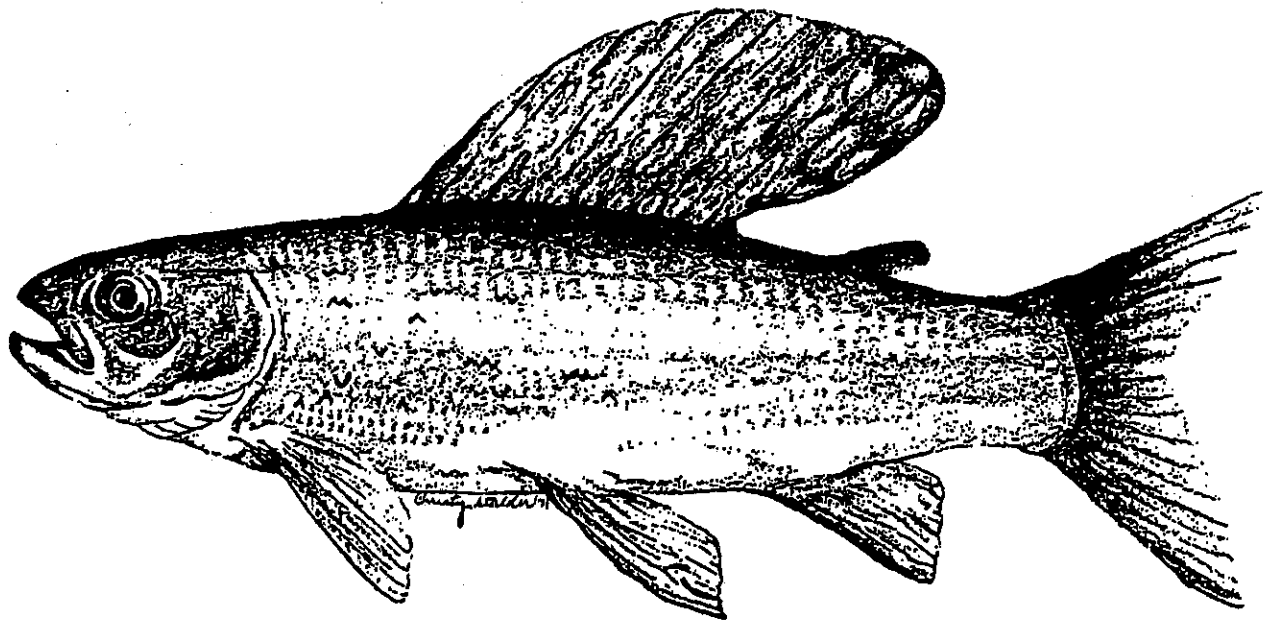


**Western Division
of the
American Fisheries Society**

July 15 - 19, 1991

Montana State University

Program Abstracts



**AMERICAN
FISHERIES
SOCIETY**



Wednesday, July 17			
Time	Concurrent Session #1	Concurrent Session #2	Concurrent Session #3
08:00 AM	Welcome & Opening Remarks		
08:30 AM	Ballroom BC		
09:00 AM	Break - Ballroom D		
09:30 AM	Marine Fisheries Regulations	Perspectives of Chang Our Elders Speak	Riparian Mark Gorges
10:00 AM	Mike Fraidenburg	John Fraley, MDFWP	BLM
10:30 AM	Room 275	Room 276	Ballroom B
11:00 AM	Lunch		
11:30 AM	Ballroom A		
12:00 PM	AFS Business Mtg.		
12:30 PM	Ballroom BC		
01:00 PM	Break - Ballroom D		
01:30 PM	Water Rights	Role of Public Participation in Fisheries Mgmt.	Contributed Papers Session I
02:00 PM	Bob Franklin	Larry Peterman (MDF	
02:30 PM	Hoopa Valley Tribe, C	Room 275	Ballroom C
03:00 PM	Ballroom B		
03:30 PM	Dinner (On your own)		
04:00 PM	Spawning Run	Mtn. Bike Ride	
04:30 PM	Social Hour and Book Unveiling		
05:00 PM	Ballroom D		
05:30 PM			
06:00 PM			
06:30 PM			
07:00 PM			
07:30 PM			

Thursday, July 18				
Time	Concurrent Session #1	Concurrent Session #2	Concurrent Session #3	Concurrent Session #4
08:00 AM	Rotenone	Threatend & Endangered Fishes	Electrofishing Injury	Native American Fish.
08:30 AM	Leo Lentsch	Duane Phinney, WDF	Wade Fredenburg	Joe DosSantos
09:00 AM	UDNR	MDFWP		CS&KT, MT
09:30 AM	Ballroom B	Room 275	Ballroom C	Room 276
10:00 AM	Break - Ballroom D			
10:30 AM	Rotenone Cont.	Threatend & Endangered Fishes Cont.	Electrofishing Injury Cont.	Kelly Meyer
11:00 AM				White Mtn. Apache, UT
11:30 AM				Native American Fisheries Cont.
12:00 PM	Lunch			
12:30 PM	Ballroom A			
01:00 PM	Advances in Fish Cult.	Contributed Papers Session II	Student Papers	Technology Transfer Session(s)
01:30 PM	Greg Kindschi, USFW	Ballroom B	Mike Moberly, UW	Ballroom C
02:00 PM	Room 275		Room 276	
02:30 PM	Break - Ballroom D			
03:00 PM	Advances in Fish Culture cont.	Contributed Papers cont.	Student Papers cont.	Technology Transfer Session(s) cont.
03:30 PM				
04:00 PM				
04:30 PM				
05:00 PM				
05:30 PM				
06:00 PM	Banquet and Awards			
06:30 PM	Springhill Ranch			
07:00 PM				
07:30 PM				
08:00 PM				
08:30 PM				
09:00 PM				
09:30 PM				

Friday, July 19	
Time	
08:30 AM	Economics Workshop
09:00 AM	Ballroom B
09:30 AM	Break - Ballroom D
10:00 AM	Economics Workshop
10:30 AM	Cont.
11:00 AM	
11:30 AM	Lunch
12:00 PM	
12:30 PM	
01:00 PM	

INSTITUTIONAL INCENTIVES AND IMPEDIMENTS TO FISHERY DECISIONMAKING

by: *Michael E. Fraidenburg* - Fish Manager

"Don't be so damn naive." That was the response to the first management plan I created, over twenty years ago. My plan was rejected and the job was handed to a "more experienced" manager. For the life of me, I didn't know why my supervisor reacted so strongly to the uniform criteria I had devised for beginning a commercial freshwater crayfish in my region.

It was not a controversial issue. A new fishery was developing on unexploited stocks. Each lake had a single population so mixed-stock fisheries would not be a problem. The population dynamics were relatively simple and easily measured. Industry was cooperating. I had compiled all the historic harvest management data and done my homework on how to set up a new fishery. I interviewed the experts, used their advice and received their encouragement. And I had set up a cooperative program with industry. There would be a controlled expansion of the fishery in accord with conservation and wise-use principles.

The more experienced manager wrote a new plan. It inexplicably closed some lakes and left other open. I could not see a pattern to these decisions. Nor were the new criteria coherently related to the crayfish populations. When I advanced the rationality of my plan versus the new plan the response was: "Don't be so damn naive. That's the way the world works."

Apparently I didn't understand "...the way the world works." Do you?

Fishery management is a complex and often contradictory endeavor. It involves well understood scientific and procedural techniques combined with largely unacknowledged institutional dynamics. Was my experience unusual? Was it unexpected? Were the decisionmakers behaving rationally? Using case history analyses this panel will examine these and other intriguing questions about institutional dynamics of fishery management. We will articulate important questions about institutional incentives and impediments to fishery decisionmaking.

MONTANA'S RIPARIAN SHOWCASE RIVERSIDE ALLOTMENT - MADISON RIVER

Rosco, J.W. Bureau of Land Management, Dillon, MT

The Riverside Allotment comprises 1043 acres of public and private lands, including 3.3 miles of the Madison River. The allotment has historically been grazed seasonlong by cattle, sheep and horses. Most recently the area was lightly stocked with yearling cattle during the summer. The narrow riparian zone along the river was in poor condition but provided habitat for deer, nongame species of birds and mammals, and most importantly, food and cover for fish. In 1987, the Bureau of Land Management, the Montana Chapter American Fisheries Society and the allotment permittee conducted a workshop to jointly develop a grazing management plan which would enhance riparian condition, and further the understanding of the resource values and livestock needs by all parties. The outcome was fencing to create three pastures, and a grazing plan which reduced use in all pastures from 90 days to 30 days. The opportunity for riparian improvement is being provided without any reduction in livestock use, and costs of implementation are being shared by BLM, MCAFS, and the operator. Riparian response has been favorable in three years despite the impacts of drought, a wildfire on the allotment, and damage from ice gorging in the river. Although significant resource values have been addressed, perhaps the greatest benefit has come from the partnerships and understanding that have been established through this effort.

THE PAST AND FUTURE OF THE MONTANA RIPARIAN ASSOCIATION

Dan Hinckley Chairman, Montana Riparian Association and Riparian Coordinator/Fishery Biologist Bureau of Land Management, Billings, Montana

The Montana Riparian Association was formed in 1986. Our goals related only to riparian-wetland areas and they were to develop: (1) an ecological classification system; (2) management information; (3) an interagency data base; and (4) provide training and continuing education.

During 1990-91, an interagency effort determined our goals for the next five years. Again, they related only to riparian-wetland areas and are as follows: (1) Print and distribute our ecological classification by July 1, 1991; (2) Refine and expand management information; (3) Provide training and continuing education in identification, function, and management; (4) Refine and expand our knowledge on successional relationships; (5) Refine and expand our knowledge of vegetation/physical site relationships by community types; (6) Continue development of a coordinated data base; and (7) Develop a better understanding of cumulative effects of multiple use management activities at the watershed level.

