NORTHWEST FISH CULTURE CONFERENCE 1973

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24th ANNUAL NORTHWEST FISH CULTURE CONFERENCE

December 5, 6, 7, 1973
Bowman's Mt. Hood Golf Club Resort
Wemme, Oregon

Chairman
Ernest R. Jeffries, Fish Commission of Oregon

24th ANNUAL NORTHWEST FISH CULTURE CONFERENCE

There were about 280 registered fisheries personnel in attendance. Fish Commission Fish Culture Division staff members worked throughout the year with the staff at Bowman's to make the physical arrangements satisfactory so that the learning aspects of the conference could be utilized to the full extent. We express to those who presented talks, to industry members who purchased display space, to the Oregon commercial salmon industry, to the management at Bowman's and to all those who attended, our sincere appreciation.

These proceedings are unedited reports of the discussions presented at the meeting. You must obtain permission of the author prior to quoting or reproducing these reports.

The Conference Chairmen for 1974 are Dr. Ernie Salo and Dr. Ernie Brannon associated with the College of Fisheries, University of Washington. The 1975 Chairman will be Dr. John R. Donaldson of Corvallis and Newport.

Ernie Jeffries

(Cover photo is from Biennial Report of the Fish Commission 1919-1920)

24th ANNUAL NORTHWEST FISH CULTURE CONFERENCE

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MASS MORTALITIES IN PUGET SOUND AQUACULTURE

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One of the functions of the Manchester field station other than applied research, is to assist the aquaculture industry in disease diagnosis, therapy and prophylaxis. The major disease problems in Puget Sound aquaculture occur during the warmer summer months and usually by early October have tapered off, causing little or no mass mortality.

The following case report concerns two evidently unrelated mass mortalities; one at Mariculture Northwest facilities in northern Hood Canal occurring in mid-October, and the other an infectious outbreak at Domsea Industries in Clam Bay near our research facility. This occurred in November and evidently spread to our facility in late November.

Mariculture Northwest personnel began feeding dry feed to approximately 60,000 coho in salt water on August 18. These fish were ungraded and averaged 18 grams each or 25 fish per pound. Prior to the 19th of October losses were nominal but occurred mostly in the smaller fish, approximately 12 grams each or 38 fish per pound. We received six moribund fish on the 19th of October with no obvious external lesions and could isolate no bacteria from kidneys on tryptica soy agar with 2 percent NaCl or tryptica blood agar. During the period October 20-22 approximately 25 percent of the estimated large fish population averaging 120 grams or 4 fish per pound and 75 percent of the smaller fish died. On the 21st of October, 27 moribund fish were taken to the Western Fish Disease Laboratory.

Conrad Mahnken and I obtained 50 ml blood from moribund fish as well as more fish and feed samples from the Mariculture Northwest site on October 23rd. Mahnken could find no obvious physical problems at the pen site - but we did notice some gill pathology at this time, i.e., clubbing of filaments and fragile, easily hemorrhaging gills. The blood samples had not clotted one hour later when we returned to Manchester and they were immediately injected intraperitoneally into ten live 20 gram coho. I also began feeding approximately 200 of the same fish intensively with a sample of dry feed received at the Mariculture site three weeks previously.

Wet mounts of the gill filaments showed large numbers of at least two morphological types of motile bacteria and we were able to grow pure cultures on trypticase blood agar from a gill smear. These bacteria would not kill fish after being painted on the gills or injected intraperitoneally.

Further attempts to isolate bacterial pathogens from moribund fish were negative.

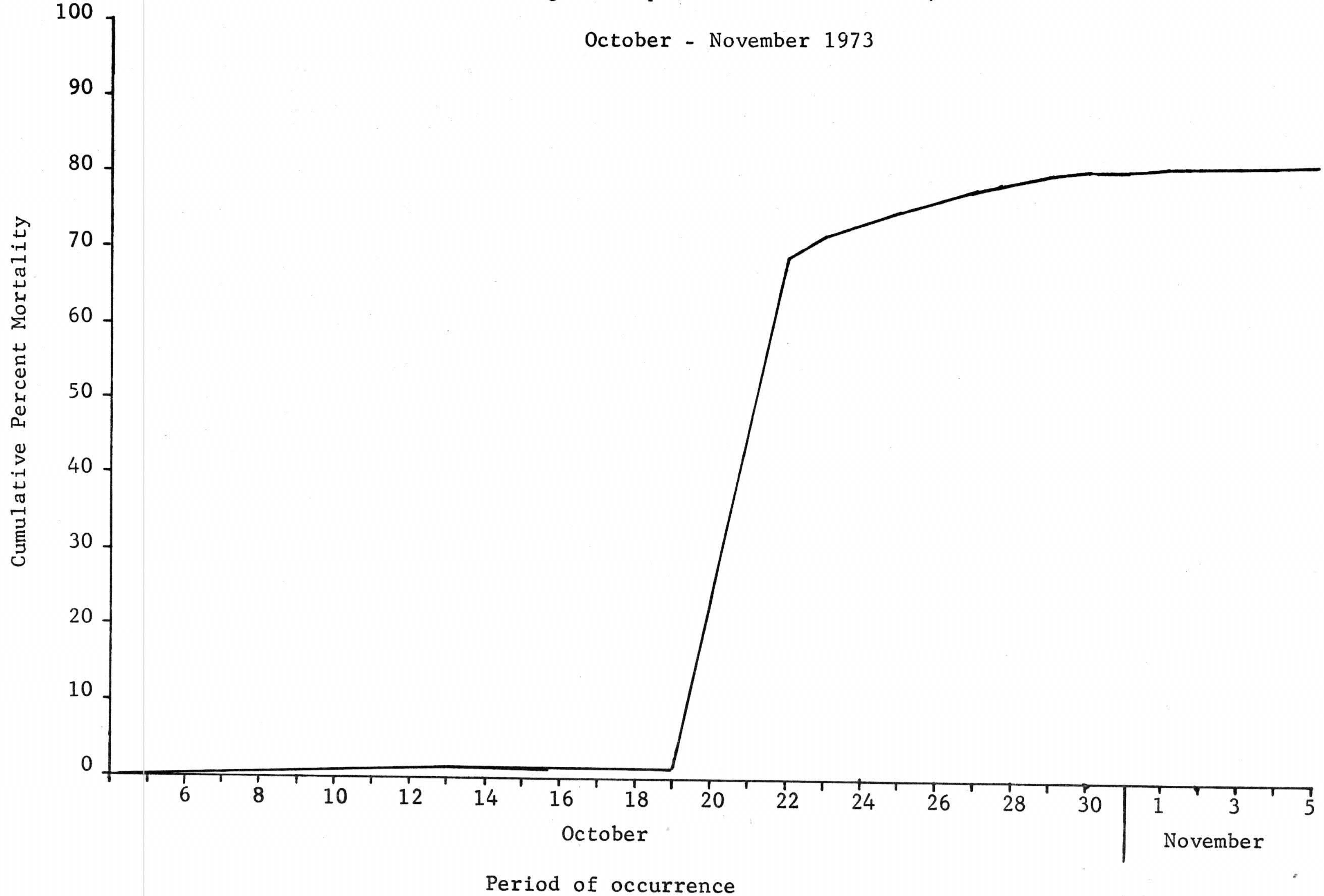
Western Fish Disease Laboratory could not isolate any bacterial or viral pathogens from these fish and I talked to Toshio Yasutake regarding the gill bacteria and we both suggest they were secondary invaders. It would now seem we are dealing either with a toxin or some heretofore unexplained metabolic disease.

The record outbreak, the one at Domsea, occurred on the 6th of November in a pen of 114 gram (4 fish per pound) coho at approximately 11°C. This epizootic continued for approximately two weeks, killing 91,000 fish before being brought under control with oral terramycin. The fish exhibited gross lesions typical of vibriosis, i.e., exophthalmia and hemorrhagic septicemia and after four to five days some bacterial cultures sensitive to 0-129 vibriostat were evident. Extensive restreaking and attempts to positively identify this slow growing pathogen showed an extremely pleomorphic vibrio, sensitive to terramycin and not readily agglutinated with specific antisera to strain 23 *V. anguillarum*.

Evidently this vibrio is another strain not previously encountered in Puget Sound and we are investigating this possibility.

Mass Mortality of Pen-cultured Coho Salmon at the Mariculture
Northwest Site (Northern Hoods Canal)
Original Population Estimate = 60,000

October - November 1973



SALMONID SEMEN
AS A TRANSMISSION AGENT OF KIDNEY DISEASE

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Dworshak National Fish Hatchery
Ahsahka, Idaho

Introduction

Kidney disease of salmonids is a chronic to subacute disease which is caused by a Gram-positive diplobacillus presently classified as a Corynebacterium. Mortality rate is often high and there is no effective chemotherapeutic agent cleared for use on food fish. With kidney disease, as with most infectious diseases, survivors do occur and most likely are sources and vectors of the infection in hatcheries. The carrier fish provide excellent distribution of the bacterium and it is postulated that transmission via sex products provides continuity of the disease between generations. There is considerable circumstantial evidence that kidney disease has been transmitted via the fertilized egg as epizootics have occurred when eyed eggs have been shipped to hatcheries previously free of kidney disease. Transmission of kidney disease via eggs and sperm has been suggested, and the purpose of this work was to determine if semen (sperm and spermatic fluid) transmit kidney disease from the adult male to their progeny.

Material and Methods

Adult spring chinook salmon (Oncorhynchus tshawytscha), were obtained from the Rapid River State Hatchery at Riggins, Idaho, through the courtesy of the manager, Evan Parish. Previous examinations had indicated a large number of kidney disease infected adults and a low level infection in yearling fish reared at the hatchery. The adult fish used for the experiment were removed from the brood ponds during the spawning operation.

Urine-free semen from several males was collected using an apparatus consisting of a collection vesicle with suction and collection tubes. To obtain semen, the collection tube was inserted into the sperm duct and a partial vacuum was maintained by sucking through the suction tube thereby delivering semen to the collection vesicle. A separate sterile apparatus was used for each male, and the samples collected were kept on ice until used for fertilization. After the semen was collected, the fish were examined to determine their disease status. Gram-stained slides of kidney material were used for diagnosis. Males with kidney lesions containing the Gram-positive diplobacillus were used to provide semen to test for the transmission of kidney disease. Uninfected males - those with no kidney lesions of Gram-positive diplobacilli in kidney stains were selected as control animals.

