one pass water system.

We started by moving the water reservoir from the bottom to the top of the system and letting the water flow from the reservoir to the incubator stack by gravity . With the help of department electricians, I was able to hook up two 120 volt, 1200 watt hot water heaters in the water reservoir. This gave us 6 gpm of 50 to 52 degree water and seems to be enough water to run one incubator stack

Then we tried a similar method on the chilled water. We put the chiller unit in the upper reservoir and were able to get about 4.5 gpm of 40 degree chilled water. We still have to recirculate about 3 gpm. of the chilled water from the bottom of the incubator stack to maintain a safe O2 level. If there is a pump failure there is enough one pass chilled water to keep every thing alive in the incubator stack.

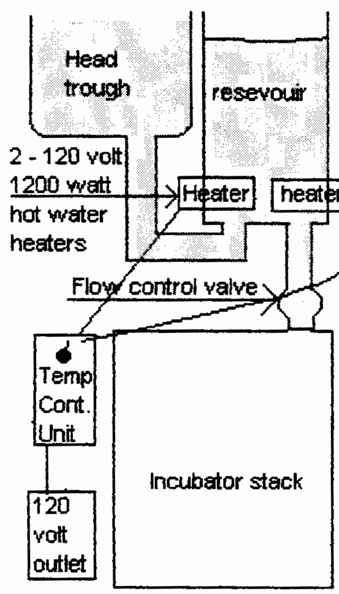
I am not trying to recommend any special brand of equipment. But I am hoping that I can plant an idea in someones head that they can use someday.

The last page has drawing of the two heating and chilling systems we are now using.

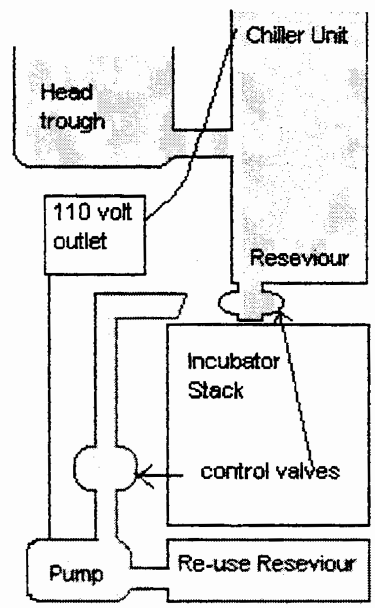
I would like to thank Gary Erickson, Dave DeVoe, Steve Moore, and Chuck Lavier for the help and support with this project. .

Another person that was of great help with support and proof reading is my wife Janet.

One Pass Heated Water System



One Pass Chilled plus Recirculation System



SESSION 4

FISHERIES PROGRAMS

Labor Saving and Innovative Hatchery Devices and Equipment (10-12 minute video)

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Abstract: The video will show various devices and pieces of equipment that are used at Iron Gate Hatchery. These items make fish culture/handling easier, safer, and more efficient. Many of the items were thought of and constructed by Iron Gate personnel and others are improvements of existing equipment or practices.

State Fish Hatcheries in California

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We have 21 fish facilities in California: 1 planting base, 1 egg quarantine station and trout planting base, 11 trout hatcheries, and 8 salmon and steelhead hatcheries.

There are approximately 170 permanent employees in the hatchery system. The cost to operate the entire hatchery system (salaries, fish food, maintenance, etc.) Is $12 million each year.

Department operated hatcheries produce approximately 53 million fish for stocking in California waters each year.

The State is broken into six different regions:

REGION I has three trout and three salmon and steelhead hatcheries.

Iron Gate Salmon and Steelhead Hatchery was built in 1996. It is located on the Klamath river near the Oregon border. The Hatchery has eight permanent employees.

Mt. Shasta Trout Hatchery was established in 1888. It is located 60 miles north of Redding. It is one of three broodstock hatcheries in the state. Five permanent employees operate the facility.

Trinity River Salmon and Steelhead Hatchery. Built in 1963, it is located 35 miles west of Redding on the Trinity River. The Hatchery has eight permanent employees.

Crystal Lake Trout Hatchery was built in 1947. It is located 50 miles northeast of Redding. The facility has as permanent staff of eight.

Darrah Springs Trout Hatchery was built in 1947. It is located 30 miles southeast of Redding. Darrah has nine permanent employees.

Mad River Salmon and Steelhead Hatchery Built in 1969, it is located 85 miles west of Redding. Six permanent employees operate the facility.

REGION 2 has one trout hatchery and three salmon and steelhead hatcheries.

American River Trout Hatchery was built in 1968. Located 12 miles east of

Nimbus Salmon and Steelhead Hatchery was built in 1955. It is located 12 miles east of Sacramento on the American River. Six permanent and four mobile crew employees work at the Hatchery.

Mokelumne River Salmon and Steelhead Hatchery. Built in 1964, it is located 25 miles southeast of Sacramento on the Mokelumne River. The facility is operated by seven permanent employees.

Feather River and Thermalito Salmon and Steelhead Hatchery Built in 1967, it is located 70 miles north of Sacramento on the Feather River. The Hatchery has14 permanent employees.

REGION 3 has one egg quarantine station and trout planting base and one salmon and steelhead hatchery.

Silverado Fish Hatchery was built in 1977. Located 50 miles north of San Francisco, the Hatchery has four permanent employees.

Warm Springs Salmon and Steelhead Hatchery and Coyote Extension. Warm Springs was built in 1980; the Coyote Extension added in 1991. Located 70 miles north of San Francisco, they have seven permanent employees.

REGION 4 has two trout hatcheries, one planting base, and one salmon and steelhead hatchery.

Moccasin Creek Trout Hatchery was built in 1954. It is located 60 miles east of Stockton. The facility is operated by eight permanent employees.

Merced River Fish Installation. Built in 1955. Located 75 miles northwest of Fresno on the Merced River. The Hatchery has a staff of two permanent employees.

San Joaquin Trout Hatchery. Built in 1955. It is located 20 miles north of Fresno and has a staff of nine permanent employees.

Kern River Planting Base was built in 1939. Located 40 miles north-east of Bakersfield.; one permanent employee operates the facility.

REGION 5 has four trout hatcheries.

Hot Creek Trout Hatchery. Built in 1941. It is located 35 miles north of Bishop at a elevation of 7,000 feet. It is one of three broodstock hatcheries. The Hatchery has 10 permanent employees.

Fish Springs Trout Hatchery was built in 1962. It has six permanent employees. It is located

20 miles south of Bishop.

Mount Whitney and Black Rock Fish Hatchery. Built 1917, it is located 40 miles south of Bishop. It is one of three broodstock hatcheries, with a staff of 10 permanent employees.

Mojave River Trout Hatchery. Built 1946, it is located 65 miles northeast of Los Angeles. The facility has five permanent employees.

REGION 6 has one trout Hatchery.

Fillmore Trout Hatchery was built 1946. It is located 65 miles northwest of Los Angeles. There are six permanent staff.

Management Strategies for Inland Salmon in California Lakes and Reservoirs

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Abstract: California reservoirs are operated variety of purposes and reservoir fisheries management is generally directed towards providing recreational fishing opportunities. Due to a lack of natural recruitment of game fish resulting from various environmental problems, fish stocking is often used to maintain and enhance fishing opportunities. Chinook salmon and kokanee for stocking are obtained from eggs collected from naturally spawning populations, checked, and certified by Department of Fish and Game pathologists to be disease free, reared in hatcheries, and stocked in lakes and reservoirs either as fingerling or yearling size fish. This effort has been collectively described as the Inland Salmon Program. Anecdotal information and recreational angler surveys suggests that this program has been very successful and enhanced California angling opportunities.

INTRODUCTION

California lake and reservoir management strategies are typically divided between coldwater and warmwater fisheries. Reservoirs that support strictly coldwater trout and salmon fisheries occur at higher elevations where warmwater species are usually considered undesirable. Reservoirs that support only warmwater fisheries are found at elevations generally less than 2,500 ft m.s.l., but may be stocked with trout during the winter when water temperatures are satisfactory. In many low- and mid- elevation reservoirs, thermal stratification provides a year-round cold, oxygenated hypolimnion. These reservoirs support both warmwater and coldwater fisheries and have been referred to as two-story reservoirs with mixed fisheries (DFG 1971).

Reservoirs have been constructed in California for a variety of purposes and support a large portion of California's recreational inland fishing opportunities. The U.S. Fish and Wildlife Service (USFWS,1980) estimated that California reservoirs make up 9% of the total number of reservoirs greater than 500 surface acres in the United States. The National Reservoir Research Program estimated that in 1980, 200 million angler-days were expended fishing reservoirs nationwide. In 1991, there were 2.2 million individuals who fished in California and expended $3.3 billion in fishing related expenditures (U.S. Department of Interior 1997). In 1988, the Department of Fish and Game (DFG) estimated that lakes and reservoirs account for 56.6 % of the water type most often fished by inland anglers (Fletcher and King 1989). California has an estimated 303 reservoirs classified as coldwater, covering 102,602 surface acres, and an additional 325 reservoirs as mixed fisheries, covering 411,098 surface acres (Barrett and Cordone 1980).

Reservoir fisheries management has generally been directed towards providing recreational fishing opportunities. Few game fish occur in the native fish fauna of California and after reservoirs were filled, native species generally did not maintain satisfactory populations. As such, management efforts emphasized game fish introductions (Shebley 1917, Evermann and Clark 1931, Lee 1995) and harvest regulations were guided by the premise that prey was abundant and natural recruitment of game fishes low. Coldwater species stocked included trout (*Salmo* and *Oncorhynchus* spp.), char (*Salvelinus* spp.), striped bass *(Morone saxatilis)*, white bass *(M. chrysops)*, walleye *(Stizostedion vitreum vitreum)*, northern pike (*Esox lucius*) and muskellunge *(E. masquinongy)*. The last three species did not develop lasting populations in California.

Numerous natural lakes occur in California, the majority at higher elevations in the Sierra Nevada. The majority of these waters did not support fish populations but have been stocked, usually with trout, by various individuals, private organizations, and the State.

Most reservoirs provided excellent fishing in the initial years following filling, but fishing quality gradually diminished with time making it more difficult to provide fishing opportunities (Dill 1946, Abel and Fisher 1953, Kimsey 1957). Higher elevation lakes and reservoirs are small and generally infertile. Cordone and Nicola (1970) reported that a major cause of poor fishing was inadequate natural reproduction. Changes in fish population structure, reduced productivity, inadequate natural recruitment, and unavailability of prey have also been suggested as contributing factors leading to poor fishing in coldwater and mixed fisheries reservoirs (Kimsey 1957, DFG 1971, Chamberlain 1972, Nicola and Borgeson 1970, Rogers 1984).

In 1950, the Department of Fish and Game initiated a series of experimental management studies designed to identify ways to increase the yield from reservoirs. Subsequent and more current strategies have included stocking fingerling or catchable-sized trout (Butler and Borgeson 1965, Borgeson 1966), nongame fish control using chemicals (Meyer 1966), introduction of predator and forage species (Cloyd and Ehlers 1960, Burns 1966, Chadwick et al. 1966, Goodson 1966, McAfee 1966, von Geldern and Mitchell 1975), establishment of terrestrial vegetation (Brouha and von Geldern 1978, Lee and Gleason 1989), and restrictive harvest regulations (Kimsey 1957). Increased yield in terms of pounds harvested was often associated with improved angling quality and creel census procedures were most often used to measure the success of management (von Geldern 1961, von Geldern and Tomlinson 1973). Rawstron (1972) reported that natural reproduction limited yield below the potential capacity in many of these waters. Although progress was reported, solutions did not come easily due to the complexity of the problem (DFG 1971).

COLDWATER MANAGEMENT STRATEGIES

Stocking and evaluation of hatchery produced fish continues to be a major portion of lake and reservoir managment efforts. Fingerling-sized trout are often stocked in higher elevation waters with limited access. Catchable-sized trout are stocked in waters with easy access and where returns of planted fish can be expected to be high. "Put-and-grow" fish stocking programs developed successful fisheries in reservoirs with abundant forage species such as threadfin shad (*Dorosoma petenense*) and wakasagi (*Hypomesus nipponensis*). Strains of catchable-sized rainbow and brown trout *(Salmo trutta*) that are more limnetically oriented, longer-lived, and that demonstrated higher return rates are stocked in late April or early May at the rate of 6 to 8 per surface acre (Rawstron 1972, 1973, 1975, Hiscox 1973).

In the 1980's, low angler returns of rainbow and brown trout stocked as part of "put-and-grow"management strategies prompted the desire to seek alternative species or strains of salmonids for reservoir stocking. In addition, increased angler interest in kokanee at higher elevation coldwater reservoirs encouraged the DFG to re-emphasize kokanee management strategies.

Inland Salmon Management

In 1986, the DFG's Reservoir Research and Management Project, funded by the Sport Fish Restoration Act, undertook activities to help enhance reservoir fishing opportunities. Some of these activities in concert with DFG regional office management efforts and support from interested angling groups eventually coalesced into the Inland Salmon Program . The goal of this program is to provide recreational angling opportunities in California lakes and reservoirs while the objectives of the programs are to: 1) identify appropriate waters for stocking, 2) increase fish populations through fish stocking, and 3) evaluate the benefits and detriments of stocking inland salmon.

Management efforts for the Inland Salmon Program are generally directed towards chinook salmon (*O. tshawytscha)* and kokanee *(O. nerka).* Coho *(O. kisutch)* have been used in "put-and-grow" stocking programs in selected California reservoirs. West (1965) described the maintenance of a non-anadromous stock of coho salmon at Crystal Springs Hatchery for stocking in inland waters while Rawstron (1975) described the results of studies involving the use of coho salmon. Coho salmon, however, have not been available for inland stocking purposed for many years.

Chinook Salmon

Chinook salmon reach a larger average size than trout and are popular with anglers. Snyder (1917) reported that chinook salmon were first stocked in a California inland water in Lake Tahoe in the early 1900's. Subsequently, McAfee (1966) described the reported success at Shasta Lake in the early 1960's of stocking chinook salmon fry and fingerling fall-run fish.

Problems associated with the use of salmon included higher production costs, uncertain availability of eggs, unpopularity with certain angler groups, and the potential to transmit diseases to downstream fisheries and hatcheries. The myxosporidium *Ceratomyxa shasta* has been identified from the Feather River drainage and is suspected as one factor that prevents maintaining a rainbow trout fishery in Lake Oroville. Because of this and the establishment of wakasagi (*Hypomesus nipponensis),* chinook salmon are considered more desirable than other salmonids for stocking in Lake Oroville.

Through the 1970's and 80's, fish surplus to Lake Oroville stocking allotments and occasionally fish from other sources were stocked in reservoirs to enhance angling opportunities. Lack of a consistent source of disease free chinook salmon eggs prevented formal expansion of the program. In 1991, the Department prepared a proposal to expand the rearing capacity for fall chinook salmon at Feather River Hatchery (FRH) to produce additional fish for ocean and sport anadromous, and inland chinook salmon programs. Concern for release of additional hatchery-reared chinook salmon in the Sacramento River system was expressed and the Department also concluded that the existing FRH facilities could meet production needs of the Inland Salmon Program. However, in the late 1990's, the Department of Water Resources (DWR) was ordered by the Federal Energy Regulatory Commission (FERC) to increased the rearing capacity of FRH to produce chinook salmon for release in Lake Oroville as part of re-licensing of the Oroville Hydroelectric Project. In addition, DWR was also ordered to produce twice the requested fish allotment for Lake Oroville as a precaution against hatchery losses. As such, fish surplus to the Lake Oroville allotment have been available for other waters. Studies conducted by the Department concluded that chinook salmon are able to utilize larger size prey than rainbow trout, are more limnetically oriented, allowing them to more effectively exploit a wakasagi forage base, and can provide a trophy fishery element to lakes and reservoirs. During the past 3 years, the Department has annually released slightly more than 600,000 chinook salmon in 12 different reservoirs (Table 1).

Kokanee

Kokanee eggs were first obtained by the DFG from sources in Idaho through the U.S. Fish and Wildlife Service and hatched at the Basin Creek State Fish Hatchery near Sonora. The fish were planted as fingerlings in 1941 as an experimental introduction into Salt Springs Reservoir south of Sacramento on the Mokelumne River. The specific purpose of the California introduction was to provide a game fish suitable for reservoirs with water level fluctuations. The fish did well and in 1943, 300,000 eggs were taken from spawning fish. Although most new fish introductions receive much attention, the Department did not make the first kokanee introduction public until sure that there would be an adequate supply to meet demand. Unfortunately, Salt Springs Reservoir was closed to the public shortly after the first introduction and anglers were not able to take advantage of the new sport fish.

Many fish introductions in California have been spread unintentionally. Such was the case for kokanee and in 1946, kokanee were reported in and around a small stream that flowed through the Tahoe State Hatchery near Lake Tahoe. The fish were through to have been the survivors of fish that escaped from the Hatchery and entered the Lake. Additional fingerling fish, including fish from the Salt Springs egg taking operation, were eventually stocked in Lake Tahoe and other waters around the basin.

In 1951, kokanee fingerlings from eggs obtained from a Kootenay Lake, British Columbia, tributary were planted in Shasta Lake to establish a forage fish for Kamloops rainbow trout. Subsequently, kokanee were planted in several other fluctuating reservoirs including Folsom and Millerton lakes. In addition to the two sources previously mentioned, kokanee eggs have also been obtained from other states, including Colorado, Idaho, Oregon, and Montana..

Kokanee provide popular fisheries when the fish reach a size acceptable to anglers. Small-sized fish, due to abundant natural reproduction, or a loss of fish due to competition with other species such as threadfin shad and opossum shrimp, are problems that have reduced management opportunities. The Department plants approximately 1.2 million fingerling kokanee into up to 24 waters annually (Table 2).

SOURCE OF FISH AND DISEASE IMPLICATIONS

Contributions to the recreational fishery of progeny from naturally spawning chinook salmon have not been documented in a California lake or reservoir. Fish apparently attempt to make spawning runs but barriers and unsuitable habitat, or other unidentified environmental factors preclude a major contribution. Sources of chinook salmon eggs for hatchery produced fish have varied and at times been inconsistent. FRH has been the most consistent source of fish due to the abundance of early fall run fish and consistent disease-free fish. However, in at least 2 years, identification of Infectious Hematopoietic Necrosis (IHN) in this run has prohibited their use in inland waters. Alternative sources of eggs have included Iron Gate and Nimbus hatcheries and, in all cases, eggs are quarantined and certified disease free prior to rearing for the inland program. Out-of-state sources for chinook salmon have been and are still considered undesirable due to potential disease transmission, and the Department is unaware of any private in-state sources. In keeping with Fish and Game Commission policy, only chinook salmon eggs surplus to the needs of anadromous salmon maintenance and enhancement programs are used for the inland program

Kokanee attempt to naturally reproduce in most waters where they occur. Both shoreline and tributary spawning has been identified and the recreational fishery contribution from natural spawning is unknown but generally thought to be small at most waters. However, at some waters, such as Trinity Lake, the over-abundance of spawning fish is believed to be a major factor for the small average-size of fish in the reservoir. Statewide, the majority of fish available to anglers are from hatchery-produced fingerling fish hatched from eggs taken from spawning adults entering Taylor Creek, Lake Tahoe; Bucks Creek, Bucks Lake; or the Little Truckee River above Stampede Reservoir. In past years, additional eggs to supplement in-state-sources have been imported from out-of-state sources to help meet allotment needs.

FISH STOCKING ALLOCATION PROCESS

Chinook salmon eggs for the inland program are procured during the fall of the year with a 2000 target goal of approximately 750,000 eggs. Based on past allotments, the statewide need for kokanee is approximately 1.5 million eggs. In the late winter or early spring of the following year, the Department allocates the both the available chinook salmon and kokanee fish based on regional requests and availability of fish.

FISHERY MONITORING

The success of the DFG's Inland Salmon Program has been extolled in popular fishing articles and the media. In 1999, the Department concluded a project to evaluate the chinook salmon fishery of Lake Oroville and, specifically, chinook salmon stocking rates. Based on the results of that study, annual stocking rates and management opportunities were described (Beer et al, 1999). Additional studies are ongoing at Lake Berryessa, and Trintiy, Shasta, and Folsom lakes. Studies involving kokanee are ongoing at Trinity Lake (spawning surveys), New Melones Reservoir, and a number of higher elevation Sierra Nevada coldwater reservoirs.

OCCURRENCES OF ESCAPEMENT AND STRAYING

Salmonids stocked in reservoirs are known to emigrate from the reservoirs. Anglers reported catching nine (0.2% of 4,312) reward tagged chinook salmon released in Lake Oroville from the 1994 through 1997 from downstream waters including the Pacific Ocean (Beer et al. 1999). In the summer of 2000, an external reward tag was returned by an angler from a chinook salmon weighing 17-18 pounds that was reported caught in the Pacific Ocean just outside the Golden Gate. The fish had been tagged and released as a yearling fish in Folsom Lake in the fall of 1997.

CONCLUSION

California recreational reservoir fisheries support a large segment of California's angling opportunities. The quality of these fisheries vary and are dependent upon a number of factors. Some factors such as the quality of the habitat and basic productivity cannot be easily changed. As such, reservoir management is generally relegated to harvest regulation, stocking and new species introductions, and habitat improvement. Many strategies have application to existing fisheries. Lack of information on the status of reservoir fisheries prevents the application of these strategies. Continued satisfactory angling opportunities in California's reservoirs require ongoing programs to provide current fisheries information and evaluate management strategies. Hatchery produced salmon stocked in lakes and reservoirs have contributed to California's angling opportunities.