ENHANCING FISHERIES RESOURCES THROUGH ACTIVE RIPARIAN MANAGEMENT

Robert E. Bilby and Peter A. Bisson, Weyerhaeuser Company, Technology Center, Tacoma, WA 98477

Removal of riparian vegetation along Pacific Northwest streams during timber harvest, and the consequent reduction in large woody debris, has led to dramatic changes in channel morphology, including reduction in pool frequency and a decrease in sediment storage. Recent changes in laws governing forest practices in the Pacific Northwest have included requirements for the retention of standing timber along streams to provide a future source of wood. However, most timber harvest in Washington and Oregon is in second-growth forests. Riparian vegetation in these stands often lacks structural complexity and vegetative diversity and thus, may not produce the channel conditions desired. Active management of the vegetation in riparian areas may offer a viable option for creating structurally complex riparian areas and streams. Objectives of this management approach would be to increase species diversity, conifer density and growth rates. Some possible options include planting desired species in patches cut to the streams edge, thinning and underplanting conifer, or releasing suppressed conifer by removing overstory hardwoods.

100 YEARS LATER: EFFECTS OF RAILROAD TIE DRIVES ON CHANNEL STRUCTURE AND RIPARIAN COMPLEXITY IN THE CENTRAL ROCKY MOUNTAINS

Young, M.K., D. Haire, and M. Bozek. USDA Forest Service, Laramie, WY

To satisfy the need for railroad crossties during the expansion of the railroads in the western United States, masses of ties were "driven" down streams during high spring flows. We hypothesized that activities associated with tie drives would alter channel morphology and riparian vegetation and that these alterations would be detectable nearly 100 years after driving of ties had ended. We selected both unimpacted and tie-driven reaches of similar length on each of three streams. We found that tie-driven reaches contained less large organic debris and fewer debris-related habitats than did unimpacted reaches; in high gradient reaches these habitats were plunge pools, whereas debris often created secondary channel units in lower gradient reaches. Furthermore, riparian zones associated with tie-driven channels were dominated by uniformly aged lodgepole pine dating back to the time of the last drive. In contrast, unimpacted riparian zones were composed of a mixture of Engelmann spruce and subalpine fir in uneven-aged, old growth stands. Finally, we simulated the effects of different silvicultural treatments of the riparian zone to evaluate the length of time necessary to restore the contribution of large organic debris from the riparian zone to stream channels to tie-driven watersheds.

DISTRIBUTION AND ABUNDANCE OF LARGE WOOD IN CENTRAL SIERRA STREAMS

Robert Ruediger Stanislaus National Forest Sonora, California

The Stanislaus National Forest conducted a survey of 17 streams to determine the distribution and abundance of large wood (LWD). A total of 93 plots were inventoried in the mixed conifer and red fir/lodgepole pine zones between 1109 m and 2316 m elevation. Fifty-seven plots were located in unlogged riparian areas, 18 plots were in salvage logged riparian areas, and 18 plots were in past railroad logged riparian areas. The unlogged/salvaged plots had greater LWD volume (152 m³/hectare) than the railroad logged plots (52 m³/hectare). There were 18 plots where the LWD volume ranged from 214-1175 m³/hectare. LWD volume declined as stream order increased. LWD volume varied by channel type (Rosgen classification). The highest volume were found in the A-channels (highest gradient), followed by the C-channels (lowest gradient). For both stream order and channel type, the railroad logged plots had less volume than the unlogged/salvaged plots.

Stable LWD made up only 30% of the total number of pieces, but represented 69% of the LWD volume. There was an average of 5.1 stable pieces/100 m in the unlogged/salvaged plots. The number of stable pieces/100 m declined as stream order increased and increased as channel gradient decreased. Again, railroad logged plots had fewer pieces than the unlogged/salvaged plots. Mixed conifer forests produced more LWD than did the red fir/lodgepole pine forest type. However, the number of stable pieces per 100 m was the same in both forest types.

THE INFLUENCE OF REDD DISTRIBUTION AND MICROHABITAT AVAILABILITY ON THE DISTRIBUTION AND ABUNDANCE OF YOUNG-OF-THE-YEAR TROUT IN THE GREEN RIVER, UTAH

Michael J. Buntjer and Timothy Modde, Utah Cooperative Fish and Wildlife Research Unit, Utah State University, Logan, Utah, 84322-5210, (801)750-2509.

Habitat models used to predict fish abundance often include the assumptions of unlimited recruitment and independence of habitat variables. However, such models are often not good predictors of fish abundance and are consequently limited in their general application across streams and geographic areas. The primary objective of this study was to determine the influence of redd distribution and microhabitat availability on the distribution and abundance of young-of-the-year (YOY) trout in the Green River, Utah. Results of microhabitat electivity data indicated that YOY trout in the Green River were not selecting microhabitat variables in narrow optima, but rather occupying the range of available habitats. In addition, dispersal of YOY brown trout (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*) from spawning sites was limited. Thus, sections of the Green River with useable habitat may have been limited by recruitment. Our results indicate when recruitment is limiting, habitat is not a good predictor of YOY trout distribution and abundance in streams. Finally, principal component and multiple regression results indicate that models which include the interaction of habitat variables with redd distribution and density data, may be better in explaining differences in the distribution and abundance of YOY trout, particularly in large regulated rivers.

QUALITY CONTROL AND ESTIMATION OF FISH HABITAT

Young, M. K., M. Bozek, D. Haire, and K. Bird. USDA Forest Service, Laramie, WY 1991.

We have rarely seen quality control procedures documented in conjunction with estimation of fish habitat. Unless quality control is performed, researchers and managers arbitrarily assume that all estimations of habitat are equally precise and accurate. To test this assumption, three people conducted independent estimates of habitat types, attributes, and amounts on three stream reaches of known length. Estimates of total reach length by different people significantly differed for two of the three stream reaches. Furthermore, each person identified a different number of habitat types for each stream; in some cases, these differences were substantial. Habitat attributes were also inconsistently estimated; one person "measured" an order of magnitude more undercut bank than did the other two people in two of the three reaches. We specify quality control practices to reduce the variability between people and to remove bias from estimates of habitat abundance.

A COMPARISON OF THREE TECHNIQUES FOR ESTIMATING BULL TROUT DENSITIES

Russ Thurow, Intermountain Research Station, USDA-Forest Service, 316 E. Myrtle, Boise, Idaho.
Dan Schill, Idaho Department of Fish and Game, Eagle Fish Lab, 1978 Trout Road, Eagle, Idaho.

The cryptic nature of bull trout and their tendency to inhabit sterile unproductive waters in Idaho pose problems when conducting inventories. Estimates of bull trout numbers are typically derived from snorkeling or electrofishing. Sampling guidelines and correction factors need to be developed so data are representative and comparable. We compared precision and total population estimates derived from electrofishing and both day and night snorkeling. Snorkel counts were replicated and stratified by habitat type. Mean day and night counts of age one and older bull trout were nearly identical within individual stations. Estimates derived from electrofishing were consistently larger than snorkel counts. However, 95% confidence intervals for all three techniques overlapped in three of the four stations where they could be calculated. Comparisons of day versus night habitat use and the influence of fish size and sampling method are discussed.

A CASE FOR CUTTING-THE-LINE ON DEEPLY-HOOKED FISH CAUGHT AND RELEASED WITH BAIT

Dan Schill, Idaho Department of Fish and Game, Eagle Fish Lab, 1798 Trout Road, Eagle, ID 83616

A hooking mortality study was conducted at the Hagerman Fish Hatchery to examine the potential benefits of cutting the line on deeply-hooked fish caught with bait. The study involved a total of 775 fish and mortality was monitored over a 60 day period. Deeply-hooked fish (gills or esophagus/stomach) in two test groups released via the traditional method of hook removal suffered mortality rates of 74 and 77 percent. Mortality rates for two test groups with fish released by cutting the line and leaving the hook intact experienced mortality rates of 47 and 49 percent or about one third less than from the usual method. Survival of deeply-hooked fish for the study period doubled when the line was cut and hook left in place. Mortality of lightly-hooked fish was 5 percent, a value similar to figures commonly quoted for flies and lures. Analysis of variance indicated no significant differences in condition factors between lightly-hooked, cut-line, deep-removed, and control fish surviving to the end of the experiment. Ninety-two percent of all deeply-hooked fish that had the hook removed died during the first seven days of the study. Cut-line mortality was slightly delayed with 83 percent of all deaths occurring during the same time period. By the end of the 5th week 99% of the cut-line fish had died. Results of the study confirm findings of past researchers examining the concept of cutting-the-line. Limitations of the study and potential application of results is discussed.

**AGRICULTURAL DRAINWATER IN THE ARID SAN JOAQUIN VALLEY:
A BLESSING OR CURSE TO FISHES?**

Michael K. Saiki, U.S. Fish and Wildlife Service, National Fisheries Contaminant Research Center, Field Research Station, 6924 Tremont Road, Dixon, California 95620, (916) 756-1946.

The San Joaquin Valley of California has an arid climate (5-14 inches of annual rainfall) characterized by hot dry summers and cool rainy winters. In order to allow intensive agricultural production in the Valley, massive irrigation projects were constructed on the Sacramento-San Joaquin River systems. Following closure of Friant Dam on the San Joaquin River near Fresno in February 1944, this river literally "dried up" over a downstream distance of about 75 miles. Today, during the irrigation season (March-October), flows in the lower 40 miles of this reach consist mostly of irrigation water from the Delta-Mendota Canal and agricultural drainwater from irrigated fields. Although many fish species reside in warmwater habitats created by agricultural drainwater, our studies indicate that these fishes have accumulated potentially harmful concentrations of contaminants such as selenium. Laboratory tests also suggest that the ionic composition of brackish drainwater (mostly sodium and sulfate) is toxic to salt-tolerant fishes.