Eggs obtained by aseptically cutting the body wall were stored in sterile containers. After the eggs were collected, the females were examined in the same manner as described for the males. Three females free of kidney disease were selected for the study. Eggs from each female were divided into two groups; one group was fertilized with sperm from a male infected with kidney disease, while the second group of eggs was fertilized by sperm from a non-infected male. The eggs were water hardened in boiled distilled water cooled to 10°C, placed in sterile plastic bags, packed in ice, and transferred to the hatching facility. Precautions were taken to insure that all equipment used was maintained in a sterile condition and that a separate set of equipment was used on each fish.

The six groups of eggs were placed on hatching trays in six self-contained refrigerated tanks supplied initially with water that had been treated by an electric grid, sand filters, and ultra-violet irradiation. The eggs were hatched in these tanks and the fish maintained for 18 months.

During the 18-month test (September 1, 1970 - March 1, 1972), water temperatures were controlled over a range of 2 to 21°C to match natural seasonal variations. Also during this time, dissolved oxygen content ranged from 4.0 to 13.3 ppm and the amount of ionized ammonia was allowed to increase to a maximum of 1.27 ppm to provide stress conditions to lower the resistance of the fish to disease organisms. Water temperatures were controlled by refrigeration, oxygen levels by aerators, and ammonia by increasing the metabolic load within the tanks and by dilution with treated make up water.

Fish in all six tanks were fed Oregon Moist Pellets during the entire test.

Results

During the duration of the study, fish were removed from each tank to reduce the load. Samples of the fish removed and all mortalities were checked by examining Gram-stained kidney smears. In addition, virological, bacteriological, and parasitic examinations were conducted. No mortalities that occurred during the test were the result of infectious agents. Mortalities, when they did occur, were due to poor water quality in the self-contained tanks.

Discussion

The results obtained suggest that kidney disease is not transmitted via salmonid semen. Since the eggs and semen were held in sterile conditions from the time the sex products were obtained, throughout the incubation and rearing period of 18 months, the only possible method of infection was through the egg and semen. The females were not infected and therefore not a source of the *Corynebacterium*. In this trial male salmon were infected with the kidney disease bacterium but did not transmit the disease to their progeny. The care by which semen was obtained from the salmon in the test is an important consideration for during the normal spawning operation body fluids, urine, and fecal material are extruded onto the eggs to be fertilized. The effect of such contamination on kidney disease transmission was not determined. The results of this test merely showed that salmonid semen did not transmit *Corynebacterium*, the causative bacterium of kidney disease, from the adult to its progeny.

INFECTIOUS PANCREATIC NECROSIS VIRUS IN TROUT FROM CENTRAL OREGON

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Prior to this year Infectious Pancreatic Necrosis virus (IPN) had been found only in anadromous salmonids in the lower Columbia River and in wild cutthroat trout from tributaries of Nan-Scott Lake in the North Santiam River System. No losses were associated with the presence of virus at any of these locations.

However in June of this year an epizootic caused by IPN virus occurred in eastern brook trout at the Oregon Wildlife Commission's Fall River Trout Hatchery. During the first 15 days of June the mortality among this group of fish was approximately 20 percent. At the time of detection these fish weighed about 900/lb. These fingerlings were progeny from adults trapped and spawned at East Lake (a high mountain lake in central Oregon). Subsequent samples were collected and IPN detected in all other lots of brook and rainbow trout present at the hatchery. The virus was also detected in brook trout collected from Fall River below the hatchery.

Immediately after the discovery of IPN all groups of fingerling at the hatchery were destroyed. This amounted to approximately 1.76 million rainbow and brook trout fingerlings. In addition 71,000 legal rainbow trout, about 20,000 lbs., were sent to the Redmond Tallow Company.

On September 8-12 Fall River was exhaustively treated with Rotenone and other fish toxicants. Subsequent examinations by electroshocking and toxicants have failed to demonstrate the presence of any live fish. Migration from the Deschutes River into Fall River is blocked by a waterfall and a series of culverts.

At the hatchery the water was turned off after the last fish were buried. The ponds were allowed to dry until September 13 when they were disinfected with a solution containing 1800 ppm chlorine applied by spraying at about 1000 psi. The hatchery buildings and all equipment were disinfected with Hyamine 3500 (1,800 ppm). All dam boards, screens, etc., were replaced.

The destruction of these fingerlings eliminated the Oregon Wildlife Commission's brook trout planting program for one year. The next steps involved the determination of a suitable virus free source of brook trout eggs and the determination whether IPN virus had been eliminated from Fall River Hatchery.

This sampling resulted in the detection of IPN in brook trout from Elk and Lava Lakes in central Oregon and Fish Lake in south central Oregon. Part of the brook trout fingerlings destroyed at Fall River Hatchery were progeny from Elk and Lava Lake adults. IPN was not found in fish obtained from East and Four-Mile Lakes. Four-Mile Lake is located in south central Oregon. Prior to spawning some 145 brook trout from East Lake had been sampled with uniformly negative results, consequently the decision was made to collect eggs for the coming year from this location. During spawning additional visceral and ovarian fluid samples were taken. No evidence of IPN virus has been detected in any of these samples.

To test for the continued presence of the virus at Fall River Hatchery, 1000 rainbow trout previously determined negative for IPN were shipped into the hatchery on November 1st. These fish will be left over the winter and periodically tested for the virus. In addition about 75,000 brook trout eggs will be incubated, hatched and carried through the middle of next year, and will also be periodically examined for virus.

THE OCCURRENCE AND DISTRIBUTION OF FISH VIRUSES IN ANADROMOUS SALMONID FISHES FROM OREGON

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In 1958 the Oregon Sockeye Virus was isolated at our laboratory from sockeye salmon at Willamette River Salmon Hatchery. This marked the first time that a fish virus was recovered in the state of Oregon. In 1971 Infectious Hematopoietic Necrosis (IHN) virus was isolated from rainbow trout in a private lake off the North Santiam River. Subsequent examination of cutthroat trout populating the streams into which the lake drained yielded Infectious Pancreatic Necrosis (IPN) virus. This was the first isolation of that agent in Oregon. Until 1971 no concentrated effort had been made to determine what, if any, viral agents were present in stocks of anadromous salmonid fishes in Oregon. We attempted to ascertain the current status of anadromous salmonids with respect to which viral agents were present.

Sampling locations were listed in order of priorities by the Oregon Fish Commission. When examining anadromous species returning to parent streams, sixty adult females were tested from each location. This enabled us to detect a 5 percent incidence level of disease based on a 95 percent confidence interval. The adult females were tested by collecting 0.1 gram samples of kidney, liver, and spleen. The visceral samples of each of five fish were collected into one pool thus giving twelve pools from each location. Two milliliters of ovarian fluid were collected from buckets of eggs after five fish were spawned providing twelve ovarian fluid samples from each location. When examining yolk-sac fry fifty fish were collected from each location.

The following is the procedure for the laboratory examination of the samples:

1. Each pooled visceral sample was placed in a chilled homogenizing cup to which was added twenty milliliters of Hank's balanced salt solution. The sample was then homogenized for two minutes at full speed in a Virtis 23 homogenizer.

2. The resulting homogenate was centrifuged at 3000 x gravity for twenty minutes to pellet whole cells and large fragments of tissue debris.

3. Following centrifugation the supernatant was diluted 1:5 in an antibiotic solution containing 2500 units of penicillin, 2500 ug. of streptomycin and 1000 units of nystatin per milliliter of Hank's balanced salt solution. This supernate-antibiotic solution was thoroughly mixed and allowed to incubate at room temperature for two to six hours.

4. The standing mixture was next centrifuged for thirty minutes at 7700 x gravity to pellet any remaining whole cells and cell fragments.

5. The supernatant was diluted 1:2 in Eagle's MEM with 5 percent serum and filtered through a Swinny filter holder containing a 0.45 micron membrane filter. The filtrate was placed directly on to two different cell lines in tissue culture microplates. The two cell lines used were a chinook salmon embryonic cell line (CHSE-#214) and a steelhead trout embryonic cell line (STE-#137).

6. When examining yolk-sac fry the same procedure was used as above except the whole fish was homogenized. Ovarian fluid samples were diluted 1:3 in Eagle's MEM with 5 percent serum and filtered through a 0.45 micron membrane filter directly onto the two cell lines.

The microplates containing the two cell lines were incubated at 18°C and observed microscopically for cytopathic effects every twenty-four hours for up to two weeks. Suspect samples showing cytopathic effects were removed, diluted 1:100 in Eagle's MEM with 5 percent serum and reinoculated on to fresh cells. This dilution and reinoculation scheme was continued until the sample had reached an overall dilution of at least one million fold with cytopathic effects observed after each dilution. Final identification was made by neutralization experiments using specific antiseras against known fish viruses.

The results of this study are detailed in the following tables:

EXAMINATION OF COLUMBIA RIVER COHO SALMON FOR VIRAL AGENTS

Location	1971 Adults	1971 Fry	1972 Adults	1972 Fry	1973 Adults
Bonneville	IPNV	IPNV	None	None	None
Cascade	----	----	IPNV	None	None
Big Creek	----	----	None	None	None
Sandy	----	----	None	None	None
Klaskanine	----	----	None	None	None

EXAMINATION OF COASTAL COHO SALMON FOR VIRAL AGENTS

Location	1971 Adults	1971 Fry	1972 Adults	1972 Fry	1973 Adults
Alsea	None	None	None	None	None
Trask	----	----	----	----	None
Siletz	----	----	----	----	None
N. Nehalem	----	----	None	None	----

EXAMINATION OF CHINOOK SALMON FOR VIRAL AGENTS

Species and Location	1971 Adults	1971 Fry	1972 Adults	1972 Fry	1973 Adults
Spring Chinook					
Marion Forks	None	None	None	None	None
Willamette	None	None	None	None	----
Pelton	None	None	----	----	IHNV*, IPNV
Fall Chinook					
Big Creek	----	----	None	None	None
Bonneville	None	None	None	None	None
Coastal Chinook					
Elk River	----	----	None	----	----

*The isolation and identification of IHN virus at Pelton was made by members of the Bureau of Sport Fisheries and Wildlife, U.S. Fish and Wildlife Service.

EXAMINATION OF STEELHEAD TROUT FOR VIRAL AGENTS

Location	1972 Adults	1973 Adults
Marion Forks	None	None
Big Creek	None	----

It has been shown that IPN virus is present in fish from the Santiam, Deschutes and Columbia River watersheds in Oregon. Infectious Hematopoietic Necrosis virus was detected in fish from the Santiam and Deschutes River systems. It is difficult to evaluate the significance of these isolations to the fish culture industry of Oregon since the viruses present in the watersheds mentioned above are apparently causing no losses. However the potential dangers and problems that do exist should not be ignored. The watersheds in which these viruses were isolated should be viewed as potential areas of concern and kept under close scrutiny.

