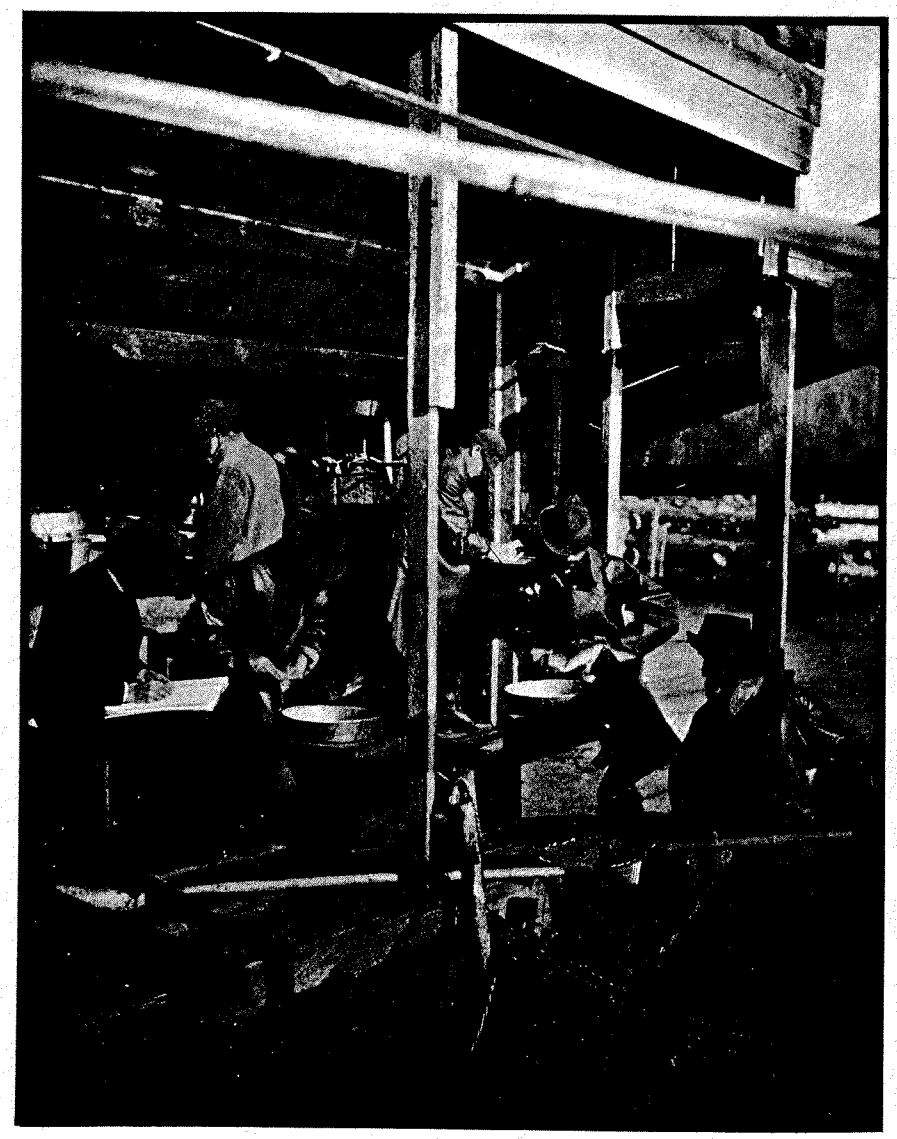
A. Kenneth Johnson

Proceedings of the Northwest Fish Culture Conference

25th Anniversary



ember 4-6, 1974 Seattle, Washington

Proceedings of

THE NORTHWEST FISH CULTURE CONFERENCE

25th Anniversary

December 4-6, 1974

Seattle, 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 or 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.

COVER PHOTOGRAPH:

Spawning of Salmon (Atlantic)
United States Fisheries Bureau,
Report of the U.S. Commissioner of Fisheries
for the Fiscal Year 1896.

PROCEEDINGS OF THE TWENTY-FIFTH ANNUAL NORTHWEST FISH CULTURE CONFERENCE DECEMBER 4, 5, and 6, 1974

The Twenty-Fifth Anniversary of the Fish Culture Conference was observed at the Sherwood Inn, Seattle, with the University of Washington College of Fisheries and the Sea Grant Program of the Division of Marine Resources acting as hosts. About 375 persons registered for the Conference.

Mr. Steven Wilson, wildlife photographer, was the banquet speaker and his superb pictures and comments were greatly appreciated. We learned much about fish and much about ourselves. Thanks again, Steve.

Thanks are also extended to Ms. Marie Fredrichs, Ms. Mary McConnel, Ms. Eileen Peterson, and Ms. Linda Scheidt, for outstanding services as receptionists, accountants, and traveler's aides.

The 1975 meeting will be hosted by Oregon State University, with Dr. John R. Donaldson as Chairman. In 1976 the meeting will be held at the University of Idaho, with Dr. George Klontz as host.

Thank you.

Ernest O. Salo, Chairman, Fisheries Research Institute
Ernest L. Brannon, Host, College of Fisheries
Terry Y. Nosho, Host, Division of Marine Resources

ACKNOWLEDGMENTS

The following persons and organizations made financial contributions to the Conference, thus helping to make the Proceedings available to the registrants. We gratefully acknowledge their contributions and we appreciate the useful displays of their products, although not all of the contributors utilized their option to display their products.

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POLLUTION AND HATCHERIES

SUBLETHAL EFFECTS OF WEST POINT TREATMENT PLANT EFFLUENT ON COHO SALMON

James A. Buckley
Cecil M. Whitmore
Municipality of Metropolitan Seattle
Seattle, Washington

INTRODUCTION

In 1961 the Municipality of Metropolitan Seattle (METRO) initiated a water quality monitoring program covering all waters in the Seattle metropolitan area affected by effluent discharges. As part of its ongoing concern with treated wastewater disposal Metro, in 1972, began a program of bioassays to define the effects of its treatment plant effluent on local, economically important organisms.

Results of previous tests at West Point concluded that chlorine is the principal toxicant to fish in the effluent. In addition, the average four-day TL50 was 7.4 percent effluent or about 0.10 mg/l residual chlorine.

The purpose of the current effluent toxicity test was to determine: (1) the concentration of effluent producing sublethal effects within the three-month test period, (2) the concentration of effluent below which no sublethal effects are noted, and (3) relate the above findings to conditions in Puget Sound around the treatment plant outfall. An additional objective was to determine which blood tests show promise as measures of effluent chronic toxicity to fish.

Testing was conducted on site at Metro's West Point Treatment Plant located on a point of land north of Elliot Bay on Puget Sound. The plant receives an average of 100 million gallons per day of wastewater from domestic and industrial sources. Following primary treatment, the effluent is chlorinated and discharged via a diffuser outfall 3,650 feet offshore at a depth of 230 feet.

MATERIALS AND METHODS

Acclimation to seawater and testing was carried out in a continuous flow system using 100 gallon circular fiberglass tanks. During testing, effluent was diluted with seawater and metered into duplicate test tanks in concentrations of 0.3, 1.1, and 3.6 percent effluent. In addition,

duplicate seawater control tanks were used. Total flow to each tank was approximately 1 gpm. Yearling coho salmon were obtained from the State Department of Fisheries at Puyallup. Blood samples were collected following anesthetization with MS-222 by wiping the fish dry and severing the caudal peduncle. Blood smears were stained with Giemsa stain, blood hemoglobin and methemoglobin were determined colorimetrically, and packed cell volume was measured by the microhematocrit method.

RESULTS

Results indicate that exposure to 0.3 percent effluent had no significant effect on the fish as measured by hemoglobin, methemoglobin, hematocrit, and differential blood cell counts. However, sublethal stress did occur in those fish exposed to 1.1 percent and 3.6 percent effluent. The stress was expressed as a reduction in blood hemoglobin and hematocrit, an increase in the percentage of immature red blood cells in circulation and a general deterioration in the condition of circulating red cells. Blood smears from stressed fish showed immature red cells indicating various stages of normal and abnormal regeneration. Vacuolated cytoplasm was evident in cells from fish exposed to 1.1 percent and 3.6 percent effluent, particularly the latter. In addition, microcytic and primary type red cells were common in fish exposed to the higher effluent concentration. About 40 percent mortality occurred in these tanks.

As previous tests have shown, chlorine is an important factor in the toxicity of the effluent to fish. Figures 1 and 2 show the relationship between the average daily concentration of residual chlorine in the effluent and hemoglobin and percent immature red blood cells in the test fish. The percentage of immature red blood cells appears to best reflect the changes in residual chlorine. This is especially evident in the period following the twelfth week when effluent exposure was terminated and the fish were in seawater only.

Table 1 contains data showing the average total residual chlorine and ammonia levels in the tanks during the test period.

Table 1. Average ammonia and residual chlorine concentrations in control and test tanks containing indicated percentages of West Point Treatment Plant effluent (mg/l)

	% Effluent			
Parameter	Control	0.03	1.1	3.6
Total residual chlorine	0.000	0.003	0.009	0.030
NH_4-N + NH_3-N	0.059	0.069	0.126	0.376
NH_3-N (free)	0.002	0.002	0.004	0.010

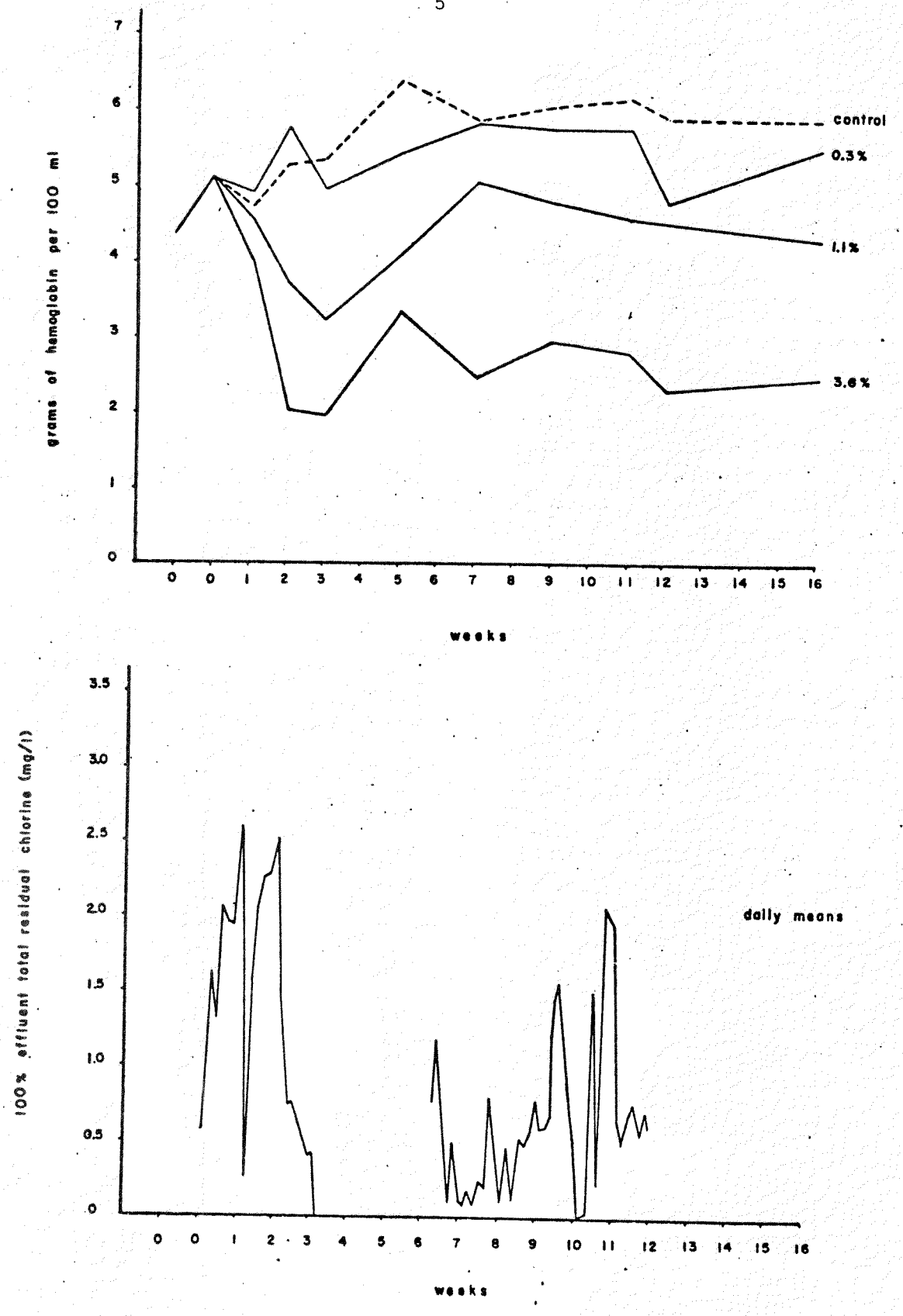


Fig. 1. Hemoglobin in test and control fish in indicated percentages of West Point Treatment Plant effluent shown with daily mean total residual chlorine in 100% effluent. Time after 12 weeks shows exposure to 100% seawater only.

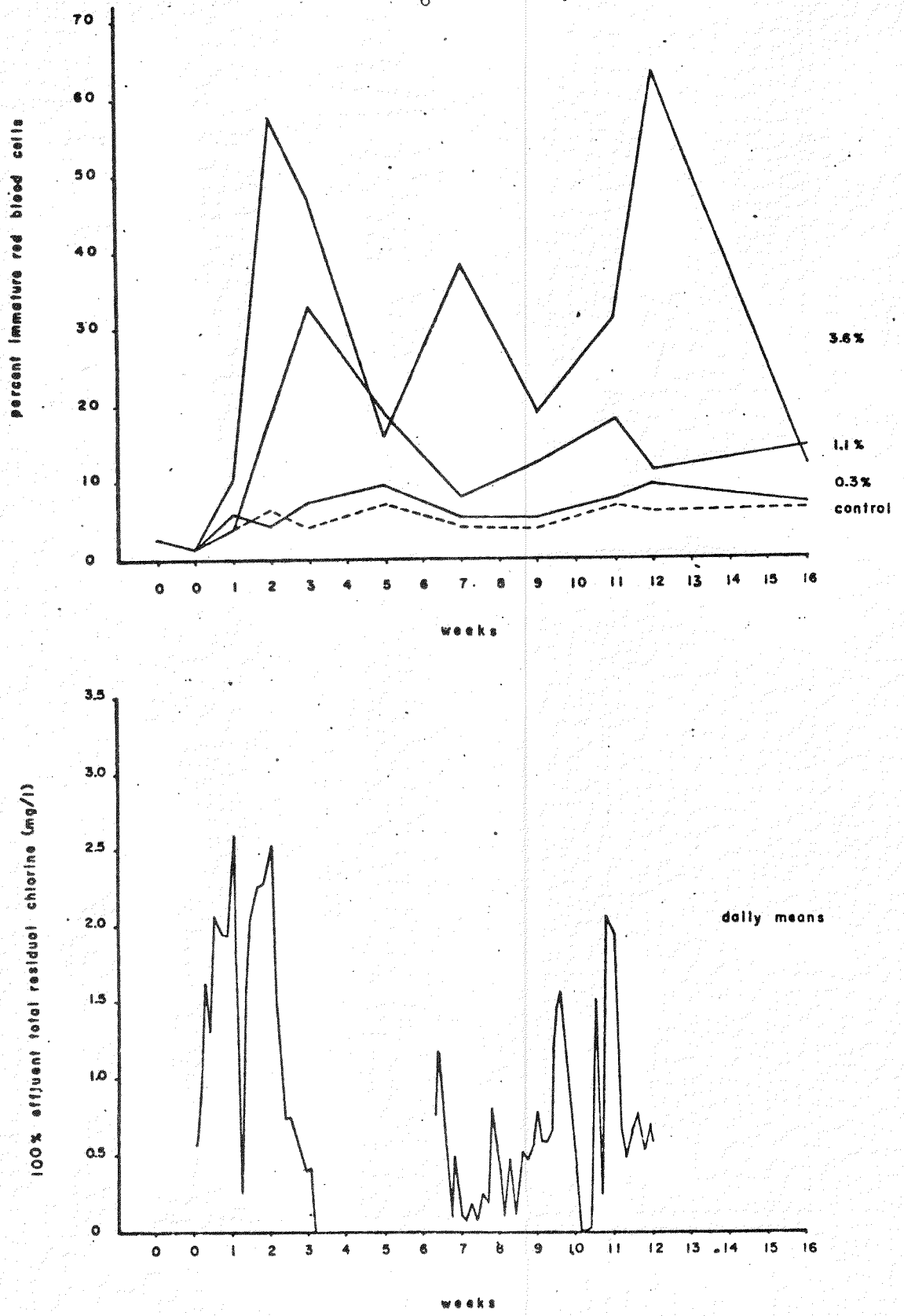


Fig. 2. Percent immature red blood cells in test and control fish in indicated percentages of West Point Treatment Plant effluent shown with daily mean total residual chlorine in 100% effluent. Time after 12 weeks shows exposure to 100% seawater only.

SUMMARY AND CONCLUSIONS

Results indicate no significant stress to test fish exposed to 0.3 percent effluent. However, sublethal stress did occur to fish exposed to 1.1 percent effluent which approximates the concentration of effluent in the immediate area of the treatment plant outfall when poor mixing conditions prevail. Such conditions would be unlikely to occur for more than a very short time and in a small area adjacent to the diffuser. Of the measures of sublethal stress used in the study, hemoglobin and information from blood smears were the most valuable.

POLLUTION ABATEMENT
TWENTY COLUMBIA RIVER PROGRAM HATCHERIES

Paul F. Ehinger, Jr.
UMA Group
Portland, Oregon

UMA Engineering Pacific, Inc. is currently conducting a study of pollution abatement at 20 of the 21 Columbia River Fisheries Program Hatcheries for the National Marine Fisheries Service, National Oceanographic and Atmospheric Administration. The objective of the study is to recommend operational changes and/or facilities necessary to achieve specific levels of pollution abatement. Implementation of operational changes and/or design of facilities will follow acceptance of a report on each hatchery.

Six levels of pollution abatement, ranging from the removal of sediment from pond cleaning wastes to 90 percent removal of BOD_5 and suspended solids were examined for Eagle Creek, Kalama Falls, and Klaskanine Fish Hatcheries. After the Environmental Protection Agency circulated a draft of their proposed effluent guidelines for fish hatcheries, the number of abatement levels studied has been reduced. Only three abatement levels were studied at Skamania and Gnat Creek Hatcheries. Effluent guidelines have not yet been finalized for fish hatcheries, but it appears that the final published standards will define best available treatment technology as the removal of solids from pond cleaning wastes. Therefore, the studies of the remaining 15 hatcheries will examine only this level. A number of other waste problems such as disease treatment chemicals and background stream contaminants such as leaves and sediment are also investigated at each hatchery. The effluent dissolved oxygen and the temperature rise in the hatchery are computed in order to determine whether or not State Stream Standards are violated.

Though it appears that in most cases hatchery pollution abatement has boiled down to determining the best method of treating pond cleaning wastes, the selection of the proper facilities for a hatchery has not become a simple process of installing a single type of unit. The large variations between individual hatcheries make a complete analysis of the problems at a specific hatchery necessary. Differences in pond construction, topography, cleaning method, and the amount of land available affect the selection of the most feasible treatment process. It is important to note that the proposed effluent guidelines will be minimum standards and more stringent standards will be applied if needed to protect the receiving water. A detailed study of each facility is needed to determine whether or not a greater level of pollutant removal is required.

If the hatchery ponds have a separate drain for cleaning, or if a separate drain can be installed, simple settling of cleaning flows will provide adequate removal of the solids in the wastewater. The separate

drain also allows separate handling of chemical treatment wastes. In many cases, a separate drain system is not feasible and a vacuum cleaning system or some other means of pumping of the cleaning wastes must be employed. After passing through a pump, the solids in the waste no longer settle well. Therefore, some method of producing a settleable floc must be used. Chemical coagulation is a possibility, but aeration prior to settling is the most easily operated method of producing a setteable floc. There are a number of variations of this sytem also. The aeration system can be followed by settling for solids removal, or the aeration basin can be operated on a batch basis to provide aeration, settling, and digestion of solids. Land disposal of the solid wastes from pond cleaning appears to be the most feasible, particularly in agricultural areas.

Malachite Green and Formalin are the most commonly used disease treatment chemicals in the Columbia River Hatcheries. At the dosages normally employed, these chemicals do not appear to present a significant environmental hazard as long as only one pond is treated at a time. If the ponds have separate drains for cleaning, the chemical wastes can be directed to the cleaning waste treatment facility to further reduce effluent concentrates by additional dilution.

Temperature rises in the hatcheries due to solar heating in the ponds have been a problem in some hatcheries where the rise causes a violation of State Stream Standards for a short period during the day. The attitude of the State Regulatory Agencies to these short duration temperature rises will determine how great a problem exists for the operating agencies.

One of the most difficult waste problems encountered at the hatcheries studied has been background contaminants which are deposited in the hatcheries. The severity of this problem varies widely from hatchery to hatchery, depending on the hatchery water supply. In many cases, the cost of removing sediment from the influent and disposal of the waste or handling of leaves removed from screens within the hatchery costs as much as or more than the facilities for treating pond cleaning wastes. Removal of these wastes prior to the rearing facilities makes handling easier and improves the quality of the water influent to the rearing units.

Removal of sediment by settling in a basin designed for easy removal of silt and sand greatly simplifies the problem associated with handling background wastes. The silt can be disposed of on land.

Leaves and other screenings should be collected and hauled away for land disposal.

Over the last few years, a wide range of pollution abatement levels have been suggested for fish hatcheries, ranging from 90 percent removal of BOD_5 and suspended solids to the relatively moderate level of removing the solids from pond cleaning wastes. While treatment of pond cleaning wastes appears to represent the generally acceptable abatement level, each individual hatchery must be carefully evaluated to determine the most appropriate treatment method and to insure that the receiving waters to which the hatchery discharges are not degraded.

POLLUTION ABATEMENT FACILITIES AT NATIONAL FISH HATCHERIES

Marvin A. Smith
U.S. Fish and Wildlife Service

Enactment of the Federal Water Pollution Control Act Amendment of 1972 required the Environmental Protection Agency to establish regulations and provide guidelines at fish hatcheries for effluent limitations for point discharge sources. Specifically the Act called for achievement by no later than July 1, 1977 of hatchery effluent limitations which require the application of the best practicable control technology currently available and by no later than July 1, 1983 of effluent limitations which require the application of the best available control technology economically achievable. These limitations were to be determined by the Administrator, EPA, pursuant to the Act.

The Environmental Protection Agency's early draft guidelines called for the reduction of the five day BOD and suspended solids in untreated hatchery wastewaters by roughly 80-90 percent to meet the limitations specified in the above Act. These values were based on effluent characteristics made possible by concentrating fish wastes in water reuse-reconditioning systems. While the Fish and Wildlife Service, and all fishery agencies for that matter, support the need to control pollutants discharged into streams, they questioned the value of water reuse systems solely as pollution control devices. Results of studies conducted by the Fish and Wildlife Service have indicated that the only pollutant of significance in fish hatchery effluent is fish feces. Furthermore, that control by sedimentation was the only practicable method of pollution control constructed and tested up to that point of time by this Service. Since then the Service has constructed two lamella separators and two sedimentation ponds at four different National Fish Hatcheries.

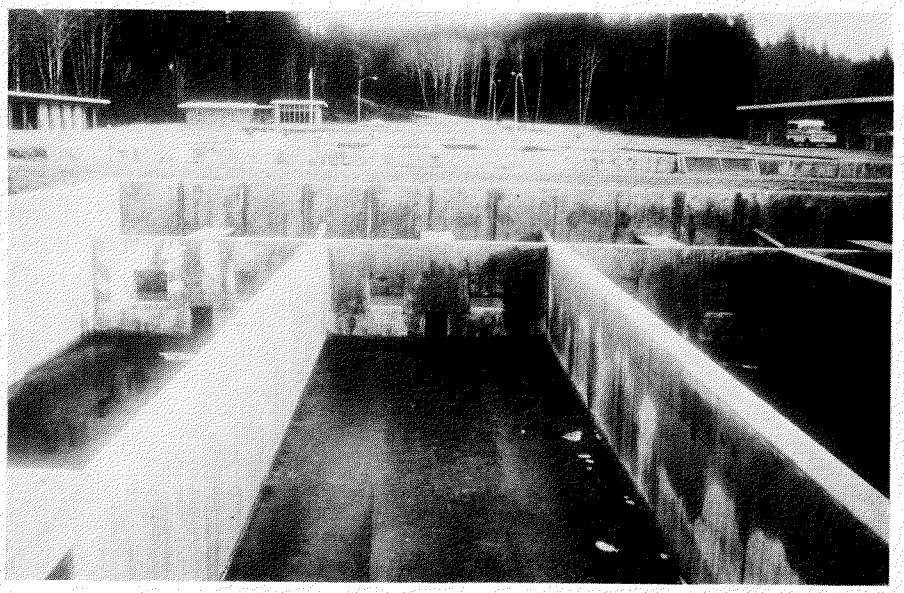
I will show you slides and discuss several of these facilities today. Time permitting I have some slides of a vacuuming system to remove settleable solids at another National Fish Hatchery.

As EPA had not yet completed its study or published effluent limitations for fish hatcheries, the Fish and Wildlife Service in 1973 requested approval from EPA to install a lamella separator at the Quinault National Fish Hatchery in Washington to provide additional pollution abatement information for the field of fish culture. EPA sanctioned the use of this installation with the understanding, that any additional treatment facilities which may be required to comply with approved effluent limitations be provided at the earliest possible date. When first proposed, the operation of the lamella separator was not expected to meet the existing proposed standards as tests with a pilot facility indicated an expected 50 and 70 percent removal of BOD and suspended solids respectively. Today's standards while not published by EPA are expected to be

far less stringent than the earlier 80-90 percent reductions. It is our understanding that effluent limitations for the 1977 and 1983 levels of technology have now been combined. We are now looking at the following pollution limitations:

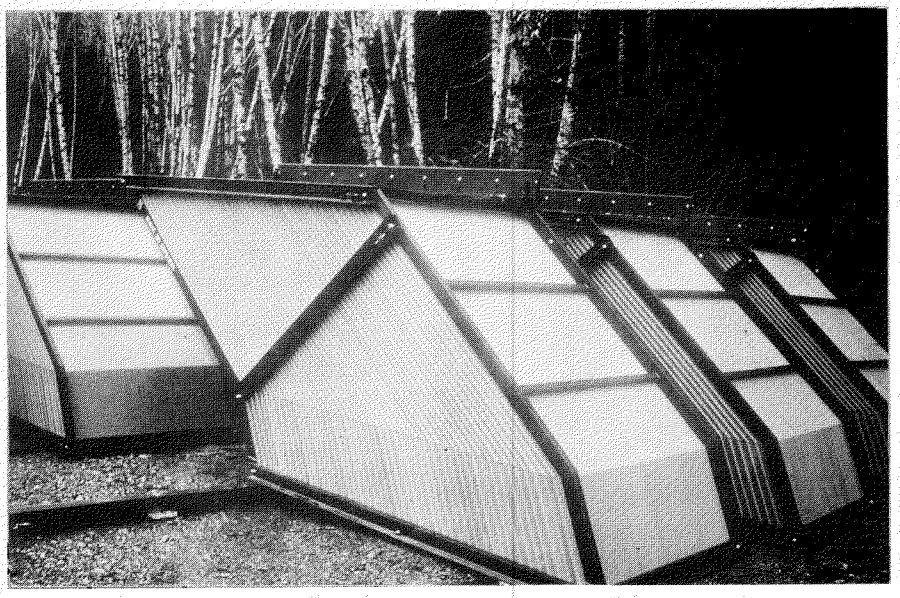
Solids	Daily average	Daily maximum	Instantaneous maximum
Suspended	2.2 lb per 100 lb of fish	2.9 lb per 100 lb of fish	15 mg per liter
Settleable	0.1 ml per liter		0.2 ml per liter

LAMELLA SEPARATION - QUINAULT NATIONAL FISH HATCHERY

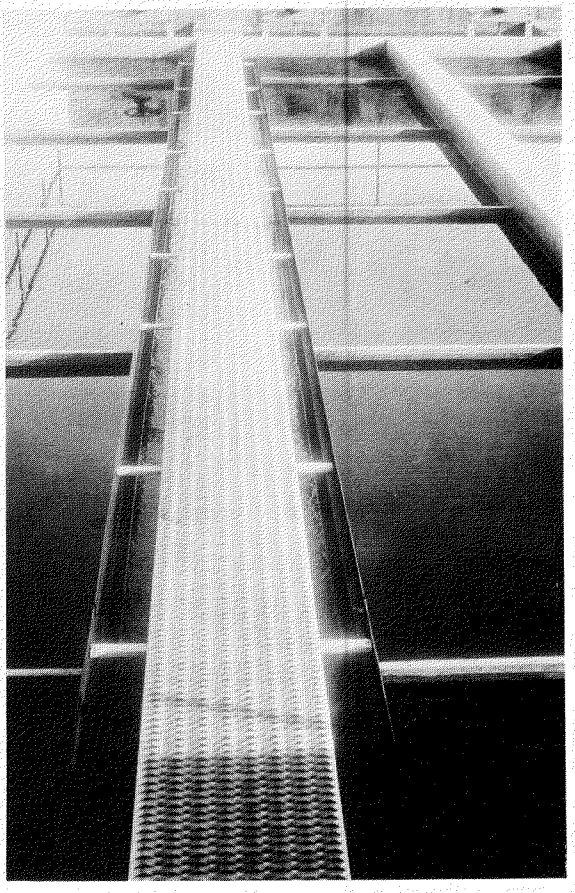


Concrete basin with lamella separator compartments.

The separation of solids from a liquid by means of gravity is primarily a matter of settling area. As many hatcheries have limited space for construction of settling basins large enough to handle the hatcheries total water flow, the U.S. Fish and Wildlife Service planned a study to test the lamella techniques of settling. Lamella separators provide a large settling area by utilizing a large number of plates a few inches apart at an angle of 41°. In operation, wastewater enteres a headbox and then passes downward between the plates where suspended solids settle out very rapidly. The clarified water is pushed up through return tubes and is discharged. Sediment collecting on the plates will slide down the plates and settle to the bottom of the control structure. It is collected by sludge scrapers, suction pumped to a concentrating hopper and finally pumped to drying beds.



Lamella separator package
40 packages installed at Quinault National Fish Hatchery



Completed lamella separator in operation
at Quinault National Fish Hatchery

SETTLING BASIN - LAHONTAN NATIONAL FISH HATCHERY

The Lahontan system consists of two basins each sized to provide 30-minute settling for its total hatchery discharge of 1,600 gpm. The hatchery effluent will be discharged to one of the two settling basins. As sludge builds up in one unit it will be dewatered and the sludge flushed to an 80 ft square earthen lagoon for digestion. During the dewatering and flushing operation, the hatchery effluent will be shunted to the other settling basin. Clarified water will be discharged directly to the river from the settling ponds.

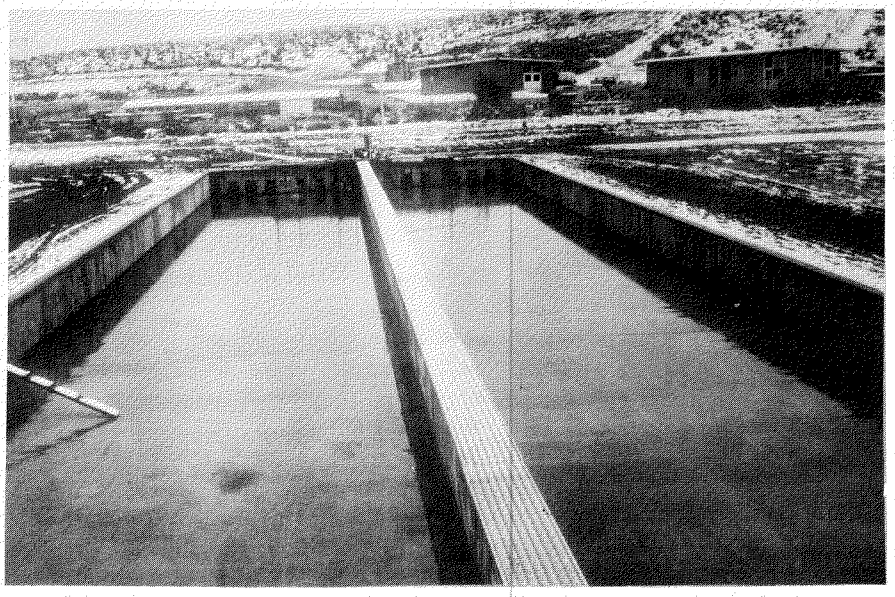
The Lahontan hatchery operates on a water reuse system and treatment of hatchery wastes in the reconditioning filters, settling ponds, and detention basin is expected to result in a 90 percent reduction in suspended solids.

See photograph on next page.

SETTLING BASIN - SPRING CREEK NATIONAL FISH HATCHERY

Spring Creek hatchery operates on a water reuse system requiring treatment of 3,200 gpm. Effluent treatment facilities at the hatchery consist of a settling and stabilizing lagoon equivalent to 18 hours of detention time. The lagoon is divided into two basins by a leaky-fence-type dividing wall. Basin One will have a retention time of about three and one-half hours and almost complete removal of settleable solids is expected to occur here. Final clarification and stabilization takes place in the larger Basin Two. The system is expected to provide total reduction of settleable solids and 70 percent reduction in suspended solids. The smaller Basin One should produce rapid digestion, requiring a 3 to 10 year cleaning interval. The greater volume and reduced solids in Basin Two is expected to limit solids removed in this basin to once in 10-15 years.

See photograph on next page.



SETTLING BASIN - LAHONTAN NATIONAL FISH HATCHERY

Basin One in foreground.

SETTLING BASIN - SPRING CREEK NATIONAL FISH HATCHERY

DIET STUDIES

HERRING MEAL REPLACEMENTS IN THE ABERNATHY DIET

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Escalating costs of feed ingredients during the past two years have caused the price of fish feed to nearly double. These increased costs have been brought about in part by the world-wide scarcity of fish meal. Herring meal is used in the Abernathy salmon diet as the fish meal of choice and supplies nearly 68 percent of the total protein. Any replacement of herring meal by less costly ingredients would result in a more economical diet.

During 1973 and 1974 using fall chinook salmon fingerlings, we conducted feeding trials with paired groups of fish reared in constant 53° F water for periods of 20 weeks. Our objectives were to lower the amount of herring meal by replacement either with other fish meals or high protein concentrates, but without a sacrifice in fish growth. The control diets are shown in Table 1 and the results from the various tests in Table 2.