**AN OVERVIEW OF CUTTHROAT SYSTEMATICS FROM MORPHOLOGY TO DNA ANALYSES:
PRESENT STATUS AND FUTURE APPLICATIONS**

Dennis K. Shiozawa (Dept. of Zoology, Brigham Young University), Richard N. Williams (Dept. of Biology, Boise State University), R. P. Evans (Dept. of Zoology, Brigham Young University), J. Kudo, (Dept of Zoology, Brigham Young University) and R. R. Sorenson (School of Medicine, University of Michigan)

Systematic relationships among cutthroat trout subspecies were initially defined by combining meristics and morphometrics with inferences based on appearance and drainage associations. Now that many populations have become extinct or hybridized with non-native trout, it has become increasingly difficult to separate subspecies using such morphological characteristics. An array of biochemical tools are now available for use in systematics, but phylogenies generated by these techniques may or may not corroborate older taxonomic designations. Few comparative studies of different techniques have been completed.

Over the past four years, we have collected approximately 60 trout populations, predominantly cutthroat, with the objective of developing a comparative database for evaluating the utility and resolution of various systematic techniques. Morphological analyses include quantification of spotting pattern and meristic data. Protein electrophoresis of allozymes and restriction fragment length polymorphism (RFLP) analysis of mitochondrial DNA have been conducted. Several new techniques, including DNA amplification via the polymerase chain reaction (PCR) and DNA sequencing, are being explored that promise increased discrimination between subspecies, as well as the ability to resolve within-subspecies differences. Data from these two techniques can be used in systematic and phylogenetic analyses, or to develop probes that will allow a more accurate assessment of restriction site variation. Finally, our ability to extract DNA from formalin preserved tissues has also made DNA information from museum specimens accessible to DNA analysis.

**ALLOZYME AND MITOCHONDRIAL DNA PHYLOGENIES OF CUTTHROAT TROUT:
SYSTEMATICS AND CONSERVATION BIOLOGY**

Richard N. Williams (Dept. of Biology, Boise State University) Dennis K. Shiozawa (Dept. of Zoology, Brigham Young University), Robb F. Leary (Div. Biological Sciences, University of Montana) and E. Bermingham, (Smithsonian Tropical Research Institute, Panama)

The current phylogeny and classification of the polytypic cutthroat trout, (*Oncorhynchus clarki*), includes 14 subspecies and is based on chromosomal and morphological data. We tested this phylogeny against phylogenies we generated from allozyme data (70 loci) and restriction fragment length polymorphism (RFLP) analysis of mitochondrial DNA (15 restriction enzymes). Allozyme and mtDNA phylogenies were largely concordant and revealed finer resolution, and hence, more information about the evolutionary history of cutthroat trout than did the morphological phylogeny. Cutthroat trout were monophyletic and differed from rainbow trout by approximately 5% of their mitochondrial genome. Four major evolutionary groups were identified within the cutthroat species which differed from one another by about 1% sequence divergence. Finally, both allozyme and mtDNA analyses revealed three minor evolutionary lines within the "yellowstone" group of subspecies that correspond to zoogeographic groupings of subspecies from north to south. Yellowstone and Snake River finespot cutthroat formed the northern clade, Colorado River and greenback cutthroat form the central clade, while Rio Grande cutthroat comprise the southern line. Bonneville cutthroat from Bear Lake and Bear River formed part of the northern clade, whereas Bonneville cutthroat trout from the southern Bonneville Basin were part of the central clade. This suggests that the Bonneville cutthroat trout is either a paraphyletic taxa, or has experienced historic introgressive hybridization with Yellowstone cutthroat trout from the north. These systematic differences have ramifications for the management and conservation of the Bonneville cutthroat trout.

MOLECULAR GENETICS AND THE FUTURE OF TROUT SYSTEMATICS:

RESTRICTION SITE MAPPING AND MITOCHONDRIAL AND RIBOSOMAL DNA SEQUENCING

J. Kudo (Dept. of Zoology, Brigham Young University), Y. Shen (Dept. of Zoology, Brigham Young University), Dennis K. Shiozawa (Dept. of Zoology, Brigham Young University), R. P. Evans (Dept. of Zoology, Brigham Young University) and Richard N. Williams (Dept. of Biology, Boise State University)

Restriction maps of the cutthroat trout mitochondrial genome were constructed for the purpose of phylogenetic analysis. Comparison of restriction site maps between the four major evolutionary groups of cutthroat trout revealed different sets of conserved restriction enzyme sites. Restriction enzyme maps of populations within groups always contained the group specific map sites, but also contained population specific sites. Mapping of conserved sites will assist our future efforts to isolate and sequence specific genes from the cutthroat mtDNA.

DNA sequences from the D-loop in mtDNA and from two internal transcribed spacer regions (ITS-1 and ITS-2) of ribosomal DNA were examined for their ability to discriminate among cutthroat subspecies and the four major evolutionary groups. Primer sequences for the ITS region were determined and synthesized. The polymerase chain reaction (PCR) was used to amplify DNA and the resulting products were sequenced. The D-loop sequence was approximately 1.1 kilobases in length. Variation in the D-loop sequence allowed discrimination among the four major evolutionary groups of cutthroat trout, but did not differentiate among subspecies within the yellowstone group. Surprisingly, the taxonomic resolution of the D-loop sequence was lower than that of our RFLP mtDNA analyses.

The ribosomal DNA ITS segments were both approximately 200 base pairs long and showed greater DNA sequence diversity among subspecies than the D-loop sequence. While we have not yet completed this analysis, some subspecies show sequence differences of greater than 10%, implying that these DNA segments may hold significant taxonomic and systematic utility in separating closely-related trout taxa. AN

THE EFFECT OF ELECTRIC CURRENT ON RAINBOW AND CUTTHROAT TROUT EMBRYOS

William P. Dwyer U.S. Fish and Wildlife Service 4050 Bridger Canyon Road Bozeman, Montana
Wade Fredenberg Montana Department of Fish, Wildlife and Parks
1400 South 19th Street Bozeman, Montana

Tests were conducted to determine if electric current has an effect on the survival of trout embryos. In the first series of tests, rainbow trout eggs were subjected to one of three treatments. In the first treatment, eggs were exposed to current from an electro shocker. In the second treatment eggs were handled in the same exact way as those exposed to electric current but without current. This was done to separate the effect of handling from the electroshock effect. In a third treatment, eggs were exposed to a standardized mechanical shock, to determine if the sensitivity coincided with the same sensitive period as to electric current. Different groups of rainbow trout eggs were exposed to one of the three treatments on days 2, 4, 6, 8, 10, 12, 14, 16, 18, 22, or 26. This was from two days post fertilization to two days prior to hatch. On each treatment day three replicates of 200 eggs each were placed into the exposure chamber where they were gently poured into a nylon basket and exposed to the output from a Coffelt BP 6 backpack shocker for ten seconds. The shocker output was measured at 0.6 amps, pulse was 250 Hz, and voltage gradient was measured at 0.9 - 1.0 volts per cm. The second group was handled in the same way but the electricity was not applied. The data shows that the most sensitive period in the development of the eggs was at day 8 post fertilization. Eggs exposed to electric current on day 8 had the highest mortality rate (approximately 60%) while the eggs handled in the same manner with no electricity experienced a mortality rate of approximately 25%. Eggs which received the physical shock had their highest mortality (99%) at day 8. The baseline mortality for all groups was 20%. In further tests with cutthroat trout eggs it was shown that the length of time and voltage are also correlated to mortality. Results of tests in which eggs were placed into artificial redds will also be presented. Results from these tests show that the above voltage and current can have an effect on the survival of rainbow trout eggs. This work implies that electroshocking in streams where trout have recently spawned may be detrimental to survival of the embryos.

**ELECTROFISHING INJURY AND MORTALITY IN COLORADO USING THE COFFELT VVP-2C
(2000 WATTS) WITH 60 CYCLE PULSED VOLTAGE**

R. Barry Nehring Colorado Division of Wildlife 2300 S. Townsend Avenue Montrose, CO 81410

The COFFELT VVP-2C electrofishing unit has been exclusively used in Colorado's coldwater stream research project for the past decade. It has been used on walk-shocking operations in streams up to 100 feet wide and on boat shocking operations using aluminum Jon boats and rafts. The walk-shocking operation uses an array of 4-5 positive DC electrodes and a stationary negative DC electrode. Boat shocking applications utilize the mobile positive DC throw electrode pioneered by the Montana Department of Fish, Wildlife, and Parks. The operating output power range is 1000-2000 watts.

Colorado has experienced no problems with electrofishing-induced injury or mortality to rainbow or brown trout with the walk shocking electrode array. The study areas are all in high visibility-heavy angler use situations under the scrutiny of concerned anglers. Two-pass electrofishing operations results in 50% to 99% of the study section trout populations being captured. Walk electrofishing-induced mortality rates are known to be in the 0.1% - 0.5% range.

Boat shocking operations occasionally result in injury manifested in either permanent spinal disfigurement (lordoscoliosis upon healing) or death. Although no quantitative studies have been done, circumstantial evidence indicates permanent injury and/or mortality rates on boat electrofishing operations are in the range of 1% to 5% or less.

These low injury and mortality ratios are believed to be the result of three important factors. First, the conductivity of most coldwater trout streams in Colorado is generally less than 100 micromhos/cm² and rarely more than 200 micromhos/cm². Second, water temperatures during electrofishing operations are rarely more than 15 C, most often in the 0-10 C range. Third, rapid removal from the energized field, usually in 1-2 seconds, reduces the time, intensity, and severity of galvanonarcosis, greatly reducing the injury and mortality rates.