This work was supported by the Oregon Fish Commission and Oregon State Sea Grant Program.

A DIFFERENCE IN RESISTANCE OF DESCHUTES RIVER STOCK SPRING CHINOOK TO *Ceratomyxa shasta* BY EXPOSURE PERIOD

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Observed *Ceratomyxa* mortalities of rainbow trout and chinook salmon rearing in hydroelectric reservoirs of the Pelton Project on the Deschutes River in Oregon 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. Purpose of this experiment was to determine the effect of early spring vs. late spring exposure of juvenile spring chinook to *Ceratomyxa shasta*.

Deschutes stock spring chinook fingerlings were transferred April 23 and June 8 from the same pond at the Round Butte hatchery into a 6-foot circular tank at the Pelton trap building, site of the old Pelton pilot hatchery. Fish of both groups averaged approximately 35 per pound June 1, and the two groups were differentiated by fin marks. Water is pumped into this building from the Pelton fish trap which receives its water from the Pelton regulating reservoir. This reservoir is homothermal and temperatures at this point are moderated by the presence of two large hydroelectric reservoirs immediately upstream. Fish were fed O.M.P. and mortalities removed daily, when possible. Terramycin was fed when it became available, to reduce the potential of bacterial diseases. Wet mounted material from the posterior large intestine of all mortalities was examined under 400x and fish determined positive if one or more spores could be found during five minutes of examination. Negative mortalities occurring before the mean date of positive mortalities for each group were not included in the results. Those occurring after this date were counted as negative. After termination of the experiment, October 16, all survivors were also examined and positive fish added to positive mortalities to determine a total infection rate for each group.

Results are summarized in Table I. The first mortalities from each group occurred July 27 and were positive for *Ceratomyxa*. The disease progressed more rapidly in Group II with a mean time till death of only 23.7 days from the first mortality. This compares with 35.3 mean days for Group I. Total positive mortality rate for Group I was 59.0 percent as compared with 80.6 percent for Group II. Among the 72 survivors from Group I, 7 were found to be positive, whereas none of the 19 survivors from Group II were found positive. This increases the infection rate for Group I to 62.9 percent while Group II remains at 80.6 percent. The 95 percent confidence intervals for infection rates of the two groups do not overlap, showing there is a difference at this level.

Graph I shows the percentage mortality occurring each week for each group and illustrates the difference in the progress of the disease. The mortality for Group II was over 11 percent for four straight weeks, whereas the mortality of Group I never reached this level. However, as shown in Graph II, the mortalities in Group I continued for a longer period of time and positive survivors were found which may have succumbed had the experiment been continued. Graph III shows the water temperatures during the exposure period.

The results of this experiment indicate that individuals of this stock may possess the ability to increase their resistance to *Ceratomyxa shasta* when exposed to the disease in a less infectious state such as must occur in the early spring. However, much more work must be done before the factors involved can be identified and understood.

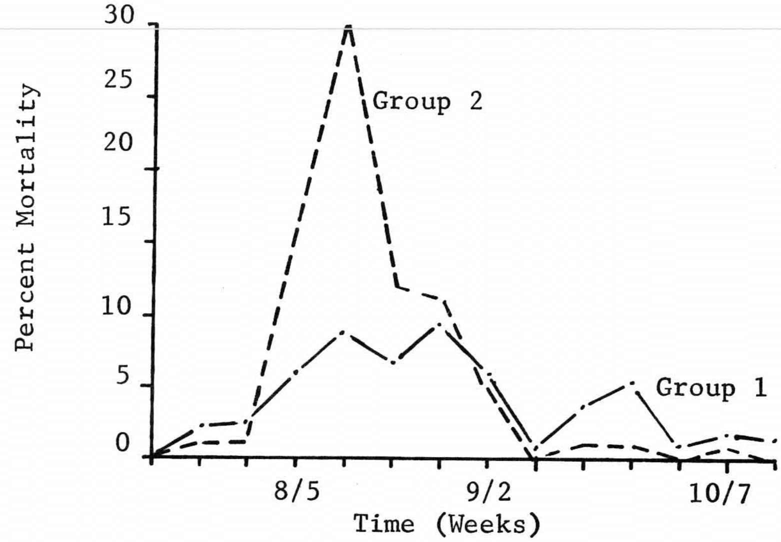
TABLE I

RESULTS

	Group I	Group II
Number of Fish	178	98
Date Exposed	4/23	6/8
Date Terminated	10/16	10/16
Mean Days to Pos. Deaths	129	72
Mean Days from First Positive Death	35	24
Positive Death Rate	59.0%	80.6%
Positive Survivors	7	0
Infection Rate	62.9%	80.6%
95% Confidence	55.8%-70.0%	72.8%-88.4%

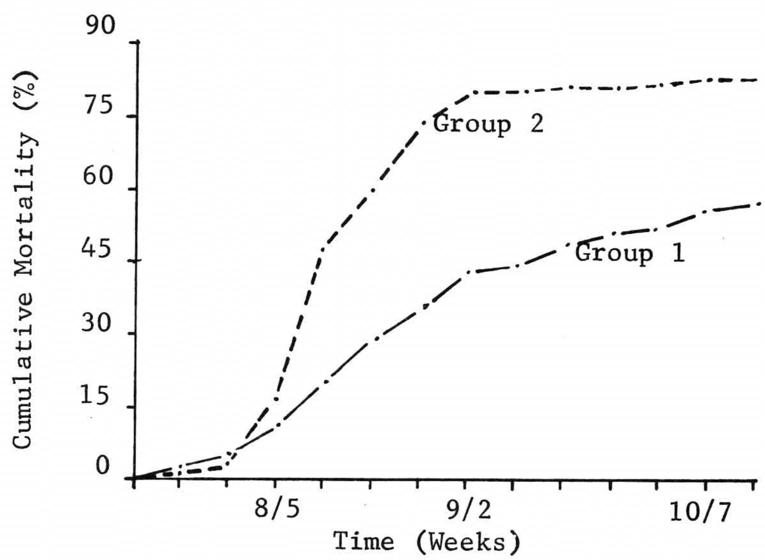
GRAPH I

Percent Mortality vs. Time



GRAPH II

Cumulative Mortality vs. Time



INCIDENCE OF *Ceratomyxa Shasta* IN SELECTED HATCHERY STOCKS OF CHINOOK SALMON*

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Five strains of chinook salmon were tested to determine their levels of resistance to infection by the myxosporidan *Ceratomyxa shasta*. The selection of resistant stocks of chinook salmon could enhance the management potential of waters containing the infectious stage of this parasite.

The groups of salmon ranging in size from 1.6 grams to 3.0 grams per fish were received at the Oregon State University Fish Disease Laboratory. To prevent bacterial infections, all fish were placed on a diet of medicated Oregon Moist Pellet (3% Tm50) eight days prior to the exposure period. This diet was fed throughout the experiment.

Each group of fish was exposed to *C. shasta* by placing them in individual live-boxes for a five day period (May 19, 1973 - May 24, 1973) in the Willamette River. Water temperatures during this period ranged from 60°to 65°F. After the five day exposure, all groups were transferred to the Fish Disease Laboratory and maintained at 64°F for the remainder of the experiment. Each lot of fish was observed daily and dead fish removed and examined microscopically for *C. shasta*. Only those specimens containing the spore stage of this parasite were considered positive for the disease.

All stocks of fish except for the Bonneville fall chinook had deaths from *C. shasta* within 21 days. However, the level of infection varied widely between the different groups. The results shown in Table I indicate that the Bonneville fall chinook and the Umpqua spring chinook were less susceptible to this parasite.

A second experiment was conducted using the Carson and Umpqua spring chinook with the Trask fall chinook as a positive control. Because of the higher water temperatures (66°- 71°F) the exposure period was reduced to 48 hours. Again the Trask fall chinook were highly susceptible to *C. shasta* with a 99 percent loss (Table II). However, the Carson and Umpqua spring chinook losses were significantly lower, 17 percent and 9 percent respectively.

The reduced exposure period in the second experiment could possibly explain the lower levels of infection in the Carson and Umpqua spring chinook. In both cases the Trask fall chinook were highly susceptible, with over 99 percent of the fish becoming infected. However with the shorter exposure period, spores of *C. shasta* were detected later and the time to death was prolonged.

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*This work supported by the Fish Commission of Oregon.

The results indicate that fall chinook strains derived from drainage systems containing the infectious stages of *C. shasta* are much less susceptible to this disease than stocks obtained from waters in which this parasite is absent. In contrast data obtained from the groups of spring chinook suggests that resistance to infection is independent of a prior history of exposure. This is demonstrated with the Carson and Umpqua spring chinook. The Umpqua spring chinook appeared less susceptible to *C. shasta* although the presence of this parasite has not been shown in the Umpqua drainage system.

TABLE I. Incidence of *Ceratomyxa shasta* in five hatchery stocks of chinook salmon (5 day exposure).

Source of Fish	No. of Fish Exposed	Total Deaths	Deaths Due to *C. shasta*	Percent Loss from *C. shasta*
Umpqua Sp. Ch.	123	28	25	20.3
Carson Sp. Ch.	122	115	65	53.2
Bonneville Fall Ch.	121	61	0	0
Elk R. Fall Ch.	85	85	75	88.2
Trask Fall Ch.	123	123	123	100

TABLE II. Incidence of *Ceratomyxa shasta* in three hatchery stocks of chinook salmon (2 day exposure).

Source of Fish	No. of Fish Exposed	Total Deaths	Deaths Due to *C. shasta*	Percent Loss from *C. shasta*
Trask Fall Ch.	112	112	111	99.1
Carson Sp. Ch.	150	41	25	16.7
Umpqua Sp. Ch.	120	46	11	9.2

OBSERVATIONS AND SPECULATIONS ON FIN EROSION

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During the summer of 1972 the Wizard Falls Hatchery was expanded with the addition of ten large 20' X 100' raceway type ponds. These new ponds are all supplied with cold (42°) Metolius river water. This new section is operated entirely separate from the old section with its 41 ponds of various designs and 11 c.f.s. of 50° pure spring water. (Color slides will show pond arrangements.)

This station annually produces three to five million fingerlings of many different species; 300,000 rainbow yearlings and 15,000 Atlantic salmon yearlings. It is with the yearling fish that we are primarily concerned.

