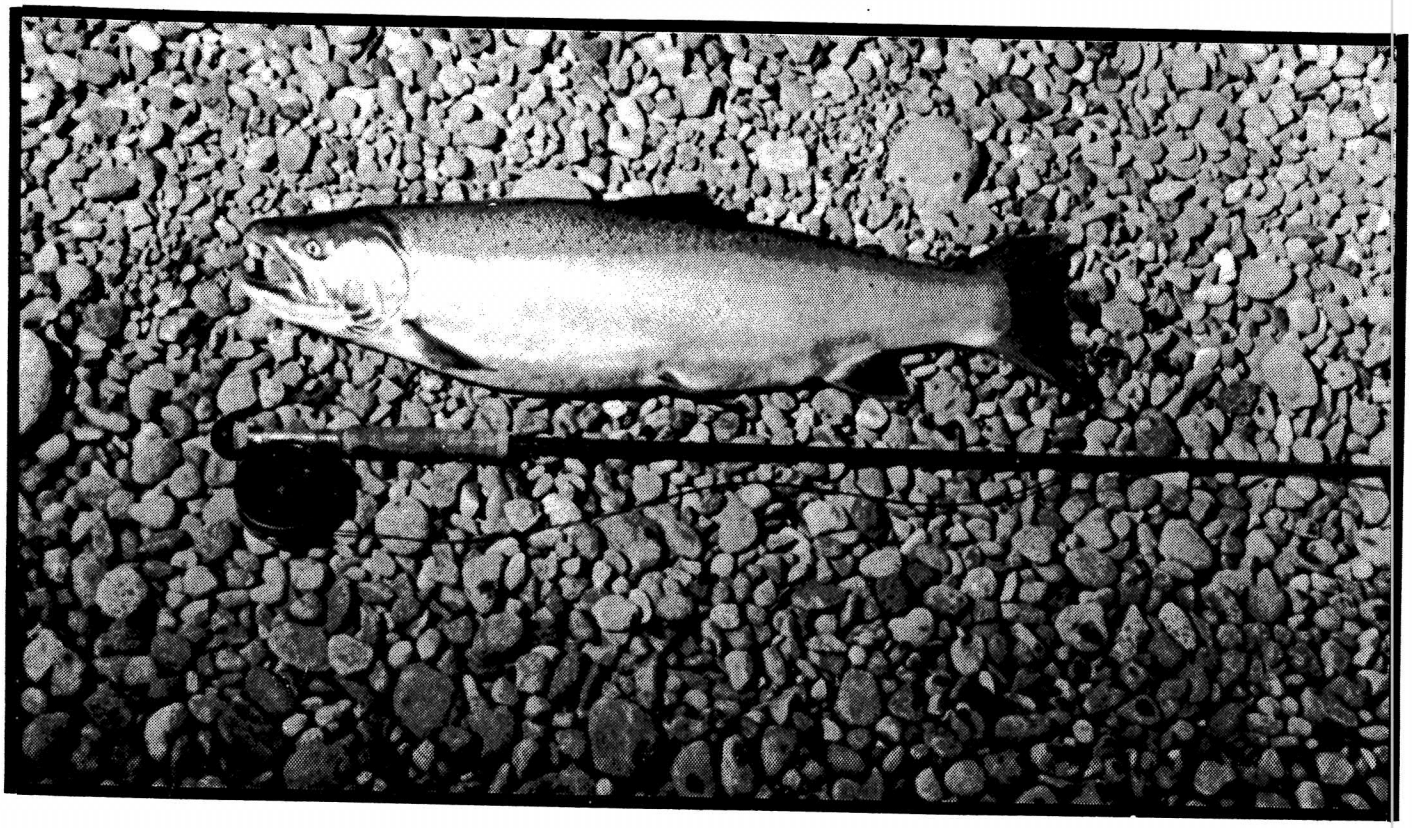
ODFW

28th NORTHWEST FISH CULTURE CONFERENCE



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TUMWATER, WASHINGTON

A B S T R A C T S

Presented At

NORTHWEST FISH CULTURE CONFERENCE

December 6 - 8, 1977

Olympia, Washington

THE NORTHWEST FISH CULTURE CONFERENCE

Northwest Fish Culture Conferences are informal meetings for exchange of information and ideas concerning all areas of fish culture. Current progress reports of management practices and problems, new developments and research studies are presented. Active discussion and constructive criticism are encouraged and furnish highlights of the conference. All persons interested in or associated with fish husbandry are invited to attend and to participate. Subject material is limited to topics that have direct application to fish culture.

The PROCEEDINGS contain unedited briefs of oral reports presented at each conference. Much of the material concerns progress of incompleted studies or projects. THESE INFORMAL RECORDS ARE NOT TO BE INTERPRETED OR QUOTED AS A PUBLICATION.

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RECENT DEVELOPMENTS IN FISH CULTURE IN ICELAND, NORWAY, SCOTLAND AND ENGLAND

Lauren R. Donaldson
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Iceland is one of the few places in the world where Atlantic salmon have maintained strong viable stocks. The fish belong to the landowning farmers who are organized into some 420 watershed cooperatives, all members of a national association. No fishery is permitted in the sea. Historical fishing rights in the rivers are carried on by the farmers or sold to rod fishermen at a fee that is shared by the farmers on the river.

The Institute of Freshwater Fisheries represents the Icelandic government in salmon management. In addition to the Institute's administrative functions, it operates a very successful experimental fish farm at Kollafjordur. This farm has succeeded in producing a good run of salmon returning to the experimental station.

Returns to the station range from 7.5% to 11% of the smolt release. A saltwater pen release produced a 17% return. Spawned-out salmon (kelts) are returned to the sea with 30% of the fish returning for a second and third spawning. Surplus eggs and smolts from the Experimental Farm are sold to the farmers for stocking their rivers. Surplus return fish are sold and the revenue used to finance the station.

The culture of Atlantic salmon and rainbow trout in saltwater pens and floating traps along the southwestern coast of Norway is a rapidly expanding industry. During the past year the 600 farmers marketed 3,000 metric tons

of Atlantic salmon and 2,500 metric tons of rainbow trout. The fish are marketed fresh at 5-12 pounds.

The industry expects to expand 10-fold as brood stocks and smolt rearing facilities are developed to meet the demand.

Scotland has a long history of successful Atlantic salmon fishery and management. Excessive netting in the sea and predation by seals, that has increased rapidly following the passage of the Marine Mammal Act, has greatly reduced the salmon stocks.

Several commercial enterprises, attempting to rear Atlantic salmon in net pens on the west coast of Scotland and in the Outer Hebrides, are making some progress.

Trout production in southern England has developed into an expanded program to provide angling in clubs and private streams and ponds. This industry centers in the Test River valley where very good quality water is available. Many of the old abandoned mill diversions and navigation canals make ideal raceways for rearing trout.

The trout are marketed at a larger size than we are used to. The English seem to much prefer a smaller take of large sized fish (4-5 lbs).

Sport fish is a very expensive experience in all countries in western Europe.

DESIGN CONSIDERATIONS FOR A CHUM AND PINK SALMON HATCHERY AT COLD BAY, ALASKA

Charles E. Torkko[1/] and Bernard M. Kepshire, Jr.[2/]

ABSTRACT

INTRODUCTION

The Russell Creek Chum and Pink Salmon Hatchery was designed for 50 million salmon eggs with 40 million resultant fry. The hatchery location on the Alaska Peninsula presented many environmental and logistical design challenges.

Hatchery design took into account the following major problems:

1. Environmental

    a. Winds exceeding 100 mph not uncommon with an average wind velocity of about 20 mph.

    b. Windblown rain, gravel and debris.

    c. Windblown snow (severe drifting with 33 foot height possible on access road).

    d. Variable wind direction.

    e. Potential creek flooding.

    f. Creek icing (anchor and frazil ice).

2. Logistical

    a. Distance (650 miles) from Anchorage.

    b. No land transportation link to rest of the state (good air transportation, however).

    c. Infrequent barge service.

    d. Short construction season.

1/ CH_2M-Hill, 310 K Street, Suite 602, Anchorage, Alaska 99501.
2/ Alaska Department of Fish and Game, F.R.E.D. Division, 333 Raspberry Road, Anchorage, Alaska 99502.

HATCHERY SITE

Site selection was based on the excellent water quantity (90 cfs projected minimal creek flow rate) and quality of Russell Creek. The site was located in an old gravel pit which provides excellent foundation material.

The distuptive effects of snow drifing will be minimized by computer-assisted site preparation comprised of snow fence location, specialized road bank grading and maximal distance between access road and road bank.

BIOLOGICAL DESIGN

Adult Holding and Spawning

A large outdoor pond (15,000 sq. ft. x 3 ft. water depth) will hold up to 14,000 adult chum salmon or a chum-pink salmon mix of 4,500 chums and 14,500 pinks at any one time. Additional adults can be held between double weirs in Russell Creek and in a small pond (2,500 sq. ft.) downstream from the large pond. Pond water (15-20 cfs) will be gravity fed from an upstream creek intake.

Adult holding criteria are: 16 lb. adults (maximum)/gpm of water, 2.5 lb. adults/cubic foot of water, 1 male:4 females ratio, 2,200 eggs/chum female, 1,600 eggs/pink female, 0.2-1.0 fps water velocity, 3 foot water depth, and 55^{o} F maximal water temperature.

A fully enclosed, movable, spawning shed with garage door will be located adjacent to the main pond.

Salmon Egg and Alevin Incubation

There will be 200 fiberglas incubators (4 ft. diameter x 2.5 ft. depth) containing artifical plastic substrate or gravel. Each incubator will hold 250,000 eggs or alevins at 25 gpm water flow rate. Incubators will be stacked two deep to conserve floor space.

Incubation (3,000 gpm) as well as rearing water can be obtained from a streamside sump or a low veolcity sub-creek gravel infiltration gallery. Ground water is inadequate. Incoming water (up to 6,000 gpm) can be filtered to remove particles smaller than 25 microns.

Salmon Fry

Emergence

All fry will volitionally migrate from the incubators into indoor raceways.

Fry from the upper level incubators will be separated from water required for lower level incubation by a stainless steel fry separator.

Holding

Fry will be held indoors for enumeration, marking and/or short term rearing.

Rearing

Optional depending on fry emergence relative to biological preparedness of the estuary and bay.

Rearing of over 4 million fry (1 g/fish maximal size) will occur in 4 indoor raceways (100 x 10 x 3 ft. water depth each) with optional rearing in the outdoor adult holding pond. All raceways will receive 6,000 gpm of water while the large outdoor pond will receive over 6,700 gpm (15 cfs). Fish can swim from the raceways in to the pond and then into Russell Creek.

Fry rearing criteria are: dissolved oxygen $\geq$6.0 mg/l, 50^{o}F water temperature, loading of $\leq$0.8 lbs. fish/ ft.^{3}, R=4.0 in each raceway, R$\geq$ 1.0 in outdoor pond, food conversion of 1.5, and growth rate = 0.6 inches/month.

Release

All fry will be released from raceways to the outdoor pond and then into the creek. Feeding and release timing are optional.

Salmon eggs and fry can be trucked to other streams near Cold Bay or flown to more remote streams in the Alaska Peninsual or the Aleutian Islands.

BUILDING DESIGN

Building locations minimize the effects of snow drifting, e.g., door locations parallel major wind directions.

Structural design will withstand snow loads and constant 120 mph winds (gusts to 160 mph). The form of the 110 x 120 foot hatchery building was based on minimal wall and roof surface area.

Building materials were selected for maximal durability and minimal on-site labor.

In addition to the hatchery building and spawning shed, there will be a maintenance building with office and laboratory, shop, generator area, pump station with water filters, and two houses.

INHIBITION OF SALTWATER TOLERANCE IN COHO SALMON (ONCORHYNCHUS KISUTCH) BY DISEASE TREATMENTS

G. R. Bouck and D. A. Johnson
National Fisheries Research Center - Seattle

Ten therapeutic and two anesthetic agents were applied to healthy coho salmon (Oncorhynchus kisutch) smolts using published disease treatments, followed by two different post-treatment circumstances. Control fish were maintained both in freshwater and saltwater with an average of 2% mortality. In condition I, fish were treated and then transferred directly to 28 °/oo seawater for ten days. No mortality occurred in saltwater among fish treated with 2,4-D, Trichlorofon, Simazine, Quinaldine or light to moderate doses of MS-222. About 10% mortality occurred in saltwater among fish treated with formalin and Nifurpirinol. High mortality occurred in saltwater following treatments with copper sulfate, Hyamine 1622, potassium permanganate, one protocol with malachite greeen and in one instance by heavy doses of MS-222. In condition II, fish were treated and allowed to rest in freshwater for four days before their medium was changed in four hours to 28 °/oo seawater. Subsequent mortality was reduced but still high for copper sulfate and potassium permanganate, albeit much lower for malachite green or Hyamine 1622, and zero for the other agents. The results indicate that as much as two weeks or more of recovery may be necessary between some treatments and exposure to saltwater.

MORTALITY OF EXPERIMENTALLY DESCALED COHO SALMON SMOLTS IN FRESHWATER AND IN SEAWATER

Gerald R. Bouck and Stanley D. Smith
National Fishery Research Center-Seattle

ABSTRACT

Removal of slime from 25% of the body caused no deaths among coho salmon (Oncorhynchus kisutch) smolts in freshwater or in seawater (28 °/oo). Removal of slime and scales from the same body area produced no deaths in freshwater, but about 75% of these fish died within 10 days after they were placed into seawater. The 10 day median tolerance limit for smolt scale loss was estimated to be about 10% scale removal immediately prior to entering seawater. Recovery from an otherwise lethal loss of scales occurred rapidly in freshwater and 90% of the fish had regained tolerance to seawater within one day.

INTRODUCTION

The integrity of the skin-scale-slime complex is especially critical to the survival of salmonids in seawater, in part because the combination provides a relatively impermeable barrier to water and electrolytes. Breeches of this complex may result in losses of body water, changes in ion balance, hemoconcentration and ultimately in death (Smith et al., 1977). During the process of smoltification, the scales become easily shed and physical contact such as grading, marking, transportation or liberation activities may cause significant amounts of scale loss. While descaling of smolts is always considered unfortunate, the resulting effect upon their saltwater tolerance has not been qualified. The present report describes our studies on the effects of slime and scale removal on the saltwater tolerance of coho salmon (Oncorhynchus kistuch) smolts.

The objectives of this study were to determine: (1) if extensive descaling would cause mortality both in freshwater and saltwater; and if so, (2) what was the median tolerance limit (TL_m); (3) whether the effects of descaling were related to body location; and (4) how quickly smolts recover from an otherwise lethal amount of descaling?

METHODS

Standardized descaling was done using the side of a dull spatula to scrape the designated area in a tail-to-head direction. Slime was removed as above, but fish were scraped in a head-to-tail direction to avoid descaling. The total scraped area is indicated in Figure 2 and was estimated as a percentage of total scaled body durface. Unless otherwise indicated, descaling was always done after anesthesia with MS-222, was above the lateral line, and required less than 30 s per fish, after which they were placed immediately into freshwater or 28 °/oo seawater. When the experiment called for larger amounts of descaled area, this was achieved by descaling more body surface on one or both sides (above the lateral line). By this means, about 50% of the total scales could be removed for median tolerance testing.

Both fresh and saltwater were supplied continuously to the test aquaria. Dissolved oxygen in the aquaria was never observed lower than 85% of air saturation. Water temperatures ranged between 11-14 C during the study. The fish were fed Oregon Moist pellets daily until the tests were conducted; food was generally withheld thereafter, because the fish usually ignore food for the first few days after they enter seawater.

Each test group contained at least 20 fish per treatment and the criterion of effect was limited to death within a 10 day period. This observation time conforms to that established by Lorz and McPherson (1977) for test of seawater intolerance. Each test included control fish both in freshwater and in saltwater.

RESULTS

Smolts descaled about 25% (of their total scales) and placed in salt or freshwater had differential mortality. None of the descaled fish died in freshwater, but an average of 75% of the fish died during the 10 day exposure to seawater.

Fish with slime scraped from 25% of their body suffered no mortality in 10 days of exposure to freshwater or seawater.

The estimated 10 day TL_m for scale loss in saltwater is shown in Figure 1. The percentage scale loss and resulting levels of mortality were significantly correlated ($r = 0.9$). Using the combined results of two tests (initial and a repeat) and the regression values of $a = 32.3$ and $b = 1.8$, one can predict that about 50% of the fish would be killed in seawater by the loss of about 10% of their scales. This corresponds to an area slightly greater than one-third of the surface above the lateral line on one side of the smolt. Since the estimated scale loss is an approximate measure, the relationship in Figure 1 serves to illustrate the fact that relatively small amounts of scale loss can produce significant mortality.

Approximately equal mortality was hypothesized for scale losses between five different body locations shown in Figure 2. Although the character of the experimental design precluded firm conclusions, descaling the front-lower quadrant (over the rib cage) produced the highest mortality. The cause of this differential mortality is unknown, but is presumed to be related to the close proximity of body organs in the rib cage area.

Healing processes were capable of restoring tolerance to seawater as indicated in Figure 3. When fish were descaled about 25% and placed into seawater, about 90% mortality resulted within 10 days. But when similarly descaled smolts were given a day to recover in freshwater before being challenged with saltwater, mortality dropped to only 10%. Allowing the fish to rest for five days in fresh-

water before saltwater challenge apparently restored their full tolerance of saltwater, as judged by the lack of mortality.

DISCUSSION

The ability of coho salmon smolts and probably other salmonid smolts to tolerate saltwater can be directly dependant upon the condition of the skin-scale complex. Loss of as little as about 10% of the total scales can induce heavy mortality if the fish are suddenly challenged with seawater. In this study, the resultant mortality was measured over a 10 day period and did not include the use of physiological criteria of good health. Had this been done, we believe that the study might have revealed that descaling has an even greater impact than mortality alone can indicate.

Two additional considerations would tend to mitigate the mortality of descaled smolts as they migrate downstream. Most descaled smolts would have an opportunity to heal before reaching saltwater in the Pacific Northwest. Furthermore, their entry into saltwater would not be as sudden as in this experiment. Furthermore, descaled smolts may volitionally decline to enter saltwater until healed, providing behavioral protection against this type of mortality.

The loss of scales during or immediately prior to a saltwater challenge is a very real threat to the life of a salmonid smolt and possibly to an adult. Thus, scale loss may be a much more serious problem for salmon in marine waters such as in mariculture or when combined with possible injury from hooks in the sport fishery. This position is supported by the findings of Smith et al. (1977), Black and Treadwell (1967), and Lasater and Haw (1961), but remains unconfirmed.

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Lasater, J. E. and F. Haw, 1961, Comparative hooking mortality between treble and single hooks on silver salmon. Pac. Mar. Fish Comm. Bull. 5:73-76.

Lorz, H. and B. McPherson, 1976, Effects of copper or zinc in freshwater on the adaptation to seawater and ATPase and the effects of copper on migratory disposition of coho salmon, Oncorhynchus kisutch. J. Fish. Res. Bd. Canada 33:2023-2030.

Smith, L. S., R. D. Cardwell and H. M. Miles, 1977, Hematological and osmoregulatory changes in juvenile marine salmon after severe scale loss. Abstracts of papers presented at the 107th Annual Meeting of the American Fisheries Society, Vancouver, B. C.

Figure 1, Relationship of percentage total scales lost to mortality during seawater challenge for coho salmon (Oncorhynchus kisutch).

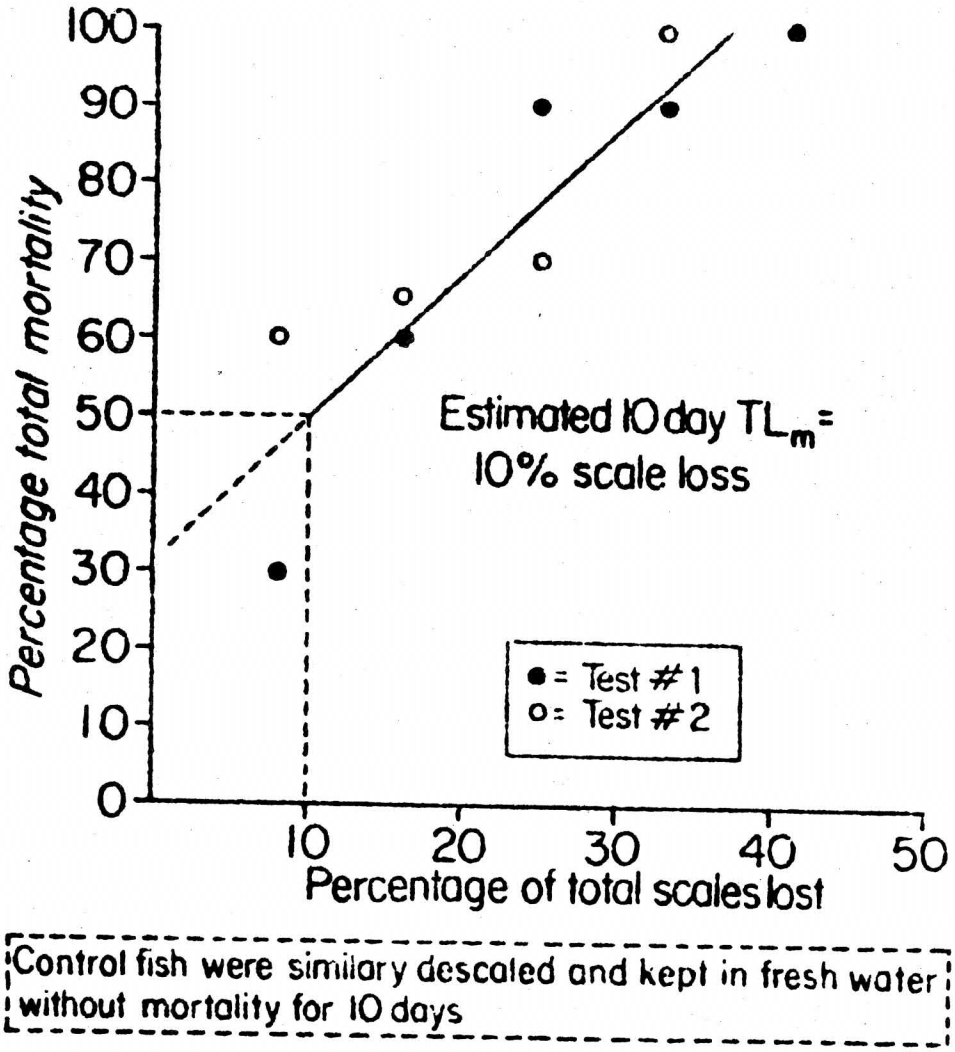
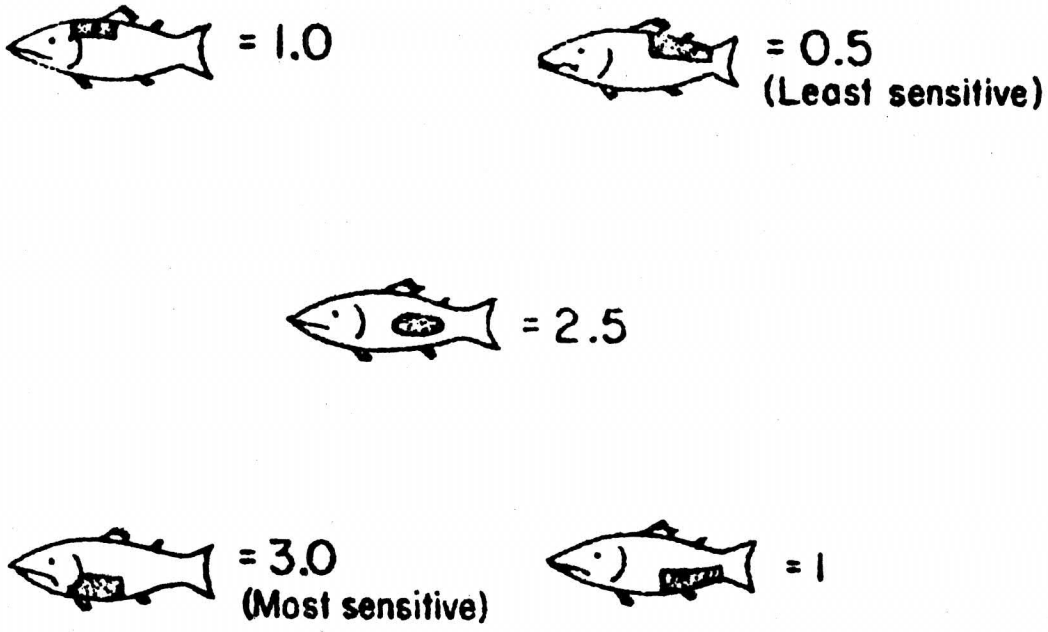
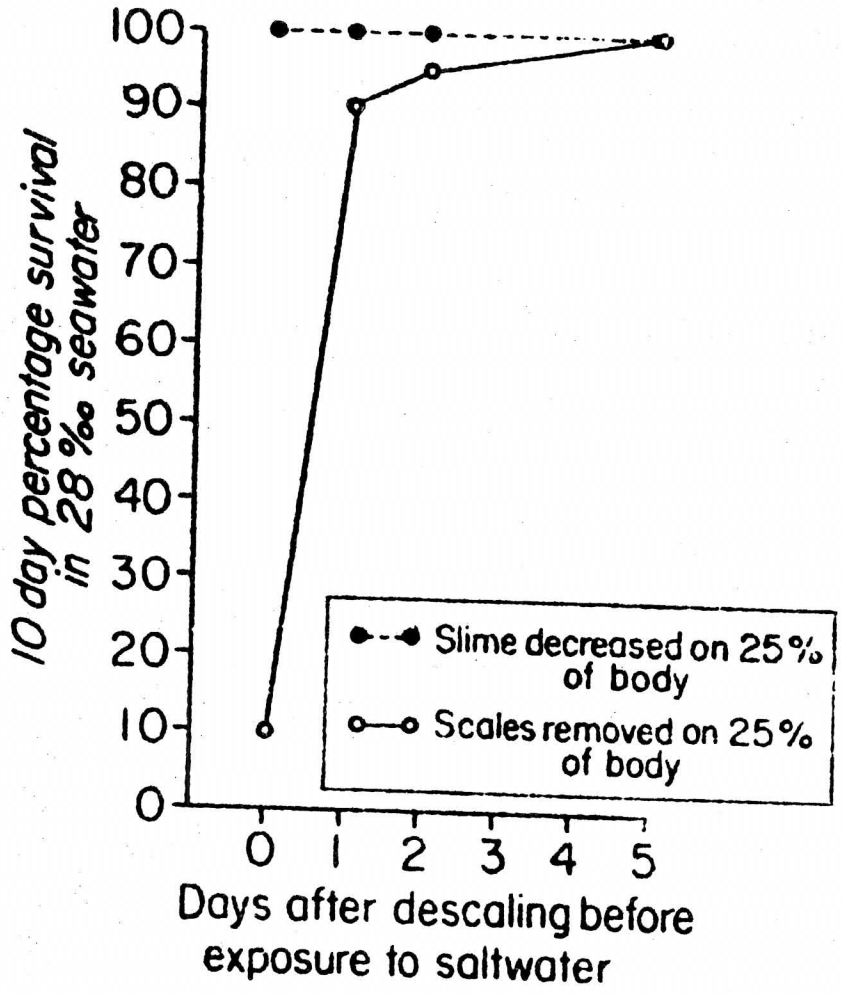