SPINAL INJURY IN TROUT ELECTROFISHED WITH A COFFELT VVP-15 OR CPS (TM) SYSTEM

Curt Meyer and Dirk Miller Wyoming Game and Fish Department Laramie, WY 82070

We investigated the occurrence of spinal injuries in trout collected by single-pass, pulsed DC electrofishing using a Coffelt VVP-15, or a Coffelt CPS (TM) shocker, and the occurrence of spinal injuries in trout collected on the fourth pass of a multiple mark-recapture population estimate using a Coffelt VVP-15 shocker. Output on the CPS (TM) was set at 460-470 V. Output on the VVP-15 was set at 370-390 V, 40 pulses/s, and 20% duty cycle. The electrofishing was done from a small raft. Spinal injuries were determined from x-rays of the collected fish. The mean percentage occurrence of spinal injuries in trout collected from a single electrofishing pass using the VVP-15 was 8% (n=45). A single electrofishing pass using the CPS (TM) resulted in a mean percentage occurrence of spinal injuries of 13% (n=110). The trout collected and x-rayed on the fourth pass of the multiple mark-recapture population estimate, using the VVP-15, were not recaptures (i.e., were unmarked fish). An average of 30% (n=65) of these trout suffered spinal injuries. We concluded that under the conditions present during this work, the CPS (TM) and VVP-15 worked comparably (i.e., good electro taxis and relatively low spinal injury). Also it appeared that fish not netted and handled suffered spinal injuries. We could not categorize these fish as having been shocked similarly to netted and handled fish, but missed by the netter, or as fish that escaped on the "fringes" of the electric field.

ELECTROFISHING INJURY AND SHORT-TERM MORTALITY IN RAINBOW TROUT IN A HATCHERY ENVIRONMENT

Geoffrey A. McMichael, James N. Hindman, James P. Olsen Washington Department of Wildlife

Four groups of hatchery-reared rainbow trout were exposed to different direct current voltages and pulse rates from a battery-powered backpack electrofisher. The fish collected with the various settings were then subjected to our typical data collection handling, including: anesthetizing (MS222), measuring length and weight, collecting scale samples, and tagging (anchor tags in fish > 200 mm). A control group was not exposed to electrofishing. The five groups were monitored daily for seven days following the initial electrofishing treatments to determine the extent of delayed short-term mortality. Samples were collected after seven days using the same settings as were initially used (and a sample was seined from the control group) and were placed on ice and necropsied within two hours of collection. Fish were examined for spinal injury by filleting the fish on both sides and visually determining the presence or absence of spinal column damage and associated hemorrhaging in surrounding musculature. An injury was classified by either the actual spinal displacement/compression or by hemorrhaging in musculature surrounding the spinal column. A total of 114 fish were necropsied. Fish from the control group showed no signs of injury. Injury rates ranged from 4% to 53% with the higher pulse rates producing the higher injury rates. When data were pooled there was a significant ($p < .01$) positive correlation between fish length and electrofishing-induced injury. Larger fish appeared to be more susceptible to injury. Only one fish (of over 100 exposed to electrofishing) died during the seven day period following the initial electrofishing treatments. The two electrofishing runs could have increased the injury rates (theoretically, this could have doubled injury rates). We noted a relationship between the chromatophore stimulation (often referred to as "bruising" or "burning") and the incidence of injury. It appears that short-term mortality due to the electrofishing conducted in this hatchery environment was negligible. Incidence of injury due to electrofishing was, however, very high (with some settings) and should be considered to deleteriously affect the fish sampled until proven otherwise.

APPROACH TO MODELLING THE HYDRAULICS OF COMPLEX ISLANDED CHANNELS OF THE CLEARWATER RIVER OF IDAHO

Edward Connor (EBASCO Environmental 10900 NE 8th Bellevue, WA 98004) and William P. Connor

The Nez Perce Tribe conducted a chinook salmon (*Oncorhynchus tshawytscha*) restoration project on the lower mainstem Clearwater River of Idaho using the Instream Flow Incremental Methodology (IFIM) as a tool to assess flow versus spawning habitat relationships. Hydraulic and fish habitat modelling is becoming increasingly important in the western United States as demands on our water resources increase and the run sizes of indigenous anadromous salmonid stocks dwindle. IFIM is a well documented modelling technique, however, most of this documentation addresses single channel reaches of small streams. The purpose of this paper is to describe the calibration details, and refinements to calibration procedures, developed and employed to model complex islanded reaches of the mainstem Clearwater River in Idaho.

We stratified the lower 70 km of the Clearwater based on flow and geomorphology into segments and assigned study sites to these segments where spawning gravel was abundant. We considered chinook salmon spawning habitat to be the product of water depth, velocity, temperature, and substrate. These variables were measured at cross-sections within the study sites. Cross-sectional data were input to the hydraulic model IFG4 to allow the simulation of unmeasured flows.

Our analysis identified two problems in complex channel modelling. The first problem involved flow apportionment among multiple channels at islanded study sites. The second problem involved the interpolation of water surface elevations at instream flow transect locations. Discharge among islanded channels was apportioned using field measurements for low flows. We then calculated partial island discharges at higher flows using Manning's equation at river discharges approximating 16,000 cfs, 36,000 cfs, and 45,000 cfs. We determined that the hydraulics at potential spawning sites changed dramatically within a narrow range of discharges. These changes were related mostly to the topping over of the islands by flow and subsequent adjustments in water slope.

**ASSESSMENT OF CHINOOK SALMON SPAWNING GRAVEL QUALITY
IN THE CLEARWATER RIVER, IDAHO**

Billy D. Arnsberg and William P. Connor Nez Perce Tribe Department of Fisheries P.O. Box 1701 Orofino, ID

The Nez Perce Tribe conducted a chinook salmon (*Oncorhynchus tshawytscha*) restoration project on the lower mainstem Clearwater River of Idaho using the Instream Flow Incremental Methodology (IFIM) as a tool to assess flow versus spawning habitat relationships. One drawback of this methodology is that substrate evaluation is limited to visual interpretation of surface characteristics. The specific goal of this paper is to discuss our assessment of spawning substrate at the hydraulic study sites, described by the previous companion paper, and the comparison of Clearwater gravel quality to that of the Snake, South Fork Salmon, and Wenatchee Rivers.

We identified two major fall chinook salmon spawning areas on the Clearwater by helicopter survey and obtained spawning substrate samples by freeze-coring with a tri-tube sampler using liquid CO₂. Samples were taken prior to natural spawning and chosen systematically on existing hydraulic cross-sections. Freeze-core samples were stratified vertically into three 10.16 cm strata and wet-sieved in the field. The Fredle index was the main substrate quality index used to describe the Clearwater spawning areas and to compare (ANOVA) with freeze-core samples taken from mass spawning areas of the lower Snake, Wenatchee, and South Fork Salmon Rivers. Percentage of fine sediment (< 0.85 mm) was used to compare spawning habitat quality and embryo survival studies in the literature.

We observed a difference in spawning habitat quality between the two study sites on the Clearwater. Fredle numbers were not significantly different (at the 0.05 level) in stratum 1 but were significantly higher in strata 2 and 3 at the upriver sampling site. Overall, spawning substrate quality of the Clearwater was most similar to that of the Wenatchee River. The Snake and the South River substrates had considerably lower Fredle numbers and greater percentage of fine sediment. Survival prediction of chinook salmon throughout incubation would be high at the two spawning sites we studied. The quality of substrate at our two study sites would not limit chinook production. However, it should be noted that the Clearwater's channel has been subject to dam related armoring and the amount of substrate of this quality is limited.

**CONSEQUENCES OF SPAWNING HABITAT SELECTION BY MAINSTEM SPAWNING RACES OF
CHINOOK SALMON ON RESTORATION EFFORTS IN THE CLEARWATER RIVER OF IDAHO**

W.P. Conner, E. Connor, and B.D. Arnsberg Nez Perce Tribe Dept. of Fisheries P.O. Box 1701, Orofino, ID

The Nez Perce Tribe conducted a chinook salmon (*Oncorhynchus tshawytscha*) restoration project on the lower mainstem Clearwater River of Idaho using the Instream Flow Incremental Methodology (IFIM) as a tool to assess flow versus spawning habitat relationships. The specific goal of this paper is to discuss our comparison of the spawning habitat available to mainstem spawning races of chinook salmon under existing flow regimes regulated by Dworshak Dam.

Our hydraulic modelling methodology was addressed by the previous companion paper. In review, we stratified the lower 70 km of the Clearwater and measured water depth, velocity, and substrate at cross-sections within the study sites. Cross-sectional data were input to the hydraulic model IFG4 to allow hydraulic simulation over a range of unmeasured flows. Since documented Snake River fall chinook salmon spawning in the Clearwater was limited, we choose to describe water velocity, water depth and substrates used by mainstem spawning summer and fall chinook salmon by measuring these variables in other more seeded mainstem rivers and by using the literature. We interfaced this habitat preference information with the hydraulic modelling output using the Physical Habitat Simulation procedure (PHABSIM) to develop flow versus habitat relationships.

Fall flood water evacuation from Dworshak Reservoir created excellent attraction and staging conditions for both races of chinook. Channel complexity had pronounced effects on the hydraulics of potential chinook salmon spawning sites. Small changes in discharge at these sites had measurable effect on the total area available for spawning. However we found no appreciable differences in the quantity of habitat available to either race of chinook under the existing flow regime. Notably, chinook salmon from the individual rivers we studied showed similarities in water velocity and substrate selection. Water depth was not an important factor in spawning site selection by either race of chinook.

FISHERIES MANAGEMENT ON EASTERN MONTANA INDIAN RESERVATIONS

Robbin Wagner USFWS Creston, Montana

In Montana, east of the Continental Divide, there are six Indian Reservations comprising over seven million acres of land home to seven different Indian Tribes. These tribes rely on the U.S. Fish and Wildlife Service for their fish and wildlife management. This presentation is a brief overview of the ongoing fisheries management activities on these reservations by the U.S. Fish and Wildlife Service.

FISHERIES MANAGEMENT ON THE FLATHEAD INDIAN RESERVATION

Les Evarts Confederated Salish and Kootenai Tribes P.O. Box 278 Pablo, Montana 59855

The Flathead Indian Reservation is the 1.2 million acre home of the Confederated Salish and Kootenai Tribes. The Reservation has a diverse fisheries resource with nearly 70,000 acres of lakes and over 400 miles of streams which are open to all anglers. Popular areas include Flathead Lake, the Lower Flathead and Jocko Rivers, high mountain lakes and several irrigation reservoirs.

Fisheries management on the Reservation has evolved over the past decade from a single Bureau of Indian Affairs (BIA) biologist into a progressive Tribally funded program. The program works cooperatively across political and state boundaries to protect and enhance the fishery resource both on and off the Reservation. The program's activities include research, regulation, planning, plan implementation and hydropower mitigation.