All fry are started in twenty circular ponds; each 25 feet in diameter and two feet deep. Fin erosion seldom becomes apparent in the circular ponds until the load approaches two pounds of fish per cubic foot of water. At this time most fingerlings are liberated except for holdovers that are graded and transferred to the lower and larger holding ponds.

Fin erosion (primarily dorsal) becomes very apparent during the fall months. As a matter of fact, from looking into one of these ponds, it would appear that all fish had been dorsal clipped. At this time the dorsal is just a white strip. It gradually heals over and by spring is much less obvious, but the erosion is still there. The fin never seems to grow back to its full shape. The pectoral fins will show some erosion, but the ventral, anal and caudal fins never seem to be affected.

With the addition of the new ponds and new water supply we had our first opportunity to spread the yearling stock out at lighter densities and carry out some evaluation work on the fin erosion problem. Table I and Table II help explain the results of this work.

Because of the construction program, the yearling stock was held at higher than normal densities for a short period of time in the spring water ponds during the late summer of 1972. It should be pointed out that nearly all of the 203,000 yearling rainbow had badly eroded dorsal fins at the time they were divided into two groups on November 14, 1972. At this time 140,000 of these fish were transferred to the new river water ponds and 63,000 were retained in the spring water ponds for comparison.

By mid January there had been such a dramatic improvement in those fish placed in the river water ponds that it was hard to believe.

A critical fin evaluation study was made on January 22, 1973 to measure the actual improvement. Table II explains this. The following criteria were used to evaluate fin condition:

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

Those fish retained in the spring water ponds showed no improvement. The most unusual fact was that pond 34 (spring water), fed at a very high rate, had the worst fin condition of all. It should also be pointed out that in this same pond 34, in the second evaluation of April 11, 1973, the 17 fish that had intact fins were the smallest fish in the pond. This has a tendency to confirm (that which we have long suspected) that all frayed fins are not just due to nipping, as many hatchery workers seem inclined to believe. It would appear that, if there is a peck order as with chickens, these smaller fish should be the ones to suffer most from nipping. Such was not the case.

It should also be mentioned that automatic pellet feeders were not installed on the new ponds until April 1, 1973; consequently the river water ponds were all hand fed, once per day during the evaluation period. The spring water ponds were all machine fed, four times per day. Whether or not feeding frequency and method has an affect on fin erosion in our particular case is unknown, but it is being investigated this winter.

The yearling stock was transferred to the river water ponds much earlier this year (August 28), and those retained in the spring water ponds were spread out at lighter densities than last year; still there was severe dorsal fin erosion. The river water fish have already shown substantial improvement.

We also currently have 15,000 Atlantic salmon yearlings in one spring water pond. They are ten per pound and at a density of about one third pound per cubic foot. Atlantics do have a tendency to bunch up, however, at the lower end of the pond and are actually much more dense in that area. They have been fed an O.M.P. diet only. They too show the same dorsal fin erosion. Their large pectorals, however, show no erosion.

Perhaps fin erosion might be due to a bacterial infection as described by Snieszko and Davis, however, it seems strange that such an infection would occur in exactly the same manner year after year, never causing a mortality or developing into a necrosis around the base of the fin. Davis also describes a condition as follows:

> The dorsal fins of fingerling rainbow trout frequently show along the margin a light-colored, thickened area that has a superficial resemblance to an early stage of fin rot. Examination with a hand lens will show however, that the margin of the fin has a smooth contour and lacks the ragged appearance and projecting fin rays characteristic of fin rot. The thickened edge of the fin is composed of scar tissue, which is apparently the result of irritation, and there is no evidence that any infection is involved. It is most common on fish in pools that are over-crowded.

The above quote describes our fin condition very accurately, although we do not feel that one third pound of fish per cubic foot of water can be considered over-crowded.

We feel that water chemistry might be playing a far greater role in the health and well being of our fishes than most of us realize. As far as I know, very little work has been done on the trace element requirements of fish.

I recall a taped speech made by Dr. C. R. Goldman about thirteen years ago describing the work he had done on two Alaskan lakes. It was his determination that Molybdenum at 0.1 to 0.5 p.p.b. was a key factor in the productivity of one lake over the other. In a personal communication with Dr. Goldman he confirmed the above. He also mentioned his work at Castle Lake, California, in which he added thirty-five dollars worth of Molybdenum and increased trout production by four to six pounds per acre. After explaining our fin problem to him, he agreed there might be some connection between the water chemistry of the two different water supplies and their effect on fin erosion.

If, and it is a big IF, the spring water is lacking an important trace element and/or if it is locked up in such a manner the fish are unable to assimilate it, then it seems possible the spring water may be responsible for producing a softer fin ray which is more susceptible to any abrasive action.

Strictly from a mechanical point of view, it also seems possible that the heavy, thickened, leading edge of the pectoral fin frequently colliding with the thin, delicate, dorsal might also be an important contributing factor. This might explain, at least in part, why the dorsal is subject to greater erosion than other fins. Obviously, the greater density the greater the erosion.

Reference is made to Table III showing comparative water analysis between the spring water supply and the river water supply. Also included is an older analysis of the Oak Springs Hatchery water supply where fin erosion appears to be minimal. We do not feel that these analyses are as complete as they should be and regret they do not include all of the trace elements.

Perhaps at some future date it will be necessary to supplement certain hatchery water supplies with particular trace elements.

We earnestly solicit your comments and suggestions to our perplexing problem.

TABLE I

WIZARD FALLS TROUT HATCHERY

Comparative Data Between River Water Ponds and Spring Water Ponds
With Regard to Growth Rates, Conversions, Density and Evaluation of Two Different Food Types
Also Results of High Level Feeding on One Pond in Each Group

For the Period
December 1, 1972 to April 1, 1973
(approximately 120 days)

Pond No.	Specie	No. Fish Start	No. Fish End	Mort.	Pounds Food Fed	Food Type	Conv.	Percent Gain	Fish/Lb. Start	Fish/Lb. End	Remarks
					RIVER WATER PONDS - 42°						
42	Rb	26,031	26,010	21	4,471	Ran 5/32	1.67	76.0	7.4	4.2	Chart level
44	Rb	21,023	21,006	17	3,720	Ran 5/32	1.55	87.6	7.7	4.1	Chart level
45	Rb	21,121	21,109	12	4,317	Clk 5/32	1.66	111.5	9.1	4.3	High level feeding
46	Rb	21,724	21,710	14	3,482	Clk 5/32	1.64	88.6	9.1	4.7	Chart level
47	Rb	15,074	15,061	13	2,482	Ran 5/32	1.60	97.7	9.5	4.8	Chart level
48	Rb	9,996	9,989	7	1,784	Ran 5/32	1.59	110.6	9.9	4.7	Chart level
49	AS	15,518	15,415	103	2,093	OMP	2.47	52.9	9.7	6.3	Some gill fungus Mal-G. controlled
					SPRING WATER PONDS - 50°						
34	Rb	10,499	10,493	6	4,473	Ran 5/32	1.62	215.0	8.2	2.6	High level feeding
37	Rb	10,448	10,445	3	3,063	Clk 5/32	1.55	165.2	8.8	3.3	Chart level
40	Rb	10,498	10,493	5	3,051	Ran 5/32	1.69	151.2	8.8	3.5	Chart level

TABLE II

WIZARD FALLS TROUT HATCHERY

FIN EROSION RESEARCH

Comparative Data Between River Water Ponds and Spring Water Ponds

Pond No.	Lbs. per Cubic Ft. Start	Lbs. per Cubic Ft. End	January 22, 1973 Fin Condition in Percent				April 11, 1973 Fin Condition in Percent				Food Type	120 Day % Gain	Remarks
			Severe	Medium	Light	None	Severe	Medium	Light	None			
					RIVER WATER								
42	0.50	0.92	2	26	66	6	0	6	71	23	Ran	76	Chart level
44	0.40	0.75	0	9	82	9	0	1	83	16	Ran	87.6	Chart level
47	0.22	0.47	0	8	91	1	0	10	66	24	Ran	97.7	Chart level
48	0.14	0.31	2	13	84	1	1	4	73	22	Ran	110.6	Chart level
49	0.23	0.37	0	32	52	16	0	10	69	21	OMP	52.9	Atlantic Salmon
					SPRING WATER								
34	0.38	1.27	4	24	71	1	23	20	40	17	Ran	215.0	High level
37	0.36	0.99	4	28	67	1	20	11	55	14	Clk	165.2	Chart level
40	0.36	0.94	13	53	34	0	18	15	56	11	Ran	151.2	Chart level

TABLE III

COMPARATIVE WATER ANALYSIS

mg/1 (or as shown)

	1972 Metolius River	1972 Wizard Falls Spring	1960 Oak Springs Hatchery
D. O.	11.3	8.0	10.6
P. H.	7.5	7.7	8.0
Carbon Dioxide	2.5	6.0	-
Alkalinity	37.0	55.0	54.0
Hardness	25.6	39.8	48.3
Av. Temperature	42°	50°	54°
Calcium	4.4	6.8	-
Sodium	5.9	8.6	4.7
Potassium	1.0	1.5	1.2
Magnesium	3.5	4.5	-
Iron	less than 0.03	less than 0.03	0.052
Manganese	less than 0.03	less than 0.03	0.12
Arsenic	less than 0.005	less than 0.005	0.03
Chlorides	8.0	8.5	(as cl) 2.56
Flouride	0.23	0.17	0.11
Aluminum	less than 0.1	less than 0.1	0.112
Phosphates	0.25	0.15	0.104
Sulfates	0.5	0.5	2.9
Nitrogen, NH_3	0.06	0.04	0.09
Nitrates	less than 0.01	0.01	0.20
Nitrites	0.01	0.02	-
Silicon	27.3	33.6	16.0
Zinc	-	0.025)	less than 0.025
Copper	-	0.26)	0.031
Lead	-	0.015) 1960	0.032
Chromium	-	0.01)	less than 0.01
Boron	-	0.15)	0.32

STUDIES ON NITRITE TOXICITY IN RAINBOW TROUT

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INTRODUCTION

In 1971, papers were presented by Williams[1/] and Smith[2/] regarding nitrite toxicity in Chinook Salmon and Rainbow Trout. Experiments were stimulated because of high mortality that occurred in fish reared in reused water that had been passed through a semi-closed submerged biological filter.