Table 1. The Abernathy control diets (in percent)

1973	Ingredients	1974	1974
38	Herring meal	39	
15	Cottonseed meal	17	
10	Dried whey product	5	
17	Wheat germ meal	7	
--	Brewers dried grains	8	
13	Wheat middlings	15	
4	Vitamin premix	4	
--	Mineral mix	1	
3	Soybean oil	4	
45	Crude protein	45	
3,065	Total available calories	3,060	
27	Percent fish meal protein	28	

To summarize, either, cottonseed meal, blood flour, or shrimp meal were found to be successful partial replacements for herring meal but soybean meal or meat and bone meal were not. Anchovy meal proved to be equal to herring meal but tuna scrap and menhaden meals were inferior.

Table 2. Results of the 1973 and 1974 feeding trials after 20 weeks of feeding

Diet variable	Average wt/fish (grams)
Control 1973	25.0
Replacement 5% herring meal protein with soybean meal	22.7
Replacement 5% herring meal protein with meat and bone meal	22.9
Replacement 5% herring meal protein with cottonseed meal	25.3
Replacement 5% herring meal protein with blood flour	26.0
Replacement 10% herring meal protein with soybean meal	20.5
Replacement 10% herring meal protein with meat and bone meal	22.1
Replacement 10% herring meal protein with cottonseed meal	24.3
Replacement 10% herring meal protein with blood flour	25.7
Replacement 12.5% herring meal protein with soybean meal	21.0
Replacement 12.5% herring meal protein with cottonseed meal	23.7
Replacement 15% herring meal protein with meat and bone meal	21.8
Replacement 15% herring meal protein with blood flour	24.9
Replacement total herring meal with anchovy meal	25.4
Replacement 1/2 herring meal with anchovy meal	26.3
Control 1974	30.1
Replacement 2% herring meal protein with shrimp meal	31.9
Replacement 4% herring meal protein with shrimp meal	30.6
Replacement 8% herring meal protein with shrimp meal	27.3
Replacement total herring meal protein with menhaden meal	27.9
Replacement 1/2 herring meal protein with menhaden meal	29.0
Replacement 1/2 herring meal protein with tuna scrap meal	28.1
Replacement 1/4 herring meal protein with tuna scrap meal	29.1

COMPARISON BETWEEN TWO METHODS OF FEEDING AS RELATED TO FIN EROSION

R. L. Hill
Fall River Hatchery
Oregon Wildlife Commission

First, I would like to review with you some of the observations on fin erosion presented to this gathering last year by Mr. K. E. Morton. Mr. Morton stated that fin erosion at Wizard Falls Hatchery has been a perplexing problem, primarily with the yearling fish.

In 1972-73, we conducted experiments in spring water at 50° F, Metolius River water--42° F, density, two different food types and high level feeding in regard to fin erosion. It was speculated by Mr. Morton that maybe the chemical makeup of the water had some bearing on the problem. He also commented that the method and interval of feeding might have some effect on fin erosion. That brings us to my topic of discussion.

We evaluated the amount of erosion on individual fins rather than a general evaluation as was done in 1972-73. The experiment covered a 125-day period, and after analyzing the data it was apparent that just the dorsal fin was the problem. Tables 1 and 2 indicate the percent of severe and medium dorsal fin erosion found in the experimental groups of fish.

The criteria for evaluating the amount of erosion was the same as the previous year:

1. Severe--fins eroded to the base.
2. Medium--50 percent eroded.
3. Light--edge eroded.
4. None--intact fins.

The two methods of feeding were as follows:

Method #1--Feed four times daily by automatic feeder.

Method #2--Feed three times a week by hand (all the fish would eat without waste).

The holdover stock was graded and moved to our larger rearing ponds on August 28 this year. In 1972, the fish were moved on November 14.

140,000--spring water (50° F).

160,000--river water (42° F).

We conducted experiments with six hatchery ponds. Four of these ponds were of the raceway type (20'x100'x4'). Two of the ponds were of the oval type (20'x45'x30"). Our experiment involved the two methods of feeding (stated above) to determine if this had any effect on fin erosion at Wizard Falls.

We carefully evaluated the fins of 100 fish from each of the experimental ponds every two months starting on November 28, 1973.

You will note that Ponds 22-23 were discontinued after the evaluation on January 31, 1974. We were forced to make room for some fingerling fish, so it was necessary to move these two ponds out to our river water rearing area. I regretted this very much. I felt that these two ponds (spring water) were the best comparisons that we had with Ponds 43-44 (river water).

The last evaluation was made on April 2, 1974. The information compiled from the three evaluation periods is shown in Tables 1 and 2 and Figs. 1 and 2.

Table 1. Percent of fin erosion in rainbow trout reared 50° F spring water and fed at different intervals utilizing two methods of feeding

	Machine fed four times daily		Hand fed three times weekly	
Examined	Raceway	Oval	Raceway	Oval
November	57%	68%	51%	64%
January	48%	57%	52%	60%
April		28%		35%

Table 2. Percent of fin erosion in rainbow trout reared 42° F spring water and fed at different intervals utilizing two methods of feeding

	Machine fed four times daily		Hand fed three times weekly	
Examined	Raceway	Oval	Raceway	Oval
November	60%		64%	
January	57%		54%	
April	16%		16%	

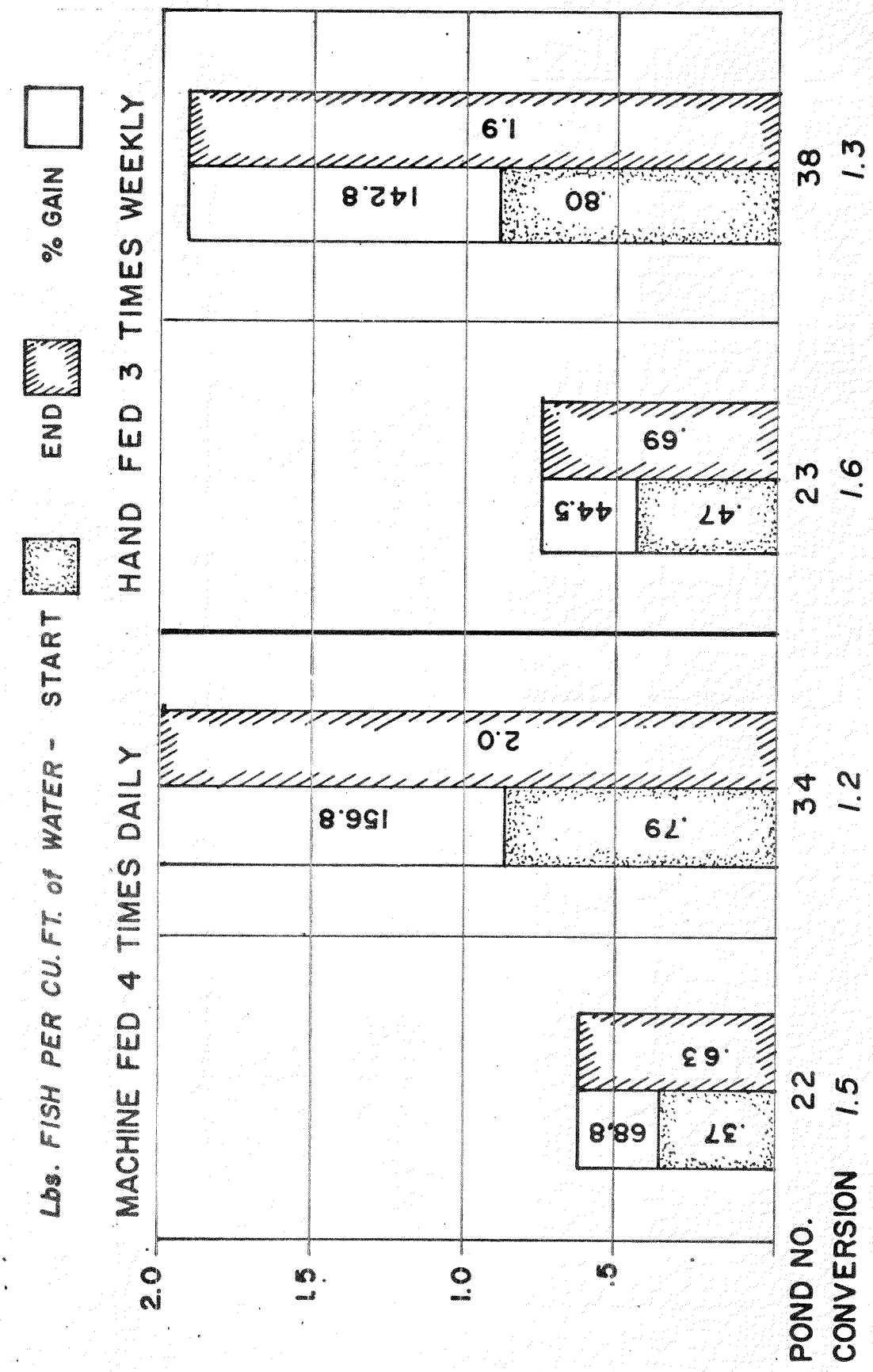

Fig. 1. Growth and conversion rates of rainbow trout reared at 50° F spring water under various densities and utilizing two methods of feeding.

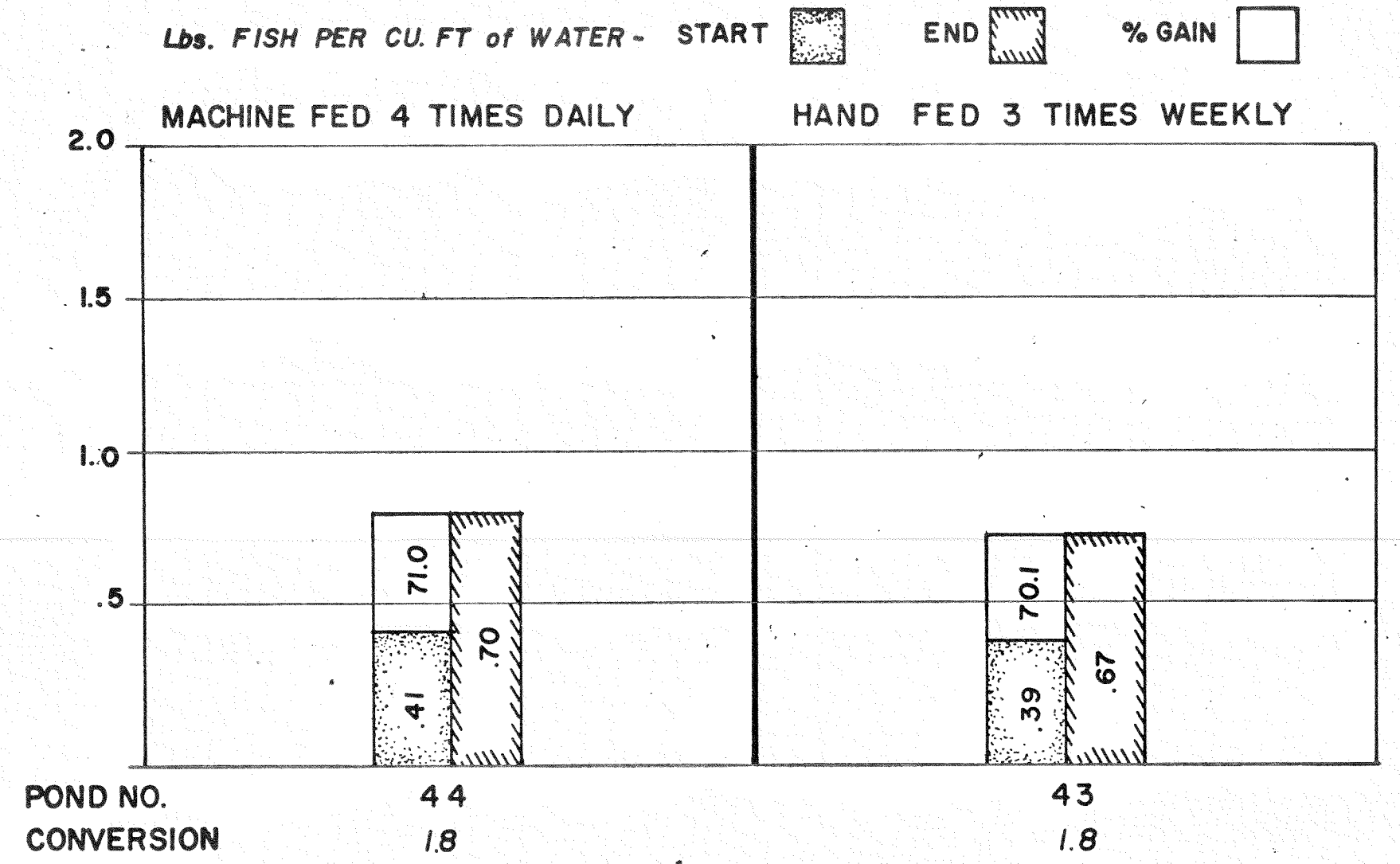

Fig. 2. Growth and conversion rates of rainbow trout reared at 42° F river water utilizing two methods of feeding.

CONCLUSIONS

1. Erosion was reduced in all groups in 125-day feeding trials.

2. Erosion reduced more in fish fed four times daily than in those fed three times weekly (but not substantially).

3. Erosion reduced more in river (42° F) water than in spring (50° F) water in 125 days.

DISCUSSION

A possible future test might include (if production schedules will allow) small fingerling fish to try to eliminate or reduce this erosion problem prior to the fall months.

FEEDING OF CHINOOK SALMON ALEVINS

Charles W. Hopley, Jr.
Research Assistant
Salmonid Aquaculture
College of Fisheries
University of Washington
Seattle, Washington

The purpose of the experiment was to determine the effect that feeding prior to the time of yolk absorption would have on the growth of hatchery-reared chinook salmon (*Oncorhynchus tshawytscha*), and on the rate of yolk absorption. The experiment was conducted during the winter of 1974 at the experimental hatchery, College of Fisheries, University of Washington.

A single lot of chinook alevins just completing swim-up was divided into six equal groups containing approximately 530 individuals with a total weight of approximately 220 g. The average blotted wet weight per individual was 0.41 g, average length was 36.3 mm, and the average yolk weight was 61 mg. The groups were held in six compartments in a standard hatchery trough, each compartment measuring 6 inches deep, 12 inches wide, and 27 inches long. Flow through the trough was approximately 2 gpm and temperature averaged 53° F.

The experiment was initiated by feeding of the first group of alevins, those occupying the compartment at the lower end of the trough. These individuals fed readily at first feeding. Food was withheld from the other five compartments. Feed consisted of the standard hatchery diet of finely ground salmon meal dusted over the surface at least hourly throughout the day.

At the end of a one-week period the fish in the second compartment were offered food while feeding continued in the first compartment and the remaining four compartments were not fed. The feeding scheme continued in this fashion at weekly intervals until, at the end of the sixth week, all compartments had been receiving food for a period of from six weeks to one week. The feeding of all compartments was continued for two more weeks for a total feeding time of eight weeks.

Sampling was carried out at the end of each weekly period throughout the study. A sample of 15 individual lengths and weights was taken from live fish from each compartment every week. In addition, five fish from each compartment were preserved in 10 percent formalin for use in obtaining yolk weights. Feeding was delayed on a day of sampling until all compartments had been sampled, usually by mid-day. Feeding was then resumed, including the first feeding of the next consecutive compartment.

Yolk weights taken from the preserved specimens showed that the yolk was completely used in all compartments by the end of the fourth week. The

fact that yolk absorption occurred at the same time in all compartments indicates that the rate of yolk absorption, approximately 2.2 mg/day over the four-week period, was unaffected by feeding regardless of the length of time the alevins had been on the feeding schedule. At this time, four of the six compartments had been feeding between one and four weeks, and two compartments had not received food.

The total growth of the alevins was definitely enhanced by feeding prior to yolk absorption. Considering only the first feeding, that group that was fed during the entire four weeks prior to yolk absorption, a comparison can be made between the original weight and the weight at yolk absorption. This group increased in average individual weight from 0.41 g to 1.16 g, or 283 percent of the average weight at the beginning of the experiment, as a result of feeding before yolk absorption. At the end of only the first week of feeding this group was already 133.93 percent of the original weight, with three weeks of feeding yet to go before the yolk was absorbed.

Those groups remaining unfed at yolk absorption, the last two groups, showed a net decrease in live weight at the end of four weeks. The average weight decreased from 0.41 g at the beginning of the experiment to 0.34 g, or approximately 83 percent of the original weight. There was no indication of growth due to yolk conversion. The length of those groups remaining unfed until yolk absorption remained about the same as the initial lengths.

The full extent of the growth gained by earlier feeding is evident when comparing the growth of those alevins fed during the four weeks of yolk absorption to that of the fish remaining unfed at the end of yolk absorption. Those alevins in the first compartment to be fed had reached a length of 45.1 mm at the end of yolk absorption while those that had not been fed were 36.3 mm in length, feeding had resulted in an average alevin of 134.13 percent of the length of those remaining unfed, a net difference of 8.8 g.

The average weight of alevins fed during the four weeks prior to yolk absorption was 1.16 g. This weight is 338.5 percent of the weight of alevins not fed during yolk absorption, their average weight at yolk absorption being 0.34 g. This 0.82 g difference in average live weight per individual is the direct result of feeding alevins during the four week period required at 53° F to absorb 61 mg of yolk material.

The groups that were fed three, two, and one weeks prior to yolk absorption were separated from each other in length and weight by the amount of growth gained or lost during a given week of feeding. This is to say that growth rate once feeding is started is the same for each of the experimental groups and the absolute size, length or weight, obtained at yolk absorption is a direct result of the time of initial feeding.

FEEDING OF HATCHERY-REARED COHO SALMON ALEVINS

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The objective of this study was to determine the stage of development when coho salmon begin ingesting food, and to determine whether food consumed prior to complete yolk absorption has any effect on growth or the rate of absorption.

The alevins and fry used in this study were obtained as eggs from the Dungeness Hatchery and were incubated to hatching at the University of Washington. On April 9 twelve groups of 600 alevins were placed in separate sections of two standard hatchery troughs. The sections were numbered one through six from the water source end of each trough. Feeding began late in the afternoon on April 9 and continued under diurnal light conditions for a period of 36 days. The mean fresh lake water temperature during this period was 11.3° C and varied between 10.3° and 13° C. Each section or experimental group of alevins in one trough had a duplicate in the second trough. Feeding of each section and its duplicate was started at different times to correspond with different stages of development. On April 9 food was first presented to section six of both troughs, and subsequently to the other five sections at intervals of five days. For all sections except section one, sampling began on the day food was first introduced and was repeated every five days thereafter. Section one was used as a control and was sampled regularly throughout the study. Wet weights and fork lengths were determined for twenty fish from each section. Five of these fish were preserved in 10 percent formalin for subsequent determination of whole body, yolk, and stomach weights. These stomachs were also examined for evidence of feeding. Differences in lengths and weights between sections were evaluated by analysis of variance for each sampling date and differences between means were compared using Duncan's multiple-range test.

Wet weight measurements of yolk during the study showed that yolk was completely absorbed between April 19 and April 24 in both fed and unfed fish (Fig. 1). Therefore sections six, five, and four received their first food prior to complete yolk absorption, and sections three, two, and one were first fed after yolk absorption. Analysis of stomach contents indicated that sections four, five, and six began ingesting food between April 19 and April 24. There was also a significant increase in feeding behavior during this period. Analysis of length-weight data indicated that the sections fed prior to yolk absorption showed the same amount of growth before yolk absorption as the unfed sections. These results indicate that these coho salmon began feeding as fry at or about the time of complete yolk absorption. When the sections were compared at various stages after yolk absorption it was

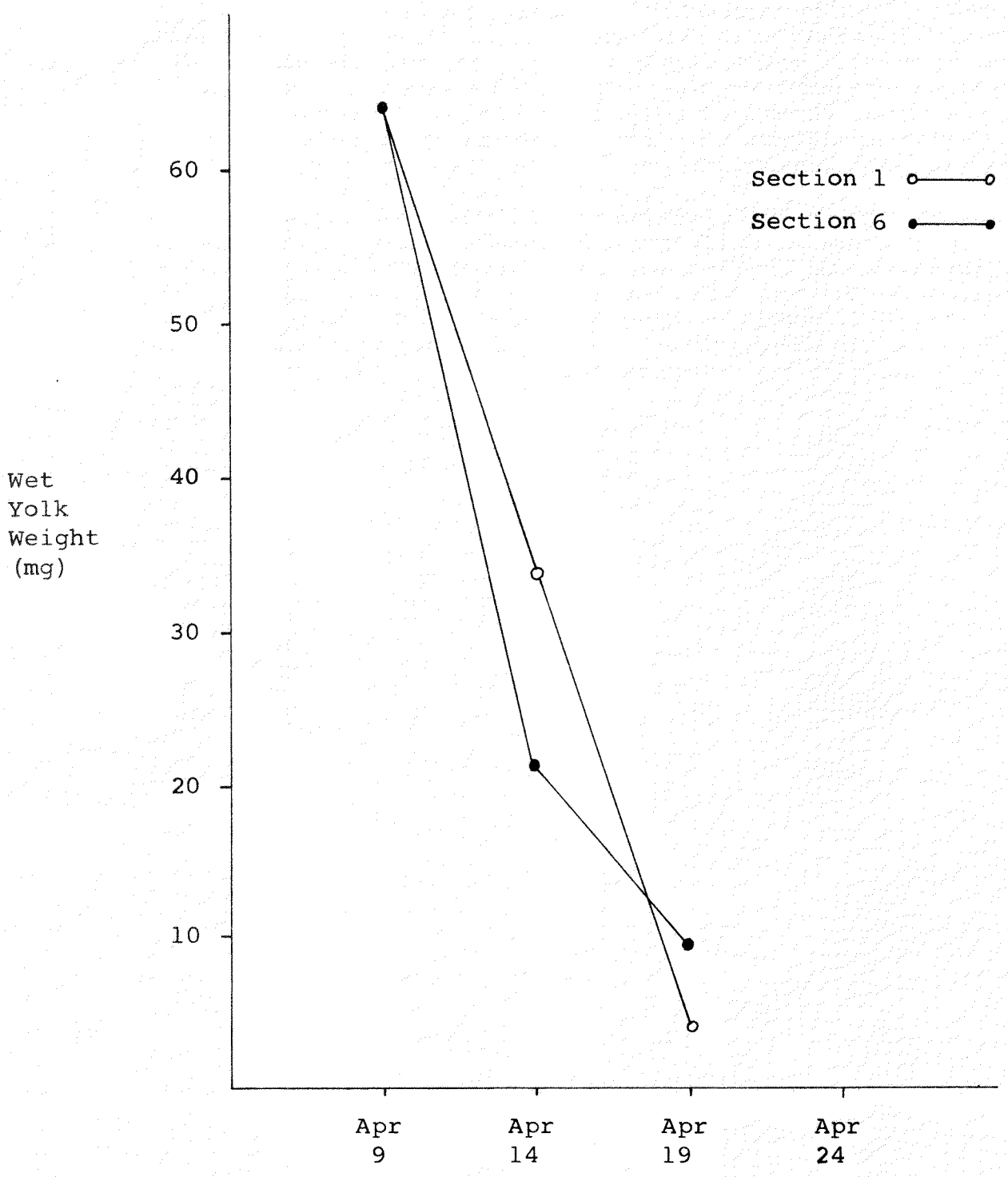

Fig. 1. Decreasing weight of yolk during period of yolk absorption in alevins from section 1 and 6.

evident that the fry utilized the first food ingested, and the effects of early and delayed feeding were seen. The sections which were receiving food at the time of complete yolk absorption continued to grow throughout the study, with only occasional and inconsistent differences among the three in length or weight (Figs. 2 and 3). The effects of delayed feeding increased in severity with the duration of delay past yolk absorption. Growth retardation was increasingly severe as was the amount of stress-related mortality. There was also a depression in feeding activity proportional to te length of starvation.

The results of this study indicate that in this population of coho salmon feeding and food utilization occurred at about the same time that yolk absorption was complete, and that no growth advantage was afforded those fish fed prior to yolk absorption. However, the results suggest that coho alevins should be examined regularly so that food may be introduced at the first sign of complete yolk absorption to avoid any of the detrimental effects of delayed feeding.

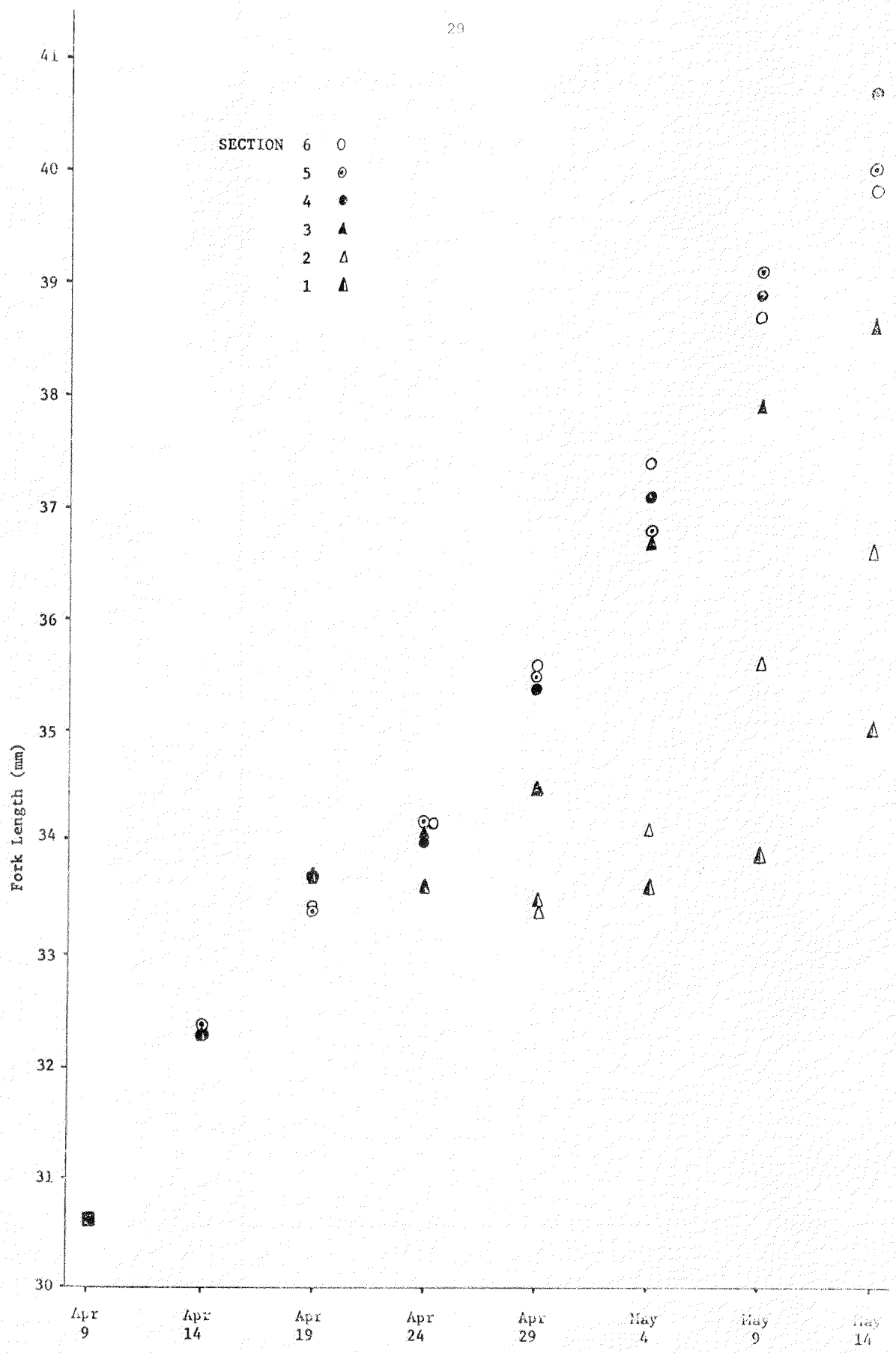

Fig. 2. Increase in folk length of coho alevins and fry fed before and after yolk absorption.

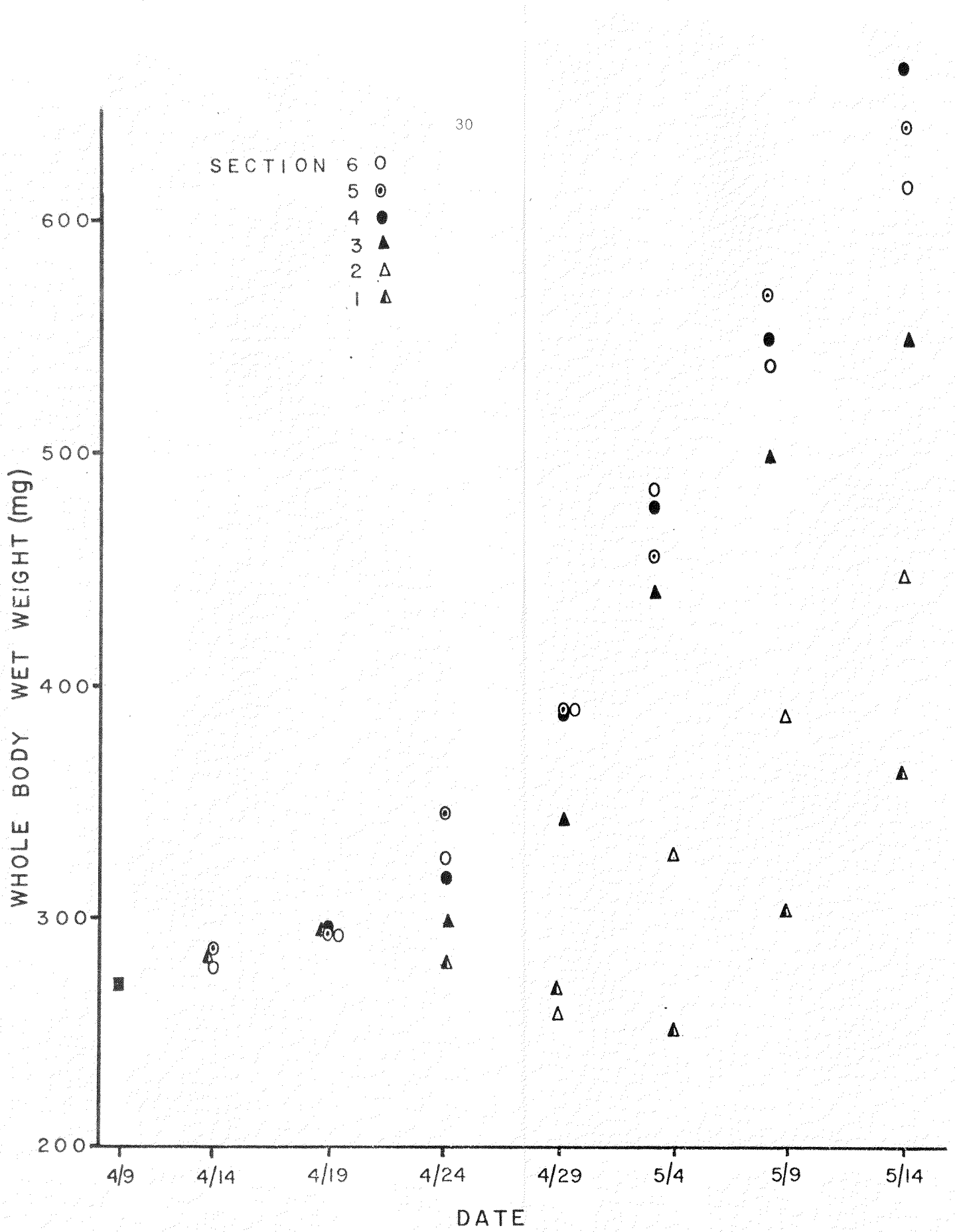

Fig. 3. Increase in wet body weight of coho alevins and fry fed before and after yolk absorption.

ATTEMPTS AT LOWERING FEED COSTS WITHOUT LOWERING FEED QUALITY

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The current trend at the University of Washington, College of Fisheries, is to explore ways of using various byproducts and fish processing wastes for feeding salmonid fishes. Our objective is simply to cut down feed costs and where possible to do so without any major reduction in feed quality.

During the past year, a 12-week feeding study was carried out to assess the potential food value of certain fishery byproducts and trash fish for young coho salmon fry that had just absorbed their yolks. Six basic diets consisting, on a dry weight basis, of 62.4 lb of either flatfish or true cod wastes; herring or spawned salmon carcasses; whole dogfish or eviscerated dogfish; plus a constant ingredient package of 10 lb each of bulgur fines and hull-less oatmeal; 5 lb each of wheat germ and whey; 2.5 lb each of kelp meal and shrimp meal; 1.5 lb of choline chloride; 1 lb vitamin premix; 0.04 lb Rhozyme B-6; and 0.03 lb each of butulated hydroxyanisole and butylated hydroxytoluene were used. These diets were compared with a widely-accepted commercial fish food, Oregon Moist Pellet, by feeding them daily, on an adjusted paired feeding procedure, to duplicate lots of 950 coho fry.

All the diets except OMP were prepared in a pilot fish meal reduction plant at the College of Fisheries, Seattle. The proximate composition, amino acid content, and fatty acid composition of the diets were determined by standard methods (Tables 1 and 2). The caloric contents of the diets were calculated, using values of 8.0 calories/g of lipid, 3.9 calories/g of protein, and 1.6 calories/g of carbohydrate.

The results obtained from the feeding trial, as well as from the analysis of the diets in terms of amino acids and fatty acids, indicated that diets made from fish processing byproducts are comparable to and in some instances are better than a widely-accepted commercial fish food (Table 3). The essential amino acid content of the diets, with the exception of phenylalanine, arginine, and lysine, is in excess of the requirements for salmonid fishes. Considering, however, that tyrosine has a "sparing effect" on phenylalanine, fish fed proteins derived from these fish processing wastes are unlikely to encounter phenylalanine deficiencies. Dogfish is not as good as salmon, cod, flatfish, or herring meal as a sole protein source for coho salmon. Diets made from dogfish contained higher amounts of methylmercury and fish fed these diets also retained higher amounts of methylmercury.