The program is presently conducting research on the physical, biological and angler use characteristics of Ninepipe and Kicking Horse Reservoirs, important largemouth bass fisheries. This study will allow the Tribes to develop a fisheries management plan for these waters, resulting in a better fishery. A similar study is being conducted for the Jocko River trout fishery. A federal irrigation project has impacted our fishery resource for some 80 years. The Tribal Council has been on record since 1939 requesting that fish screens and ladders be built to protect the fisheries. The first screen was built in 1987. Currently there are five fish screens and four ladders on the Reservation, built by the BIA. The Tribal Fisheries Program conducts the research which identifies site selection.

In 1985 the Tribes filed suit against the BIA to prevent the dewatering of Reservation streams by irrigation. Due to this, several subsequent lawsuits, the Tribes now have legally imposed instream flows for the protection of Treaty fishing rights with a priority date of time immemorial. The Tribal Fisheries Program assisted the BIA in developing these instream flows.

The Tribes have historically and culturally revered their fishery resource, but unfortunately have also witnessed their native fish fauna dwindle. Today, the Tribes are indeed dedicated to the protection, enhancement and restoration of this important resource.

VIDEO BASED ESTIMATION OF PACIFIC SALMON ESCAPEMENT

Doug Hatch Columbia River Inter-Tribal Fish Commission

Timelapse VHS video tape equipment was used to record salmon passage at the fish ladder viewing window in Tumwater Dam on the Wenatchee River, Washington. Salmon passage was recorded during two years of migration. Tests of escapement estimation accuracy, tape reviewer precision, and tape recording speed were conducted.

Video-based escapement estimates were within 2% of inter-dam-based estimates. Inter-dam escapement estimates are derived by subtracting in-person counts of each species made at an upstream dam from in-person counts made at a downstream dam. One-way analysis of variance showed no significant difference ($P>0.05$) among five different tape reviewers based on fish counts of three species, chinook salmon (*Oncorhynchus tshawytscha*), sockeye salmon (*O. nerka*) and steelhead (*O. mykiss*). Paired Wilcoxon tests indicated that fish counts were not significantly different ($P>0.286$) between 48 and 72 hour timelapse recording speed modes.

Using timelapse video equipment appears to be an effective means to estimate escapement of Pacific salmon and offers several advantages over in-person counting. Video-based methods are more cost effective in areas with low escapement and video provides a permanent record of passage. The video record can be independently verified and tape analysis may be automated using a computer program similar to the one described in Irvine et al. (1991). *Advancements in Fish Culture*

**EVALUATION OF AN ELECTRONIC WALLEYE FRY COUNTER AND
AND ELECTRIC GRID TO PREVENT FISH ESCAPEMENT**

Greg A. Kindschi, Frederic T. Barrows, U.S. Fish and Wildlife Service Bozeman Fish Technology Center,
4050 Bridger Canyon Road, Bozeman, Montana 59715
Bill Kirkpatrick, 647 Canyon View Road, Bozeman, Montana 59715

We evaluated a fry counter (Jensorter, Inc. model FC 2) for accuracy, precision, ease of use and effects on survival of walleye fry (*Stizostedion vitreum vitreum*). Also evaluated was a grid utilizing 60 Hz, 220 volt single phase electricity to prevent escapement of walleye into a particular drainage. Overall, the greatest differences between the counter and hand counts averaged only 4.7%. Sample estimates volumetrically differed by 46.9% from hand counts, whereas gravimetric samples differed by 17.2%. Survival of electronically counted walleye fry after 66 h (96.9%) did not differ from those counted by hand (97.1%), gravimetrically (97.3%), or volumetrically (98.8%). The counter was easy to use, much faster than hand counting, and more accurate than volumetric or gravimetric methods. The device is potentially useful for counting larvae of other small fish species as well as walleye. Walleye fry were shipped in for research purposes and it was critical that none be allowed to escape. Experimental tests established that most effective results were obtained with an electric contact of .4 second and an electric potential gradient of 100 volts per 2.5 cm. The use of 220 volts along with grounding plates on entry and exit ends of the grid served as safety precautions by maintaining zero net volts to ground in the vicinity surrounding the grid.

REMOVAL OF RADON GAS LIBERATED BY AERATION COLUMNS IN FISH HATCHERIES

William P. Dwyer, U.S. Fish and Wildlife Service, 4050 Bridger Canyon Road, Bozeman, Montana 59715
 Wesley H. Orr and Jon V. Gravning, U.S. Fish and Wildlife Service Ennis National Fish Hatchery, Ennis, Montana 59729

The high levels of radon gas measured in hatchery buildings is due to the water flowing through the aeration columns in some cases. By developing new and more effective methods to degas and aerate water, we have created a new, but not insurmountable, problem. Radon gas, a by radioactive product of uranium decay, is found naturally in the ground water in some areas of the country. Aeration of this water can cause some of it to be released into the atmosphere. Exposure to high levels can cause increased risk of lung cancer. Radon concentrations in the atmosphere can be reduced by ventilation. Obviously this may not be the most energy efficient method since large volumes of outside air are needed and heated inside air is lost. A more energy efficient method is to collect gases given off in the aeration process and vent to the outside. This will require less air exchange to get rid of the radon gas and waste less heat energy. Tests were conducted at the Ennis National Fish Hatchery. Off gas collectors were installed on a test column to demonstrate that it would be possible to trap the gas and to vent it to the outside. The off gas collectors consisted of an inverted 14 by 18-inch tub to capture the escaping gas from around the bottom of the column. The tub was sealed around the column and extended 3-4 inches below the tank water level in order to prevent gas from escaping. A 1-inch plastic pipe fitting was placed in the collector and the gas was vented to a 2-inch pipe which was extended through the wall to the outside of the building. Four, 8-inch columns operated with flows of 60 gallons per minute were vented on one 2-inch pipe without creating back pressure. The radon monitor was used to measure the radon content of the off gas from the vent. The average reading after 24 hours was 428 pCi/L, thus demonstrating that a significant amount of radon was being liberated by the column. Thirty-eight columns were retro-fitted with off gas collectors at a cost of \$600. After installation of off gas collectors at Ennis National Fish Hatchery radon gas levels have decreased from 250 pCi/L to 25-40 pCi/L. This is a simple inexpensive method to deal with a dangerous health problem.

**THE EFFECT OF OXYGEN SUPPLEMENTATION ON THE TOXICITY OF AMMONIA (NH₃)
 IN RAINBOW TROUT Oncorhynchus mykiss**

Todd D. Hanna, U.S. Fish and Wildlife Service, Bozeman Fish Technology Center, 4050 Bridger Canyon Road, Bozeman, Montana 59715

Oxygen supplementation has been shown to be of value in fish production. Production capacities can be increased and nitrogen gas supersaturation problems can be alleviated through the use of oxygen. While some of the effects of oxygen supplementation have been demonstrated, the effects of supersaturated dissolved oxygen concentrations (DO) on un-ionized ammonia (NH₃) toxicity have not been reported. Arlee rainbow trout (*Oncorhynchus mykiss*) were tested at three NH₃ levels (<0.01, 0.04, and 0.06 mg/L) and two DO levels (<98.0 and 180.0% saturation.) Controls were exposed to (0.01 mg/L NH₃ and 97.0% DO.) Rainbow trout exposed to high DO's consumed more DO than controls and fish exposed to 0.04 mg/L NH₃ consumed more DO than either controls or fish exposed to 0.06 mg/L NH₃ over nine weeks of the study. Immune response and hematology were not affected by either NH₃ or DO concentration. Gills from rainbow trout exposed to both 0.04 and 0.06 mg/L NH₃ had an increased number of chloride cells and an increased incidence and severity of epithelial swelling and edematous tissue when compared to controls. Dissolved oxygen concentration had no effect on these changes. Rainbow trout exposed to 0.04 and 0.06 mg/L NH₃ gained more weight/fish than controls over 14 weeks of the study. Feed conversion, condition factors, survival, dorsal and caudal fin condition were not affected by either NH₃ or DO concentration. Control and rainbow trout exposed to 0.04 mg/L NH₃ had more mesenteric fat than those exposed to 0.06 mg/L NH₃ and the bile of rainbow trout exposed to high DO's was more green in color than that of controls. Rainbow trout in this study were not severely stressed by elevated NH₃ concentrations and the effects of elevated NH₃ exposure that were noted were not alleviated by increased DO's.

Present Address: Wyoming Game and Fish Department Dan Speas Rearing Station 5120 Alcova Route, Box 10 Casper, Wyoming 82604

AN ALTERNATIVE METHOD FOR THE MANUFACTURE OF FISH FEEDS

Rick Barrows, U.S. Fish and Wildlife Service, Bozeman Fish Technology Center, 4050 Bridger Canyon Road, Bozeman, Montana 59715

Many new species of fish are now being evaluated as candidates for intensive culture. The culture of these fish has resulted in the discovery of several specialized feeding problems. Larval diets for small-egg fish, conversion diets and the processing of fish silage are three areas where a new feed processing technique could be beneficial. Rearing of the larval stage of many species, such as striped bass, walleye, red drum and many others, is very difficult due to the extremely small size of the larvae. The small size of the fish necessitates small feed particles. Conventional diets have been shown to be ineffective with these species due to excessive nutrient leaching and unpalatability of the small feed particles. These problems have been related to the conventional feed processing techniques that are currently being used (steam compression pellets). The extrusion-marumerization processing technique does not expose the feed to excessive heat, thus preventing the reduction of protein digestibility, and results in a discrete feed particle (down to .5 mm in diameter). Other areas of application of this processing technique include: 1) coating feed particles with a shell of feeding stimulant to enhance feed consumption 2) processing of fish silage into feed. These topics will be discussed and results of a walleye conversion-diet trial presented.