Results of experiments carried out to confirm nitrite as the toxicant demonstrated that 55 percent of the trout exposed to 0.55 mg/l nitrite nitrogen (NO_2-N) died within 24 hours. Trout exposed to 0.15 mg/l for 48 hours did not die, but were definitely stressed due to a build-up of methemoglobin in the blood. Methemoglobin is an oxidation product of the normal blood pigment hemoglobin and is incapable of transporting oxygen. If methemoglobin concentrations are high enough fish may die from anoxia.

At times, fish may encounter prolonged exposure to low concentrations of nitrite. This may be due to industrial pollution or it may occur in biological filters designed to remove ammonia through nitrification. Nitrites are intermediate in the nitrification process.

We therefore felt it important to determine (1) LC_{50} nitrite concentration for various time periods, and (2) the minimum nitrite concentration that trout could tolerate over prolonged periods.

Since previous tests demonstrated that small trout were less sensitive to nitrite than larger trout, we designed the following acute and chronic nitrite bio-assays to determine LC_{50}'s to various sized rainbow trout.

METHODS

Four individual tests were conducted. One test using ten 14-gram trout lasted 96 hours. A second test using 100 2-gram trout lasted 10 days. The third test with 20 235-gram trout lasted 15 days, and test four, which was run in duplicate using 20 12-gram trout, lasted 24 days.

Fish were placed in each of 6 tanks in all tests. Fish in 5 tanks were exposed to 5 varying concentrations of nitrite and fish in the 6th tank served as controls.

Mariotte bottles were used to deliver sodium nitrite to the larger fish. Mount and Brung[3/] serial diluters delivered nitrite to the other groups.

Nitrite levels were determined[4/] daily and are expressed as Nitrite Nitrogen (NO_2-N).

RESULTS

Results of each test after 96 hours are shown in Figure 1. The 96 hours LC_{50} for 2, 12, 14 and 235-gram trout was 0.39, 0.20, 0.27 and 0.20 mg/1, respectively. The tests clearly demonstrated that 2-gram trout are about twice as resistant to nitrite as 12-gram and larger trout.

LC_{50} concentrations for 12-gram trout at intervals over a 24-day period are given in Table 1.

Results not presented in Table 1 show that mortality did not occur in 235-gram trout exposed to 0.06 mg/1 NO_2-N for 10 days. However, when the NO_2-N level was .1 mg/1 a 28 percent mortality occurred. No mortality occurred in 2-gram trout exposed to 0.14 mg/1 for the same time period.

Most fish dying from nitrite poisoning showed clinical signs typical of those reported previously by Smith,[2/] namely, chocolate brown-colored blood and thymus lesions.

In summary, LC_{50} concentrations of nitrite have been given for rainbow trout weighing 2, 12, 14 and 235-grams at various time intervals. Trout weighing 2-gram each were twice as resistant to nitrite as 12-gram and larger trout.

LITERATURE CITED

1/ Williams, W.G., Nitrite Toxicity in Trout Held in Water Re-use Systems; proceedings, 22nd N.W. Fish Cultural Conference, Portland, Oregon, 1971.

2/ Smith, C.E., Effects of Nitrite on the Blood and Tissues of Salmon and Trout; proceedings, 22nd N.W. Fish Cultural Conference, Portland, Oregon, 1971.

3/ Mount, D.I., and W.A. Brung - 1967. A Simplified Dosing Apparatus for Fish Toxicology Studies, Water Research 1:21-29.

4/ Standard Methods for the Examination of Water and Waste Water - 12th Edition, p.400, 1965.

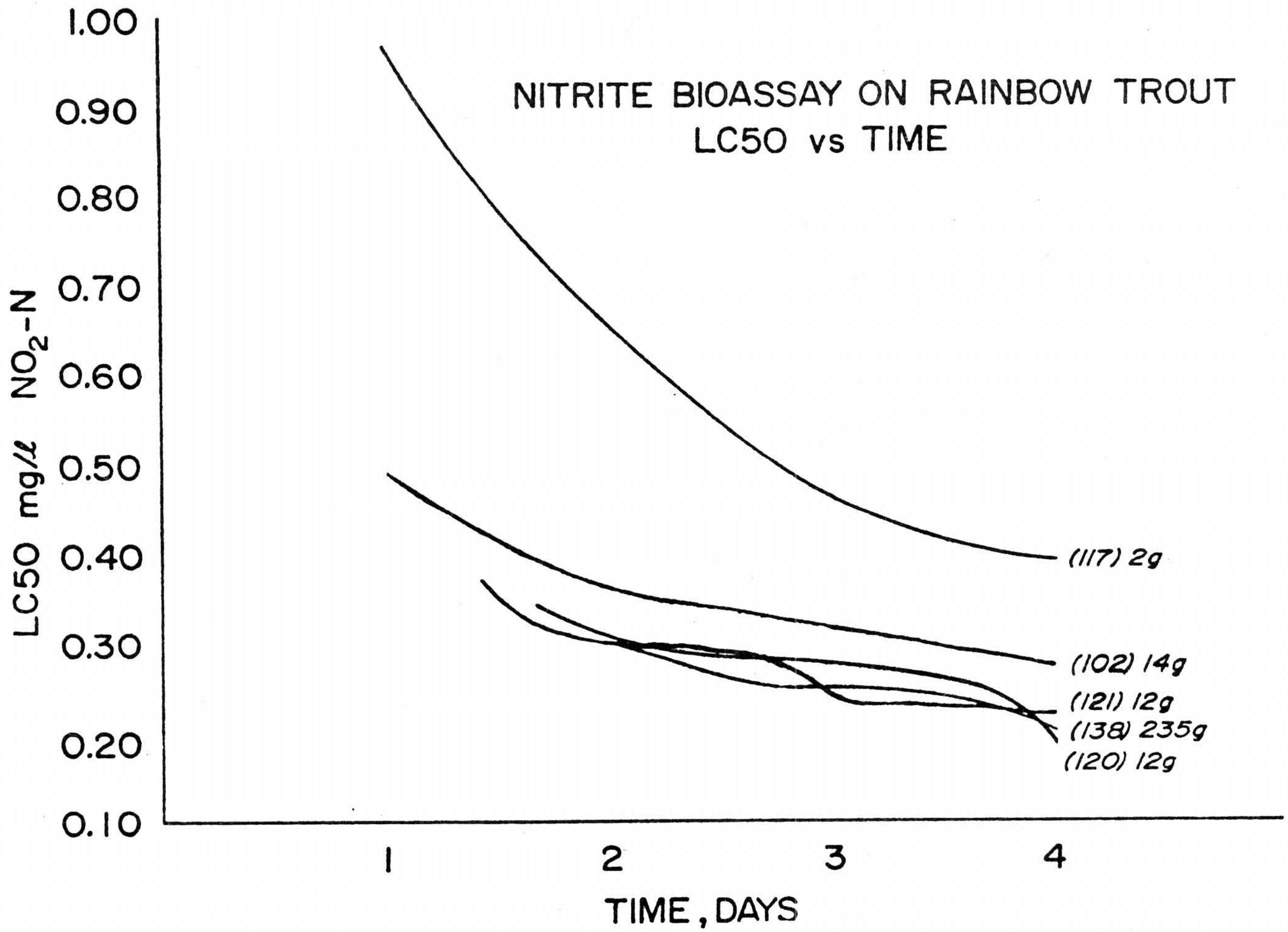
NITRITE BIOASSAY ON RAINBOW TROUT
LC50 vs TIME
LC50 mg/ℓ NO2-N
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
1
2
3
4
TIME, DAYS
(117) 2g
(102) 14g
(121) 12g
(138) 235g
(120) 12g

Figure 1

TABLE 1

LC_{50} CONCENTRATIONS OF NITRITE FOR 12 g RAINBOW TROUT

Hours	Days	LC_{50} (mg/liter)
48	2	.300
72	3	.235
96	4	.220
120	5	.205
	6 & 7	.200
192	8	.145
	9 - 14	.145
384	16	.145
	17 - 20	.145
	21 - 23	.140
	24	.135

EFFECTS OF WATER TEMPERATURE ON INFECTION OF YOUNG SALMONIDS BY *Chondrococcus columnaris* 1/

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Studies were conducted to determine the effect of different water temperatures on laboratory induced infections of *Chondrococcus columnaris* in young coho and spring chinook salmon and rainbow trout. Two control and two experimental fish groups of the species being tested were tempered to water temperatures ranging from 39 to 74 F at 5 degree intervals. The fish in each of the two experimental tanks at all temperatures were then exposed for 10 minutes to a *C. columnaris* cell suspension equivalent to $3\text{-}6 \times 10^6$ cells per ml. After the exposure all tanks were examined daily for dead fish and bacteriological cultures were made from the gills and/or kidney of each fish. The *C. columnaris* isolate used in this study was obtained from a gill lesion of an adult spring chinook salmon at the Fish Commission of Oregon, Dexter Dam Holding Pond on the Willamette River.

Table 1 shows the effect of water temperature on the percentage mortality for each fish species at 25 to 35 days after the exposure. Results at water temperatures of 44 and 39 F are not recorded because very little loss occurred at these temperatures and *C. columnaris* was never isolated from the few that died. Fish infected with *C. columnaris* were observed at temperatures from 74 F down to 54 F with the greater number of losses occurring at the higher water temperatures. Results of the coho salmon and rainbow trout experiments were nearly identical. With the spring chinook salmon, the percentage mortality at 59 F and above was lower than in the other species.

Chondrococcus columnaris was isolated from the gills or kidney of most of the experimental fish that died in each group held at water temperatures of 54 F and above but not from any experimental fish at 49 F or below or from control fish at any temperature. Using this particular isolate 54 F was the lowest temperature at which laboratory induced infections occurred. The losses accelerated at 59 F and reached epizootic proportions at 64 to 74 F.

For the three salmonid species studied the average time from exposure to death ranged from 1.0 to 2.3 days at 74 F compared to 8.9 to 12 days at 54 F. This indicates that at the higher temperatures death occurred in the shortest time and that at each lower temperature it took longer for a fatal infection to develop. Thus, the rate of death was also found to be related to water temperature.

1/ This work was conducted at the Department of Microbiology, Oregon State University, Corvallis, Oregon, and supported by the Environmental Protection Agency Grant 18050 DIJ.

TABLE 1. Effect of Water Temperature on *Chondrococcus columnaris* Infection in Young Coho and Spring Chinook Salmon and Rainbow Trout.