Table 1. Proximate composition and amino acid content of diets fed to young coho salmon

	Flat-fish	True cod	Visc. dog-fish	Salmon car-cass	Whole dog-fish	Her-ring	Oregon Moist Pellet	Re-quire ments[1]
Protein (N x 6.25)	42.7	45.2	42.9	43.4	40.6	43.9	44.6	
Lipid	6.9	7.1	8.6	7.4	10.5	9.2	8.9	
Ash	10.2	9.0	10.0	8.6	10.3	7.8	7.4	
Moisture	32.0	30.4	30.8	32.6	31.6	31.8	31.5	
Carbohydrate	8.2	8.3	7.7	8.0	7.0	7.3	7.4	
Calculated Kcal per g	2.4	2.5	2.5	2.4	2.5	2.6	2.6	
% calories as protein	70.0	72.0	67.0	66.0	62.0	67.0	68.0	
Mercury content (ppm)	0.3	0.5	1.2	0.5	1.7	0.3	0.3	
Amino acid (% of diet)								
Alanine	2.2	2.4	1.9	2.0	2.1	2.1	2.1	
Arginine	2.0	3.3	1.9	2.3	2.0	2.0	2.0	2.5
Aspartic acid	2.6	3.1	2.4	2.8	2.9	3.1	3.2	
Glutamic acid	4.1	5.0	4.2	4.4	4.7	5.0	5.0	
Glycine	3.1	3.2	3.0	2.7	2.9	2.1	2.1	
Histidine	0.6	0.7	0.6	0.7	0.7	0.6	0.8	0.7
Isoleucine	1.3	1.4	1.1	1.3	1.4	1.5	1.6	1.0
Leucine	2.0	2.3	1.8	2.0	2.1	2.5	2.5	1.5
Lysine	1.9	2.4	1.7	2.1	1.7	2.4	2.5	2.1
Methionine	0.8	0.9	0.6	0.8	0.8	1.0	0.9	0.5
Phenylalanine	1.1	1.2	0.9	1.1	1.1	1.3	1.4	2.0
Proline	2.0	2.2	2.0	1.8	2.0	1.7	1.8	0.8
Serine	1.5	1.7	1.2	1.3	1.4	1.4	1.4	
Threonine	1.2	1.5	1.1	1.3	1.4	1.4	1.5	
Tryptophane								
Tyrosine	0.9	1.1	0.7	0.9	1.0	1.1	1.1	
Valine	1.4	1.7	1.2	1.4	1.5	1.7	1.8	1.5

[1]Requirements for chinook salmon.
Source: Halver, J. E. 1961. A big role for vitamins and amino acids. U.S. Trout News 6(4).

Table 2. Fatty acid composition of diets as percent of fat in diets[1]

Chain length	Flat-fish	Cod	Visc. dogfish	Salmon carcass	Whole Dogfish	Herring	Oregon Moist Pellet
14:0	7.4	2.2	1.3	3.3	1.6	5.1	11.6
16:0	10.0	14.5	15.2	20.6	10.2	14.5	9.9
16:1	11.3	6.3	7.7	8.1	10.2	7.0	6.1
18:0	3.5	2.3	3.8	3.0	3.6	4.1	2.7
18:1	20.9	24.7	25.5	25.3	22.7	17.2	11.8
18:2	11.7	7.1	5.3	6.9	5.1	5.1	5.9
16:3+18:3	-	1.7	1.3	1.9	5.1	2.7	3.8
20:0	1.7	0.9	1.3	1.1	2.3	2.5	2.6
20:1	3.4	4.0	3.2	4.3	3.4	10.0	8.6
20:4	1.4	1.5	2.3	0.5	1.6	0.4	-
22:0	17.2	14.2	13.3	9.7	15.7	11.3	14.8
22:1	-	1.7	2.7	2.0	2.7	9.0	11.6
22:3	-	0.5	0.7	-	0.5	1.3	-
22:6	7.9	15.3	14.2	11.4	13.2	8.7	8.6
24:0	3.1	2.2	2.0	2.4	1.6	1.0	-

[1]Analysis were carried out at the Fish Nutrition Laboratory, Cook, Washington, Courtesy of Dr. J. E. Halver, Director.

Table 3. Summary of results of coho salmon fry fed fish processing by-products as the main protein source for 12 weeks (Temperature 10.5° C)

Diet	Length (cm)			Weight (g)			Condition Factor[1]	Mortality		Food			Mercury in fry (ppm)
	Initial	Final	% gain	Initial	Final	% Gain		No.	%	Fed (g)	Efficiency factor[2]	version[3]	
Flatfish	3.5 0.36	6.7 0.49	90	0.46 0.13	3.7 .91	700	1.2	26	1.4	7600	0.80	1.3	0.09
Cod	3.6 0.41	6.9 0.51	87	0.49 0.19	3.9 0.92	708	1.2	29	1.5	7600	0.86	1.2	0.11
Viscerated dogfish	3.5 0.39	6.1 0.45	69	0.57 0.15	2.8 0.66	451	1.2	36	1.9	7600	0.53	1.9	0.40
Salmon carcass	3.6 0.33	6.8 0.51	82	0.47 0.17	3.5 0.90	656	1.2	34	1.8	7600	0.76	1.3	0.06
Whole dogfish	3.6 0.36	6.0 0.51	67	0.45 0.14	2.6 0.70	496	1.2	53	2.8	7600	0.55	1.8	0.24
Herring	3.6 0.40	6.9 0.51	97	0.48 0.15	4.2 1.11	763	1.2	19	1.0	7600	0.91	1.1	0.06
Oregon Moist Pellet	3.6 0.38	6.4 0.49	80	0.47 0.14	3.2 0.83	534	1.1	37	2.0	7600	0.61	1.6	0.03

1. $= \frac{W100}{L^3}$ where W = weight in g
L = total length in cm

2. $\frac{\text{Total weight gain}}{\text{Total weight of food fed}}$

3. $\frac{\text{Total weight of food fed}}{\text{Total weight gain}}$

The ranking of the diets purely from a nutritional point of view was herring, cod, flatfish, salmon carcass, OMP, and dogfish. However, from an economic point of view it is three times as expensive to use OMP to produce 1 lb of fish as it is to use any of the other diets, except dogfish. It costs about 130 percent more to produce 1 lb of fish when using OMP instead of dogfish (Table 4).

Studies of these types have immediate applications to management, because fish processing waste represents a potential source of less expensive nutrients of considerable value to coho salmon, especially with fish meal decreasing in supply.

Table 4. Average feed costs per pound of fish gain

Diet	Feed cost per lb (cents)	Feed cost/ fish gain (cents)	Ingredient	Cost per lb dry wt basis[1] (dollars)
Herring	14.6	16.05	Dogfish or herring	0.14
Cod	11.6	13.92	Other fish scraps	0.10
Flatfish	11.6	15.08	Bulgur fines	0.05
Salmon carcass	11.6	15.08	Hull-less oatmeal	0.05
Whole dogfish	14.6	26.28	Wheat germ	0.15
Eviscerated dogfish	14.6	27.74	Whey	0.09
Oregon Moist Pellets	30.0	48.00	Kelp Meal	0.10
			Bio-dry shrimp meal	0.14
			Choline chloride	0.22
			Vitamin premix	1.25
			Rhozyme B-6	1.18
			Butylated hydroxytoluene	10.00
			Butylated hydroxyanisole	10.00

[1]Costs are as of February 1, 1974 at Seattle, Washington

COMPARATIVE NUTRITIONAL CHARACTERISTICS OF FILLET CARCASS WASTE TO FISH

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Expanding aquaculture programs of state, federal, and private agencies have created a demand for a wider ingredient base for fish rations. The most important of these ration ingredients would encompass a protein source. Fluctuating supplies and cost of fish meal have further accentuated this need. Among the protein sources not yet extensively used by aquaculturists is the bottom or trawl fish scrap. In 1968 over 57 million lb of sole, flounder, cod, lingcod, and rockfish were landed in Oregon and Washington. Approximately 70 percent is fillet scrap, giving us a theoretical 40 million lb of waste. Presently this scrap is being used by mink farmers, pet food manufacturers, reduction plants, and by a small but increasing number of processors who are upgrading the waste for human consumption. The present price for this scrap on the mink market is 2 cents/lb. Though this price may be attractive detailed nutrition studies on the use of fillet scrap in a fish ration have been limited. In this study fillet scrap of Dover sole (*Microstomus pacificus*), true cod (*Gadus macrocephalus*), English sole (*Parophrys vetulus*), petrale sole (*Eopsetta jordani*), lingcod (*Ophiodon elongatus*), and yellowtail rockfish (*Sebastes flavidus*) were used as protein sources and compared to whole turbot and herring meal.

The fish used in the feeding experiment were rainbow trout (*Salmo gairdneri*), Mt. Shasta strain, that were randomly distributed into two lots per treatment. Each treatment of 100 fish was held in 3-ft circular tanks supplied with 12.5° C well water at 5 gpm. The tanks were located indoors and were illuminated by artificial light.

The rations were formulated to contain 35 percent protein, 18 percent fat, and 30 percent starch dry weight. Seventy percent of the total protein was provided by the herring meal and 30 percent by the test protein. The rations were fed twice daily, five days a week on a comparative dry weight basis for a period of 14 weeks.

These results indicate that in general whole turbot, petrale sole scrap, and herring meal protein sources are somewhat nutritionally superior in the parameters examined. The fillet scrap from the other species, with the exception of the yellowtail rockfish, appear to be of sufficient quality as to be an alternate source of protein. Yellowtail rockfish scrap is lower in nutritional effectiveness but not substantially so.

It may be noted that machine separation of the carcass waste could markedly improve the quality of the protein. In protein efficiency ratio studies with rats (Crawford, Law, and Babbitt 1972) significantly higher values were obtained for the separated flesh fraction.

REFERENCE

Crawford, David L., Duncan K. Law, and Jerry K. Babbitt. 1972. Nutritional characteristics of marine food fish carcass waste and machine-separated flesh. Agri. Food Chem. 20(5):1048-1051.

A TEST OF "SALTY HERRING MEAL" IN OREGON PELLETS

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and

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During the recent fish meal crisis, our feed manufacturers asked us if they could use the so called "salty herring meal" in Oregon Pellets. Although considerable quantities of the salty meal were available, we insisted, with very little basis at the time, on keeping a 3 percent sodium chloride restriction on the meal. This maximum 3 percent salt restriction came from the Official Publication of the Association of American Feed Control Officials, which states for fish meal ..."If it contains more than 3% salt (NaCl), the amount of salt must constitute a part of the brand name, provided that in no case must the salt content of this product exceed 7%."

"Salty herring meal" results from use of herring which have been salted to aide a roe extraction process, the roe being sold for human consumption. The salt retards bacterial spoilage, but the carcasses may have undergone some degree of decomposition.

We obtained samples of "salty herring meal" with sodium chloride levels of 4.9 percent, 7.6 percent, and 12.4 percent. We tested them in Oregon Pellets fed to chinook salmon for 15 weeks. Dietary sodium chloride levels were 1.0 percent in a control using regular herring meal; and 1.6 percent, 2.9 percent, and 4.2 percent when the salty meals were used. The diets were formulated to be isonitrogenous in regard to fish meal protein. The fish averaged 150/lb at the start. We used duplicate lots of 200 fish and results were evaluated by ranking.

Table 1 summarizes results. Responses with the same exponent letter did not vary significantly at the 5 percent level.

Table 1. Summary of results

Dietary NaCl (percent)	Mean weight gain (percent)	Feed conversion (as fed)	Hematocrit (percent)
1.0	497.6a	1.28a	37.0a
1.6	487.0a	1.25a	34.6a
2.9	404.7b	1.34b	35.8a
4.2	378.6c	1.42c	37.6a

In regard to weight gain, response from the diet with 1.6 percent salt (487% gain) did not vary significantly from the control (497.6% gain). The diets with 2.8 percent and 4.2 percent salt produced significantly less weight gain (404.7% and 378.6%, respectively) than the other two, with 4.2 percent salt being the worst.

Feed conversion showed the same picture as weight gain. The result from the diet with 1.6 percent salt was not significantly different from the control, while results from 2.9 percent and 4.2 percent salt were inferior, with 4.2 percent worst of all.

There were no significant differences in hematocrit. Only one mortality occurred, and that in a control lot.

The fish ate the higher salt diets with seemingly less enthusiasm than the control or 1.6 percent salt during the first 10 weeks, and feed consumption in percentage of body weight was down for the high salt diets during the first 5 weeks. However, I think feed conversion had as much effect on results as did feed consumption.

As a result of this work, we decided to keep the salt restriction on herring meal, with a maximum of 3 percent sodium chloride when used in Oregon Pellets.

FISH DISEASE

FISH HEALTH AND VETERINARY PRACTICE ACTS

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Aquaculture as a private industry is growing in the United States. Attendant disease problems are also growing as is the need for qualified persons to diagnose, treat, and certify fish as specific pathogen free. As the industry grows, the reliance on state and federal fish pathologists for help in solving fish disease problems will have to diminish. The industry will have to rely more on the private fish disease specialist. With this demand, increased entry of individuals into this field will undoubtedly take place.

The Fish Health Section of the American Fisheries Society has as one of its primary goals the establishment of a system of professional certification and registration for those working within the fish health field. The purpose of certification is to recognize professional expertise available in the field of fish health and to make this recognition available to public and private employers of fish health specialists. The proposed system would establish future educational requirements and tests for competency. Almost all professional groups have developed some system of self-regulation and recognition of competence for their own legal protection and for the protection of the public which they serve. It may also act as a safeguard from those who represent themselves as competent in a given field without recognition by their colleagues.

The need to certify those persons who practice fish medicine in the private sector is particularly important for at least two major reason. The first involves the potential danger to the fisheries resource of an area by the rapid spread of infectious agents throughout entire watersheds. Resource managers should be particularly concerned with this and should vigorously support programs that would define the educational requirements, the laboratory facilities and the professional ethics of those practicing fish medicine in the private and public sectors.

A second major reason for the certification of those practicing fish medicine stems from the fact that improper use of antibiotics and other chemotherapeutics in fish destined for human consumption has human health implications. Drug resistant pathogens resulting from improper use of antibiotics in the water supply may also be of concern to those responsible for domestic animal health.

One may then ask what the Veterinary Practice Acts have to do with individuals practicing fish medicine in the private sector. It was brought to my attention that in one western state, the practice of fish medicine is in fact mentioned specifically in the veterinary practice act through the inclusion of fish in the definition of animal. Examination of several other veterinary practice acts revealed that the term animal was defined as meaning "but not exclusive of" horses, cows, etc. A survey was conducted on a state to state basis to determine to what extent the practice of fish medicine was covered under existing veterinary practice acts. Although the survey is not complete, many of the western states have replied. It was the sole intent of this survey to define the extent of the inclusion of the practice of fish medicine under current veterinary laws. I felt that information of this type would be useful in the formulation of criteria for professional standards by the Fish Health Section and would be useful in defining needed changes in existing laws.

RESULTS

Although veterinary practice acts may vary from state to state, the typical law contains the following items:

1) Prohibits the practice of veterinary medicine and surgery except by those with a valid and existing license.

2) Defines the practice of veterinary medicine and lists exceptions and exemptions.

3) Gives an agency of state government the responsibility of approving schools and courses of study, determining qualifications of applicants for a license, administering examinations, and issuing licenses.

4) Specified fines and penalties for violations.

Although veterinary practice is generally thought of as pertaining to domestic mammalian and avian species, such is not the case according to the laws. The following definition of "animal," as used throughout the text of a typical practice act, reads:

> "Animal" means any animal other than man and includes fowl, birds, fish and reptiles, wild or domestic, living or dead.

Other state acts simply refer to the term animal, excluding humans, then list a number of animals and conclude with the phrase "but not limited to the following." Still other states refer to "domestic animals" only. Fish are animals according to Webster's Dictionary and according to most accepted zoological definitions. They may or may not be considered as domestic animals depending on interpretation.

Again, according to definitions contained in typical practice acts, "practice of veterinary medicine" means:

1) To diagnose, treat, correct, change, relieve, or prevent animal disease, deformity, defect, injury or other physical or mental conditions including the prescription or administration of any drug, medicine, biologic, apparatus application, anesthetic or other therapeutic or diagnostic substance--or to render advice or recommendation with regard to any of the above.

2) To represent directly or indirectly, publicly or privately, an ability and willingness to do any act described in subsection 3(a) of this section.

The following western states specifically include the term fish in the definition of animal: (1) Idaho (2) Colorado (3) Wyoming.

States referring only to the word animal without further definition include: (1) Oregon (2) Washington (3) Utah (4) California (5) Arizona (6) Nevada.

Interpretation as to the scope of including fish in those acts not specifically using the term fish, is subject to question. As most laws are interpreted, a broad term is inclusive unless exceptions are specifically mentioned. Animal is considered, by practice act administrators or others answering the questionnaire, to include fish for the purpose of the practice acts in the following states: (1) Oregon (2) Nevada (3) California (4) Washington. Utah did not comment and Arizona and Alaska did not feel fish were included.

Most state Veterinary Practice Acts also have the following exceptions:

1) Any person who practices veterinary medicine surgery or dentistry upon any animal owned by him and the employee of any such person when the practice is upon an animal owned by his employer.

2) Any person who is engaged in bona fide and legitimate medical, dental, pharmaceutical, or other scientific research provided that any practice of veterinary medicine--is directly related to and a necessary part of such research.

3) Any state employee performing his defined duties.

CONCLUSION

The practice of fish medicine by unlicensed persons with or without monetary compensation may be a violation of several state veterinary practice acts depending on the explicit or implied definition of the term animal. Individuals treating state-owned fish for public agencies as part of their jobs or individuals treating their own or employers' fish would be exempt if this practice were part of his normal duties. Since these are general suppositions, one should consult the practice act pertaining to his locale for specifics.

It is probably unreasonable to think that most veterinarians administering veterinary practice acts insist that only licensed veterinarians may practice medicine on fish. Although veterinarians are trained in the broad concepts of medical practice, most are not prepared academically to deal with the unique problems faced by the fish culturist. Fisheries biologists and other professionally trained individuals who have worked with diseases of fish have an appreciation of the unique problems of the fish culturist, and have been the primary group responsible for fish disease research, certification, diagnosis, and treatment. It is also within this group that the majority of the interest in fish diseases lies.

To have the veterinary profession regulate the practice of fish medicine may be unpalatable to many within the fish health fraternity. However, the fact remains that the legal authority to regulate the practice of fish medicine in the private sector in many states unfortunately has been delegated to Veterinary Medical Examining Boards. It is doubtful at this time that most Boards would inhibit qualified fish health specialists from practicing fish medicine. However, there are exceptions now, and may be in the future, to this assumption.

To legalize the private practice of fish medicine, present laws will have to be changed or clarified in regard to fish through legislative process. However, substantial reason and/or public pressure may be necessary to institute such changes. Laws seldom are changed for the purpose of leaving a void. A second route would be to provide fish practitioners with a limited license under current veterinary practice acts. This has been indicated as a legal alternative by several states surveyed. However, the question asked by veterinarians responsible for the administration of veterinary practice acts and those veterinarians responsible for meat inspection and regulatory animal medicine is "what type of medical training do those who practice fish medicine receive?" "What type of individuals provide this service and what controls are available to assure that the public is protected from those not qualified or from those who might perform unethically?" This is of particular importance where human health or other animal health is involved. Those administrators responsible for the fisheries resource within various states should also ask themselves "How qualified are those individuals

who are diagnosing and reporting infectious diseases of fish within the private sector?" Veterinary practice acts were instituted many years ago with these types of questions in mind, but mostly as they pertained to the livestock and poultry industries of the United States. Fish health specialists or fish pathologists should also recognize the need for professional recognition outside of their small fraternity. If the present laws are to be changed to legally recognize the expertise of the fish health professional, it will require a cooperative effort from both the fisheries profession and the veterinary profession. A system of professional certification under the Fish Health Section of the American Fisheries Society would be the first step in this cooperative effort. Without such a program within the fish health profession itself, there can be no hope of recognition of professional competence and responsibility by those responsible for human and animal health in the United States. Without support by these individuals, laws that would legalize, through licensure, the practice of fish medicine would be difficult if not impossible to change. Without this legal recognition, the fish practitioner may be liable for losses attributable to "malpractice," have no legal basis for collection of fees, or conceivably be legally prohibited from the practice of fish medicine (Hannah and Storm 1965).

Fishery biologists have been slow to develop formalized and legal standards for their profession. This may be a result of the diversity of talents and potential routes of entry into fisheries work. It may also be related to the fact that most biologists are state or federally employed, and hence, in practical terms, may be inhibited in any attempt to have input into legislative or administrative process. It is also possible that persons in fisheries work are dispositionally too "free spirited" or too independent to accept any suggestion to restrict their activities via a "license to practice." The concept of licensure or certification of fish health specialists may arise deep-seated emotions and fears of disinfranchizement. However, for the protection of the resource and for the ultimate benefit of those who practice fish medicine, legal recognition should be established.

Change is in the wind and similar events are probably in store for other fisheries biologists, including those who conduct pollution bioassays. According to the American Fisheries Society's Water Quality Committee, a majority of resource agency respondents favored the licensing of pollution bioanalysts apparently because their decisions can have very important effects on the aquatic ecology, waste treatment costs, industrial growth, and society in general (Bouck et al. 1974). It is no less the case for those who practice fish medicine.

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PREVENTION AND CONTROL OF INFECTIOUS HEMATOPOIETIC (IHN) VIRUS DISEASE IN RAINBOW TROUT

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ABSTRACT

Two methods of control and prevention of infectious hematopoietic necrosis (IHN) in rainbow trout (*Salmo gairdneri*) were attempted. The first involved manipulation of water temperature, and the second, disinfection of eggs from carrier brood stock.

In the temperature experiments, the disease was controlled in infected fish by holding them at 17 C, but 3 of 18 fish were found to be carriers when evaluated 3 years later. Holding carrier fish at 15 C for 14 days before spawning did not prevent shedding of virus after fish were returned to 10 C.

In the disinfection experiments, prevention was achieved by treatment of virus contaminated eggs with iodophors (50 ppm iodine) combined with judicious isolation and disinfection program at a hatchery where carriers previously existed.

From this data, it appears that IHN disease can be prevented by disinfecting eggs and rearing the fry in virus-free water. Once fish become infected, no effective way of eliminating the virus has been found.

FURTHER EVIDENCE OF TWO STRAINS OF PATHOGENIC VIBRIOS IN SALMON IN PUGET SOUND

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The National Marine Fisheries Service has recorded the cultural, biochemical, and pathological characteristics of one strain of *Vibrio anguillarum* (isolate #775) in central Puget Sound. We also reported (Northwest Fish Culture Conference - December 1973) the occurrence of a seemingly different *Vibrio* that was first isolated in November 1973. This bacterium (isolate #1669) was first obtained from the kidney, liver, eye, and vent of moribund and freshly dead coho (200-500 g) in commercial and research pen-rearing areas in Clam Bay (central Puget Sound). The water temperature was approximately 10° to 11° C during the period of mortality.

The #1669 *Vibrio* required three to five days (at 22° C) to grow on trypticase soy agar as compared to 24 hr for the #775 isolate at the same temperature. Both the #1669 and #775 isolates are typical of the *Vibrio* group in that they are Gram-negative, motile, comma-shaped rods which are anaerogenic fermenters, are Kovac's oxidase positive and are inhibited by the vibriostatic compound, 0/129. They differ, antigenically, however, as shown by immunodiffusion tests and they differ in many biochemical culture reactions. Rabbit and salmon antisera were developed against these isolates and are routinely used in rapid slide agglutination and plate agglutination tests to determine serotypes of vibrios recovered from naturally-infected fish.

In June of this year, most of the experimental salmon held in salt water at the Manchester Aquaculture Experiment Station had been parenterally vaccinated against the #775 (*V. anguillarum*) isolate using a heat killed bacterin. In July, Pacific Ocean Farms (POF) began operation with approximately 280,000 cohos in net-pens at Rich Passage (central Puget Sound) which had also been parenterally vaccinated with a similarly prepared bacterin made from #775 isolate. Serving as a control for the vaccinated groups were NMFS fish held over winter which had not been vaccinated and also nonvaccinated chinook being reared by the Washington State Department of Fisheries at Clam Bay.

Subsequent monitoring of these various fish populations showed *Vibrio* with characteristics of #775 isolate caused substantial mortality in both the nonvaccinated NMFS fish held over winter and in the chinook (nonvaccinated) being reared in the same general area by the Washington

State Department of Fisheries. On the other hand, the monitoring (of #775 vaccinated fish) at POF has shown no mortalities from #775, but rather a low level mortality caused by a bacterium identified as characteristic of #1669. Assay of serum agglutinating antibody in POF's fish and in NMFS's vaccinated fish indicates that as titers against #775 *Vibrio* drop, the incidence of #1669 infection increases.

On August 1, 1974, we transferred 450 sockeye smolts to salt water net-pens at Manchester. One pen contained 150 nonvaccinated control fish, and two pens contained equal lots of sockeye vaccinated with the heat-killed #775 bacterin. Ninety-eight percent of the nonvaccinated sockeye died within the first 50 days, primarily from *Vibrio* with characteristics of #1669. Mortalities in the vaccinated lots were only 8 percent and 24 percent (Fig. 1). Losses in the vaccinated groups have climbed steadily, and by mid-November 1974 had reached approximately 37 percent, all from the #1669 *Vibrio*. These field data from NMFS and the POF production operation suggest some degree of cross-protection from the #775 vaccine against #1669 pathogen. Further laboratory and field studies are underway to clarify this point.

Another pathological condition that could be a potential problem in salt water culture has shown up frequently in production chinook and coho this year. It is evidently a result of some liver function defect and appears as an obvious gall bladder condition. The bile is condensed into a caseous (cheese-like), sometimes gritty material, white to yellow in color. Dr. Bruce McCain (University of California at Davis working at the Northwest Fisheries Center) conducted a virological examination of the affected fish and found no cytopathic effect on his chinook cell line. Additional studies are in progress.

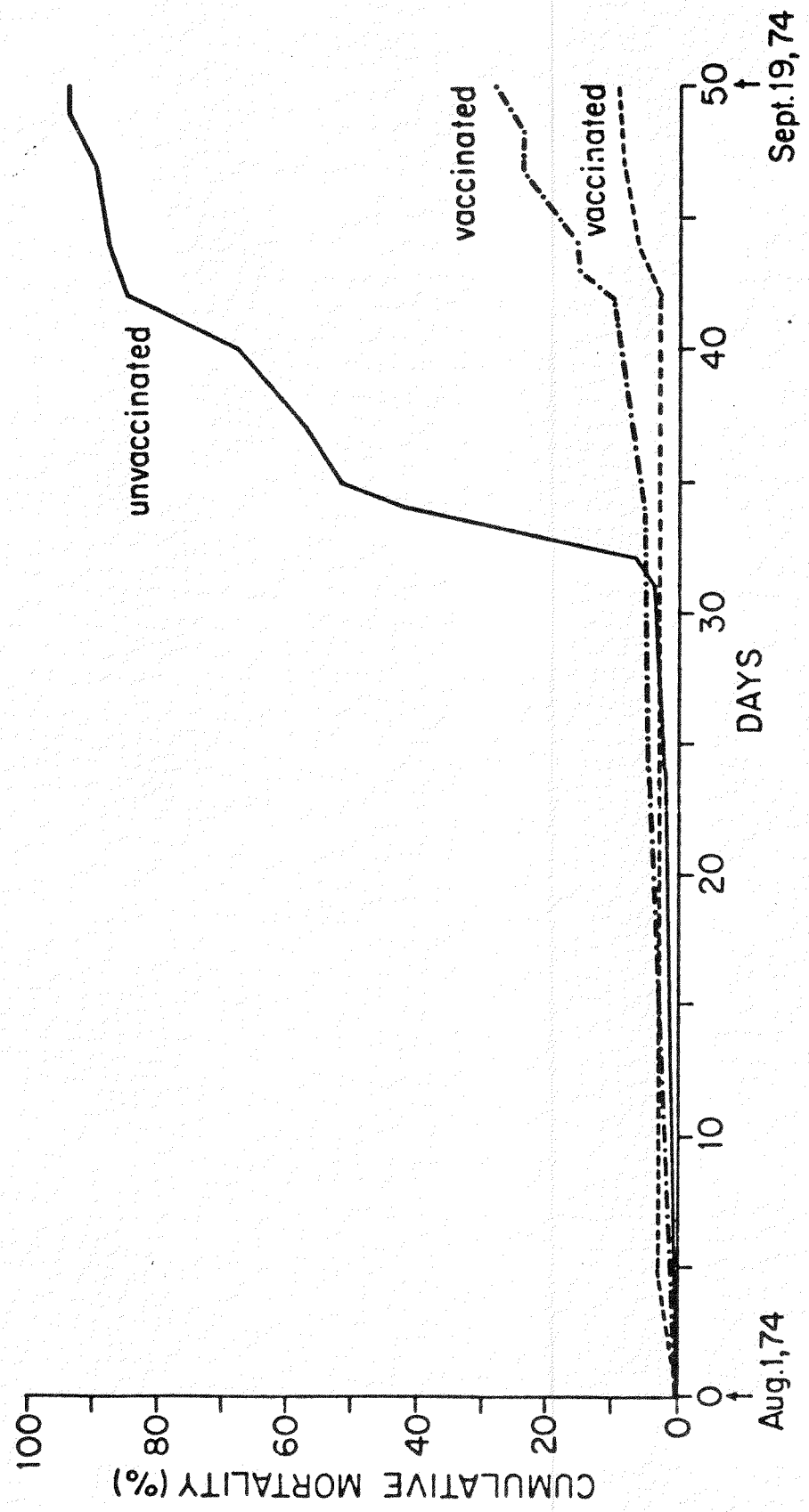

Fig. 1. Cumulative mortality of sockeye smolts at Manchester. Heat killed #775 bacterin-vacinnated lots show mortalities of 8 percent and 24 percent.

KIDNEY DISEASE POSTORBITAL LESIONS IN CHINOOK SALMON

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INTRODUCTION

Corynebacterial kidney disease (KD) is enzootic at both the Little White Salmon National Fish Hatchery in Cook, Washington, and the Carson National Fish Hatchery in Carson, Washington. Mortalities average 2.5 percent or less in the stocks of spring chinook salmon prior to release at each facility. The majority of the moribund fish display the characteristic gross symptoms of KD, i.e., low grade exophthalmos, distended abdomen due to ascitic fluid, and gray pustules in the kidneys upon dissection. During the fall and winter of 1973-1974, small numbers of yearling spring chinook salmon (0.5% or less) in the same raceways exhibited gross exophthalmos in one or rarely both eyes. A histological investigation was undertaken to determine the cause of the exophthalmos.

METHODS

The eyes, kidneys, liver, and spleen of four exophthalmic fish were preserved in Bouin's fixative and stained with hematoxylin and eosin, Wolbach's modified Giemsa (Lillie 1948), Ziehl-Neelsen's Acid Fast, and a new tissue Gram stain (Brown and Hopps 1973). Preliminary examination indicated bacteria involvement, after which additional fish were sampled. Blood smears and tissue imprints of the postorbital tissue, kidneys, liver, and spleen were made and stained with both Leishman Giemsa and the Gram stain. In addition, similar tissues were fixed in Bouin's for further histopathologic study.

Frozen exophthalmic fish were sent to Dr. G. L. "Pete" Bullock of the Eastern Fish Disease Laboratory, who cultured postorbital material and conducted Ouchterlony gel diffusion tests (Chen et al. in Press) for positive identification.

Exophthalmic fish were also held in aquaria at the Little White Salmon National Fish Hatchery to determine the duration of the condition.

RESULTS

Upon dissection the postorbital region contained a mass of grayish white tissue and small amounts of bloody-purulent fluid. The eye itself was either greatly distended or ruptured, depending on the duration and degree of exophthalmos. The ocular muscles were either degenerating or destroyed, causing the eye to protrude markedly.

Fresh imprints of the postorbital tissues revealed large numbers of Gram-positive diplobacilli. In most cases imprints of the other tissues from the same fish failed to demonstrate bacteria; however, in terminal cases of moribund fish, the kidneys and spleen were swollen and contained Gram-positive diplobacilli.

Dr. Bullock's bacterial cultures were unsuccessful but the Ouchterlony test showed bands of identity formed between the wells with optic lesion homogenate and wells with soluble KD antigen, a positive identification of corynebacterial KD. No precipitation bands were formed with kidney homogenate from the same fish.

Gram and Giemsa stained postorbital tissue sections revealed large numbers of diplobacilli, many of which had been phagocytized by macrophages and neutrophils. The bacteria were Acid Fast negative.

Histologically, the lesions were chronic granulomas as described by Wood and Yasutake (1956). Distinct nodules of hypertrophied fibroblasts (epithelioid tissue) were often present among the more diffuse fibrous elements. Large numbers of macrophages and some neutrophils and lymphocytes were present within the connective tissue framework. Blood vessels were common throughout the granulomas but apparently were insufficient to supply the mass of tissue since large necrotic areas were present in most lesions. Ocular muscles were infiltrated by inflammatory cells, with some lesions exhibiting shrinking, necrosis, and almost total destruction.

The fish held in aquaria became moribund and died periodically over a period of two months. In each case the disease had become systemic and numerous Gram-positive diplobacilli could be found in the kidneys and spleen, in addition to the postorbital region.

DISCUSSION

Previous studies (Wood and Yasutake 1956) indicated that granulomatous tissue formed behind the eye during the terminal stages of KD, but the present study indicates that the postorbital region can serve as a primary site of infection for *Corynebacteria* sp. in spring chinook salmon, and that massive granulomatous lesions occur postorbitally before the disease becomes systemic. The fish are apparently capable of isolating the bacteria in the postorbital site for considerable periods of time. The predisposing factors allowing bacterial entry at this site are unknown, as is the incubation period required to produce gross exophthalmos.

The inability to detect KD antigen in the kidneys of fish exhibiting gross exophthalmos emphasizes the importance of recognizing this aberrant site for KD. Fish with postorbital KD may serve as carriers and remain undetected by routine diagnostic procedures.

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THE IMMUNODIAGNOSIS OF BACTERIAL KIDNEY DIEASE

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A gel diffusion method devised by P. K. Chen and G. L. Bullock for detection of bacterial kidney disease (KD) was described. A rabbit anti-KD serum was employed to detect a soluble antigen in fish kidney tissue. The soluble antigen was detected in KD-infected fish and in KD-bacteria cultures, but was not found in uninfected fish or in cultures of *Ameromonas liquefaciens*, *A. salmonicida*, *Vibrio anguillarum*, the causative agent of redmouth disease, *Corynebacterium diphtheriae* strains *gravis* and *mitis*, *C. hofmanni*, *C. xerosis*, or *C. diphtheriae* ATCC reference strain 19409.

This technique was found to be more sensitive and reliable than either the kidney smear or culture methods for detection of KD.

ORAL AND PARENTERAL IMMUNIZATION OF FISH FOR THE CONTROL OF VIBRIOSIS

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ABSTRACT

Efficacious vaccines have been developed for the control of *Vibrio anguillarum*, the etiological agent of vibriosis in salmonid fish. These bacterins can be administered either orally or parenterally. It was determined that both formalin-killed lyophilized whole cells and wet-packed whole cells of the organism are effective oral immunogens. Intraperitoneal injection of 0.1 ml containing 2×10^8 formalin-killed bacterial cells suspended in saline and mixed with Freund complete adjuvant is capable of providing protection to fish exposed to natural challenge with *V. anguillarum*.