ACKNOWLEDGMENTS

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Table 1. Number of chinook salmon stocked in California inland waters 1993 - present.

Water	Region	1993 (92BY) Fingerling	1993 (92BY) Yearling	1993 (92BY) Total	1994 (93BY) Fingerling	1994 (93BY) Yearling	1994 (93BY) Total	1995 (94BY) Fingerling	1995 (94BY) Yearling	1995 (94BY) Total	1996 (95BY) Fingerling	1996 (95BY) Yearling	1996 (95BY) Total
Shasta	1	0	0	0	0	0	0	0	0	0	0	15,045	15,045 FRH
Trinity	1	0	0	0	0	0	0	0	0	0	0	0	0
Whiskeytown	1	0	0	0	0	0	0	0	0	0	0	2,800	2,800 FRH
subtotal		0	0	0	0	0	0	0	0	0	0	17,845	17,845
Almanor	2		99,250	99,250 FRH a		68,450	68,450 FRH	0	156,365	156,365 FRH	0	69,972	69,972 FRH
Folsom	2	0	0	0	0	0	0	0	0	0	0	202,354	202,354 FRH
Oroville	2	102,585	60,600	163,185 FRH	104,400	55,200	159,600 FRH	101,922	90,001	191,923 FRH	105,841	150,435	256,276 FRH
Salt Springs	2	0	0	0	0	0	0	0	0	0	0	9,960	9,960 FRH
Spaulding	2	0	0	0	0	0	0	0	25,145	25,145 FRH	0	0	0
subtotal		102,585	159,850	262,435	104,400	123,650	228,050	101,922	271,511	373,433	105,841	432,721	538,562
Berryessa	3	0	0	0	0	0	0	0	0	0	0	0	0
Del Valle	3	0	0	0	0	0		0	0	0	0	0	0
subtotal		0	0	0	0	0	0	0	0	0	0	0	0
Isabella	4	0	0	0	0	0	0	0	0	0	0	10,007	10,007 FRH
McClure	4	0	0	0	0	0	0	0	0	0	0	35,200	35,200 FRH
Don Pedro	4	0	40,920	40,920 FRH	0	0	0	0	0	0	0	0	0 FRH
Pine Flat	4	0	0	0	0	0	0	0	0	0	0	37,400	37,400 FRH
subtotal		0	40,920	40,920	0	0	0	0	0	0	0	82,607	82,607
Total		102,585	200,770	303,355	104,400	123,650	228,050	101,922	271,511	373,433	105,841	533,173	639,014

Water	1997(96BY) Fingerling	1997(96BY) Yearling	1997(96BY) Total	1998 (97BY) Fingerling	1998 (97BY) Yearling	1998 (97BY) Total	1999 (98BY) Fingerling	1999 (98BY) Yearling	1999 (98BY) Total
Shasta	0	53,950	53,950 FRH	0	75,050	75,050 IGH b	0	53,535	53,535 FRH
Trinity	0	15,400	15,400 FRH	0	20,000	20,000 IGH b	0	24,518	24,518 FRH
Whiskeytown	0	0	0	0	0	0	0	0	0
subtotal	0	69,350	69,350	0	95,050	95,050		78,053	78,053
Almanor	0	16,165	16,165 FRH	0	60,000	60,000 IGH	0	60,000	60,000 FRH
Folsom	0	9,900	9,900 FRH	40,000	30,200	70,200 IGH	0	60,000	60,000 FRH
Oroville	105,267	250,228	355,495 FRH	106,143	350,000	456,143 IGH	128,750	287,040	415,790 FRH
Salt Springs	0	0	0	0	0	0	0	0	0
Spaulding	0	0	0	0	10,000	10,000 IGH	0	10,450	10,450 FRH
subtotal	105,267	260,128	365,395	146,143	390,200	536,343	128,750	357,490	486,240
Berryessa	0	0	0	0	25,000	25,000 IGH	12,300	39,060	51,360 FRH
Del Valle	0	0	0	0	15,024	15,024 IGH	0	15,024	15,024 FRH
subtotal	0	0	0	0	40,024	40,024	12,300	54,084	66,384
Isabella	0	0	0	0	5,000	5,000 IGH	0	40,040	40,040 FRH
McClure	0	0	0	0	0	0	0	6,500	6,500 FRH
Don Pedro	0	0	0	0	40,000	40,000 IGH	0	20,284	20,284 FRH
Pine Flat	0	0	0	0	30,000	30,000 IGH	0	30,600	30,600 FRH
subtotal	0	0	0	0	75,000	75,000	0	97,424	97,424
Total	105,267	329,478	434,745	146,143	600,274	746,417	141,050	587,051	728,101

a FRH = Feather River Hatchery egg source.
b IGH = Iron Gate Hatchery egg source.

Table 2. Number of fingerling kokanee stocked in California waters, 1982 - present.

Water	Region	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	Total
		Year																			
Bass	4		56,000	102,400	47,360	54,000			45,000	24,000		49,910		50,160	46,766	50,478	50,076	50,000	47,965	50,220	724,335
Boca	2	52,500	32,000	26,800	53,280	45,000			22,500			30,240			75,600	30,256	25,200	54,300	25,200	50,820	523,696
Bowman	2														29,190	104,432	60,009		91,696	32,565	317,892
Bullards Bar	2		310,000	257,280	296,000	216,000			254,250	129,600	27,000	156,800		340,561	325,000	301,548	150,336	100,800	75,600	100,928	3,041,703
Camanche	2	52,500												51,675	161,524						265,699
Donner	2											30,240		154,240	201,000	150,000	100,224	75,000	25,760	50,160	786,624
Don Pedro	4																			45,982	45,982
Fallen Leaf	2	52,500	56,000		79,920	45,000			45,000			25,920		49,820	102,000	75,520	39,600	75,900	20,550	75,400	743,130
Folsom	2	112,200	173,600						22,500	24,000				100,000	158,856						591,156
Hell Hole	2								45,000			73,500		74,960	71,750	51,975	50,050	35,600	25,000	25,026	452,861
Huntington	4			153,600	148,000	162,000			72,450	60,000		33,635		43,662	38,115	49,761					761,223
Indian Valley	3															50,000	51,840	50,400	24,600	50,400	227,240
Little Grass Valley	2			52,800	53,280											27,075	30,680	28,400	40,040	46,927	279,202
Los Vaqueros	3																			105,461	105,461
New Melones	4																66,600	106,700	107,935	166,698	447,933
Pardee	2		111,600	117,475	103,600	90,000			175,500			129,600		51,675	149,284	99,547	100,350	79,500	70,119	130,850	1,409,100
Ruth	1	54,000	62,000	63,360	50,320	45,000														100,098	374,778
San Pablo	3																			54,400	54,400
Scotts Flat	2		24,800	32,160	53,280										50,825	24,720	25,200		50,000	51,495	312,480
Shaver	4				53,280	54,000			44,550	60,000		49,910		51,240	49,920	49,720	52,052	50,500	50,000	49,980	615,152
Stampede	2		320,000	204,288	284,160	93,600			189,000	120,000	27,000	134,040		126,000	300,000	164,186	159,989	107,600	30,320	50,048	2,310,231
Tahoe	2	1,151,000	1,204,400	591,856	854,000							85,255			358,950	148,478	340,560	250,700	149,917	302,459	5,437,575
Union Valley	2													51,200	47,955	71,070	50,032	76,800	24,660	75,026	396,743
Whiskeytown	1	258,000	260,000		251,600	225,000											51,850			50,000	1,096,450
Total		1,732,700	2,610,400	1,602,019	2,328,080	1,029,600	0	0	915,750	417,600	54,000	799,050	0	1,145,193	2,166,735	1,448,766	1,404,648	1,142,200	859,362	1,664,943	21,321,046

GROWTH AND CONTRIBUTION TO THE FISHERY OF CHINOOK SALMON AT LAKE OROVILLE, CALIFORNIA

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ABSTRACT

Angler and fish population surveys and tagging studies were conducted at Lake Oroville from July 1993 through June 1999 to characterize the recreational fishery and evaluate the chinook salmon stocking program. Angler effort varied seasonally but was primarily directed at black bass (63%) or coldwater species (33%) of which spotted bass and chinook were the predominant species caught by anglers, respectively. Angler catch rates for salmonids varied seasonally but were greater than 0.3 fish per hour in half of the 24 calendar quarters surveyed. Based on the number of effectively tagged chinook salmon released and recaptured, the salmon fishery is maintained by stocking. Chinook salmon stocked as fingerlings contributed to the fishery at a lower rate than yearlings and returned at a ratio of approximately one to five during most years of the study. Chinook salmon growth rates appeared to be related to chinook salmon densities and growth decreased as the number of salmon stocked increased. Chinook salmon reached or exceeded "target lengths" of 305 mm and 381 mm TL by age 18 months and 24 months, respectively, when 170,000 'yearling equivalents' or less were stocked. A 'yearling equivalent' was defined as the number of fingerlings and yearlings stocked in combination that would produce a similar angler catch if only yearlings are stocked and is based on return rates of CWT'ed chinook salmon in the recreational fishery. Most angler-caught salmon were three years of age or less. Trophy-size salmon were defined as fish greater than 5 pounds in weight and exceeded approximately 610 mm TL based on length weight regression of angler-caught salmon from Lake Oroville. Trophy-sized salmon appeared to be faster-growing three year old fish. Chinook salmon in Lake Oroville were highly piscivorus and threadfin shad, wakasagi and unidentified fish remains comprised 89 percent of the stomach contents. Chinook salmon condition factors and prey abundance indexes did not appear to be related to stocking rates but condition factions were higher when the prey abundance index increased, although the relationship was not statistically significant. In 1994, higher than normal summer releases from the reservoir may have resulted in reduced survival or increased emigration from the reservoir based on poor angler returns of 1993 BY fingerlings. Extremely low returns of yearling chinook salmon and brown trout tagged with external reward tags suggested high tag shedding or high mortality of tagged fish. Based on analysis of information gathered, a maximum of 170,000 yearling chinook salmon or 'yearling equivalents' is recommended for annual stocking to maintain a quality salmonid fishery and provide for trophy fishing opportunities.

Black bass were the predominate warmwater species caught at Lake Oroville during the study. Fishing was considered good and angler catch rates exceeded 0.5 bass per hour in all but one of the 24 calendar quarters surveyed. Spotted bass were the most abundant black bass species reported and observed caught during angler surveys and captured

during electrofishing. Electrofishing catch rates for all black bass exceeded 40 fish per 1,000 seconds of pulsator output in all but one year and did not demonstrate any trends during the study. Smallmouth and largemouth bass electrofishing catch rates declined during the study but were not statistically significant. Spotted bass demonstrated good condition factors in all years and condition did not appear to be related to the prey abundance index. Condition factors for spotted bass 46 months of age and older were higher than for younger age groups of bass. There did not appear to be a relationship between chinook salmon stocking rates and black bass index of abundance, condition factors, or catch rates.

INTRODUCTION

Lake Oroville is a large (6,400 HA) two story fluctuating reservoir in the northern Sierra Nevada foothills of California. Hiscox (1979) provided a physical description of the lake. The lake supports popular fisheries for both coldwater and warmwater gamefish. Threadfin shad were intentionally introduced to provide forage for gamefish in 1967. In 1975, wakasagi (pond smelt), *Hypomesis nipponensis*, were observed in Lake Oroville and are established in the lake. The fish most likely originated from an upstream source (Aasen et al, 1998).

In California waters where wakasagi are the principal forage, put-and-grow programs utilizing sub-catchable or catchable-sized rainbow trout have been largely unsuccessful. Lee (1980) reported that at Freshwater Lagoon, Humboldt County, only rainbow trout >279 mm fork length (FL) utilized pond smelt as forage. Rogers (1984) reported that pond smelt did not become an important part of the rainbow trout diet at Lake Shastina (Siskiyou County) until the trout exceeded 254 mm FL. In addition, the myxosporidian protozoan *Ceratomyxa shasta* is present in Lake Oroville. This organism causes serious losses in rainbow trout and no drugs or treatments for control are known.

The California Department of Fish and Game (CDFG) developed and instigated the Trophy Trout Program as a management strategy for large fluctuating reservoirs. Criteria for the Program were established but the objective of producing trophy-sized fish (fish ≥5 pounds) was not met (Rawstron 1973). In addition to trout, coho salmon *Oncorhynchus kisutch* have been successfully utilized in put-and-grow programs but are relatively expensive to produce due to a long rearing time in the hatchery (Rawstron 1975) . Brown trout *Salmo trutta* have been utilized at Lake Oroville, but returns of tagged fish in the past has been low suggesting that anglers do not catch a large percentage of the planted fish.

Chinook salmon *Oncorhynchus tshawytscha* were first stocked in a California reservoir in the early 1960's. The fish grew rapidly and reach sizes exceeding 15 pounds in three years (McAfee 1966) . Chinook salmon have demonstrated production advantages for California hatcheries, are able to utilize larger size prey, and are believed to be more limnetically oriented, allowing chinook salmon to more effectively exploit the wakasagi forage base. In addition, chinook salmon are a native species which historically occurred in the streams impounded by Oroville Dam. Although chinook salmon have been routinely stocked at Lake Oroville in the past, Chinook salmon have been used in managing California reservoir fisheries since the 1970's stocking rates have been based on those developed for other species.

Black bass are the most popular species in the warmwater fishery at Lake Oroville and have been managed with a 305 - 381 mm (12-15 inch) protected slot limit since 1983. Effects of the regulation on the fishery at Lake Oroville were evaluated by Lee et al (1992). Black bass tournaments have been held at the lake for a number of years and since 1998, the CDFG has issued exemptions to the slot limit regulation. Black bass angling interests have expressed concern over the potential effects of increased salmon stocking on the black bass fishery.

The purpose of this study was to determine appropriate chinook salmon stocking size and numbers needed to maintain a quality and trophy fisheries, and to continue data collection to evaluate the black bass fishery. This assessment of the Lake Oroville fishery was undertaken in cooperation and under contract with the reservoir operator, the California Department of Water Resources (CDWR).

METHODS

Recreational fishery surveys were conducted by stratified random sampling to obtain information on angler catch, harvest and use. Due to the physical characteristics of the reservoir an access point survey design was employed (Malvestuto 1983). All fish examined were identified to species and total length recorded. The number of hours fished, method of fishing, target species, angler origin, and other pertinent information was collected from each angler contacted. Weights were taken of a representative sample of salmonids examined. Data on fish reported caught and released was collected and classified by fish type ('black bass', 'salmonid', 'panfish', 'catfish', 'other') and by size class (< 305 mm, 305-381 mm, and > 381 mm). These 'small', 'medium', and 'large' size classes correspond to the black bass slot limit.

Surveys were conducted on both weekdays and weekends throughout the year. The majority of boat anglers utilized the ramp at the Oroville Dam spillway. The three other improved boat ramps were primarily used by recreational boaters and use of the five car top boat access points was typically low. Since recovery of tagged fish and collection of angler catch data were primary goals of this study, surveys were conducted to maximize contact with anglers. There was no effort made to estimate total angler use of the reservoir, but due to the limited shore and road access at Lake Oroville we feel that the majority of angling effort was assessed.

All chinook salmon planted in Lake Oroville from May 1993 through June 1998 were identified with coded wire tags (CWT's). Both tagged and untagged chinook salmon yearlings were released in November 1998 and tagged fingerlings were released in May 1999. The study plan called for an annual stocking of 100,000 fingerlings in the spring and a stepped increase in yearling numbers to be stocked in the fall of each study year.

In the spring of 1993, chinook salmon from the 1992 brood year (BY) were tagged at the Silverado Fisheries Base (Napa County) and the Merced River Fish Facility (Merced County). In subsequent years, all chinook salmon were tagged during the spring at the Feather River Hatchery or the Thermalito Annex Facility of the Feather River Hatchery, both in Butte County near the city of Oroville. Eggs from early fall run Feather River chinook salmon were used for all brood years except 1997. Adult early fall run 1997 BY Feather River salmon tested positive for infectious hematopoietic necrosis (IHN) and eggs taken at Iron Gate Hatchery (Klamath River stock) were used for the CDFG's inland chinook salmon program in calendar year 1998.

Chinook salmon examined by angler survey personnel were checked for the presence of CWT's and heads were removed from a sample of tagged salmon for recovery and identification of tags. All CWT's were processed at the CDFG Fisheries Programs Branch laboratory in Rancho Cordova. CWT's were decoded and numbers of fish and mean TL determined by month for each brood year and planting type (fingerling or yearling). For each BY the percent of the fingerling tag group caught was compared to the percent of yearling cohorts caught in order to develop relative return rates. Chinook salmon condition factors (K) were calculated from CWT return data. Stomachs were taken from a sub-sample of chinook salmon caught by anglers to evaluate prey species preference.

Approximately 400 yearling CWT chinook salmon were tagged with $10 reward tags during each year of the stepped increases in yearling stocking. Additional 1993, 1995, and 1996 BY yearling chinook salmon and 1991 and 1993 BY catchable brown trout were tagged with $10 reward tags. Reward tags were returned by anglers, catch data entered into the database, a letter of acknowledgment sent to the angler, and an authorization for reward payment forwarded to the CDFG fiscal section.

Hydroacoustic surveys were conducted monthly to characterize prey species abundance and distribution. Equipment included a Lowrance X-15 paper graph recorder operating at 192 kHz through a 20 degree cone angle transducer. Standard sampling protocols were established which included operating the echosounder at maximum sensitivity, surface interference suppression set at '2', chart speed adjusted to maximum, and the 'grayline' adjusted to achieve a clear bottom trace without introducing 'noise' onto the chart in the area of the water column. Boat speeds were kept to a minimum to eliminate interference from the boat's passage through the water. Due to the extreme depth of the main body of the lake (to 180 meters) a maximum recording depth was set on the sounding unit in order to achieve sufficiently detailed tracings of target fish. This depth was set to 30 or 45 meters depending on the distribution of target fish. Four transects were established utilizing landmarks which would be recognizable at all lake elevations and under most lighting and weather conditions. These transects crossed two of the inundated tributary canyons and the main body of the lake. Transects ranged in length from 1,370 meters to 4,160 meters and all transects were run consecutively during each sampling effort. Echosounder charts for each transect run were categorized by the relative number of traces (fish or schools) after Wilde and Paulson (1989).

Electrofishing surveys were conducted quarterly to collect species composition, size distribution and condition factor data for littoral species. Surveys were conducted using a Smith-Root SR-18 electrofishing boat, with one boat operator and two netters. All surveys were conducted at night.

RESULTS

Lake Oroville Fishery Evaluation

Angler interviews were conducted on a total of 893 days from July 1, 1993 through June 30, 1999. During this period 19,797 anglers were contacted who reported fishing a total of 113,670 hours (Table 1). Chinook salmon comprised 54.2 percent and spotted bass 27.9 percent of the 11,612 fish examined (Table 2). No other species made up more than 4.7 percent of fish examined. Angling effort varied seasonally but was primarily directed at either black bass (62.8 percent) or coldwater species (33.1 percent) with black bass percentage of effort increasing slightly and coldwater effort decreasing slightly during the study (Fig. 1).
Effort by other angling groups was highest during the second and third quarter of all years but was much lower than effort directed at coldwater species or black bass.

The black bass fishery is predominately 'catch-and-release' with less than seven percent of all black bass reported caught being kept. Anglers kept approximately 15 percent of black bass less than 305 mm and 11 percent of black bass over 381 mm (Table 3). Over 50 percent of the black bass reported caught were within the 305 to 381 mm protected slot and were thus illegal to keep. Coldwater anglers also demonstrated 'catch-and-release' angling and approximately one-third of all salmonids caught were reported to have been released. Interviewed anglers released roughly one half of sub-305 mm salmonids, one third of 305 - 381 mm salmonids, and one quarter of salmonids over 381 mm (Table 3).

The coldwater catch by size group varied seasonally with catch of large salmonids generally higher during the third quarter of the year and small salmonid catch higher during the fourth quarter following the stocking of yearling chinook salmon in the fall (Fig. 2). Black bass catch by size group was less variable. Overall black bass catch rates were generally lowest during the first quarter of the year (Fig. 3).

Chinook Salmon Growth and Fishery Contribution

A total of 1,582,622 chinook salmon was released in Lake Oroville from May, 1993 through June 30, 1999, including 1,371,901 effectively CWT''ed fish (Table 4). We recovered 2,037 CWT'ed chinook salmon from the fishery representing six brood years. For each BY of chinook salmon, the numbers of fish caught and mean total length (TL) were computed monthly for fingerlings, yearlings and both stocking sizes combined. Growth data was grouped quarterly for comparison of fishery contribution by individual BY's.

Growth of fingerling and yearling stocked CWT chinook salmon was compared by BY using computer generated power regression analysis (Lotus Development Corporation, 1994). For purposes of analysis, a TL of 60 mm was assigned to all BY's at two months of age. Growth was greater for fingerlings as compared to yearling chinook salmon for all brood years except 1993 (Fig. 4). Insufficient numbers of 1993 BY fingerlings were recovered for comparison.

Relative return rates for fingerling and yearling CWT'ed chinook salmon were determined for each BY by calculating the percent of available tags recovered (Table 5). Relative return rates were variable among years and ranged from 2.5 yearlings per fingerling return for the 1994 BY to 51.9 yearlings per fingerling return for the 1993 BY. Relative return rates were used to calculate a 'yearling equivalent' value for comparing stocking rates (Table 5). The 'yearling equivalent' describes fingerling and yearling combined returns as the number of yearlings alone required for an equivalent number of fish in the catch.