Temperature (F)	Group	Percentage Mortality 1/		
		Coho 2/	Spring Chinook 3/	Rainbow Trout 4/
74	Experimental	100	92	100
	Control	1	0	26
69	Experimental	100	70	100
	Control	1	2	2
64	Experimental	99	56	92
	Control	4	2	2
59	Experimental	51	31	40
	Control	3	2	0
54	Experimental	4	20	8
	Control	1	6	6
49	Experimental	0	6	0
	Control	0	8	0

1/ Combined results of two tanks of fish in each group at each temperature.

2/ There were 35 fish per tank and average fish weight was 33 g.

3/ There were 25 fish per tank and average fish weight was 10 g.

4/ There were 25 fish per tank and average fish weight was 3 g.

LIVING RIVER

16 m.m. Colour Sound Film
Time - 28 Minutes
Written and narrated by Roderick Haig-Brown
Produced and filmed by Dick Harvey

R.R. #1 Qualicum Beach
British Columbia

This motion picture was filmed in its entirety on Vancouver Island and was made expressly for school children.

Following the life cycle of the Pacific salmon through the changing seasons, it shows other wildlife dependent on a river and/or salmon for survival.

Included is a natural spawning sequence and development of the egg through the alevin stage to fry. Underwater photography includes salmon and trout.

The film was designed to show the aesthetic value of a watershed combined with nature's harmony. Narration is simple but explanative, acceptable to all age groups.

Suggested subjects: Science
Language Arts
Outdoor Education

CONFERENCE CHAIRMAN'S NOTE: This is an excellent movie with superb photography. It was well received by the conference members.

ARTIFICIAL PROPAGATION OF QUINAULT SOCKEYE SALMON

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The Quinault River sustains a unique run of sockeye salmon by virtue of earlier timing and smaller average size that represent a fish product of high quality. These fish generally mature as adults at 3.5 lbs, and enter the river net fishery in January with a maximum abundance in numbers in May. Historically, the commercial catch has varied from 6,000 to 500,000. Principle spawning occurs in the upper Quinault River and tributaries above Lake Quinault. Lake Quinault is roughly 30 miles from the Pacific Ocean, has a surface area of 3,729 acres and an average annual rainfall of 135 inches. Recent land use activities in the spawning environment have been minimal since the area is bordered on the north by Olympic National Park and on the south by Olympic National Forest land. It has been reported that early logging activities at the turn of the century have changed the channel configuration from one channel with heavily timbered banks to the present unstable braided condition.

Historical catch statistics suggest a decline in catch from 1910 to the present. This apparent decline can be better understood when the effect of artificial propagation of sockeye salmon by a federal hatchery located at Lake Quinault is taken into consideration. This hatchery operated from 1914 to 1947 releasing from ¼ million to 16 million fry and from 1 million to 6 million fingerling. Stocking of fry was terminated in 1936 and approximately 2 million fingerling were released annually thereafter. Analysis of data indicates that the artificially produced sockeye were contributing significantly to total run size which were reflected in higher catches.

Natural production from Lake Quinault was acoustically estimated by the Fisheries Research Institute at the University of Washington from 1971 to 1972. The smolt production was estimated at 2 million. Based upon the apparent success of early propagation efforts with sockeye a program of artificial propagation utilizing more recent fish cultural techniques will be employed on the Quinault Indian Reservation. Quinault sockeye eggs will be incubated in shallow bed gravel incubation systems and fry will be transferred to Lake Quinault for pen culture. Preliminary investigations indicate that sockeye are amenable to pen culture and exhibit the best growth response of any species tested so far. A small lot of fish from the 1972 brood year were 6.6 fish/lb (68.8 gms) in November (1973). Considering this type of growth response it appears feasible to raise an age 0 smolt for release in June. A naturally produced smolt in Lake Quinault requires one year of residence before smoltification. This type of "ocean ranching" hopefully will not seriously impact the freshwater rearing capacity, but will materially increase the total run size and therefore the commercial catch. The extent to which this program is successful will be evaluated by recovery of coded wire tags in the commercial fishery.

THE SIZE OF COHO SALMON AND TIME OF ENTRY INTO SEA WATER: PART 1 EFFECTS ON GROWTH AND CONDITION INDEX

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The culture of pan-size salmon in Puget Sound waters was initiated on a commercial scale in 1971. Today there are four commercial saltwater farms in Puget Sound and adjacent waters, three use floating net enclosures and one uses earthen-diked lagoon enclosures. For economic reasons, these growers, using temperatures of 12-15°C accelerate the growth of their fingerlings so that they smolt by the first summer after hatching. Growers want their stocks to smolt in time to coincide with high summer temperatures in the growout pens in salt water. If a grower is unable to transfer his fish by early summer or if growth schedules in salt water are not met, he will not be able to harvest in December and January. Since there is not much growth from December to April, the fish farmer is forced into the expense of overwintering. To avoid this, he must depend on accelerated growth in fresh water to provide zero-age smolts at precisely the right time in late spring or early summer.

In an attempt to clear their raceways because of overcrowding or lack of freshwater, growers have occasionally moved coho stocks to saltwater pens when the fish weighed less than 15g each (30/lb). Large portions of these populations have reverted to parr, and suffered higher than normal mortalities, poor growth and poor feed conversion.

From May-November 1973, experiments were conducted to determine what lasting effect, if any, early conversion to salt water would have on zero-age coho salmon. The present study suggests that growth and survival after transfer to salt water are intimately linked with smolting and can be modified by photoperiod even after entry into salt water.

Experimental coho were grown at the Domsea Farms hatchery at Gorst Creek near Bremerton. The stock was obtained from the state hatchery at Skykomish.

The growth of these fish (from a November 1972 egg take) was accelerated so that they were nearly ready to smolt by early May 1973. At that time they were transported from Gorst to the NMFS experiment station at Manchester and placed in fresh water in eight, circular tanks, 100 fish to a container. Average starting weights for the fish in the eight tanks ranged from 9.5-10.5 grams (45/lb).

At approximately three-week intervals throughout the spring, summer and fall months, the fish were anesthetized, weighed to the nearest 1/10 gram and measured for fork length.

Starting on 9 May and every three weeks thereafter, following weighing and measuring, two replicate tanks were switched to full salt water (30 0/00). No attempt was made to acclimate the population to salt water.

By 10 July all fish had been converted to full salt water and were transferred to 4' X 8' X 6' deep net pens at dockside. The presence or absence of parr marks was noted at all weighing periods thereafter.

A majority of the first 200 fish transferred to salt water (average 10.3g each, 44/lb) had not smolted. Almost all of the last group (averaged 19.3g, or 24/lb) had smolted by the time of saltwater conversion as evidenced by loss of parr.

All fish were fed to excess four times daily on Oregon Moist Pellets.

Results of the study showed high mortality and high percentage of parr-reversal in fish populations averaging 15.0g or less at time of entry into salt water (Table 1). The rates of mortality and reversal to parr were gradual throughout the experiment. There were no mass mortalities.

Table 1. Mortality and parr-reversal in four lots of zero-age coho, 120 days after conversion to full salt water.

	Size at time of saltwater entry (grams)			
	10.3	12.4	15.0	19.3
Percent Mortality	26	18	11	8
Percent Reverting to Parr	36	32	21	10

Fish with parr marks at time of conversion to salt water or those later reverting to parr showed nearly no growth in salt water for the duration of the experiment, while fish without parr grew well and at about the same rate in all groups. By November, the average size of all fish with parr was less than 20g size (23/lb), while the average for fish without was about 120g (3.8/lb).

Condition index declined during smoltification in fresh water and was further depressed at time of conversion to salt water. Condition index rose in the fall of the year in all groups.

In all lots larger fish began to exhibit parr marks, by September. By November, some 50-gram fish had parr marks and are believed to have reverted. The fate of these larger parr-reversal fish is not known. We suspect however, that they will also exhibit poor growth and higher than average mortality. It appears that a critical size may have to be attained by the fall months as the photoperiod declines or fish will revert to parr.

THE SIZE OF COHO SALMON AND TIME OF ENTRY INTO SEA WATER: PART 2 EFFECTS OF VIBRIO VACCINATION

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Our previous attempts to accurately define the effects of the size of zero-age coho salmon and the time of entry into sea water upon subsequent growth have been frustrated to a certain extent by the interactions of disease. Direct transfers of zero-age coho salmon from fresh water to 30 0/00 sea water are usually conducted (both experimentally and on a production scale) during the period from late May to early August in our Puget Sound region. This period also coincides with the peak incidence of vibriosis, especially in the Manchester area. Epidemics of this bacterial disease in sea water tanks and experimental floating net-pens in past years have created serious problems in maintaining statistical control, and in making repeated measurements of fish growth. We felt that these problems could be eliminated by the intra-peritoneal (IP) injection of a vaccine prepared from a local isolate of the infectious agent, *Vibrio anguillarum*. Research conducted in Oregon by J. Fryer and R. Garrison, indicated that a single injection of 300 to 1,000 ugm of killed, wet-packed cells in physiological saline would be sufficient to provide immunity against the pathogen.

Isolates of *V. anguillarum* from salmon cultured in net-pens in Clam Bay (Manchester), Washington were used to innoculate flasks of sterile trypticase soy broth containing 2 percent NaCl. The broth cultures were incubated for 24 hours at 24°C. The broth was then centrifuged, and washed three times with sterile physiological saline, centrifuging after each wash. The cells were concentrated in a single tube, and the tube was placed in a boiling water bath for two hours to produce the heat-killed antigen. Excess moisture was removed, and the wet-packed cells were weighed and suspended in sterile physiological saline. The final dilution contained approximately 2,240 ugm of wet-packed cells per cc. The vaccine was kept in refrigerated storage after adding 0.5 percent phenol as a preservative.

The time interval between the placement of the first experimental group of coho into full sea water and the last group was designed to be 60 days (see Part 1 of this presentation). We felt that an interval of 60 days between vaccination and natural exposure to the bacterium might be too long. Therefore, in order to provide equal treatments to all fish, all four groups were vaccinated once with 560 ugm of wet-packed cells on May 9, 1973, and again with 560 ugm on July 10, 1973.

The fish were anesthesized in MS222, and an automatic syringe was set to deliver ¼cc of vaccine with each injection (it was interesting to note that with this technique, we could vaccinate fish at a rate of 720/hour/person).

The first group (I) was introduced to full sea water (30 0/00) within 24 hours post-injection. The second group (II) was introduced 19 days later, and the third group (III) 41 days post-injection. At 62 days post-injection the vaccination procedure was repeated on all groups (July 9) and the fourth group (IV) was introduced to sea water within 24 hours. Each of the four groups tested were represented by replicates of 100 fish each (800 total). The average size of the fish at the first injection was 10.3 gm. Both fresh and sea water were maintained at the temperature of the ambient sea water.