Several parameters under which the oral vaccine can be effectively used were examined. These investigations revealed that protection is provided to fish vaccinated for 15 days with a ration containing 0.5 mg of the wet whole cell vaccine per gram. Increasing the number of days the vaccine was fed to as many as 45 days did not increase the degree of resistance in immunized fish. Decreased mortality was also not observed in groups of fish fed a diet containing higher concentrations of vaccine. Other studies demonstrated that oral immunization of fish can be successfully accomplished at water temperatures ranging from 4° to 21° C.

MORTALITIES OF PEN-REARED SALMON ASSOCIATED WITH BLOOMS OF MARINE ALGAE

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The objective of the pilot fish farm project at the Pacific Biological Station is to test the feasibility of culturing salmon to market size under conditions applicable to the Pacific coast. This year has been our first full-scale production experiment and our goal to market a total of 50,000 lb of sockeye, chum, and coho (1/2-3/4 lb each) would have been attained but for heavy mortalities particularly of stocks held in pens at Departure Bay. A substantial portion of the mortalities appeared associated with certain algal blooms, the subject of this paper.

As also occurred in the fall of 1973 the gills of the dead fish were covered with an olive-green scum, and the gill lamellae were surrounded with diatomaceous algae most notably, and other microscopic cells. The high concentration of *Chaetoceros* spp. with their numerous pointed and barbed "whiskers" or setae suggested once again that this type of alga might be responsible for the mortalities. It had previously been found by one of us (Bell) that the rigid, siliceous spines (setae) of *Chaetoceros convolutus* could penetrate the gills of aquarium-held lingcod (*Ophiodon elongatus*) and it was speculated that this type of alga damaging the gills might have led to observed mortalities of lingcod in commercial, floating pens, and in laboratory aquaria (*Nature*, Vol. 192, p. 279, 1961). However, there the matter was dropped to await further field investigation by marine biologists. Was this merely an oddity of the laboratory or was it a significant natural phenomenon? Accumulated evidence from our own work and the experience of others such as reported by Lee Harrell at this conference last year, and in the Special Report (October 10, 1974) by Jim Fraser induced us to obtain and examine field data concerning the concentration and distribution of *Chaetoceros* spp. near the pens and to conduct some laboratory tests.

But first of all the circumstances and details of the 1973 and 1974 mortalities are given in Table 1. At the time that mortalities were occurring, many fish were seen crowding the corners of the net near the surface, breathing rapidly, and gasping continually. Their behavior suggested oxygen deficiency but oxygen concentrations at various levels in the pens were at, or near saturation. By October 28 we had lost about one-fourth of our sockeye stock, and fish were still dying. On

September 25, 1974 routine plankton sampling in the vicinity of the pens revealed the presence of *Chaetoceros decipiens*, and to a small extent *Chaetoceros debilis*, as important components of the sample but no *C. convolutus* the more substantial and damaging appearing species, were found. On October 2 there were 20 *C. convolutus* cells/liter and these increased to 8,360 cells/ liter by October 23 after which heavy mortalities occurred, even though the water appeared remarkably clear (Secchi disc reading 7.5 m). On October 30 when the intensive mortalities had passed, *C. convolutus* concentrations at the surface and at 85 ft in the vicinity of the pens were 3,680 cells/liter and 2,180 cells/ liter respectively. By November 7 these values were approximately 650 cells/liter at both depths and mortalities had dropped to almost nothing. Surface water temperatures of around 9° C were tending to decrease at the end of October and the beginning of November.

Table 1. Mortalities of sockeye salmon held in floating pens during fall algal blooms in Departure Bay (About 300 fish/day at the peak of mortalities.)

Mortalities/week		
Percent	Cumulative numbers	Average weight (g)
	1973 September 12 - October 9	
18	180	27
	1974 October 24 - November 5	
37	1,080	60

In the meantime we set up an experiment to see if plankton collected from Departure Bay did indeed kill fish and if so, to learn something of the mechanism involved. Sockeye averaging 47 g and coho fingerlings averaging 12 g exposed in two tanks to 1.27×10^6 *Chaetoceros* cells/liter (75 g wet weight plankton added to 180 liters) and 7.1×10^5 cells/liter, had all died within 1.5 and 7 hr respectively. (Concentrations such as these were reported as occurring in nature by E. A. Cupp [Bull. Scripps Institution of Oceanography, Tech. Series, Vol. 5, 1950.]) A volume of plankton "soup" equivalent to that used to obtain the higher concentration of cells was filtered to remove particulate matter >0.8 mμ and then added to a tank of fish. No deaths occurred. Nor did cell-free sonicates of the particulate matter kill any fish. It appeared then that the lethal effect of the plankton was not due to chemical toxicity. Finally, an aliquot of plankton was digested in hot nitric acid, neutralized and the undigested silica "husks" of diatoms added to a tank of

fish to give a final concentration of *Chaetoceros* calculated to be ca. 7×10^5 cells/liter. Mortalities were slow in occurring but within 24 hr 4/6 sockeye and 2/5 coho were dead. By 72 hr 5/6 sockeye and all coho were dead. Mortalities would probably have been more rapid and higher but the undigested "husks" tended to float and aggregate even when the water was continuously mixed, thus reducing contact with the fish. Fish exposed to control preparations of boiled, neutralized nitric acid suffered no mortalities.

Our results suggest that barbed algae can cause mortalities of captive sockeye and coho salmon - perhaps salmonids generally, and other fishes - when the fish are exposed to high concentrations of cells. Since the heaviest mortalities of fish in our pens occurred after net scrubbing or changing, it is possible that fish were exposed to concentrations of cells much higher than the approximately 3,600-8,300/liter (surface), the highest found this year in the Bay during the late October bloom. The barbed algae might act by physically damaging the gill lamellae, and examination of histological sections supports this suggestion; by irritatively causing suffocating mucus production, or by both.

Why do similar kills not appear to occur in nature? Perhaps fish and algal bloom never meet, or perhaps the less sedentary wild fish keep their gills better flushed so that algae don't accumulate.

1974 *CERATOMYXA SHASTA* STUDIES AT THE PELTON PROJECT, DESCHUTES RIVER, OREGON

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Observed *Ceratomyxa shasta* mortalities of rainbow trout and chinook salmon rearing in hydroelectric reservoirs of the Pelton project prompted studies of the effect of this parasite on native salmonids. All studies are in cooperation with, and under the supervision of, the Oregon Wildlife Commission. The purpose of studies in 1974 were twofold: First, to determine the effect of exposure period on the survival of Deschutes River stock spring chinook fingerlings. Second, to determine the location of the infective stage of *C. shasta* in Lake Simtustus, the reservoir behind Pelton Dam.

In the first experiment, approximately 100 chinook fingerlings were transferred the first of each month, March through July, into sixft circular tanks in the Pelton trap building which utilized pumped Deschutes River water known to be infective for *C. shasta*. Water temperatures at this point are moderated by two large hydroelectric reservoirs upstream (Fig. 1). In addition to these five groups, two were exposed to Deschutes River water for a period of time, removed to spring water, and returned to river water at the same time as two of the monthly groups.

Fish were fed medicated (TM-50) Oregon Moist Pellets and mortalities removed daily, when possible. Wet mounted material from the posterior large intestine of all mortalities was examined under 400x and fish determined positive for *C. shasta* if one or more spores could be found during five minutes of examination. Mortalities negative for *C. shasta* occurring before the mean date of positive mortalities in each group were not included in results. Those occurring after this data were counted as negative. This was done to minimize the effect of other mortality factors on results of the experiment. The experiment was terminated October 23 and survivors killed for future inspection.

The results are not complete, as survivors have yet to be examined for presence of *C. shasta*. However, observing the pattern of positive mortalities gives an insight into progress and extent of the disease in the different groups. Figure 2 shows cumulative positive mortality versus time for the five groups of chinook salmon. All groups suffered high losses from *C. shasta*. However, March, April, and May groups were less affected than those from June and July. Figure 3 shows the 95 percent confidence intervals for the final positive mortality rates for the five groups. It can be seen that intervals for April and May groups are below and do not overlap those of the June group. This agrees with results obtained in 1973 when a group exposed from April 23 was less

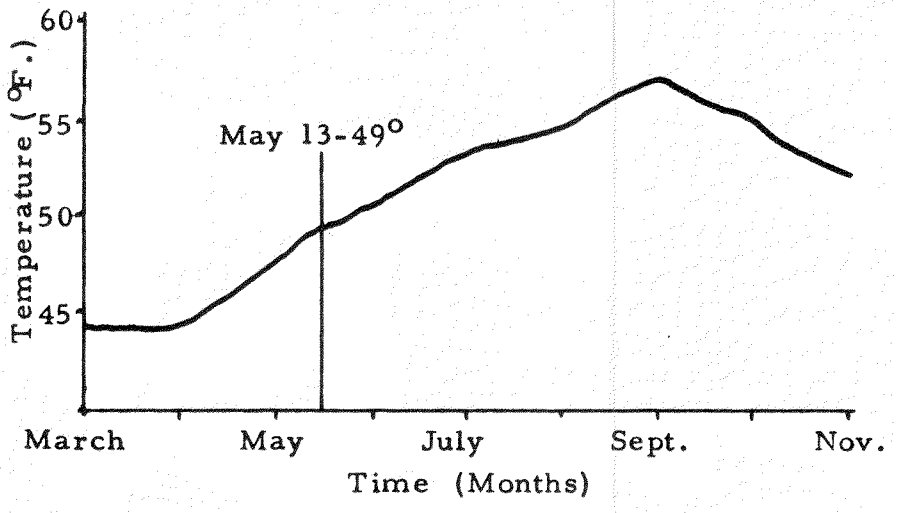

Fig. 1. Water temperature versus time.

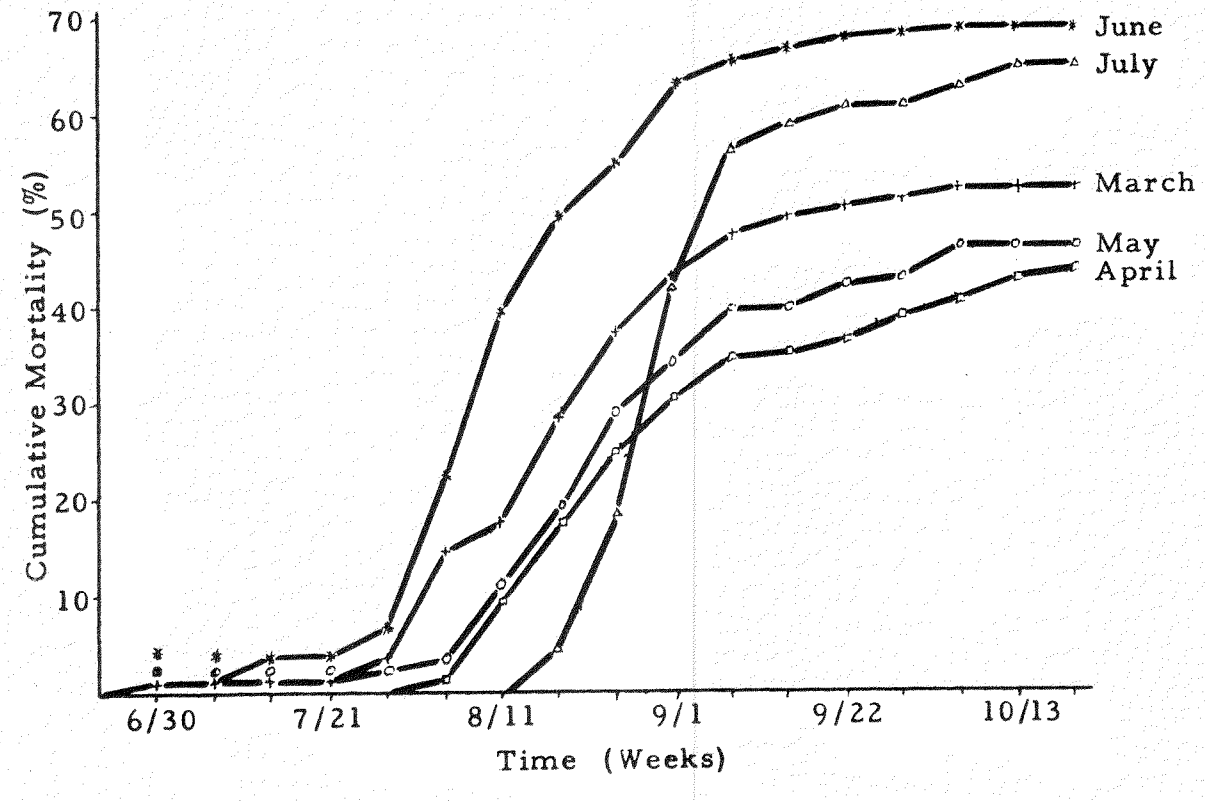

Fig. 2. Cumulative mortality versus time.

A. Kenneth Johnson

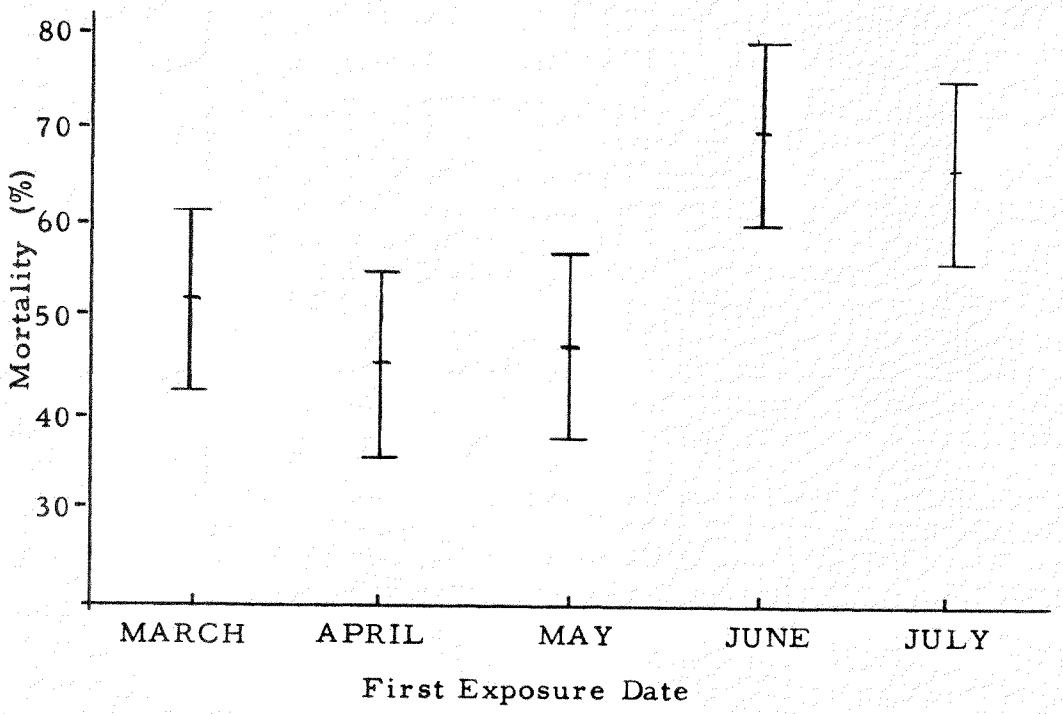

Fig. 3. Mortality versus exposure date, 95 percent confidence intervals.

affected than one exposed from June 8. It also agrees with the first infective date of May 13 of this year for Oak Springs stock rainbow trout moved once a week from these same tanks into noninfective incubation water (Fig. 1). Figures 4 and 5 compare June and July groups with those given prior exposure. In the first prior exposure group, 100 chinook were exposed to Deschutes River water for 27 hr on May 3 (48° F), returned to noninfected water at 50° F until June 1, then exposed with the June group. The second prior exposure group was exposed for 96 hr starting June 1 (50° F), returned to 50° F noninfective water until July 1, then exposed with the July group. In both cases, the group given the short prior exposure suffered least mortality. The 95 percent and 90 percent confidence intervals overlap in the first groups (June), but in the second groups (July), the 90 percent confidence intervals do not (Fig. 5).

Figure 6 summarizes the second experiment. Live boxes were placed on a rope at the levels shown. Oak Springs stock rainbow trout were finclipped, placed in the live boxes with noninfective water, and the boxes enclosed in plastic bags. They were lowered to depth and the plastic bags removed by divers. After a seven-day exposure (July 22-29), bags were replaced by divers, live boxes raised, and fish immediately transferred to the Willow Creek holding trough for incubation. This trough utilizes noninfective spring water varying in temperature from 65° to 72° F. These fish were fed and handled the same as the chinook. The experiment was terminated September 11 and survivors killed and preserved for possible future examination.

The results of the second experiment are summarized in Fig. 6. Trout in live boxes at the surface and 5 ft were negative. Fish in the 15-ft live box in the Willow Creek arm were negative, and only one of seven rainbows in the 15-ft live box in the main reservoir was positive. Fish in live boxes at 25 ft and below, as well as those below the reservoir in the Pelton tailrace and the Deschutes River, were positive. Fish exposed to Round Butte tailrace water at the head of Lake Simtustus died during exposure due to a valve malfunction. However, chinook salmon exposed at this location during 1972, and rainbow trout exposed in 1973 were negative, while fish exposed to river water below the project were positive.

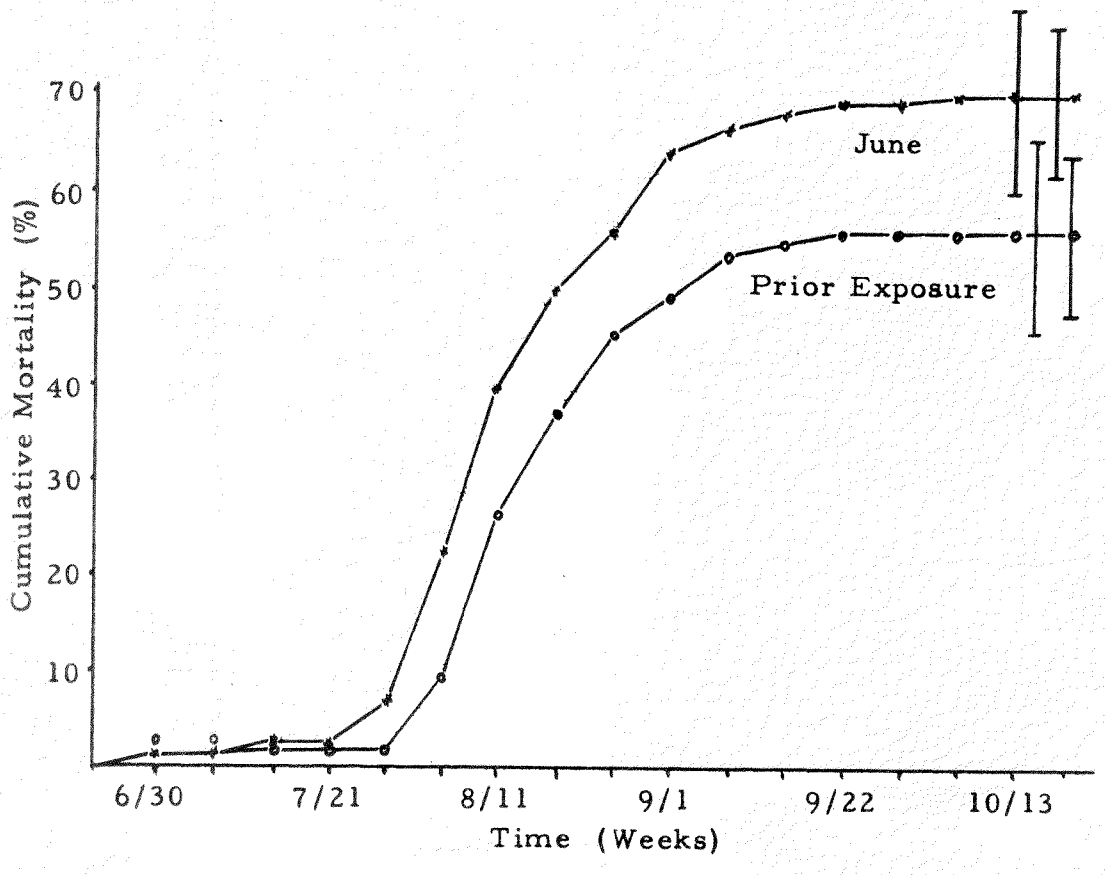

Fig. 4. Cumulative mortality versus time, June group and prior exposure group.

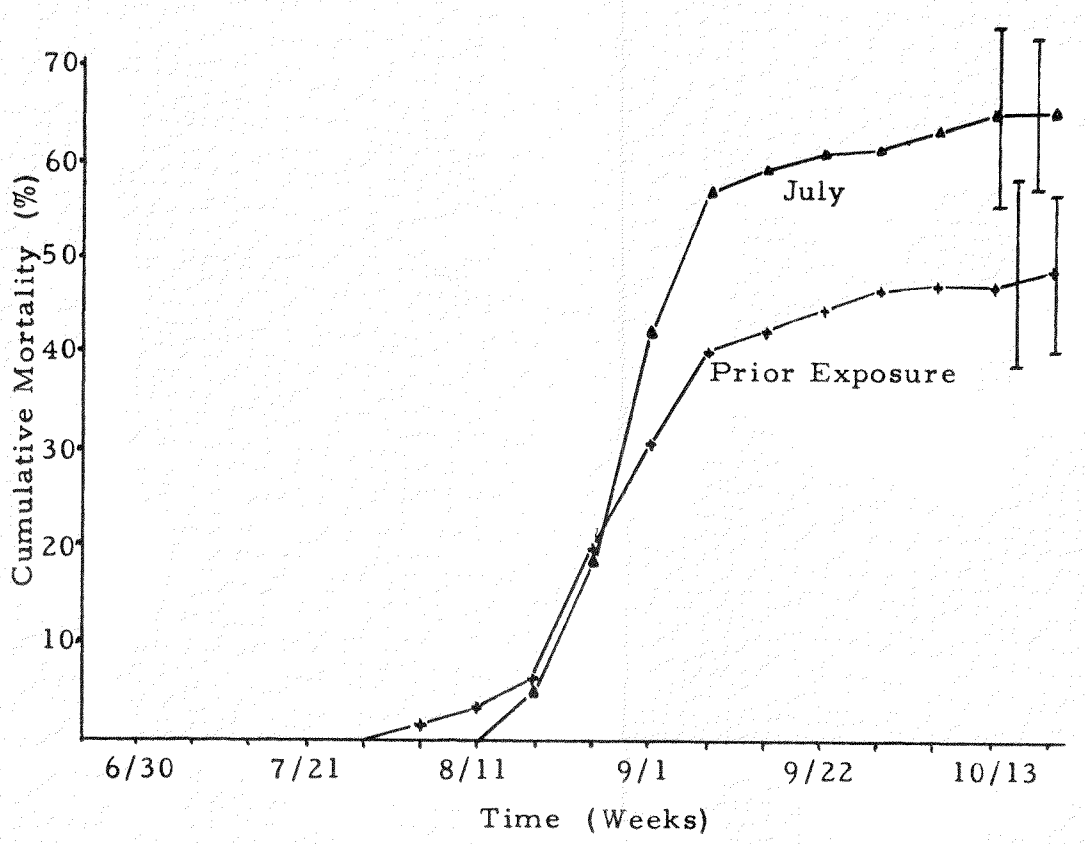

Fig. 5. Cumulative mortality versus time, July group and prior exposure group.

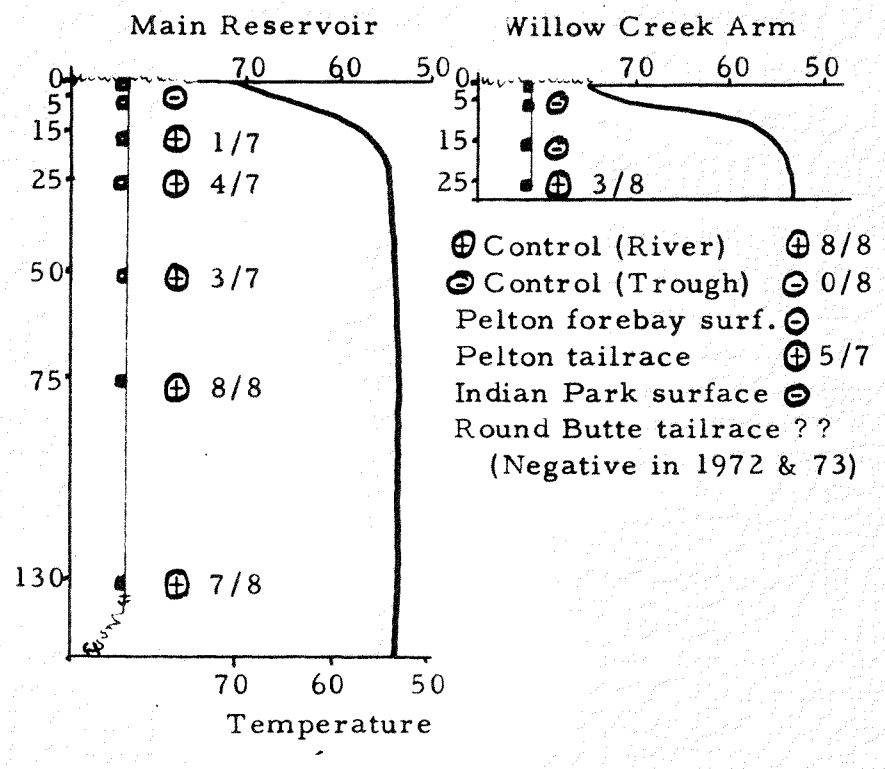

Fig. 6. Lake Simtustus 1974 vertical live box series data.

SURVEY FOR INFECTIOUS HEMATOPOIETIC NECROSIS VIRUS IN ALASKA SOCKEYE SALMON *ONCORHYNCHUS NERKA*

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Dr. Rucker predicted in the early 1950's the presence of sockeye virus disease in Cook Inlet, Kodiak Island, and Chignik on the Alaska Peninsula. Alaska Department of Fish and Game personnel requested assistance from the Western Fish Disease Laboratory (WFDL) to explain the loss of 93 percent of 100,000 Red Lake 1972 sockeye (*Oncorhynchus nerka*) juveniles their first spring. Infectious hematopoietic necrosis virus (IHNV) was detected by the WFDL in these moribund fish. Some of these eggs had been previously sent to Hokkaido University in Japan (now experiencing IHNV from these eggs). Red Lake 1973 sockeye alevins died at a rate of 99 percent of 1×10^6 eggs during the first winter/spring. IHNV was detected from moribund fish. In an attempt to determine the distribution of the virus in Alaska sockeye, this survey was attempted.

MATERIALS AND METHODS

The sampling of *O. nerka* was confined to mature females and males returning to parent streams in the summer and fall of 1974. Females were sampled exclusively where possible but otherwise males were included as dictated by weather, egg ripeness, or fish availability to achieve the 150 samples needed to detect a 2 percent incidence of disease carriers per population based on a 95 percent confidence level. A total of 16 fish stocks were inspected according to approved methods outlined by Amend, 1970.

Processing procedures utilized were similar to those of Amend and Wood (1972) with preliminary processing in the Anchorage State Fish Pathology Laboratory and final processing at the WFDL.

Ovarian and seminal fluid were collected in five-fish pools separately. Samples were transported on ice and decontaminated within 72 hr by centrifugation at 2,000 rpm/15 min, addition of penicillin/streptomycin mixture (1,000 μ and 1,000 mcg respectively) mycostatin (1,000 μ) and

gentimicin (1 mg) to sterile tubes containing 2.1 ml of sample fluid. Samples were retained at 22° C for 2 hr, then stored at 2-5° C and shipped on ice for final processing.

Fat head minnow cell cultures showing characteristic cytopathological effect (CPE) of IHNV were processed using passive hemagglutination for confirmation.

RESULTS

The geographical location of sample sites and the results of the survey are shown in Fig. 1 and Table 1. Percentage of 5 fish pools positive for IHNV ranged from 0 to 47.5 percent ($\bar{x}$ = 13.2%) for males and 6.7 to 94.1 percent ($\bar{x}$ = 44.0%) for females.

Sites showing highest incidences are in order: Frazer Lake 70.0 percent, O'Malley River 63.5 percent, Naknek Lake 62.1 percent, Lake Nunavaugaluk 54.2 percent and Karluk Lake beach spawners 53.3 percent. The lowest levels of virus were found in Lake Nerka beach spawners 6.7 percent, Red Lake 6.9 percent, Ualik Lake 13.3 percent, and Becharof Lake 16.7 percent. Four out of eight sites in which males were tested showed IHNV positive (Nunavaugaluk 47.5%, Karluk beach spawners 28.6%, Naknek Lake 16.7%, and Ualik Lake 8.3%). All 16 sets of females tested contained IHNV.

DISCUSSION

This initial IHNV survey exhibits an almost omnipresent distribution as represented in spawning females. Levels of carrier incidence vary considerably in both sexes. The different incidence levels between males and females have been found repeatedly by the junior author.

Salmon enhancement or rearing projects are either underway or planned in many of these locations including Lake Nunavaugaluk, Big Lake, Becharof Lake, Naknek Lake, Frazer Lake, Akalura Lake, and Eyak Lake. IHNV will certainly be one of the determining facts in the success or failure of these projects.

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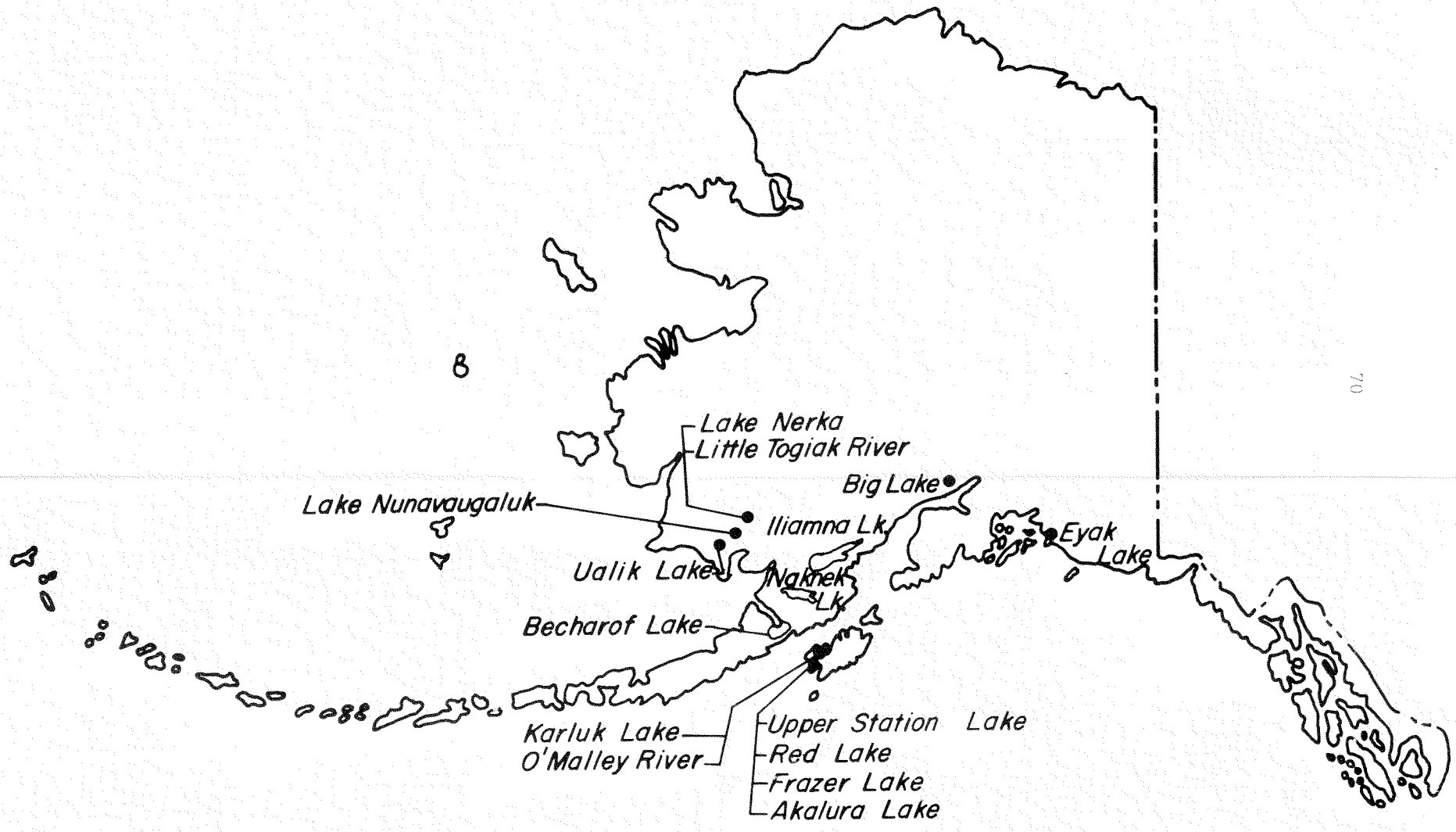

Fig. 1. Map of Alaska showing locations where adult sockeye were sampled for virus (IHNV).

Table 1. Alaskan sockeye salmon IHNV survey

Location	Male				Female				Total			
	Fish sampled		Positive for IHNV		Fish sampled		Positive for IHNV		Fish sampled		Positive for IHNV	
	No.	Pools	No.	%	No.	Pools	No.	%	No	Pools	No.	%
Red Lake	-	-	-	-	145	29	2	6.9	145	29	2	6.9
Frazer Lake	-	-	-	-	150	30	21	70.0	150	30	21	70.0
O'Malley River	-	-	-	-	150	30	19	63.5	150	30	19	63.5
Karluk Lake (Meadow Creek)	-	-	-	-	150	30	9	30.0	150	30	9	30.0
Karluk Lake (beach)	70	14	4	28.6	80	16	12	75.0	150	30	16	53.3
Akalura Lake	65	13	0	0	70	14	8	57.1	135	27	8	29.6
Upper Station Lake	-	-	-	-	145	29	9	31.0	145	29	9	31.0
Lake Nerka	-	-	-	-	150	30	2	6.7	150	30	2	6.7
Little Togiak River	-	-	-	-	145	29	8	27.5	145	29	8	27.5
Lake Nunavaugaluk	95	19	9	47.5	25	5	4	80.0	120	24	13	54.2
Ualik Lake	120	24	2	8.3	30	6	2	33.3	150	30	4	13.3
Naknek Lake	60	12	2	16.7	85	17	16	94.1	145	29	18	62.1
Iliamna Lake	-	-	-	-	150	30	15	50.0	150	30	15	50.0
Becharof Lake	95	19	0	0	55	11	5	45.5	150	30	5	16.7
Big Lake	95	19	0	0	45	9	8	88.9	140	28	8	28.6
Eyak Lake	45	9	0	0	105	21	14	66.7	150	30	14	46.7

REPORT ON THE CAUSE AND TREATMENT OF STEELHEAD MORTALITY AT THE WELLS DAM HATCHERY AND AT THE WASHBURN ISLAND REARING POND

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PROCEDURES

On September 2, 1973 Michael Albert, Superintendent of the Wells Dam Hatchery, noticed that his steelhead fingerlings being held in the rearing pond had stopped feeding and could be seen gathered in large clusters near the surface. Examination of a number of the fingerlings revealed that cataracts were present on the eyes. Wayne Brunson was notified on September 6, 1973. An initial examination of the fingerlings was made on September 8. Cause of the cataracts was traced to the strigeoid trematode *Diplostomum spathaceum* (Rudolphi). On September 11 through 13, the rearing pond was seined in an attempt to separate the remaining healthy fish from the blind fish. Approximately 80,000 fish were taken in this manner and transferred to one of the concrete raceways. The remaining 138,000 steelhead fingerlings were released into the Columbia River at the rearing pond sluiceway. The pond was then drained.