Chinook salmon growth rates decreased as numbers of fish stocked was increased (Table 6). Mean total length of recovered CWT chinook salmon at age 12 months and 24 months was generally greater when fewer fish were stocked.

Quarterly percent of catch by BY was computed to compare the relative contribution of stocking groups and age of fish at capture (Table 7).

Chinook salmon condition during the study period did not appear to be related to either fish age or stocking numbers (Table 8). Condition factors for Lake Oroville chinook salmon from September 1995 through June 1999 have varied seasonally but are consistently higher than those recorded for the period June 1993 through June 1995, in spite of greatly increased numbers of yearling chinook salmon planted in the fall from 1996 through 1998 (Table 8).

A total of 4,312 yearling chinook salmon was tagged and released with ten dollar ($10) reward Carlin tags (Table 9). First year exploitation, natural mortality and annual survival were calculated after Ricker (1958) and were adjusted to exclude out-of-basin recoveries and incomplete recovery information. Estimated first year chinook salmon exploitation ranged from < 0.01 for the 1996 BY to 0.09 for the 1994 BY. Estimated natural mortality for chinook salmon ranged from 0.66 for the 1995 BY to 0.94 for the 1994 BY. Mean annual survival calculated from reward tag recoveries was 0.14 for BY's 1992 through 1995. Tag return data is incomplete for the 1996 and 1997 BY's.

A total of 1,398 brown trout from two year classes was tagged with $10 reward tags (Table 10). Estimated first year brown trout exploitation was 0.05 for the 1992 BY and 0.03 for the 1994 BY. Estimated natural mortality was 0.95 for the 1992 BY and 0.66 for the 1994 BY. Annual survival estimated from reward tag returns was 0.00 for the 1992 BY and 0.31 for the 1994 BY.

Thirty-nine boat nights of sampling comprising 125,322 seconds of electroshock time were conducted between August 1994 and June 30, 1999. A total of 8,202 fish was identified to species, measured and weighed. Spotted bass were the most frequently caught species followed by bluegill and largemouth bass. Overall game fish catch rates (fish per 1,000 seconds of electrofishing effort) ranged from 39.53 for spotted bass to 0.03 for white crappie (Table 11). Catch rates were 1.90 for threadfin shad and 1.96 for pond smelt.

We used spotted bass as an indicator species for potential effects of chinook salmon stocking on warmwater fish populations. A total of 4,624 spotted bass was captured by electrofishing and measured. Of these 4,094 were large enough to weigh. Length-frequency distributions were determined for all quarterly samples to assign probable year classes to weighed fish. Spotted bass condition factors were calculated quarterly by brood year for fish age 12 months and over (Table 12). Spotted bass condition was lower than predicted for the 1994, 1996, 1997, and 1998 BY's ($t = 2.365$, $df = 7$, $P = 0.05$).

Stomachs were collected from 206 chinook salmon to determine prey species preference. Forty eight (23 percent) were empty. Total stomach contents by volume consisted of approximately 28 percent wakasagi, 29 percent threadfin shad and 32 percent unknown fish remains. Insect larvae and zooplankton made up a small percentage of stomach contents. We confirmed predation on wakasagi by chinook salmon as small as 240 mm TL. Prey species preference was variable with wakasagi tending to appear in chinook salmon stomachs at higher rates during the fall and winter and threadfin shad generally taken at higher rates during the spring (Fig. 5).

Monthly hydroacoustic survey data was grouped to develop quarterly abundance indices. Separate forage abundance indices were developed for each of three depth strata; 0 - 12 meters, 12 - 24 meters, and over 24 meters (Fig. 6). Forage abundance was more variable from July 1996 through June1999 than for the period from July 1994 through June 1996 (Fig. 6).

DISCUSSION

Length-weight data collected indicates that chinook salmon at Lake Oroville reach Trophy Trout Program criteria of 2.27 kg (5 pounds) or greater at a length of approximately 610 mm (Fig. 7) and at an age of forty-eight months or older (Fig. 8). Our results suggest that chinook salmon growth in the reservoir is inversely related to stocking density. To provide for the trophy trout fishery at the Lake Oroville and maintain a quality fishery, we set minimum growth standards for chinook salmon a minimum of 267 mm (10.5 in) mean TL at age 12 months, 330 mm (13 inches) at 18 months and 406 mm (16 inches) at 24 months.

Growth of the 1992 through 1996 BY chinook salmon at Lake Oroville was relatively consistent within each year class through age 24 months (Fig. 8). Growth in the third year of life was more variable and very few chinook salmon (0.25 percent in this study) in Lake Oroville survive past 36 months of age. In addition, recovered chinook salmon over 36 months were slow growing fish with a mean TL of only 500.4 mm.

Chinook salmon from the 1994 BY (yearling equivalent = 132,000) met all three of the above growth standards while the 1995 BY (yearling equivalent = 170,000) had adequate growth through 12 months but fell short of the 18 and 24 month standards (Table 5). The 1996 BY (yearling equivalent = 271,000) failed to meet any of the three standards and the 1997 BY (yearling equivalent = 422,000) failed to meet the 12 or 18 month standards. The 1997 BY is not yet 24 months old. Stocking levels for these four years by reservoir surface area are; 1994 BY = 20.6 fish per hectare, 1995 BY = 26.6 fish per hectare, 1996 BY = 42.3 fish per hectare, and 1997 BY = 65.9 fish per hectare (Table 5). The 1993 BY (yearling equivalent = 57,000) failed to achieve the 18 month standard but did reach the 24 month standard. This group of fish suffered very high losses in the hatchery due to bird predation and this growth pattern is perhaps a reflection of that stress.

Growth rates of chinook salmon stocked as fingerlings was higher than that of yearling cohorts. This may be due to improved growth in the lake environment or it may be an artifact caused by a higher mortality of smaller chinook salmon in the open lake than occurs in the hatchery. Because of this higher growth rate, fingerling stocked chinook salmon could make an important contribution to a trophy fishery.

The relatively high return of fingerling stocked chinook salmon during most years provides management with additional options for achieving desired fishery goals. The concept of a 'yearling equivalent' allows for the adjustment of stocking numbers in response to environmental conditions through consideration of factors such as predicted runoff and estimated reservoir releases. Because of the spawning time of chinook salmon, fingerling stocking numbers do not need to be finalized until late spring. By this time of year the CDWR has data on the state's snow pack and can estimate runoff and predict reservoir releases with considerable accuracy.

The poor fishery contribution of 1993 BY fingerling stocked chinook salmon may be the result of emigration of much of this group from the reservoir. Due to downstream temperature requirements for anadromous salmon, Lake Oroville releases were relatively high from June through October 1994, resulting in an elevation reduction of over 27 meters over this five month period (U.S. Geological Survey, 1995). It is possible that this flow carried a significant number of the recently planted chinook salmon fingerlings downstream.

Oroville dam releases are provided through a shutter system which is operated to provide optimal water temperatures for chinook salmon production at the Feather River Hatchery approximately eight miles downstream from the dam. It is likely that these temperatures are also optimal for the chinook salmon in the reservoir and releases would have been drawn from a stratum where reservoir chinook salmon were abundant. If such a dramatic summer reservoir draw down is predicted for a given year, fingerling stocking numbers could be reduced and these fish held for stocking as yearlings in the fall when reservoir releases are reduced.

As of June 30, 1999, anglers had reported catching nine reward tagged chinook salmon downstream from Lake Oroville. Three of these fish (all 1993 BY) were reported caught in the Pacific Ocean. Three (one 1992 BY and two 1993 BY) were reported caught in the Feather River downstream from Lake Oroville, two 1994 BY from the South Forebay north of the town of Oroville, and one 1996 BY from a pond on the Oroville Wildlife Area south of town. Three reward tagged 1993 BY brown trout were also reported caught in the Feather River below the reservoir. All of these reward tagged fish were released in the reservoir as yearlings, so passage of these larger fish through the dam has been confirmed.

Low returns of reward tagged chinook salmon and brown trout may reflect the relatively low percentage of tagged fish (0.2 to 1.3 percent) in the population. Low numbers may be due to higher than expected tag shedding or mortality of tagged fish. We speculate that either of these or a combination may have occurred, however, numbers of salmon in all years were adequate to provide for a quality salmonid fishery characterized by high angler catch rates and when stocking numbers were less than or equal to 170,000 yearling chinook or yearling chinook equivalents, a trophy fishery component. We depicted a recommended fingerling and yearling stocking rate necessary to reach our minimum growth-at-age goals and provide for a trophy fishery (Fig. 9).

ACKNOWLEDGMENTS

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Table 1. Survey effort and estimated target angler catch rates for salmonids and black bass at Lake Oroville July 1993 through June 1999.

Year	Quarter	Number survey days	Number anglers contacted	Total hours fished	Total fish caught	Total fish kept	Total salmonids caught	Total bass caught	Total other caught	Coldwater hours fished	Bass hours fished	Salmonid catch per hour	Bass catch per hour
1993	3	36	826	4,567	2,280	497	163	1,826	291	853	2,343	0.19	0.78
	4	30	831	4,761	2,171	393	482	1,654	35	1,756	2,503	0.27	0.66
1994	1	27	1,236	7,396	2,042	864	1,143	898	1	4,080	2,907	0.28	0.31
	2	38	1,194	7,414	4,637	465	393	4,575	62	2,468	4,305	0.16	1.06
	3	33	826	4,734	2,795	731	413	2,336	46	1,341	2,502	0.31	0.93
	4	39	1,130	6,225	3,223	269	188	3,026	9	2,062	3,712	0.09	0.82
1995	1	38	1,293	7,710	3,209	478	471	2,737	1	2,598	4,774	0.18	0.57
	2	30	677	4,240	5,146	395	81	5,126	20	725	3,207	0.11	1.57
	3	38	694	3,798	2,665	541	342	2,276	47	889	2,452	0.38	0.93
	4	38	896	4,824	2,689	768	1,043	1,629	17	2,339	2,223	0.45	0.73
1996	1	40	1,185	6,790	3,801	1,472	1,921	1,878	2	3,444	3,215	0.56	0.58
	2	44	1,072	6,715	6,269	634	485	5,762	22	1,433	4,809	0.34	1.20
	3	41	717	4,114	3,235	747	629	2,592	14	1,403	2,398	0.45	1.08
	4	38	729	3,382	2,843	246	231	2,601	11	1,228	2,351	0.19	1.11
1997	1	43	851	4,665	1,998	109	13	1,984	1	675	3,854	0.02	0.51
	2	45	810	4,878	6,230	527	65	6,116	49	588	4,108	0.11	1.50
	3	39	553	3,021	2,687	386	79	2,582	26	526	2,290	0.15	1.13
	4	36	620	3,420	3,331	338	463	2,868	0	893	2,469	0.52	1.16
1998	1	43	929	5,470	3,581	236	471	3,110	0	1,203	4,146	0.39	0.75
	2	37	920	5,763	6,520	527	455	6,000	65	823	4,661	0.55	1.29
	3	32	312	1,861	1,289	185	250	1,020	19	401	1,177	0.62	0.87
	4	32	391	2,033	856	120	340	513	3	996	957	0.34	0.54
1999	1	34	563	3,067	1,489	181	304	1,185	0	909	2,045	0.33	0.58
	2	42	542	2,821	2,985	503	490	2,486	9	687	1,941	0.71	1.28
Totals/means		893	19,797	113,670	77,971	11,612	10,915	66,780	750	37,630	71,349	0.32	0.91

Table 2. Fish examined by species in Lake Oroville angler survey July 1993 through June 1999.

YEAR	CHIN	RT	BN	SPB	SMB	LMB	REB	PANF	CATF	TOTAL
93-94	1,492	7	99	313	104	33	3	40	39	2,130
94-95	672	6	70	756	160	98	27	31	35	1.855
95-96	2,229	29	227	621	126	39	76	38	14	3,399
96-97	649	16	22	633	26	63	186	26	11	1,632
97-98	645	9	2	631	10	28	133	65	17	1,540
98-99	556	11	6	259	4	18	68	19	12	953
Total	6,243	78	426	3,213	430	279	493	219	128	11,509
Percent	54.2	0.7	3.7	27.9	3.7	2.4	4.3	1.9	1.1	

Table 3. Salmonids and black bass kept and released by size group at Lake Oroville July 1993 through June 1999.

Size group	Number of fish kept	Number of fish released	Total	Percent of catch
		Salmonids		
< 305 mm	2,424 (48.3) *	2,594 (51.7)	5,018	45.9%
305 - 381 mm	2,222 (69.5)	975 (30.5)	3,197	29.3%
> 381 mm	2,100 (77.6)	605 (22.4)	2,705	24.8%
Subtotal	6,746	4,174	10,920	
		Black bass		
< 305 mm	2,601 (14.8)	14,941 (85.2)	17,542	26.4%
305 - 381 mm	473 (01.3)	35,923 (98.7)	36,396	54.8%
> 381 mm	1,353 (10.8)	11,154 (89.2)	12,507	18.8%
Subtotal	4,427	62,018	66,445	
Totals	11,173 (14.4)	66,192 (85.6)	77,365	

* Number in parenthesis is percent of total

Table 4. Numbers of coded wire tagged chinook salmon released and recovered at Lake Oroville May 1993 through June 1999.

Brood year	Total number fish released	Number effectively tagged fish released	Number of CWT salmon collected each year following release			Total
			Year 1	Year 2	Year 3	
1992	163,185	150,970	310	104	0	414
1993	159,600	141,882	139	51	0	190
1994	191,923	180,653	724	29	2	755
1995	256,276	237,301	167	125	(6)[1]	298
1996	355,495	324,922	196	(142)[1]	N/A	338
1997	456,143	336,173	(42)[1]	N/A	N/A	42
Totals	1,582,622	1,371,901	1,578	451	8	2,037

[1] Partial year (January through June) returns

Table 5. Numbers of CWT fingerling and yearling chinook salmon planted and recoveries by planting group at Lake Oroville, May 1993 through June 1999.

Brood year	Total Fish size	Number of number released	Total effectively tagged fish	Relative CWT recoveries	(%)	Approximate return — Year : Fing	'Yearling equivalent'
1992	Fing	102,585	96,430	91	(0.094)		
	Year	60,600	54,540	323	(0.592)	6.3 to 1	77,000
1993	Fing	104,400	89,166	6	(0.007)		
	Year	55,200	52,716	184	(0.349)	51.9 to 1	57,000
1994	Fing	101,922	97,743	245	(0.251)		
	Year	90,001	82,910	510	(0.615)	2.5 to 1	132,000
1995	Fing	105,841	98,750	34	(0.034)		
	Year	150,435	138,551	264	(0.191)	5.5 to 1	170,000
1996	Fing	105,267	96,214	26	(0.027)		
	Year	250,228	228,708	312	(0.136)	5.0 to 1	271,000
1997	Fing	106,143	102,534	(13)	(0.013)[1]		
	Year	350,000	233,639	(29)	(0.012)[1]	(1.0 to 1)	(422,000)
Totals	Fing	626,158	580,837	415			
	Year	956,464	791,064	1,622			
Grand total		1,582,622	1,371,901	2,037			

[1] 1997 BY returns available only through age 18 months.

Table 6. Chinook salmon 'yearling equivalent' stocking rate and length at age by BY at Lake Oroville May 1993 through June 1999.

Table 6. Chinook salmon 'yearling equivalent' stocking rate and length at age by BY at Lake Oroville May 1993 through June 1999.

Brood year	Number of 'yearling equivalent' stocked	No. fish per HA	Mean total length @ 12 mo.	Mean total length @18 mo.	Mean total length @24 mo.
1992	77,000	12.0	276 mm	392 mm	489 mm
1993	57,000	8.9	280 mm	318 mm	421 mm
1994	132,000	20.6	275 mm	362 mm	436 mm
1995	170,000	26.4	273 mm	325 mm	401 mm
1996	271,000	42.3	256 mm	298 mm	385 mm
1997	(422,000)	(65.9)	240 mm	302 mm	N/A
Total	1,129,000				

Table 7. Percent contribution of individual brood years to the salmon fishery at Lake Oroville July 1993 through June 1999.

	Calendar year						
Brood year	1993	1994	1995	1996	1997	1998	1999
Pre-1992	99.0%	58.3%					
1992	01.0%	41.4%	01.2%				
1993		03.0%	54.7%	02.7%			
1994			44.1%	93.5%	00.8%		
1995				03.8%	94.7%	26.5%	03.6%
1996					04.5%	68.4%	74.7%
1997						05.1%	21.7%

Table 8. Lake Oroville chinook salmon condition factor (K) by brood year.

	1992 BY		1993 BY		1994 BY		1995 BY		1996 BY		1997 BY	
Age in months	Mean TL[a]	K factor	Mean TL	K factor	Mean TL	K factor	Mean TL	K factor	Mean TL	K factor	Mean TL	K factor
13-15					318	0.99	270	0.92	277	1.07	287	0.98
16-18			290	0.74	349	0.96	310	0.91	283	1.02	303	0.98
19-21	470	0.79	412	1.10	381	1.07	327	1.04	344	1.00		
22-24	481	0.86	429	0.98	430	1.03	386	1.03	387	1.02		
25-27	511	0.88	484	0.92	430	0.97	414	1.02	422	0.91		
28-30	510	0.65	465	1.13	477	0.87	466	1.08	445	0.88		
31-33			597	1.10	443	0.94	554	1.23				
34-36			520	0.94	421	0.91	508	1.14				
Mean K		0.80		0.97		0.98		1.05		0.98		1.01

[a] TL is in mm.

Table 9. Catch, exploitation, natural mortality, and survival of Carlin tagged chinook salmon released at Lake Oroville 1993 through June 1999.

Brood year	Number of fish tagged	Number of tags returned Year 1	2	3	4	Total	First-year catch C1
1992	408	31	4	1	0	36	0.08
1993	793	76	8	0	1	85	0.10
1994	402	24	0	0	n/a	24	0.06
1995	1,300	6	3	n/a	n/a	9	0.00
1996	613	4	n/a			4	0.01
1997	796	n/a				n/a	n/a
Totals/means	4,312	141	15	1	1	158	0.04

Brood year	Number of tags removed	Number of tags in fishery	First-year exploitation u	Number fish kept	Natural mortality v	Annual survival s
1992	6	402	0.07	3	0.79	0.14
1993	13	780	0.09	76	0.82	0.10
1994	5	397	0.06	24	0.94	0.00
1995	8	1,292	0.00	6	0.66	0.33
1996	3	610	0.01	4	n/a	n/a
1997	0	796	0.00	n/a	n/a	n/a
Totals/means	35	4,279	0.04	141	0.80	0.14

Table 10. Catch, exploitation, natural mortality, and survival of Carlin tagged brown trout released at Lake Oroville 1993 through June 1999.

Brood year	Number of fish tagged	Number of tags returned Year 1	2	3	4	Total	First-year catch C1
1991	800	35	0	0	0	35	0.04
1993	598	18	8	0	0	26	0.03
Totals/means	1,398	53	8	0	0	61	0.04

Brood year	Number of tags removed	Number of tags in fishery	First-year exploitation u	Number fish kept	Natural mortality v	Annual survival s
1991	5	795	0.05	38	0.95	0.00
1993	6	592	0.09	23	0.66	0.31
Totals/means	35	1,387	0.04	61	0.81	0.15

Table 11. Electrofish catch per 1,000 seconds by species at Lake Oroville, August 1994 through June 1999.

Year	Effort (Sec.)	LMB	SMB	SPB	REB	BG	GSF	RSF	BCR	WCR	CCF	WCF	TFS	JPS
		Species caught												
1994	18,134	11.47	4.03	56.36	3.81	20.29	0.22	0.00	0.17	0.06	0.50	0.06	5.68	0.11
1995	37,689	12.18	1.96	22.50	2.10	7.35	0.37	0.00	0.58	0.00	0.48	0.21	0.61	1.46
1996	20,013	5.10	0.45	33.33	3.05	16.64	0.70	0.05	0.05	0.00	0.55	0.05	2.65	1.90
1997	28,290	2.72	0.25	42.38	3.89	7.60	0.67	0.28	0.07	0.00	0.46	0.07	1.13	3.39
1998	12,118	5.12	0.17	46.79	2.89	10.07	1.65	0.00	0.00	0.00	0.58	0.00	1.32	2.89
1999	9,078	3.75	0.11	35.80	1.76	12.56	1.43	0.00	0.33	0.11	0.11	0.00	0.00	1.98
Mean catch		6.72	1.16	39.53	2.92	12.42	0.84	0.06	0.20	0.03	0.45	0.07	1.90	1.96

Table 12. Lake Oroville spotted bass condition factors by brood year.