The mortalities of groups II and III in fresh water ranged from 0.023 percent per day to 0.21 percent per day. Group IV was in fresh water for the longest period, and mortalities ranged from 0.13 percent per day to 0.39 percent per day. There was a great deal of variation in mortality between tanks in fresh water. In almost all cases, the causative agent (isolated from the kidneys of moribund fish) was Aeromonas salmonicida (furunculosis). No medication was used in either fresh or sea water.

The average weights of the coho when introduced to 30 0/00 sea water were: Group I - 10.3 gm; Group II - 12.4 gm; Group III - 15.0 gm; and Group IV - 19.3 gm. At 120 days post-salt water entry, there was little difference in the cumulative mortality between Groups III and IV (Figure 1). Zero-age coho introduced to full sea water when the average weight is less than 15 gm appear to suffer from a higher stress mortality (Groups I and II). Fresh dead fish were examined as they appeared, and smears from the kidney were streaked onto tryptose blood agar and trypticase soy agar (2 percent NaCl) plates. Smaller fish were usually negative (no bacteria found), and the larger fish were frequently infected with furunculosis. No vibrios were found while the fish were in circular tanks in the hatchery.

In July, all groups were transferred to small experimental net-pens, arranged to maintain separate identities. Throughout the summer, we were only able to isolate vibrios from several moribund fish. The cumulative mortality in the Group IV fish was 10 percent (0.16%/day) through November 12th, a period of 64 days from the last injection. In contrast, the cumulative mortality of the Group I fish was 34 percent (0.5%/day) during the same period. When one considers that each fish was anesthesized, weighed and measured every three weeks, and received no medication throughout the experiment, the survival of the Groups III and IV fish is remarkable. If these fish were handled in the same way without vaccination or medication, the mortality would be in the order of 95 percent or higher, primarily from vibriosis.

Serum agglutination titers against the vibrio antigen were negative prior to vaccination. Dr. Robert Gunnels (College of Fisheries, University of Washington) conducted serum agglutination titers on sub-samples of these coho after the second vaccine injection, and the results are shown in Table 1.

Table 1. Serum agglutination titers of sub-sampled (vaccinated) coho against the vibrio antigen.

Date of Sub-sample	No. of days Post-2nd Injection	TITER									
		N	0	2	4	8	16	32	64	128	256
August 7	29	18	0	0	0	0	1	0	2	3	12
September 19	71	24	1	4	9	6	3	0	1	0	0

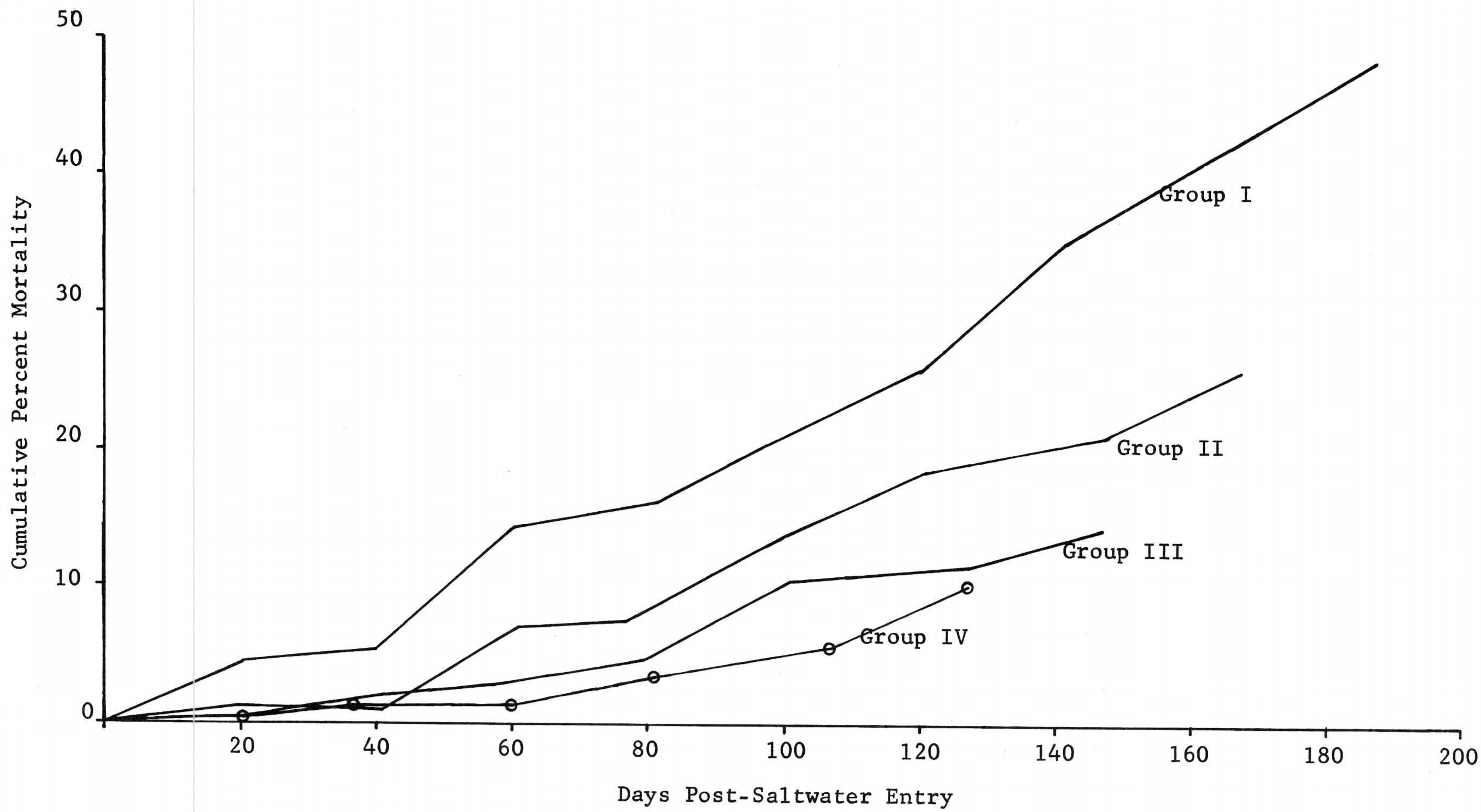
We expected that the natural, continuous challenge by the live vibrio organisms in the bay would stimulate antibody production. Apparently, this is not the case, as antibody production was dropping rapidly by mid September. Vibriosis outbreaks in September can be severe in Clam Bay, and indeed were in other non-vaccinated cultured salmon. Mortalities in vaccinated Groups III and IV were low throughout September, October and early November. However, in late November, at a temperature of 9.5 to 10.3^{o}C., a serious epidemic of vibriosis occurred in the vaccinated groups.

The total mortality at this writing is not known, but prior to treatment with antibiotics, it approximated 5%/day. Blood samples were collected from dying fish, and the highest serum agglutination titer against our stock vibrio antigen was 1:2. Most were negative.

Large lots of other experimental coho that were routinely vaccinated during the summer with single injections ranging from 500 to 1,500 ugm of wet-packed cells were not affected by this late fall outbreak of vibriosis. However, these fish were not handled as frequently as the salinity test coho.

It appears to us (at this writing), that a single IP injection of vibrio vaccine will afford a great deal of protection to zero-age coho salmon throughout the summer and early fall, but probably cannot be extended beyond late fall without the use of an adjuvant. However, I think that we have clearly demonstrated the use of physical vaccination in clarifying the causes of mortalities in young coho, other than vibriosis.

Figure 1. Saltwater Mortality of Four Lots of Zero-Age Coho Salmon



SELECTIVE BREEDING OF COHO SALMON AT EAGLE CREEK NATIONAL FISH HATCHERY

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The coho salmon selection program at Eagle Creek includes an evaluation of the early maturity and growth potential of jack salmon by crossing them with 3-year-old adult females. This cross was evaluated for three brood years (see Table). When the progeny of these crosses were compared with progeny of adult by adult crosses of the same brood year, only one consistent difference stood out, the jack male-adult female cross produced a greater percent return. This was due primarily to a larger return of jacks. Also, the adult return data suggest that percent survival to maturity was slightly better for the progeny of the jack male-adult female cross. This was evident despite the fact that the progeny of the jack male-adult female cross received what is thought to be the more deleterious mark in two of the three brood years. Results of statistical analysis indicate that there was no consistent size difference between progeny of the two crosses when compared as returning jacks and adults. For brood-year 1964 the adult by adult cross returns were larger, for brood-year 1965 the jack by adult cross returns were larger and for brood-year 1966 there was no significant size difference between the returns of the two crosses. These differences may be explained by the differential deleterious effects of the marks. There also appeared to be no significant difference in condition factor between the returns of the two crosses for all three brood years.

The consistently larger jack returns for the jack male-adult female cross suggest that the progeny of this cross possess a genome which predisposes early maturity for males.

EAGLE CREEK NATIONAL FISH HATCHERY SELECTIVE BREEDING PROGRAM

Brood Year	Cross	Release Size No./Lb.	Return Year	Percent Return Males	Percent Return Total		Sex Ratio (♂/♀)
1964	Jack X Adult	14	1966	4.48	4.48	5.22	16.2/1
	Mark-Ad/LM		1967	0.43	0.74		
	Adult X Adult	14	1966	1.53	1.53	1.85	9.3/1
	Mark-Ad		1967	0.14	0.32		
1965	Jack X Adult	24	1967	0.43	0.43	0.62	8.3/1
	Mark-RM		1968	0.12	0.19		
	Adult X Adult	22	1967	0.17	0.17	0.35	4.4/1
	Mark-Dorsal		1968	0.11	0.18		
1966	Jack X Adult	20	1968	0.28	0.28	0.56	3.3/1
	Mark-RM		1969	0.15	0.28		
	Adult X Adult	20	1968	0.12	0.12	0.33	2.2/1
	Mark-AN		1969	0.10	0.21		

CONTROLLED TEMPERATURE REARING OF FALL CHINOOK SALMON

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A water reuse and reclamation system with temperature control capabilities was completed in 1967 at the Abernathy Salmon Cultural Development Center. This system proved feasible for rearing salmon fingerlings in controlled temperature environments on a production basis and led to laboratory studies of growth at various constant water temperatures. Of the four constant temperatures (50°, 55°, 60°, 65°) investigated in the laboratory, 60°F produced maximum growth. Prolonged rearing from the first feeding stage at constant 45°, 50°, 55°, and 60°F. established differences in growth potential of chinook fingerlings over given periods of time at a wide range of temperatures. Observed rates of increase in average length at 45°, 50°, 55°, and 60°F were .40, .54, .69, and .79 inches per month respectively.