On September 18, snails were collected from the Wells Dam Rearing Pond and from the spawning channel where water from the Columbia River first enters the outside rearing facilities. Snails were also collected from the Washburn Island Rearing Pond.

Samples of steelhead fingerlings from the Washburn Island Rearing Pond, Wells Dam Rearing Pond, and raceways were examined for eye flukes. In addition, three whitefish, one carp, two suckers, and two sockeye salmon were examined for eye fluke at Wells Dam.

Four ring billed gulls (*Larus delawarensis*) were shot at Wells Dam and examined for the adult stage of the parasite.

On September 18, the rearing pond at Wells Dam was treated with chlorine (HTH) at 20 ppm in an attempt to kill the remaining snails in the pond.

RESULTS

Snails

Examination of snails from Washburn Island and Wells Dam resulted in the confirmation that *Lymnaea palustris* is the primary carrier of *D. spathaceum* at both installations. This is shown in Table 1. The incidence of infection in *L. palustris* at Washburn Island is probably higher as the nonrandom nature of snail selection probably did not reflect the true percent composition.

Table 1. Incidence of infection in snails

Location	Species	Number examined	Percent infection
Wells Dam (rearing pond)	*Lymnaea palustris*	20	25
	L. auriculariae	12	00
	Physa propinqua	2	00
Wells Dam (spawning channel)	*L. palustris*	35	00
	L. auriculariae	00	00
	P. propinqua	13	00
Washburn Island	*L. palustris*	25	08
	L. auriculariae	2	00
	P. propinqua	5	00

Sea Gulls

Infection of the adult stage of *D. spathaceum* was found in only one of four ring billed gulls examined. It is most probable, however, that all the gulls were infected. The inability to find it in other gulls was probably due to the lack of a dissecting scope. It was necessary to try and find organisms 1.5 mm to 2.5 mm long with a flashlight and the naked eye.

Steelhead Fingerlings

Wells Dam

All steelhead examined by Wayne Brunson from the lower portion of the rearing pond contained numerous eye flukes. Average intensity was 88 per eye. Steelhead swimming near the intake to the rearing pond appeared to be the most healthy fish remaining in the pond. Specimens from this area of the rearing pond revealed an average infection of only five per eye. As mentioned earlier, these fish were seined and transferred to a raceway in an attempt to save fish with lower infections. Of the fish saved in this manner, only 7,000 to 8,000 were remaining at the time of this report.

Steelhead that had not yet been placed in the rearing pond were checked in all of the raceways. No infections were noted.

Of three suckers examined, all possessed light infections of three to eight. Three whitefish examined possessed only one per eye. No eye flukes were found in the carp and sockeye salmon.

Washburn Island

Of 30 steelhead fingerlings examined at the Washburn Island Rearing Pond, all were infected. Average intensity was 90 flukes per eye. Maximum intensity was 232 per eye. Minimum intensity was 37 per eye.

CONCLUSIONS

The presence of both the definitive host (sea gull) and suitable intermediate hosts (*L. palustris* and *P. propinqua*) in and around the rearing ponds at Wells Dam and at Washburn Island have produced an enormous reservoir for the proliferation of *D. spathaceum*. The proliferation of the eye fluke within the rearing ponds has in turn led to the blinding or partial blinding of nearly all steelhead fingerlings kept within the rearing ponds.

Fish loss at Wells Dam this year can be attributed to two factors: (1) The number of steelhead reared in the pond was increased by 150,000 fish over last year's quota. (2) Steelhead fry exhibited a faster growth rate this season than in previous years. Both factors caused early crowding in the raceways and resulted in the placement of steelhead into the rearing pond on July 27 rather than late September as in previous years. This was important in that snails emit cercaria during the summer months when the the water temperature is warm. However, by September, the water temperature is falling and development of the cercaria within the snails is retarded until the following spring when the water temperature again rises. Placement of steelhead in the Wells Dam Rearing Pond on previous years in September had avoided the peak emissions of cercaria. However, placement of steelhead in the rearing pond in July had allowed sufficient time for the development of the sporocyst and emission of cercaria. This resulted in the massive infection of the steelhead fingerlings.

The situation at Washburn Island is similar in that the presence of snails and gulls in and around the rearing pond has allowed nearly a 100 percent infection of all steelhead. Placement of steelhead in the rearing pond in June insured that a maximum dose was obtained prior to a fall in the water temperature. Losses in previous years may have been a result of massive eye fluke infections.

RECOMMENDATIONS FOR MANAGEMENT

Wells Dam

In order to prevent future losses at Wells Dam, the following procedures should be followed:

1. Change the water supply from Columbia River water to well water. If not feasible:

2. Delay placement of steelhead within the pond until September when the development of cercaria is retarded.

3. Check the eyes of the fingerlings after the first month in the pond. Use a dissecting scope. If you wait until cataracts can be seen with the naked eye, it's too late to help.

4. After draining the pond, suitable treatment (i.e., HTH) should be administered to kill snails and their eggs. Do not refill until just prior to use.

5. In the future, all infected fish should be destroyed. Release of infected fish into the river only enlarges the reservoir for the parasite by infecting the numerous immature gulls that utilize the Columbia River basin. This could lead to mortalities at various lakes within the Columbia River basin and throughout the Pacific flyway. A sea gull may live 20 years. It is not known how long an adult *D. spathaceum* will live within the gull.

6. All raceways should be examined for the presence of snails and treated with potassium permanganate or formalin if snails are present.

Washburn Island

Eye fluke infection at Washburn Island is less likely to respond to treatment or preventative measures. The design and basic characteristics of the rearing pond encourage the growth of a large snail population. Eradication of the snails would be impossible due to the exclusive use of Columbia River water. In order to reduce eye fluke infection at Washburn Island:

1. Use of the rearing pond should be limited to September through May.

2. Treatment with 10 ppm bayluscide should be utilized before introducing fish during June, July, or August.

3. Fish should be checked periodically for signs of eye fluke infection.

It is recommended that all hatcheries utilizing rearing ponds be made aware of the preventive measure that can be taken.

We have been informed that the salmon hatchery at Rock Beach Dam downstream from Wells likewise has suffered excessive losses of salmon held in rearing ponds in the summer time. This same parasite has been implicated in mortalities, some serious, in at least eight lakes in Washington in the last five years and is probably more widespread than we realize.

METHODOLOGY

AN ELECTROFISHER FOR SORTING ADULT SALMON AND STEELHEAD

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Cole Rivers Hatchery
Oregon Wildlife Commission

As the use of drugs for anesthetizing fish is becoming more costly and restrictive, other methods of quieting fish were explored at Cole Rivers Hatchery.

CO_2 was first used and found to be rather toxic resulting in 25 percent to 30 percent mortality when the fish were quieted sufficiently for handling. A portable battery operated DC shocking unit was then tried and found to have some promise although fish coming in contact with the anode for an extended period of time often had broken vertebrae.

A larger Smith-Root Type VI Electrofisher was then installed with five anode rods suspended in the anesthetic tank, the rods being shielded with plastic pipe drilled with holes. Undoubtedly, the exposure time and voltage necessary to stun the fish would vary between waters. At Cole Rivers Hatchery, it requires 30 to 40 seconds at 425 volts to quiet the fish and they still have some movement when handled on the sorting table.

Approximately 2,500 adult spring chinook salmon and summer steelhead have been sorted using the electrofisher with no significant mortality. About 50,000 salmon eggs were taken from fish using the electrofisher with no excessive egg mortality and the fertilization was good. Some of the eggs have hatched and the fry appear normal.

SOME USES OF HATCH, A HATCHERY SIMULATION MODEL

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The State of Washington Department of Fisheries is currently using a computer simulation model, called HATCH, as a tool in helping to form management policies for its hatcheries. In this report I will briefly discuss the model and give an example of how it has been used.

Dr. Frederick C. Johnson, who programmed the model, describes it as "...an automated system for analyzing the physical, biological, and economic factors of fish hatchery operation."[1] Specific uses are numerous and include: computing the optimal policy under a given set of circumstances; helping to design new facilities; and as a pedagogical device for training hatchery managers or university students. It's most important use to date has been in comparing present policy to possible alternate policies such as adding new ponds, changing the stocks of fish reared, changing the proportions reared of the current stocks, or of altering the time and/or size of release.

Before using the model, one must provide the program with certain data. This data includes: physical factors such as the number and sizes of the ponds, water flow, and water temperature; biological factors such as species and stocks being reared, growth rates, survival rates, maximum allowable densities, and the timing of events such as egg take and ponding; economic factors such as capital investment, interest rates, the values of fish when caught, and the costs of supplies, maintenance, labor, food, and trucking; and fishery factors such as what proportion of the fish released are caught, where they are caught, and how much they weigh.

After all the basic data has been provided, how one proceeds will depend on what use the model is to be put to. For instance, suppose one wishes to compare present policy with an alternate policy that would cut back on coho production and increase chinook production. He could first specify how many eggs of each species are taken and when the fish are planted under present policy and then specify the egg take and planting dates under the alternative. In either case the program will compute monthly space and water needs, food requirements, and mortality. It will determine the number and pounds of fish planted and the number, pounds, and value of the fish caught. Finally, it will compute the costs and benefits associated with each program and calculate a benefit/cost ratio. On the other hand instead of comparing two alternatives one

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[1]Johnson, Frederick C. 1974. HATCH--A model for fish hatchery analysis. Report 74521. National Bureau of Standards, Washington, D.C.

might want to determine the optimum thing to do under a given set of circumstances. In this case one must describe what stocks of fish are available and when they can be planted. The program will then calculate how many eggs of each stock should be taken and when the fish should be planted, so as to give a maximum benefit/cost ratio.

As an example of how the model has been used, I'll discuss a question that concerned us at Elokomin Hatchery, namely what stock of coho should be raised there. Elokomin is a lower Columbia River station which raises fall chinook and coho. The coho stocks available are the present early returning stock which we call Toutle coho and a late returning stock which we call Cowlitz coho. In order to use the model to help compare the two stocks we described the biological characteristics of each coho stock and of the fall chinook. We also described the physical attributes of the hatchery and defined the costs associated with raising fish at Elokomin and the benefits associated with the fish which are caught. For the fishery we made a simplification which said that one fish would be caught for every pound of fish released. Next we required that all coho be released around May 1 and that chinook be released either in June or else as delayed chinook in the fall. Finally we ran two simulations. In the first simulation we had the model maximize the benefit/cost ratio using fall chinook and Toutle coho; in the second simulation we had it maximize the benefit/cost ratio using fall chinook and Cowlitz coho. With Toutle coho the model showed that the best we could do would be to raise 102,000 lb of coho, 27,000 lb of June-released chinook, and 29,000 lb of delayed chinook. With Cowlitz coho on the other hand we could raise 144,000 lb of coho, 32,000 lb of June-released chinook, and 26,000 lb of delayed chinook. In other words by switching from early running Toutle stock to late running Cowlitz stock we could increase coho production by about 40 percent while maintaining chinook production at about the same level.

Why is this possible? The answer is that with Toutle coho there is a two-month period when age-0 fish use up space and water which could otherwise be used for the yearlings which are present at the same time. This overlap is avoided with Cowlitz coho because the age-0 fish can be ponded later after the yearlings have been released. In effect a large block of space and water is made available just when it is needed most.

The model then clearly shows how much we would stand to gain in terms of pounds produced by switching stocks. Before such a switch were made however many questions would have to be asked. The model could be used to answer some of the questions, but there are other questions beyond the scope of the model. A few questions that come to mind are: What would be the cost of increasing production? What if Toutle coho contributed to the fishery at a higher rate than Cowlitz coho? What are the implications of the different ways the two stocks are distributed in the ocean? What are the implications for the management of the Columbia River fisheries? What ecological factors ought to be considered? On

these questions the model can be used to estimate the increased food costs; it can determine how much better the Toulte stock would have to contribute before there would be no economic gain in switching, and it could show the economic implications of differences in the ocean distribution of the fish. What it would not do is estimate the increased costs due to supplies or labor. It also could not assess the political implications of changes in the ocean distribution. Nor could it answer questions pertaining to the management of fisheries or ecological considerations.

The point of discussing these additional factors is to dispel any notion that the model is a piece of magic which can provide a definitive solution to every problem. This does not distract from its value, however, as it is still the most powerful tool available for systematically analyzing many complex questions of hatchery management.

Development and implementation of the model was supported by the Columbia River Program of the National Marine Fisheries Service.

SALMON HOMING - A MANAGEMENT TOOL?

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This study was initiated to determine the feasibility of creating or enhancing fisheries in specific areas by releasing salmon smolts into those areas. In 1970, two groups each of approximately 100,000 1968-brood coho salmon, *Oncorhynchus kisutch*, were marked with a right ventral (RV) or a left ventral (LV) finclip at Little White Salmon National Fish Hatchery near Cooks, Washington. The LV-marked group was transported by truck to Youngs Bay, 19 km (12 miles) from the mouth of the Columbia River near Astoria, Oregon, and released in April 1970. The RV-marked group was released in May 1970 at Little White Salmon Hatchery, 242 km (150 miles) from the mouth of the Columbia River. The Youngs Bay and Columbia River gill-net fisheries were sampled for these marks in the fall of 1970 and 1971. The two groups homed to their respective areas of release with very little straying. The LV-marked group contributed 7.7 fish to the fisheries sampled for each 1,000 fish released, and the RV-marked group contributed 11.7 fish to the fisheries sampled per 1,000 fish released. However, a fair comparison of the contribution of the two groups is inhibited by (1) incomplete sampling for these marks in the ocean fisheries; (2) the difference in time and size of release of the groups; (3) the unknown effect of delayed mortality due to hauling the LV-marked group; and (4) duplication of these marks in the ocean fisheries.

A PRELIMINARY STUDY INTO THE RECREATIONAL VALUE OF FISH HATCHERIES

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Fish hatcheries have proven to be popular recreational sites. They serve as a place to go on family outings, mixing education with entertainment. With the public new awareness, many people are visiting hatcheries to learn what has been done with regard to ecology and the environment as well as to see how their tax money is being spent. In addition, with the present controversy over fish and fishing rights, many come to find out what efforts are being made to assure stocks of fish for the future.

The goal of this study is to determine the economic value that can be placed on hatchery visits. In this regard, questionnaires specifically designed to collect information about individual trips were distributed randomly to visitors at seven hatcheries funded by the Columbia River Development Office of the National Marine Fisheries Service, Department of Commerce. The operating agencies and the hatcheries are: (1) U.S. Fish and Wildlife Service - Carson and Little White Salmon National Fish Hatcheries; (2) Fish Commission of Oregon - Big Creek and Bonneville Hatcheries; (3) Oregon Wildlife Commission - Gnat Creek Hatchery; and (4) Washington Department of Fisheries - Kalama Falls and Klickitat Hatcheries. These questionnaires, when filled out, contain enough information so value calculations can be performed using either the direct, i.e., how much is a person willing to pay rather than be excluded, or the indirect approach; i.e., measure willingness to pay from time and travel costs. In addition to the questionnaires, total visitor counts per hatchery were kept.

Preliminary considerations have been performed on results from Bonneville Hatchery. Thus far it is the only one with enough responses to make calculations statistically valid. Economists contracted to evaluate the data have computed a per visitor value of $0.42. With Bonneville's visitor total for the year through November 15 being in excess of 300,000, this amounts to an economic value of approximately $126,000. This figure is only preliminary and will probably show a significant increase as the evaluation techniques are perfected, but it does show the considerable recreational value that the hatchery does have. Figures for the other hatcheries will be developed after the proposed end of the study on February 1, 1975. By this time enough data will have been collected to run these analyses. Depending on results obtained, there is a possibility of extending the study through 1975 for several of the hatcheries with the possibility of one additional being added.

THE EFFECT OF ACCELERATED GROWTH AND EARLY RELEASE ON THE TIMING, SIZE, AND NUMBER OF RETURNS OF COHO SALMON (*ONCORHYNCHUS KISUTCH*)

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University of Washington and
Quinault Resource Development Project

Two groups of University of Washington, College of Fisheries, coho salmon were reared under the same conditions for approximately six months. During the rearing period the groups grew at similar rates, were marked differentially, and released at the size of wild smolts one year older.

The RV stock (November spawning) was significantly larger at release than the LV stock (December spawning) and returned as two-year-old adults in significantly greater numbers and at larger size (Table 1). The parent size of the two stocks, their size as alevins, and their total age were comparable. Therefore, the factor responsible for size differences is attributed to release size-induced behavioral differences. Based on scale interpretation, greater than 50 percent of the LV stock delayed migration in extended freshwater residence. The larger RV stock had an initial migration of 90 percent, and returned at a larger size and in greater numbers. Therefore, the following conclusions were made:

1. The age at maturity of coho can be reduced by one year by rearing at optimal temperature and with proper nutrition in the first six months of life.

2. Larger size at release results in larger size at return.

3. Larger size at release results in better survival to return.

4. Migration tendency is a function of size. As the release size of the coho increases, the tendency to migrate increases.

5. Failure to achieve migratory size results in extended freshwater residence.

6. The spawning period of progeny follows that of the parents.

Table 1. 1970 brood year coho salmon, University of Washington Hatchery

Date	Sex	Mark	Fork length (cm) Mean	Fork length (cm) Range	No.	Percent return	Average length (cm)
				Releases			
1971 May 28		LV			32,952		8.00
		RV			30,930		9.95
					63,882		
				Returns			
1972	F	LV	55.4	26.7-69.3	182	1.1046	
	M	LV	50.8	27.8-67.6	318	1.9301	
	F	RV	56.5	41.9-69.3	251	1.6230	
	M	RV	54.6	32.0-73.6	324	2.0951	
1973	F	LV	60.6	43.5-67.2	9	0.0005	
	M	LV			0		
	F	RV	62.8	55.4-69.1	3	0.0002	
	M	RV	75.6	58.5-86.5	9	0.0006	
				Total: LV	509	1.5447	
				RV	587	1.8978	

COSTS AND RETURNS OF SALMON HATCHERY PRODUCTION ALTERNATIVES

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For purposes of this study, two hatcheries were analyzed, the Little White Salmon National Fish Hatchery and the Willard National Fish Hatchery. These hatcheries are located on the Little White Salmon River, a tributary of the Columbia River, about 60 miles above Portland. Both hatcheries are of medium size, with the Willard Hatchery producing about 141,000 lb of coho salmon during fiscal year 1973 (July 1, 1972 to June 30, 1973). The Little White Salmon Hatchery has the capacity to release from 150,000 lb to 158,000 lb of salmon per year, depending upon the species produced. The Little White Salmon Hatchery has a rearing pond capacity of nearly 76,000 ft^3, as compared to about 67,000 for Willard, which can be used for fish rearing.

Average Fish Costs Per Pound with Fish Food Reduced Below Current Production Levels

In times of budget cut-backs, it sometimes has been necessary to reduce expenditures for fish food, since fish food represents over one-half the nonlabor expenditures, and these nonlabor expenditures are often the only variable expenses, given the Civil Service employment arrangement of the fish hatcheries. Using the fiscal year 1973 costs for the Little White Salmon and Willard fish hatcheries, average costs were computed at various assumed levels of fish food:

Percent of fiscal year 1973 fish food level	Predicted average total cost per lb
20	$5.00
40	2.63
60	1.83
80	1.49
100 (1973 production level)	1.38

Given the preceding average cost figures, it is apparent that reducing expenditures by reducing funds available for fish food would be an inefficient way to reduce costs, since a reduction in fish food reduces production much more than costs, resulting in higher average costs per pound produced.

Average Fish Costs Per Pound with Fish Food Increased Above Past Production Levels

If more fish could be successfully reared per cubic foot of rearing space, then production could be increased even further, allowing average total costs to decline every more.[1] Assuming that the fish are not crowded enough to adversely affect survival after release, then average cost per pound of fish could be lowered from $1.38 to $1.13/lb by increasing production by 30 percent over the usual production levels, a cost reduction of about 18 percent.

MAXIMIZATION OF ECONOMIC BENEFITS

Before economic benefits can be computed, some measure of value must be assigned to the salmon harvested in the commercial and sport fisheries.

Estimated Fish Values, Assuming Equal Sport Value for Coho and Chinook

Based upon marking studies for fall chinook and coho salmon, the following values were estimated, assuming equal values for sport-caught chinook and coho. (Further details on the computation of values are given by Brown and Hussen (1974).

Value per 1,000 Fish Released and per Pound

Little White Fall Chinook

$$\text{value} = \underset{\text{(Commercial)}}{\$1.16(69.125 \text{ lb})} + \underset{\text{(Sport)}}{\$20(1.327)} \doteq \$107 \doteq \$10.70/\text{lb released.}$$

Little White Coho

$$\text{value} = \left(\frac{22.7}{25.8}\right)\underbrace{[\$0.916(241.3 \text{ lb})}_{\text{(Commercial)}} + \underbrace{\$20(14.75)]}_{\text{(Sport)}} \doteq \$516\left(\frac{22.7}{25.8}\right) \doteq \$454$$

$$\doteq \$11.71/\text{lb released.}$$

[1] Pond loading capacities at Willard were first calculated by David Bruhn and his staff at Willard National Fish Hatchery, reported by Bruhn (1970). These heavier loading capacities were actually implemented in the spring of 1974.

Little White Spring Chinook

$$\text{value} = \left(\frac{100}{14.67}\right)(\$107) \doteq \$730 \doteq \$10.70/\text{lb released.}$$

Willard Coho

$$\text{value} = (22.7 \div 22)(516) \doteq \$532.5 \doteq \$11.71/\text{lb released.}$$

Values and Benefit-Cost Ratios with
Fiscal Year 1973 Levels of Fish Food

Given the preceding values for the salmon, and assuming a fiscal year 1973 level of fish food, a maximum of economic benefit would result from releasing about 4,075,405 coho from Little White Salmon and about 3,112,451 coho from Willard.

Total value from Little White Salmon would be

$$\$454(4,075.405) \doteq \$1,850,234.$$

Total value of the Willard Hatchery release would be

$$\$532.5(3,112.451) \doteq \$1,657,380.$$

$$\text{Little White B-C} = \frac{\$454(4,075,405 \text{ Coho})}{\$214,910} = \frac{\$1,850,234}{\$214,910} \doteq 8.61.$$

$$\text{Willard B-C} = \frac{\$532.5(3,112.451 \text{ Coho})}{\$197,581} = \frac{\$1,657,380}{\$197,581} \doteq 8.39.$$

Values and Benefit-Cost Ratios with
Increased Fish Food at Willard

$$\text{B-C} = \frac{\$532.5(5,170,000 \text{ Coho})}{\$197,581 + \$26,401} \doteq \frac{\$2,753,025}{\$223,982} \doteq 12.29.$$

For the additional fish food,

$$\text{the marginal B-C ration} = \frac{\$1,095,645}{\$26,401} \doteq 41.50.$$

Estimated Fish Values, Assuming Sport Values are Porportional to Fish Weights

Assuming about 6.51 lb/coho and 13.51 lb/fall chinook, a sport-caught value of $16.44/coho and $34.25/chinook was computed. Thus, Little White

fall chinook value = $125.63/1,000 released ($12.56/lb).

coho value = $407.85/1,000 released ($10.52/lb).

spring chinook value = $856.37/1,000 released ($12.56/lb).

Values and Benefit-Cost Ratios with Fiscal Year 1973 Levels of Fish Food

With these new values, the linear programming solution for Little White indicated a maximum net economic benefit from a release of 1,422,470 spring chinook and 5,778,800 fall chinook. The corresponding benefit-cost ratio was:

$$\text{B-C ratio} = \frac{\$856.37(1{,}422.47) + \$125.63(5{,}778.8)}{\$214{,}910} \doteq \frac{\$1{,}944{,}151}{\$214{,}910} \doteq 9.05.$$

Thus, a modest change in assumption regarding value of sport-caught salmon was more than enough to switch the solution from all coho to a combination of spring and fall chinook at the Little White Hatchery.

For the Willard Hatchery, only coho were considered because the water is too cold for good growth of chinook. Then, for Willard,

$$\text{B-C ratio} = \frac{\$478.3(3{,}112.451)}{\$197{,}581} \doteq \frac{\$1{,}488{,}685}{\$197{,}581} \doteq 7.53.$$

CONCLUSIONS

Estimated B-C cost ratios under FY 1973 prices and costs were quite favorable, ranging from 7.53 to 12.29. For Willard, increased benefits of about $1 million were predicted from heavier loading and increased fish food costs of $26,400. Production of chinook and coho gave surprisingly similar estimated benefits, indicating that the present balanced production of both coho and chinook, considering all hatcheries, is prudent.

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A NEW EGG SORTING DEVICE FOR SALMON, TROUT, AND STEELHEAD EGGS - A SLIDE PRESENTATION

Larry Buzzell, Vice President
Donald A. Musgrove, President
B.E.P. Corporation
Post Ofice Box 117
Winlock, Washington 98596

In the past, there have been many egg sorters developed. Unfortunately, the disadvantages common to them have been a stumbling block to their unanimous adoption by fish culturists. These disadvantages are complexity, which causes problems in maintenance and repair; poor accuracy, which reduces overall usefullness; and high cost, which lowers the benefit-to-cost ratio.

Our new egg sorter has no moving parts during the sorting process, which takes care of the complexity and reliability; it has an accuracy of less then 0.001 percent bad eggs in the good, and less than 1 percent of the reject eggs appear as "good" eggs. The cost of our unit is low enough so that all fish culturists that raise trout, salmon, or steelhead may economically enjoy the freedom from time-consuming hand egg picking each year. This sorter is capable of accurately sorting 5,000 salmon eggs/min, and 8,000 trout eggs/min. No external connections are required except a water hose.

This concludes our prepared presentation. We would be happy to answer any questions by mail at the above address.

PRODUCTION VERSUS PRODUCT: A PARADOX?

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One of the accepted definitions of paradox is "a statement or proposition seemingly self-contradictory or absurd, and yet explicable as expressing a truth." I think that fits where we are with the aquaculture industries - both public and private. We have tended to measure a fish raising facility's worth by the pounds or numbers of fish released or sold or processed. We have also used food conversion as a measure of production. I think in doing so, we have neglected the most important goal of fish production; namely, the product.

Piper, Willoughby, Holway, and I all have espoused the fact that our fish raising facilities are underproducing the quantities of fish they were designed to do. We have set forth many formulae to assist the fish culturist in getting the most fish out of the least water using the least amount of feed to do the job. At the risk of incurring my colleagues' wrath, I have come to think that none of the many formulae applicable to fish culture are worth the paper they are printed on - because they have applied as goals rather than means.

The goal of fish culture must be defined in terms of the quality of fish produced. It should dictate - limit - prescribe - or whatever term is applicable - the quantity of fish a particular facility can produce. The quality of the fish should be based on what it is that we as resource managers or food fish purveyors wish it to do. Some of the terms used in describing fish quality are: survive, grow, look like a native fish, return, convert commercial feed well, and so on. I purposely left out any reference to disease because I think disease problems are more fish hatchery management oriented than intrinsically fish related. There is a great deal of data - both published and unpublished - to substantiate that assumption.

Once the product is defined the process of symphonically orchestrating the elements of fish culture - namely, management, fish, container, water, and nutrition - becomes rather straightforward. Then - and only then - can the formulae for carrying capacity, loading factor, feeding level, water velocity, and density index be properly and economically applied.

EVALUATION OF CLINOPTILOLITE FOR AMMONIA REMOVAL

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Water reuse and reconditioning technology has been developed to allow the production of larger quantities of fish from a given water source. The first attempts to increase the fish-rearing capacity per unit flow of supply water involved simple water reuse, consisting of reaeration of the effluent water from a raceway or other rearing unit before introducing it to a second rearing unit. Water can be reused two or three times in this way. Further reuse is limited by the progressive buildup in the water of ammonia, a toxic byproduct of the nitrogenous catabolism of fish. During the early 1960's a reuse-reconditioning method was developed that utilized biological nitrification for removal of ammonia. Ammonia was partially removed by bacterial nitrification and solids and BOD (biological oxygen demand) concentrations were also reduced. The nitrifying filter has several basic benefits:

1. It allows water to be reused 10 times or more.
2. It provides nitrification to remove ammonia.
3. It simplifies temperature control in the rearing system.
4. It provides a controlled environment favorable for disease prevention.
5. It reduces concentrations of suspended solids and BOD.

The effectiveness of a nitrifying filter is dependent upon the metabolic activity of nitrifying bacteria. These bacteria metabolize most effectively under optimal environmental conditions. Too-high or too-low levels of temperature, salinity, pH, or available nutrients can inhibit their activity. They may also be adversely affected by exposure to certain chemicals or by sudden changes in temperature or water quality.

A physical-chemical system for reduction of the ammonia, suspended solids and BOD content of fish-rearing water would be superior to a biological system in several ways: (1) The ammonia-removal effectiveness of a physical-chemical system would not be closely dependent upon temperature or water chemistry; (2) ammonia removal would not be impared by exposure to chemicals.

With these factors in mind, it was decided to test a physical-chemical water reconditioning system. A system was designed that utilized a

high-rate sand filter for removal of suspended organic solids, followed by an ion-exchange bed for removal of ammonia. The ion-exchange material selected was "clinoptilolite," a zeolite material that exchanges sodium ion for ammonia. The results of tests with this system are presented in this report.

TEST PROCEDURES

Figure 1 illustrates the system tested. The system consisted of a circular fish tank 12 ft in diameter and 3 ft deep, a pump for water recirculation, a clinoptilolite column with 0.5 ft^2 of surface area, and a baker sand filter with 2.2 ft of surface area. The water reuse system was operated on a 90 percent basis.

Samples were collected from the following locations:

1. Influent side of sand filter.
2. Effluent side of sand filter.
3. Effluent side of clinoptilolite column.

The following tests were conducted on the samples:

1. pH
2. Ammonia
3. Suspended solids
4. COD
5. BOD

A composite sample of the backwashing water was collected and analyzed during the testing. The results of this analysis are shown in Table 1.

The results in Table 2 indicate that removal of ammonia by the sand filter was low and variable (average 7.9 to 15.2%), while removal of ammonia by the clinoptilolite column was high and consistent (average 96.3 to 98.9%).

Since 97 to 98 percent of the ammonia entering a clinoptilolite column will be removed regardless of the initial concentration (over the range of concentrations tested), the size of the treatment system can be based on the total flow and the percentage of total flow from which ammonia

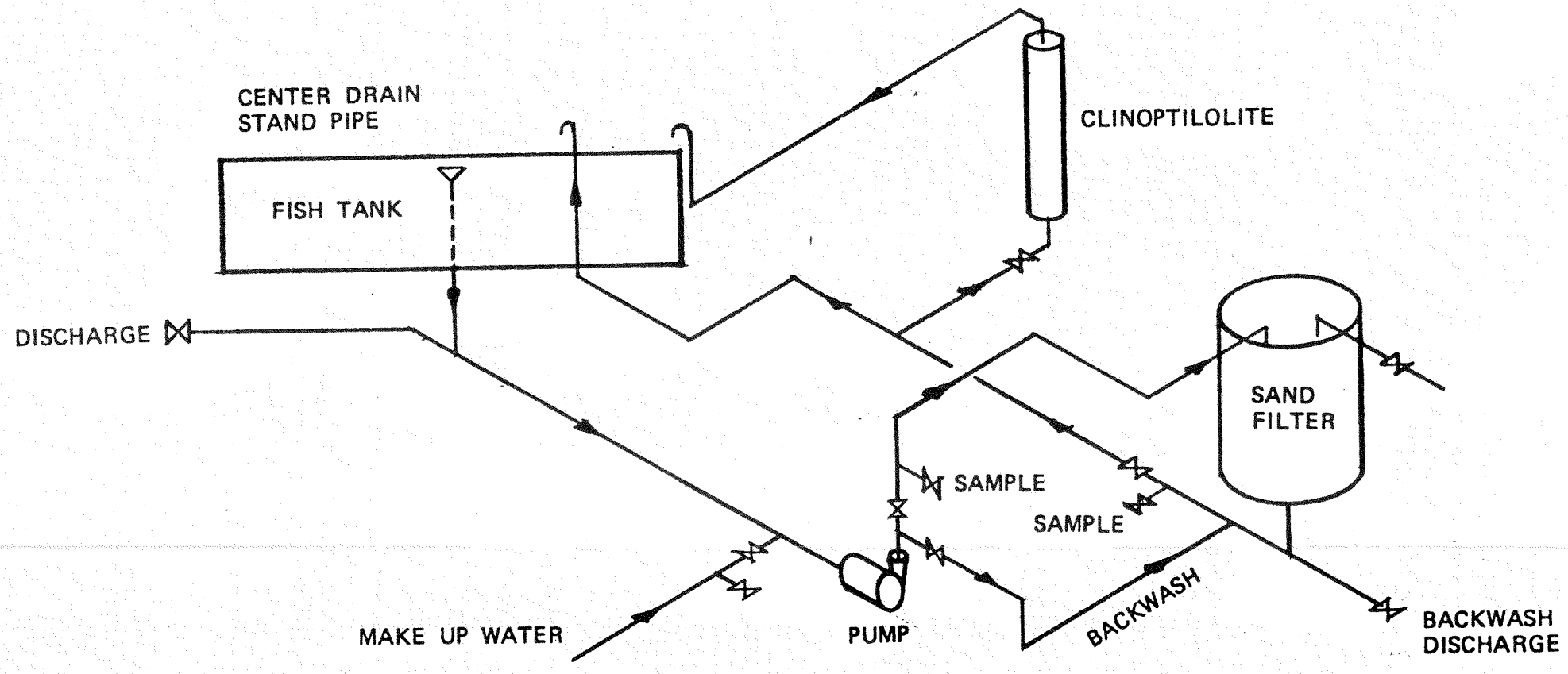

Fig. 1. Physical-chemical system tested at Oregon Aqua Foods Wright Creek Hatchery.