Figure 2, Descaled areas and relative sensitivity during a seawater challenge of coho salmon (Oncorhynchus kisutch).



Note: Shaded areas were descaled with a dull spatula immediately before the fish was placed into 28 °/oo seawater.

Figure 3, Effect of time after descaling on subsequent mortality in seawater among coho salmon smolts (Oncorhynchus kisutch).



Fraser Valley Trout Hatchery - British Columbia's First Hatchery Using a Recirculation System

This presentation consists of a brief overview of the facilities at the newly-constructed Fraser Valley Trout Hatchery at Abbotsford, B. C. The purpose of this talk is to acquaint people in conjunction with some slides, with the fact that British Columbia has a new hatchery, and to present some of the more noteworthy features of the facility.

A. Location

The hatchery is located at Abbotsford, B. C. - about 45 miles east of Vancouver, B. C.'s largest population centre, and about 1 mile north of the Canada - U. S. border.

B. Construction and Operation

The hatchery was designed by the Department of Public Works of the provincial government with input from, among others, biologists of the Fish and Wildlife Branch. The major contractor was Commonwealth Construction Company and the cost of construction, which was virtually completed in March 1977, was approximately $7.4 million. The production facilities are staffed by members of the Fish Culture Section of the B. C. Fish and Wildlife Branch. Department of Public Works operators maintain the machinery (pumps, heating, etcetera) necessary for the hatchery's operation.

C. Background

Well pump testing on the property revealed an available constant supply of approximately 10 CFS. However, because of an increasing urbanization of the area an agreement was made with the local municipality that we would extract no more than 5.6 CFS of water at any time. This of course drastically influenced possible fish production and, because foreseeable

fish requirements would demand a flexible facility as well as a marked overall production increase it was decided to build a hatchery utilizing a recirculation system needing only 10% fresh make-up water. Such a facility would be very expensive but would give us flexibility (in sizes, number, and species raised) as well as a reasonable (to us) amount of annual production. It was also decided to incorporate other features in order that such an expenditure could provide the taxpayers with other benefits as well as straight fish production.

D. Features

Following are some brief points detailing a few of the salient facts and features which can be quickly discussed as the slides are shown:

1. Water Supply

   - 3 wells, producing 5.6 CFS groundwater, at a fairly constant temperature of 9.6° C, containing approximately 8 ppm oxygen.

2. Production Units

   - 11 circular ponds - 9 of 25 feet diameter, 2 of 18 feet diameter; centre floor drain with outside stop-log depth control.
   - 108 stainless steel troughs, 16 feet long; water re-use is provided by having the troughs arranged in a step-down formation so that 2 troughs use the same water.
   - 2 different water temperature regimes are available at any time to the trough room.
   - The incubation room consists of 20 Heath incubators (240 trays) with room for almost that many again; 3 different water temperature regimes are available at any time.

3. Water System

   - The key to the recirculation process is the clarification -

filtration process; the hatchery's water is treated as follows:

a) Water from the incubators and troughs can be either wasted or re-used by adding it to the pond supply. If it is directed to the ponds it is filtered (Ronnington-Petter filter) then sterilized by passing it through an ozonator. It then enters the pond supply just prior to aeration.

b) Pond water can be approximately 90% recirculated. From a pond the water enters the primary clarifier which has a retention time of about 15 minutes, thus enabling many solids to settle out. The sludge is collected at the bottom of the clarifier and is pumped to the municipality's sewer system. The clarified water is passed through the Graver filters and then aerated. Prior to aeration fresh water (make up) is added; after aeration waste water is sent out. The waste water passes through an oxidation ditch before entering a natural stream. Backwashing effluent from the filters passes through a clarifier as well as the oxidation ditch before it enters the stream. Again, sludge from this clarifier is sent to the municipality's sewer system. Only one temperature regime is available to the ponds at any one time, but a heat exchanger system allows us to maintain an ambient temperature at any point from 9.5^{o} C to 15^{o} C. The 3 Graver filters themselves have ample capacity to handle the flows from all ponds (2 gal./sq. ft.) and have an efficient air-water back wash system. The filter

bed is 30 inches in depth and consists of 1-2 mm diameter crushed granite particles. Outgoing water quality appears good - nitrite nitrogen levels are 0.005 ppm or less, oxygen is about 9 ppm, and pH is around 7.1-7.2.

A discrete single-pass water supply of aerated unheated groundwater is provided to two quarantine ponds which are set apart from the production ponds.

4. Information and Education

A very extensive information and education section was designed. This consists of a self-guided tour on the upper floor of the facility which enables visitors to look into the trough room, the mechanical room, and look out over the ponds. Many informative and educational displays regarding hatchery operations, environmental quality, habitat protection, and fisheries management options are provided along with the numerous live fish aquaria. In addition, a lecture theatre is available where films can be shown or seminars and lectures given.

5. Research

One wing of the hatchery is staffed and operated by the Fisheries Research Section of the Fish and Wildlife Branch. Although under the same roof, this area is segregated from the rest of the hatchery in order to avoid fish disease transference. The Research wing is equipped with a large dry lab, a reference library, an apartment suite, a conference room, and numerous offices. In addition it has a well organized wet lab which features an area with about 20 feet of vertical clearance (testing fish ladders, etcetera) and central control

outlets (water, electricity, etcetera) which will allow flexible servicing of any project underway. Fish rearing tubs can be moved around (or right out) easily; water temperatures can be either chilled or heated. A quarantine room, with complete photoperiod control, is provided. Outside servicing provides for use of outside rearing ponds as in a "natural" hatchery operation.

6. Brood ponds

A brood pond-spawning house was also provided for use with our cutthroat and rainbow trout brood stocks. A recirculation and water distribution system will hopefully entice mature fish from their pond section up a channel into the brood house where they can be sorted and handled.

The foregoing was a brief look at our new hatchery. It has been in operation for about 6 months and so far we have encountered no serious problems. We are busy monitoring water quality, fish health, and production performance. At this time next year we should be in a position to present a technical report on the evaluation of the recirculation system.

Neil Todd.

N. L. Todd
December 20, 1977

NLT/lh

POTENTIAL FISH-CULTURE APPLICATION FROM THE USE OF WASTE HEAT

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A study was generated by the Province of Alberta in the Spring of '77 as a consequence of an in-house study undertaken by Alberta Gas Trunk Line Company Limited (AGTL) on potential uses of waste heat from their natural gas compressor stations. From preliminary discussions between AGTL and Alberta Recreation Parks and Wildlife, the use of waste heat appeared to have possible implication with Alberta's proposed Brood Stock program, as well as perhaps other types of aquaculture operations. These compressor stations, which "dot" the province as part of a pipeline network, generate from 50 to 76 x 10^6 BTU's/hr of waste heat. As a measure of relativity, this would provide sufficient heat for some 500 average-size Alberta homes at -33^{0}C.

Seven sites were examined as to suitability. Notwithstanding the realization at the outset that finding a compressor station in immediate proximity to a favorable water supply would be remote, one site (referred to as Clearwater) did indeed offer considerable potential.

A closer examination was therefore conducted regarding the practicality and economics of capturing, transferring and utilizing this waste heat at the Clearwater site. The greatest challenges which were presented centered around the heat exchanger(s) at the producing end, as well as the transfer media required to transport this heat to the receiving end.

However, in tallying up all anticipated capital costs for this concept, it was determined that a sum of $900,000 would be required for waste heat capture components, and an additional $1,100,000 for other site development work. When

compared with Alberta's current Brood Stock scheme, it became apparent that the anticipated return on investment would not warrant further pursuit of this concept.

In turn, an analysis on a commercial type of aquaculture operation which catered to the private stocking marketplace, indicated an incompatibility between investment required, and expected returns.

MONITORING SMOLT OUTMIGRATION OF HATCHERY STEELHEAD IN THE WILLAMETTE RIVER SYSTEM

David V. Buchanan
Research Section
Oregon Department of Fish and Wildlife

Low adult returns from Skamania summer steelhead released in the McKenzie River and fluctuating returns in the Santiam River indicate that successful Spring outmigration of hatchery smolts from the Willamette system depend on certain environmental parameters. We believe that temperature in the lower Willamette River can reach critical levels, above 17C, which could trigger bacterial infections or reduce the migratory urge of spring migrating steelhead. We also believe that outmigration delay could occur in the McKenzie River due to cool water temperatures at the time of release. Monitoring smolt outmigration near the release sites and in the lower Willamette River near Willamette Falls was done to determine peak movement of hatchery release groups and identify possible migration delay.

Fifteen separate hatchery release groups were marked by fin removal or sprayed with fluorescent dye. Outmigration was monitored by seining and electrofishing on the lower McKenzie and Santiam rivers. Smolts reaching Willamette Falls were monitored by a downstream migrant trap located in a hydro-electric plant operated by Portland General Electric Company.

Results indicate that 15cm appeared to be a minimum size for hatchery fish reaching Willamette Falls even though smolts as small as 11cm were released upstream. The migration rate of smolts varied with time of release. Smolts released in early April took 30 days to peak at Willamette Falls, yet smolts released in late April peaked in only 10 days. Smolts released into the McKenzie River peaked later at Willamette Falls than those released into the Santiam System.

PROGRESS OF STRAIN EVALUATION STUDIES

Harold L. Kincaid

Fish Genetics Laboratory

Beulah, Wyoming 82712

The problem of matching specific strains of trout to specific environments where they will perform best is one which has faced fisheries managers for many years. In 1974 the Fish Genetics Laboratory initiated a program designed to genetically characterize strains of rainbow trout for a wide variety of both cultural and non-cultural traits. The primary goal of the program is to provide strain performance characteristics information to the fishery resource manager so that he can utilize strains best suited to his management situation.

The strain evaluation program is divided into six separate segments. Segments of the program are:

1. Culture in a standardized rearing environment for one generation from egg fertilization to sexual maturity. Data is collected on traits such as egg hatch, fry survival, growth curve, feed conversion, age to eight inches, age of maturity, weight at maturity, etc. Eight strain have evaluated through this program.
2. Biochemical profile. Each strain is characterized for isozyme frequency of 22 different biochemical traits by strach gel electrophoresis. Two strains have been evaluated through this program.
3. Morphology profile. Each strain is characterized by X-ray examination for fin ray counts, vertebrae counts, and frequency of vertebrae fusions. Six strains have been evaluated through this program.

4. Field testing in a spring fed pond situation. Fish are planted at seven months of age and evaluated during three recovery periods at 12, 18, and 24 months of age. Each recovery period consists of 1,000 rod hours of angling and 100 hours of gill netting operations. Six strains have been evaluated in this program for traits such as growth curve, susceptibility to angling, and total recovery.

5. Hatchery production testing in cooperation with the National Hatchery System. Production lots are distributed to individual hatcheries where they are grown to a catchable size (8 inches) under standard hatchery rearing conditions. Each strain is tested in at least four different hatcheries over a two-year period. Six strains have been evaluated.

6. Field testing in cooperation with the Office of Federal Assistance. Fish from the hatchery production test are planted in a least one stream and two impoundment situations for evaluation by creel census. This segment of the program was initiated in the fall of 1977 and therefore, no strains have completed the evaluation.

Data presently available from the first five program segments (above) have shown large strain differences in many of the traits evaluated. Especially large strain differences were found in the following traits; fry survival, growth rate, feed conversion, weight at first maturity, and frequency of vertebrae fusion. Data from the six program segments are analyzed separately and then combined to produce the strain performance profile for each strain. In addition, correlation analysis is conducted to examine and measure the relationships between all traits evaluated.

At the present time seventeen different strains of rainbow trout are being evaluated, six strains from "wild sources" and eleven strains from "hatchery sources".

A Method of Conducting Hatchery Diet Trials

George W. (Bill) Klontz
Fishery Resources
University of Idaho

Evaluation of production hatchery diets should be an integral part of the fish culture activities of every hatchery - public and private. The method to be described is one which can be accomplished by any fish culturist and requires only a minimum amount of mathematical effort but a great deal of common sense and "stick-to-it-ivity".

At nearly all the fish raising facilities with which I am familiar, a diet is evaluated on its ability to have a low conversion ratio; i.e., the lowest pounds of feed required to produce a pound of gain on a population of fish. There are many factors which influence this figure and not all of them are associated with the diet per se. The main factor influencing the feed conversion figure is not knowing the correct weight of fish in the pond. Many (and I mean many) facilities carry 25%-30% of their stock as paper fish - for what reason, I do not know. Thus, they are either overfeeding their fish or underfeeding them. In either case, the feed conversion figure will not be accurate. The main source of the error lies both in initial ponding weights and inaccurate subsequent inventories. These inaccuracies, I am hasty to add, are usually not due to faulty techniques as much as they are due to the nature of fish; i.e., sampling error. What is a good sample of pond fish? Ideally, all of them but that is not realistic. So, an all encompassing answer is not offered other than to be as consistent as possible and practical.

The method we used this past summer to evaluate two commercially available diets fed to rainbow trout is neither new nor difficult. It entails the establishment of feeding goals during an inventory period. (We used 14 day intervals). We purposely set our goals high so that each diet would have an

equal opportunity to realize this goal as best as it could. We have been wrestling with the ΔL concept (the incremental length change) for the past year or so and have found that the ΔW (the incremental weight change) is much more realistic and practical. After all, are we feeding pounds of feed to pounds of fish or to inches of fish? Obviously, it is pounds to pounds since we base our feeding rate on a percentage of body weight. Haskell's formulation gives us a method to convert length to weight - somewhat inaccurately, I might add. Thus, by getting an accurate figure for number of fish per pound and having an accurate head count, the pond weight can be accurately estimated rather than "guesstimated".

To apply Haskell's feeding formula, the number of fish per pound is then looked upon the standard weight-length table for the fish being raised and then the average length of each fish is determined. But what if the K-factor (the length-weight conversion factor) is in error? Then the wrong length is obtained and the inherent error is further magnified.

Once having gone through an inventory period or two, it becomes clear that a diet can only produce so much weight gain in a group of particular sized fish. The small, first-feeding fry just cannot grow as fast as 4-inch fish because their stomachs just do not hold that much feed. If the weight gain is a straight line then the estimate can be brought into alignment and less feed wasted. In this way the feed conversion figure comes into line.

Another evaluative technique is to weigh a sample of fish - individually or collectively - before and after evisceration (including removal of the gills). This will give a fairly good indication if the fish are using what they eat or are storing it as fat and/or glycogen. The average weight loss should be no more than 21-22% of the body weight. An overweight fish is, in my opinion, a poor survival prospect in either a put-and-take fishery or an anadromous fishery. In addition, the dress-loss is a good indication of overfeeding for the particular water temperature.

The most revealing evaluative technique we used was to have a proximate analysis run (in duplicate) on samples of feed and feces collected during the trial. These data, when compared to the growth data, gave us a good indication of what and how much was being taken out of the diet for growth. This diet quality test directly relates to dietary efficiency; i.e., validates the recorded feed conversion thereby excluding the influence of feeding techniques and so forth.

In summary, it is my opinion that trout and salmon feeds must be continually evaluated for their efficiency. This approach requires only the addition of one more set of data - the proximate analyses of feed and feces - beyond those collected routinely in the raising of fish.

KELP MEAL AS A DIET SUPPLEMENT FOR SALMONIDS

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ABSTRACT

The results of substituting kelp meal (Isocaloricly) into the diet of rapidly growing juvenile salmonids based on the energy content (Table 1) and the proximate analysis of the diets (Table 2) were expected to cause rapid and continuous reduction in growth (length, weight, K-factor) of the test groups as compared to the control groups fed a basal ration. The rainbow test group (RK) had a 10% less increase in total length and 14% less total weight increase than the control group, (RC). Atlantic salmon test group (AK) had 5% less increase in total length and 5% less total weight gain than the control group (AC). A greater difference in growth rates had been expected as the fat and protein content in the test diet were approximately 25% and 70% respectively of that found in the basal ration (Table 2). Carbohydrate levels in the test ration were 2.5 times greater than the basal ration which may have provided some protein sparing action. In addition, the test diet contained 17% fewer calories (1024 Kcal/lb) than the basal ration (1234.0 Kcal/lb). Control and test groups showed a similar continuous increase in conversion ratios indicating that both diets were inadequate for growth. The similar rates of growth between controls and test animals indicate that some nutritional benefits may have been derived from the Kelpmeal.

DIETS:

Table 1. The energy content and ingredients of the basal ration and test diets prepared in 300 gram quantities.

A. Basal Ration - Labled BR-S

Ingredients	Grams	Kcal/gm	Calcaulated Total Kcal
Salmon Starter Mash	125.0	5.131	641.375
Gelatin	30.0	4.606	138.195
Water	145.0		
	300.0		779.57

Calculated Kcal/gm 2.598
Actual Kcal/gm 2.718
Totla Kcal/lb 1234.0

B. Test ration with 25% Kelp Meal-Labled TR-S-25

Ingredient	Grams	Kcal/gm	Calculated total Kcal
Salmon Starter Mash	87.0	5.131	446.397
Gelatin	30.0	4.606	138.950
Kelp Meal	62.54	3.121	194.891
Water	120.55		
	300.0		779.40

Calculated Kcal/gm 2.598
Actual Kcal/gm 2.257
Total Kcal/lb 1024.0

Table 2. Proximate Analysis of salmonid diets:

Lot #	Ether Extract % Fat	% Moisture	% Ash	% Crude Fiber	% Crude Protein	% N.F.E.
BR-S	13.16	48.98	6.55	0.76	67.01	12.55
TR-S-25	3.45	48.98	11.60	6.56	47.24	31.15

THE USE OF DRIED SLUDGE FROM THE SECONDARY TREATMENT OF POTATO PROCESSING WASTES AS A FEED INGREDIENT FOR RAINBOW TROUT

by

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ABSTRACT:

The potato processing industry is faced with a disposal problem of its bipond sludge. The secondary treatment of potato wastes results in a sludge of mostly Sphaerotilus bacteria and associated species. This biomass, when dried, results in a light brown powder containing 60 percent protein, 23 percent carbohydrate, 0.5 percent fat, 9 percent ash and 7.5 percent moisture. The amino acid composition of this potato biomass compares favorably with herring meal, and the calcium and phosphorus content is 0.95 and 0.41 percent, respectively. Two isocaloric diets containing the dried potato-waste biomass were formulated and fed to six-month-old rainbow trout. The Oregon Test Diet (OTD), a semi-purified casein-gelatin diet (65 percent moisture), was used as the control. Biomass I was a moist-pelleted diet (32 percent moisture) containing 35 percent biomass and Biomass II was a soft gel diet (65 percent moisture) containing 30 percent biomass. The protein level of each of these diets was adjusted to 45 percent with casein or casein-gelatin. These diets were fed to duplicate lots (50 fish each) of rainbow trout for 8 months. Each lot was weighed and feed conversion was calculated monthly. There was no significant difference in the growth rates between the fish fed the two test diets and the control diet. Biomass I diet resulted in a slightly higher feed conversion ratio (1.24) than Biomass II diet (1.10) and the OTD (1.04). Results from a taste panel (40 tasters) showed no significant difference between the trout fed the control diet (OTD) and the two biomass diets with respect to flesh color, texture, flavor and over-all desirability. The only significant abnormality observed among these trout was a high incidence of kidney "stones" in the trout fed Biomass I diet. This condition is easily induced in the trout at our laboratory because of the high calcium level in the water. We feel a modification of the diet formulation would alleviate these kidney "stones." The results of this study indicate that dried sludge from potato processing wastes contains good quality protein which is able to produce a fast growing and highly acceptable rainbow trout.

A NATURALLY OCCURRING TOXIN AND CARCINOGEN IN COTTONSEED PRODUCTS

by

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In the late 1950s and early 1960s an extensive epizootic of liver cancer occurred in hatchery rainbow trout in the United States and in other trout producing countries. The primary cause of this epizootic was discovered to be a toxin, later called aflatoxin B_1 (AFB_1), produced by the mold Aspergillus flavus. This toxin occurred as a contaminant of cottonseed meal, an important ingredient of pelleted trout rations. Additional research, however, showed that AFB_1 was not the sole cause of the liver cancer epizootic. Cyclopropene fatty acids (CPFA), naturally occurring components of cottonseed oil, acted as synergists with AFB_1 to produce more and larger tumors in less time than AFB_1 by itself. Recently, we have discovered that CPFA, as sterculic acid, also reduce the growth rate of rainbow trout at levels as low as 5-15 ppm, produce toxic liver damage in rainbow trout at levels as low as 10 ppm, and produce hepatocellular carcinomas at 15 ppm. Levels of cottonseed meal, currently incorporated into many commercial diets, supply 5-30 ppm of sterculic acid, the most active CPFA, and up to 80-90 ppm of total CPFA. For rainbow trout these levels are sufficient to produce low level liver toxicity and reduced growth and could result in liver cancer in brood stock held for several years. The effects of CPFA on salmon are unknown but will be investigated in the near future. These data indicate that hatchery salmonids should be monitored histologically for possible CPFA toxicity, and that it may be beneficial to lower the level of cottonseed meal in salmonid rations.