OZONE FOR DISINFECTING HATCHERY WATER SUPPLIES

David E. Owsley, P.E., Environmental Engineer, U.S. Fish and Wildlife Service, Dworshak National Fish Hatchery, P.O. Box 18, Ahsahka, ID 83520

Ozone is the preferred choice for disinfecting hatchery water supplies. The superior disinfecting power of ozone and the increase of viral infections in hatcheries makes ozone the logical choice for a disinfection system. Capital costs and operation and maintenance costs show ozone to be a viable alternative for hatchery operations. Ozone is presently being used in a production mode at Dworshak National fish Hatchery in Idaho and Coleman National Fish Hatchery in California. Several major facilities are in the design phase for large scale ozone disinfecting systems. These include the Cowlitz and Merwin State Hatcheries in Washington, Cold Lake Hatchery in Alberta, Canada, Marquette Hatchery in Michigan and the Mora National Fish Hatchery in New Mexico. Ozone and aquaculture will continue to expand in the future.

MOIST INCUBATION USING CHILLED WATER TO RETARD THE DEVELOPMENT OF RAINBOW TROUT EGGS

Dave Erdahl, Bozeman Fish Technology Center, 4050 Bridger Canyon Road Bozeman, MT 59715

This study was conducted to determine if moist incubation techniques with chilled water could be used to retard the development of trout eggs. Trials were conducted with eggs obtained for Arlee and Kamloop strain rainbow trout. A pooled sample of fertilized eggs from each strain was split into five treatment groups: 1) standard Heath incubation; 2) moist incubation at ambient water temperature (54F), 3) moist incubation at ambient temperature for six days followed by moist incubation at 42F. Moist incubation eggs were placed in egg baskets from Heath incubation units and wrapped in cheesecloth. Individual baskets were stacked vertically in an insulated, enclosed box for incubation. The incubation box was fitted with a water distribution manifold to provide uniform dispersion of water over the egg baskets. Water was provided by a small submersible pump controlled by a timing device. The timer was set to run the pump for 30 seconds every 15 minutes (24 hr/day). Each incubation box received approximately 4 gph. Chilled water was provided by a Frigid Units 1/3 HP water chiller.

Results of this study indicate that moist incubation using chilled water is an effective method of retarding the development of trout eggs without adversely affecting egg viability. Percent eye-up and percent hatch data were similar between all 5 treatment groups. Moist incubation using chilled water (42F vs 54F) retarded the rate of egg development to the eyed stage by 10-14 days. Such techniques may provide broodstock managers with an economical tool by which the rate of egg development can be manipulated to better meet stocking and production strategies.

THE STRESS RESPONSE OF RAINBOW AND CUTTHROAT TROUT TO LOADING BY FISH PUMP, CONVEYOR, OR DIP NET

Eric J. Wagner and Diane Driscoll, Fisheries Experiment Station Division of Wildlife Resources, Logan, UT

The stress response of rainbow and cutthroat trout to three methods of loading fish for transport was evaluated. Rainbow trout demonstrated a stress response to loading by an increased level of plasma cortisol, but plasma cortisol concentrations did not differ among the loading methods tested. Based on plasma chloride analysis of cutthroat trout samples, the conveyor appeared the least stressful. In cutthroat trout, all loading methods caused a significant response in chloride and cortisol, relative to the baseline sample. Cortisol data suggested that the dip net and conveyor method were the least stressful for cutthroat trout. Chloride concentrations of cutthroat trout loaded by fish pump and dip netting were not significantly different from each other. Glucose concentrations in either rainbow or cutthroat trout were not elevated after loading, and did not differ among loading methods. Leucine aminopeptidase in plasma samples of rainbow trout did not differ among methods or in response to loading. No descaling was observed as a result of loading by any of the methods.

MERISTIC ANALYSIS IN A GENETIC MONITORING AND EVALUATION PROGRAM FOR POPULATIONS OF SALMON IN THE SNAKE RIVER BASIN

Orlay W. Johnson, Army E. Cook, and Robin S. Waples, National Marine Fisheries Service, 2725 Blvd. E., Seattle, WA 98112.

Yearly samples of juvenile chinook salmon (*Oncorhynchus tshawytscha*) are being collected from selected wild and natural populations and four hatchery supplementation programs in the Snake River basin. The purpose of the program is to evaluate the effects of outplanting hatchery-reared fish on natural and wild populations over three years. Fluctuating asymmetry observed in paired meristic characters (ex. fin ray and gill raker counts on right and left sides of an individual) can be used to detect reduced developmental stability. Fish analyzed from the first year of the study reveal that morphological divergence within drainages is more uniform than between drainages and suggests some hatchery populations have a higher mean number of characters showing asymmetry than coincident wild populations.

HABITAT USAGE OF SALMONIDS IN MADISON RESERVOIR, MONTANA AS DETERMINED BY RADIOTRACKING

Patrick A. Byorth, Montana Department of Fish, Wildlife, and Parks, Bozeman, Montana
Alan F. Olson, and Steven W. Wolff, EA Engineering, Science, and Technology, Inc., Redmond, WA
L. Brent Mabbott, Montana Power Company, Butte, Montana

Madison Reservoir (Ennis Lake), Montana, contains one of the few remaining potentially endemic populations of Arctic grayling (*Thymallus arcticus*) in the lower 48 states, and their continued protection is of importance to the state of Montana. Populations of rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*) also inhabit the reservoir. Recent abundance estimates by the Montana Department of Fish, Wildlife, and Parks (MDFWP) have suggested that the population of grayling which spawn in the Madison River is likely less than 1,000 individuals. Portions of Madison Reservoir contain heavy densities of macrophytes during the late summer and concerns have been raised about the affect winter drawdowns may have on macrophyte growth, and subsequently upon fish populations within the reservoir. Montana grayling were historically a river dwelling species, so little is known about their habitat requirements in a lacustrine environment and it is unclear to what extent the macrophyte community in Madison Reservoir is utilized. To address these concerns, the Montana Power Company is sponsoring a study to attempt to define the habitat utilization of salmonids in Madison Reservoir. This study is being conducted by the MDFWP and EA Engineering, Science, and Technology. During the spring, individuals of all three salmonid species were surgically implanted with radio transmitters having a battery life of 5 or 15 months. Fish movements will be monitored by both continuous tracking and spot checks at least three days per week and will continue for the life of the tags. It is our objective to determine the movement patterns of tagged individuals within the reservoir and the degree of macrophyte habitat utilization. In addition, we hope to determine some of the locations of tributary spawning by individuals tagged with the long-term transmitters.

EFFECTS OF SIZE AT RELEASE, TIMING, AND INITIAL NUMBER ON SUMMER SURVIVAL AND GROWTH OF HATCHERY COHO SALMON (*Oncorhynchus kisutch*) STOCKED IN WESTERN WASHINGTON STREAMS

Brian R. Fransen, Peter A. Bisson, and Robert E. Bilby, Weyerhaeuser Company, Technology Center, Tacoma, WA 98477

Underyearling coho salmon of hatchery origin have often been stocked in western Washington streams in an attempt to compensate for inadequate adult escapement or to aid the recovery of natural coho populations after severe environmental disturbances. The success of fry stocking programs is often unpredictable and difficult to quantify. Since the early 1980s we have examined the summer survival and growth of hatchery coho fry planted in streams at a wide range of sizes, densities and release dates. Small coho fry that were stocked in spring soon after yolk absorption were rapidly redistributed throughout the stream and population densities appeared to be controlled by the amount of suitable physical habitat. Large fish, stocked in late spring or early summer tended to remain in pools near the planting location and were less likely to colonize all available habitat. Therefore, large fry appeared to have better initial survival than those of smaller size, based on the rate of residency near the release site. As summer progressed, however, the capacity of the stream to support a large coho biomass became increasingly limited, resulting in compensatory adjustments in the growth and mortality of large fish. These adjustments often caused the density and average weight of large, late stocked fry and small, early stocked fry to converge by summer's end. In a number of instances we found that the small, early coho fry were actually larger and as numerous than large, late fry by summer's end. By more closely mimicking the size and timing of naturally produced fry at emergence, stocking small fish early in the year may provide a more effective and cheaper means of increasing coho salmon production in underseeded streams, possibly with fewer impacts on natural populations.

DESIGN AND STATISTICAL ANALYSIS OF WATER QUALITY STUDIES WITH EXAMPLES FROM THE SNOHOMISH AND STILLAGUAMISH RIVER PROJECTS

Kit Rawson, Kurt Nelson, Kathleen Thornburgh, Kit Paulsen, Gino Lucchetti, Tulalip Fisheries Department, 3901 Totem Beach Road, Marysville, WA 98270

The Tulalip Tribes are conducting water quality studies on the Snohomish and Stillaguamish watersheds in western Washington to establish a baseline water quality monitoring program in order to evaluate the contribution to nonpoint source pollution from several different land use types. Land uses include commercial agriculture, hobby farms, residential areas with septic systems, and relatively pristine areas. Sampling sites are located in pairs upstream and downstream of stream reaches each characterized by a single land use. Sample pairs are located in both mainstem and tributary areas throughout both watersheds, and they are sampled during both the wet and the dry seasons each year. Approximately ten percent of the samples are randomly replicated and both banks at each mainstem site are sampled once per season. The design allows the comparison of water quality variables at upstream and downstream sampling locations using a repeated measures analysis of variance, controlling for year to year and wet-dry season differences. The sample replication allows us to compute an estimate of the intrinsic variability of a single sample, and the bank-to-bank replication allows us to examine and statistically test the significance of the variability between opposite banks at a mainstem site. Three and one half years of data from the Snohomish River project have been analyzed and will be used to illustrate the design and statistical analysis methods.

**AN ASSESSMENT OF FREEZE BRAND AND PIT TAG RECOVERY DATA ON
JUVENILE SALMONIDS (*Oncorhynchus* spp.)**

Clinton S. McCutcheon, and Albert E. Giorgi, National Marine Fisheries Service, Northwest Fisheries Center,
2725 Montlake Blvd. East, Seattle, WA 98112

Juvenile salmonids (*Oncorhynchus* spp.) have been monitored at several dams on the Columbia and Snake Rivers for over 20 years. The principal mark used to monitor salmonid migration has been the freeze brand. In 1984, the National Marine Fisheries service began a study on the feasibility of the PIT tag as a new fish tagging system. PIT-tag monitor stations were installed at hydroelectric dams where freeze-brand monitoring occurs. Preliminary investigations at McNary Dam suggested that PIT-tagged juvenile salmonids were recovered in significantly higher proportions than those which were freeze-branded.