Table 1. Composite sample from sand filter backwash water

	Average mg/l	
Suspended solids	206	(204, 207)
Chemical oxygen demand	320	(300, 340)
Biological oxygen demand	35	(34, 35)

Note: Turbidity from make-up water included in above results.

Table 2. Average removals per pass by the physical-chemical system

Parameter	Concentration range mg/l	Average removal percent	Range percent
Ammonia removal			
Sand filter			
No. 20 sand	0.40 - 1.60	7.9	1.6 - 15
No. 30 sand	0.75 - 1.96	15.2	2.3 - 35.2
Clinoptilolite			
Series No. 1	0.34 - 1.43	98.9	96.7 - 100
Series No. 2	0.68 - 1.27	97.2	96.3 - 98.4
Suspended solids			
Sand filter			
No. 20 sand	2.2 - 16.7	90.9	70.6 - 100
No. 30 sand	4.3 - 18.2	73.6	48.8 - 91
BOD sand filter			
No. 20 sand	4.1 - 11.4	31.5	7 - 56
No. 30 sand	3.4 - 14.6	28.7	20.3 - 39
COD sand filter			
No. 20 sand	10.0 - 23.5	67.5	55 - 80
No. 30 sand	16.5 - 35.0	39.5	24.2 - 51

must be removed. The percentage of total flow which must be treated can be calculated from the formula:

$$C = \frac{1}{1 - R + RE}$$

where C = the allowable ammonia concentration divided by the ammonia produced per pass

E = efficiency, decimal fraction

and R = reuse, decimal fraction

For C = 2 in a 90 percent reuse system, the required ammonia removal would be 44 percent, so 45 percent ($44\% \times \frac{1.08}{0.98}$) of the flow would be diverted through a clinoptilolite exchange column. (*See* Fig. 2).

Effect on pH of the Clinoptilolite Column

The pH was measured for all samples collected on both the influent and effluent sides of the sand filter. The results show that the clinoptilolite column generally raised the pH by approximately 1 pH unit. Generally, the pH increased from 6.7±0.1 on the influent side to 7.7±0.1 on the effluent side. Since the system was on a 90 percent reuse mode, the overall pH of the system in the fish-rearing tanks remained in the 6.8 to 6.9 range. The data indicate that the pH increase was not due to a large increase in alkalinity. However, this would have to be measured to be verified.

CONCLUSIONS

The following conclusions can be drawn from the results of this study:

1. Clinoptilolite is highly efficient in removing ammonia. Ninety-seven percent to ninety-nine percent of the ammonia introduced to the clinoptilolite column was removed, and the efficiency of removal was independent of the initial value over the range tested (0.34 to 1.43 mg/l ammonia N). High removal efficiencies were obtained despite hydraulic loading of the column at 8 gpm/ft^2.

2. The physical-chemical treatment system tested appears to be a viable alternative to biological nitrification. Physical-chemical removal of ammonia is intrinsically more reliable than biological nitrification.

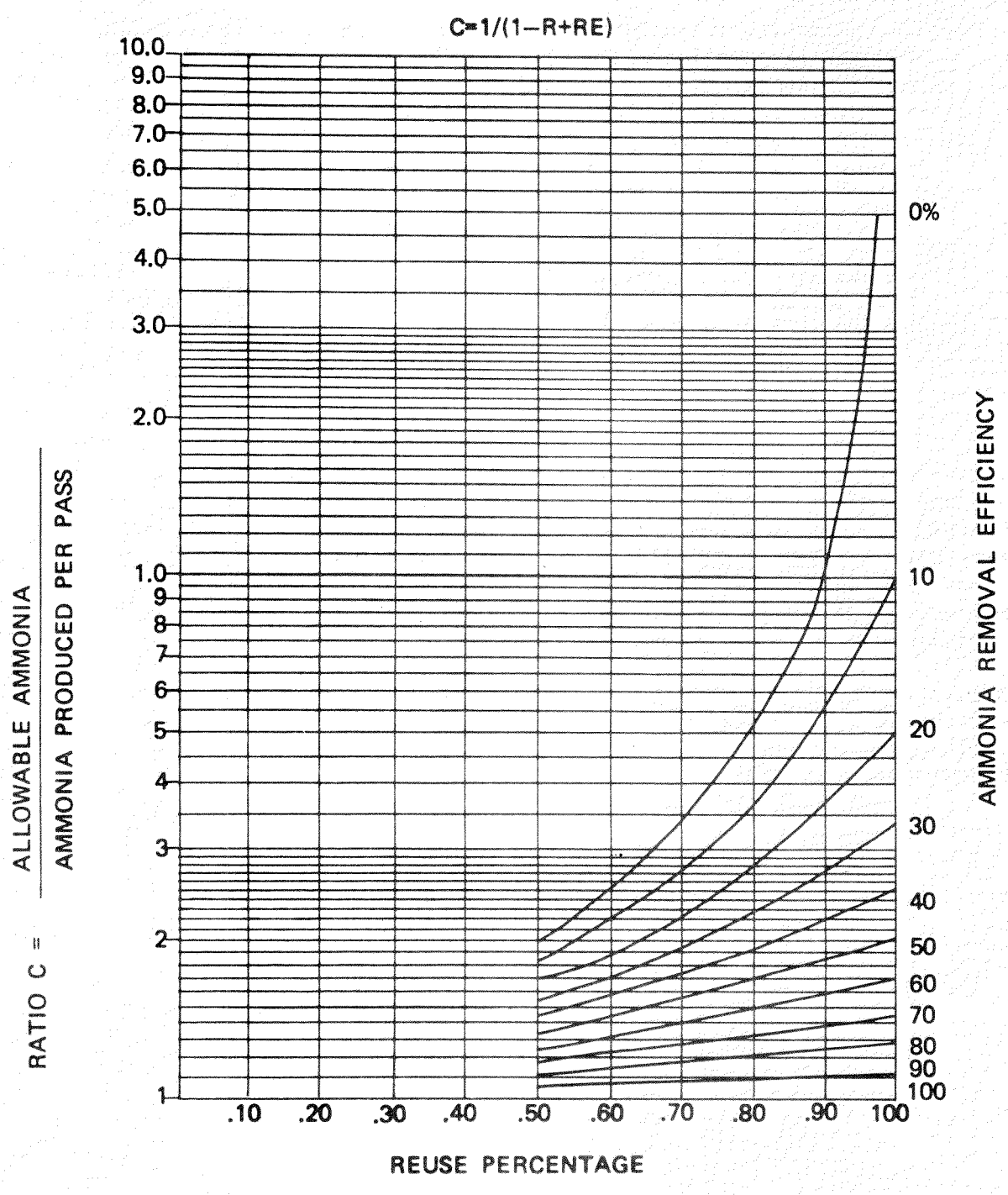

Fig. 2. The relationship between reuse percentage efficiency of ammonia removal, allowable ammonia concentration, and ammonia production rate.

3. The clinoptilolite column used in this testing program would require regeneration after approximately 2 to 3 weeks. Regeneration is accomplished with a lime-rock salt solution, or with seawater, if available. The volume of regenerating solution required is approximately 150 gal/ft^3 of exhausted clinoptilolite. As the lime-rock solution passes through the clinoptilolite, calcium and sodium ions are substituted for ammonia ions bound to the clinoptilolite. The used regenerating solution, which will contain very high concentrations of ammonia, can be discharged into the hatchery pollution control facility, or the ammonia can be removed by an air-stripping process.

COST

Tentative cost estimates for the sand filter-clinoptilolite treatment system were made to determine how the cost compared to a biological treatment system. This cost estimate was based upon a 90 percent reuse system, with the same physical facilities as the biological nitrification processes when they were cost estimated. It appears that capital costs (together with aeration cost) for this system would be comparable with that estimated for a biological trickling filter system.

However, operation and maintenance costs of the physical-chemical system will be higher than the biological trickling filter system because of the higher pressure head used and because of backwash and regeneration requirements.

CRYSTAL LAKE: ALASKA'S NEW WATER REUSE FISH HATCHERY

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Crystal Lake Hatchery, located 17.5 miles south of Petersburg, Alaska, on the Mitkof highway, was completed in the spring of 1973. It utilizes incoming water purification, heated water, water recirculation, and effluent treatment systems to rear salmon and trout for Alaska Department of Fish and Game stocking projects in Southeast Alaska.

Crystal Lake Hatchery has three basic units: the hatchery building where eggs are incubated, hatched, and initial fry feeding begins, three large rearing ponds where the fry are fed to obtain shipping or release size, and the mechanical and heating plant which houses the pumps and boilers for pumping and heating all water for the station. Living quarters for the hatchery personnel are located on the 40-acre site in close proximity to the fish rearing complex. The hatchery was built at a cost of $2.2 million as part of a bond issue passed by the citizens of Alaska.

At present, the hatchery can produce about 60,000 lb of salmon and trout per year. Depending upon the size of the fish at release, this would be up to four million fingerling or smolt salmon and trout annually. With the replacement of the two large butyl-lined earthen ponds with high capacity concrete ponds scheduled for completion by 1975, the output potential of the hatchery will be increased to 100,000 lb of fish annually.

The need for a dependable source of water led to the selection of the site on Crystal Creek near Petersburg. The hatchery can circulate up to 7,500 gpm with only 10 percent of this volume having to be replaced within the system. If the main source (a hydroelectric power plant penstock tail race collector) from Crystal Lake should fail, the hatchery is designed to obtain water from nearby Crystal Creek or Blind Slough.

Hatchery operations in Alaska have always been hampered by cold water temperatures which slow fish growth. The water at Crystal Lake Hatchery is heated to obtain optimum fish growth temperatures depending on the requirements of management programs and fish species.

Basically, water enters the hatchery system through pressure filters which remove micro-organisms and particulate matter larger than 25 microns. It is then sterilized by ultraviolet radiation to minimize the possibility of introducing disease organisms into the fish stocks within the "closed system." The water is then aerated (or supersaturated dissolved gasses sparged) and pumped, heated or unheated, into the first point of use; the incubators and troughs in the hatchery building.

After going through the hatchery system the water flows through "up-flow" biological filters to remove fish metabolic and catabolic waste products. It is then reaerated, buffered, and recirculated through the rearing ponds. About 90 percent of the water is recycled. Final waste water is treated by sedimentation in two settling ponds (secondary clarifiers) prior to discharge back into Crystal Creek. A dual alarm system provides a visible and audible signal of any critical electrical and mechanical failures within the entire system.

As the hatchery is located on Mitkof Island, airplane and the Alaska Marine Ferry System are the prime means of distributing fish stocks to Fish and Game management projects in Southeast Alaska. The system is working well with only minor occasional setbacks. From startup time of the hatchery to date November 1974, about 60,000 lb of salmon and trout numbering approximately 3.6 million have been produced at Crystal Lake Hatchery.

PROGRESS? REPORT ON SUMMER-RUN STEELHEAD AT SKAMANIA HATCHERY

Marvin Hull
Washington State Game Department

An acceptable goal to satisfy all sport fishermen has been more and larger fish to catch. How have factors affecting this twin goal been expanded or altered?

EGGS:

1. Supply eggs state wide and out-of-state. Fewest eggs of 148,000 in 1960. First exceeded million in 1962. Largest spawn 5,588,000 in 1972.

2. Selecting progeny from early spawn moved season from March-April-May back to January-February-March by 1966. Using tungsten light in 1970 the spawning season peaked in January.

   A. To extend this further might put natural spawning adults out of phase with nature unless in spring water area.

   B. Now bottleneck to optimum size yearling is three months from spawning to start of fry feeding.

   C. Egg allotments to warmer water stations are picked up green and will reach optimum planting size.

ADULT:

1. First two years of all wild adults and next six years with all hatchery reared adults marked total wild adults return varied from 81-166.

2. Adult return size peaks 22-23 inches with 1 salt and 27-28 inches with 2 salt.

3. New run starts February, peaks July, and trails into December.

4. 1964 1,000 adults arrived to spawn. 1966 greatest return an enigma.

5. 1967 first marked 3 salt adults return. Too scarce for size peak.

6. From 1965 to 1973 adult return to trap 3-6 percent of plant.

   A. There is a sport fisheries below and above hatchery operations.

7. 1973 had a sub 2 percent return and unusual in other respects. *See* Fig. 1 for comparison of 73 size, both male and female, with previous five years.

SMOLT:

1. First attained 100,000 release to brood stream in 1962.

   First planted six Columbia River tributaries in 1962.

   First all yearling smolt plant to hatchery 1966, plus 1963.

2. Since 1962 hatchery plant of total production summer-run has been 38 percent twice, 27 percent four times, 19 percent three times, 13 percent three times. Goal 16 percent.

3. Except 6 of 17 years smolt release at hatchery has not been all yearling. Holding two years freshwater more expensive, requires more space for same numbers, has greater weight during lowest water flow and results in higher percent of one salt adult return.

4. Winter growth has determined submigrant carry-over to second year.

Date	Yearling size	Date	Submigrants kept	Average size yearling plant
12/1/67	33	6/68	69,000	7.7
12/1/68	28	6/69	-0-	7.5
12/1/69	24	6/70	346,000	8.3
12/1/70	32	6/71	74,000	6.2
12/1/71	26	6/72	110,000	7.5
12/1/72	37	6/73	53,000	7.1
12/1/73	24	6/74	119,000*	7.1
12/1/74	14.6			

*Not kept.

5. Cold Water Disease endemic. Not serious problem till 1972. In May 300,000 or one-third fry load lost on Vogel water. In May 1973 one-third fry load lost on Vogel water. Cercaria also reported. In May 1974 loss one-half fry load on North Fork water. March 265,000 received into North Fork water only feeding. Loss was 326 in May and 1,177 total. Small March

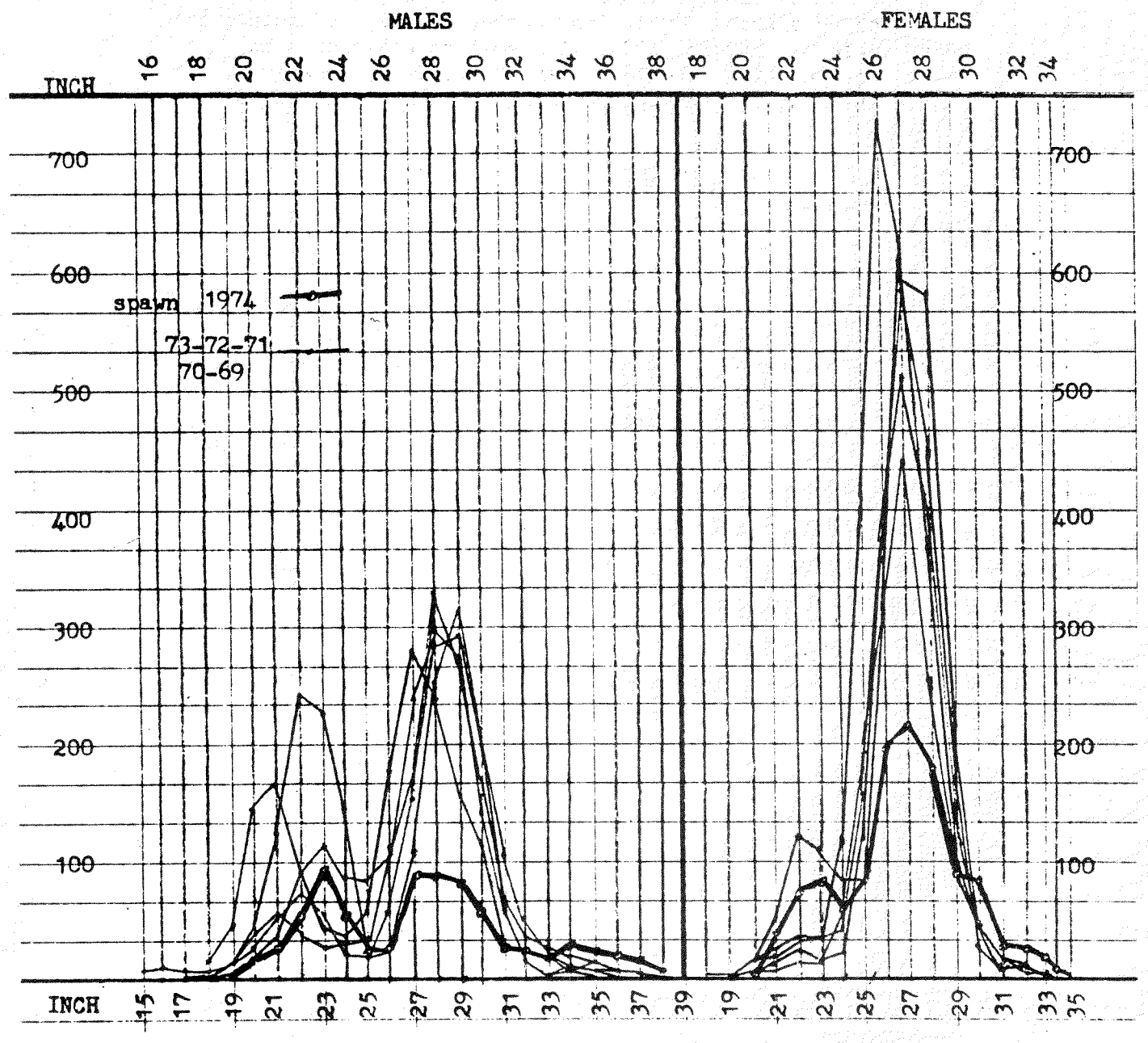
MALES
FEMALES
INCH
16 18 20 22 24 26 28 30 32 34 36 38
18 20 22 24 26 28 30 32 34
700
600
500
400
300
200
100
spawn 1974
73-72-71
70-69
INCH
15 17 19 21 23 25 27 29 31 33 35 37 39
19 21 23 25 27 29 31 33 35

Fig. 1.

spawn held with small loss. December 1 count 38. Earlier spawn, transferred back, now count 14.6, *see* above.

A. Late yolk sac, swim up fry, now more susceptible.

6. Progeny from earliest spawn and largest adults kept with plant for hatchery stream. Sufficient numbers, 1972, to isolate and mark, Table 1. Return, 1975, of 3 salt should show size peak. Return, 1976 from 1973 plant, should be at least double the 3 salt. Percentage unknown, except bimodal with 2 salt.

Table 1.

Plant Year	Age	Mark	Lb	Count	Number	Date	Salt Water period 1/2 or non	1-1/2	2-1/2	3-1/2
1971*	1	L Ven	1530	5-1/2	10,000	4/18	3	16 m 3 f	13 m 58 f	
1972+	1	R Max	9370	6-1/2	60,000	5/3-11-26	0	2 m		
1972	1	none	5885	6-1/2	38,000	"--"				
1972	2	R Ven	8400	2-1/2	21,000	4/17	0	165 m		
1973+	1	R Pec	6700	7-1/2	50,000	5/1				
1973+	1	none	7095	7-1/2	50k000	5/14				

*All 70-71 nitrogen freeze brands were failure.
+Select high grade.

AMMONIA PRODUCTION RATE AND ITS APPLICATION TO FISH CULTURE SYSTEM PLANNING AND DESIGN[1]

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INTRODUCTION

Traditionally, water requirement estimates are mainly based on oxygen consumption of fish. This method is reliable wherever water quality is normal. Mistakenly, most fish culturists believe that as long as the water is not reused, the carrying capacity approximated based upon oxygen consumption is appropriate. This practice has on a few occasions, resulted in higher fish mortality and/or lower fish growth rate due to ammonia effect. Even at a single-pass hatchery where water is not reused, yet due to higher temperature and higher pH value, ammonia may become a limiting factor in determining fish carrying capacity or (water requirements). Therefore, it is obvious that both oxygen consumption and ammonia production rates must be taken into account in determining water requirements for any fish culture system.

This paper is intended to briefly summarize ammonia production rate and its application in fish culture system planning and design.

AMMONIA PRODUCTION

Basically, there are three ammonia sources related to a fish culture system. First, there may be ammonia contained in the water supply; second, there is ammonia produced by the fish through their metabolism of food (or in some cases through catabolism); and third, there is ammonia generated through bacterial decomposition of sludge (feces and uneaten food).

The ammonia associated with the water supply is normally known prior to selection of a water source. However, approximation of ammonia related to the second and third sources is somewhat complicated.

Practically, ammonia generated in a culture system, either by fish metabolism or by bacterial decomposition, is primarily a result of fish food utilization. This may be graphically illustrated by Fig. 1. Ammonia is a byproduct of fish and bacterial metabolism of protein contained in food. Protein content in food varies from brand to brand.

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[1]Technical Reprint No. 35.

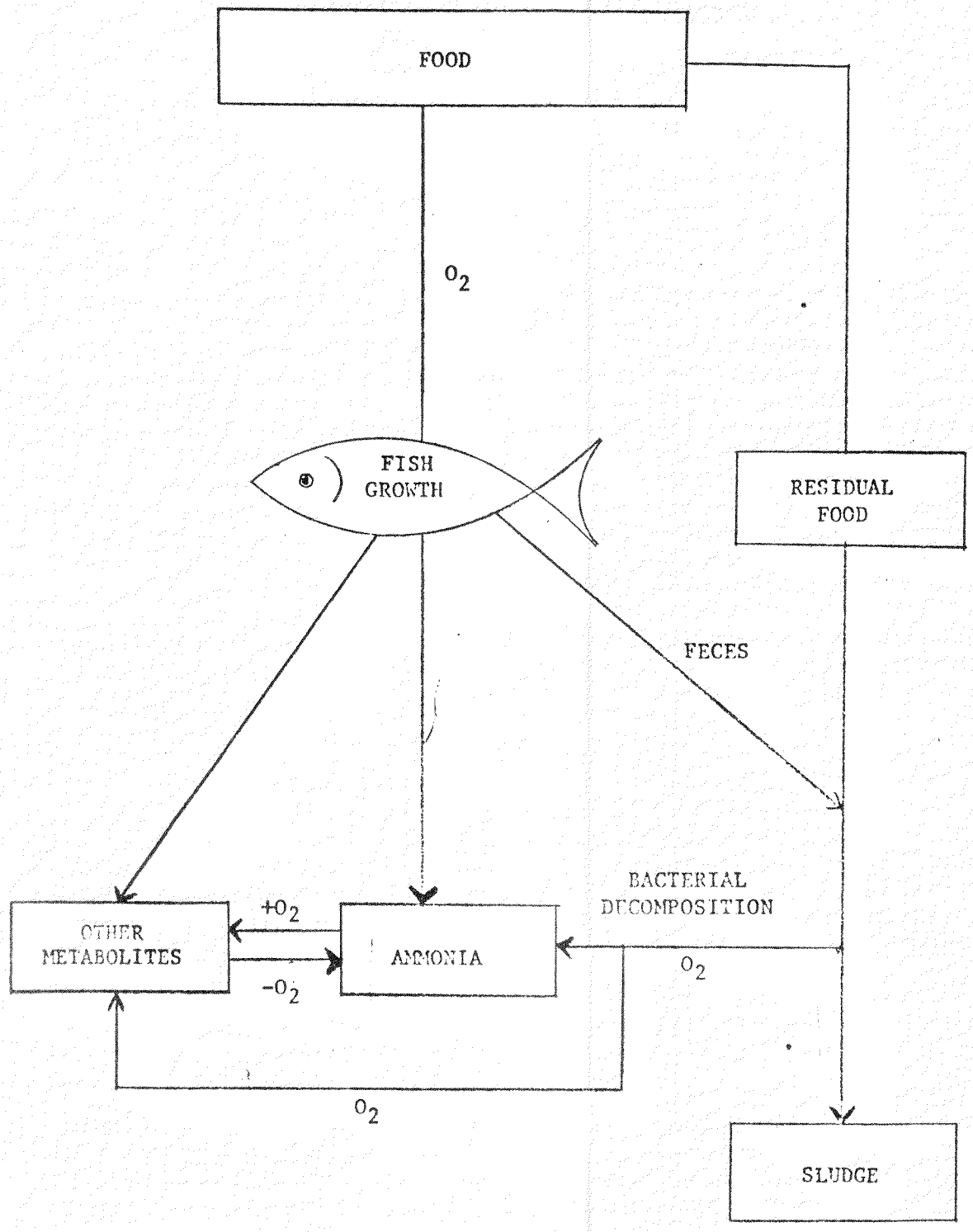

Fig. 1. Ammonia model.

Even within the same brand of food, protein content may vary with moisture. For example, protein content in Oregon Moist Pellets (OMP) ranges from about 37 percent to 55 percent, depending on water content (as indicated in Table 1).

Table 1. Mean composition of OMP (Opr-1)

Components	Dry weight	Percent (%) A	Wet weight B
Moisture	0	10	32.92
Ash	10.96	9.85	7.33
Fat	14.05	12.63	9.42
Protein	55.32	49.79	37.12
Carbohydrate	19.67	17.73	13.21
Total	100%	100%	100%

The nitrogen content of protein varies with type of protein. Due to the variety of food available on the market, it is difficult to determine the exact quantity of nitrogen in food without chemical analysis. However, nitrogen content of protein normally ranges from about 10 to 20 percent, with an average of about 15 percent. Knowing the protein content of the food, one can approximate the total amount of nitrogen. For example, assuming protein content of food is 50 percent, the total amount of nitrogen in 1 lb of food can be calculated. That is,

$$\text{Nitrogen} = 1 \text{ lb} \times 50\% \times 15\% = 0.075 \text{ lb}$$

(or nitrogen content of food is 7.5%). Not all of the nitrogen contained in food will be released as ammonia. Some nitrogen will be converted into fish mass; a fraction converted into microorganisms mass; a portion released as urea first and then oxidized to ammonia, nitrite, and nitrate; and the remaining portion may be bound in raceway sludge (known as organic nitrogen). In addition, there may be some nitrogen entering into rearing water from the atmosphere. However, in most cases this portion of nitrogen from atmosphere is negligible.

The amount of nitrogen converted from food into biomass (fish or organisms) is beyond the scope of this discussion. This then leaves two major groups of interest. They are group 1 - inorganic nitrogen (ammonia, nitrite, and nitrate) and group 2 - organic nitrogen. Of these two groups, the nitrogen distribution is variable depending upon bacterial

activity, residence time, and oxygen level. Organic nitrogen can be further converted to ammonia by bacterial action (known as secondary ammonia production). The amount of ammonia produced by fish through metabolizing food is known as primary ammonia production. Depending upon water quality condition, ammonia may be converted to nitrite and nitrate, or the reaction may be reversed. Usually, more ammonia may be measured when the raceways are not frequently cleaned due to secondary ammonia production as illustrated in Fig. 2. Figure 2 is derived from a laboratory test using sludges taken from a fish culture system. Digestion took place under anaerobic conditions and at a temperature of 20° C. Though the bottom of the raceway is seldom septic and rearing water temperature may be different from laboratory testing temperature, it is conceivable that as long as sludges stay in raceway, there will be secondary ammonia produced.

Quantitatively, one may want to relate ammonia production to fish in hand. However, due to different feeding schedules, approximation of ammonia production based on fish in hand may be misleading. Available data indicate that average nitrate (nitrogen) and ammonia (nitrogen) production rates are 2.4 percent and 2.9 percent, respectively, based on food fed. Therefore, ammonia production rate can be estimated using:

$$A = 0.029\ F \qquad \text{----------(A)}$$

where A = ammonia production rate, lb NH_4-N/day

F = feeding rate, lb/day

However, in a case where feeding schedule is not available, ammonia production may be approximated based on oxygen consumption rate. That is,

$$A = 0.053\ O_2 \qquad \text{----------(B)}$$

where O_2 = oxygen consumption rate, lb/day

If oxygen consumption rate, O_2, is expressed in pounds oxygen/100 lb of fish/day, ammonia production rate, A, should be computed and expressed accordingly. Oxygen consumption rate can be calculated using the following formulas:

$$O_2 = KT^nW^m \qquad \text{----------(C)}$$

See reference[2] for detail of equation (C) derivation.

Combining equations (B) and (C), ammonia production rate can be expressed as:

$$A = 0.053\ KT^nW^m \qquad \text{----------(D)}$$

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[2]Liao, Paul B. Water requirements of salmonids. The Prog. Fish Culturist. 33(4):210-224.

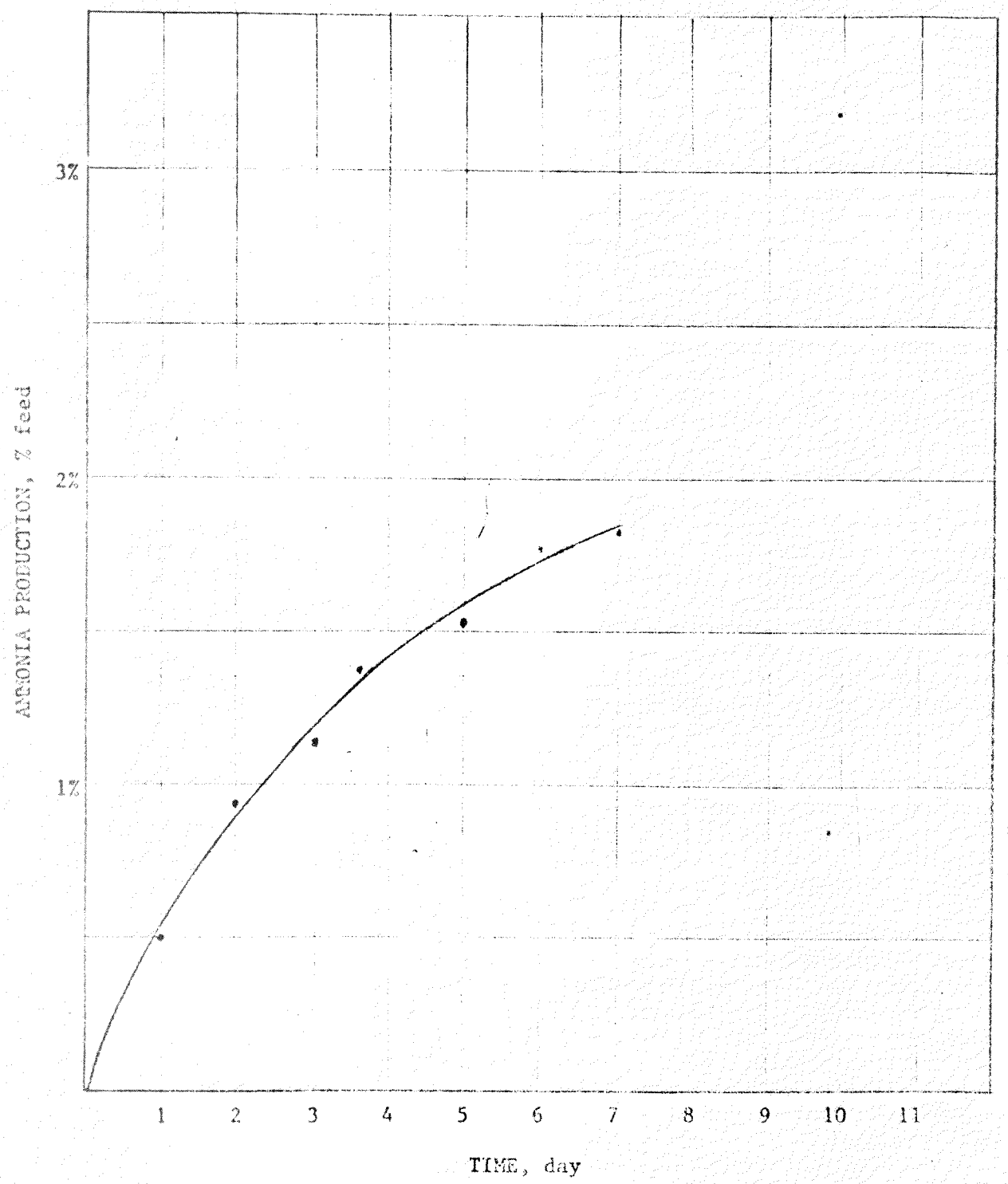

Fig. 2. Secondary ammonia production at 20° C at anaerobic condition. Courtesy of Alfred Wallace

APPLICATION OF AMMONIA PRODUCTION RATE

The major application of ammonia production rate to fish culture system planning and design is the determination of fish carrying capacity (or water supply rates), though fish loading density (rearing folume) may to some extent be affected by ammonia, also. On the other hand, carrying capacity affects both water treatment and transportation (piping and pumping) systems. Thus, ammonia not only affects the fish cultivation, but also governs the capital, operation, and maintenance costs of a culture station. Therefore, an understanding of the ammonia effect on and its application in fisheries system planning and design is essential. Documentation of ammonia toxicity to fish is thus far inadequate, yet it is commonly understood that only the unionized ammonia (ammonia gas) is toxic to fish. Unionized ammonia is regulated by pH and temperature (as indicated by Fig. 3). When the acceptable unionized ammonia level (NH_3-N) is selected, the total allowable ammonia concentration (NH_4-N) can be computed by dividing the NH_3-N by the fraction taken from Fig. 3 at a given temperature and pH value. This computed NH_4-N can then be used to check whether fish carrying capacity (water supply rate) determined based on oxygen consumption is within an acceptable limit. If carrying capacity calculated based on oxygen consumption will result in a total ammonia concentration higher than the allowable level, then the carrying capacity must be adjusted. In this case, carrying capacity, derived based on ammonia, controls. This principle applies to both a single pass system and a reuse system. This method can be used to determine potential fish production based on a given amount of water available. Similarily, it can be used to compute water supply rate required to facilitate a decided fish production goal.

For a reuse system, the application of ammonia to determination of fish carrying capacity (water requirement) is quite complicated. This is because ammonia level is also affected by the degree of water reuse and efficiency of the water reconditioning unit. However, the application may be illustrated by Fig. 4.

With procedures set forth in Fig. 4, the water requirements can either be estimated graphically or calculated by a computer program. For comparison, the water requirements for fish at various stages of hatchery rearing are determined using a computer program. Table 2 lists water requirements of coho salmon from egg incubation to release time based on oxygen only. Water temperatures during the rearing period and various factors used in computations are also noted. In order to produce 400,000 fingerlings (5.7 inches) for release, the minimum amount of water required is 2,085 gpm. This flow is much less than the 4,468 gpm computed when both oxygen and ammonia are considered (as shown in Table 3). The conditions for computation are the same for both tables except in the second case (Table 3), water must be reused three times. Also, a water reconditioning system with 20 percent ammonia removal efficiency must be provided.