Age in months	Brood year 91	92	93	94	95	96	97	98
13-15					1.27	1.30	1.27	1.21
16-18		1.33		1.30		1.11	1.18	
19-21			1.29	1.21		1.13		
22-24			1.35		1.19		1.28	
25-27				1.30	1.20	1.24	1.26	
28-30	1.36		1.24		1.17	1.21		
31-33		1.43	1.27	1.31	1.17			
34-36		1.39		1.34		1.38		
37-39			1.33	1.22	1.31	1.11		
40-42		1.30		1.18	1.24			
43-45	1.33	1.32		1.24				
46-48	1.46		1.45		1.43			
Mean K	1.38	1.35	1.32	1.26	1.27	1.21	1.25	1.21

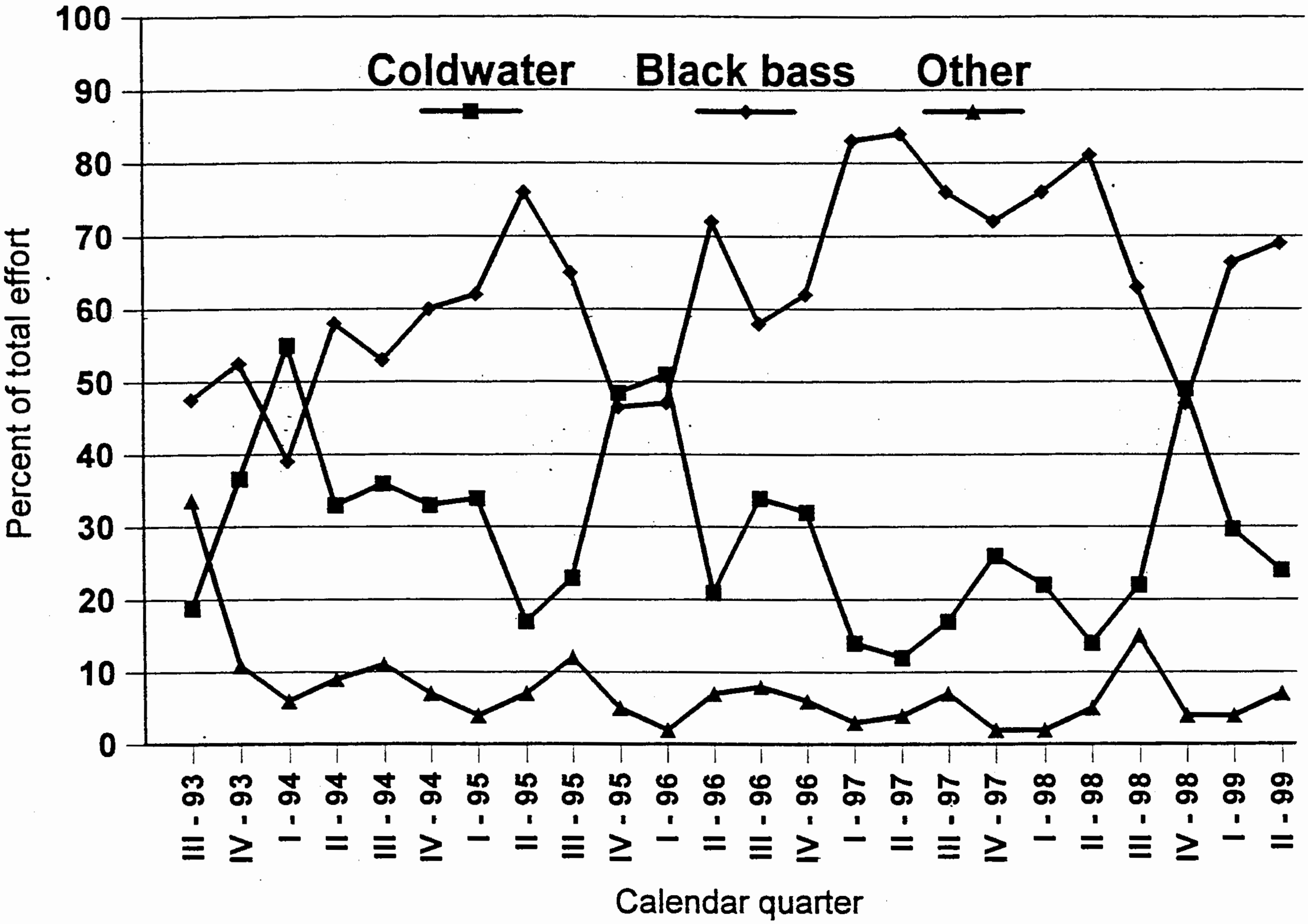

Figure 1. Angler effort by gear type at Lake Oroville, Jule 1993 through June 1999.

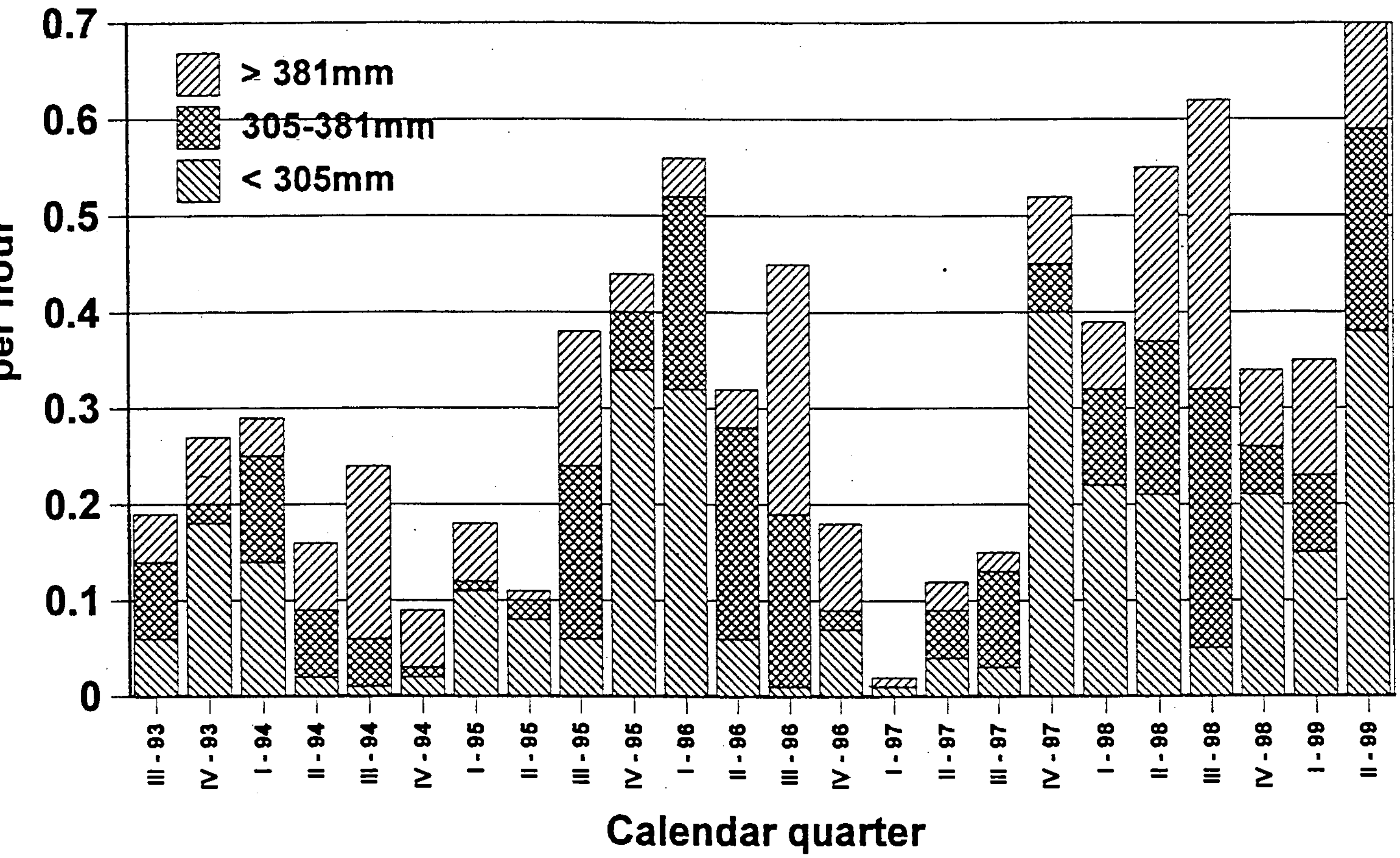

Figure 2. Salmonid catch per hour at Lake Oroville, July 1993 through June 1999.

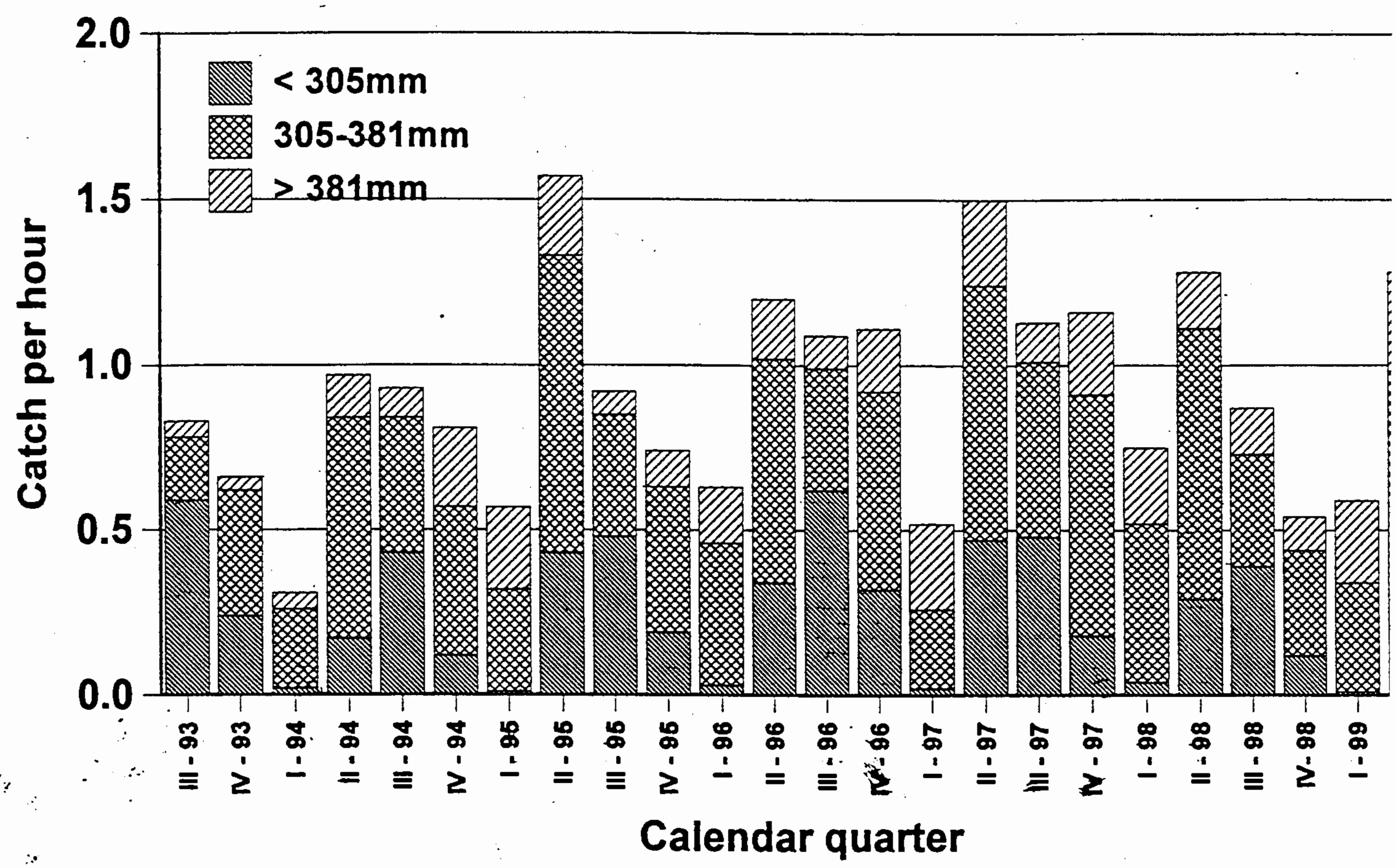

Figure 3. Quarterly black bass catch per hour rates for three size groups of fish at Lake Oroville, July 1993 through June 30, 1999.

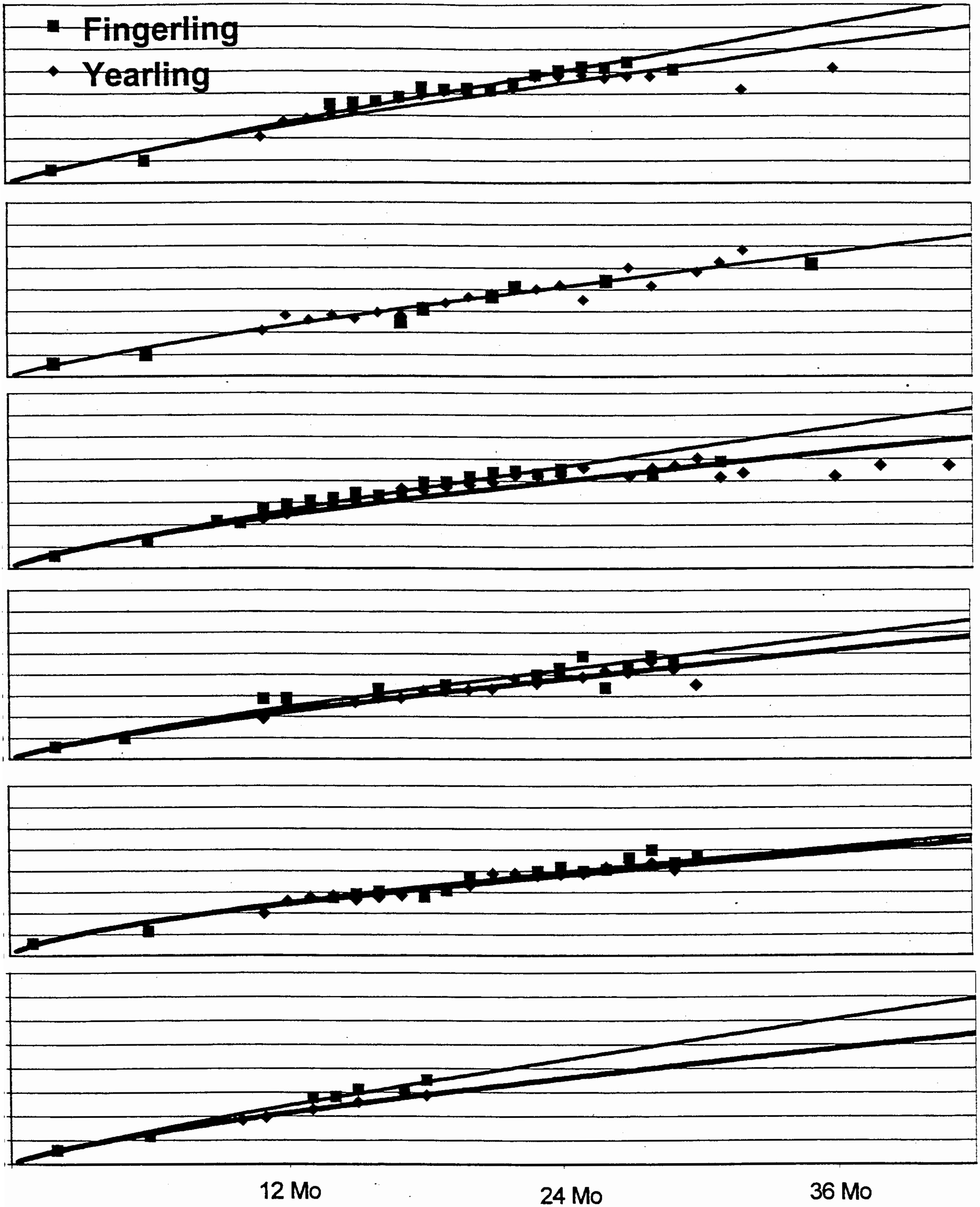

Figure 4. Mean total length at age of fingerling and yearling coded wire tagged chinook salmon from Lake Oroville, July 1993 though June 1999.

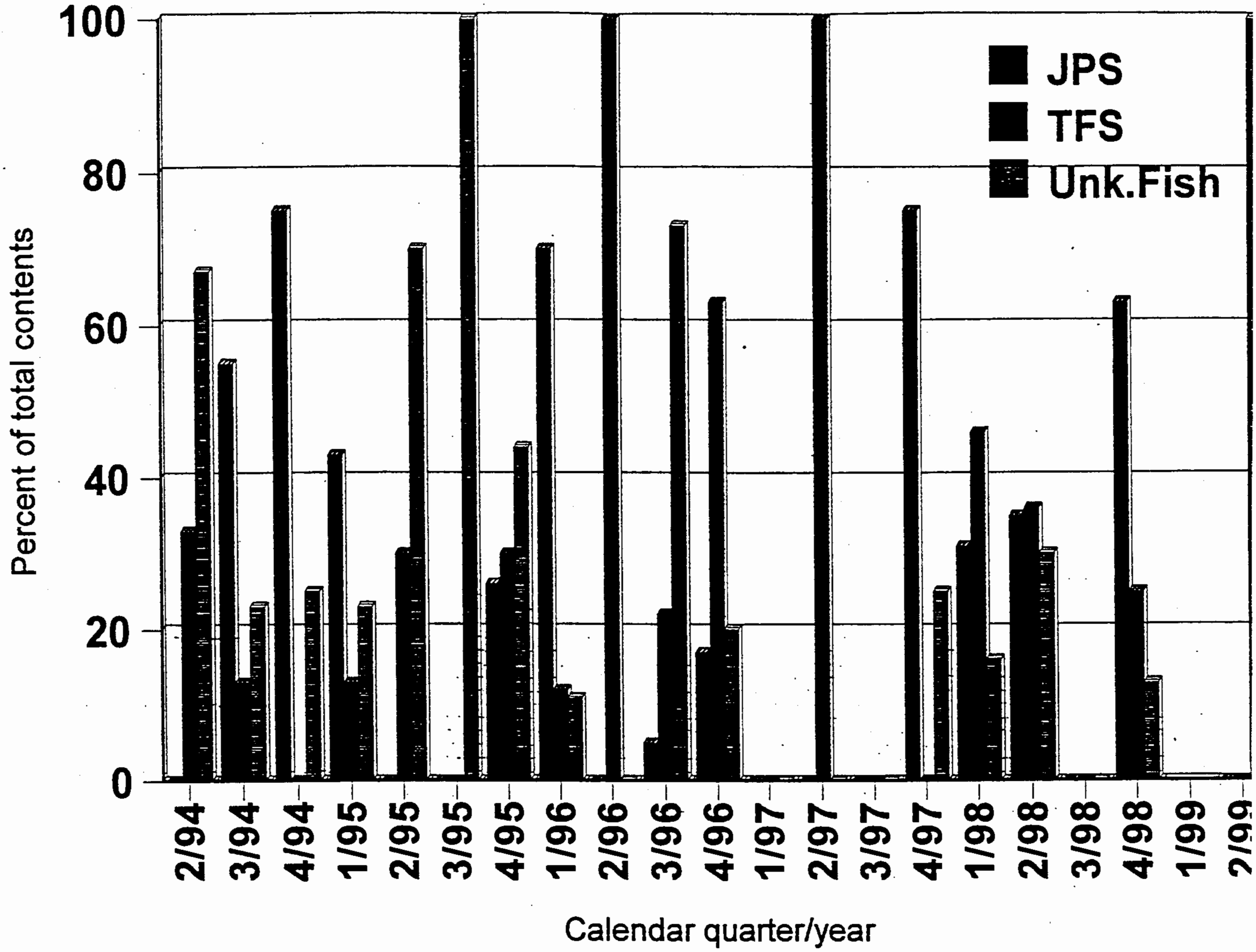

Figure 5. Chinook salmon stomach contents expressed as a percent of total composition collected at Lake Oroville, April 1994 through June 1999.

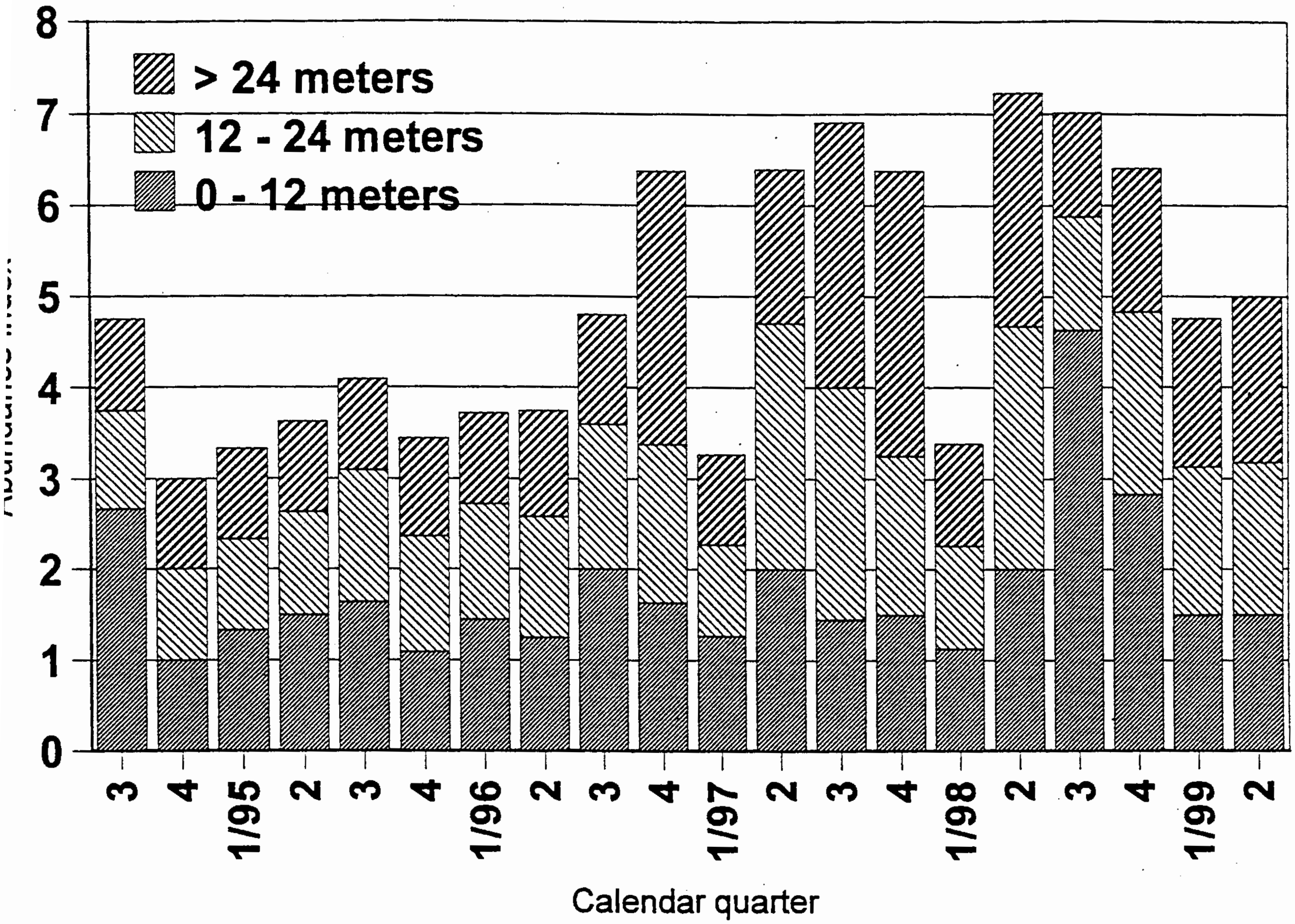

Figure 6. Index of forage abundance from hydroacoustic sampling, Lake Oroville, July 1995 through June 1999.