Preliminary Results on the Control of Fungus on Fish Eggs with a New Antifungal Chemotherapeutic

Philip Scordelis, University of Washington

Abstract

There exists a need for a safe, effective hatchery treatment for the prevention of fungal infestations on incubating eggs. A number of experimental compounds were screened for *in vitro* efficacy against a species of *Saprolegnia*, and it was found that with continuous exposure R41653 was fungistatic at 30 ppm and fungicidal at 50 ppm, while R41782 was fungistatic at 20 ppm and fungicidal at 30 ppm. Short exposure tests showed R41653 to be inhibitory for seven days post-treatment with a 200 ppm, 60 minute exposure, while R41782 was inhibitory with a 100 ppm, 30 minute exposure.

In vitro toxicity tests of two compounds on eyed RBT eggs showed R41653 to be quite toxic at its effective antifungal levels, while R41782 was found to be non-toxic at its effective levels. A test of the toxicity of R41782 to various developmental stages of RBT eggs (1 hour, 8 days, 14 days post-fertilization) showed the compound to be safe at its antifungal concentrations.

A test to determine an effective treatment regimen for R41782 is currently under way.

TABLE 1

Antifungal activity of various chemicals to Saprolegnia sp.

	Drug Concentration (ppm)						
	0	5		50		500	
		static	cidal	static	cidal	static	cidal
R18531	+	no	no	yes	no	yes	yes
R23979	+	no	no	yes	no	yes	yes
R27180	+	no	no	yes	no	yes	yes
R31525	+	no	no	yes	no	yes	yes
R41400	+	no	no	yes	no	yes	yes
R39500	+	no	no	yes	no	yes	yes
R41653	+	no	no	yes	yes	yes	yes
R41782	+	no	no	yes	yes	yes	yes
R30591	+	no	no	no	no	yes	yes
R31119	+	no	no	no	no	yes	yes
R34026	+	no	no	no	no	yes	no
PVP-I_2	+	no	no	no	no	no	no

TABLE 2

Minimum fungistatic and fungicidal activity of R41653 and R41782 to *Saprolegnia sp.*

	Drug concentration (ppm)					
	0	10	20	30	40	50
R41653						
fungistatic	no	no	no	yes	yes	yes
fungicidal	no	no	no	no	no	yes
R41782						
fungistatic	no	no	yes	yes	yes	yes
fungicidal	no	no	no	yes	yes	yes

TABLE 3

Fungicidal activity of R41653 and R41782 to *Saprolegnia* sp. following short exposures[1]

Drug	Exposure Time (min)	Drug Concentration (ppm) 0	25	50	100	200
R41653	5	+	+	+	+	NT[2]
	15	+	+	+	+	+
	30	+	+	+	+	NT
	60	+	+	+	+	-
R41782	5	+	+	+	+	NT
	15	+	+	+	+	-
	30	+	+	+	-	NT
	60	+	+	+	-	-

[1]Results recorded as (+) of fungus, (-) no growth of fungus after 7 days at 18°C.
[2]NT - Not Tested

TABLE 4

Inhibition of Saprolegnia sp. growth by R41653 and R41782 on solid agar plates[1]

Drug	Exposure Time (min)	Drug Concentration (ppm) 0	50	100	200	400
R41653						
	15	60	60	60	22	13
	60	60	43	23	7	2
R41782						
	15	60	60	43	9	8
	60	60	18	8	9	8

[1]Results recorded as diameter of mycelial growth in milimeters 7 days after exposure to the drug. In all cases growth completely covered the plates in 2 days in the control groups (60 mm maximum growth).

TABLE 5

Percent mortality of eyed rainbow trout eggs following exposure to R41782 and R41653. There were 50 eggs in each group and held at 12°C

Drug	Concentration (ppm)	Exposure Time (Min.) 5	15	30	60
R41782	0	2	2	0	2
	50	0	0	0	4
	100	2	0	0	2
	200	0	0	2	4
	400	2	2	0	2
R41653	0	0	0	0	0
	50	0	0	2	48
	100	0	4	48	92
	200	22	90	96	100
	400	62	100	100	100

TABLE 6

Toxicity of R41782 on early developmental stages of rainbow trout eggs. There were 50 eggs/group.

EXPOSURE 1 HOUR POST-FERTILIZATION

Concentration (ppm)	400				200				100				50				0			
Treatment Time (min.)	60	30	15	5	60	30	15	5	60	30	15	0	60	30	15	0	60	30	15	0
# Dead	47	39	36	26	28	14	14	10	20	15	17	8	18	10	10	12	17	15	10	10
%	94	78	72	52	56	28	28	20	40	30	34	16	36	20	20	24	34	30	20	20

TABLE 6 (cont.)

EXPOSURE 8 DAYS POST-FERTILIZATION

Concentration (ppm)	400				200				100				50				0			
Treatment Time (min.)	60	30	15	0	60	30	15	5	60	30	15	5	60	30	15	5	60	30	15	5
# Dead	12	10	10	9	11	14	14	10	14	8	12	14	14	5	8	7	6	15	7	8
%	24	20	20	18	22	28	28	20	28	16	24	28	28	10	16	14	12	30	14	16

TABLE 6 (cont.)

EXPOSURE 14 DAYS POST-FERTILIZATION

Concentration (ppm)	400				200				100				50				0			
Treatment Time (min.)	60	30	15	5	60	30	15	5	60	30	15	5	60	30	15	5	60	30	15	5
# Dead	5	10	3	1	6	3	4	0	7	5	6	0	4	3	3	5	10	5	2	1
%	10	20	6	2	12	6	8	0	14	10	12	0	8	6	6	10	20	10	4	2

PROGRAMMING FISH GROWTH

John McNair
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ABSTRACT

Programming is increasing in popularity but may not be useful in all situations. A growth program is based on linear daily changes in length (ΔL). Conversions have to be measured carfully for each varying situation concerning size of fish and brand and size of feed. The daily % body weight to be fed is determined from Haskell's formula:

$$\frac{\Delta L \times \text{conversion} \times 3 \times 100}{\text{Length}}$$

A careful inventory is necessary every two to four weeks measuring number per pound and length carefully, in addition to keeping close records of morts and weight of feed. Programming also provides numerical monitoring of pond densities using any one of several methods for maximum loadings. Other factors to consider when programming are: species and race of fish, water quality, velocity and temperature, photoperiod, nutrition and disease history. Eventually custom-made programs may be implemented through computer terminals at each hatchery which will make programming easier. In any event, computer applications will increase in fish culture.

Genetic marking: A uniquely valuable tool for fish culturists

FRED M. UTTER

Simple genetic differences reflected through electrophoretic variants of proteins may be advantageously used in hatchery breeding programs as a means of identifying individual fish from a particular source. This kind of selection differs drastically from (1) selection for quantitative traits (e.g. growth rate) where many genes are involved and correlated responses anticipated, and from (2) selection for classical single-gene variants (e.g. albinism) where carriers of the trait are masked, and individuals expressing the trait are almost always at a selective disadvantage relative to "wild-type" individuals. Many (probably most) protein variants that are present at moderate to high frequencies in natural populations appear to be selectively equivalent and all genotypes are identifiable with equal ease. If care is taken to minimize inbreeding, the parent and selected stocks are virtually genetic equivalents because of the minute amount of genetic change that has occurred. Major advantages of the prudent use of electrophoretic variation in breeding programs contrasted with traditional methods of marking and tagging are outlined in the following table:

	Handling of individual fry	Potential for disability or deformity	Permanance in individual	Genetic component	Expression in descendents	Size requirement	Information retrieval time from adults	Cost
Coded wire nose tag	yes	low	high	none	no	yes	long	high
Fin clipping	yes	high	variable	none	no	yes	immediate	high
Scale analysis	no	none	variable	low	no	yes	short	none
Genetic tagging	no	none	100%	100%	yes	no	short	low

The unique attribute of genetic marking - genetic expression beyond the immediate generation - coupled with its endurance, ease of application and low expense all indicate that the procedure will ultimately find broad application

GENETIC MARKING: ITS USE IN THE EVALUATION OF COHO FRY PLANTS

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National Marine Fisheries Service

Jim Seeb
Pacific Fisheries Research

Genetic marking using an LDH-4(116) variant was used to identify coho fry planted in six native Puget Sound coho streams. Both fed and unfed fry were planted. Using these genetic markers, the planted fish will be followed during their residence in the streams. The fish will also be identifiable when they return and their contributions to the next generation can be assessed. Interactions between planted and native fish as well as data on dispersal of plants and the relative survival of fed versus unfed fry plants are being collected.

PRELIMINARY REPORT ON THE EFFECT OF SIZE AND TIMING ON GILL ATPase IN QUINAULT SOCKEYE AND STEELHEAD AND QUEETS FALL CHINOOK

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Quinault Department of Natural Resources

Gill ATPase analysis was periodically performed on 1976 Brood Quinault Sockeye and Steelhead and Queets Fall Chinook fingerlings pen reared at Lake Quinault. Wild Fall Chinook were obtained from two sampling stations on the Queets River for comparison to pen reared stocks.

Sockeye

Sockeye (1975 Brood) sampled in the 1976 experiment exhibited a minimum size and general time frame at migration. Fingerlings smaller than 6.5 cm in length never exhibited elevated ATPase. Fingerlings greater than 6.5 cm had elevated ATPase from July 7 when it diminished to pre-smolt levels.

The 1977 experiment virtually replicated the 1976 experiment. Again, 6.5 cm was found to be a minimum length for ATPase activity and mid-July was the terminal date for elevated ATPase activities (Fig. 1). Since Sockeye reared at Lake Quinault are part of a zero age release program, it is presently impossible to determine an initial date for activity increase.

Steelhead

Yearling Quinault Steelhead were periodically sampled for gill ATPase activity. Analysis of variance for the results indicated a minimum size of 45 grams for ATPase activity increases. Unlike sockeye sampling, initial and terminal dates for activity were determined. The results indicated elevated activity between April 15 and June 1, Fig. 2. Accelerated temperatures of the 1977 spring may have influenced the terminal dates of activity.

Quinault Fall Chinook

Wild zero aged Fall Chinook of the Queets River were pen reared at Lake Quinault. Periodically, samples were obtained for ATPase analysis between May 25, 1977 through December 2, 1977. Wild stocks obtained from two river sites were also analyzed within this period. Unlike sockeye and

steelhead no size - ATPase correlations were found in Fall Chinook. ATPase activity increased over time regardless of size until mid-July. Wild stocks though smaller in size exhibited elevated activities during similar time periods (Fig. 3). ATPase activity increased in all groups mid-July and the end of August. The elevated activity periods correlated well with river mouth outmigration. Activity levels fell to pre-smolt by the first week in December.

12/5/77
/pc

Fig. 1. ATPase ACTIVITY FOR 76 BROOD QUINAULT SOCKEYE

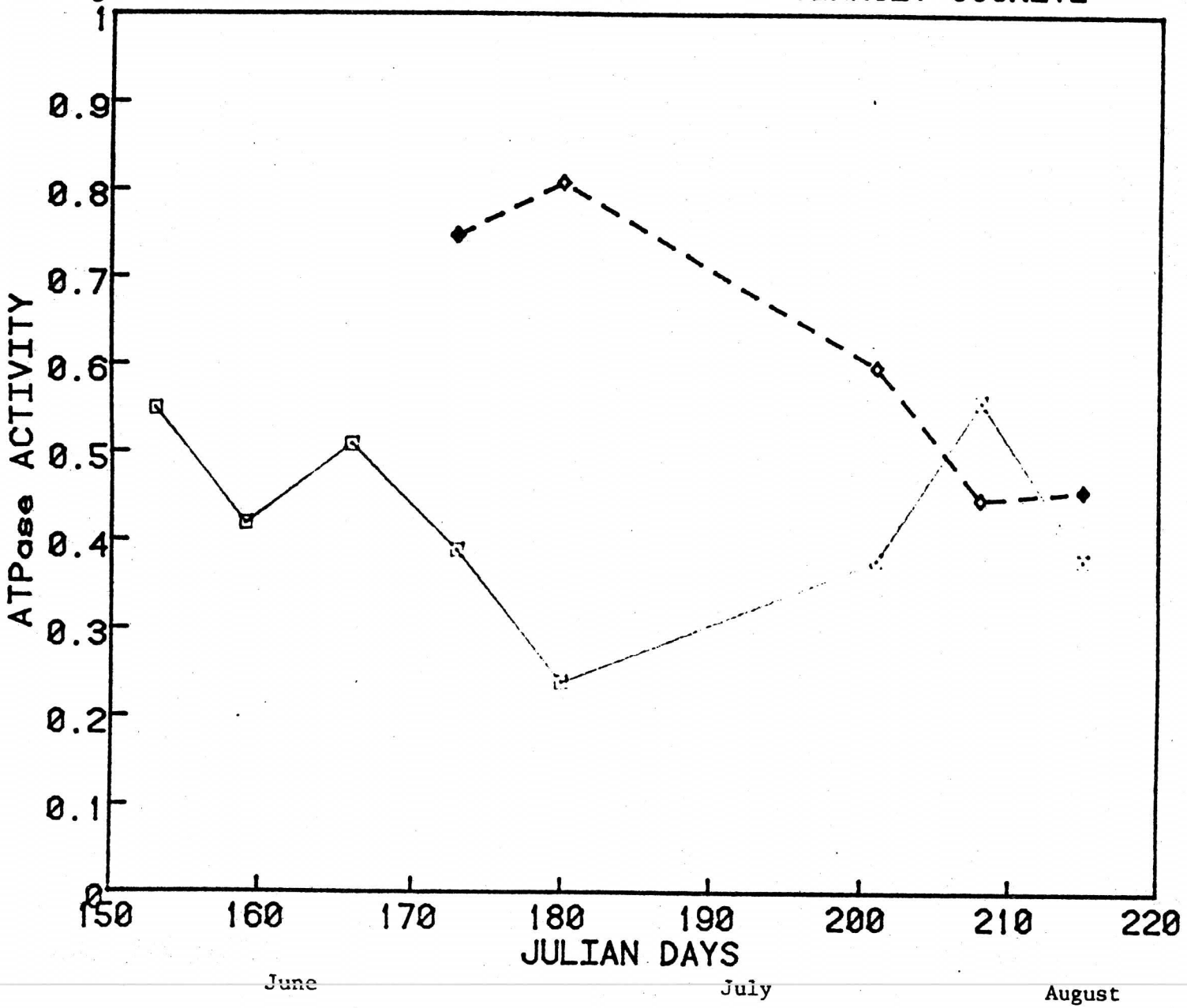

Fig. 2. ATPase ACTIVITY FOR QUINAULT STEELHEAD 76 BROOD

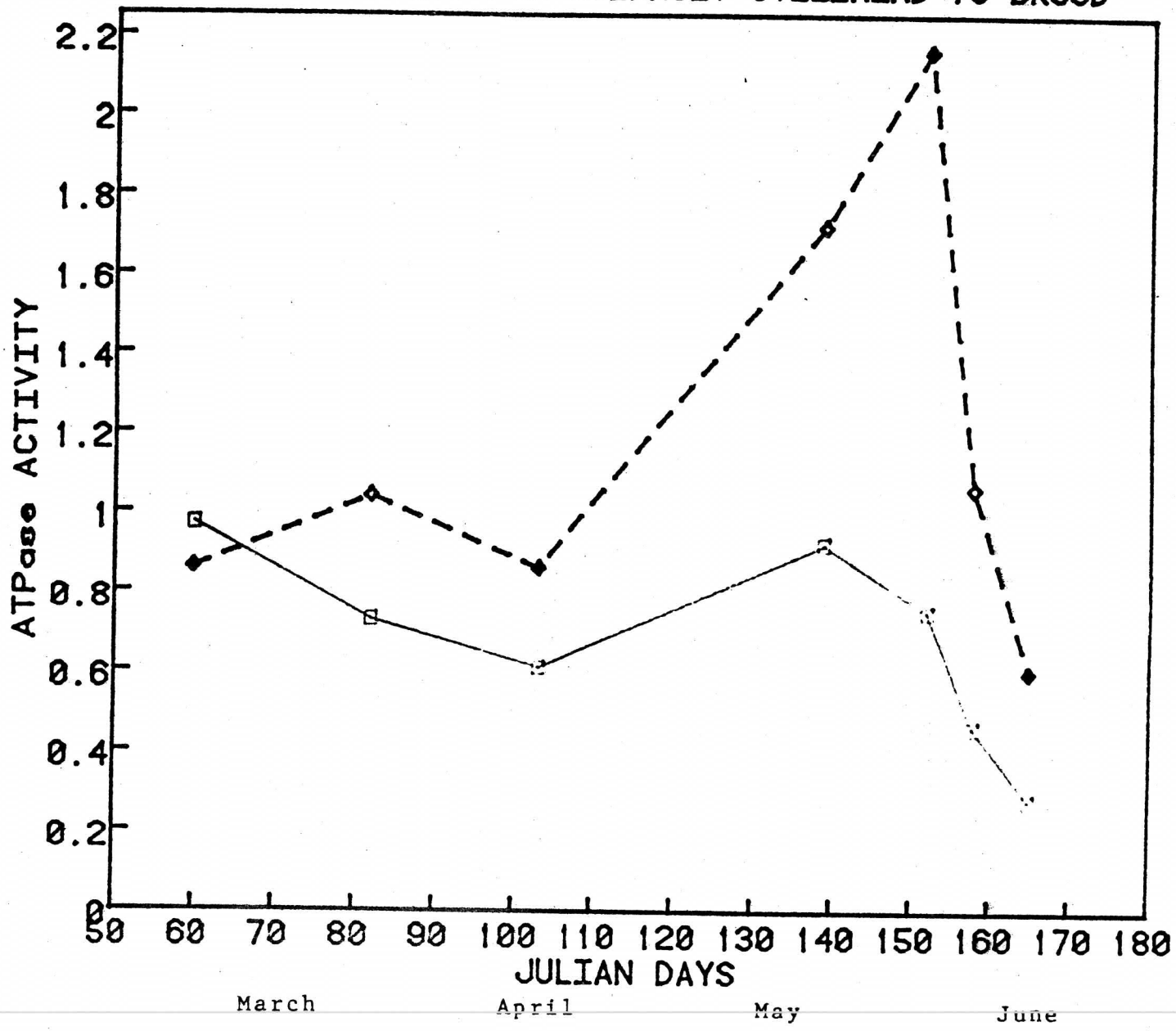

Fig. 3. ATPase ACTIVITY FOR 76 BROOD QUEETS FALL CHINOOK

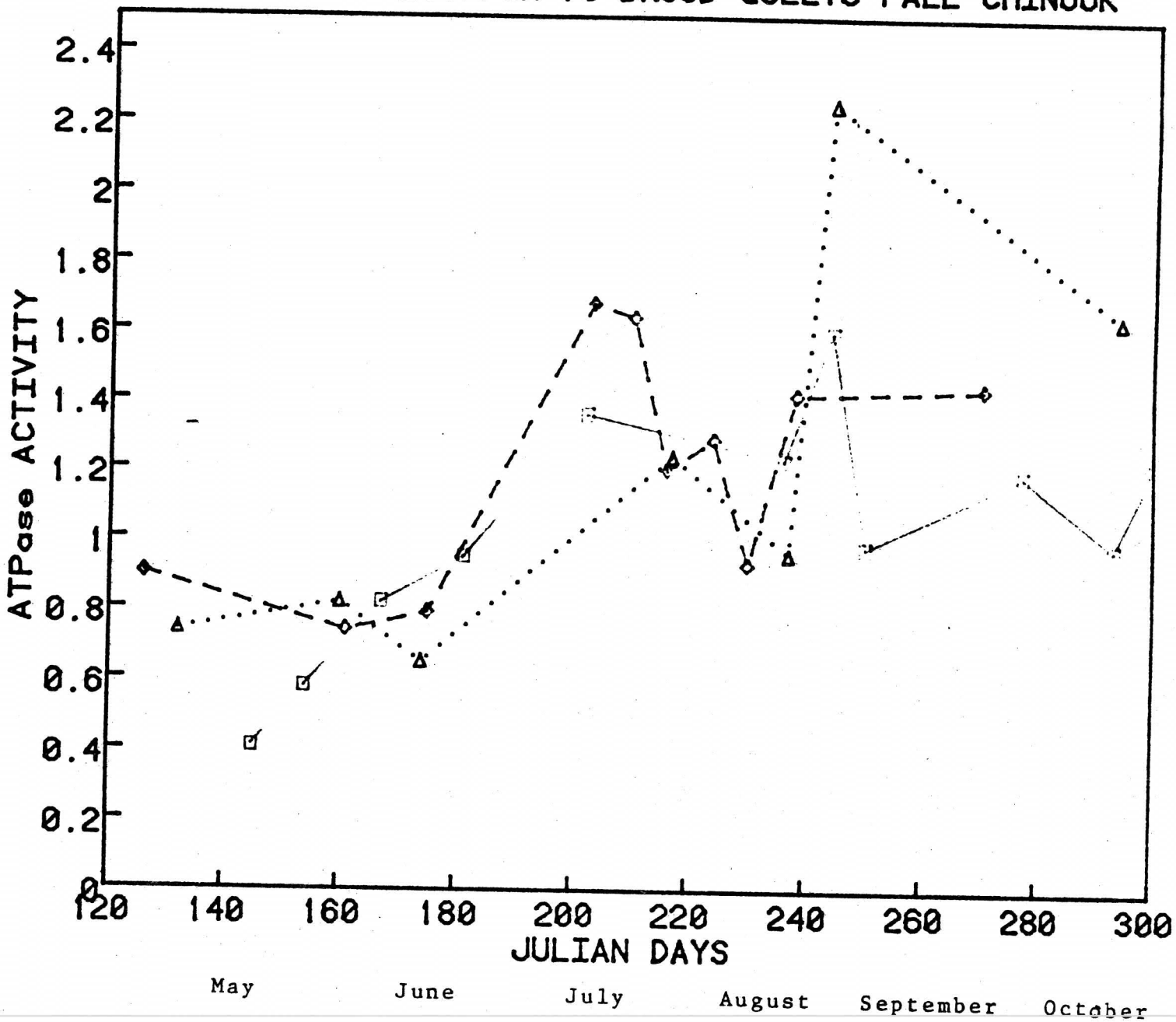

Table 1. ANOVA of Gill ATPase activity of 1976 Brood Sockeye fingerlings.

Date	Length	ATPase	F	Salmon Fingerlings
6-2	$\bar{X}$ < 6.5 cm.	.55	NA	
6-8	$\bar{X}$ < 6.5 cm.	.42	NA	
6-15	$\bar{X}$ < 6.5 cm.	.51	NA	
6-22	$\bar{X}$ < 6.5 cm.	.39	9.34	**
	$\bar{X}$ ≥ 6.5 cm.	.75		
6-29	$\bar{X}$ < 6.5 cm.	.24	18.6	***
	$\bar{X}$ ≥ 6.5 cm.	.81		
7-20	$\bar{X}$ < 6.5 cm.	.38	2.54	
	$\bar{X}$ ≥ 6.5 cm.	.60		
7-27	$\bar{X}$ < 6.5 cm.	.55	1.00	
	≥ 6.5 cm.	.45		
8-3	$\bar{X}$ < 6.5 cm.	.38	.11	
	$\bar{X}$ ≥ 6.5 cm.	.45		

Table 2. Two way ANOVA of ATPase activity between two size groups of the 1976 Brood Sockeye Salmon fingerlings.