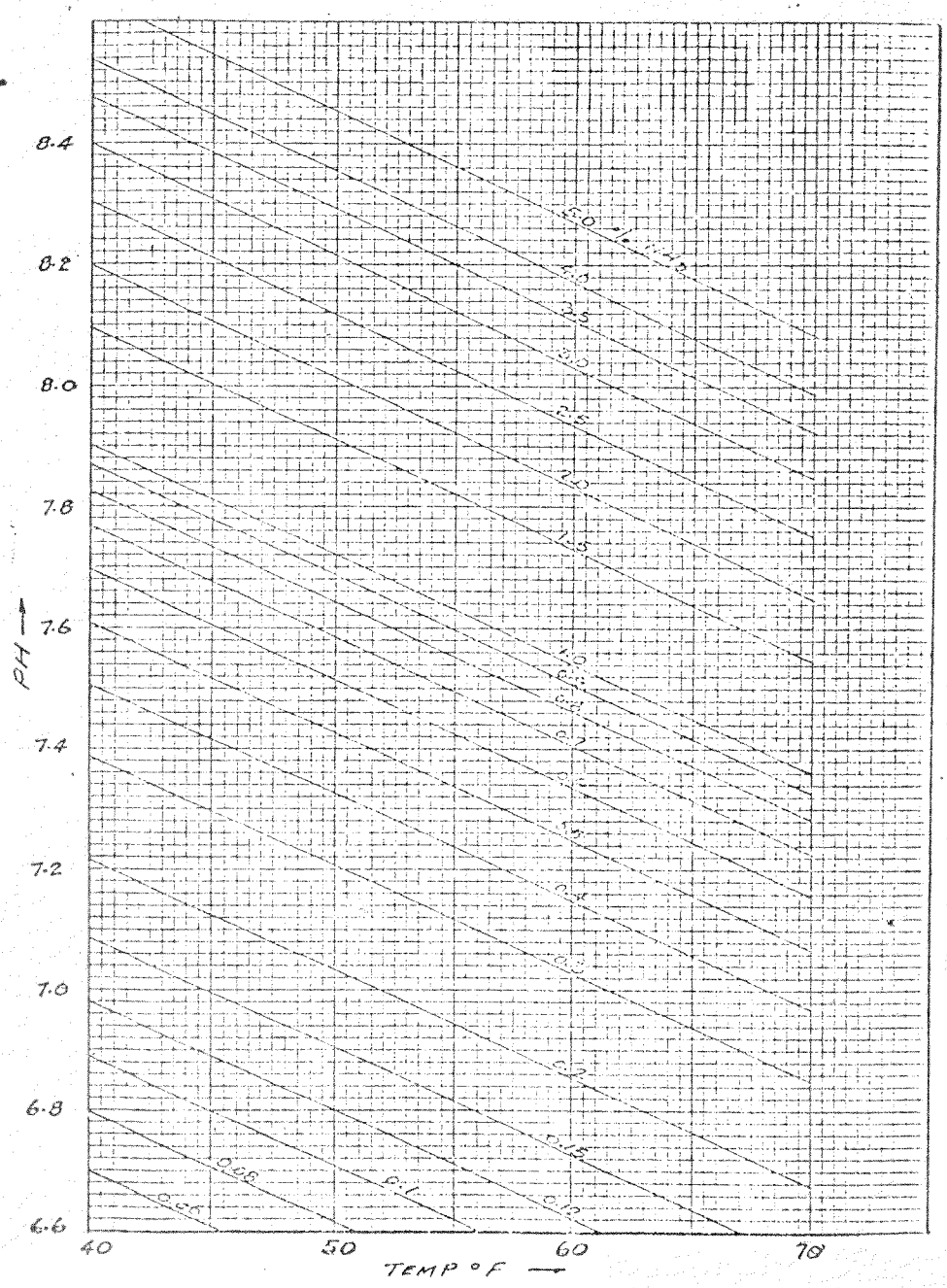

Fig. 3. Percentage of unionized ammonia versus temperature and pH.

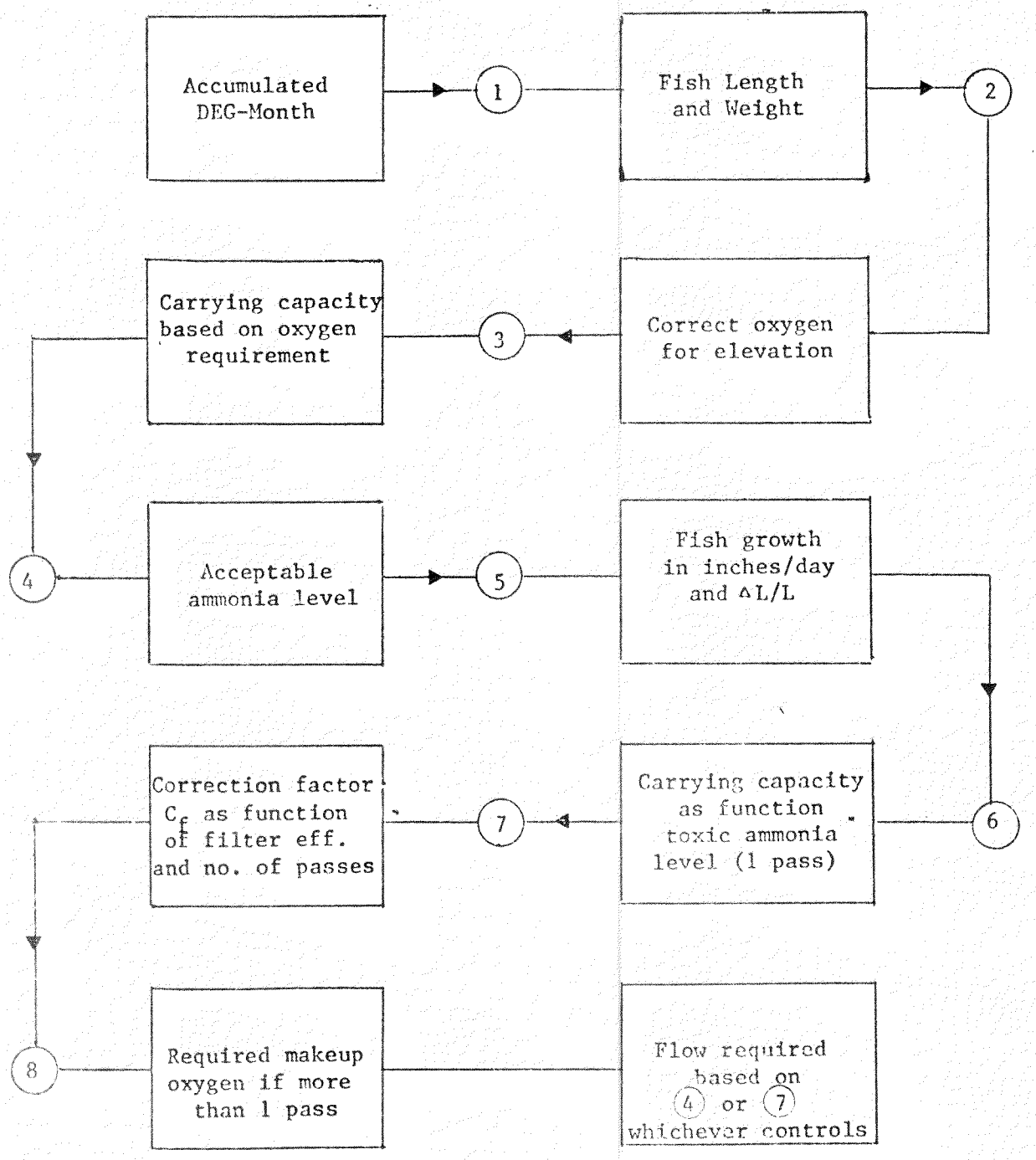

Fig. 4. Schematic diagram for determining water requirement based on oxygen and ammonia.

Table 2. Fish growth schedule and water requirements based on oxygen only

Type of fish in the porgram is coho salmon

Date	Water Aver	Temp Max	Temp Add	Status or event	Cumulative °-days fr fert egg	Length inches	Weight each lb	No of eggs or fish	Total wt lb	Flow reqd gpm	Rear vol cf	NH^4 ppm	BTU hr	Cum cost $
10/15/72				Egg take	0	----	----	500900	----	45	Incu.	----		
	45.0	46.0												
11/ 1/72				Incubation	208	----	----	496100	----	45	Incu.	----		
	45.0	46.0												
12/ 1/72				Incubation	598	----	----	487200	----	45	Incu.	----		
	45.0	46.0												
12/24/72				Hatch	900	----	----	480200	----	45	Incu.	----		
	45.0	46.0												
1/ 1/73				Sac fry	991	----	----	478200	----	45	Incu.	----		
	47.0	50.0												
1/24/73				Swim up	1350	----	----	469900	----	55	700	----		
	47.0	50.0												
2/ 1/73				Fry	1455	----	----	467500	----	58	700	----		
	48.0	51.0												
2/22/73				All feeding	1800	1.31	.0009	459600	409	58	700	----		
					Cumulative deg-month fr 1100/lb			Number of fingerling						
2/22/73				Rear fingerling	0	1.31	.0009	459600	409	58	700	****		
	48.0	51.0												
3/ 1/73				Rear fingerling	1	1.37	.0010	458600	474	58	700	****		
	49.0	54.0												
4/ 1/73				Rear fingerling	12	1.76	.0022	453900	982	127	1200	****		
	50.0	55.0												
5/ 1/73				Rear fingerling	23	2.16	.0040	449400	1816	223	1700	****		
	50.0	57.0												
6/ 1/73				Rear fingerling	35	2.58	.0069	444800	3063	383	2400	****		
	49.0	53.0												

Table 2. Fish growth schedule and water requirements based on oxygen only - continued

Type of fish in the porgram is coho salmon

Date	Water Aver	Temp Max	Temp Add	Status or event	Cumulative deg-month fr 1100/lb	Length inches	Weight each lb	Number of fingerling	Total wt lb	Flow reqd gpm	Rear vol cf	NH^4 ppm	BTU hr	Cum cost $
7/ 1/73				Rear fingerling	45	2.95	.0103	440400	4539	410	3100	****		
	46.0	48.0												
8/ 1/73				Rear fingerling	53	3.22	.0134	435900	5858	347	3700	****		
	46.0	46.0												
9/ 1/73				Rear fingerling	60	3.49	.0172	431400	7399	347	4300	****		
	46.0	46.0												
10/ 1/73				Rear fingerling	67	3.75	.0213	427100	9115	410	4900	****		
	45.0	46.0												
11/ 1/73				Rear fingerling	74	3.99	.0256	422800	10833	470	5500	****		
	45.0	46.0												
12/ 1/73				Rear fingerling	80	4.21	.0303	418600	12674	532	6100	****		
	46.0	48.0												
1/ 1/74				Rear fingerling	88	4.49	.0365	414300	15138	738	6800	****		
	47.0	50.0												
2/ 1/74				Rear fingerling	96	4.79	.0446	410000	18299	1028	7700	****		
	48.0	51.0												
3/ 1/74				Rear fingerling	105	5.11	.0539	406200	21913	1251	8700	****		
	49.0	54.0												
4/ 1/74				Rear fingerling	116	5.49	.0670	402100	26950	1803	9900	****		
	50.0	55.0												
4/15/74				Release date	121	5.69	.0747	400000	29899	2085	10600	****		

Controls used: Min, D.O. 5 ppm, D.O. Sat. 95.0%, Elev. 1300 ft, Growth rate 27.8 tu/inch,
Cost of fuel: $0.00 for oil/gal.

Table 3. Fish growth schedule and water requirements based on oxygen and ammonia

Type of fish in the porgram is coho salmon

Date	Water Aver	Temp Max	Temp Add	Status or event	Cumulative °-days fr fert egg	Length inches	Weight each lb	No of eggs or fish	Total wt lb	Flow reqd gpm	Rear vol cf	NH^4 ppm	BTU hr	Cum cost $
10/15/72				Egg take	0	----	----	500900	----	45	Incu.	----		
	45.0	46.0												
11/ 1/72				Incubation	208	----	----	496100	----	45	Incu.	----		
	45.0	46.0												
12/ 1/72				Incubation	598	----	----	487200	----	45	Incu.	----		
	45.0	46.0												
12/24/72				Hatch	900	----	----	480200	----	45	Incu.	----		
	45.0	46.0												
1/ 1/73				Sac fry	991	----	----	478200	----	45	Incu.	----		
	47.0	50.0												
1/24/73				Swim up	1350	----	----	469900	----	55	700	----		
	47.0	50.0												
2/ 1/73				Fry	1455	----	----	467500	----	58	700	----		
	48.0	51.0												
2/22/73				All feeding	1800	1.31	.0009	459600	409	58	700	----		
					Cumulative deg-month fr 1100/lb			Number of fingerling						
2/22/73				Rear fingerling	0	1.31	.0009	459600	409	58	700	****		
	48.0	51.0												
3/ 1/73				Rear fingerling	1	1.37	.0010	458600	474	205	700	0.74		
	49.0	54.0												
4/ 1/73				Rear fingerling	12	1.76	.0022	453900	982	367	1200	0.71		
	50.0	55.0												
5/ 1/73				Rear fingerling	23	2.16	.0040	449400	1816	607	1700	0.68		
	50.0	57.0												
6/ 1/73				Rear fingerling	35	2.58	.0069	444800	3063	859	2400	0.68		
	49.0	53.0												

Table 3. Fish growth schedule and water requirements based on oxygen and ammonia - continued

Type of fish in the porgram is coho salmon

Date	Water Aver	Temp Max	Temp Add	Status or event	Cumulative deg-month fr 1100/lb	Length inches	Weight each lb	Number of fingerling	Total wt lb	Flow reqd gpm	Rear vol cf	NH^4 ppm	BTU hr	Cum cost $
7/ 1/73				Rear fingerling	45	2.95	.0103	440400	4539	1011	3100	0.71		
	46.0	48.0												
8/ 1/73				Rear fingerling	53	3.22	.0134	435900	5858	878	3700	0.80		
	46.0	46.0												
9/ 1/73				Rear fingerling	60	3.49	.0172	431400	7399	1023	4300	0.80		
	46.0	46.0												
10/ 1/73				Rear fingerling	67	3.75	.0213	427100	9115	1172	4900	0.80		
	45.0	46.0												
11/ 1/73				Rear fingerling	74	3.99	.0256	422800	10833	1174	5500	0.83		
	45.0	46.0												
12/ 1/73				Rear fingerling	80	4.21	.0303	418600	12674	1299	6100	0.83		
	46.0	48.0												
1/ 1/74				Rear fingerling	88	4.49	.0365	414300	15138	1629	6800	0.80		
	47.0	50.0												
2/ 1/74				Rear fingerling	96	4.79	.0446	410000	18299	2202	7700	0.77		
	48.0	51.0												
3/ 1/74				Rear fingerling	105	5.11	.0539	406200	21913	2703	8700	0.74		
	49.0	54.0												
4/ 1/74				Rear fingerling	116	5.49	.0670	402100	26950	3864	9900	0.71		
	50.0	55.0												
4/15/74				Release date	121	5.69	.0747	400000	29899	4468	10600	0.68		

Controls used: Min, D.O. 5 ppm, D.O. Sat. 95.0%, Elev. 1300 ft, Growth rate 27.8 tu/inch, Cost of fuel: $0.00 for oil/gal, Max. Q 5000 gpm, Max. NH^4 .005 ppm, pH level 7.60, No. pass 3, Filter eff. 20.0%, Degree day base 32° F, Degree month base 38.6°F.

The center of flow calculation for Table 3 is the acceptable unionized level of 0.005 ppm. It is obvious that from this comparison, a hatchery water supply system based on oxygen consumption only will be insufficient to meet the production goal. If this is not known beforehand and the hatchery is designed and dedicated as planned, severe operational frustrations and/or losses will occur.

FUTURE WORK

Much emphasis has been made on the importance of the ammonia factor in hatchery water requirement determination. Nevertheless, the validity of the model discussed relies heavily on ammonia production rate and acceptable ammonia level. Ammonia production rate can be reliably estimated using equation (A). However, documentation on ammonia toxicity to fish is inadequate. As a result, acceptable ammonia levels cannot be confidently established. Therefore, future work should be directed toward defining mechanisms of ammonia toxicity to fish and establishing acceptable ammonia levels for various fish species.

GENETICS

SELECTIVE BREEDING RESEARCH STATION

MAPLE, ONTARIO

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The UMA Group
Calgary, Alberta

As part of the total management of the Sports Fishery for the Province of Ontario, the Ministry of Natural Resources have over the years been very active in related fish research. The facilities utilized have serviced admirably in the development of the Splake and other research programs. However, a gradual increase in program size, diversity and direction has taxed the existing research facilities to their limit, and has now reached a point which demands construction of a new Selective Breeding Research Station.

The translation of the requirements for this station, in engineering language, relates to an enclosed facility of 18,400 ft^2 which is to be constructed at the Maple Research Station. At present, Maple is an integrated complex of activities for forestry, wildlife, and fisheries research located some 40 miles north of Toronto, and consisting of 108 acres of Ontario countryside.

The design of the Selective Breeding Research Station is centered around the provision of 32 Rearing Modules, each of which is capable of reconditioning water at the rate of 36 Igpm on a recycle basis. Basic rearing space and related ancillary functions are to be provided on a main floor level, with attendant mechanical services provided on a lower floor level which occupies but a small portion of the total structure. The rearing units are situated in an arrangement which surrounds a "pit" housing the reconditioning units, and a mezzanine floor above the pit supports the aeration tanks and other mechanical equipment.

Tenders for construction are due to be called imminently, and anticipated construction costs are in the order of $2.1 million.

PRELIMINARY RESULTS OF SELECTIVE BREEDING TO INCREASE THE YIELD OF COHO SALMON PRODUCED AT BIG CREEK HATCHERY

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INTRODUCTION

Selective breeding experiments designed to increase the yield to the fishery of coho salmon produced at Big Creek Hatchery near Astoria, Oregon were described by McIntyre and Johnson (1973). The objective of this report is to present the results of an experiment with the 1971 brood. The data must be considered preliminary because the accumulation of tags from adult fish is incomplete.

EXPERIMENTAL PROCEDURES

The 1968-brood coho salmon produced at Big Creek Hatchey were tagged with color-coded wire tags from which their parents could be specified. The number of adult fish from each pair of parents (a family) that returned to the hatchery in November 1971 and that were sampled from the ocean and Columbia River fisheries was divided by the number of smolts released for each family to estimate their percentage yield. These percentages ranged from 0.1 to 2.1 and averaged 0.8.

Ten families had a percentage yield greater than 1.0 percent. Individuals from these families were used as broodstock for the 1971 brood. The average yield of these "select" families was 1.5 percent. Unmarked adults obtained from the holding pond were mated to provide a control group. A total of 45 families--30 select and 15 control--was produced by mating 45 females, each with a single male. The juveniles produced from these matings received a coded-wire tag and an adipose mark prior to their release.

Enumeration of the 1971-brood adult return to the hatchery and recovery in the ocean and Columbia River fisheries is nearing completion at the present time. Numbers of marked fish sufficient to intensify selection were available at the hatchery on November 15, 1974 and the matings were made based on the available data. Substantial numbers of tags have been collected at the hatchery and from the Washington ocean-fishery since that time and are included in the results presented here.

RESULTS AND DISCUSSION

Substantial numbers of fish were recovered from our experimental groups (Table 1). The percentage recovery of the release differed in the select and control groups by 0.1 percent. The average yield of select and control families was 1.23 percent and 1.16 percent, respectively.

Table 1. Tag recoveries of select and control groups of Big Creek coho salmon

	Select	Control
Smolts released	41,665	16,235
Marine recovery		
Canada	13	1
Washington	160	52
Oregon	165	63
California	52	36
Columbia River gill-net fishery	50	12
Hatchery	94	27
Total recovery	534	191
Percentage of release	1.28	1.18

The heritability of yield can be estimated from the data for individual families by rearrangement of:

$R = \sigma_p h^2 i$ (Falconer 1960); where,

R = response to selection (mean yield of select families minus mean yield of control families)

= 1.23 - 1.16 = 0.07.

σ_p = standard deviation of yield = 0.393

i = mean of families selected minus mean of all families before selection/σ_p

$$= \frac{1.451 - 0.788}{0.393} = 1.69$$

By rearrangement: $h^2 = \frac{R}{\sigma_p i} = \frac{0.07}{0.66} = 10.6\%$. This heritability estimate can be used in the above equation to predict the response and expected yield for different selection intensities as:

Percentage of available families discarded	Selection intensity[1]	Response	Expected yield
50	0.80	0.03	1.19
75	1.27	0.05	1.21
95	2.06	0.09	1.26

[1]*See* Falconer (1960).

From the above, it can be seen that a large number of families must be available to ensure that the high selection intensities required to realize a substantial increase in yield are attained. Another requirement that must be met to be successful in comparable breeding programs was indicated by the absence of any significant correlation ($r = 0.05$) between the percentage yield by each family to the fishery and their percentage return to the hatchery. Because of the absence of any correlation here, tag recoveries from the fishery must be accumulated and the relative yield of each family evaluated prior to the time that selective breeding to increase yield is continued.

The preliminary evidence presented here suggests that increases in yield of Big Creek coho salmon can be realized through selective breeding. It must be pointed out, however, that breeding programs such as the one described here may be more or less successful with other species and with coho salmon at other hatcheries.

RFERENCES

Falconer, D. S. 1960. Introduction to quantitative genetics. Ronald Press, New York. 365 pp.

McIntyre, J. D., and A. K. Johnson. 1973. Progress of coho salmon genetic studies at Big Creek. 24th Annual Northwest Fish Culture Conference. pp. 48-50.

GROWTH AND DEVELOPMENT IN YOUNG CHINOOK SALMON DERIVED FROM INTERYEAR-CLASS CROSSES

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University of Washington
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In 1971 a program was initiated to investigate the effects of making crosses between different age chinook salmon adults from the University of Washington stock. The purposes were: (1) To look for a combination which would improve stock quality and increase production; (2) To attempt to take advantage of the apparent faster growth rate of jacks; and (3) To determine if age class might be an appropriate trait on which selection could be based to yield a more productive stock.

Crosses were made with various aged chinook salmon of three different brood years, as shown in Table 1. Each female was crossed with a single male and the lots were maintained separately during incubation. At swim-up the lots were combined according to the type of cross made and reared as separate groups. Prior to planting, each group was marked by finclipping or liquid nitrogen freeze-branding. Also, data were taken on the smolt size at planting.

Although most of the results of this work are still at sea, preliminary data have given some indications on part of the crosses. The crosses made with fish from the 1971-brood year are presented in Table 2. At planting the smolts from th 3 x 2 cross were larger, and the returns to date indicate that more fish are returning as mature adults from this cross, but they are somewhat smaller than those from the 3 x 3 cross.

In 1972 the number of crosses made, based on adult age, were increased to include chinook salmon that were four years old. As shown in Table 3, the smolts at planting were larger in the groups with younger parents; that is, the progeny of the 3 x 2 cross were the largest, those of the 4 x 4 cross the smallest, and the other two crosses were intermediate. This difference, based on analysis of variance, is significant at the 5 percent level. The return of adult fish to date indicates that again the fish from the 3 x 2 cross returned in greater numbers, but were somewhat smaller.

Unfortunately the crosses were repeated with the 1973-brood-year fish, with the addition of one more type of cross, 4-year-old females x 2-year-old males. As shown in Table 4, the smolt size with these crosses was larger in the groups from the older parents. Instead of the smolts from the 3 x 2 cross being the largest fish as in 1971 and 1972, they were the smallest. Return data to date are only on "0"-age fish and are inconclusive.

Table 1. The types of chinook salmon crosses, based on parental age, used in the three brood years studied. The marks, either finclips or liquid nigrogen freeze-brands, used on progeny from these crosses are also indicated

Female age		Male age	Mark
		1971 brood year	
3 years	x	2 years	RV
3 years	x	3 years	LV
		1972 brood year	
3 years	x	2 years	LHBD
3 years	x	3 years	LHBH
4 years	x	3 years	RHBD
4 years	x	4 years	RHBH
		1973 brood year	
3 years	x	2 years	RSBH
3 years	x	3 years	LSBH
4 years	x	2 years	RSBD
4 years	x	3 years	RSUD
4 years	x	4 years	LSBD

Table 2. Length and weight data on the progeny of the interyear-class crosses from the 1971-brood year, and the number of adult chinook salmon returning to the College of Fisheries

Cross	Mark	Sex	No. returns	Average length (cm)	Average weight (gm)
		Planting data			
3 x 2	RV			9.71	11.43
3 x 3	LV			9.61	11.27
		1973 returns			
3 x 2	RV		433	50.5	1.58
3 x 3	LV		117	53.0	1.84
		1974 returns			
3 x 2	RV	Male	337	71.6	4.23
3 x 3	LV	Male	183	81.4	5.07
3 x 2	RV	Female	150	73.6	5.13
3 x 3	LV	Female	100	75.4	5.53

Table 3. Length and weight data on the progeny of the interyear-class crosses from the 1972-brood year, and the number of "0"-age and "jack" chinook salmon returning to the College of Fisheries

Cross	Mark	No. returns	Average length (cm)	Average weight (gm)
		Planting data		
3 x 2	LHBD		9.99	11.39
3 x 3	LHBH		9.88	11.02
4 x 3	RHBD		9.62	10.11
4 x 4	RHBH		9.38	9.50
		1973 returns		
3 x 2	LHBD	25	24.0	200
3 x 3	LHBH	12	21.2	140
4 x 3	RHBD	34	23.9	200
4 x 4	RHBH	14	23.2	190
		1974 returns		(kg)
3 x 2	LHBD	149	47.7	1.34
3 x 3	LHBH	20	49.2	1.50
4 x 3	RHBD	29	51.7	1.66
4 x 4	RHBH	35	48.0	1.40

Table 4. Length and weight data on the progeny of the interyear-class crosses from the 1973-brood year, and the number of "0"-age chinook salmon returning to the College of Fisheries

Cross	Mark	No. returns	Average length (cm)	Average weight (gm)
		Planting data		
3 x 2	RSBH		9.99	11.42
3 x 3	LSBH		10.32	12.47
4 x 2	RSBD		10.10	11.69
4 x 3	RSUD		10.20	12.14
4 x 4	LSBD		10.57	13.72
		1974 returns		
3 x 2	RSBH	4	21.8	160
3 x 3	LSBH	22	24.6	230
4 x 2	RSBD	15	21.0	130
4 x 3	RSUD	11	22.6	170
4 x 4	LSBD	10	24.5	230

In addition to analyzing the crosses on the basis of natural return and production, samples of each type of cross from the 1973-brood year were placed in net pens for saltwater rearing. This was done in cooperation with Conrad Mahnken of NMFS at Manchester, Washington. The various groups, based on the type of cross, were vaccinated I.P. with vibrio vaccine, kept in separate lots with equal numbers of individuals, fed on a paired feeding schedule, and weighed and measured monthly. The results on the growth of these fish are shown in Fig. 1. As indicated in this figure, there were no significant differences in the growth rates of the various crosses in saltwater. However, this study is being continued and differences may be evident later.

In addition to the growth rate, several observations were made on the fish in saltwater pens which may be of value to culturists working with chinook in captivity. Compared to coho salmon of the same age, the chinook exhibited much less variability in size. However, similar to coho salmon, there was a typical "break" in the growth curve between the October and November weighing (between about 1600 and about 1900 temperature units in Fig. 1). This is a larger decrease in growth rate than is demonstrated by coho salmon, and may be caused by the change in photoperiod, size of the fish, or a combination of both.

To summarize, the following results are indicated at this point:

1. With three-year-old females, more "jacks" return in the population when "jacks" are used as the male parent.

2. The cross of a 3-year-old female x a 2-year-old male appears to produce more, but smaller adult fish.

3. Different year classes of chinook salmon may yield quite different results, even though they are part of a single breeding population.
4. Growth in captivity in saltwater and in a natural situation appears to be different, but should yield some valuable correlations.

Data in subsequent years should substantiate these tentative results and will be presented more completely at a later date.

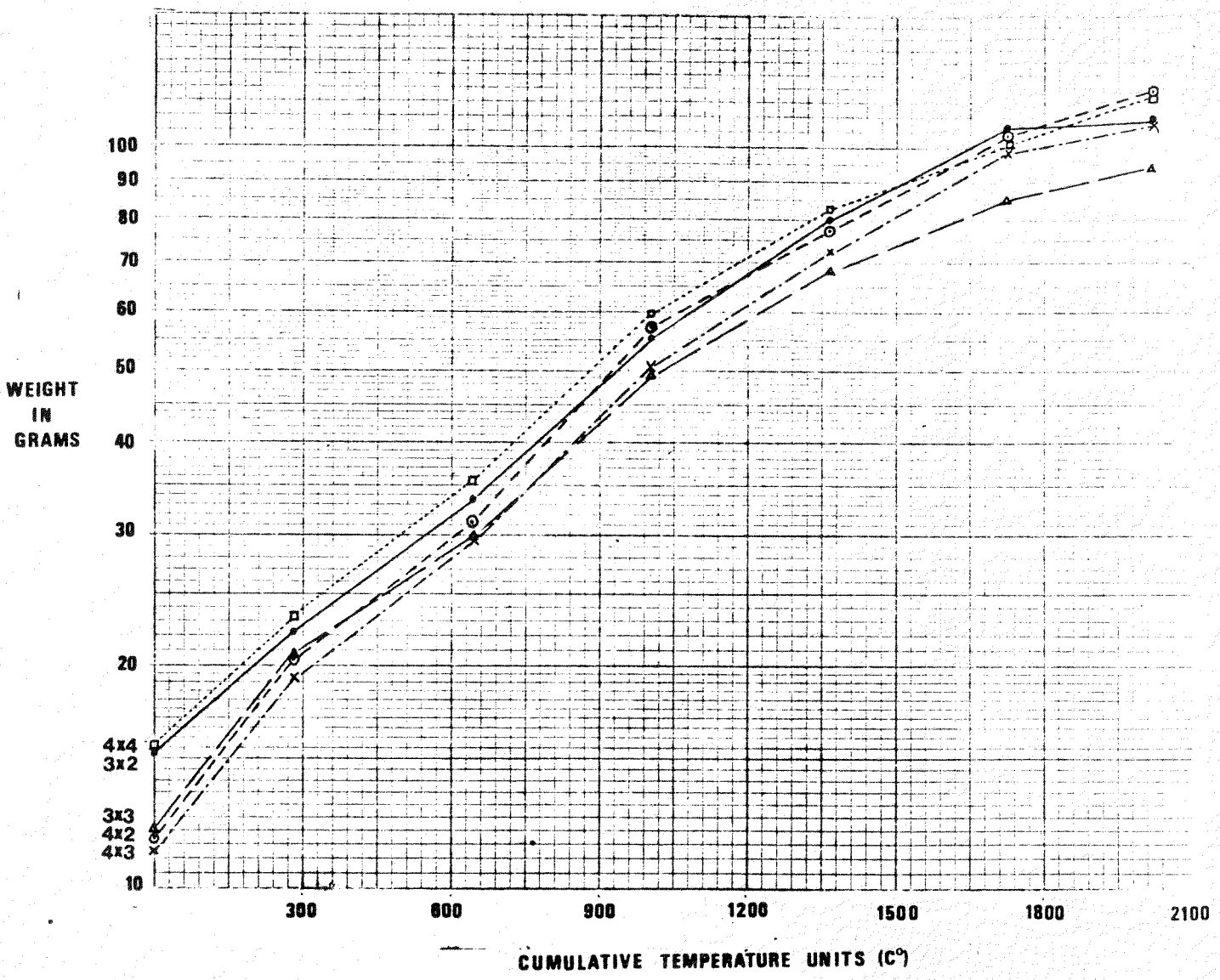

Fig. 1. Growth rate in saltwater pens of the five interyear-class crosses from the 1973-brood year of the University of Washington chinook salmon. Each point on the lines represents an interval of one month.

EXPERIMENTAL CROSSES OF HATCHERY AND WILD STEELHEAD AT COLE RIVERS HATCHERY, OREGON

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Cole Rivers Hatchery
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INTRODUCTION

There is a growing concern among fisheries biologists over the possible consequences of superimposing hatchery-reared steelhead on wild populations. This concern has two basic roots: (1) where the hatchery run predominates numerically over the wild run, it is necessary to avoid the establishment of a monoculture of hatchery fish and prevent the biological drawbacks attendent in all monoculture systems. By reference to monoculture, we mean the development of a hatchery population with greatly reduced genetic variability. Reduced variability may be expressed as a reduced time over which the spawning migration occurs, a shift in the timing of the peak migration period and the loss of some life history types. These changes toward a more uniform population of steelhead have been observed at the Oregon Wildlife Commission's Alsea Hatchery. (2) Another area of concern is the situation where the hatchery run is numerically less than the wild population. In this case, the goal of the hatchery program may be the enhancement of a viable wild population or mitigation for the partial loss of spawning grounds as a result of water development projects. Under these conditions it is necessary to rear and release hatchery steelhead in a manner that minimizes competitive interaction with the wild population and minimizes the impact of random matings of hatchery and wild fish in the river. Enhancement of a wild-steelhead population through the introduction of hatchery-reared fish should not be achieved at a cost to the wild stock.

One course of remedial action common both of these problems is the exclusive use of wild fish for hatchery brood stock.[1] If this method of brood stock selection were implemented it would tend to reduce the impact of hatchery selection on the genetic makeup of the wild population. The impact would be minimal because hatchery-reared steelhead would be, at most, one generation removed from the genetic makeup of the wild-type fish.

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[1]Dr. Harry Wagner, Oregon Wildlife Commission, Corvallis, Oregon, personal communication.

EXPERIMENTAL DESIGN

To evaluate the type of brood stock selection proposed above, we crossed hatchery and wild-summer steelhead from the 1974 brood at Cole Rivers Hatchery, using Rogue River stock. There were four crosses as shown in Fig. 1, hatchery male and hatchery female, wild male and female, wild male and hatchery female, and hatchery male and wild female. One male fertilized the eggs from two females. Three males and six females were used in each of the four crosses. The eggs from each female were incubated separately. After "button-up" the progeny from the individual females of a given cross were combined and reared in one of four separate ponds.

Length, weight, fecundity, and eggs per ounce were determined for the brood stock. Egg mortality for individual females was recorded. Lengths and weights of the progeny are being recorded.

RESULTS

There were no significant differences between hatchery and wild-brood stocks for the parameters measured. Also, egg mortality was not significantly different among the four crosses. Admittedly, the sample size for this experiment was small which, combined with large variances, may have masked any real differences in these data.