Beginning in 1987 a two-year study was initiated to assess the extent and nature of the differential recovery proportions in yearling and sub-yearling chinook salmon (*O. Tshawytscha*), sockeye salmon (*O. nerka*), and steelhead (*O. mykiss*). In 1987, sixteen paired groups consisting of either PIT-tagged or freeze-branded fish, totaling 8,120 and 168,906 respectively, were released from hatcheries and in-river tagging sites. Fish were monitored at McNary Dam. In 1988, eleven groups of double-marked fish (freeze branded and PIT tagged) totaling 8,114 were released directly into the collection system at McNary Dam. PIT-tagged stocks of yearling chinook salmon, sockeye salmon, and steelhead were consistently recovered in significantly greater proportions ($P < 0.001$) than freeze-branded counterparts, with the brand data being more variable than the corresponding PIT-tag data. We conclude that recoveries of PIT tags were more consistent than brands due to automated recovery and absence of human error; whereas, the low and variable recovery of brands was subject to errors associated with brand grading, detection, interpretation, and sub-sampling.

**DOES JUVENILE SALMONID CONDITION AFFECT THEIR VULNERABILITY TO PREDATION BY
NORTHERN SQUAWFISH?**

Matthew G. Mesa and Dena M. Gadomski, U.S. Fish and Wildlife Service, Columbia River Field Station, Star
Route, Cook, WA 98605

Northern squawfish are major predators of juvenile salmonids in the Columbia River. However, the overall significance of predation as a mortality factor remains a question if northern squawfish are selective predators or if prey in poor conditions are more vulnerable to predation. In laboratory experiments, we compared predation rates on control fish versus three categories of "substandard" juvenile salmonids: dead, descaled, and stressed. Northern squawfish ate significantly more dead than live prey whereas descaled and control prey were eaten in roughly equal proportions. Juvenile salmon exposed to multiple handling stresses or 5 min. of vigorous agitation did not differ significantly from controls in their vulnerability to predation. Selected indicators of stress (e.g., plasma cortisol, glucose, and lactate), however, revealed that juvenile salmon were in a state of physiological dysfunction for various lengths of time. Current research is aimed at a more thorough assessment of the effects of various stressors on prey vulnerability and also conducting similar experiments in field situation.

NEW COLVERT AND RETROFIT DESIGNS FOR PASSAGE OF WEAK SWIMMING FISH

C.E. Behlke, Professor of Civil Engineering Emeritus, University of Alaska, Fairbanks, Box 82230, Fairbanks, AK 99708

A recently completed design guide for new culvert and culvert retrofit design to achieve upstream passage of weak swimming fish is described. The design guide describes the appropriate hydrologic parameters, bio fluid mechanics of swimming fish, and culvert hydraulics where fish actually swim in culverts. It then puts these parameters together to achieve culvert designs acceptable for passage of weak swimming fish. Stream hydrology and allowance for acceptable fish passage delay have considerable influence on acceptable design stream discharge. The length of the weak swimming design fish for the stream is selected by the appropriate resource agency. Fish swimming fluid mechanics and red and white muscle power and energy output are analytically described. Culvert length and slope together with knowledge of the design fish's red muscle and white muscle power and energy output capabilities define the passage time which can be expected. With this information, the design engineer uses an interactive technique for matching culvert hydraulics to the swimming capabilities of the design fish.

Observations in culverts show that swimming locations favored by stressed fish are at the sides of the culvert near the water surface. Field measurements also clearly prove hydraulic conditions there to be least difficult. Culvert outlet and inlet provide potentially difficult locations for fish passage and often require white muscle swimming power and energy from fish. Because of the lengthy time weak swimming fish must spend in a culvert barrel, they must resort there only to red muscle power. Acceptable barrel hydraulics must be designed which recognize the quite limited power output which weak swimming fish are capable of delivering for prolonged periods.

The 165-page design guide describes how to design circular and depressed invert culverts for acceptable passage of weak swimming fish. It also describes a design procedure for use of weir baffles for passage of weak swimming fish through steep sloping culverts. Design methods for determining possible retrofit methods for passage of such fish through existing culverts are given. Design software for new culvert and retrofit design are available as a part of the design guide. Use of the design guide requires a knowledge of open channel hydraulics.

TRANSMISSION STUDIES OF SARCOMA DISEASE IN THE SOFT-SHELL CLAM, Mya arenaria

McLaughlin, Shawn, M., C. Austin Farley, NOAA National Marine Fisheries Service Cooperative Oxford Laboratory Oxford, Maryland 21654

Frank M. Hetrick Microbiology Department University of Maryland College Park, Maryland 20742

Epizootic sarcomas reported in Chesapeake Bay soft-shell clams, *Mya arenaria*, may adversely affect the commercially valuable fishery. Soft-shell clam sarcomas are transmissible, progressive, and lead to mortalities; however, the etiology of the disease remains uncertain. A viral etiology was investigated in soft-shell clam sarcoma transmission experiments. Non-diseased clams were injected with either whole neoplastic hemolymph or a cell-free ultrafiltrate prepared from neoplastic hemolymph. Injected clams were held in separate flow-through aquaria and examined for sarcomas by histocytology and histology. Data at 17 weeks showed a 41% prevalence of sarcoma disease in clams injected with whole neoplastic hemolymph. No sarcomas were observed in clams injected with the ultrafiltrate or in the controls. The lack of sarcomas in clams injected with the ultrafiltrate supports a non-viral etiology of disease transmission. In a second study, non-diseased clams were injected with neoplastic hemolymph and held in 12 and 18°C aquaria. After three weeks, 58% of the clams held at 18°C developed sarcomas, compared with 24% of the clams held at 12°C. The results suggest that temperature may affect development of sarcoma disease in soft-shell clams.

EVALUATION OF GROWTH INTERRUPTION AS A MEANS OF MASS-MARKING HATCHERY TROUT

Patricia E. Bigelow University of Montana

Marking fish is a valuable technique which fisheries workers have used for centuries. Studies involving migration patterns, age and growth, stock identification, population abundance, stocking success, and mortality rates all require later identification of fish involved. Despite importance of marking fish, there remains substantial room for improvement in types of marks used, methods of administering them and means of mark detection.

Two experiments were conducted to determine the feasibility of marking hatchery trout by inducing recognizable patterns on their scales using feed regime and water temperature manipulation. Difficulties with the first year's experiment precluded any separation between groups. However, models built the second year, based on scale pattern analysis, separated fish correctly, on the average, 95.6, 80.9, 91.2; and 96.4% of the time for experimental feed groups when compared with the control groups. Also, correct identification of group origin occurred, on the average, 97.6, 97.8, and 75.6% of time for fluctuating water temperature experiments. This experiment has shown environmental changes can be manipulated to induce "marks" on trout scales. Changes in feeding regime and, somewhat less precisely, water temperature effectively altered circuli spacing on treatment trout scales. These alterations were significant enough to allow a verifiable "mark" to be produced on trout scales. "Marks" were used to accurately predict fish group origin, constituting a simple, inexpensive, efficient, and harmless method of mass-marking trout in a hatchery setting. The actual marking of fish with this method can be done at no cost. Some costs would be incurred for scale handling and data analysis, but overall expenses would be minimal.

However, several questions regarding this technique still exist and need further investigation. Size of fish to be marked, duration of marking period, adequate posttreatment period needed for environmental changes to be reflected in scale patterns, and scale sample selection are all variables that need additional examination.

FACTORS RELATED TO VARIABILITY IN FEEDING INTENSITY OF JUVENILE COHO AND CHINOOK SALMON IN COASTAL WATERS OFF WASHINGTON AND OREGON

Richard Brodeur, Fisheries Research Institute, University of Washington, Seattle, Washington

Variations in the feeding intensity of juvenile coho *Oncorhynchus kisutch* and chinook *O. tshawytscha* salmon collected in coastal waters of Washington and Oregon were examined with respect to year, month and area of collection and physical and biotic factors (light intensity, chlorophyll, zooplankton biomass, and salmon abundance) measured at the location of capture. Although the absolute amount of food in stomachs increased with increasing predator length, there was not a significant relation between the stomach contents (as percent body weight) and length of fish for either species.

Different results were obtained by examining each factor independently as opposed to examining several factors at the same time in a multiple regression or analysis of covariance model, indicating that interactions occurred among the variables. Variations by year and month of collection were significant in the ANCOVA for coho salmon and but only areas was significant for chinook salmon. Chlorophyll concentration (for coho salmon) and light intensity (for chinook salmon) contributed somewhat to the variability in feeding intensity as determined by the multiple regression analysis but the abundance of salmon at the location of capture did not. Feeding intensity of juvenile coho was also positively related to the biomass of plankton in surface (neustonic) waters but no to the overall biomass throughout the water column.