Source	DF	MS	F	Significance Level
Total	117			
Main Effects	5	.24	3.37	**
Length	1	.8	11.42	***
Time	4	.03	.38	
Interation	4	.28	3.98	**
Error	108	.04		

Table 3. ANOVA of Gill ATPase activity of 1976 Brood Quinault Steelhead fingerlings.

Date	Wt.	ATPase	F	Significance Level
3-1	$\bar{X}$ < 45 gm.	.97	.50	
	$\bar{X}$ ≥ 45 gm.	.86		
3-23	$\bar{X}$ < 45 gm.	.73	2.4	
	$\bar{X}$ ≥ 45 gm.	1.03		
4-13	$\bar{X}$ < 45 gm.	.61	7.43	*
	$\bar{X}$ ≥ 45 gm.	.86		
5-19	$\bar{X}$ < 45 gm.	.92	6.5	*
	$\bar{X}$ ≥ 45 gm.	1.67		
6-1	$\bar{X}$ < 45 gm.	.74	7.1	*
	$\bar{X}$ ≥ 45 gm.	2.16		
6-7	$\bar{X}$ < 45 gm.	.45	6.28	*
	$\bar{X}$ ≥ 45 gm.	1.06		
6-14	$\bar{X}$ < 45 gm.	.28	4.37	*
	$\bar{X}$ ≥ 45 gm.	.60		

Table 4. Two way ANOVA of ATPase activities between two size groups of 1976 Brood Quinault Steelhead.

Source	DF	MS	F	Significance Level
Total	190			
Main	7	4.94	23.20	***
Size	1	7.09	33.3	***
Time	6	2.00	9.4	***
Interation	6	.79	3.71	**
Error	177	.213		

RESULTS OF TREATMENTS FOR SOFT SHELL EGG DISEASE IN CHINOOK SALMON

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Soft shell egg disease (perforations in the egg shell leading to premature hatching) has caused mortalities in chinook eggs at Round Butte hatchery every year since eggs were first taken.

Malachite green and acriflavine have been used in past experiments, to attempt control of this disease. Acriflavine proved to be the most effective but also the most costly.

In 1976 it was learned that other ODFW hatcheries (Klamath and Roaring River) were using formalin to control soft shell in rainbow trout eggs. We then designed the present experiment to determine the most effective and least expensive means to control this disease.

Four experimental groups of 4,464 and one of 150,000 summer chinook eggs were placed in Heath Incubator trays in seperate stacks. Each stack received a constant 5 gpm of 50°F water throughout incubation. Each group was treated with a malachite green flush (1.4 g) every other day to control fungus. Malachite green flush was stopped four days prior to eye-up when experimental treatments started. Each treatment involved mixing the chemical in one gallon of water and dripping it into the upper tray over a 15 minute period. The following treatments were administered until hatching commenced 25 days later:

Test 1	2 g acriflavine	daily	7 ppm
Test 2	4 g acriflavine	daily	14 ppm
Test 3	19 oz formalin	daily	1900 ppm
Test 4	6 g gentian violet	every-other-day	21 ppm
Test 5	control	no treatment	-

All treatments effectively controlled the disease (Table 1) as very few of the treated eggs developed perforations. In comparison most eggs in the control group developed perforations in the egg shells. Hatching commenced four days earlier in the control group and continued four days longer. The control group experienced more than 12% mortality from premature hatching and entrapment of the alevins. Their tails would stick out through a hole in the shell reducing their ability to break out. Also, egg shells in the control group did not dissolve normally and had to be hand siphoned from tray. The 1 to 2% mortality in the treated groups was also mostly from premature hatching.

Following is a cost comparison between treatments if the entire production of Deschutes spring and summer chinook at Round Butte hatchery was treated over the 25 day period:

Test 1	2 g acriflavine	daily	$192-$552 1/
Test 2	4 g acriflavine	daily	$384-$1104
Test 3	19oz formalin	daily	$33
Test 4	6 g gentian violet	every-other-day	$47

1/ note fluctuation in acriflavine costs

It should be mentioned that this experiment was done in 1976. The only difference being the number of eggs used in each test group (700 in 1976). No soft shell developed in any of the test groups including the controls. This led us to believe that there was an association factor involved and more eggs would have to be used or the disease is not present every year.

TABLE 1. Results and comparitive costs of treatments for soft shell.

Test Number	Chemical	Conc.(ppm)	Frequency	Number 1/ Eyed Eggs	2/ % Loss	Cost/Stack 3/ Per Season
1	acriflavine	7	daily	3,441	1.7	$32-$92
2	acriflavine	14	daily	150,000	1.8	$64-$184
3	formalin	1900	daily	4,232	1.5	$5.50
4	gen. violet	21	every-other day	4,232	1.0	$7.80
5	control	-	no treatment	4,232	12.4	-

1/ All Deschutes stock summer chinook

2/ Loss from eyed stage to hatching

3/ Cost for 16 tray Heath Incubator stack over 25 day treatment period

RESPIRATORY DISEASES AND THEIR TREATMENT

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Respiratory diseases can be divided into two main types - infectious and non-infectious problems. The infectious respiratory problems are caused by bacteria, protozoa, trematodes, crustacea, and occasionally, leeches. Non-infectious respiratory diseases often remain unnoticed in fish until secondary problems occur. Non-infectious diseases can be divided into three catagories: water associated, nutrition associated, and management associated.

After identifying a respiratory problem in a group of fish, you must obtain a cultural history of the fish. Observe their behavior, take simple water analysis and necropsy several fish. Examine the gills on a wet mount under a microscope to identify the infectious or non-infectious problems. Make a presumptive diagnosis and take the fish off their feed for a minimum of twenty-four hours. If possible, split and clean the fish ponds. Choose the chemotherapeutic agent and the method of application. Place a small number of fish in a container and perform the chosen treatment to determine effectiveness. Correct the dosage if necessary. Treat the fish in the ponds and remain on site to prevent major accidents from occurring. Examine a few fish after the treatment to varify the results.

THE CONTROL OF BACTERIAL KIDNEY DISEASE: 1977 UPTAKE

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ABSTRACT

Erythromycin phosphate (aqueous solution) was administered subcutaneously to adult spring chinook salmon at the rate of five milligrams of active indredient per pound of fish. Groups of 71, 2,069, 6,242, and 7,011 adult salmon received injections in 1974, 1975, 1976, and 1977, respectively.

At spawning, the incidence of kidney disease (KD) lesions was one-fourth to one-third of those occurring in uninjected control fish. The antibiotic injections had no apparent adverse effects in either the adults or their offspring.

Eggs from treated and control adult females were raised to smolts in isolated conditions. Parr from treated females exhibited no signs of KD while offspring from control females exhibited periodic mortality due to bacterial kidney disease.

Distribution of the Infective Agent for *Ceratomyxa shasta* at the Pelton Project, Deschutes River, Oregon

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During the period 1972-1977, studies were conducted to determine when and where *Ceratomyxa shasta* infects fish at the Pelton Project; a hydro electric project consisting of a downstream regulating dam and two hydroelectric dams (Pelton and Round Butte). Susceptible rainbow trout were exposed to the waters in question and the infective agents were determined present if one or more became infected. To determine the vertical distribution of the infective agent in Lake Simtustus (Pelton Reservoir), rainbow trout were placed in live boxes attached to a rope at various levels. The live boxes were enclosed in plastic bags when being lowered and raised to prevent exposure to more than one level of the reservoir. For incubation of the disease, the exposed fish were held in a covered trough which utilizes *C. shasta* free spring water. To determine when the infective agent first becomes active in the spring, fish were held in the waters in question and 5 to 10 moved weekly into the trough.

The Deschutes River below Lake Simtustus was found to contain the infective agent for *C. shasta* each spring. In the three years tested, initial infections below Lake Simtustus were found within two weeks of May 1. Water temps. on the dates of the first infections were 9.0, 9.5, and 8.0°C in 1973, 1974, and 1975 respectively. It was determined the infective agents originate from the hypolimnion of Lake Simtustus and are not present in the epilimnion when the reservoir is stratified. Fish exposed to the Round Butte Dam tailrace during the springs and summers of the study period did not become infected. A small percentage of the fish exposed during the fall and early winter of 1975 and 1976 became infected. The infective agents contacted by these fish may come from upriver sources and be delayed in Lake Billy Chinook until fall.

Why Lake Simtustus is a source of infective agents and not Lake Billy Chinook is not certain. One possible explination can be found upon examination of fish liberation records. Since its creation in 1958, Lake Simtustus has received an average annual stocking of 90,000 legal rainbow trout from stocks susceptable to ceratomyxosis. Most of those not caught by anglers within a short time are known to have died from ceratomyxosis. These fish develope severe infections and a large number of spores are produced. Lake Billy Chinook received stockings of fingerling rainbow trout from its formation in 1964 through 1970. Fingerlings becoming lethargic from ceratomyxosis would likely be devoured by predators before the spore stage of the protozoan would form. Although the life cycle of *C. shasta* remains unknown, it is probable that the production of large numbers of spores would give rise to large numbers of infective agents and result in a high rate of ceratomyxosis in susceptible fish.

Anyone wishing more information on this work should write Don Ratliff, P.G.E. Co., P.O. Box Q, Madras, Oregon 97741.

THE 1977 MIGRATORY BEHAVIOR OF JUVENILE CHUM SALMON RELEASED FROM THE HOOD CANAL HATCHERY AT HOODSPORT, WASHINGTON

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This is a preliminary report on a pilot study on the use of fluorescent pigments for the marking of large numbers of small juvenile salmon to study their migratory behavior. An outmigration study of chum salmon juveniles in Hood Canal was conducted by the University of Washington, Fisheries Research Institute (FRI) and the Washington State Department of Fisheries (WDF) from April 20, 1977 to July 25, 1977. The final report will be available in February 1978.

The objective of the study was to investigate the migration rates and distributions of different sizes of chum salmon that had been marked with fluorescent pigment and released at different times during the emigration period.

METHODS

Marking

The marking of juvenile chum salmon (38-60-mm) with fluorescent pigment, as described by Jackson (1959) and Pribble (1976) and modified by WDF, was selected as the most efficient technique for short-term studies of the early-marine life history of salmon. The technique consists of forcing fluorescent pigment granules through the epidermis and into the dermis of the fish by means of a small sandblasting gun and compressed air. The gun was modified to use 0.94ℓ (1 qt) polybottles instead of the standard 0.94ℓ canister. The gun was fitted with a 2.4-mm (3/32 in) siphon and blast orifice. Air was supplied by the use of 6.9 m^3 (244 ft^3) air cylinders fitted with a double stage oxygen regulator. A trough was developed by WDF for marking large numbers of fish quickly.

The fish were marked with Day-Glo, Jeffery Mill Grind (JMG) (30-350 μ) Arc Yellow and Rocket Red. This is a fluorescent polystyrene pigment that is biologically inert. The pigment is not readily excited by normal light but will fluoresce under ultraviolet illumination. It was found that the manufacture's grind contained particles much larger than the 350 μ granule upper size limit. These large particles, when sprayed at high pressure during pretest studies, caused excessive mortalities necessitating the sieving of the pigment.

Sampling

A floating 37-m beach seine with 18-m, 3-cm wings, and a 0.6 x 2.4 x 2.3-m bag of 6-mm stretch mesh (Schreiner, 1977) was used for sampling nearshore. This method has been used extensively for the salmonid outmigration studies in Hood Canal (Schreiner 1977a, 1977). Offshore sampling was conducted simultaneously (with beachseining) by surface townetting. The net is 15-m long with a 3.1 x 6.1-m opening with mesh sizes grading from 76-mm at the opening to 6-mm at the bag. (Schreiner, 1977)

Fish Analysis

Captured fish were examined for fluorescent pigment under ultraviolet light in a "black box" (Pribble 1976).

RESULTS

Marking

On April 18-19, groups of fish totaling 256,000 were marked with Rocket Red pigment. Each group was sprayed for 6 sec. at a distance of 45.7-cm (18 in) with one pass at 100 PSI pressure. These fish had a mean fork length of 53.7 ± 8-mm. There was a 1.2 percent initial marking mortality and a subsequent cumulative mortality of 0.6 percent in a 25 day period. Test lots were held in aquaria for 4 weeks after the release of the marked groups. One week after marking, 95.9 percent of the fish had retained the pigment. Though mark retention by group was good, the amount of pigment present on individual fish was generally very small (one or two granules). This made analysis difficult and probably accounted for a significant error.

On June 1-3, a total of 375,000 (57.2 ± 5.5-mm) fish were marked with Arc Yellow pigment. The fish marked June 1 were marked at 40.6 cm (16 in) with one pass at 120 PSI for 6 sec. An effort was made to increase the amount of pigment retained by the fish without increasing the mortality. This increase in pressure and decrease in distance caused a 10 percent initial mortality. The mortality was identified by James Wood, WDF Fishery Pathologist, as physical damage. There was erosion of the epithelium causing edema of the body musculature. To limit physical damage, the pressure was reduced to 100 PSI on June 2 and 3. The overall initial marking mortality was approximately 6.2 percent. There was a subsequent mortality of 3.2 percent for the 24 day period after marking. Test lots of marked fish were held two weeks to determine mark retention. One week after marking, retention was 89 percent. The amount of pigment present on the fish was significantly increased over the April marking.

SUMMARY

1) Large numbers of fish may be economically and efficiently marked with fluorescent pigment, but great care must be exercised to keep mortality low with pre-marking trials being mandatory.

2) Fish from the April release ($\bar{x}$ length 53.7-mm) migrated northward faster (up to 10 miles per day) than the June release ($\bar{x}$ length 60.2-mm) (up to 5 miles per day). This disparity in rate of migration is possibly due to changes in habit with time, food availability, or differences in size. (Table 1)

3) Monitoring of 1977 marked releases showed that the fish dispersed into large indiscernable groups by the second week after release. Some crossed Hood Canal soon after release. (Table 2)

4) Fish from the April release indicate an offshore movement at 44-mm, where the June released fish moved offshore at approximately 69-mm.

5) Migration patterns indicate a more random distribution in the Bangor area than 1975 and 1976 when the majority followed the east (Bangor) shoreline. (Table ?)

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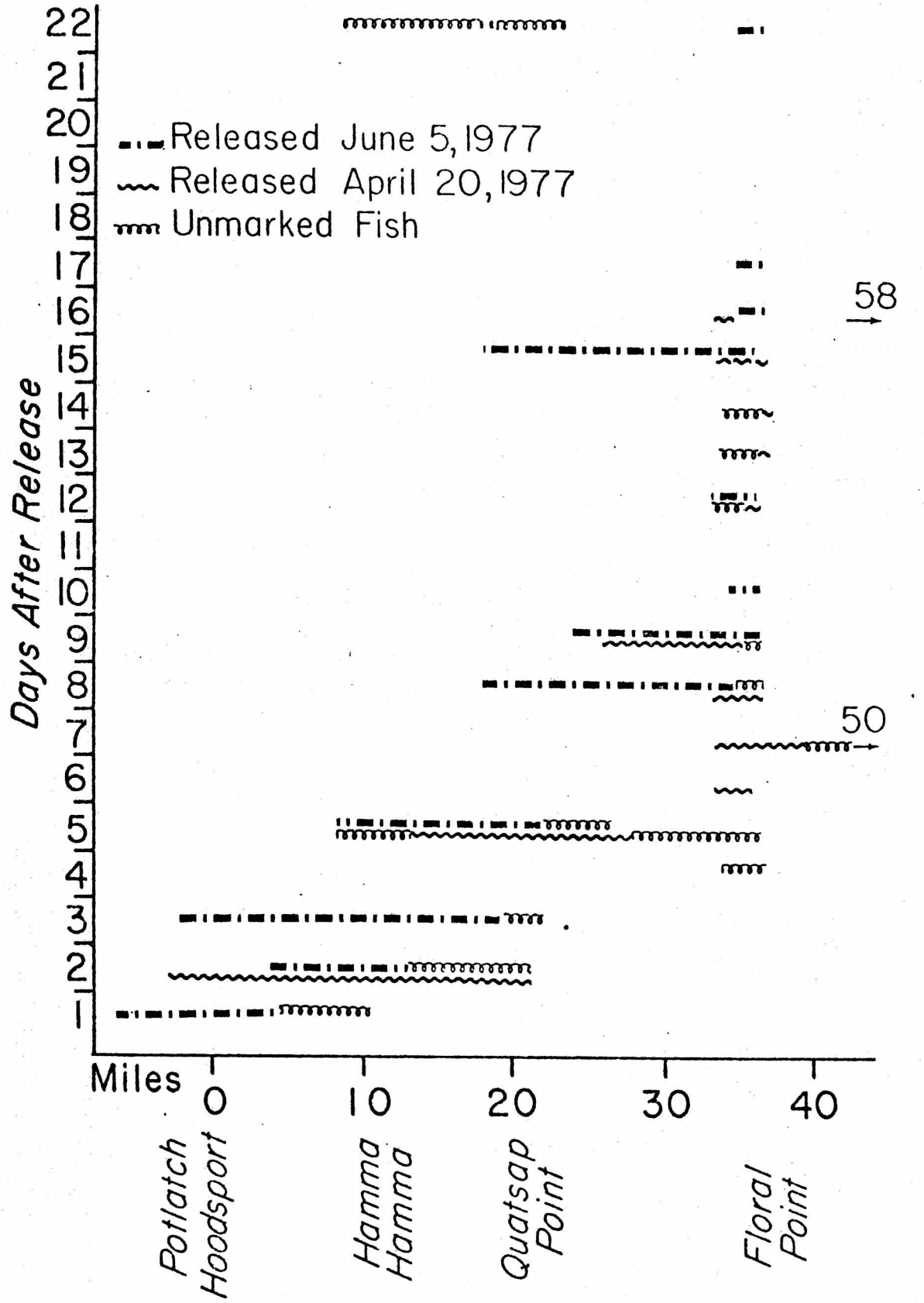
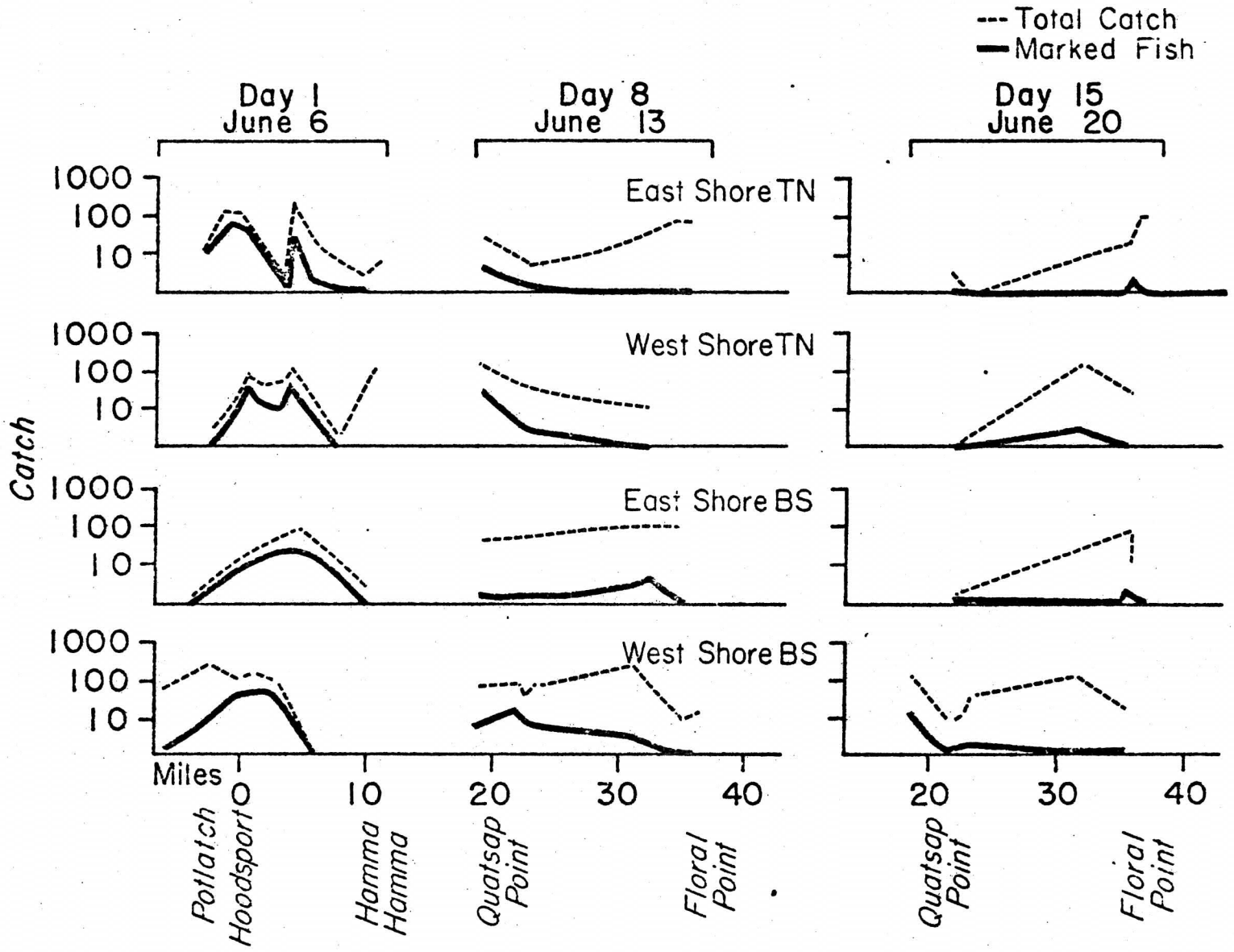

Released June 5, 1977
Released April 20, 1977
Unmarked Fish
Days After Release
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
58
50
Miles
0
10
20
30
40
Potlatch Hoodsport
Hamma Hamma
Quatsap Point
Floral Point



DISTANCE RANGE OF RECAPTURED MARKED CHUM SALMON IN HOOD CANAL

TABLE 2

Selection to Increase Yield of Big Creek Coho Salmon

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Introduction

At the 1974 Conference in Seattle, we reported results of our efforts in selective breeding to increase the yield (recoveries/thousand released) of the 1971-brood Big Creek coho salmon (McIntyre and Johnson 1974). Results of that experiment were inconclusive. In this report, we describe preliminary results for the second generation of selection with the 1974-brood.

Methods

In the summer-fall 1974, coded-wire tags were recovered from the 1971-brood Big Creek coho salmon harvested by the fisheries and that returned to Big Creek Hatchery near Knappa, Oregon. These fish originated from 45 families that were distinctively marked in April 1972, and then reared in the common environment of a raceway until they were released in April 1973.

After the yield for each family was calculated, males and females from families producing the highest yield values were selected from those returning to the hatchery for use as parents of the 1974-brood families. Mature, unmarked fish were obtained from the holding pond to produce a series of unselected control families.

Matings were made to produce 20 select and 12 control families. Each family consisted of all of the progeny from a single female. In the summer-fall 1977, coded wire tags were removed from samples of these fish as they entered the fisheries.

Many of the details of our experimental methods were described at the Seattle Conference (McIntyre and Johnson 1974).

Results and Discussion

Coded-wire tagged 1974-brood Big Creek coho salmon recovered from the 1977 fisheries and from Big Creek Hatchery are summarized in Table 1. Yield for the combined select families was greater than yield for the combined control families ($X^2 = 36.3$) indicating a significant effect due to selection.

Table 1. Coded-wire tagged Big Creek coho salmon found in samples taken by the commercial fisheries and recovered from adults at Big Creek Hatchery, numbers of smolts released, and yield of combined select and combined control families.

	Select	Control
Smolts released	37,355	20,617
Adults recovered:		
Marine fishery	48	3
Columbia River gill net	3	2
Big Creek Hatchery	61	7
Total	112	12
Yield (recoveries/000's released)	3	0.6

The correlation of the average for male and female parent family yield values (1971 brood) with yield values for the corresponding offspring family (1974 brood) was $r = 0.50$. The significance probability for r with 30 degrees of freedom was less than 0.01. This correlation shows that progress in selection will be determined by the numbers of mature fish available from high yield families.