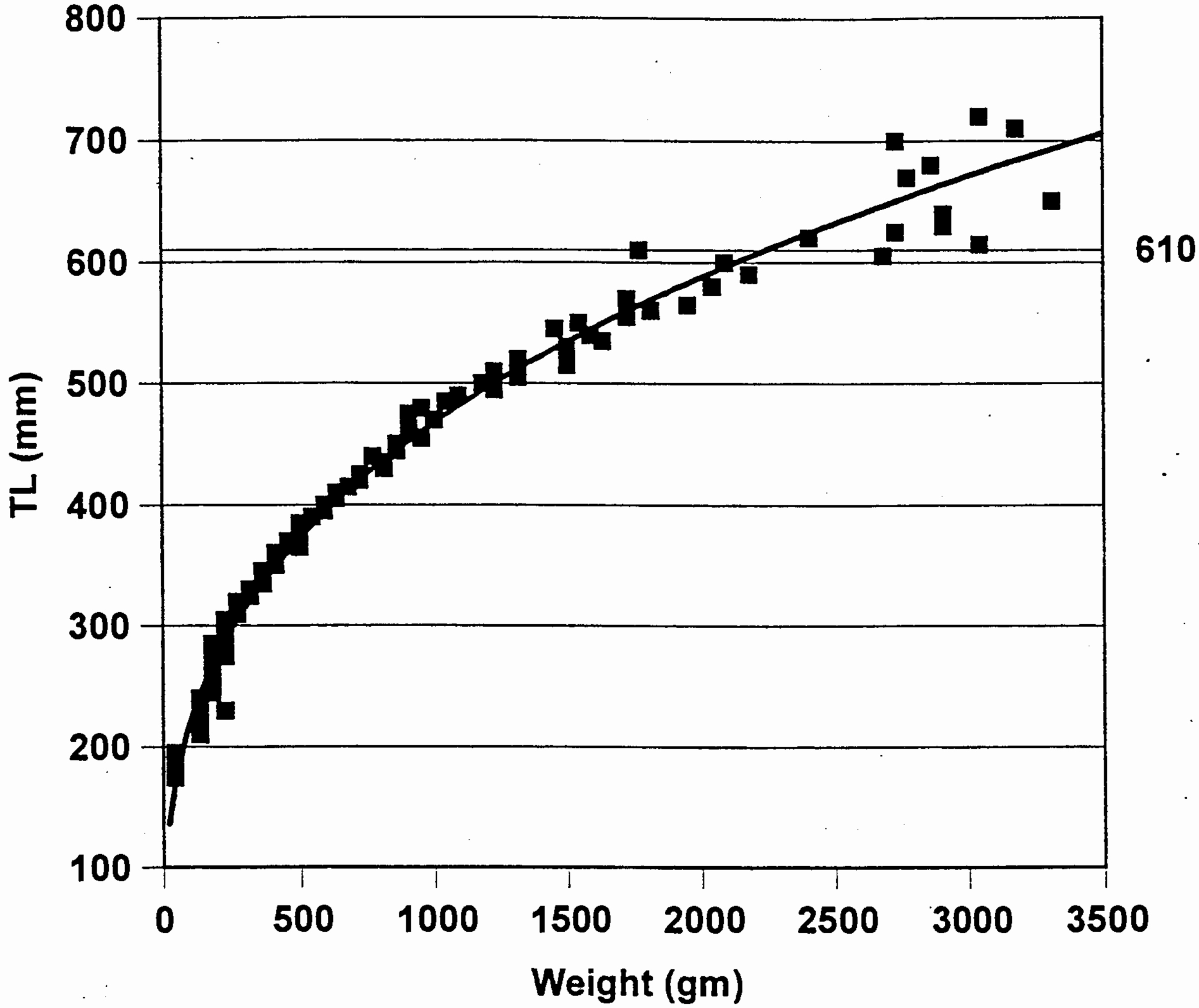

Figure 7. Length weight relationship of chinook salmon sampled at Lake Oroville, July 1993 through June 1999.

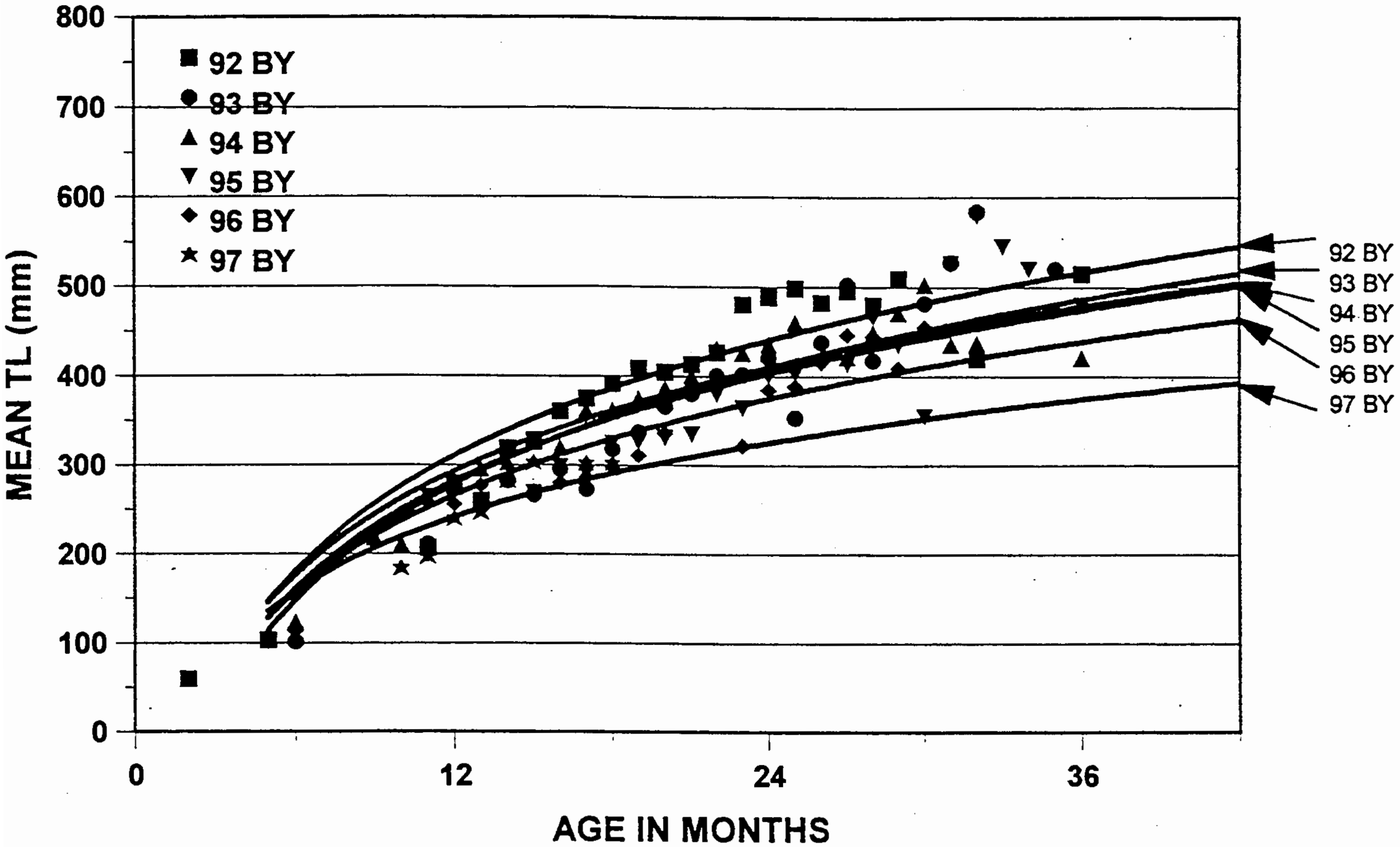

Figure 8. Mean total length at age of coded wire tagged chinook salmon collected at Lake Oroville, July 1993 through June 1999.

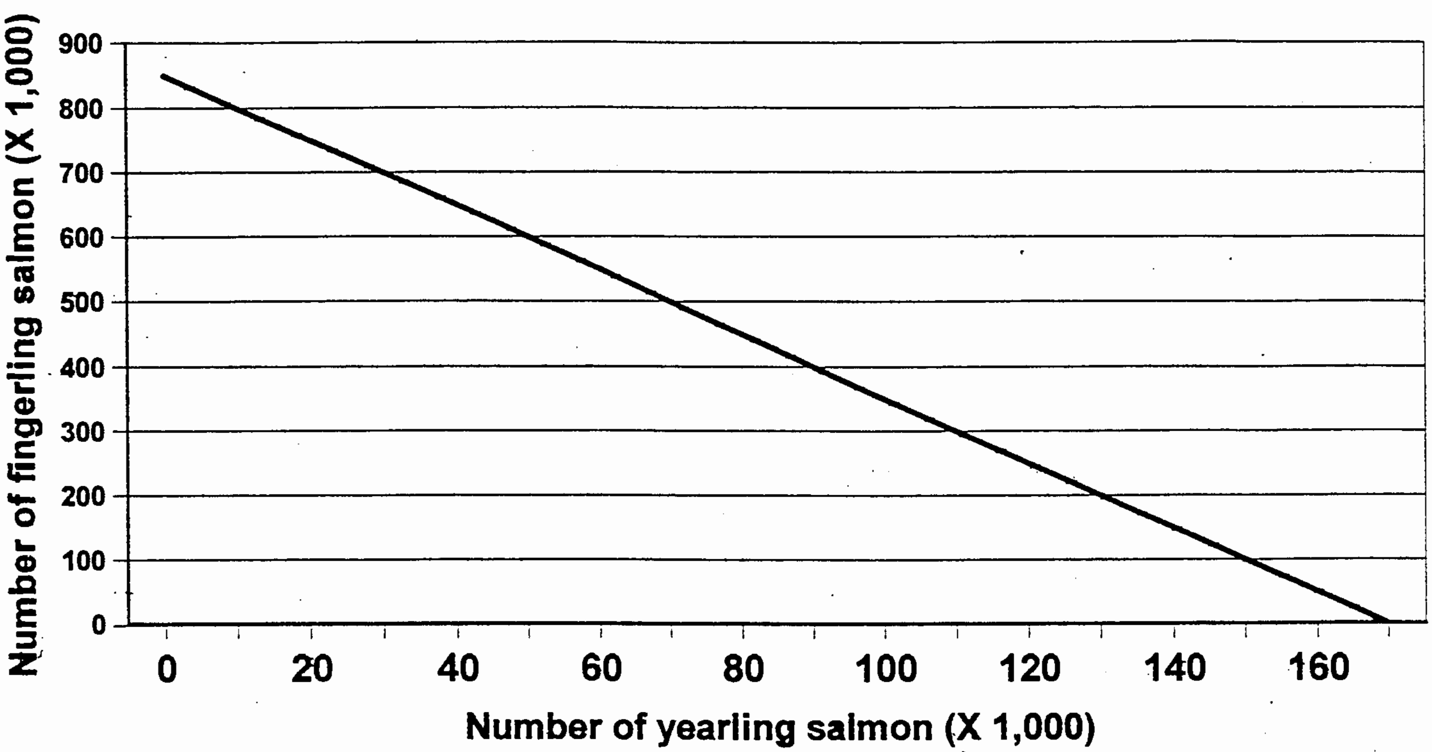

Figure 9. Recommended fingerling and yearling chinook salmon stocking numbers for Lake Oroville, Butte County.

Eagle Lake Trout Broodstock Program

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Abstract: A slide presentation discusses the operation of the Pine Creek spawning facility at Eagle Lake, California, which is responsible for the broodstock programs at Crystal Lake, Darrah Springs, and Mt. Shasta hatcheries. This is one of the most successful programs in the California Department of Fish and Game.

Eagle Lake, in Lassen County, is located in the northeastern part of California. It sits at an elevation of 5,100 feet and, with 25,0000 surface acres, it is the second largest natural lake in California. It has a maximum depth of 100 feet.

Because of the high alkalinity in Eagle Lake (pH of 8.4 to 9.6), the Eagle Lake trout is the only trout that can survive and are indigenous to the lake.

In 1949, a trap was constructed on Pine Creek to count the fish. Approximately 45 fish were counted each year during the following 5 years. In 1959, 16 fish were spawned, the eggs taken,and hatched and reared at Crystal Lake Hatchery before being stocked back into the lake. From those 16 fish has grown a fishery that today sees several thousand fish swimming into the trap each year. Just less than 5,700 fish were reported at the trap during the spawning season this past year.

Adobe Creek Restoration Project

Authors: Dan Hubacker and Kim Illian, Casa Grande High School, 333 Casa Grande Rd. Petaluma, CA 94954

Adobe Creek Restoration Project and Salmon and Steelhead Trout Fish Hatchery offers students a creative approach to learning through:

- Integration of science and mathematics with an emphasis on aquatic environmental studies (grades K-12).
- Utilization of hand-on techniques by working in a "live" environment.
- Student-initiated problem solving and higher level thinking.
- Collaboration with peers and mentorship with science and technology experts.
- Involvement of the local and business communities in education.
- Cooperation between students and government officials with a single goal - save a species from extinction.

YOUTH TAKING ACTION

As part of the ongoing task of educating others on Environmental Awareness, the students of Casa Grande High School are putting a plan in action to incorporate students of all ages, kindergarten through college, into the Adobe Creek Restoration Project: *to heal a stream, repair its habitat, and save a fish from extinction.*

These students often give up their lunch hours, evenings, and weekends to put in extra hours at the hatchery and in the creek. The jobs they do go far beyond that of taking out the garbage and sweeping the floor. They use the knowledge and skills of well trained marine biologists every time they step into the hatchery or a creek. And though each member is an extraordinary student, it isn't because they are on the honor roll or have a block in every sport. It's because they care enough to meet the challenge and make a difference.

ABOUT THE PROJECT

Background

Petaluma, California is typical of any small community found in America. It's 48,000 people spend many hours commuting to San Francisco. Their lives are filled with average daily thoughts, the furthest of them being the welfare of a little creek in their hometown. Once the major source of drinking water, in 1880, Adobe Creek's seven mile course was unfortunately typical; polluted, diverted, trashed, and abused. Until Adobe Creek was finally declared dead by state officials. What was once the main attraction to the Petaluma Valley in 1830, was now a public embarrassment.

The Need for the Project

Three situations that led to the creation of our Adobe Creek Restoration Project at Casa Grande High School:

1) The city, county, and state had given up on nearby Adobe Creek. It was labeled "dead" and a nuisance, and plans had been drawn up to put it in an underground tube.

2) The Adobe Creek Steelhead Trout would become extinct without direct human intervention to save its dwindling numbers.

3) Young people were looking for a way to feel connected to their environment and a positive outlook on their future. They were very concerned about the degradation of the earth environment and wanted to better current conditions.

Four Goals of the Restoration Project

I. The Complete Ecological Restoration of the Entire Seven Mile Long Creek

How this goal was achieved:

1983 - conditions of creek before project

- City of Petaluma diverting 100% of the water flow into the water reservoir system.
- lower 5 miles of creek devoid of riparian habitat
- occasionally salmon and steelhead trout seen
- littered, polluted, and channelized
-

1996 - conditions of creek after 13 years of restoration by students

- The City of Petaluma takes down **all** water diversions. The stream was set free after 100 years, the entire 7 miles of creek have water.
- students plant 1,100 trees per year to provide shade and a riparian habitat
- over 25 tons of debris cleaned from creek
- 64 steelhead return to spawn in 1995

II The Protection of the Biological Diversity and Genetic Variability

How this goal was accomplished:

- Protection of genetic variability is a crucial ingredient to the success of the project and the future existence of the Adobe Creek steelhead trout and the chinook salmon.

How this will continue to be accomplished by students:

- Shadowing the scientists at nearby Bodega Bay Marine Labs, students are on the leading edge of current developing technology. Several members of United Anglers of Casa Grande High School have taken up intern positions at the lab, where they work with scientists in the fields of Pathology, Broodstock Development, and Genetic Analysis.

- The coordination of collection of steelhead trout and chinook salmon material for analysis at Bodega Bay Marine Lab. The results are plotted and graphed, then returned to the facility at Casa Grande High School. This allows students the opportunity to perform correct spawning procedures. This technology allows genetic variability to remain intact.

III. The Development of a Fisheries Research Facility / Conservation Hatchery on the Casa Grande High School Campus

1983 - students undertake task of creating a site which would provide the following:

- a "state of the art" education facility to study the genetic structure of these fish
- a site which would serve as an "insurance policy" to preserve genetic material
- an alternative safe site for up to 50,000 Steelhead Trout in case of a creek-related problem

  source to supplement naturally spawning fish
- a site in which fish could be housed to "buy time" until conditions in the entire system have recovered

1993 - After several years the hatchery is born!

- Students raised over **$510,000.00** to complete the facility by April 1993, a triumph of determination! The site is currently meeting all of the above objectives.

IV. The Education of an Entire Community

The Goal to educate ALL:

- Local newspapers, TV, and radio stations have publicized the project; many to the point of winning National Press Awards.
- door-to-door educational campaign by students and parents
- public speaking engagements to community service groups, businesses, corporations, and schools
- Over 6,000 people have toured our research facility.

The Results of Our Efforts are Proof Positive

What the Adobe Creek Restoration Project has done for the Fish Population

- Returning chinook salmon in Petaluma Watershed
- Returning native steelhead in Adobe Creek

What the Project Has Done to Better Students' Lives

Examples:

- instills self-esteem and gives students a feeling of self-worth
- promotes great interest in school and learning
- stimulates interest to continue education encourages others to "follow suit"
- provides opportunity for students to see the "real world"

- demonstrates positive role of team work
- gives students a feeling of pride and accomplishment

Budget Needs

This project's single largest monetary need lies in its operating budget. Students maintain a fully functioning Fish Research Facility / Conservation Hatchery, and are responsible for on-going maintenance of Adobe Creek. Funds are presently needed for repair, replacement, and modernization of the hatchery facility mechanical systems (ozone disinfectant system replacement, replacement of water chiller with a larger unit, repair water pump system for raceways). All donations given to this project go toward support of the students' efforts in Adobe Creek and the Hatchery. **This project has no administrative costs.**

United Anglers of Casa Grande High School is a tax deductible entity, non-profit organization, which is eligible to receive **tax deductible** donations. The school maintains its own non-profit tax ID number. If you would like to make a donation, contact us through the at the address above.

Summary

Evidence has shown that the effort of these students has brought the Adobe Creek Steelhead Trout and Adobe Creek itself back from the EDGE OF EXTINCTION. With your help and support we can keep this project alive for generations. . .**KEEP THE DREAM ALIVE!**

PROJECT HIGHLIGHTS

1910-1983

Adobe Creek in Petaluma, California is deemed "dead" by community and state officials as a result of city water diversions which take 100% of Adobe Creek water. *All downstream life dies.*

1984

Students form the group, United Anglers of Casa Grande High School, and officially adopt Adobe Creek in an effort to see if they can really make a difference in its environmental condition.

1984

Massive creek cleanup begins: over 30 truckloads of illegally dumped waste is hauled out of Adobe Creek *(e.g., stoves, refrigerators, tires, old engines and car parts, etc.)*

1985

Student tree planting project begins and continues through today, averaging 1,200 trees annually.

1986

Fund raiser nets $6,000 to convert abandoned on-campus green house into a student operated fish hatchery.

1987

Approximately 2,000 baby steelhead trout are rescued from drying summer pools.

City rejects students request to release water diversions blocking Adobe Creek

1988

Fish Hatchery building closed and condemned after failing earthquake standards.

Graduates fill seats in local Natural Resource and Environmental college programs throughout the state.

1989

Students line the creek in February, as 21 of their fish return to spawn.

County works project bulldozes 200 3-year-old redwoods planted by students, valuable shade area lost.