**DYNAMICS OF THE FOOD AND FEEDING HABITS OF LONGFIN SMELT
(*Spirinchus thaleichthys*) IN LAKE WASHINGTON**

Chigbu, P. and T.H. Sibley Fisheries Research Institute University of Washington (WH-10) Seattle, WA

The increase in longfin smelt (*Spirinchus thaleichthys*) abundance, coupled with a reduction in mysids (*Neomysis mercedis*), a major prey of smelt, in Lake Washington has raised some concerns about the impacts that smelt might have on juvenile sockeye salmon. Stomach content analysis of smelt collected from 1985 to 1990 was conducted to determine if smelt have: (1) switched to prey preferred by juvenile salmon thereby increasing competition between the two species or (2) become piscivorous on salmon fry. We observed that the number of smelt containing mysids in summer and fall has declined by over 90% in 0+ smelt and 20-50% in 1+ smelt. During late spring, summer and fall, the biomass of *Daphnia* ingested by 1+ smelt was greater than other microzooplankton spp. *Daphnia* and *Epischura* comprised the major prey of 0+ smelt. The percent contribution by dry weight of mysids in the gut of 1+ smelt varied from approximately 24% in summer 1989 to about 89% in fall 1988. Generally, these are remarkably lower than values (97.2% and 96.7% respectively) reported in 1960s during the same seasons. To make up for the relatively scarce mysids, smelt prey primarily on *Daphnia* spp. as well as amphipods and chironomids. *Daphnia* were never reported in the stomachs of smelt and the percent biomass of amphipods and chironomids never exceeded 7% during 1960s. In this study, *Daphnia* contributed at least 10% and 31% (dry weight) respectively, of the diet of 1+ smelt during summer and fall and amphipods comprised up to 66% during the winter. This change in the diet of smelt from mysids to microzooplankton, (especially *Daphnia*) and amphipods produces a diet for smelt that is much more similar to the diet of juvenile sockeye salmon. Therefore, there is a potential for increased competition as smelt abundance increases. Fish were rare in the stomachs but when present contributed as much as 10-25% of the diet. The identifiable specimens were sculpins. This indicates that sockeye fry are not seriously at risk of predation by smelt, at their present density.

**OUT-MIGRATION AND SPATIAL DISTRIBUTION OF RAINBOW TROUT IN
ROCKPORT RESERVOIR, UTAH**

Brad Schmitz and Timothy Modde Utah Cooperative Fish and Wildlife Research Unit Utah State University

Post-sucking losses of juvenile rainbow trout (*Oncorhynchus mykiss*) in impounded waters reduces the potential of recreational fisheries. Losses may occur due to a variety of factors. Handling stress, emigration and predation are major factors which reduce the efficiency of "put-grow-take" fisheries.

Population estimates of fingerling trout stocked into Rockport Reservoir during 1989 and 1990 indicated less than 5% of the fish survived through the first year after stocking. Following stocking fingerling trout were distributed primarily inshore with higher densities nearer the dam. Shoreline collections of fingerling trout declined precipitously during the month of August. No corresponding increase of offshore collections was observed during the same period. Fish were collected both downstream and upstream of the reservoir, coincident with the decline of fingerlings in the reservoir. Loss of spring stocked fingerlings was evaluated with zooplankton density and abundance. Fingerlings stocked in the fall of 1990 were observed downstream of the reservoir within 24 hours of stocking. Population estimates of the fall stocked fish indicated that less 3% of the fingerlings stocked on September 20 remained in the reservoir on December 1, 1990. Our study suggested that outmigration is a major factor influencing the retention of fall stocked fingerlings in Rockport Reservoir. In addition, spring stocked fingerlings are also emigrating out of the reservoir, however, the magnitude of losses are confounded with mortality associated with both bird and fish predation.

**EFFECTS OF POPULATION SIZE AND TEMPERATURE ON GROWTH OF 0+
ENGLISH SOLE, *Parophrys vetulus*, OFF WASHINGTON, USA**

Yunbing Shi, Donald R. Gunderson, and David A. Armstrong School of Fisheries University of Washington

Data were collected through a series of extensive trawl surveys in two major estuaries (Grays Harbor and Willapa Bay) on the Washington coast and in an adjacent area of the open coast (depth <60 m) during 1985 - 1988. Growth rates of English sole, *Parophrys vetulus*, were estimated by the length modal progression method while population sizes were estimated by an area-swept method. Growth of 0+ English sole was linear over time ($R^2 > 0.97, P < 0.001$) during the period of study from May to September. Growth rates and population sizes varied significantly between years. Growth of 0+ English sole was density dependent ($P < 0.05$), and there was also a significant difference in growth of the 0+ sole that recruited at different times during the year ($0.01 < P < 0.02$). Ranking analysis showed that year class strength was usually established by the end of June. Temperature data were collected at selected stations during each survey. The population-weighted mean temperatures were more variable among the months within a year (typical range = 12.0 - 15.0°C) than between years (range of mean = 13.5 - 14.3°C), and we detected no significant effect of temperature on growth with the observed range of temperature.

**STRUCTURAL DEGRADATION OF *Zona radiata* IN TWO SPECIES OF PACIFIC SALMON
(*ONCORHYNCHUS*) BY SOFT SHELL DISEASE**

Kathy Cousins University of British Columbia, Vancouver, BC, Canada.

Many fish hatcheries experience egg loss due to a condition known as soft-egg or soft shell disease. To date, the cause, the source of infection, and the mode of transmission of this disease are unknown. The purpose of this study was to investigate the degradation processes of the zona radiata by soft-shell disease in both chinook salmon (*Oncorhynchus kisutch*) and coho salmon (*Oncorhynchus tshawytscha*) using standard histological techniques. In the laboratory, a subsample of coho salmon eggs obtained from a hatchery with a history of soft-shell disease was incubated in an attempt to induce the condition. During incubation, temperature and water hardness were manipulated, and egg hydrostatic pressures were calculated by measuring egg diameters with a tonometer. Although I could not induce soft-shell disease, my results suggest this problem may be due to the combination of direct and indirect effects of high water temperatures. The direct effect of high incubation water temperature is the increase in egg hydrostatic pressure. An increase in tension causes the central plugs in the externus pore canals of the zona radiata to protrude upward and thus provide a possible entry point for opportunistic pathogens. The indirect effect of high incubation temperature is the increase in bacteria abundance.

**POPULATION DYNAMICS, FOOD HABITS, AND HABITAT USE OF NORTHERN PIKE IN THE
COEUR D'ALENE LAKE SYSTEM, IDAHO**

Bruce A. Rich and David H. Bennett Department of Fish and Wildlife Resources University of Idaho
Moscow, ID 83843

Northern pike *Esox lucius*, illegally introduced into the Coeur D'Alene Lake System (14,400 hectare) in about 1973, now support the only significant esocid fishery in Idaho. An understanding of this population was necessary as a result of the increasing popularity of the pike fishery, the apparent expansion of pike distribution within the system, and possible predatory impacts on kokanee *Oncorhynchus nerka* and native westslope cutthroat trout *O. clarki*. Young and adult pike were sampled in suitable habitat in four of the lateral lakes of the Coeur D'Alene River and in Coeur D'Alene Lake from March 1989 to November 1990. Catch rates of young-of-year pike were similar in both years. Adult pike densities were in the lowest quartile of the range reported in the literature whereas somatic growth rates and condition factors were high. Angler exploitation was directly proportional to accessibility and popularity of lakes and bays. Prey type varied seasonally and with local prey availability. Yellow perch *Perca flavescens*, salmonids, and catostomids were more common prey items while brown bullhead *Ictalurus nebulosus* and Tinca tinca were least common. Twenty-one pike (1.7-9.0kg) implanted with radio transmitters from March through August 1990 used mostly shallow (<7m), vegetated habitats. Little use of pelagic or non-vegetated sites was observed. Information gathered in this study should be useful for managing pike fisheries in this and similar western lake systems and for evaluating species interactions and habitat associations of potential pike introductions into other systems.

INTEGRATED AGRICULTURE-AQUACULTURE IN ARIZONA

Jennifer Budhabhatti, and Eugene Maughan, Arizona Cooperative Fish & Wildlife Service, University of Arizona, Tucson, AZ 85711.

Channel catfish were cultured in cages in lotic and lentic pre-irrigation waters and in lentic post-irrigation waters. Several different types of cages were used; each designed to fit conditions in a particular type of water. Fish were cultured at replicated densities and were fed a nutritionally complete 32% protein floating feed six days a week. Feeding rate was set at approximately 3% of body weight. Water quality and growth of fish were monitored throughout the growing season.

In the lotic pre-irrigation water ditch, cages enclosed 0.3 cubic meters. A 1989 pilot project, using four different densities of fish, showed high mortalities at the higher densities and low fish growth (average 0.28kg) at all densities. In the 1990 studies, two replicates of 100 fish and two of 85 fish were grown for 110 days. The average size of the fish in the 1990 study was 0.48kg (lower density) and 0.46kg (higher density) and the food conversion ratio was 1.75 (low densities) and 2.35 (high densities).

Fish were reared in the pre-irrigation lentic water in 0.8 cubic meter cages. Fish cultured at densities of 250 and 150 fish per cage, reached a mean size of 0.51kg (low density) and 0.57kg (high density) respectively. Feed conversion ratios were 3.0 (low densities) and 2.3 (high densities) respectively. A bacterial disease outbreak was probably responsible for the elevated food conversion ratios at both densities. Fish were also cultured in 1 cubic meter cages in a sump (area 0.58 hectares) which received irrigation return flow from the agricultural fields. A pilot study in this pond in 1989 showed the best growth rates at the lower density (300 fish per cage) but poor food conversion ratios. In 1990, a deeper feeding screen was added to the cages and the pond was rotenoned to remove wild fish.

At high densities (300 fish) the average weight was 0.61kg and 0.67kg at low densities (250). Food conversion ratios at high densities was 1.15 and 1.5 at low densities.

INDUSTRIAL EFFLUENTS:

THEIR PHYSICOCHEMICAL CHARACTERISTICS AND EFFECT ON FISH SURVIVAL

Mohammed K. Alam, and O.E. Maughan, Arizona Cooperative Fish and Wildlife Research Unit, 210 Biological Sciences East, University of Arizona, Tucson, AZ 85721.

Water samples taken from selected industrial drainages and receiving streams in and around Islamabad, Pakistan, during the summers of 1987 and 1990 showed disturbances in pH and low oxygen levels. Selected metals (Fe, Pb, Zn, Cd, Cu, Ni, Hg) were higher in all effluents than in receiving waters. Static bioassays of the undiluted industrial effluents from the Ordinance factory, the Ghee Mill, and the Paper Mill caused 100% mortality in carp during the first 24 hrs. Fishes also suffered 30 to 60% mortality when exposed to undiluted industrial effluents in the Islamabad region and some mortality when industrial effluents were diluted by 50%.

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Notes