Progress in the selection program at Big Creek Hatchery has been slowed because of restricted space for rearing separate families. If the results described here encourage others to initiate comparable programs, we recommend that facilities for rearing separate families be provided to the extent that adequate numbers of brood fish can be obtained only from families with the highest yield values.

References

McIntyre, J. D. and A. K. Johnson. 1974. Preliminary results of selective breeding to increase the yield of coho salmon produced at Big Creek. Proc. 25th Ann. Fish Cult. Conf. pp 124-126.

MEASURING LONG-TERM CHANGES IN THE FALL CHINOOK POPULATION IN ELK RIVER[1/]

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Elk River Hatchery was started in 1968 with the wild stock of fall chinook salmon captured from spawning areas in the river. The hatchery program has followed the natural life history of the fish with releases primarily occurring in autumn at large sizes (8 to 16 fish/lb). If Elk River Hatchery has been successful to now with survival rates averaging 3 to 5% and with good contributions to the sport and commercial fisheries, does it necessarily follow that the hatchery program will be successful into the future? This question is the basis of long-term research at Elk River to monitor changes in the population as a result of the hatchery operation.

Several characteristics of the hatchery population have been measured through time since 1968 and have shown some deviation from the biological variability of the original wild population:

1) Jacks are abundant in the natural population. Jacks were not used for spawning in the hatchery program, and of the adult males used, only a relatively small number were used. Jacks are no longer a strong component of the hatchery population. In the future we will increase the numbers of males used to be in equal proportion to the number of females spawned and involve a wide cross section of ages including jacks.

1/ *Abstract of a talk at the 1977 Northwest Fish Cultural Conference, Olympia, Washington, December 6-8, 1977.*

2) The natural population includes females from age 3, 4, and 5 with age 4 usually being the most abundant. At the first return of hatchery fish in 1971, many age-3 females were available and provided for a substantial deviation from previous years in the age distribution of females spawned. A more uniform distribution of females will also be chosen in the future.

3) Spawning of the wild population is protracted over a three-month period. However, in the hatchery program there is evidence that timing of egg takes was moving forward and that the spread of the egg take was being reduced. Steps are now being taken to spawn throughout the run.

4) Wild fish were used exclusively for spawning in the early years of the hatchery program, but now only 10% or less of the eggs come from wild fish. We may need to include more wild fish in the future to assure more biological variability in the program.

Our best strategy at this hatchery and possibly at most hatcheries is probably to maintain as much biological variability as possible in the program to assure reasonable stability from year to year. At the same time, we can cautiously test genetic selection for desirable traits in part of the production to improve survival and contribution to the fisheries.

Presentation of the Oregon Department of Fish and Wildlife Mobile Microtagging Unit

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To meet the demands of current microtagging projects, a self-contained mobile tagging unit was developed in 1977 by the Oregon Department of Fish and Wildlife. The following is a review of tagging equipment and associated systems within the unit.

A 34-foot Barth motor home with 29 feet of flat, usable floor space houses the microtagging operation. While power is primarily obtained from either 110 or 220 volt circuits available at hatcheries, a built-in gasoline generator supplies standby electricity when needed. Two external, submersible pumps supply water for the main system and fish grader. A booster pump located inside the unit provides adequate water pressure to the quality control devices during tagging and circulates a disinfectant solution through the system after completion of a tagging operation.

As fish enter the tagging unit, they pass through a grader and into a compartmentized fish stock tank. From the stock tank graded fish are dipnetted into a hopper and transferred, via a 4" gravity flow line, to any of five injector station stock tanks. Each microtag injector is supplied with a head mold of specific size to accommodate a given range of fish size. At each station fish are dipnetted from the stock tank, anesthetized, placed in a freshwater recovery bath, fin-marked by adipose excision and injected with tag by the attendant. Fish then pass through a quality control device which separates any untagged fish for retagging. Microtagged fish enter a 3" gravity flow transfer line for their return to a rearing pond.

OREGON DEPARTMENT OF FISH AND WILDLIFE
MOBIL MICROTAGGING UNIT

To meet the demands of current and proposed microtagging projects, a self-contained mobil microtagging unit was developed and made operational in the spring of 1977 by the Hatchery Practices Section of the Oregon Department of Fish and Wildlife.

The following is a review of the tagging equipment and associated systems within the unit.

Slide #1

Some of our earlier microtagging operations were rather primitive due to the limited accommodations at some hatcheries; no two hatcheries allowed the same operational setup. This was one of the incentives for developing our present unit.

Slide #2

Construction began in 1976 when the Oregon Department of Fish and Wildlife purchased a Barth motor home shell. It has an overall length of 34 feet with 29 feet of usable floor space inside. The floor is flat with no wheel wells to interfere with equipment location. It is equipped with a 405 Chevrolet V8 engine, automatic transmission, power brakes and steering, cruise control, and two 55 gallon gasoline tanks. The roof has a full length storage area with a rack for storing hoses and pipes when not in use. A ladder on the rear provides access to the roof. Additional storage compartments are located under the floor with access from the outside and cabinets were installed inside.

Slide #3

The first step in a microtagging operation is to locate the unit as close as possible to the pond of fish to be tagged and then level the unit. There are level indicators at four locations inside which are calibrated to indicate the amount

of adjustment necessary. After it is leveled, four jack stands are placed under the frame to maintain the desired position.

Slide #4

A gasoline powered 110 volt, 6.5 KW generator for use in an emergency or where no electrical power is available is located just behind the rear wheels on the left side; an electrical control compartment is located next to it.

Slide #5

A close up of the breaker panel box with a 110 volt to 12 volt transformer located under this coiled extension cord and an extension cord for hook up with external power.

Slide #6

Most of the hatcheries are wired with 20 amp circuits to the pond areas. We had a problem getting enough amps to satisfy the demands of the equipment, especially in cold weather when the heaters were in use. Therefore, an electrical box that would split 220 volt single phase to four 110 volt circuits was constructed. We have 130 feet of 220 volt cord and four 110 volt cords 100 feet long. This has taken care of our electrical requirements.

Slide #7

Two 110 volt submersible pumps provide the water supply. One is the main water supply and the other is the fish grader water supply.

Slide #8

The green 2 inch hose carries water inside and the yellow 3 inch hose takes discharge water and tagged fish back to the ponds. We can connect either or both hoses to the other end of the unit if it is more convenient to the pond location.

Slide #9

Located inside under the main stock tank is a 110 volt booster pump to provide adequate pressure to the Quality Control Devices. An adjustable pressure control valve located in the pump outlet line provides 24 pounds of water pressure to the machines. Two three-way valves make it possible to use the pump to recirculate disinfectant solution through the equipment.

Slide #10

Now we start the actual tagging operation. The fish to be tagged are crowded in the pond, dipped out, put in a bucker and dumped in a hopper on the outside of the unit. We have been using a step ladder to reach the hopper but are currently constructing an aluminum platform with steps.

Slide #11

The hopper and pipe carry the fish through the window and into the grader.

Slide #12

This shows the inside of the hopper with its own water supply.

Slide #13

The fish are added slowly and steadily as this increases the efficiency of the grader. Note the water supply hoses for the hopper and grader.

Slide #14

Now the fish are inside. This view taken beside the grader tank in the rear shows the location of most of the components. Corner of grader, grader tank, individual stock tanks, distribution pipe with gates, anesthetic pans, freshwater pans, injectors, funnels, Quality Control Devices and reject buckets. Note the

angle of the tables. The tagger stands in one place and moves in an arc without any unnecessary turning or reaching. The hopper for the fish distribution tube is just out of view on the left but this will be shown later.

Slide #15

Back to the fish. They enter through the pipe, drop onto the upper end of the grader, and are separated into the five screened compartments of the tank below. Fish are graded to reduce size variation at each tagging station, thereby enhancing tag placement and increasing tag retention.

Slide #16

Actual grading in process with water spraying over the grader bars.

Slide #17

Here graded fish are shown in screened compartments below the grader.

Slide #18

Fish are dipped from a selected compartment and dumped into a hopper at the end of the distribution tube. Each station receives fish from a respective compartment compatible with a head mold of predetermined size.

Slide #19

Each individual tank has its own opening and is controlled by a gate.

Note the combination water supply and aerating system which is used on each tank.

Slide #20

Each tagger has two dip nets. Fish are dipped out of the tank and the net is set in the anesthetic pan.

Slide #21

When the fish are anesthetized they are moved to the freshwater recovery pan and more fish are placed in the anesthetic. Now the fish are ready to be tagged.

Slide #22

Here is a detailed view of the pans and bath tank located under the table. Water enters at one end of the bath tank, flows around the anesthetic pan for temperature control, supplies water for the freshwater recovery pan through perforations in the bottom and leaves through the stand pipe located at the other end of the bath tank. We have never found more than 1°F differential between the anesthetic water and the pond water even in the hottest weather with this sytem. The anesthetic water is usually changed every 2 hours.

Slide #23

The fish has the adipose fin clipped.

Slide #24

The head is inserted into the head mold, the injector is activated by pressing the touch switch, and a microtag is injected in the nose of the fish. The fish is then dropped into the funnel located below the tagger's hand.

Slide #25

A hose from the funnel carries the fish to the Quality Control Device which separates the tagged from untagged fish.

Slide #26

If the fish was tagged, it goes out the right hand hose to the discharge line and out to the pond with the discharge water. If it failed to be tagged, it goes out the left hand hose and into the reject bucket to be retagged. The metal lids of the Quality Control Devices were replaced with transparent plastic covers so we could watch the operation of the machine and take meter readings without disturbing the box or getting water inside.

Slide #27

This is the 3 inch discharge line, 2 inch water supply line, and 1 inch higher pressure line with pressure gauge for the Quality Control Devices. These run the full length of the mobil unit. This is the front and where the water supply and discharge hoses can be connected with quick coupler connections.

Slide #28

The reject bucket is located at the tagger's feet and the overflow hose drains into the main discharge line.

Note the bath tank with discharge hose and the individual stock tank with discharge pipe.

Slide #29

The fish have been tagged and are returned to the pond with the discharge water.

After the tagging operation is completed the unit is disinfected before being moved to another hatchery.

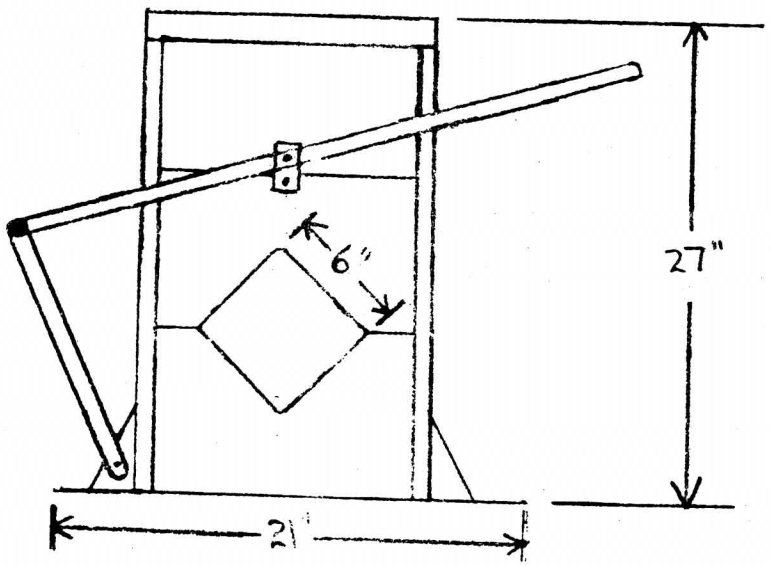
A GUILLOTINE FOR THE REMOVAL OF FISH SNOUTS CONTAINING CODED-WIRE-TAGS

Tom Worchester
Oregong Department of Fish & Wildlife

Due to the large number of experimental fish returning to Sandy Hatchery containing coded-wire-tags, we had a guillotine constructed which can be used to remove fish snouts. The basic design for our unit was taken from the commercially available guillotines which are used to decapitate small laboratory animals. (See accompanying diagram)

We mounted the guillotine and a measuring board together on a table so that the fish could be processed with a minimum of handling. The fish's length and sex can be recorded, its snout removed and placed in a bag all in one quick and safe operation. Using three people, we have processed 300 fish per hour with this unit.

Cost of construction: $200.00

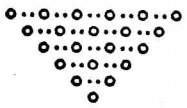


AN INTERNAL MAGNETIC TAG FOR SALMON SMOLTS

Y. HARACHE (*), P. LAGARDE (***), P. PROUZET (*)

WITH THE TECHNICAL COLLABORATION OF

G. COUDERCHON (***), J.L. GUILGUE (***) AND G. NEDELEC (*)



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With the help of the R & D department of LEANORD
(METALIMPHY and LEANORD are subsidiaries of CREUSOT-LOIRE).

28th North Western Fishculture Conference
(Olympia, Wash. - 5 - 7 December 1977)

AN INTERNAL MAGNETIC TAG FOR SALMON SMOLTS

Y. Harache, P. Lagarde, P. Prouzet

ABSTRACT

An internal magnetic tag built by MATALIMPHY was tested at the Centre Océanologique de Bretagne (France) on Coho salmon smolts (*Oncorhynchus kisutch*).
This system allows an automatic detection and identification of tagged salmon when the fish is swimming freely through an identification coil. The actual tag provides 127 combinations but could be improved for further development.
When properly inserted in the body cavity through a ventro lateral incision, the plastic tag (25 mm - 1.5 mm) did not affect the survival and behaviour of the fish during a 30 days test period. During the same time, the weight growth was only slightly reduced (9.1 %) compared to the growth of control adipose clipped fish (11.3 %).
Providing a control of long term effects on fish survival, this tagging procedure appears to bring new possibilities to fishery management.

RESUME

Une marque magnétique interne, fabriquée par la société METALIMPHY, a été testée aux laboratoires du Centre Océanologique de Bretagne sur des smolts de saumon Coho (*Oncorhynchus kisutch*).
Ce système permet la reconnaissance et l'identification des poissons marqués lorsqu'ils nagent librement à travers un solénoïde. La marque utilisée permet 127 combinaisons, le nombre pouvant être amélioré pour des applications ultérieures.
Les marques (25 mm - 1.5 mm), insérées dans la cavité abdominale par une incision ventro-latérale, n'ont affecté ni le taux de survie ni le comportement des poissons pendant la période d'essai de 30 jours. Pendant la même période, la croissance en poids a été légèrement inférieure (9.1 %) à celle de témoins marqués par ablation de la nageoire adipeuse (11.3 %)
Sous réserve d'un contrôle des effets à long terme sur la survie des poissons marqués, cette méthode peut apporter des possibilités nouvelles dans la gestion d'une pêcherie.

Salmon stock management requires the knowledge of the importance and the characteristics of the adult run in a given river. The constant evolution of the restocking techniques makes it necessary to evaluate the success of various smolt plantings to improve the efficiency of the fish hatcheries.
Numerous ways of branding or tagging fish have been developed and described for these purposes, each procedure being adapted to particular use conditions and to precise requirements. Some of the tagging procedures allow individual identifications, others are designed for group identification only.

Until now, the different procedures have required a careful identification of individual fish, including capture of the fish, handling out of the water or, in certain cases, dissection of the sacrified fish. Most of the tags actually used alter the ability of the fish to survive in the wild environment and thus give an inaccurate picture of the salmon life history (ISAKSSON & BERGMAN, 1977 - MORGAN & ROBERTS, 1976 - ROBERTS et al, 1973 - SAUNDERS, 1968 - STOLTE, 1973 - SWAIN, 1958).

Recent development of magnetic nose tags (JEFFERTS et al., 1963 - ISAKSSON, 1973) constituted a real improvement, but so for are readable only on sacrified fish. If the tagging itself can be done very rapidly, dissection and reading of the tag require a non negligeable amount of labour. According to LINDROTH (1953), internal stainless steel tags are perfectly supported by the fish and can be used in salmon smolts. Comparable metallic tags are commonly used to tag groups of various species of marine fish such as herring, mackerel or menhaden (GYTRE & JAKUPSSTOVU, 1977). In this case, however, it is only possible to sort out marked and unmarked fish, if dissection is not used to identity the type of tag.

METALIMPHY, a french company well known for its alloys with particular properties, has recently designed and patented a magnetic identification technique which appeared easily adaptable to fish tagging and allows an automatic "in situ" identification of the tag on swimming fish, without any handling. The actual tag design makes it easy to count over one hundred combinations.

The feasibility of such a technique was tested at the Centre Océanologique de Bretagne (CNEXO) on Coho salmon smolts. The present paper describes the results obtained and discusses the possible applications in fishery management.

MATERIAL AND METHODS

- *Principle of the tagging*

The induction of a magnetic sample with a rectangular hysteresis loop submitted to an alternative excitation field, reverses at each half period every time the field passes over a threshold value situated very near the coercitive field (Hc).
Flux inversion is observed in a detecting coil as an induced voltage pulse (fig. 1). If not only one, but n samples of different coercitive fields -Hc_1, Hc_2, ... Hc_n- are placed in the excitation coil, n different pulses appear during each half period of excitation phase, their respective positions depending upon the corresponding Hc value.
The presence or absence of one or more pulses among the n pulses of which the position is so defined allows a code with $2^n - 1$ possibilities.
For instance, the use of 7 coercitive fields allows to distinguish 127 combinations. Such a code could be improved by using more alloys of different characteristics or by using different amplitude levels for each pulse. This possibility is not dealt with in the present study.

- *The excitation and identification coils*

The excitation is given by a 38 cm diameter coil with 60 wounds of copper flattened wire. When connected to a 24 volts - 50 cycles per second (cps) source, the axial field is about 130 Oersted (Oe).
The detection is obtained with a set of two identical coils, connected in opposition to each other in order to cancel the excitation signal. Each of them is made of 1200 wounds of thin copper wire (fig. 2 and 3).

The whole device is contained in a waterproof tubular plastic casing, allowing fish to swim through a 30 cm free opening. That device was immerged in a plastic rearing tank where the fish were forced to swim through it.
During the experiment, the signal was filtered and amplified to a level compatible with a scope input and pictures were taken with an adaptable polaroïd camera.

For operational use, the electronic circuits will give a direct and decoded numeric signal for display or recording.

- *The tags*

The tags are composed of 4 wire segments (20 mm length, 100 microns diameter) of alloys giving 4 different Hcs (2 to 60 Oe) with square hysteresis loops. Another 3 extra wires of the same dimensions give to the tag the size of a 7 wire - unit as, at the time of the experiment, only 4 magnetic Hcs were available in the wanted diameter.

Each wire is separately isolated in a plastic tube, and all of them are sealed in a thermoretractable irradiated polyethylene coating, closed at each extremity with thermofusible polyolefine.
External dimensions of the tag are 25 x 1,5 mm.

The choice of the isolating materials for packaging of the alloys was made to meet the immediate laboratory needs, but more elaborated solutions might be found for industrial tags.
For the "in situ" tests, a tag containing the maximum of available signals (4) was chosen as presenting the most difficult case for an accurate pulse separation.

- *Tagging of the fish*

We used Coho salmon subyearlings (9 months) reared in France in a trout hatchery. Most of them were apparently at the parr - smolt stage. After 2 days of fasting, fish were chosen at random, in the range of size of 30 to 60 g, anesthetized (MS 222), measured, wrighed and gathered in 3 groups of 40 fish. The tags were desinfected in 90° proof alcool before the insertion in the fish.
In the first group, a lateral incision was done with a lancet, on the left side, below the lateral line, above the pelvic fin, after cleaning the surface of the skin with alcool. The tag was then inserted inside the body cavity through the orifice with sterilized forceps.
In the second group, the tag was introduced in the anus and forced through the rectum wall in the body cavity.
It was thus possible to mark 4 or 5 fish per minute with each process.
The fish belonging to the third group were adipose clipped, and used as a control group.

All the groups were allowed to recover for 5 minutes in a solution of formol and malachite green, then transfered in square (2 x 2 m) swedish type fiber-glass tanks fed with a 1 to 2 cubic meter per hour freshwater inflow. Temperature fluctuated between 13 and 15°C during the experiment.

The fish were slightly fed the day after tagging, then fed ad libitum twice daily with a rehydratable french pellet (AQUALIM).
The tanks were inspected every day for tag losses and mortality recorded. Every dead fish was carefully examined.
After 30 days, all the fish were slaughtered, measured and weighed, examined and dissected to observe the place of the tag and possible lesions.

RESULTS (table 1)

- *Mortality*

Dead fish appeared rapidly in group 2 marked through the rectum wall. The mortality reached 12.5% after 5 days then stopped; in this group, dead fish had either lost their tags or show internal damage with hemorragic regions, some presenting a perforation of the gill bladder.
It appeared also very difficult to feel if the tag was inserted in the right position in the body cavity, some fish having still the tag in the intestinal tract when dying.

No fish died either in group 1 or in group 3 during the experiment

- *Tag Losses*

Tag losses from fish tagged through the anus (group 2) reached 61%, probably due to improper tagging. As for the fish tagged through a ventro-lateral incision (group 1), the tags were still in place in all specimens after the 30 days control period.

- *Behaviour and growth*

Due to the stress from the handling and also possibly to the low density of population in the tanks, all groups came back slowly on the feed and started to feed normally only after 10 to 15 days. No difference in behaviour appeared between tagged fish and fish from the control group (group 3). At start and end of the experiment, no significant difference was found between the three groups, either as regards weight or length; all the groups presented an homogeneous growth with however a slightly higher value for the adipose clipped control fish.

- *Place of the tag after 30 days*

On fish tagged through ventro-lateral incision, the operation scar was still visible after 30 days, but complete cicatrisation of the muscle was evident in all the fish checked. Two tags, probably incompletely introduced in the body cavity when marking, had a slight muscular adherence at one extremity. Most tags (32) were found partially behind the incision place, in the vicinity of the intestinal tract, enclosed in a peritoneal membrane and surrounded with adipose tissue. Two tags were found between the right body wall and the pyloric caeca. One tag was found attached to the external membrane of the gill bladder, and four of them were found inside the gill bladder which appeared completely cicatrised. No lesion was visible either on the gill bladder tissue or on the kidney surface.

The fish tagged through the rectum wall showed more variations, with a higher rate of tags found in the gill bladder, and fewer tags enclosed in adipose tissue.

No hematomes or ulcers were observed in either group.

- *Tag identification*

Pulses appeared as easy to read on live swimming fish as in dry simulation tests ran at the laboratory.
The sensivity of the present detection device allows theoretically to "read" a tag at swimming speeds exceeding 1 meter per second.
Typical photographs obtained during the "in situ" reading on live fish are given in fig. 4.

DISCUSSION

It is almost impossible to find a universal type of tagging satisfying all the possible users, however, the technique described appears to provide original and attractive characteristics which could be used on a large scale in fishery management.

- *Satisfactory acceptance by the fish*

The tags inserted in the body cacity through a ventro-lateral incision apparently did not alter seriously the behaviour and stamina of the marked fish. The mortality was nil after 30 days and the growth appeared similar to that of adipose clipped control fish.

It would have been interesting to carry on the experiment during several months, but as the dissection showed a stabilized situation after 30 days and no internal lesions, further damage seems improbable. However, the tagging procedure will have to be improved in order to standardize the way of inserting the tag at the exact wanted place.

The results of this experiment, although preliminary, suggest that this type of tags, properly inserted in the fish, would not affect seriously the ability of the fish to feed and to escape predators.

- *Easy automatic identification of tagged fish*

Recording of the informations can be obtained with a minimum of stress for the fish, when it is swimming through the identification coils. The fish stays in its natural environment, without any handling.

Tag reading can be fully automatized, without human field observation, when a fish trap or a counting device is present on the river.
The reading apparatus is simple and resistant. The device is limited to a replaceable coiling fed with usual industrial power, and to a simple and classical electronic set which can be used by non qualified operators. The whole system could be industrially produced at a reasonable price.