The only measurable difference between the crosses appears in the growth of the progeny (Fig. 2). Juveniles from the hatchery male and female cross have grown at a faster rate than those of the other crosses. The wild male and female cross exhibits the slowest growth rate. In addition to growth, the feeding behavior of the hatchery-hatchery cross and the wild-wild cross is markedly different. Progeny from the hatchery-hatchery cross are more aggressive in their feeding behavior, coming to the surface and aggressively pursuing and ingesting the feed. Juveniles from the wild-wild cross, however, are much less aggressive; remaining near the bottom of the pond, ingesting feed in a passive manner.

DISCUSSION

The differences in growth between progeny of hatchery and wild parents becomes more significant when one considers that the hatchery-brood stock was only one or two generations removed from the wild. Similar crosses with Deschutes River stock have been carried out at Round Butte Hatchery resulting in growth patterns similar to those described for the Rogue River stock.[2]

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[2]Jim Fessler, Oregon Wildlife Commission, Corvallis, Oregon, personal communication.

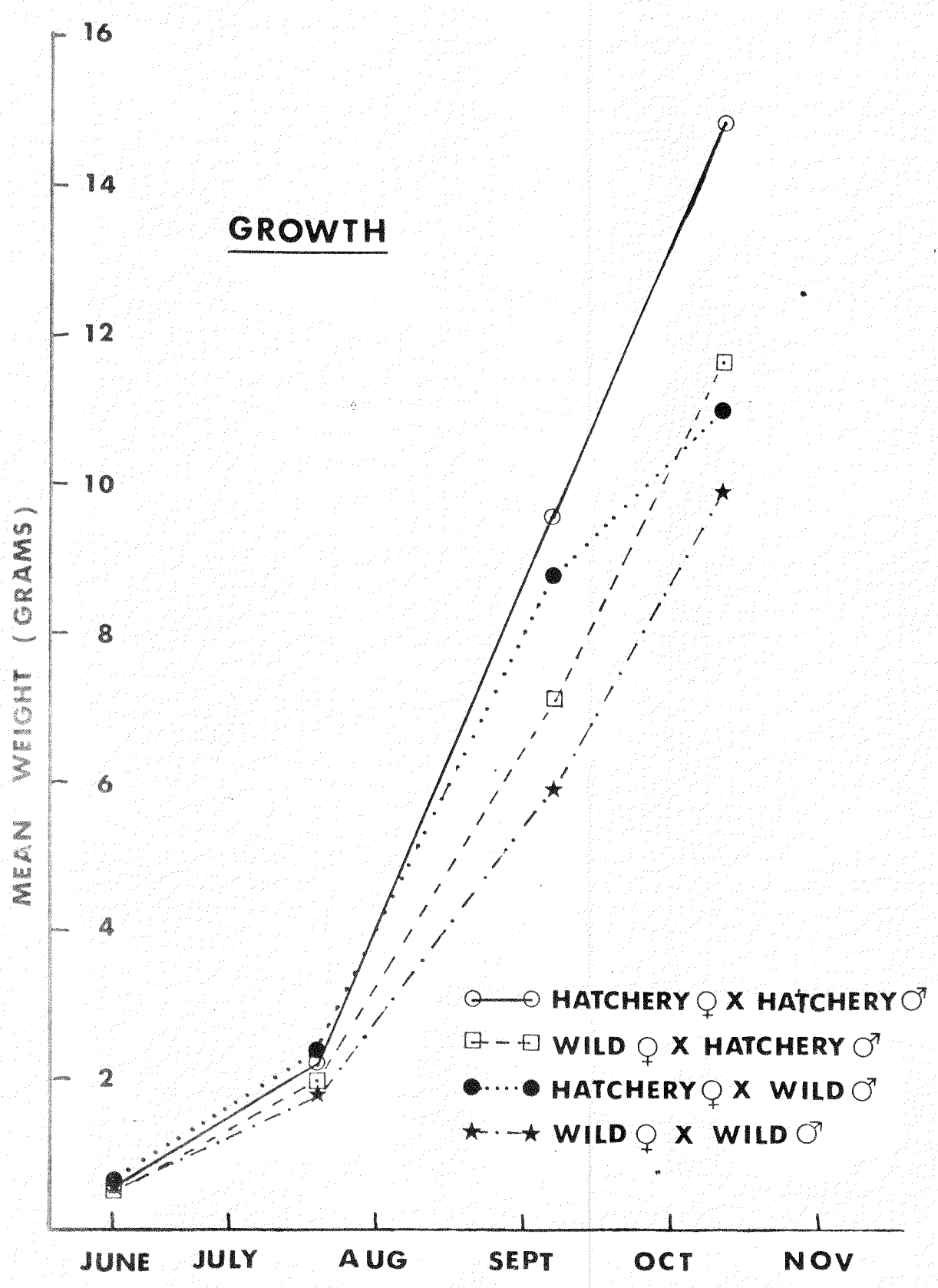

Fig. 1. Experimental crosses of summer steelhead at Cole Rivers Hatchery. Each box or circle signifies a single male or female steelhead respectively.

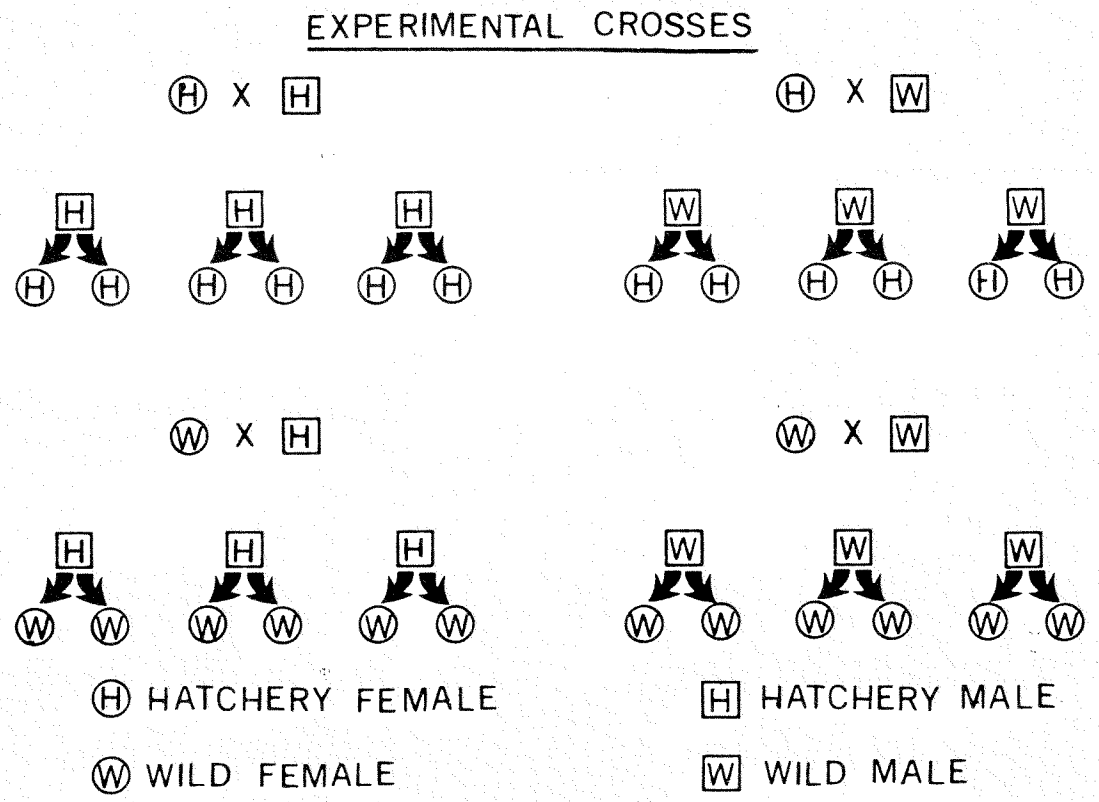

Fig. 2. Change in weight in four groups of juvenile summer steelhead at Cole Rivers Hatchery. Each group represents the progeny from a specific cross of hatchery and/or wild parents.

Since this experiment is not yet complete, it is difficult to draw definitive conclusions. Downstream migration after release, residualism, and ocean survival need to be evaluated. However, the results obtained thus far warrant further investigation. Another experiment employing more fish in each cross will be conducted.

Earlier in this paper we mentioned a scheme for brood-stock selection intended to reduce the impact of hatchery operations on the genetic diversity of the stock. That scheme proposed the exclusive use of wild fish for brood stock. The data collected so far in this experiment indicate that such a scheme would involve a possible loss in the efficiency of a hatchery operation. The slower growth rate and reduced food conversion exhibited by the progeny of wild-wild crosses as compared to hatchery-hatchery crosses could require a two-year-rearing program in order to attain the minimum size necessary for parr-smolt transformation to occur. The slower growing progeny of wild parents, if released after one year of hatchery growth, may be more prone to residualism, thus reducing hatchery operation efficiency even further. While the exclusive use of wild-brood stock in steelhead hatcheries may be desirable from a genetic standpoint, the tradeoff required to accomplish these goals would require extensive study and appraisal to arrive at an optimal brood-stock-selection procedure.

MISCELLANEOUS

POTENTIAL FOR SEX STEROIDS AS GROWTH PROMOTERS IN SALMON CULTURE

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Sex hormones are compounds which assert their main effect on the sex related functions of an animal. However, these compounds also affect the growth either of specific parts of the anatomy or the whole animal.

In our laboratory in Vancouver, we have, for some time, been carrying out experiments to assess the effectiveness of sex hormones and related substances on the growth of salmon. If these hormones are effective, their use could be of benefit in two areas of salmon culture, namely, in hatchery management especially where water temperatures are low and in rearing of salmon for the fish market.

In our early experiments, we tested two estrogens - estradiol and diethylstilbestrol. Estradiol was ineffective when tested on coho parr. Diethylstilbestrol produced undesirable changes in coho parr, namely, reduction in growth rate and increased mortality.

Of androgens or male sex hormones, we have been working mostly with 17α-methyltestosterone. This is a synthetic androgen, although chemically very closely related to the natural hormone testosterone. It has growth promoting properties, but has been more commonly used in medicine for the correction of hormonal disorders.

I will give details of two recent experiments in which we tested methyltestosterone on juvenile coho.

EXPERIMENT 1

Long-Term Effects of Methytestosterone Supplemented Diets on Coho Juveniles

The coho fry at the start of the study were about two months past hatching and weighed an average of 0.76 g. Groups of 350 fish were held in 50 gal fiberglass tanks supplied with running water and air. The study was initiated in April 1972 and terminated 72 weeks later in October 1973. The fish received either 10, 1.0, 0.2, or 0 mg of steroid per kg of food.

Growth in weight was exponential during the first 16 weeks (Fig. 1, Table 1). After 20 weeks, the number of fish in each tank was reduced from 350 to 150. These tanks were then continued on the original feeding schedule but with rations reduced in accordance with the reduction in number of fish. Of the surplus from the group which had received the 10 mg steroid diet, 150 fish were retained and fed the control ration. The surplus fish from the other three groups were discarded.

Table 1. Net weight gain of 17α-methyltestosterone treated groups as percentage of control group

	Length of treatment								
	8	16	24	32	40	48	56	64	72
Dose	Temperature (° C)								
(ppm)	9	13	11.5	6.5	5.5	5.5	9.8	11.0	11.0
10	9	14	55	85	118	120	125	73	3
+1	14	20	37	55	69	72	71	64	45
0.2	3	2	-1	3	17	-1	4	-4	-5
10[1]			37	40	32	32	12	10	-2

[1]Hormone withdrawn after 20 weeks.

After the 20th week of methyltestosterone feeding, the water temperature declined from its maximum of 14° to 5° C. Consequently, the growth rate of the control group declined. The group receiving the lowest dose (0.2 mg/kg) followed the same trend and these two groups gained very little weight between the 24th and 48th weeks. In contrast, the coho receiving the two higher doses continued to gain weight although at a lower rate than during the first 24 weeks. The fifth group, consisting of coho which received methyltestosterone for 20 weeks only - after steroid withdrawl, maintained their weight gain for some time, but gradually lost it.

By the 57th week of treatment, the fish in the control group displayed the external signs of smolting. At this point, the fish in all five groups were gradually introduced to saltwater. During the following weeks, a number of mortalities were recorded among the fish held on the 10 ppm steroid ration. Furthermore, the growth rate of this group showed a marked decrease.

Changes in tissue constituents from that of the controls were restricted to fish on the 10 ppm steroid diet (Table 2).

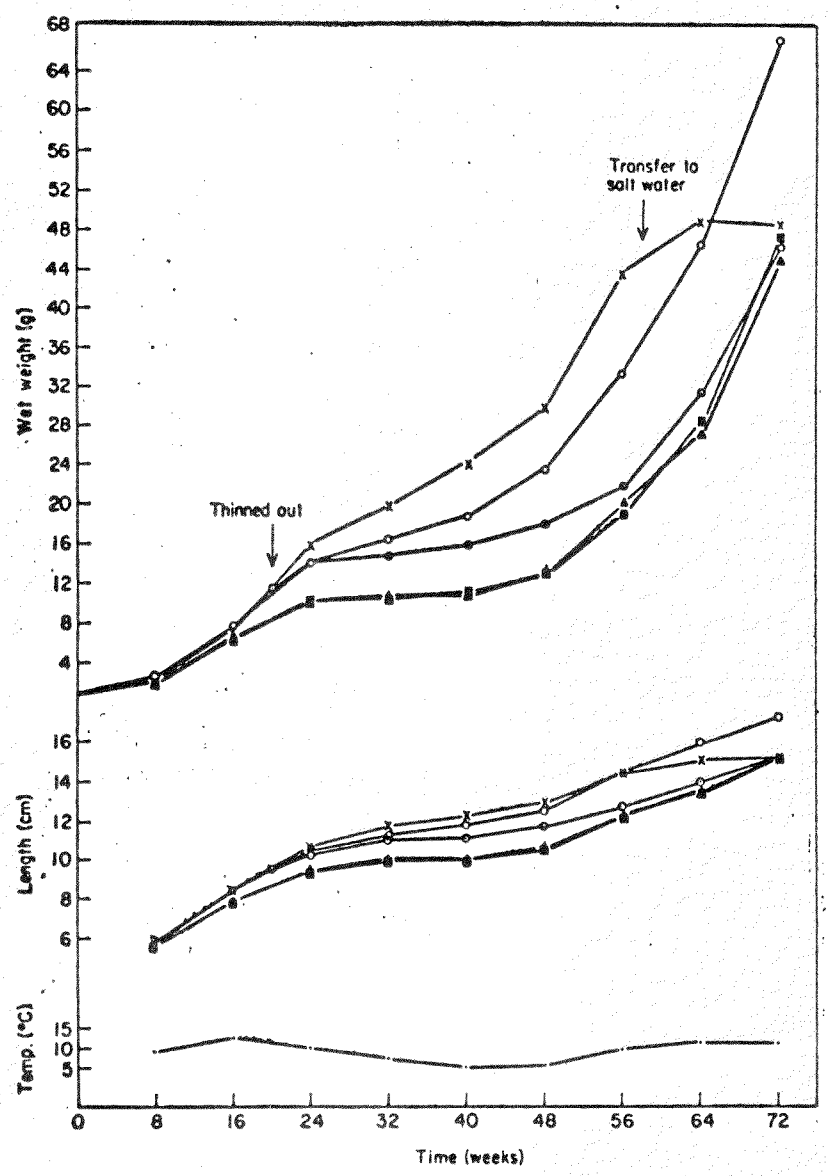

Fig. 1. Mean weights and length of groups of coho salmon receiving 17α-methyltestosterone supplemented diets. Methyltestosterone dosage (mg/kg of feed): X, 10; O, 1; ▲, 0·2; ■, 0; ⊙, 10. (Hormone withdrawn after 20 weeks.)

Table 2. Flesh content as percentage of wet body weight and moisture and lipid content of flesh of coho smolts fed 17α-methyltestosterone supplemented diets for 49 weeks

	Flesh determination			Moisture and lipid determination				
Dose (ppm)	Mean body wt (g)	Flesh (%)	P[1]	Mean body wt (g)	Moisture (%)	P[1]	Lipids (%)	P[1]
10	29.6	28.5	0.001	22.0	79.1	N.S.	3.46	0.001
1	24.5	33.9	N.S.	21.2	78.6	N.S.	2.53	N.S.
0.2	13.2	35.2	N.S.	15.9	79.4	N.S.	2.65	N.S.
0	13.1	35.0		14.2	79.5		2.41	

[1]Comparison with the control group in a *t* test.
N.S. Not significant at the 99% level.

External Characteristics

At the start of the study, the fish in all groups displayed the typical characteristics of coho parr. After feeding 10 ppm of methyltestosterone for 16 weeks, the skin of most fish in this group lost its sheen. At the same time, the fins acquired a yellowish tint. The body of some of the fish deepened in the region of the anal fin and in some fish, the head widened in the area of the lower jaw. A few fish developed a hump back reminiscent of the sexually mature male salmon. At the time of transfer to saltwater, where the fish in the other groups were silvery, all of the fish receiving 10 ppm of steroid exhibited prominent parr marks. These changes in external appearance persisted until the end of the experiment.

Gonad Structure

Alterations in gonad structure occurred only in the tests of males receiving the 10 mg/kg hormone ration. At the end of the first four weeks of feeding, a marked swelling of the organ was noted in all males examined and after eight weeks, clear degenerative changes were evident. The sperm producing cells were visibly enlarged and at the same time, there was a distinct reduction in the numbers of these cells.

At the end of the 32nd week, the testes in the 10 ppm group were reduced to a thickened tissue capsule or tunica. Confirmation of the apparent sterilization of the males was obtained at the end of the 72nd week when all of the fish in this group were killed.

The effect of the 1 mg/kg hormones dose was much less severe. Some changes were seen after 57 weeks. After 72 weeks of feeding, 13 males were examined. Of these, two appeared to be sterile, three showed a highly variable reduction in the number of spermatogonia, and eight appeared unaffected.

The ovaries were not affected by methyltestosterone.

EXPERIMENT 2

Effect of Methyltestosterone Supplemented Diets on the Growth Rates of Juvenile Coho Exposed to Two Different Temperatures

For this study, we held juvenile coho at two constant temperatures, 11.5 and 16.5° C.

The experimental procedures in this experiment were essentially the same as those described for the preceding study. Prior to the commencement of steroid feeding, the fish were given a two week period in which to acclimate to the elevated test temperatures. The temperature of the water was raised at a rate of 1° per day.

Growth Responses

The study was started in May 1973 and terminated in February 1974. Each group consisted of 160 fish (mean weight 1.4 - 1.5 gm) and held in freshwater in 250 gal tanks.

A strong anabolic response was evident in all test groups (Fig. 2, Table 3). Of particular interest is the growth response obtained in the fish fed the 0.2 ppm steroid ration. In the previous study, carried out at ambient temperatures, this concentration of the steroid failed to evoke a response. It is noteworthy that at the termination of the study the weight of the fish held at 11.5° C and fed the 0.2 ppm steroid ration exceeded that of the controls held at 16.5° C.

Table 3. Mean weight and net weight gain over controls of groups of coho treated with methyltestosterone for 36 weeks

Dose (ppm)	Temperature			
	11.5° C		16.5° C	
1.0	66.1 g	96.1%	136.1 g	148.8%
0.2	62.1 g	84.3%	112.0 g	104.8%
0	33.7 g		54.7 g	

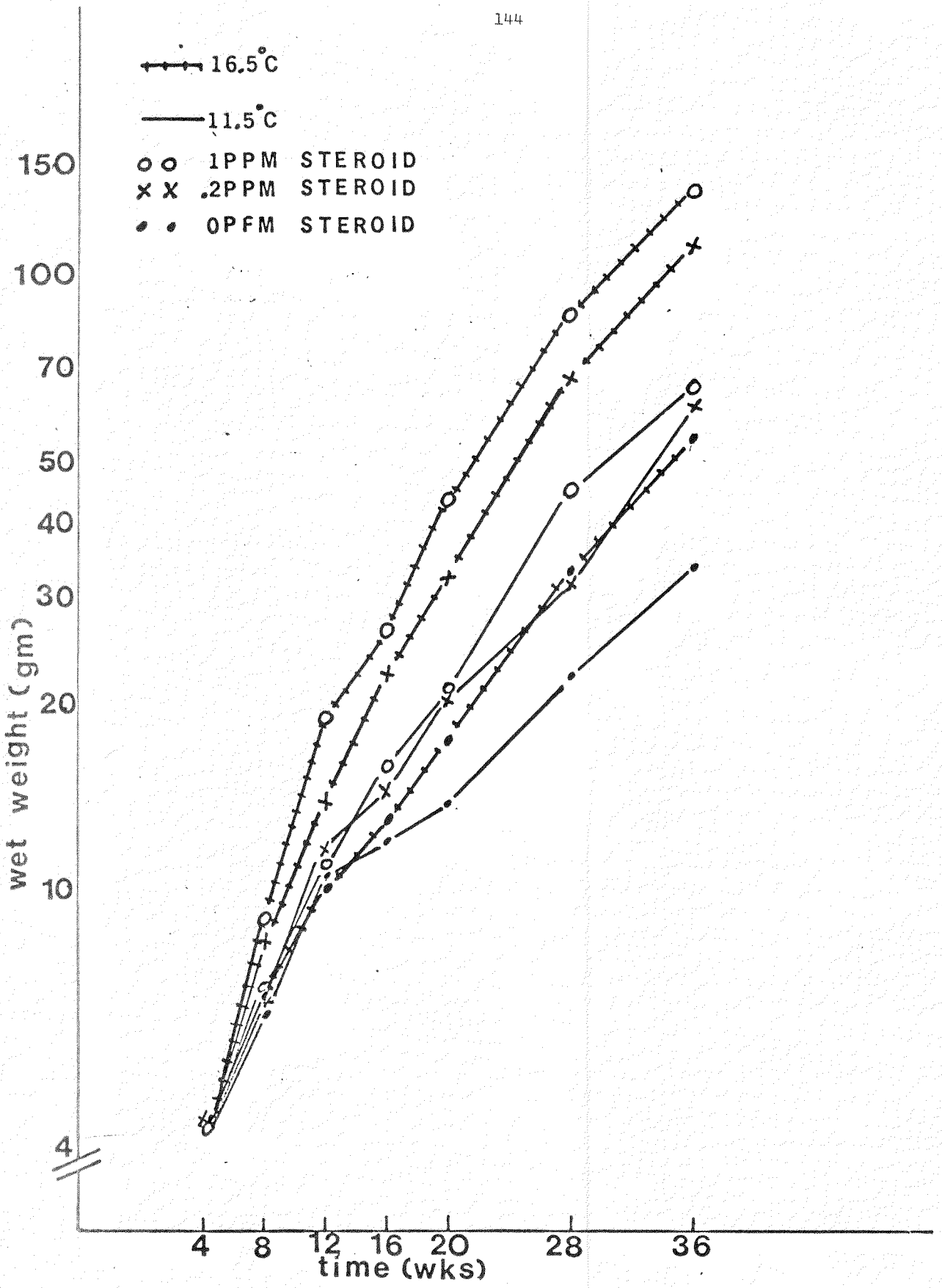

Fig. 2. Wet weight vs time for the various dosages of steroids. (Ed.'s caption).

CONCLUSION

In conclusion, a number of points are worth noting. It is clear that the inclusion of 17α-methyltestosterone in the diet has yielded a highly significant increase in the growth rate of juvenile coho. It is equally clear that excessive amounts of the steroid can lead to the introduction of marked androgenic effects. Hormones are being investigated at the moment, which may have a reduced androgenic effect.

STATUS OF THE IDAHO FOOD FISH INDUSTRY

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Moscow, Idaho

The Idaho Fish and Game Department issued 72 permits to raise fish commercially in 1974. The majority of the permit holders reside in Twin Falls, Jerome, and Gooding Counties. Larger farms use water from springs emerging from the massive aquifer system terminating for many miles along the base of the northeasterly canyon wall of the Snake River. Other farms use water from springs arising on the flat land south and west of the Snake River.

The commercial food fish industry in Idaho is rather complex. No two individual fish raising facilities are alike from the standpoints of pond design, water utilization, feeding practices, fish density per unit of water volume, and fish husbandry methods. For convenience the industry can be divided into six basic components plus five supportive components.

The basic components are:

1) Egg Producers: There are five commercial sources of eyed rainbow trout eggs in Idaho. Of these, three are currently using the eggs produced solely for their use while the remaining two have statewide and out-of-state sales.

   At a typical brood stock or egg producing facility rainbow trout are raised to sexual maturity--usually three years--and spawned manually for three to four successive years before they are sold either for processing or fee-fishing stock. A survey of fish farms conducted in 1973 was not designed to take into account the number of eggs taken on these farms. One owner of a brood stock farm reported having taken over 50 million eggs in 1972, the majority of which were sold to fish farmers in other states.

2) Growers: There are 14 separate companies (28 farms) raising rainbow trout in Idaho. In addition, one is raising channel catfish, three are raising coho salmon on a trial basis, and one is raising cutthroat trout.

   In this type of operation, salmonid eyed-eggs are hatched and the resultant fry are raised to either market-size or farm pond stocking size. Some fish are live-hauled to other states for stream stocking and for fee-fishing operations. Approximately 10-14 months are required to produce a market-size fish in 59° F (15° C) water. The channel catfish are received in the fingerling stage from sources outside the state.

3) Grow-out or Farm Pond Operators: In 1973 and early 1974 there were 46 individuals within a 10-15 miles radius of Buhl raising fish for growers. In this type of operation, the grower transferred 6-8 inch fish from his facility to the farm pond for rearing to market-size (approximately 12-13 inches). The grower, retaining title to the fish, supplied the feed and professional assistance. The time required to produce a marketable fish in a farm pond was four to six months. Farm pond operators were paid on the net gain in pounds of fish. Many farm ponds did not operate the year around because of inadequate water quality and quantity. In general, the appearance of fish produced in a farm pond was better than those produced in a high density raceway situation because of the low stocking rate of fish per unit of water volume. In mid-1974, the farm pond activity was discontinued because of over-production.

4) Processors: There are six trout and catfish processing plants in Idaho, all within the Twin Falls-Buhl area. All are integrated with a fish-raising facility. Each receives fish from their associated fish-raising operation and several others.

In 1972 they processed over 20 million lb of fish and over 18 million lb in 1973, the decrease being due to production cut-backs to meet market demands. The fish were marketed as dressed (eviscerated) and iced, dressed and frozen, boned and frozen, boned and breaded, and continental dressed. The usual packaging was in 5 lb lots with each fish individually wrapped. The shipments were destined for wholesale houses all over the United States and Canada.

5) Fee-fishing or Fish-out Pond Operators: There are at least 16 individuals raising rainbow trout and brook trout for fee-fishing. In this operation a person visiting the facility has an opportunity to catch his or her own trout dinner. A fee is charged based on either the length or weight of fish caught.

None of these operations was visited during the 1973 and 1974 survey because the surveys were designed to document the health and management status of commercial fish and it was through that the fee-fishing operations would have minimal input.

6) Live-haulers: At least four fish farmers ship live fish of varying sizes for stocking ponds in other states. In addition, there is one individual who contracts to haul live fish but is not associated with any fish-farming operation. Affecting this venture is the increasing number of states requiring live fish and/or eggs be certified free of specified disease producing agents. At this time Idaho has no such regulations on fish or eggs entering the state.

The supportive components are:

1) Feed Manufacturers: There are at least three manufacturers of fish feed in Idaho. Two are associated with a fish raising operation, one of which produces feed for use solely within the parent operation. The other sells fish feed nationwide and also maintains an up-to-date fish nutritional research facility. The third fish feed producer is not associated with a fish-raising operation but is part of a large feed-milling company.

2) Transportation: Some of the fish processors maintain their own freezer trucks while the rest use public transportation--airlines, freezer trucks, stage lines--for distributing their product.

3) Construction: During the past three to four years many fish farms have expanded and/or updated their facilities tremendously. One farm alone in 1973 used over 10,000 yd^3 of reinforced concrete in expanding the fish-raising capabilities. The economic benefit to the local construction industry is not known, nor is it known if only local workers were used.

4) Packaging Materials Manufacturers: In the majority of processing operations only boxes manufactured and printed in Idaho are used. The economic effect on state industry of this practice is not known.

5) Employment: In 1973 approximately 302 persons were directly employed in the food fish raising and processing industry in Idaho. Of these approximately 147 were involved in raising fish *per se* and 155 were involved with the processing operations (Table 1). The number of people in Idaho indirectly affected by the food fish industry is not known.

Table 1. Summary of components in the food fish industry in Idaho

	1972	1973	1974
Employees (No.)			
Fish culture (full time)	159	132	118
(part time)	13	15	39
Processing	140	155	185
Number of facilities engaged in:			
Egg production	5	5	5
Market-size fish production	22	23	25
Processing	6	6	6 Grow-out (farm pond) 40 46 1
Number of facilities operating	25	26	28
Plus farm pond operations	(40)	(46)	(1)

THE FALL CHINOOK PROGRAM AT ELK RIVER HATCHERY

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ABSTRACT

Studies of the natural life history of fall chinook salmon in Elk River have shown that this stock of fish spawns mainly in December and January. The juveniles emerge from the gravel primarily in April and usually remain in freshwater through most of the summer. In late summer and autumn most juveniles gradually move downstream through the small, shallow estuary on their way to the ocean. A few remain in the river through the winter and migrate to sea as yearlings.

Elk River has a small but viable natural population of fall chinook salmon. There has been no previous hatchery influence. When Elk River Hatchery was built in 1968, the Fish Commission decided to use only the native stock for releases in Elk River and to conduct a study of the impact of the hatchery on the river and its natural population. The rearing program at the hatchery was designed to simulate the natural life history of the native stock. The operating policy of the hatchery was established with the idea of trying to supplement the natural run rather than replacing it with hatchery fish, a task which is difficult at best. Natural spawning and rearing areas were to be fully utilized in an attempt to maintain strength of wild-produced fish. Competition between hatchery released juveniles and the wild population was to be kept to a minimum.

The hatchery has now been in operation for six years, and returns from the first releases have shown the hatchery to be generally successful (Tables 1 and 2). The autumn releases have been most successful and have produced especially high returns of jacks. The yearling release in the spring of 1970 produced few jacks but slightly higher rates of returns as age 3, 4, and 5 fish than the earlier release in autumn 1969. However, the overall survival rate of yearling fish was lower in the absence of a large jack return. The yearling fish were also difficult to rear through the winter with high incidence of greytail and heavy mortality.

In addition to these releases which followed the natural life history of this stock, a group of large juveniles was also released on June 25, 1971 (Table 3). Only preliminary information is available, but indications are that many of these fish remained in the river after release from the hatchery, few have survived to return, and many of those that have survived possessed a scale pattern indicating extended residence in the river until autumn.

Table 1. Survival back to the river of 1968-brood fall chinook salmon, Elk River Hatchery[1]

	Mark	
	RV	LV
Number released	234,880	50,771
Size of release	15.7 fish/lb	6.8 fish/lb
Date of release	10/15/69	3/16/70
Age at return	Percentage survival	Percentage survival
2	1.32	0.04
3	0.57	0.67
4	1.20	1.23
5	0.19	0.30
Total	3.28	2.24

[1]Survival rates based on population estimates of maturing salmon entering Elk River.

Table 2. Survival back to the river of 1969-brood fall chinook salmon, Elk River Hatchery[1]

	Mark
	Ad-LM
Number released	107,808
Size at release	8.0 fish/lb
Date of release	10/21/70
Age at return	Percentage survival
2	2.00
3	0.98
4	2.18
5	?
Total	5.16

[1]Survival rate based on population estimates of maturing salmon entering Elk River.

Table 3. Survival back to the river of 1970-brood fall chinook salmon, Elk River Hatchery[1]

	Mark
	RV
Number released	409,092
Size at release	47.0 fish/lb
Date of release	6/25/71
Age at return	**Percentage survival**
2	0.13
3	0.05
4	?
5	?
Total	0.18

[1]Survival rate based on population estimates of maturing salmon entering Elk River.

In our initial efforts at Elk River Hatchery, we have significantly increased the total run of fish. For example, in 1973 about 10,000 hatchery fish and 2,000 wild fish entered the river. The study has not advanced far enough to determine impacts of the hatchery other than preliminary numerical effects. However, we will continue to monitor the population and its biological characteristcs as we gradually, but not intentionally, convert the population from a wild to a cultural one. Elk River offers a unique opportunity to examine these short- and long-range effects of a fish-cultural system on a salmon run.

CHUM CULTURE IN JAPAN

Harry G. Senn
Washington Department of Fisheries

During the fall of 1974, Dr. Stephen B. Mathews, from the University of Washington College of Fisheries, and myself visited the Japanese island of Hokkaido to review in detail their very successful chum program.

All phases of their program were reviewed and will be included in a comprehensive report available upon request through Dr. Mathews or myself at the following addresses:

Dr. S. B. Mathews
University of Washington
College of Fisheries WH-10
Seattle, Washington 98102

or

Mr. Harry G. Senn
Washington Department of Fisheries
Hatchery Division
Olympia, Washington 98504

SUMMARY OF REPORT

The report covers a relatively detailed review of the fish cultural procedures from adult trapping through release and harvest. Their organizational structure is briefly discussed along with the role of the cooperatives.

Their fish cultural program is then compared with the artificial propogation of chum salmon as conducted by the Washington Department of Fisheries.

SPRING CHINOOK - TIME AND SIZE AT RELEASE STUDIES

Don Swartz
Fish Commission of Oregon

Several years ago we made a survey of available data to ascertain the influence of release date and fish size at release on survival rates of hatchery reared spring chinook. The data suggested that the best time to release was during the period from October to May (about seven months), and the best size to release was from 6 to 30 fish per pound. Our survey could best be summed up as being inconclusive.

To gather more precise information several studies were conducted at FCO hatcheries. From Willamette Hatchery eight groups of marked springs were released from two successive broods to determine the relative survival of large (4-6/lb) and small (11-17/lb) sized fish when released in winter (December-January) and spring (March). At Trask and South Santiam hatcheries fall (October-November) releases at 5 and 9/lb were compared with late winter (February) releases at 5 and 7/lb.

The results of these studies indicated that at Williamette the large fish experienced twice the survival rate of the smaller fish and the spring releases produced twice the survival of the winter releases. Final conclusion of the Willamette study was that smolts about 12/lb released in the spring will provide the greatest returns. At Trask and South Santiam hatcheries the fall releases were from two to five times more productive than the late winter releases.

Then the Washington Department of Fisheries released from their Kalama Hatchery a group of tagged springs at 23/lb in early September 1971 and another at 6/lb in March 1972. To date the recoveries from these groups show spectacular benefits for the late summer release group when compared to the spring release group.

So now, armed with this new information, we can expand that seven month period (October-May) to an eight month period (September-May) as being the best time to release, and reaffirm that the best release size is probably in the range of 6 to 30 fish per pound. In general the data is still inconclusive and it is probable that a best time and size to release will have to be determined at each individual station.