Students begin stocking the Petaluma River with striped bass, also involves elementary school and local business groups.

1990

FIVE King Salmon return to spawn in Adobe Creek: first time documented this century.

Ground breaking takes place for a new state-of-the-art on-campus conservation fish hatchery, estimated cost: $510,000.

1991

Students begin massive fund raising, over 200d students apply for one of the 20 spots in UACG.

1992

Oldest Redwoods, planted in 1985, are stolen.

After 100 years, the city of Petaluma announces it's plan to abandon all water diversions on Adobe Creek, giving it back to nature and the United Anglers of Casa Grande High School.

Students reach goal of $510,000, enabling the completion of the hatchery by Spring 1993.

1993

Past and present members of the United Anglers of Casa Grande High School show their pride at the grand opening if their state-of-the-art on-campus fish hatchery, April 25, 1993.

1994

Federal Government grants the Casa Grande fish hatchery a permit to raise Winter Run Chinook Salmon from the Sacramento River, a registered endangered species; becoming one of three nationally selected hatcheries to participate in the project, and the only student group.

1995

Students rescue 38 adult chinook salmon from warm water conditions in Petaluma River.

1996

"ESPN Outdoors" with Jerry McKinnis airs fourth documentary on our project.

1997

Director of Fish and Game, Jacquelin Schafer, spends over 4 hours visiting creek, hatchery, and individual talks with students.

1998

Main electrical transformer on school grounds explodes, causing power outage in hatchery. Our back-up generation performs well for 72 hours, then QUITS. Repair costs exceed $25,000 to generator and over $15,000 to related electrical equipment. Power outage lasts for 43days and causes students to monitor system24 hours a day for all43 days. Fund raisers still underway to repair equipment. World renowned primatologist and environmentalist Dr. Jane Goodall visits to honor students for16 years of hard restoration work leading to the saving of Adobe Creek steelhead trout from extinction.

EDUCATIONAL INSTITUTIONS INVOLVED WITH THE ADOBE CREEK RESTORATION PROJECT

COLLEGES

University of California - Davis
Humboldt State University
Sonoma State University

HIGH SCHOOLS

Casa Grande High School**
San Antonio High School

JUNIOR HIGHS

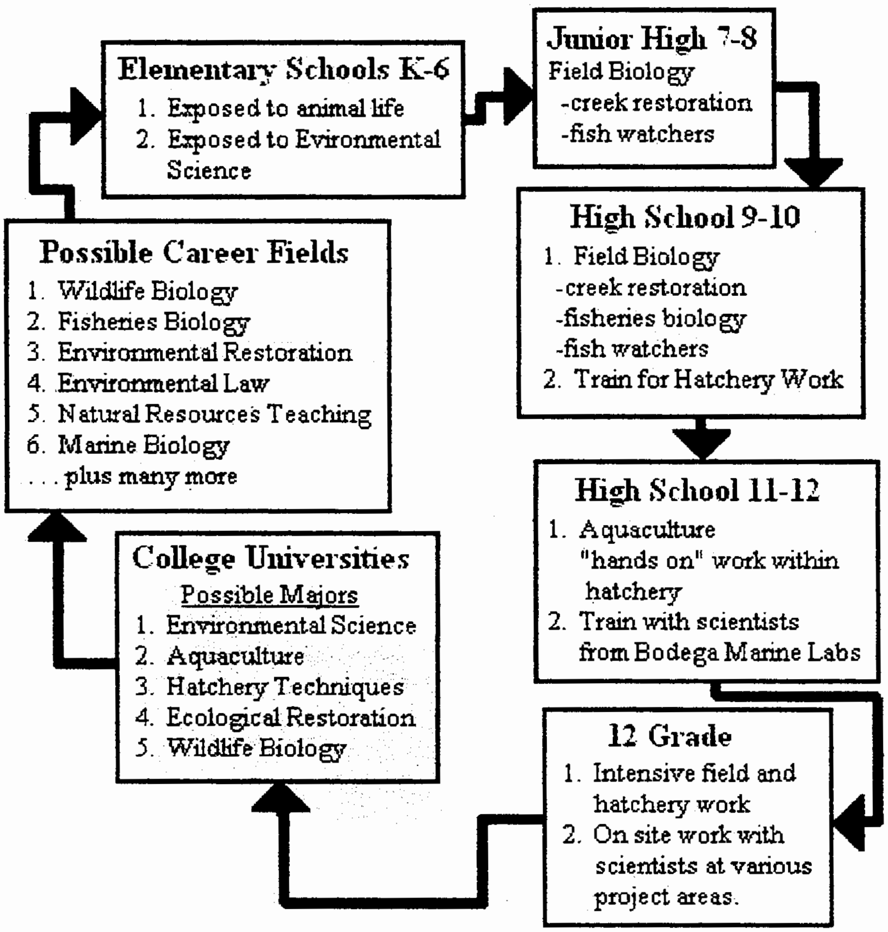
Kenilworth Junior High

ELEMENTARY SCHOOLS

Miwok Valley Elementary
Bernard Eldridge Elementary
Old Adobe Elementary
La Tercera Elementary
Cherry Valley Elementary
Valley Vista Elementary
Grant Elementary
McDowell Elementary
McKinley Elementary
McNear Elementary
Penngrove Elementary
Marin Primary

EDUCATION CYCLE FOR CREEK RESTORATION CREATED BY ADOBE PROJECT

A Model for National Environmental Education, "Changing the way we learn in America."



Long Live the Kings - Restoring Wild Salmon

Authors: Barbara Cairns, Kathleen Hopper – presenter, and Michael Kern, Long Live the Kings, 1305 Fourth Avenue, Suite 810, Seattle, WA 98101, (206) 382-9555 (W), : (206) 382-9913 (F), lltk@lltk.org,

Abstract: Long Live the Kings (LLTK) is a non-profit organization whose mission is to restore wild salmon to the waters of the Pacific Northwest. Since 1986, LLTK has created on-the-ground and in-the-river recovery projects designed to rescue and rebuild imperiled salmon runs. LLTK is known for developing and demonstrating innovative fish rearing techniques, empowering local communities to establish watershed recovery plans, and creating community-based project partnerships between tribal, business, government and non-profit leaders. In recent years, LLTK has gained a reputation for involving strategic and innovative thinkers and stimulating private sector involvement in long standing salmon management and recovery issues. LLTK's unique experience and approach is being recognized as an essential aspect of wild salmon recovery in the region. LLTK's projects fall into four categories: 1) The Endangered Species Act and the Private Sector; 2) Hatchery Reform; 3) Wild Salmon Rearing and Habitat; 4) Community Building.

The Endangered Species Act and the Private Sector

In 1999, much of Washington state's most densely populated urban corridor was declared the critical habitat of endangered chinook salmon, the first time in the history of the federal Endangered Species Act that cities have been challenged to save fish. While timber and agricultural communities and traditional fishing interests know the score, a host of new players is now being thrust upon center stage. Long Live the Kings seeks to involve the insurance, banking, aerospace, software industries and private landowners and organizations in a meaningful role in the recovery of Puget Sound chinook.

LLTK's belief that private sector leadership is critical to wild salmon recovery has been borne out time and again. From serving on policy committees to directing innovative rearing projects to facilitating and communicating statewide hatchery reform efforts, the unique attribute LLTK brings to the table is the type of energy, know-how and resources that are keys to success in the private sector. Partners and funders in these activities include The Bullitt Foundation, Washington Roundtable, Meridian Institute, and Greater Seattle Chamber of Commerce.

Tri-County Salmon Recovery

LLTK serves as a member of the Executive Committee of the Tri-County (Snohomish, King, Pierce) Puget Sound Chinook Recovery Council. We serve alongside mayors, city and county council members, tribal, federal and state agency representatives, and private sector interests. While there are 12 counties in the Puget Sound watershed, these three have begun the process of working together to develop a coordinated recovery plan that addresses the particular needs of densely populated, heavily urbanized and industrialized areas newly charged with the responsibility of recovering dying salmon runs. The Council is preparing the counties' 4[d] application for fall, 2000 (rules promulgated under section 4[d] of the federal Endangered Species Act identify what constitutes a "take" of a listed species).

Puget Sound Salmon Collaboration (formerly Washington Salmon Collaboration)

LLTK helped design and staff, and was a founding member of the Washington Salmon Collaboration, an effort convened and chaired by Bill Ruckelshaus to make early, joint recommendations on salmon recovery from environmental and business leaders, while urging strong leadership from the Governor's office in developing a long-term recovery plan for Puget Sound chinook. The effort also included working closely with the western Washington treaty tribes and the National Marine Fisheries Service. The group disbanded, having achieved its purpose of creating joint recommendations. A March 1999 Statement from the Collaboration is available from the LLTK web site Publications page or by contacting LLTK administrative office.

Puget Sound Salmon Leadership Forum

The Collaboration referenced above cited the need for a Puget Sound-wide forum to address wild salmonid recovery in a coordinated way. LLTK helped design and staff the resulting Puget Sound Salmon Leadership Forum, chaired by Bill Ruckelshaus and Senator Dan Evans. This event brought together over 200 leaders from around the Sound and resulted in a call for a regional, shared strategy for salmon recovery. That shared strategy is currently under development and will be presented at a follow-up forum this fall. LLTK will serve on the steering committee for that forum.

Puget Sound Salmon Foundation

LLTK has served as fiscal agent for the nascent Puget Sound Salmon Foundation, which plans to seek, receive and distribute funds from the private sector for salmon restoration and protection, based on scientific criteria.

Chamber Leadership Conference

LLTK was asked by the Greater Seattle Chamber of Commerce to help steer development of its 1998 Leadership Conference, Saving Salmon in An Urban Setting. Chaired by Bill Ruckelshaus and Christine Gregoire, this conference was held in October 1998 in Vancouver, B.C. LLTK co-chaired a breakout session, leading 100 participants through an exercise designed to determine, "What are the Priorities, and How do We Pay for Them?"

Hatchery Reform in Puget Sound & Coastal Washington

For 15 years, LLTK has been conducting projects that demonstrate how hatcheries can be used to help restore wild salmon. Now, Washington's state, tribal and federal salmon co-managers have committed to doing system-wide what LLTK has being doing one stream at a time. The Hatchery Reform Project is a systematic, science-driven redesign of how hatcheries will be used to achieve new purposes: 1) helping to recover and conserve naturally spawning populations and 2) supporting sustainable fisheries. The U.S. Congress specified LLTK as the project's independent, third party facilitator. Partners and funders include the U.S. Fish and Wildlife Service, Washington State Department of Fish and Wildlife, Northwest Indian Fisheries Commission, and National Marine Fisheries Service.

The History of Hatcheries: Management for Production

There are approximately 100 hatchery facilities in Puget Sound and Coastal Washington operated by the Washington State Department of Fish and Wildlife (WDFW), Puget Sound and Coastal Indian Tribes, and the US Fish and Wildlife Service (USFWS). These hatcheries produce more than 100 million juvenile salmon and steelhead every year, playing an important role in the North Pacific sports and commercial fishing economy and in meeting tribal treaty harvest obligations. In operation for decades, most hatcheries were built to produce fish for harvest, compensating for declines in wild salmon populations.

Hatcheries have generally been successful at fulfilling this purpose. However, they have also been identified as one of the factors responsible for the depletion of wild salmon stocks. Some facilities have stressed wild fish, kept smolts from getting downstream and spawning fish from getting upstream, and lowered water quality. Physical and genetic interactions between wild and hatchery fish may have weakened natural stocks. Hatchery management decisions have often been piecemeal, not system-wide.

The Future of Hatcheries: Management for Sustainable Fisheries and Helping Recover Wild Stocks

With several Puget Sound and Coastal salmon and steelhead stocks listed or proposed for listing under the federal Endangered Species Act (ESA), producing fish for harvest can no longer be the sole purpose of hatcheries. As part of a larger recovery process, state and tribal co-managers of Washington's salmon and steelhead resources must ensure that their hatcheries do not present a risk to listed species. But the co-managers are seeking to go beyond merely complying with ESA directives that hatcheries be operated to minimize risks to endangered fish. They have embraced a new vision of reforming hatchery programs to provide benefits to the process of recovering wild salmon and providing sustainable fisheries. The co-managers have established a Hatchery Reform Coordinating Committee to work together on the "big picture" of this effort to reform hatcheries. Enthusiasm for this new approach is high.

The Hatchery Reform Project

In 1998, Senator Slade Gorton (R-WA) convened a group of leading scientists representing federal, state and tribal agencies to advise him on salmon hatchery reform. In May 1999, this Gorton Science Advisory Team presented its recommendations in a report entitled The Reform of Salmon and Steelhead Hatcheries in Puget Sound and Coastal Washington to Recover Natural Stocks While Providing Fisheries. The report determined that the potential exists for hatcheries to have a major positive impact on the recovery of wild salmon, in just a few years and at relatively small costs. The team called for a comprehensive hatchery reform effort led by a panel of independent scientists to conserve indigenous genetic resources; assist with the recovery of naturally spawning populations; provide for sustainable fisheries; conduct scientific research; and improve the quality and cost-effectiveness of hatchery programs.

With the support of Senator Gorton, Congressman Norm Dicks (D-WA) and Washington Governor Gary Locke, the US Congress adopted and funded the Gorton Science Advisory Team's recommendations in fiscal year 2000, launching the Puget Sound and Coastal Washington Hatchery Reform Project. The appropriations language provided funding to:

- Establish an independent scientific panel to ensure a scientific foundation for hatchery reform;
- Provide a competitive grant program for needed research on hatchery impacts;
- Support state and tribal efforts to implement new hatchery reforms; and
- Provide for the facilitation of a reform strategy by an independent third party.

LLTK was specified in the appropriation as the project's third party facilitator. Having operated our own facilities for 15 years, LLTK understands Washington's unique state and tribal co-management regime like no other non-profit organization and has strong relationships with these co-managers. LLTK works with the full range of stakeholder interests from the business community to salmon advocates and coalitions, schools, Native American tribes, scientists and the academic community, farmers, commercial and sport fishing groups, and local, state and federal agencies. This puts us in a unique position to promote reform.

LLTK's role includes providing facilitation and staff support to the Project's scientific panel and policy-level Hatchery Reform Coordinating Committee; and helping the state and tribal co-managers of Washington's salmon and steelhead resources communicate hatchery reform progress to Congress, state legislators, stakeholder groups and the public. Additionally, LLTK was invited to be a member of the Coordinating Committee.

Comprehensive Reform Driven By Independent Science

The Hatchery Scientific Review Group (Scientific Group) is the independent scientific panel established by Congress to ensure that hatchery reform programs in Puget Sound and Coastal Washington be scientifically founded and evaluated; that independent scientists interact with agency and tribal scientists to provide direction and operational guidelines; and that the system as a whole be evaluated for compliance with scientific recommendations. The objective of the Scientific Group is to assemble, organize and apply the best available scientific information to provide guidance to policy makers who are implementing hatchery reform.

The Scientific Group is composed of five independent scientists (selected by the Gorton Science Advisory Team from a pool of candidates nominated by the Past Presidents Council of the American Fisheries Society) and four agency scientists designated by WDFW, the Northwest Indian Fisheries Commission (NWIFC), NMFS and USFWS. Like the independent scientists, the agency scientists are responsible for evaluating scientific merits and are not to represent agency policies.

Where Does the Process Stand?

The Scientific Group is coordinating its activities and work products so that they are compatible with and build on the efforts of the co-managers. The Scientific Group has funded an initial round of research and has completed a scientific framework. It is working with the co-managers on an action plan for regional review and reform of the Puget Sound and coastal hatchery system. The Scientific Group and LLTK reported to Congress in June 2000 on progress made and work remaining.

Wild Salmon Rearing and Habitat

Glenwood Springs, Orcas Island

With wild salmon populations depressed and facing federal Endangered Species Act (ESA) listing throughout Puget Sound, LLTK brought chinook salmon and a natural rearing program to an Orcas Island stream. This new fishery diverts pressure from wild runs and provides salmon for sport and commercial fishers from Oregon to Alaska. Now, LLTK is working with the National Marine Fisheries Service to explore the feasibility of creating a naturally-spawning, self-sustaining chinook run at Glenwood, thereby exploring a significant scientific unknown in salmon recovery planning. Partners and funders at Glenwood include LLTK Board Chairman Jim Youngren and his wife Kathy, the Washington Department of Fish and Wildlife, YMCA's Camp Orkila, Moran State

Park, Orcas Island schools, and approximately two dozen Orcas Island residents (from shop owners to neighbors to school kids to fishermen) who volunteer to assist with the yearly spawning activities.

Lilliwaup, Hood Canal

An emergency room for imperiled fish, the captive brood stock facility at Lilliwaup-built entirely with private funds helps preserve the genetic blueprint of endangered Hood Canal summer chum salmon and steelhead. LLTK is also returning naturally spawning chinook salmon runs to the Hamma Hamma and Duckabush rivers. Partners and funders include the Hood Canal Salmon Enhancement Group, private landowners, U.S. Fish and Wildlife Service, National Marine Fisheries Service, Point-No-Point Treaty Council and Washington State Department of Fish and Wildlife.

Willapa River

Federal and state-driven recovery plans will require rethinking the way we use and manage hatcheries. As part of a 5-year project concluding in 2000, LLTK and its Willapa Project partners have already modified hatchery rearing ponds to simulate conditions found in nature. The results have been encouraging. The project has also been developing recommendations for more effective and natural rearing techniques that can be implemented at all hatcheries. State agency and academic scientists plan to continue the work started by LLTK. Partners and funders include the National Fish and Wildlife Foundation, National Marine Fisheries Service, University of Washington Center for Streamside Studies, Washington Department of Fish and Wildlife, and Weyerhaeuser Company Foundation.

Wishkah River

LLTK's Wishkah River Project helps restore depleted chum, chinook, and coho salmon runs in the Chehalis Basin by capturing wild adults, spawning them, raising their young in natural ponds, and releasing them back to their native river. LLTK has turned a small, state-owned hatchery into a unique facility supporting wild salmon recovery, refinement of natural rearing techniques, habitat development and restoration, and a popular Grays Harbor fishery. Partners and funders include WDFW, USFWS, the Weyerhaeuser Company, Roglins Construction, Thompson Construction, Hancock Timber Resources Group, the Cheney Foundation and the Archibald Foundation. The project enjoys dozens of volunteers and donations from long-time supporters in the basin, such as the Chehalis Basin Fisheries Task Force, Ocosta High School, Elma Game Club, Grays Harbor Chapter of Trout Unlimited, and the Grays Harbor Poggie Club. Habitat improvements have been made in partnership with Simpson Timber and GeoEngineers, and with equipment provided by ITT Rayonier, MRGC, the Campbell Group and the Weyerhaeuser Company.

Community Building

LLTK's community building projects seek to provide the tools and resources needed to foster and support community leadership in wild salmon recovery. The focus is on innovation and the needs of individual watershed communities in building collective will and action.

Skagit Watershed Council

In the Skagit River watershed, LLTK's community building activities revolve around the Skagit Watershed Council, which LLTK helped form and now chairs. The Skagit River watershed (containing the third largest river on the west coast) is best known for its colorful rows of tulips in lowland fields each spring, and for historically abundant salmon runs heading toward hundreds of miles of tributaries. All six species of salmon make their home in this watershed, as does one of the nation's largest populations of wintering bald eagles. A federally designated Wild and Scenic River, the Skagit contributes 35% of the fresh water in Puget Sound.

Tribal fishing and commercial and family farming have been at odds over Skagit watershed resources for the last 100 years. Now, these interests have agreed to work together around the same table to develop a comprehensive restoration and protection strategy for endangered salmon. This common table is the Skagit Watershed Council, an unlikely coalition of farmers, tribal members, conservation groups, timber companies, small landowners, and local, state, and federal government representatives.

LLTK helped form the Council in 1997 as a way of creating a comprehensive and integrated salmon restoration and protection strategy where only piecemeal, non-scientific restoration efforts had prevailed. The Council is the only non-governmental organization in the state to be named a lead entity for watershed habitat recovery activities. Partners and funders include the Northwest Area Foundation and the 36 businesses, state, tribal and federal agencies, and non-governmental organizations that are members of the Council.

Hood Canal Community Building

In the Hood Canal watershed, LLTK□s community building activities are intended to establish an informed and motivated constituency for salmon recovery, complementing the fish rearing and restoration work at LLTK□s Lilliwaup facility and Hood Canal conservancy sites. Partners and funders have included the Hood Canal Coordinating Council (Jefferson, Mason and Kitsap counties; Port Gamble S'Klallam and Skokomish tribes; multiple ex-officios), Hood Canal Salmon Enhancement Group, Planning Association of Washington, U.S. Fish and Wildlife Service, Washington State Department of Wildlife, Point No Point Treaty Council, Olympic Resource Management, and Northwest Renewable Resources Center.

Eight rivers flow through the 550-square mile watershed, providing habitat to chum, coho, chinook, and pink salmon. Hood Canal's diverse habitats and freshwater tributaries once sustained some of the highest quality salmon fisheries in the world. However, population growth along shorelines, forestry in upland areas, and historical over-fishing have contributed to severe declines in salmon populations. Residents of this watershed have a strong placed-based identity. Despite jurisdictional and cultural differences, they all agree that the Canal is a special place that needs to be protected and that preserving salmon is essential.