- *Possible application to mass-marking-*

The tag actually used allows to identify over 100 combinations, which is generally enough for a given river system or even a wider geographic area. Further developments should possibly increase the number of possibilities.

The risk of tag losses seems to be very low and probably lower than in most of the known techniques. The quality of the signal depends only upon the alloy wires and is so far unchanged during the life of the fish, whatever the number of reading is.

The cost of tagging itself will probably be very competitive with the other methods due to the possible automatic injection, reducing labour costs and

CONCLUSION

Compared to the usual other ways of tagging fish, this technique, as all the other internal tagging methods, presents the disadvantage of being invisible on the fish. It is obvious that the identification of the fish captured before entering the counting device, either in fresh or sea water, is less evident for the average fishermen than an external labelled tag (carlin, floyd) even if signaled by a distinctive external mark like adipose clip.

However, automatic sampling of fish captured at sea is possible at landing, by passing the dead fish, even in the ice (presenting or not the adipose clip), through a detection set. The same examination can be performed on rivers, when the rod fisherman is obliged to declare its catches. In both cases, identification of the tagged fish is a rapid process which does not require mutilation of the fish and thus does not affect its commercial value.

On the other hand, it seems that, as for the magnetic nose microtag, the tag loss rate might be very inferior to most of the external tagging techniques or much more safely read than external cold branding (EVEREST & EDMUNDSON, 1967 - FUJIHARA & NAKATANI, 1965 - GROVES & NOVOTNY, 1965 - MIGHELL, 1969 - PIGGINS, 1972). It is presumed thus that the results obtained might be more accurate than most of the other methods.

The absence of visible and attractive signs on the fish probably lowers the incidence of predation (SMITH, 1957) and no change in behaviour has been found in fish internally tagged, by opposition to what is observed with smolts wearing the Carlin tag (POWER, 1966) or mutilated by clipping of a fin other than adipose.

Providing a control of long term effects on fish, we feel that the survival rates in the wild might be higher than with usual external marking. However, this possibility will have to be demonstrated by further studies.

The design of an automatic tagging device should make it possible to use this magnetic internal tag on a larger scale.

Direct reference to the authors for further developments should be welcome.

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	Mortality (%)		Tag losses %	Average weight (g)		Weight gain %	Remarks on the situation of the tag after 30 days %
	7 days	30 days		Start	End		
Internal tag Ventro-lateral incision	0	0	0	44.55 ± 1.70 (1)	48.60 ± 2.75	9.1	Adipose tissue : : 80 Pyloric caeca : : 5 Inside gill bladder : 10 Muscle adherence : : 5
Internal tag Rectum insertion	12.5	12.5	61.1	44.44 ± 1.90	48.20 ± 2.75	8.5	Adipose tissue : : 17 Inside gill bladder : 17 Inside intestine : 6 No tag : 61
Adipose clip	0	0	-	43.10 ± 1.82	47.95 ± 2.16	11.3	-

TABLE 1 - SUMMARY OF THE RESULTS AFTER 30 DAYS

(1) - 5% confidence interval of the mean.

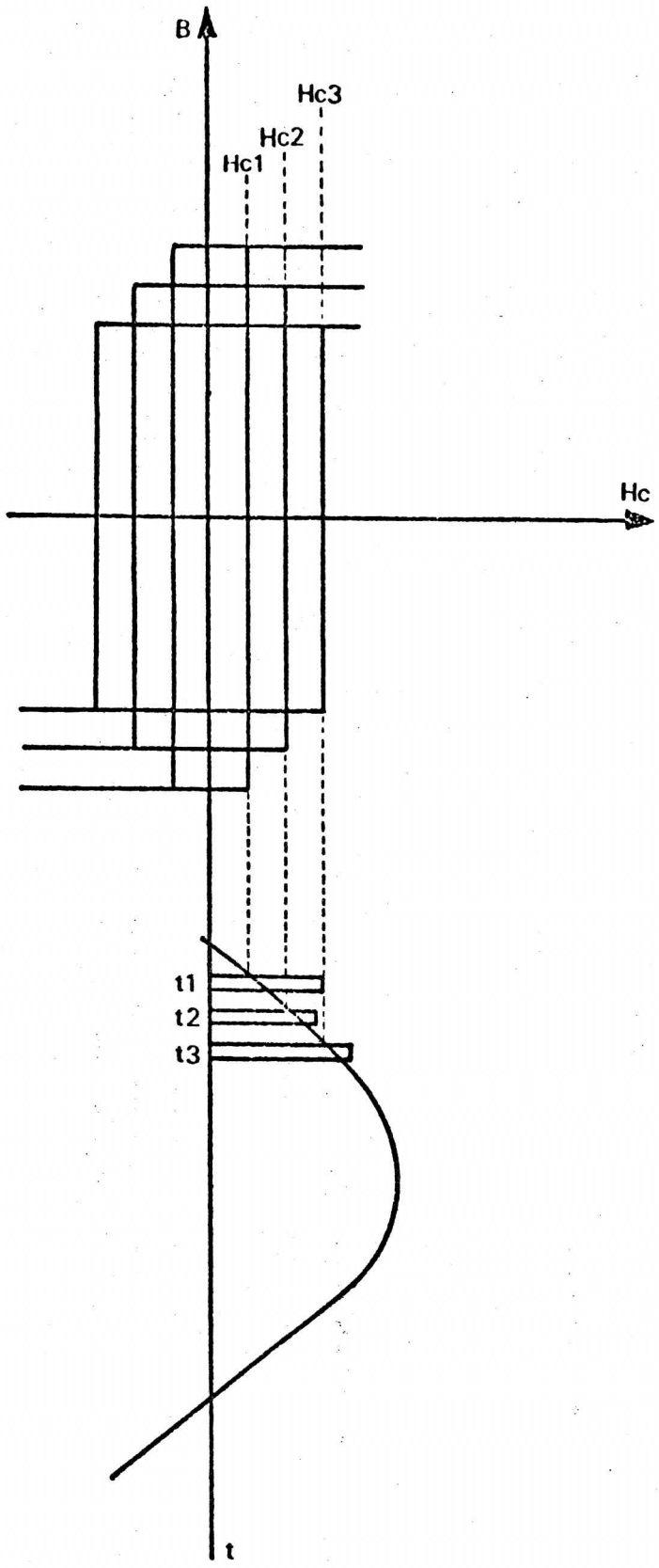


FIGURE 1 - Principle of the magnetic identification.

B = induction, Hc = magnetic excitation field, t = time

Hysteresis loops of each alloy are characterized by a particular coercitive value Hc_1, Hc_2, Hc_3.

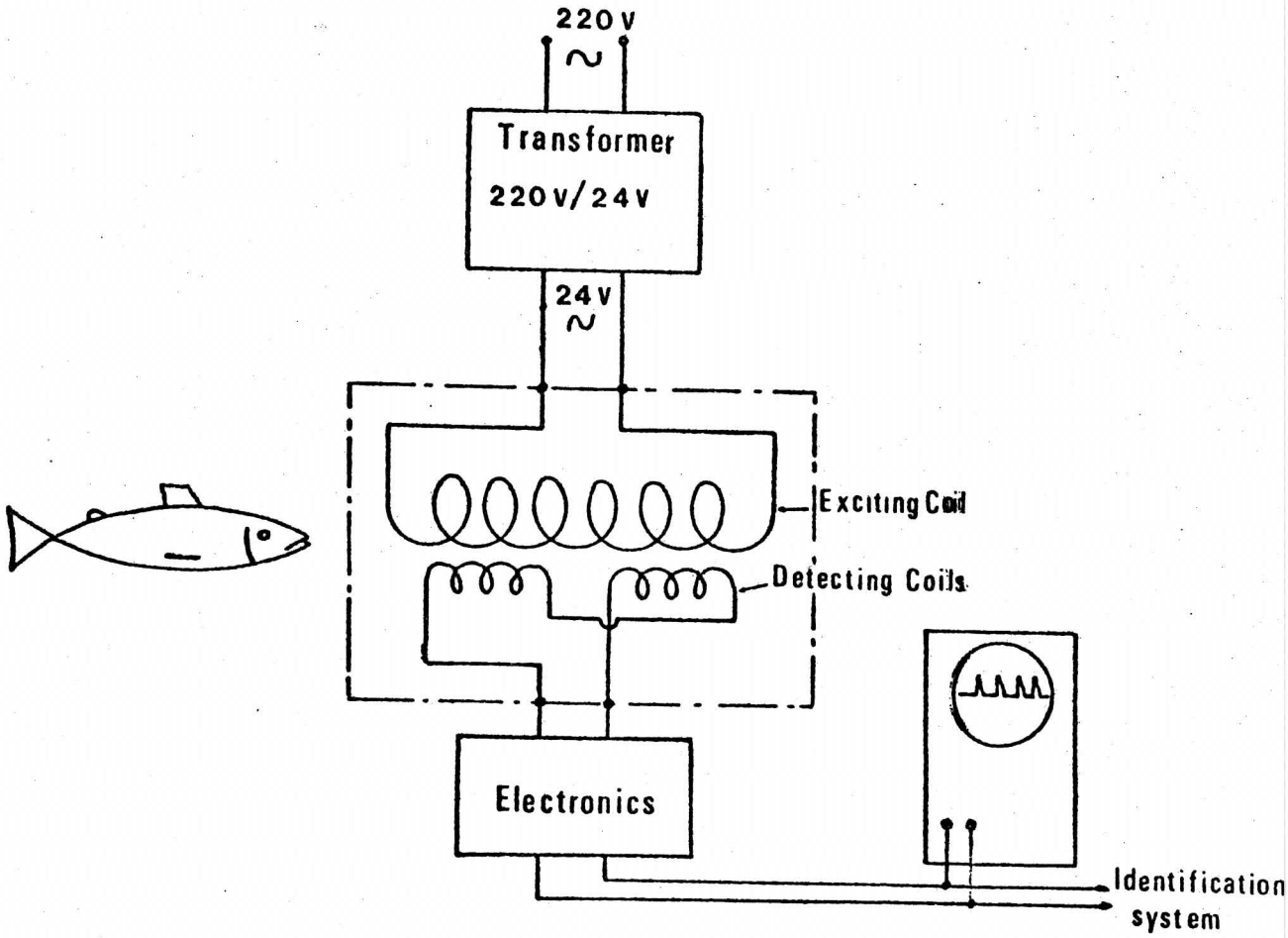


FIGURE 2 - Electrical circuits of the excitation and identification set

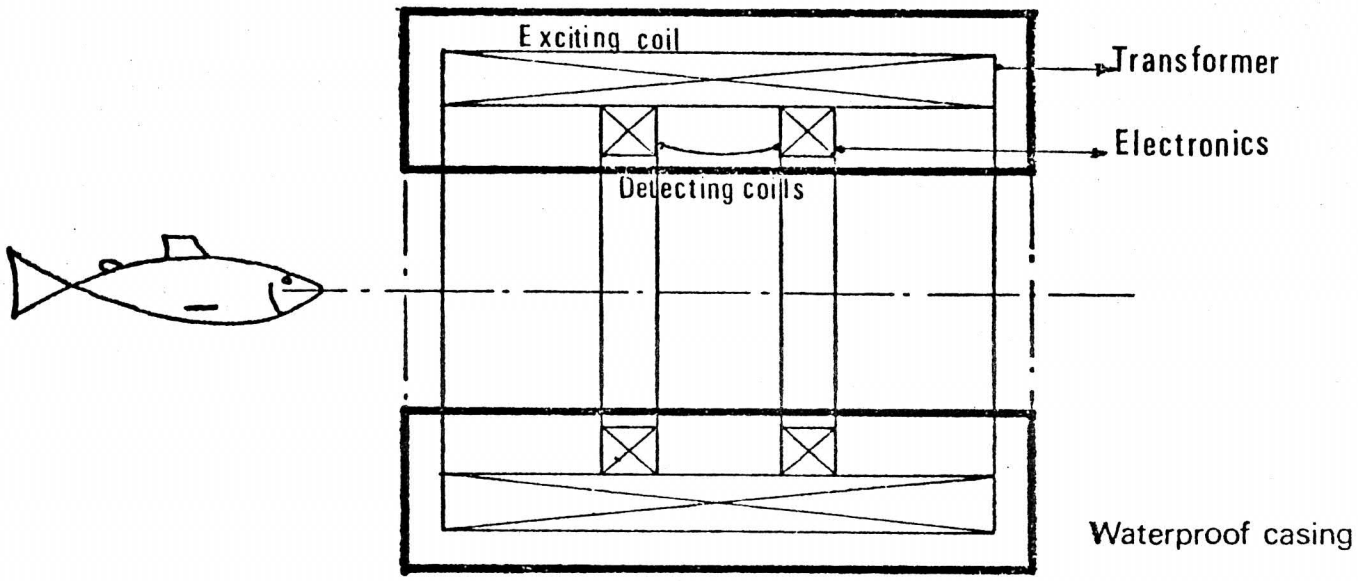
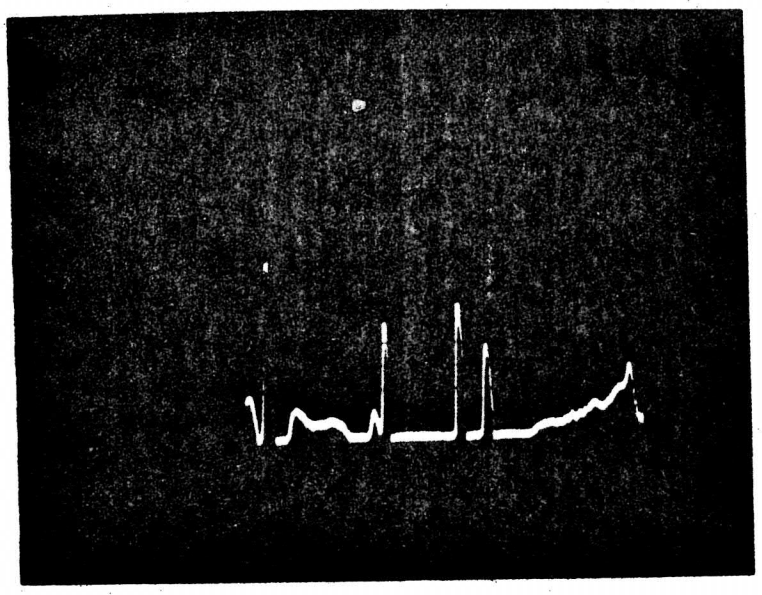


FIGURE 3 - Detail of the identification set



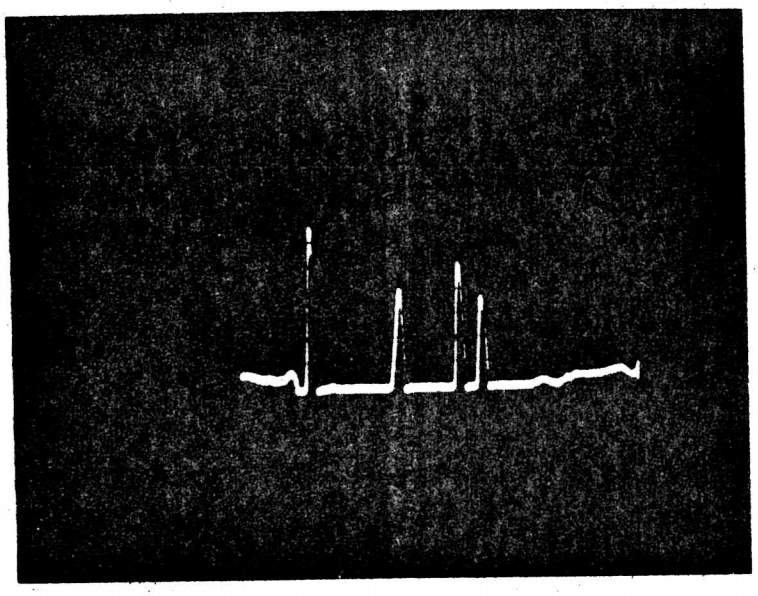


FIGURE 4 - Typical signals obtained on swimming fish.
(the 4 pulses correspond to: 59.5, 30.7, 8.6, 1.9 Oe).

THE UNITED STATES DEPARTMENT of AGRICULTURE ROLE IN AQUACULTURE

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This paper will be a considerable change from what you have been hearing the last two days. You have been exposed to many fine papers on research and management techniques, but because of much recent legislation on aquaculture, we thought you might want to hear about what has been passed and will soon be passed and what the implications will be. If you don't want to hear it, I guess you can go to coffee early. I realize also that the legislation recently enacted deals more with the commercial enterprise while most of you in this room are with public hatcheries - that may be all the more reason to go to coffee early. For those of you who stay, you may see how you and your organization will fit into the scheme of things to come.

Aquaculture is the culture or husbandry of aquatic animals or plants: by private industry for commercial purposes, or by public agencies to augment natural stocks. It involves the rearing of aquatic organisms under controlled conditions using the techniques of agriculture, animal husbandry, and marketing. Aquaculture can provide human food as well as products used in animals feeds.

At least 24 freshwater fish species are being raised in the Unites States for commercial production. However, the Nation's primary food fish production consists of channel catfish (50 million pounds) and trout (16-20 million pounds). Miscellaneous fishes, crustaceans, mollusks, annelids, marine plants, etc. are produced in smaller quantities, often experimentally. These have potential for expanded production.

The practice of aquaculture has the potential to be greatly expanded and yields may be appreciably increased through the use of modern science, technology, and information delivery systems.

Aquaculture and fish farming have repeatedly been the subject of legislation over the past five years, but none has been enacted.

In November 1975, the National Oceanic and Atmospheric Administration (NOAA) distributed a final draft of its aquaculture plan. The plan stated:

> "Federal leadership and guidance should be expressed by a national policy to encourage aquaculture as a means of expanding food production. Federal actions are needed to channel the diverse efforts within and without government into a coordinated program which will provide the scientific and technical information, environmental protection, and institutional arrangements required for expansion of aquaculture."

Programs related to aquaculture are included in autherizations responsibilities or interests of about 20 federal agencies - notably the Fish and Wildlife Service (FWS) and National Marine Fisheries Service (NMFS) of the Departments of Interior and Commerce, respectively and several agencies of the Department of Agriculture.

Current Involvement:

The current USDA involvement includes: The Cooperative State Research Service's financial support of research on freshwater aquaculture at the State Agricultural Experiment Stations of Land-Grant Colleges. This involves 48 research projects having a total scientific manpower input of about 20 scientist-years. The combined total effort on all aquaculture projects at these state institutions was about 50 scientist-years in 1975.

The Extension Service, as the educational arm of the Department of Agriculture, is charged under the Smith-Lever Act "to aid in the diffusing among the people of the United States useful and practical information on subjects relating to agriculture and home economics, and to encourage the application of the same."

Thus, using research information provided by the state experiment stations and other research agencies, Cooperative Extension has been actively engaged in fish pond management in 26 states; and added programs on marine resource education, the commercial fish industry and the Sea Grant Program.

The Agricultural Research Service does not currently conduct research directly related to aquaculture.

In field offices in nearly all counties in the United States, the Soil Conservation Service is able to work directly with land owners and operators whose desires and farm resources indicate a satisfactory opportunity for some aspects of aquaculture.

The Soil Conservation Service assists the would-be aquaculturist to assess the potential of his resources for growing and marketing his product and to match his resources with the right kind of enterprise. Assistance is primarily with freshwater fish farming.

Assessment of resources includes: (1) water quality (field testing), (2) water quantity, (3) general soils information, (4) market potential (general), (5) human resources, and (6) financial resources.

The small percentage of survivors of this initial resource appraisal (estimated to be less than five percent) then are given detailed assistance in developing a resource conservation plant considering: (1) water quality (monitoring and laboratory), (2) water quantity (monitoring and measuring), (3) cost-return analysis (break-even point), (4) fish habitat management, (5) specific soils information, (6) site limitations (physical), and (7) design and layout.

Where FmHA financing is involved, the SCS may be requested to inspect construction as it proceeds.

SCS technicians usually do not aid in day-to-day management of the operating facilities. They do occasionally assess specific problems that may develop such as oxygen deficiencies and bank erosion and provide fish farmers new research results and results of experience gained by others. The matter of diagnosis and treatment of diseases is specifically against SCS policy. The cooperator is referred to other agencies or private consultants for assistance with thos problems.

Future Outlook:

The Food and Agricultural Act of 1977, signed into law in September by President Carter, cites aquaculture as a basic function of the Department of Agriculture, it underscores the Secretary's authority to conduct aquaculture research and extension and make loans to fish farmers and authorizes the Secretary to cooperate with federal, state and other public agencies and non-profit organizations in developing plans for the conservation and utilization of water for aquaculture purposes.

The bill did not assign exclusive federal responsibility for aquaculture to the USDA, but it did legislate cooperation and coordination. It provides for a federal subcommittee, chaired by the USDA, with representatives of all federal departments and agencies that would be directly concerned with aquaculture - these are Department of Interior, NOAA, Tennessee Valley Administration, EPA, and Energy Resources and Development Administration.

Other legislation which will pass soon includes: The Aquaculture Policy Act of 1977 was introduced in the U.S. Senate October 19, 1977, by Senator Richard Stone (D-Florida) to promote the development of aquaculture.

Among other things, the measure, Senate Bill 2218, would:

Make the Department of Agriculture the lead agency for aquaculture.

Direct the Secretary of Agriculture to conduct an aquaculture assessment.

Direct the Secretary of Agriculture to provide fish farmers with advisory, educational, marketing and technical assistance and to maintain an aquaculture information system.

Establish a grant program and authorize the Secretary of Agriculture to enter into contracts with educational institutions and other qualified organizations or individuals for purposes of aquaculture research and development.

Amend the Federal Crop Insurance Act to permit the Secretary of Agriculture to underwrite crop insurance policies on aquaculture operations.

WASTE HEAT AQUACULTURE*

for Presentation at the Northwest Aquaculture Conference
Olympia, Washington - December 6-8, 1977

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Introduction

In today's world of energy and food shortages, the best and wisest use must be made of those resources available to us. The generation of electricity in thermal plants releases considerable waste heat into the environment. In fact, with today's technology, more than half of all the heat generated by fuel burned to produce power, whether nuclear, fossil, or whatever, is rejected. With the growing realization that the earth's energy sources are finite and exhaustible, there is increasing interest in using this waste heat rather than disposing of it in ever more costly ways. Existing technology is capable of recovering some of this energy, and using it in a variety of applications. Possible uses range from moderate management of thermal discharges to complete engineering control for industrial use or building heat. Recently, there has been attention paid to increasing food production in temperate climates. In certain areas, experimental greenhouses are making use of waste heat. One of the most often discussed uses is in aqauculture where near-optimum temperatures for growth for the cultured species can greatly increase protein output.

Thermally enhanced aquaculture can be beneficial in several ways. It can be used to increase growth rates over nature, as in an accelerated smoltification program for salmon. Or, it can be used to rear animals in areas that would otherwise be too cold for their survival and growth, as in the case of the giant freshwater prawn, Macrobrachium. It may also be used to extend an otherwise short growing season, as in the case of catfish. All this is not without its problems, however. Any utility company will tell you that its primary product is electricity, not fish, and consequently any aquaculture operation at a powerplant must operate on a strictly non-interfering basis. This means that periodic sudden changes in effluent temperatures due to changing loads or shutdowns are to be expected, as well as the presence of cleaning and anti-sliming chemicals in the cooling water. In addition, the legality of rearing animals for human consumption directly in the condenser cooling water of a nuclear plant is largely untested.

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In this paper, I intend first to present an overview of present-day attempts at waste heat aquaculture, and second, to describe an aquaculture facility as part of an entire waste-heat utilization system being contemplated at the Vermont Yankee Nuclear Power Station at Vernon, Vermont.

Review of Existing Facilities

Several waste-heat aquaculture projects are presently being carried out in various areas of the country.

The Texas Agriculture Extension Service and the National Marine Fisheries Service have been cooperating on an experimental rearing program for peneaid shrimp near Corpus Cristi, Texas. They have been using heated water from the Barney M. Davis Generating Station in ponds to overwinter the shrimp.

Personnel at the San Diego State University, supported by funds from Sea Grant and the State of California, have been rearing the American lobster, Homarus americanus, in two experimental units at the Redondo Beach Generating Station and the Encina Power Plant in Southern California. They have determined that uptake of heavy metals from power plant effluents is not a problem in the lobster.

The Tennessee Valley Authority (TVA) has been experimenting with the feasibility of rearing catfish in the warm-water effluent of the Gallatin Steam Plant in Tennessee.

Long Island Oyster Farms is producing seed of the American Oyster, Crassostrea Virginica, in warmed water effluent of the Long Island Lighting Company's plant at Northport, New York. They report a doubling of maturation rate and a considerable drop in mortality.

Public Service Electric and Gas Company of New Jersey has been experimenting with diseasonal aquaculture in their Mercer Generating Station at Trenton, New Jersey. They have successfully reared rainbow trout in the winter and the giant freshwater prawn, Macrobrachium rosenbergii, in the summer. They are presently starting a pilot production plant.

Maine Salmon Farms, Inc. in Wiscasset, Maine, has been pen-rearing coho salmon in the effluent stream of Central Maine Power Company's Mason Generating Station. They report that the warm water permits growth throughout the winter.

Clearly, this concept is becoming a reality.

The Proposed Vermont Yankee Facility

It is all very well to say that warm water grows fish faster. But what sort of magnitudes are involved? A quick look at some numbers will show why large power plants are ideal candidates for waste-heat recovery, for the heat demand of a commercial scale fish rearing facility in a northern climate is truly staggering. I will use as an example a commercial rainbow trout rearing facility that Kramer, Chin & Mayo designed to utilize power-plant cooling water in the Northeastern United States. A year-round growing temperature of 60°F was desirable, and the production goal was 100,000 pounds of market-sized fish per year. On a single-pass system, a maximum heat demand of over 60 million BTU/hr. would be needed. This exceeded the entire output of a refuse-derived fuel boiler planned for the site. Clearly, this sort of energy demand cannot be purchased, and still market fish at a realistic price.

Now, perhaps, power generation waste heat can be viewed in its proper perspective, as a resource. The Vermont Yankee Nuclear Power Station, for example, is a nominal 500 megawatt steam-turbine electrical generating plant. At full power operations, it produces some three billion BTU/hr that are presently discarded to the Connecticut River from the main condenser system, at a flow of about 370 thousand gallons per minute. The temperature of this water varies from about 72°F in winter months to as much as 110°F in the summer.

In a project supported by the USEPA and ERDA (now the Department of Energy), the Vermont Yankee Nuclear Power Corporation of Rutland, Vermont, began to look at a comprehensive waste heat recovery system. Early in 1977 a meeting was held at the plant site in Vernon, Vermont among the principal contractors who would participate in the design of the system. These included representatives of Cornell and Dartmouth Universities, the University of Vermont, Marine Environmental Services, the Vermont Yankee Nuclear Corporation, and Kramer, Chin and Mayo, Inc. Two major components of this system were designed, both using waste heat rejected by the power plant: horticulture and aquaculture. The horticulture facility will consist of four greenhouses producing year-round cash crops. Three of the greenhouses will be heated by plant effluent, and the fourth is to be heated by methane gas produced in a bio-gas generator. This generator will use cow manure from an adjacent dairy farm, and will depend on warm water to attain an estimated 70% level of efficiency.

As originally envisioned, the aquaculture component will consist of a commercial brook-trout rearing operation producing approximately 100,000 pounds of market-sized fish per year, at a rearing temperature of 55°F during the winter, and a test-rearing facility for the Atlantic salmon. The salmon facility is designed to produce approximately 25,000 smolts each spring from 0-year fry stocked in the previous fall, at a rearing temperature of 60°F throughout the winter.

A support system of heat exchangers, pumps and boilers supplies the various components with water at the necessary flows and temperatures.

THESE SLIDES SHOW THE GENERAL LAYOUT OF THE TEST REARING FACILITY AND THE VARIOUS COMPONENTS OF THE WATER SUPPLY SYSTEM.

The design of the Atlantic salmon test rearing facility illustrates the problems encountered when trying to adapt a fish rearing operation to the functioning of a nuclear power plant.

The primary objective of the fish rearing program is to stock out 25,000 Atlantic salmon smolts each spring. In order to accomplish this, approximately 31,000 underyearling fingerlings will have to be stocked into the facility each fall, assuming a 20% mortality. Temperatures will be maintained as close as possible to 60°F during the rearing period, as Saunders and Henderson (1969) have reported this to be the most favorable temperature for growth of pre-smolts. In addition, photoperiod control will be used, as Knutsson and Grav (1976) have demonstrated that constantly increasing day length over the rearing period enhances survival. Atlantic salmon need rearing space, not rearing volume, or they become aggressive and disease results. They also need relatively swift-flowing water. Circular tanks were therefore specified as rearing units.

There are two obvious problems with using plant discharge water to rear fish: temperature fluctuations and chemicals added to the cooling water. Nuclear plants are subject to "SCRAMS," which are sudden unplanned shutdowns due to mechanical or other problems. These are rarely of long duration, but are sufficient to cause a drop from 70°F to near-ambient river temperature within an hour. In the winter this will be about 33°F.

The plant also adds certain chemicals for slime control to its cooling water stream. Among these are sodium hypochlorite, sulfuric acid, and a demineralizer regenerant. Although there are no planned releases of radioactive substances into the cooling water stream, the possibility of an accidental release, however slight, does exist.

In order to avoid these difficulties as far as possible, the use of a heat exchanger was specified. The rearing water would then come from the Connecticut River, upstream from the plant, and be warmed indirectly by the discharge water. In order to minimize the effects of temperature fluctuations, an oil-fired back-up boiler will be used in conjunction with the heat exchanger.

A limited number of fish will be held in pure discharge water as an experiment. If it is technically feasible to rear fish directly in discharge water, and any legal difficulties can be overcome, then an expanded scale facility could be built and operated at a considerable savings without the use of a heat exchanger.

These problems will be common to almost any power-plant aquaculture operation, and it is interesting to note how some of the existing projects have dealt with them. The Public Service Gas and Electric facility at Trenton, New Jersey, has installed a link between the plant chlorinator and the fish-rearing pumps, so that the pumps are shut down any time that a slug of chlorine is passing through the system. This, however, requires recirculation and/or aeration, and a fail-safe system. The Maine Salmon Farm operation simply raises their fish in pens in the effluent stream in a bay, depending on dilution to avoid toxicity problems. A single-unit nuclear plant, such as Vermont Yankee, is particularly susceptible to sudden temperature changes, as when the reactor shuts down, all of the heat source is lost.

In order to gain some idea of the legal implications of rearing fish directly in the effluent of a nuclear power station, the Vermont Yankee Nuclear Corporation obtained an opinion from their attornies, the firm of Ropes and Gray in Boston. This states, in part, "Since the use of nuclear power plant waste heat for aquaculture and horticulture is very recent, there is little law which directly establishes standards applicable to the Vermont Yankee Waste Heat Project. The requirements affecting the project are chiefly case-by-case permit requirements of the EPA and the Nuclear Regulatory Commission."

"The precise application of the Food, Drug and Cosmetic Act depends largely upon whether heat exchanger systems are used, and if they are not, upon the probability that the circulating water will contain potentially unhealthy substances. If heat exchangers are used, as is generally contemplated, the FDCA will not apply unless food accidentally becomes contaminated with poisonous or deleterious substances. If heat exchangers are not used, the Delaney Clause setting zero tolerance levels for carcinogens will still not

be implicated to the extent that contamination is not to be expected, despite the fact that Vernon is a nuclear station; but a regulation may be required for certain chemicals or pipe residues contained in the cooling water. The FDCA also is implicated if particular food produced at the project becomes contaminated so as to present a health hazard."

Future Applications

Does the concept of waste-heat aquaculture have any future promise for the Northwest? I certainly think so, and in fact, a costly mistake might be made by not thinking along these lines now. Salmonid aquaculture, whether for resource enhancement or commercial enterprise, thrives here in the Northwest. While we have neither the extreme winter or summer temperatures of the Northeast, there is little question that thermally enhanced fish growth programs could be a real advantage in this region. There are presently two nuclear power plants on the drawing boards for Western Washington, on the Skagit and at Satsop. The cost of making provision for an aquaculture facility in the original design of a power plant is far less than the cost of adding it on at a later date. Provisions for thermal backup and addition of anti-slime agents can be tailored to the requirements of a downstream fish-rearing facility without compromise to the electrical generation capacity of the plant.

Vermont Yankee Nuclear Power Corporation is presently in the process of applying for funds to build the salmon test-rearing facility, as well as the greenhouses. Hopefully, this will provide incentive for aquaculturists and the power industry alike to utilize this tremendous, wasted resource.

THE IMPACTS OF LOGGING ON SALMONID RESOURCES IN THE PACIFIC NORTHWEST

C. J. Cederholm

I am here representing the University of Washington, Fisheries Research Institute, and we appreciate the opportunity to present our views of logging practices in the Pacific Northwest. We are presently involved with studies of the effects of logging on the Clearwater River and Bear Creek on the Olympic Peninsula Coast of Washington.

Pacific Northwest streams contain a complex variety of watershed characteristics which have resulted in a highly variable complement of abundant natural salmonid populations. From the dry interior to the wet coastal belt salmon and trout have provided multi-million dollar commercial and sport fishing industries for nearly a century. Even with the advent of artificial propagation and hatchery technology our natural populations have contributed a major portion of the fishery catch. In recent years, however, these once abundant natural populations have been showing a general decline in some areas largely due to overharvest and gradual but continuing loss of freshwater habitat from assorted land use practices which includes logging

The sheer magnitude of commercial timber land acreage and miles of logging roads in the Pacific Northwest illustrates the serious potential for watershed degradation. In 1975 there was a total of over 65 million acres of commercial timber land and over 250 thousand miles of logging roads in Idaho, Alaska, Oregon, British Columbia and Washington (E.P.A., 1975).

Qualitatively, logging and its associated disturbances appear to cause unquestionable damage to the fisheries resources; however, quantitative research directed toward documenting these apparent impacts under natural conditions have met with surprisingly few definitive results (Gibbons and Salo, 1973; Myren, 1976). Often logging effects are masked by variable harvest in the commercial and sport fisheries, other man-related disturbances, and natural climatic fluctuations. Uncontrolled natural variability in the environment which affects the survival and size of populations of salmon and trout often compounds the problems of quantitatively evaluating the intensity of logging effects (Myren, 1976). Also, logging effects can be subtle and thus difficult to detect in short-term studies using the sampling tools available to the fishery biologist today.

Since the 1950's, a number of agencies throughout the Northwest have become increasingly involved with research into the negative effects of logging practices on fish and their freshwater habitats. The published literature is extensive and can generally be found in the following works: Cordone and Kelley, 1961; Gibbons and Salo, 1973; Meehan, 1974; Moring and Lantz, 1975; Myren, 1976, E.P.A., 1975, 1976, 1977; Schaumberg, 1973.

THE IMPACTS OF LOGGING ON SALMONID RESOURCES IN THE PACIFIC NORTHWEST

Abstract

C. J. Cederholm

Northwest streams contain a complex variety of physical characteristics which have resulted in a highly variable complement of natural salmonid populations. These once abundant salmonid resources are showing a general decline largely due to overharvest and a gradual but continuing loss of freshwater habitat from assorted land use practices which includes logging.

To the casual observer, logging and its associated disturbances must cause unquestionable damage to the fisheries resources; however, quantitative research directed toward documenting these apparent impacts under natural conditions have met with surprisingly few definitive results. Often logging effects are masked by natural climatic fluctuations, overharvest in the commercial and sport fisheries, and other man-related disturbances. Also, logging impacts can be subtle and thus difficult to detect in short-term studies using the sampling tools available to the fishery biologist today.

Since the 1950's, a number of agencies throughout the Northwest have become increasingly involved with research into the negative effects of logging practices on fish and their habitats. Literature is extensive in Idaho, Alaska, Oregon, British Columbia, and Washington. Surprisingly few studies have looked at the possible beneficial effects of controlled logging, although some noted authors have mentioned this possibility. There seems to be a recent change in attitude favoring prevention through "Best Management Practices" rather than rehabilitation after non-compliance with questionable standards.

Some logging practices have been found to cause degradation to the watersheds and result in impacts to salmonid resources. For convenience, logging activities with potential to impact fisheries resources can be divided into four categories: 1) road construction and maintenance; 2) canopy and residue removal; 3) addition of chemicals including herbicides and fertilizers; and 4) log storage and transportation.

Federal and State laws that have been adopted to control logging practices and their effects on salmonid resources are briefly covered and some thoughts concerning future research needs are discussed.

Several logging and associated practices have been found to be related to degradation of watersheds and apparent negative impacts on fisheries resources. For convenience, these practices can be divided into four categories:

A. Logging road construction and maintenance

1. Siltation of the spawning and rearing substrates with sand-sized and smaller particles can:

   a. decrease intragravel survival of salmonid eggs and embryos and reduce their post-emergent fitness (Coble, 1961; Hall and Lantz, 1969; Koski, 1975; Tagart, 1976).

   b. reduce the number of aquatic fish-food organisms (Cordone and Kelley, 1961; Gebhardt, 1970; Nuttle and Bielby, 1973).

   c. fill intragravel spaces used by fry and other aquatic organisms as hiding cover during the summer and winter months (Chapman and Bjornn, 1969; Phillips, 1970; Bustard and Narver, 1975; Murphy, 1977).

2. Suspended sediment (turbidity) at very high levels has been found to:

   a. cause physical abrasion to the respiratory structures of fish and aquatic insects (Koski, 1972; Usinger, 1971).

   b. affect the feeding behavior of coho salmon smolts (Noggle, 1977).

   c. reduce the photosynthetic processes of aquatic algae by inhibiting light penetration to the stream bed (Tarzwell and Gaufin, 1953).

3. Also related to road construction at stream crossings are serious juvenile and adult migration blockages (Evans and Johnston, 1972).

4. Cause sluiceouts and landslides to occur in small steep headwater streams due to alterations in natural drainage patterns. (Cederholm and Lestelle, 1974; Swanston and Swanson, 1976).

B. Forest canopy and residue removal

1. Logging of large openings in watersheds has been found to:

   a. increase streamflows and in some cases cause a more rapid attainment of peak flows during fall freshets (Kittredge, 1948; Rothacher, 1970; Moring and Lantz, 1975). These increased flows can cause additional streambed scour which can result in the loss of salmon eggs and larvae (Gangmark and Bakkala, 1960).

b. cause daily mean and maximum summer temperatures to reach the upper lethal limits (Brown and Krygier, 1967; Hall and Lantz, 1969).

c. cause winter temperatures to be further depressed to near threshold limits (Chapman, 1962; Lantz, 1970).

2. Logging across and through streams can cause:

a. large amounts of fine organic material to enter the stream; and this debris can have a high biological demand for dissolved oxygen that would otherwise be available to fish (Hall and Lantz, 1969; Servizi, et al., 1970; Froelich, 1973).

b. the entry of large organic debris into streams which can cause erosion of embankments, logjams that block adult and juvenile migration and cover spawning and rearing areas (Narver, 1970).

c. physical damage to the stream bed and embankments during log yarding which results in additional sedimentation and unwanted stream alterations.

C. Application of chemicals

The use of chemical fertilizers, herbicides, and pesticides is a common practice in the Pacific Northwest. Fertilizers are used to supplement soil nutrient deficiencies to increase conifer production; herbicides to suppress undesirable "weed" species that compete with conifers; and insecticides to control pest problems in commercial timber stands. Brown, et al. (1977) points out that under proper use, there are no known instances of significant damage to aquatic ecosystems from the application of presently registered herbicides and fertilizers now used in silviculture. Mason and Narver (1975) state, however, that herbicides used in alder suppression along streams may substantially affect litter, terrestrial food to fish, nitrogen and bank stabilization provided by vegetation. Thut and Haydu (1970) have stated that field studies conducted to date indicate that the concentrations of urea fertilizer and its breakdown products are well below toxic levels for aquatic life. An increase in the rate of eutropication of some lakes remains a possibility. Studies of forest fertilization and its impact on water quality have been carried out by the U. S. Forest Service (Moore, 1974) in streams throughout western Washington and Oregon in a wide range of soils, climate, and vegetative species. It was found that both the amount of applied nitrogen entering streams and the maximum concentrations measured can be kept at minimum levels by ensuring that adequate buffer strips are left along main streams and larger tributaries. In addition, fertilizer should not be applied to forested watersheds during periods of spring snowmelt or heavy storm activity. The insecticides, particularly chlorinated hydrocarbons, are more toxic than most herbicides to aquatic life. There

have been instances where insecticides applied to forests, particularly the defunct DDT, were directly toxic to stream life; such has not been demonstrated with herbicides applied to forests. These statements are generally supported by a recent survey of the literature by the E.P.A., 1977. We feel this is an area that needs additional research.

D. Log Storage and transportation

Schaumberg (1973) investigated the environmental impact of log handling on freshwater in Oregon. He concluded that:

1. significant quantities of bark are dislodged during log dumping and rafting activities.

2. bark deposits exert a small, but measurable, chemical and biological demand for oxygen from overlaying waters.

3. organic compounds leach from logs when stored in water.

4. log "leachates" exert a chemical and biological oxygen demand.

5. log leachates add color producing substances to the water; and

6. Douglas fir leachates are acutely toxic to rainbow trout and chinook salmon fry in freshwater.

Pease (1973) studied log rafting and dumping in the marine environment of South East Alaska and found that all wood leachates (red cedar, yellow cedar, hemlock, and spruce) were more toxic to pink salmon in freshwater than in 20 ppt seawater. Spruce was the most toxic wood species in freshwater and yellow cedar the most toxic wood species in 20 ppt seawater.

Studies by the International Pacific Salmon Fisheries Commission of log driving in the Stellako River of British Columbia in 1965 found that log jams caused damage to approximately eight percent of the sockeye spawning grounds by erosion of gravel and bark deposition. It was later observed that subsequent spawning populations avoided the damaged areas. Laboratory results indicated that moderate gravel disturbance due to erosion and gouging by individual logs could also have killed incubating trout eggs.

Around the turn of the century until about 1925 "splash dams" were used extensively in Washington for moving logs down river to the mills at tidewater (Wendler and Deschamps, 1955). These log crib dams were often 50 feet high and often blocked salmon and trout migration. Some of the dams were equipped with ladders; but they were essentially ineffective during winter migration periods. The Chehalis River and its tributaries alone had over 55 dams which were later determined to block over sixty percent of the river's spawning and rearing areas.

Surprisingly few studies have investigated the possible beneficial effects of controlled logging, although some noted authors have mentioned this possibility. As early as 1962, Chapman referred to the possible benefits salmonids might derive through increasing summer streamflows and spring and summer water temperatures through controlled logging. Sharpe (1975) mentioned that increased illumination

of headwater streams may increase primary production which would have benefits throughout the food chain; also that openings within the riparian zone would encourage the production of terrestrial insects which would supplement the diet of trout. He also said that altering the species composition of stream-side vegetation might increase nutrient concentrations by means of throughfall from certain vegetative species. Mason and Narver (1975) point out however that deforestation and removal of stream-side vegetation exposes the stream to greatly increased insolation that can result in marked increases in water temperature and in algae growth. Such results can affect, either negatively or positively, the production of stream salmonids.

Due to past research and a growing public awareness for protection of our natural streams, there seems to be a recent change in the attitudes of foresters and loggers favoring prevention through "Best Management Practices" rather than rehabilitation after non-compliance with questionable standards. This improved attitude, however, requires frequent encouragement, particularly during fluctuations in market demand. This public awareness is evidenced in the passage of the 1972 Federal Water Pollution Control Act Amendments. The Act set a broad water quality goal of swimmable, fishable waters, wherever attainable, by 1983. To achieve this objective, new Federal/State programs were established to "prevent, reduce, and ultimately eliminate water pollution." The E.P.A. was given the authority to implement the Act, but the primary responsibility for water pollution control was reserved for the individual states (Waterline, 1977).

The 1972 law recognizes two sources of water pollution--point and non-point. Point sources are "end-of-the-pipe" discharges such as those from pulp and paper mill effluent; non-point sources, however, have no easily identifiable discharge point (i.e., clearcut area). These latter sources of pollution generally cannot be collected and treated, and can only be reduced by greater care in management of the water and land resources (Waterline, 1977).

In meeting the obligation to control the non-point sources, the states of Oregon (in 1971), Washington (in 1974), and Idaho (in 1976) have developed State Forest Practices Acts. Alaska has not developed an Act as such but has been working toward a set of "Best Management Practices" similar to the other three states.

These State Forest Practices Laws apply to approximately 26 million acres of State and Private forest lands; and have generally been supported by the forest industry. Companies such as Weyerhauser, I.T.T. Rayonier, and Crown Zellerbach have published in-house Forest Management Practices Handbooks in which they pledge to manage their private forest lands in an "environmentally sound manner." The United States Forest Service and Bureau of Land Management who administer federal forest lands have formal agreements with the states which say they will meet or exceed state water quality standards.

In 1972, the British Columbia Forest Service adopted a set of Coast Logging Guidelines which, in part, have emphasized stream protection practices (Mason and Narver, 1975).

It is a pleasure to report that the Forest Practices Acts in Oregon and Washington are alive and working; however, it is too early to report on the efforts being made in Idaho, Alaska, and British Columbia. The Oregon Department of Forestry and the Washington Department of Natural Resources were given the on-the-ground responsibility for enforcing and administering the Acts. Each forestry organization is working closely with their respective state fish and wildlife departments to develop a workable relationship. It is the general opinion of those people working closely with the Acts in Oregon (Lantz, 1976; Bakke, 1977; Brown, et al., 1977) and Washington [Deschamps (W.S.D.F.) and Ward (W.S.D.G.) personal communications, Mikesell, 1977] that we have come a long way with these acts but there are of course still some basic improvements needed.

The rules and regulations of each state contain numerous words that are subject to personal interpretation (i.e., significant, where practical, minimize, etc.) however, the Acts do require compliance with State water quality standards as administered by Oregon's Department of Environmental Quality and Washington's Department of Ecology.

There is a basic need for additional manpower to handle forest practices compliance in both states. In 1976 Oregon had over 7500 forest practices notifications and Washington had over 8800. In Oregon only 50% of the sites were visited for compliance while each site was visited an average of 1.6 times in Washington.

Some basic differences between the Oregon and Washington Forest Practice Acts:

1. Oregon has two classes of waters, Washington has five.

2. Oregon constructs bridges and culverts to the 25-year flood, Washington constructs to the 50-year flood.

3. Oregon's water classification scheme is not defined, and the stream classification is done completely by the Fish and Game Department.

4. Oregon does not have a temperature-sensitive criteria system, while Washington does.

Some Forest practices being used in Washington and Oregon that have helped to reduce the impacts of logging on salmonid habitat are: 1) skyline logging systems such as helicopter and balloon logging to decrease road millage and soil disturbance; 2) old growth buffer strips and "streamside management zones" to reduce exposure of streams to summer and winter temperature extremes and minimize

streambank damage from logging; 3) tree jacking and tree pulling of trees away from the stream when operating in the riparian zone; 4) improved road locationing during road construction; 5) end hauling of waste material rather than sidecast during road construction; 6) use of crushed rock and asphalt paving to reduce sediment contribution from road surfaces; 7) use of bridges and arch culverts to assure juvenile and adult migration and avoid streambed disturbance; and 8) grass seeding of exposed road cuts to reduce erosion.