LLTK began its community-building and outreach efforts in Hood Canal in 1995, when it co-sponsored the Hood Canal Community Circle with the Northwest Renewable Resources Center. This relationship-building effort pulled together local government, tribal and citizen leadership to establish a foundation for working together to protect Hood Canal and its resources. From 1996 through 1998, LLTK staff expanded this work by hosting "salmon supper clubs," co-hosting regional conferences, disseminating information on salmon populations in the watershed, and working with local community groups to further inform and motivate citizens toward salmon recovery. LLTK has also committed staff and resources to assisting the Hood Canal Coordinating Council in its efforts to develop a comprehensive, regional approach to recovering threatened Hood Canal summer chum salmon. Now, LLTK is developing a first-of-its-kind handbook on the Endangered Species Act (ESA) to help smaller, rural counties and cities (such as those in Hood Canal) without the staff or infrastructure larger local governments rely on to respond to ESA requirements.

Seattle Salmon Stream

The vision of the Seattle Salmon Stream Project is to create a salmon stream on the working waterfront of urban Seattle, in order to educate and delight residents and visitors and inspire them to restore wild salmon to the landscape of the Pacific Northwest. The Seattle Salmon Stream will be an educational park with interpretive exhibits and recommended actions visitors can take on behalf of wild salmon recovery. The project is being conducted as the joint effort of a broad base of organizations including the Port of Seattle, City of Seattle, University of Washington, Bullitt Foundation, Henry M. Jackson Foundation, Seattle Foundation, National Fish and Wildlife Foundation, Norcliffe Foundation, Burlington Northern Santa Fe Foundation, ARCO, Chevron, Western States Petroleum Association, Ravenna Creek Alliance, Alliance for Education, and Jones and Jones, Architects.

Conclusion

Although much important work is being done in the Northwest to push in the short-term for more stringent restrictions on activities that *harm* salmon, few organizations have the resources, the experience and the vision needed to undertake medium- and long-term projects that actually *assist* salmon recovery. This is somewhat understandable when you consider that it requires seeing through the up to 12-year cycles that accompany on-the-ground salmon restoration efforts. No other private, non-profit organization in the Northwest has the infrastructure, know-how and partnerships needed to conduct these science-based projects that use hatcheries and targeted rearing opportunities to support wild salmon recovery.

Having operated its own facilities for 15 years, LLTK understands Washington's unique state and tribal co-management regime and has strong relationships with these co-managers. LLTK works with the full range of stakeholder interests - from the business community to salmon advocates and coalitions, schools, Native American tribes, scientists and the academic community, farmers, commercial and sport fishing groups, and local, state, and federal agencies. This puts the organization in a unique position to promote reform via the four types of project categories detailed above.

Experimental Development and Use of Tiger Trout

Author: Michael G. Seefeldt, Mt. Whitney Hatchery, HCR 67, Box 26, Independence, CA 93526; 760 878-2272(W), mtwhitney@dfg.ca.gov

Abstract: Tiger trout are created by crossing a male brook trout with a female brown trout. Reciprocal crosses do not work. There are many stunted brook trout populations in the eastern Sierra region of California which are underutilized as a game or food fish fish due to their small size. Our goals with the tiger trout experimental project are:

1. Develop methodology to increase the fertility/hatch ability and survivability from green egg to fingerling. Historically, a six percent (6%) success level is average. Our goal is to achieve at least 30%.

2. Scientifically establish that these fish are sterile and will not reproduce, thus ensuring the genetic integrity of any wild or native species.

3. It is strongly believed that Tiger Trout will prey heavily on other fish. It is our goal to establish that these fish will indeed be a controlled Predator and thus reduce the numbers of small brook trout, resulting in larger, more desirable fish to the angler.
4. Evaluate their performance, with possible expansion into other management areas.

The California Department of Fish and Game initiated a limited experimental program for tiger trout (Salmo trutta x Salvelinus fontinalis) at the Mt. Whitney Fish Hatchery in the fall of 1997. The first experiment was conducted through normal spawning procedures, which resulted in little or no success. We have two strains of brown trout at our installation but we do not have brook trout. We obtained the milt from Crystal Lake Hatchery in northern California. The actual spawning occurred the day after the sperm was taken. In 1998 (see attachment), we began experimenting with heat shock treatments in an attempt to induce triploidy (Scheerer et al. 1987). Our first year results were very encouraging, with a 68% and 91% survival to the eyed-egg stage. Hatchability was another matter. The surviving fish have reached 2 years of age (1.5 pounds each) netting a final yield of 18.3%. In 1999, we followed the same procedure. We achieved 65% and a 73% eyed egg count but a net yield of only 3.4%. If we are to continue this experiment, we will increase our temperature treatment time to 10 minutes and increase our temperature to 81F.

HANDOUT - Nevada Department of Wildlife - Curtis A. Baughman

This hand out will further explain some past experimentation on increasing survival of tiger trout from green egg to production size.

I would like to take a brief moment to add some background as to the reasoning for this experimental project. It had come to our attention that our local biologist was engaging in a back country program that was focusing on lowering the population densities of brook trout within several alpine lakes as part of his research with the yellow legged frog. Tiger trout have proven to be an aggressive game fish and we have had some experience with them back in the late 1970's. Our records show that these fish have reach massive size (20 pounds +) within 5 years, as demonstrated by actual production at Mt. Whitney Hatchery. There were several questions that arose from my initial proposal. They are as follows;

1. Can we produce enough fish each brood year to make the program viable and cost efficient?

2. Is there scientific proof of the sterility of these fish? What we need is a sterile fish to use in fisheries management, in this case, as a controlled predator.

The answer to the first question was tough. We didn't know how many fish the biologists might need during any given year and our past experience with the development was over 20 years ago. Research lead me to the Nevada Department of Wildlife. I had heard that their agency had an on-going tiger trout program as did as several other states. I was able to attain information on their experimental program and have since adopted it, while continuing to explore other methods to increase survival. What I have found so far is that our success is similar to theirs in that what works today may not work tomorrow! The heat shock method does appear to be the most promising. I would like to try pressure chamber treatments in the future to achieve triploid fish. My conclusion at this time is that we can indeed meet the needs of the biologists' program. If it is to be expanded, then we need to fine tune our procedure(s).

The issue of sterility was a little harder to document. Although widely believed that tiger trout are indeed sterile, I was unable to find any documented proof. I turned to our pathology department to help me find the answer. To date, we have completed two mature year class necropsy examinations and are awaiting the results from the third. All indication is that the females, thus far, do not develop viable eggs. The males do develop gonads but it believed that they are non functional. The final results will be published soon.

WHERE ARE WE NOW?

Our biologist, Curtis Milliron, has put his request through our Department and has now presented it to the U.S. Forest Service for their input and discussion. As of this writing, the USFS is resisting the project on the grounds that the introduction of a "new" species of fish in wilderness areas is not within their proposed wilderness management plan. This issue is still being debated. Wether or not we continue with the tiger trout propagation pilot project is in the hands of the Forest Service.

Note: Even if we are not able to stock these fish into the wilderness areas as was proposed, we will have gained some knowledge into their physiology and production limitations.

Steelhead Enhancement Project for Whale Rock Reservoir

Author: Kenneth Robledo, California Department of Fish and Game, Fillmore Fish Hatchery, P. O. Box 666, Fillmore, CA 93016

Abstract: Whale Rock Reservoir is located 8 miles north of Morro Bay, California. Its dam was completed in 1960, preventing upward migration to head water tributaries. Since then, a small land-locked population of southern steelhead has existed, creating a need for enhancement. Prior to this project being started, the steelhead were first cleared with Fish and Game pathologists, who checked for viral diseases which could potentially infect Fillmore Fish Hatchery. No diseases were detected. In March of 2000 the project began and culminated in October with a release of 7,500 fingerlings.

In March 2000, California Department of Fish and Game personnel, along with Whale Rock Reservoir personnel, spawned seven lots of steelhead. All spawns were at approximately 1100 hours. Water temperatures ranged from 56 degrees Fahrenheit on March 9th to 66 degrees on April 20th. During this time, a total of 19 females was spawned, for a total of 23,623 eggs.

The hatchery building at Fillmore Fish Hatchery was prepared with a separate drainage system which was routed from the designated steelhead troughs and away from the production ponds and water system. Upon arrival at the Hatchery, the eggs were first disinfected with iodophore. They were then incubated, hatched, and reared in a water temperature of 60 degrees. Seventy-five hundred fish at 61/lb were released as fingerlings by the Fillmore Hatchery personnel on October 13th at Whale Rock Reservoir.

Fillmore Fish Hatchery is a production trout hatchery that receives eggs that are already in the eyed stage. These eggs are hatched and raised to a catchable-sized fish, at which time they are released. This project was experimental based on the assumption that a 60 degree water temperatures would be too warm for eyeing eggs and for their proper development. The literature indicates that at 56 degrees adverse effects and increased egg mortality begin to occur (Leitritz 1980).

While there was accelerated egg development of approximately12 days to eye and 17 days to hatch, there were no visible adverse effects due to the warmer water temperatures which were present from the time of spawning through rearing. Therefore, these elevated temperatures may support the belief that southern steelhead have adapted to withstand the higher water temperatures of southern California and could be particularly important as a genetic stock (McEwan and Jackson 1996).

Acknowledgments: Fillmore Fish Hatchery Crew, John Modin Fish Pathologist, Dave Highland Fish Habitat Specialist, and the Whale Rock Reservoir crew.

References:

Leitritz, Earl. 1980. Trout and Salmon Culture (Hatchery Methods) California Fish Bulletin #164. Spawning Effect of Temperature on Broodstock and Eggs.

McEwan, Dennis and Terry A.. Jackson . 1996. Steelhead Restoration and Management Plan. South Coast, Status. 51-60.

Appendix 1.

Eggs Spawned / Taken at Whale Rock Reservoir

Spawn date	Lot #	No. female	Eggs per oz	Total oz	Total eggs	Water temp (F)
3-09-00	1	5	239	28	6,692	56
3-16-00	2	1	272	6	1,632	58
3-23-00	3	3	254	13.5	3,429	60
3-29-00	4	4	270	20	5,400	61
4-06-00	5	3	258	15	3,870	63
4-13-00	6	2	260	6	1,560	65
4-20-00	7	1	260	4	1,040	66
		Total		Total	Total	
		19		92.5	23,623	

Lot #1 was a total loss, possibly due to over-ripe females and/or low fertility in the males. Subtracting the first lot, along with subsequent losses from hatch to fingerlings, gave a 44% release rate.

Bimodal Length Frequencies in Chinook Salmon and Their Relationship to Adult Survival.

Authors: R. D. Ewing and G. S. Ewing, Biotech Research and Consulting, Inc., 2340 SE Ryan St., Corvallis, OR 97333, 541-752-8259 (W), 541-758-7005 (F)

Abstract: Unregenerated scales were taken from juvenile spring chinook salmon from14 experimental ponds at Willamette Hatchery and analyzed for the relationship between scale radius and fork length. Correlations between scale radius and fork length were linear and positive ($R^2 = 0.943$). Using this relationship, scales from returning adult salmon derived from these groups were analyzed for size at entry into the ocean. These sizes were compared with the length distributions at the time of release.

Bimodal distributions in the size of juvenile chinook salmon before release were observed in most experimental ponds for all of the four release years of the experiment. In 1989 and 1990 broods, adults were derived from fish entering the ocean at a size smaller than that of fish in each experimental pond at release. In 1991 and 1992 broods, adults were derived from fish entering the ocean at the same average size as those experimental groups released from the hatchery. Size at ocean entry of returning adults was not associated with either of the two modes of length frequency seen in the hatchery juveniles. These results suggest that the bimodal distributions seen in hatchery populations of chinook salmon do not have the same relationship to smolting and to ocean survival as those found in Atlantic salmon.

Older age classes of adults tended to be derived from fish of smaller sizes at ocean entry. Within an age class of adults, the size of returning adults and the size that the juveniles entered the ocean were not correlated. Growth of adults, as measured by changes in average adult size in each age class, was linear from ocean entry to age 4. Growth slowed in age 5 and age 6 adults.

The Kootenay White Sturgeon Conservation Hatchery - A Transboundary Success Story

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Ron Ek, British Columbia Fisheries, Kootenay Trout Hatchery, Fort Steele, B.C. V0B 1N0, 250-429-3214 (W), Ron.Ek@gems9.gov.bc.ca

Abstract: The Kootenay Trout Hatchery has been an integral part of the British Columbia trout culture program for 35 years. Since 1999, in cooperation with the Kootenai Tribes of Idaho, we have been contracted to grow endangered white sturgeon (*Acipenser transmontanus* Richardson) from the Kootenai River, a transboundary tributary of the Columbia River. A new facility was built on the trout hatchery site, and due to the possibilities of disease transmission between the trout and sturgeon stocks, multiple safeguards have been employed to minimize or eliminate the chances of cross contamination. After 15 months of rearing, our first sturgeon have been successfully released back into the Kootenai River.

The Kootenay Trout Hatchery, located in southeastern British Columbia, has been a part of the provincial government trout culture program for 35 years. The Hatchery presently raises several strains of native rainbow trout, as well as eastern brook trout and westslope cutthroat trout. Bull trout, lake trout, and kokanee salmon have also been cultured at Kootenay Hatchery in the past. Fish from Kootenay Hatchery are stocked over a large portion of Bristish Columbia, including the Columbia, Fraser, Skeena, and Peace watersheds. Because fish from our facility are released over such a large area, it is extremely important that we produce a disease-free product. The Hatchery has five full-time fish culture staff, two full-time maintenance staff, plus various auxiliary positions. The water supply comes from four production wells which are capable of producing up to 17,000 liters per minute of 5-8 C water.

In August 1997, B.C. Fisheries was approached to determine the feasibility of building a facility to back up the Kootenai River Sturgeon Hatchery at Bonner's Ferry, Idaho. The Bonner's Ferry hatchery, begun as an experimental project in 1991, is operated by the Kootenai Tribe of Idaho, (KTOI), with funding from the Bonneville Power Administration. The initial impetus for the program was described in the proceedings of the 1996 Northwest Fish Culture Conference, (Anders et al. 1996), but suffice it to say that the Kootenai River white sturgeon (*Acipenser transmontanus* Richardson) was listed as endangered by the U.S. Fish and Wildlife Service in September 1994. Preliminary work done at the Kootenai River Sturgeon Hatchery from 1991-1995 indicated that reasonable survival of hatchery reared sturgeon juveniles could be expected. Since then, for various reasons, the Kootenai River Sturgeon Hatchery has had limited and variable success in rearing required numbers of sturgeon to release size, with the subsequent result that a back-up rearing facility was sought. The Kootenay Trout Hatchery, located in the upper Kootenay watershed, was seen as a potential candidate.

In the fall/winter of 1998/99, an agreement was made between the KTOI and BC Fisheries which contracted BC Fisheries to be that back-up. Although there were many reasons for the choice, some of them included: 1) a secure, disease-free water supply; 2) a facility with 24-hour, on-site emergency back up staffing; 3) an experienced fish culture staff (with a combined total of over 125 years of fish culture experience). BC Fisheries was contracted to grow a portion of the eggs collected by KTOI to release stage, (estimated originally at 2 years), with a planned 50% of the release number to come from each facility. Each hatchery was to keep sufficient numbers of fish to back up the other in case of higher than anticipated losses. Release numbers were to be determined by the Kootenai White Sturgeon Recovery Team. The original contract objectives stated , "Approximately 100,000 sturgeon eggs representing up to 5 sturgeon 'families' will be transferred to the Kootenay Sturgeon Conservation Hatchery, (KSCH), in April, May and/or early June each year. Fish will be cultured by BC Fisheries staff for two years. Except for the first year of operation, (99/00), 5,000 two year old fish will be produced by the facility each year for stocking into the Kootenai River (Idaho) to support the recovery of the wild population."

Once the agreement was made, the challenge really began. It quickly became apparent that even though the sturgeon have been able to pass across the 49th parallel for 10,000 years on their own with no apparent problem, when people want to move them, some agencies have problems. Our Canadian Federal/Provincial Fish Transplant Committee (FTC) presented us with a list of "Special Conditions for Importation of Kootenai White Sturgeon Eggs" which included:

1. The Kootenay Sturgeon Conservation Hatchery (KSCH) will be inspected and approved by the FTC before sturgeon eggs are transferred.
2. All sturgeon brood at the Bonner's Ferry Hatchery that contribute to the imported eggs and milt will be tested. If IPN is detected in the brood, all stocks at KSCH will be destroyed. If other filterable agents are detected, the FTC, together with other fish health experts from the Department of Fisheries and Oceans and the Province of British Columbia, shall determine whether the stock at KSCH must be destroyed or whether additional disease control measures must be put into place.
3. Only disinfected eggs will be transferred from Bonner's Ferry Hatchery to the KSCH.
4. The KSCH will be divided into two separate areas to limit the risk of disease transfer between year classes: the quarantine area will house the 0+ year class; and, the isolation area will house the 1+ year class.
5. Effluent water from egg incubation and rearing stages to 120 days post-hatch will be sterilized with ozone and discharged only to ground.
6. Effluent water from rearing stages from 121 days to 360 days post-hatch will be sterilized with ozone then discharged to surface.
7. The ozone system used to treat KSCH effluent water will be pre-tested for four months prior to initial egg transfer.
8. An ozone monitoring program to ensure specifications for ozone concentration and contact time are met.
9. In the event of a power interruption or a failure of the ozone equipment, the system will be automatically 'fail-safe', i.e. effluent water from the incubation and early rearing area will be discharged only to ground.
10. Sentinel fish (brook char; rainbow trout) will be reared in the 0+ sturgeon effluent. Sentinel fish and sturgeon will be tested regularly for disease using protocols approved by and results made available to, the Fish Transplant Committee.

11. Effluent water from the sentinel fish will be treated in the same manner as effluent from the egg incubation and early rearing stages.
12. No Kootenai River sturgeon will be released to natural waters in the Province of British Columbia.

Needless to say, we felt that we had to jump through more flaming hoops than a lion at Ringling Brothers' Circus! However, with some firm guidance from our Section Manager, Don Peterson, and patient persistence by our hatchery staff and our B.C. Buildings Corporation staff, the project came together. It was not any easy process, but the end result is proving to be satisfying. One of the exciting things for us was that our crew had the opportunity to provide the majority of input into the basic hatchery design. With funds for construction provided through KTOI, the hatchery was constructed between April and August 1998, and tested using various lots of trout prior to the arrival of our first sturgeon eggs in June, 1999.

We have had to develop a set of protocols for keeping any possible diseases from being transferred around our facility, or into the Kootenay River aquatic system which include: the previously mentioned ozone treatment of the quarantine side effluent water; construction design to prevent minor backup/overflow waters from exiting the building; change area for boot/shoe and outer garment removal; multiple wash up protocol; totally separate equipment, including boots for the quarantine and isolation sections; use of disposable gloves in the quarantine section for the first 120 days of rearing ; triple screening to prevent any possible escapes. We also have an intensive sampling program for disease detection which calls for monthly sampling of each family and sentinel group, for the first four months, then bimonthly sampling after that.

The KSCH consists of two distinct sections:
1. The Quarantine Section, where eggs are brought into, hatched and reared for almost 1 year. Hatching is done in MacDonald jars; the eggs hatch in 7-10 days at 14C. Fry swim out of the hatching jars and feeding is initiated about 10 days later. One of the keys to our success we feel is the use of a very high quality initial starter feed, (we use BioTrainer), then switch over fairly quickly to Biodiet Starter diets, and later to BioMoist. Once the fish are well onto the food, they are transferred from the troughs to small circular tanks, and are split into larger circulars as they outgrow the smaller tanks.
2. The Isolation Section is for the final grow out stage. Fish are transferred into this section once all disease sampling requirements have been met in the Quarantine Section. Effluent from this section is allowed to go directly into our hatchery creek untreated.

At present, we are compiling the growth and survival data, but we felt that we had very good survivals overall (as long as the initial egg quality was good). Once the fish reached 5 grams, we suffered virtually no loss of fish, and we have been able to grow our fish to an 80 gram average in 15 months. Our largest fish weighed almost 200 grams. We were given permission to release our first sturgeon in September, 2000, when we released 1348 fish from 4 families into the Kootenai River in Idaho.

We are into our second year of production, with a full complement of five families, which will be ready for release in September 2001.

So far, I think we have shown several things with this project:

1. That cooperative cross-border fish culture programs can work successfully. We are indebted to the many people, mainly here in the USA, that have so willingly supplied us with information and hands on training to make this project a success.
2. That, I believe, it has been cost effective to piggyback a conservation hatchery onto an existing facility. A big part of that is that an experienced and dedicated work crew is already there. With the combined amount of culture experience at our facility, I feel that within a short period of time, we could culture almost any kind of fish.
3. That although there are always bugs in any new project, having a knowledgeable crew can help to correct them quickly and effectively.
4. That an entirely new program (i.e. sturgeon) added to a fairly established program (i.e. trout), can be stimulating to a crew that has been in the business for a long period of time.
5. That despite being hamstrung by daunting lists of regulations and permit requirements, one can work step by step to overcome them and live up to them, for all intents and purposes.

With a seemingly ever-increasing list of threatened and endangered species, conservation projects such as the Kootenay Sturgeon Conservation Hatchery will likely become more common in the future. My encouragement to you would be not to look at these projects as 'something extra I just don't need right now' - and believe me that was my basic attitude - but as an opportunity not only to learn something new and exciting as well as to be a real part in helping these imperilled species to survive another generation.

Acknowledgements

The authors thank the Kootenai Tribe of Idaho, for their substantial support of the Kootenay Sturgeon Conservation Hatchery, in funding, in supplying the eggs and technical advice. We thank the many people who have contributed professional and technical advice including, but not limited to, Scott LaPatra, Joel Van Eenaanam, Dave Owsley, Gord Edmunson, Dave Erdahl.

References

Anders, P.J., and R.E. Westerhof. 1996. Conservation aquaculture of endangered white sturgeon (*Acipenser transmontanus*) from the Kootenai River, Idaho. Proceedings of the Northwest Fish Culture Conference, pp. 132-140.

LaPatra, S.E., S. Ireland, J.M. Groff, K. Clemens, and J. Siple. 1998. Adaptive disease management strategies for the endangered population of Kootenai River white sturgeon (*Acipenser transmontanus*). Proceedings of the Northwest Fish Culture Conference, pp. 21-26.

Hatchery Reform in the Pacific Northwest Begins with a Review of Current Hatchery Practices

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Abstract: Hatchery reform has been the subject of planning for many years in the Pacific Northwest. Reform of the hatchery program may range widely in its recommendations, from the transfer of production to local stocks, with no alteration of the goals of the program, to reform of the goals to assist in recovery. Yet, little has been done to compile current uses of hatchery fish, and to determine the potential for reform. Towards these objectives, we have compiled the use of anadromous fish from conventional hatchery programs in Oregon, Washington and Idaho. We conclude that there is a substantial "surplus" production of fish beyond the needs of hatchery broodstock and terminal fisheries. We suggest that surplus fish, if produced under the right conditions, could be used to repopulate suitable habitat and increase natural production.

Russian River Basin Planning and Restoration Program

Author: Bryan Freele, Associate Fishery Biologist, California Department of Fish and Game, Hopland Field Station, Hopland, CA..

The Russian River Basin Planning and Restoration Program inventories habitat and channel conditions for anadromous salmonids in the Russian River watershed and implements restoration efforts based on analysis of physical and biological surveys. Physical habitat is measured for all sub-basins and tributaries to provide quantitative data for analysis. Biological sampling inventories are carried out for macro invertebrates, fish and includes tissue collection activities for genetic analysis. Data has been collected and reports generated for nearly half of the tributaries of the Russian River. Completed surveys provide qualitative data for assessment and provide the basis for treatment recommendations and restoration work.

Restoration efforts based on the results of data analysis include the use of a variety of bioengineering techniques. Restoration efforts implemented by this program include methods adopted in the California Department of Fish and Game's California Salmonid Stream Habitat Restoration Manual and include a variety of techniques. Restoration project design may include components of in-stream structure construction, re-vegetation, fish passage improvement, rock armoring, erosion control techniques/sediment input reduction, and livestock exclusionary fencing. Generation of reports based on physical and biological data will ultimately culminate in the development of a comprehensive basin plan addressing fisheries management for the entire Russian River watershed.

POSTERS

Mineral Nutrition in Pacific Salmon

Authors: Ann Gannam, U. S. Fish and Wildlife Service, Abernathy Fish Technology Center, 1440 Abernathy Creek Rd., Longview, WA 98632, 360-425-6072 (W), ann_gannam@fws.gov, Mark Hack, U. S. Fish and Wildlife Service, Abernathy Fish Technology Center, 1440 Abernathy Creek Rd., Longview, WA 98632, 360-425-6072 (W), mark_hack@fws.gov.

An indication that more mineral nutrition work needs to be done is seen in one study where samples of hatchery-raised coho *Oncorhynchus kisutch* had significantly less copper and zinc content than wild smolts collected in the same watershed. In addition, other studies have shown that the use of a highly digestible chelated copper improves fin condition in rainbow trout. Research comparing the digestibility of chelated and inorganic trace minerals has had mixed results which may be due to the composition of the feed and the alkalinity/hardness of the water. The objective of this study was to determine the appropriate level of copper required in a practical diet for Pacific salmon.

Copper was added to the diet for coho, *Oncorhynchus kisutch*, either as copper sulfate or chelated copper at 3, 6, or 9 mg/kg diet. Differences, related to the level of copper in the diet, were seen in the liver copper/selenium levels and in the Cu-Zn superoxide dismutase activity. From this preliminary study, the supplemental copper for coho salmon is estimated to be 6 mg/kg diet. More studies need to be done with a narrower range of copper levels to determine the exact requirements.

Conservation Aquaculture: An Adaptive Approach to Prevent Extinction of an Endangered White Sturgeon Population (*Acipenser transmontanus*)

Authors: Susan C. Ireland, Kootenai Tribe of Idaho Fisheries Department, P.O. Box 1269, Bonners Ferry, ID, 83805, (208) 267-3620 (W), (208) 267-1131(F), ireland@kootenai.org, Paul J. Anders, University of Idaho, Aquaculture Research Institute, Moscow, ID, 83844-2260, (208) 885-2823 (W), (208) 885-5968 (F), panders@uidaho.edu, John T. Siple, Presenter, Kootenai Tribe of Idaho Fisheries Department, P.O. Box 1269, Bonners Ferry, ID, 83805, (208) 267-7082 (W), (208) 267-1131(F), siple@kootenai.org

Abstract: The white sturgeon, *Acipenser transmontanus*, population in the Kootenai River was listed as endangered by the U.S. Fish and Wildlife Service on September 6, 1994, due to a virtual lack of recruitment during the last 2 decades. Conservation aquaculture was chosen as an approach to preserve genetic variability, begin rebuilding natural age class structure, and prevent extinction of the population while measures are identified and implemented to restore natural recruitment. A breeding plan, including culture methods to minimize potential detrimental effects of conventional stocking programs, has been implemented to guide management in the systematic collection and spawning of wild adults before they are lost from the breeding population. The objectives of the program are to produce 4 to 9 families per year and use preservation stocking criteria to produce 4 to 10 adults per family that survive to breeding age. Monitoring and evaluation will assess survival, growth, movement, and habitat use of released juveniles. Success of the project will be determined by: 1) an increase in the number of juvenile sturgeon; 2) survival of hatchery fish to sexual maturity; 3) retention of wild sturgeon life history characteristics; and, 4) an understanding of the life history characteristics and factors limiting natural recruitment. Because the Kootenai River drainage lies within Montana, Idaho, and British Columbia, success of recovery efforts for the white sturgeon will also depend upon cooperation and coordination among all entities and agencies within the geographical area.

COMMERCIAL EXHIBITORS

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Bio-Oregon, P.O. Box 429, Warrenton OR 97146 — 800-962-2001

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- Walter Kost
- Dennis Roley
- Ron Anderson
- Bruce Buckmaster

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- Catherine Holmes
- Britt Holmes

Common Sensing, P.O. Box 130, Clark Fork ID 83811-9998 — 208-266-1541

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David Knutzen

ORGANIZING COMMITTEE

51st NWFCC COMMITTEE

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	Ken Hashagen	Retired
	Judy Urrutia	Warm Springs
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	Julia Devore	Mt. Shasta
	Debbie Shoemaker	Crystal Lake
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Trade-Show	Anna Kastner	Feather River
Session Chairs	Mike Haynie	S.H.S. Region 6
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Hospitality Room	Charlotte Keys	Darrah Springs
	Lorriane Overton	Redding
Poster Room Innovation Board	Jim Groh	Moccasin Creek
Door Prizes	Sid Poe	Silverado Fisheries

LISTING OF PAST MEETINGS

North West Fish Culture Conference
Historical Record

Year	Location	Host Agency	Chairman
1950	Portland, OR	U.S. Fish and Wildlife Service	Ted Perry
1951	Wenatchee, WA	U.S. Fish and Wildlife Service	Roger Burrows
1952	Seattle, WA	Washington Dept.of Fisheries	Bud Ellis
1953	Portland, OR	Fish Commission of Oregon	Fred Cleaver
1954	Seattle, WA	U.S. Fish and Wildlife Service	Bob Rucker
1955	Portland, OR	Oregon Game Commission	John Rayner
1956	Seattle, WA	Washington Dept.of Game	Cliff Millenbach
1957	Portland, OR	U.S. Fish and Wildlife Service	Harlan Johnson
1958	Seattle, WA	Washington Dept.of Fisheries	Bud Ellis
1959	Portland, OR	Fish Commission of Oregon	Ernie Jeffries
1960	Olympia, WA	Washington Dept.of Game	John Johansen
1961	Portland, OR	Oregon Game Commission	Chris Jensen
1962	Longview, WA	U.S. Fish and Wildlife Service	Roger Burrows
1963	Olympia, WA	Washington Dept. of Fisheries	Bud Ellis
1964	Corvallis, OR	Oregon State University	John Fryer
1965	Portland, OR	U.S. Fish and Wildlife Service	John Halver
1966	Portland, OR	Fish Commission of Oregon	Wally Hublou
1967	Seattle, WA	University of Washington	Loren Donaldson
1968	Boise, ID	Idaho Dept. of Fish and Game	Paul Culpin
1969	Olympia, WA	Washington Dept. of Game	John Johansen

1970	Portland, OR	Oregon Game Commission	Chris Jensen
1971	Portland, OR	U.S. Fish and Wildlife Service	Marv Smith
1972	Seattle, WA	Washington Dept. of Fisheries	Dick Noble
1973	Wemme, OR	Oregon Fish Commission	Ernie Jeffries
1974	Seattle, WA	University of Washington	Ernie Salo
1975	Otter Crest, OR	Oregon State University	Jack Donaldson
1976	Twin Falls, ID	University of Idaho	Bill Klontz
1977	Olympia, WA	Washington Dept. of Game	Jim Morrow
1978	Vancouver, WA	U.S. Fish and Wildlife Service	Dave Leith
1979	Portland, OR	Oregon Dept. of Fish and Wildlife	Ernie Jeffries
1980	Courtenay, B.C.	Fisheries and Oceans, Canada	Keith Sandercock
1981	Olympia, WA	Washington Dept. of Fisheries	Will Ashcraft
1982	Gleneden Beach, OR	National Marine Fisheries Service	Einar Wold
1983	Moscow, ID	University of Idaho & Idaho Dept. of Fish and Game	Bill Klontz & Evan Parrish
1984	Kennewick, WA	Washington Dept. of Game	Jim Gearheard
1985	Tacoma, WA	U.S. Fish and Wildlife Service	Ed Forner
1986	Eugene, OR	Oregon Dept. of Fish and Wildlife	Chris Christensen
1987	Tacoma, WA	Washington Dept. of Fisheries	Will Ashcraft
1988	Richmond, B.C.	B.C. Ministry of Fisheries	Don Peterson & Peter Brown
1989	Gleneden Beach, OR	National Marine Fisheries Service	R.Z. Smith
1990	Boise, ID	Idaho Dept. of Fish and Game	Bill Hutchinson
1991	Redding, CA	California Dept. of Fish and Game	Ken Hashagen

1992	Wenatchee, WA	Washington Dept. of Wildlife & Alaska Dept. of Fish and Game	John Kerwin & Irv Brock
1993	Spokane, WA	U.S. Fish and Wildlife Service	Ed Forner
1994	Sunriver, OR	Oregon Dept.of Fish and Wildlife	Rich Berry
1995	Fife, WA	Washington Dept. of Fish and Wildlife	Larry Peck
1996	Victoria, B. C.	B.C. Ministry of Environment, Lands, and Parks & Dept. of Fisheries and Oceans, Canada	Don Peterson & Greg Bonnell
1997	Gleneden Beach, OR	National Marine Fisheries Service	R.Z. Smith
1998	Boise, ID	Idaho Dept. of Fish and Game	Tom Rogers
1999	Seattle, WA	U. S. Fish and Wildlife Service	Dave Owsley
2000	Sacramento, CA	California Dept. of Fish and Game	Judy Urrutia

HALL OF FAME

NORTHWEST FISH CULTURE HALL OF FAME

1999 Dr. Lorin Edward Perry: Chairman, N.W. Fish Culture Conference 1950 (Region One Biologist, US Fish & Wildlife Service). Our Pioneer and Founder of the NW Fish Culture Conference called this conference to coordinate research and development on nutrition, disease, diets, and hatchery technology for the salmon rehabilitation program of the Columbia River Development Program. Roger Burrows outlined diet and technology, Robert Rucker, disease control, John Halver, nutrition and diet development for the USFWS. Tom McKee had input from Oregon on coordinated projects of the CRDP. Al Kemmerick of the Bureau of Commercial Fisheries controlled the money allocations for each phase of work. Ted Perry was born in Twin Falls, Idaho in 1914, completed his BSc at Utah State in 1939 and his PhD at University of Michigan in 1943. After WW II duty in the US Public Health Service he joined the Fish and Wildlife Service in 1946, became the Region One fishery biologist in 1948 and served on research and management of salmon through out the Columbia Basin until retirement in 1975 as Deputy Regional Director, USFWS for Region One. He has coordinated extensive fish culture and management research and development programs throughout the Pacific Northwest and the Columbia River basin for salmon restoration. We would not have the hatchery system and the NW Fish Culture Conference today without Ted Perry.
John Halver – sponsor.

1999 Mr. Roger Eugene Burrows: Born Nov. 3, 1909, in Dubuque, IO. At the age of seven, his family moved to Seattle, WA., where his father was employed as a marine engineer. After attending grade and high school in the Seattle area, Roger enrolled at the University of Washington and received a degree in Zoology in 1934. He said "It took him longer to graduate than normal since he dropped out several quarters to work and earn money". He missed the graduation ceremonies because he had accepted a job with the USFWS and started working on stream surveys in eastern Washington. His first hatchery job was at Dexter, NM, and later transfers found him at Creede, CO, and Quilcene, WA, in 1938. Here he started to work with Pacific salmon and the control of their diseases. In 1940, he transferred to Mullin, ID, as a hatchery manager and later back to WA to Leavenworth NFH. At Leavenworth and working with Frederic Fish, he established an annual fish culture school for hatchery managers and fish culturists. He continued to work on disease control and also started developing practical diets for salmon. His next move was in 1951 to Entiat, WA, where he established the Salmon Cultural Laboratory with the Bureau of Scientific Inquiry which was to later become the Fishery Research Division under the Bureau of Sport Fisheries. At Entiat, Roger and co-workers experimented with the development of practical diets and pioneered work on maturation of adult salmon with the use of injected pituitary material and the control of photoperiod. The lab also examined pond designs, methods of egg enumeration, and development of an egg and fry incubator that became the prototype for the commercial vertical incubators used worldwide. They developed an electrical weir to divert upstream migrating adult salmon from a modification of the electrical devices used in the Great Lakes to control lamprey.

The lab also improved the types of holding ponds used for adults as well as determined the effects of accumulated excretory wastes on fingerling salmon. Experiments to determine the temperature thresholds for incubation of eggs were also done at Entiat. In 1961, the Salmon Culture Laboratory moved to Abernathy west of Longview, WA, on the lower Columbia River. Here the emphasis was to test diets that eventually led to the development of a dry pelleted formulation suitable for Pacific Salmon. The lab also developed the first recirculation system with biofilters and aeration devises designed to rear fish in a limited water supply. During Roger's years before retirement, he authored several chapters in books including one on Salmonid Husbandry Techniques that appeared in "Fish Nutrition" and two chapters in "Sport Fishing USA". All in all, he authored or co-authored some 40-50 publications, many of which are still referred to and used in fish husbandry today. Roger retired in 1971 at the age of 61 after 37 years with the USFWS. He was given the Distinguished Service Award of Excellence from the USFWS as well as the Award of Excellence from the Western Division of the American Fishery Society. He was listed in Who's Who in America and in the Who's Who of the West as well as in the Biographical Dictionary in England. After retirement, he continued to work as a consultant in hatchery design for UMA Engineer, Inc., Portland, OR, until his death on Oct. 14, 1980, in Longview WA. He was elected to the AFS Fish Culture Hall of Fame in 1993, posthumously.
Laurie Fowler – sponsor.

1999 Mr. James W. Wood: Jim was born January 22, 1925 in Seattle, Washington. He was raised in Port Angeles, WA and received a B.S. and M.S. in Fisheries from the University of Washington. He also took graduate course work from The Massachusetts Institute of Technology. Jim served his country in both W II and Korea. His fisheries career started in the 1950's as a fish pathologist for the Oregon State Fish Commission. In 1960, Jim moved to Washington and became the fish health manager for the Washington Dept. of Fisheries and remained in that position until his retirement in 1985. During his tenure he authored numerous research papers and also wrote Diseases of Pacific Salmon – Their Prevention and Treatment, a text with great insight on the cause and cure to disease problems in salmon. This book continues to be used by fish health practitioners around the world. Jim was awarded the Snieszko Achievement Award by the Fish Health Section of the AFS for his many contributions and his exemplary career in fish health. Jim Wood had many traits which won him the respect of his subordinates and cohorts, alike. First, he was focused on producing healthy, quality fish and worked closely with the hatchery crews to make sure it happened. Jim prided himself at getting to every hatchery he visited about an hour before the crew arrived for work. In this way, he could make an accurate assessment of the health of the fish, mortality levels, and the quality of fish culture. To achieve this feat, on a regular basis his road trips started before 3 am. Jim was not afraid of expressing his opinions to agency administrators if he felt the health of "his" fish were being compromised in any way by their decisions. Though he was a man of few words, "BS" was one he used frequently. As you can imagine, he was at times cross-wise with administration. In particular, I recall his opposition to the construction of a hatchery which planned to use a water supply contaminated with *Nanophyetus salmincola*.

Unfortunately, the project moved ahead in spite of his opposition and the facility in question continues today to be problematic to operate. We all remember Jim as not wanting anyone to make a big fuss over him and it was with great difficulty that we got him to his retirement party and to the Fish Health Section banquet to receive his Snieszko Award. It comes as no surprise that Jim decided to leave this world as he lived, without fanfare. On November 18, 1998, Jim Wood died peacefully at his home in Bothell, WA. His death was caused by Creutzfeldt-Jakob disease. We all have lost a great fish doctor, friend, and mentor. His dedication to fish health and his pond-side manner were an inspiration to health practitioners, fish culturists, and educators alike.
Kevin Amos, Washington Dept. of Fish and Wildlife
Bill Klontz – sponsor

1999 Dr. Loren Donaldson: Began his career in 1929 with Montana Dept. of Fish & Game. In 1930, he entered the University of Washington School of Fisheries, where he eventually received his doctorate in fish nutrition. Loren dedicated over 60 years of his life to the University. Hecreated the University's first hatchery, raising Chinook and Coho salmon that later became an unexpected successful return. His research laid the groundwork to understand the concepts of stocks and fecundity, growth rate, and nutritional requirements. But Loren will be remembered for his work in hybridization of salmon and trout which eventually led to the very popular "Donaldson Trout". Other contributions included one of the first attempts to re-enhance the Frazer River. In 1987, he received the "Alumnus Summa Laude Dignatos" the Univ. of Washington's highest award to an alumnus. He continued feeding fish at the University well into his 90's.
Jack Donalson – sponsor

1999 Mr. Robert G. Piper: Received his Bachelor of Science degree in biology from Cornell University, Ithaca New York, in 1952. After graduating, he managed a commercial trout hatchery in Pennsylvania for 4 years prior to joining the USF&W Service in 1956. His career began at the Eastern Fish Disease Laboratory in Leetown, West Virginia, where after receiving training, he worked as a fish disease biologist. During this time he diagnosed infections and parasitic diseases of fish at federal, state and commercial fish hatcheries in the Eastern U.S. He was the first in a long line of hatchery biologist to be trained at the Leetown Laboratory. He transferred to La Crosse, WI. in 1958, where he worked as a hatchery biologist, responsible for operation of a regional fish disease diagnostic laboratory. In 1963, he transferred to the Fish Genetics Lab, in Beulah, Wyoming, where he was instrumental in setting up facilities for genetic studies. He spent the next 4 years conducting selective breeding studies on trout. During this time he developed the concept of the flow and density index for determining carrying capacities of hatcheries. These methods were further developed and tested later in his career and today are widely accepted and used by hatchery personnel at federal, state, and private hatcheries throughout North America. In 1967, Piper moved to Bozeman, Montana where he became Assistant Director of what is now the Bozeman Fish Technology Center. In 1973, he was appointed Director of the Center, a position he held until 1985. Bob's ability

as an instructor has not gone unnoticed. Many students, both young and old, have been educated and motivated by this fine man. He has been an instructor in the FWS's Cold Water Fish Culture course since its inception in the mid 1970's. Even in his retirement, Piper continues to teach the course with the same boundless enthusiasm he has always exuded as an instructor. In 1977, Piper was assigned the duty of Editor-in-Chief of a task force to develop a fish culture manual; the 517 page publication, Fish Hatchery Management was published in 1982, through the U.S.Government Printing Office; the AFS arranged for five additional printings. This book is used by fish culturists throughout the country and universally accepted as a text at many universities. Bob is a Certified Fishery Scientist with the American Fisheries Society and was instrumental in the development of the Fish Culture Section of AFS. He served as President of the FCS and was the first editor of the Section's newsletter. He is also a Past President of the Montana Chapter of AFS. Piper received numerous awards throughout his illustrious career with the FWS which spanned 29 years. He also has numerous publications to his credit, being either author or co-author of over 30 publications related to fish culture and fish health. Bob received the Hall of Fame Award from the AFS , Fish Culture Section in 1990 and Award of Excellence from the Bio-Engineering Section in 1991. Since retiring from the FWS, Piper has re-mained active in the arena of Fish Culture. He became Editor of The Progressive Fish Culturist in 1985, a job which he held for 10 years. He currently works part time out of his home in Bozeman as a fishery consultant through his company, Piper Technology. Bob Piper has left a legacy that many fishery workers never achieve. He has definitely championed the cause of fish culture.
Charlie Smith - sponsor