There exists a need for research into the effects of logging on fisheries resources. Attempts should be made however to combine laboratory studies with studies out in the natural environment. This will allow one to isolate specific variables in the laboratory, and provide the opportunity to observe them in the natural environment. We stress the importance of working in the natural streams because one must be careful never to lose contact with the real world. Studies are presently being carried out in various parts of the Pacific Northwest to further define the negative and positive impacts of logging on fisheries resources. The National Marine Fisheries Service is proposing a long-term before and after study on logging effects in Alaska (Koski speaking for Rietze, 1976). The Comprehensive Carnation Creek Experimental Watershed Project on Vancouver Island, British Columbia (Narver, 1974). The Clearwater River and Bear Creek studies on the Olympic Peninsula coast of Washington (Cederholm and Lestelle, 1974, Martin, et al., 1977). Student degree studies are also being carried out at Oregon State University under Dr. Jim Hall, and at the University of Idaho under Dr. Ted Bjornn.

In conclusion, forest practices in the past have had a definite impact on our natural salmonid populations. These impacts have been difficult to quantify due to variable commercial harvest, other man-related disturbances, and natural climatic fluctuations. However, since the relatively new forest practices acts there seems to be a change in the attitude of the forest industry which is stressing "Best Management Practices" rather than non-compliance with questionable standards. We still must keep an eye on forest industry; but practices are definitely improving.

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THE USE OF PLASTIC BIO-FILTERS IN HEATH TECNA INCUBATORS AS AN ARTIFICIAL INCUBATION SUBSTRATE FOR CHUM SALMON ALEVINS

by

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Introduction

Heath Tecna incubators are being used on the West Coast of North America for the incubation of chum salmon. Previous studies have identified rugose substrates during alevin development to be a important factor in the incubation of salmonids in hatcheries (Brannon, 1965; Bams, 1967 and 1969; Bailey and Heard, 1973; and McNeil, 1973). In an effort to locate a suitable substrate for Heath incubators trays an artificial substrate (i.e. Astroturf) was tested during the 1974-75 season at the Big Beef Creek research hatchery and proved unacceptable for use under production conditions (Snyder and Schroder, 1977). Subsequently, in 1976 plastic bio-filters[1] were selected as a possible substrate. Actifil media or bio-filters are used for BOD reduction, nitrification and de-nitrification in water-reuse systems and consist of two shapes; Bio-saddles and Bio-rings. Bio-rings were chosen as they provide the maximum voids and resting space for fry to maintain an upright position while supporting maximum fry densities without inter-alevin chain reactions.

Methods

Production Heath incubation experiments were conducted during 1975-76 at two hatcheries to determine the feasibility of using plastic Bio-rings in Heath incubators for improving the quality (size) of chum salmon fry at ponding. Four artificial incubation substrates (i.e. 1½ inch Bio-rings, FH-06 astroturf, stream gravel, and unaltered screens) in Heath incubator trays were tested at production levels of 8,000 eggs/tray (36.4 egg/in^2) using water with and without sediments, at the Washington Department of Fisheries Hood Canal hatchery and Big Beef Creek research hatchery, respectively. Chum salmon eyed eggs were obtained from the peak of the run of the 1975 brood at the Hood Canal hatchery and incubated at each hatchery in Heath incubators until buttoned with 5 to 6 gpm (19-22 l/min) of water at a minimal cross-sectional linear velocity of 875 cm/hr. The Hood Canal hatchery used creek water, with sediment, ranging from 6.11 to 9.99 C while the Big Beef Creek hatchery used artesian well water without sediment, ranging

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[1]Bio-filters manufactured by Norton Chemical Process Products, P.O. Box 350, Akron, Ohio 44309 - (216) 633-3224

from 9.3 to 9.9 C. Alevin development was monitored at each hatchery at 75 Temperature Units C (TU's) intervals from 675 TU's C to the completion of the incubation period.

Results

At the completion of the incubation period, 120 days (1025 TU's C) at Hoodsport and 113 days (1033 TU's C) at Big Beef Creek, differences existed in the substrates fry sizes with the fry from the screen substrates being inferior. The differences in fry incubated on 1½ inch Bio-rings and unaltered screen substrates were .1 g/fry and 4.9 mm/fry average wet weight and length, respectively, at both hatchery sites. Bio-rings substrates for both hatcheries produced fry of lower K_D values ranging from 1.84 to 1.89 whereas screen substrates ranged from 1.90 to 1.92 indicating a less developed fry. Comparing the conversion of yolk materials to larval tissue, the screen substrate were 16.4% and 18.6% less efficient at Big Beef Creek and the Hood Canal hatchery, respectively, than fry incubated on 1½ inch Bio-rings. Analysis of variance tests between Bio-rings and screen substrates revealed the unaltered screen substrate fry to be significantly different at the $P < .005$ level for both hatcheries.

At the Hood Canal hatchery at ponding the average size of chum salmon fry incubated on a screen substrate were .27 g/fry (1677 fish/lb) while fry from 1½ Bio-rings were .37 g/fry (1225 fish/lb) a difference of 453 fish/lb between groups, which would require a 3-week rearing period to reach the initial ponding size of fry from the 1½ Bio-ring substrates. (personal communication R. Schwab, Hood Canal Hatchery supervisor)

In conclusion, plastic, 1½ inch Bio-rings provided a suitable substrate and significantly improved chum salmon fry quality in Heath Tecna incubator trays at production hatchery levels in waters with sediment or without sediment. Costs for using 1½ inch Bio-rings in Heath trays are $1.63/tray with a nominal amount of time required to "scatter" one-layer of rings in the trays prior to hatching and separating (seining) the rings and fry at ponding.

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T R E A T - T H I N K - A N D B E W A R Y,
F O R T O M O R R O W T H E Y M A Y D I E

Presented by George W. (Bill) Klontz
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FOR SOME very strange reason it is easy to minimize the villain's role, played by disease-producing organisms, in the theater of modern fish culture. Much concern is felt over the food bills footed each month by the hatcheries, but very little is thought about the dead fish which are picked from the hatchery troughs during the same period.

Perhaps for our general peace of mind it is just as well that we do not know all that we might about the cost of dead hatchery fish, but from the little we do know, it appears that every time the hatcheryman hands a one-dollar bill to the food man out the front door, the Grim Reaper makes out the back door with fish worth a dollar and a half. Add up the combined hatchery food bills in the United States and you will reach an impressive sum. Add up the annual bills for dead fish and you will undoubtedly reach the conclusion that it is high time we stopped pussyfooting about diseases and took a little more interest in them.

The food bill is plenty high but it is comforting to see the food cost per-pound-of-fish-produced slowly coming down in response to the uncreasing attacks upon the problem through patient research and the immediate application of laboratory findings in the hatcheries. Can the same be said for the rising costs of dead fish? In answer to that question, I shall merely quote Dr. W. Rushton, eminent English biologist and ichthyologist, who, in reminiscence of his visit to the United States in 1936, wrote: "The work on nutrition being carried out at some of the hatcheries and the selective breeding and rearing was exceptionally fine and pleased me beyond measure, but the amount of work being carried out on disease and the conditions causing it was not developed to the extent one expected..."

There are two reasons why our bill for dead fish is so high. In the first place, for years losses among hatchery fish were not considered of sufficient importance to warrant consideration or investigation. Unlike the food bill which is stated in dollars and cents, the dead fish bill is stated, primarily, in terms of wasted effort and wasted resources which must be translated into monetary figures. This translation is seldom attempted, thanks to a peculiar psychology concerning losses which developed during the adolescence of fish culture. In its infancy, artificial propagation was sold to the general public on the premise that "an egg in the hatchery is an egg saved". This wish eventually became father to the thought and it was carried along through dubious accounting methods justified by the fervent hope that the hatcheries, losses or no losses, were still more efficient than Nature. As long as this attitude prevailed, there seemed little point in devoting attention to such an abstract subject as diseases and their effect upon hatchery production.

The second reason for the high dead fish bill is that, although the importance of hatchery losses is now being recognized, still too few hatcherymen find the time or inclination to apply the little knowledge we now possess to their own problems. Most fish culturists will do everything in their power to check an epidemic once it develops in their hatchery, but few connect such trouble with some possibly preventable occurrence which took place several weeks before the epidemic appeared.

As this article is intended to be informative and not a wailing stone, there seems little point in dwelling further on the first reason for the high price we pay for dead fish as that condition is slowly curing itself. The second point, however, will bear considerable expansion.

The hatchery disease problem falls, essentially, into two categories: Disease prevention and disease control. Of these disease prevention is of greater importance at the moment for it is herein that knowledge has far outstripped its application. These two categories are best discussed separately although they are in no small way interrelated.

I. DISEASE PREVENTION

Water supply and equipment.

The prevention of disease starts with the location and equipment of the new hatchery. No hatchery should be dependent upon an unfiltered water supply, although unfortunately, Nature's great source of filtered water, the spring, is not always available and some compromise must be made. However, it must be remembered that compromises in fish culture invariably lead to lowered efficiency. Regardless of the source, the water for a hatchery should be chemically and bacteriologically pure, high in dissolved oxygen, and without extreme daily or annual fluctuations in temperature. Needless to say, all wild fish should be removed from the water supply, if a spring is used, before the hatchery is under production for it may be practically impossible to remove them afterwards. As for equipment, not more than two troughs should ever be used in series and, preferably, each trough should be independently supplied and drained. While such an arrangement may reduce the capacity of a hatchery, nevertheless it is far better to start with fewer fish and bring them all through in a healthy condition than to stack in the eggs and take losses from overcrowding. Hatchery capacity should be judged by the number of healthy fish produced and not by the total number of eggs which can be carried in the troughs. Ponds, at least for fingerling fish, should be small enough and suitably designed so that they may be kept absolutely clean at all times. The shallower the pond, the more rapid the replacement and therefore the purer the water. Cleanliness is not next to godliness at a fish hatchery; it supersedes it.

Inter-hatchery exchange.

Once the hatchery is under production, much can be done to avoid disease, the major approaches being to prevent the spread of disease from one hatchery to another and from place to place in the same hatchery. Every hatchery should be an independent unit, raising eggs taken from their own brood stock and thus avoiding all importation of alien stock. While this is true of many of the

hatcheries in the East, it is decidedly the exception in the West. Under such conditions wherein the hatcheries cannot be independent units, it should be, but definitely is not, a hard and fast fish cultural law that under no circumstances should fish ever be transferred from one hatchery to another except as eggs. This law should further provide that all eggs must be sterilized before shipment, carried only on sterilized trays in sterilized cases and cushioned with sterilized moss. Eggs are easily sterilized without injury by immersion in a 1 to 2,000 solution of neutral acriflavine for 25 minutes. Egg trays and moss may be sterilized in boiling water for one minute, never by the use of chemicals. Egg cases may be thoroughly dried, preferably in sunshine, for at least eight hours before use. All of these methods have been known for several years but are seldom applied.

Spread of diseases within the hatchery.

Preventing diseases from spreading within a hatchery consists, essentially, in preventing the spread of water from one trough to another for in so far as is known all disease of fish are water-borne. This may seem quite elementary, but it is amazing how many times in a day water is carried from one trough to another on brushes, food dippers, nets, or even on the attendant's hands. It is done so often that it becomes involuntary which means that it is a very difficult habit to stop. Avoiding the transfer of water, possibly carrying disease-producing organisms, from one trough or pond to another involved keeping the hands dry. When this is impossible, the hands should be thoroughly dried before moving on to the next trough. It involves feeding the fish from above, allowing the food to fall upon the surface of the water rather than washing it off a spoon or through a dipper. Fish should be attended in reverse order to the size, the smallest ones first, and yearling and adult fish should be left alone as much as possible. Last, but of great importance, the habit of sterilizing every brush, net, or other utensil used in the troughs just as soon as it is taken from the trough must be acquired to the point wherein such action becomes second nature.

It is not at all difficult to keep these utensils in a 1 to 100,000 solution of some powerful disinfectant, such as H.T.H.-65, from which they may be taken when needed and to which they are returned. Likewise, whenever fish are removed from a pond or trough, regardless of their past history, that pond or trough should be sterilized before it is again used. Sterilization of a pond or trough is most simple; merely fill it slightly above the normal water level, plug the drain and inflow, and add sufficient H.T.H.-65 to make a 1 to 100,000 solution (one ounce of the powder to every 740 gallons of water to be sterilized). This solution should be left in the trough over night and be thoroughly flushed out the following morning. A four pound can of H.T.H.-65 costs in the neighborhood of a dollar and a half and will make slightly more than 50,000 gallons of a 1 to 100,000 solution.

While the general adoption in the hatcheries of what the bacteriologists call "sterile technique" may appear to be an unnecessary luxury, it is the basic requirement for preventing disease. Sterile technique, an uncontaminated water supply, and the absolute prohibition of alien stock together comprise the basic requirements for an efficient hatchery wherein contagious diseases are unknown. It is quite true that few, if any, hatcheries possess and practice these requirements. However, as food for thought, it is likewise true that fish culture today is the most backward branch of animal husbandry. In the interest of efficiency,

eventually fish culture will be driven to the universal adoption of these fundamentals and the longer their adoption is deferred, the longer disease will continue to be the greatest limiting factor to the success of artificial propagation.

II. DISEASE CONTROL

Difficulties of treatment.

The second part of this story concerns the control of diseases once they have appeared in the hatchery. Suprisingly enough, in spite of the fact that disease control measures have become almost an every day occurrence at most hatcheries, actually very little is known about their exact effect. These control measures, for the most part, consist in various methods for immersing ailing fish in a disinfecting solution following the theory that the solution will kill the troublesome bugs before it will kill the fish. This theory is decidedly open to question and there is little doubt that in many instances the solutions used may or may not have killed the bugs but they certainly did kill the fish. One of the reasons for this unfortunate and very expensive occurrence is the fact that pathologists have been woefully negligent in evaluating treatments before recommending them to the hatcherymen. Pathologists, likewise, have been negligent in warning hatcherymen that treatments are decidedly not such innocuous affairs as the directions given would indicate.

Everyone concerned with the artificial propagation of fish is well acquainted with the familiar directions to "dip all ailing fish in a 1 to 2,000 solution of copper sulphate for approximately two minutes". Such a recommendation should be applied with a prayer for in following these directions, the dip may be of very limited value at a hard-water hatchery where much of the copper (which is the disinfecting ingredient) immediately combines with the carbonates present in the water to form an insoluble, and therefore ineffective compound. Again, if these directions are followed explicitly at a soft-water station, such as are found in the far West, the dip will kill healthy fish, let alone those weakened by disease. Yet in spite of this, all the directions for the use of copper sulphate in dips completely ignore this wide discrepancy in its effect or refer to it in a very vague manner. Obviously, it would be impossible to predetermine the exact effect of copper sulphate under the particular water conditions to be found at every hatchery in the United States. However, it is not impossible to warn fish culturists that any treatment whatever is a physical ordeal for the fish even when applied with the utmost care. The failure to impress this fact upon the hatcherymen has resulted in a universal impression that any form of treatment can do no harm and might do some good regardless of the method of administration. Under the circumstances, this is an unhealthy state of mind and no doubt has sacrificed more fish in the past than treatments have ever saved.

All treatments, with the possible exception of salting, at best represent an exceedingly close race between killing the parasite and killing the fish and the margin between these effects is entirely too narrow to justify the custom of weighing out disinfectants by the handful instead of by the gram and in timing the bath with the physiological stopwatch of knocked-out fish. The man in the hatchery must be aware of all methods of treatment recommended to him although this does not imply that he should merely sit back on his haunches and do nothing

about a new method, or an old one either for that matter. Every method recommended by a reliable laboratory has undoubtedly been found effective under a certain set of conditions and it is up to the hatcheryman to work out the application of this method to conditions found at his own establishment before the need for treatment arises. Working with small experimental lots of healthy fish, he should apply the recommended treatment with the utmost care, varying the concentration of disinfectant and the duration of exposure until he finds the proper dose which can be administered without harm to fish at his own hatchery. Each fish culturist must work out his own salvation at his particular hatchery; the laboratory findings are merely a base from which to deviate in finding an effective, yet non-toxic, application.

Methods of treatment.

Regardless of the concentration of disinfectants used, the technique of application influences the success of any treatment to no small degree. It might, therefore, be advantageous to breifly outline the various methods of treatment in common use and the recommended technique for their application.

Aside from medicines administered with the food, treatments may be roughly divided into four basic methods: 1) salting; 2) flushing; 3) hand dipping; and 4) prolonged treatments.

Salting.

Salting is an ideal trough treatment except for the one limitation that it will not cure everything. In troughs, it is extremely simple to apply; it is reasonably effective against the external protozoan parasites; it is an excellent tonic to the fish; and its application demands the least accuracy of any known form of treatment.

There are many ways to salt fish, some good and others definitely bad. My own choice, which I think as good as any and superior to most, is to determine the volume of water contained in a trough drawn down to a predetermined depth, say two inches. By multiplying the inside length of the trough by the inside width and the product of these two numbers by the predetermined depth, all expressed in inches, one obtains the water content in cubic inches. For each 150 cubic inches of water in the trough at this predetermined depth, one ounce of finely ground salt is dissolved in a pail half full of water. To administer the salting, shut off the inflowing water, drain the trough to the predetermined depth, and spread the salt solution from the pail evenly over the trough.

Fingerling trout will withstand this concentration for six to ten minutes. When several of the weaker fish have turned over, the inflow is resumed at the maximum rate which the fish will withstand and the drain partially opened to permit a rapid replacement of the salt water. This method may be applied to fish as often as desired without apparent injury and, indeed, with a definitely tonic effect. When repeated three times at 24 hour intervals, salting is quite effective in curbing epidemics caused by external protozoans and it is the only treatment which should ever be applied in the absence of definite knowledge regarding the cause of any mortality. Salting, however, becomes progressively more expensive, less effective, and more difficult to apply as the size of the body of water to be treated increases.

Flushing.

Regarding the second method, namely flushing, which is used primarily as a preventive, very little is known - far too little to justify much comment. The method consists in routinely adding several fluid ounces of a disinfectant solution of definite strength to the upper end of a trough and allowing it to flow down the trough and out. This method may have distinct possibilities. At least as now usually applied it does not appear to be toxic to the fish. However, in my own experience at least, on the only occasion which has come to my attention this method of applying copper sulphate solution definitely did not prevent an epidemic of Gyrodactylus, unquestionably, this method should be further investigated under controlled conditions.

Dipping.

The third basic method, hand dipping, could be the subject of several closely written volumes. Suffice it to say that this method is a dangerous one for the solutions used are powerful and relatively concentrated, hence the difference between an effective dose and a killing one is exceedingly narrow in view of our present lack of knowledge concerning this very common method of treatment. When applied with extreme care, it undoubtedly may be of great value in controlling epidemics of external parasites and certain types of bacterial diseases such as fin rot, ulcer disease, and the eastern type of gill disease. However, the way hand dipping is often administered undoubtedly does more harm than good. The belief is generally prevalent that hand dipping expectedly is accompanied by an excessively high mortality. Many times, if one takes the trouble to analyze the daily mortalities, the dipping incurred a greater mortality in a single day than the disease being treated would have claimed in a period of two weeks. The inevitable reply to this fact is a knowing estimate of the astronomical numbers of fish which the disease would have taken had not treatment, disastrous as it was, been given. The answer is problematic no doubt, but if a hatcheryman will sometime leave a typical trough of fish untreated as a control to indicate what would have happened in the absence of all treatment, he will have an extremely valuable check upon his technique of dipping and a possible insight into that usually overlooked phenomenon called natural recovery. Certainly, hand dipping should never be applied to any large number of fish unless there is valid reason to believe that some external parasite is causing the losses. In the absence of such reason, a dip should be applied to a small number of fish as an experiment. If the percentage loss on this isolated group does not fall significantly below that of the entire group of affected fish within two days after the experimental treatment was administered, that method of treatment should be foregone.

As for the exact technique of hand dipping, in my opinion it is best done in a dipping box. This apparatus fundamentally consists of a solidly constructed, watertight, wooden box, in cross section about two inches narrower than the hatchery troughs, about half again as deep, and approximately three feet long. The box is legibly marked at the height attained by a known volume of water. In this dipping box is slung an inner compartment, resting on four "ears" which are sufficiently wide to rest on the top of the dipping box, yet sufficiently narrow to slip into the hatchery troughs. This inner compartment is made from two wooden sides, rounded vertically at the ends and the bottom is covered with a coarse mesh galvanized wire screening. The galvanized mesh, in turn, is

covered with bobbinet on the inside, the bobbinet being caught to the wire mesh at a sufficient number of points to keep the bobbinet from floating off.

In use, the deisred quantity of disinfectant is weighed out and dissolved in the box filled to the calibration mark. The inner compartment is then placed in the trough containing the fish to be treated where a convenient number of fish may be placed in it from the trough by means of a scaff net. The compartment is then removed to the dipping box and the fish immersed in the disinfectant. After the required time for the dip has elapsed, the inner compartment is carefully lifted from the dipping box and immersed in the trough to contain the treated fish. By slowly lifting the "upstream" end, the fish slip out of the "downstream" end. The solution in the dipping box should be aerated constantly and renewed frequently. Needles to say, the temperature differences between the infected trough, the dipping box, and the treated trough should at no time exceed 5° F.

Prolonged treatment.

The fourth method of treatment, namely prolonged treatment, is based upon the theory that a long exposure to a dilute solution of disinfectant is more efficacious and less toxic than is the short, concentrated hand dip. Furthermore, it may be applied without handling the fish, a factor which is not serious if the fish are carefully treated from troughs but may become very much so when the fish are in ponds where a seine must be used and a large number of fish are involved. Prolonged treatment of fish, either in ponds or troughs, does obviate this very objectionable feature. Unfortunately, prolonged treatments must still be regarded as in the experimental stage and while they are, theoretically, far superior to hand dips, we have much to learn concerning their practical application.

Prolonged treatment originally consisted of adding to the inflowing water by means of some convenient apparatus, sufficient dissolved disinfectant at a uniform rate to maintain a constant concentration of disinfectant over a definite period of time, usually one hour. This method of trating the inflowing water is subject to an inherent inaccuracy due to the diluting influence of the residual water in the pond at the time treatment is started. This inaccuracy is not serious in the case of troughs or small raceways which may be drained practically to dryness and which fill rapidly, but it becomes progressively more so as the size of the body of water to be treated is increased. For the treatment of the larger types of fish cultural equipment such as circular pools and raceways, the most recent development in prolonged treatments is essentially identical to the method of salting described above except that the disinfectant concentration used as much weaker so that the fish may be safely exposed for a period of several hours during which time, the water is recirculated in a closed system from the lower end of the pond to the upper by means of a centrifugal pump. This assures adequate aeration during the time when the inflowing water is stopped.

When to treat.

In any method of treatment, time is of vital importance. Disease rapidly lowers the vitality of small fish and although today they may withstand the rigors of treatment, tomorrow may find them too weak. The fish culturist must maintain strict watch on his stock. Many external parasites give early warning of their presence which is evidenced by the fish refusing to eat, scratching

themselves or assuming a characteristic bluish-grey sheen. Fungus, of course, is an excellent indicator of trouble but it usually does not appear until after the tell-tale rise in the daily losses which are the surest proof that trouble is present.

Immediately upon any suspicion of trouble and always in the event of increasing losses, the fish should be carefully examined for gross lesions and all possible extraordinary factors such as bad food, silt, sudden fluctuations in water temperature, etc., should be checked. If nothing can be found, the fish should be examined for parasites and microscopic lesions. If still no demonstrable source of trouble can be found, a few obviously affected fish should be preserved in a ten percent solution of formalin and forwarded, with full particulars, to the nearest pathology laboratory. Following this, all fish should be salted. In the early stages of disease when relatively few fish are as yet affected, these should be removed to an isolated "hospital trough" to prevent spread of the disease to the healthy fish. Needless to say, strict quarantine must be employed to keep the disease from spreading through the rest of the hatchery stock.

Such is the story of our bill for dead fish today. The path already taken to lower the food bill must be followed in the case of fish disease by laboratory workers and fish culturists alike. Every step along this path not only lowers the cost of production but also puts more fish in the streams which, after all, is the fundamental purpose of artificial propagation.

By Frederic F. Fish, U.S. Bureau of Fisheries, Seattle, Washington. The Progressive Fish Culturist, Memorandum I-131; No. 39, 1938.