Tests to evaluate the effects of rearing salmon fingerlings in heated water on adult survival were conducted in the production system yearly from 1967 through 1972 (Table 1). In every instance, fingerlings reared at elevated temperatures in reused water and released at a larger size produced significantly greater returns to the hatchery.

TABLE 1. Summary of fall chinook mark-return experiments, 1967-72

Year	Variable	Release Date	Release No./lb.	Recovery Ratio
1967	Reuse (heated water)	May 3	32	8.0
	Creek	May 3	96	1.0
1968	Reuse	May 14	26	17.9
	Creek	May 14	80	1.0
1969	Reuse Late Release	April 30	21	2.7
	Reuse Early Release	March 18	47	1.0
1970	Reuse Late Release	May 1	25	5.8
	Reuse Early Release	March 19	45	1.0
1971	Reuse Only	May 5	23	4.5
	Reuse + Creek	May 4	43	1.0
1972	Reuse Only	May 4	26	4.9
	Reuse + Creek	May 4	43	1.0

THE EFFECT OF TEMPERATURE ON GILL ATPASE ACTIVITY, SALINITY TOLERANCE, AND MIGRATION IN WINTER STEELHEAD TROUT

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In earlier studies Dr. Harry Wagner showed that temperature had two measureable effects on the parr-smolt transformation. Winter-run steelhead reared under a variable temperature cycle moved downstream in greater numbers and in fewer days than fish reared at constant temperature, regardless of photoperiod. Temperature also influenced the duration of the migratory period.

Zaugg et al (1972) found that yearling summer steelhead held in fresh water at cold temperatures ($<10^{\circ}C$) showed an increase in gill microsomal Na+, K+-stimulated gill ATPase activity whereas fish held in warm water 15° and $20^{\circ}C$ did not. These researchers, on the basis of their experiments, suggest that $12^{\circ}C$ (about $54^{\circ}F$) is the upper limit of water temperature at which we might expect good migration of juvenile steelhead. They further suggest that steelhead reared at warmer temperatures (up to $15^{\circ}C$) in state and federal hatcheries should be exposed to cooler environmental temperatures (6° to 10°) for 1 to 2 months prior to release to allow time for the parr-smolt transformation.

The objective of this study was to confirm Dr. Zaugg's earlier observation, that smolting of winter steelhead is inhibited at temperatures above $13^{\circ}C$. Three groups of fish were reared at the laboratory under a normal photoperiod but different constant temperatures. The temperature regimes used were 8°, 12° and 16°. Parr-smolt transformation was characterized by changes in gill ATPase activity, migratory behavior, coefficient of condition and tolerance to sea water.

Fish under a normal photoperiod and simulated normal temperature (NL-NT) and normal photoperiod and constant temperature (NL-CT) of $12^{\circ}C$ or less showed an increase in enzyme activity during April whereas fish reared at $16^{\circ}C$ did not show this increase.

Samples of the experimental fish were released into a small coastal stream where a weir and trap had been installed to monitor downstream migration. As the data on the Na+, K+-stimulated ATPase activity would suggest, the fish reared at $16^{\circ}C$ did not migrate at the same rate as those fish reared at lower temperatures. A portion of the fish reared at $16^{\circ}C$, however, did eventually migrate but showed about a three week delay. Measurements from downstream migrants showed that the ATPase activity had increased during this three to four weeks.

The results of this study indicate a close relationship exists between elevated gill Na+, K+-stimulated ATPase activity and seaward migratory movement. In addition these data provide information on the deleterious effect of elevated temperature and the parr-smolt transformation.

INFLUENCE OF TEMPERATURE ON GILL ATPASE ACTIVITY IN COHO SALMON

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Studies conducted during the past several years have consistently shown a close association between the transformation of parr salmonids to smolts and the development of an elevated Na+, K+-stimulated ATPase activity in microsomes isolated from gill filaments. Therefore, we find that juvenile steelhead and coho migrating seaward have elevated enzyme activity. Our investigations have shown that when smoltification in steelhead is accelerated or delayed by photoperiod manipulation there is an attending and simultaneous elevation of gill ATPase activity. Indeed, we feel justified in concluding that any steelhead, coho, or chinook will have higher gill ATPase activity as a smolt than as a parr. It is highly probable that the same may be said for other species of salmonids not yet examined.

When steelhead smolts revert to a parr-like stage in late June, there is an associated decrease in enzyme activity. Likewise, steelhead smolts placed in warm water (55 to 59°F) experience a decrease in ATPase activity in one to three weeks and fish reared in water of temperatures in this range show reduced migratory behavior. Thus, when a decrease in ATPase activity is brought about in steelhead by extended photoperiods or by elevated temperatures, there is a reduced tendency to migrate. With the information we have now collected we conclude that the level of ATPase activity in steelhead gill is a good indication of the degree of smoltification, and hence, of migratory tendency. Since experiments with salmonids other than steelhead have not yet been as extensive, we cannot declare with the same degree of certainty that a similar relationship exists between migratory behavior and elevated ATPase activity. However, we presume a high probability that such a relationship does occur in species like coho salmon.

During the past year we have measured ATPase activities from the end of December to mid-July in juvenile coho salmon held in four different constant temperature environments. Figure 1 summarizes the results. Na+, K+-ATPase activity in coho held at 6°C (43°F) increased steadily, beginning in mid to latter March, reaching peak activity in June, and remaining elevated through mid-July. Fish held at 10°C (50°F) also showed an increase in activity, which began to decline by the 1st of June. Coho at 15°C (59°C) showed a much more rapid rise in activity than either the 10° or 6°C groups. Also, the activity reached a higher level but declined earlier than in 10°C fish. Fish held at 20°C (68°F) appeared to pass through a transitory period of elevated activity.

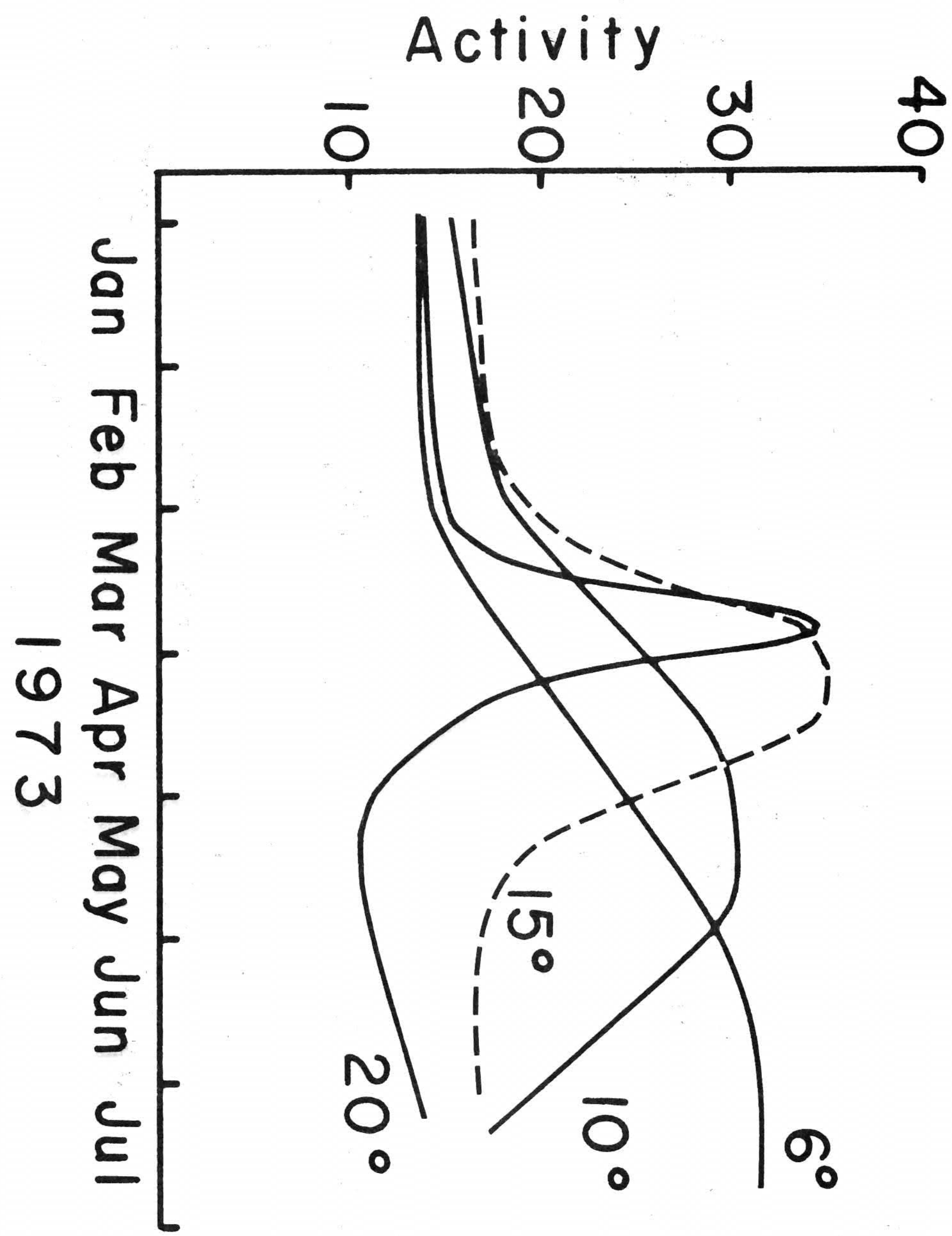
Fish which were transferred from one temperature to another tended to produce ATPase activities typical of the fish at the temperature to which they were transferred. Thus, 20°C fish transferred to 6°C water developed an elevated ATPase activity which remained high in mid-July while 6°C fish transferred to 20°C water lost activity rapidly (Figure 2).

From these experiments we make the following observations:

(1) Parr-smolt transformation in coho salmon, as measured by gill ATPase activity, is accelerated by warm water.

(2) As water temperature is increased, elevated ATPase activity becomes more inclined to decrease to presmolt levels. However, once elevated, the activity can be stabilized by placing fish in cooler water.

(3) The possibility exists, based on observations with steelhead, that migratory movement may decline when ATPase activities fall after coho are exposed to warm water.


Activity
40
30
20
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Jan Feb Mar Apr May Jun Jul
1973
6°
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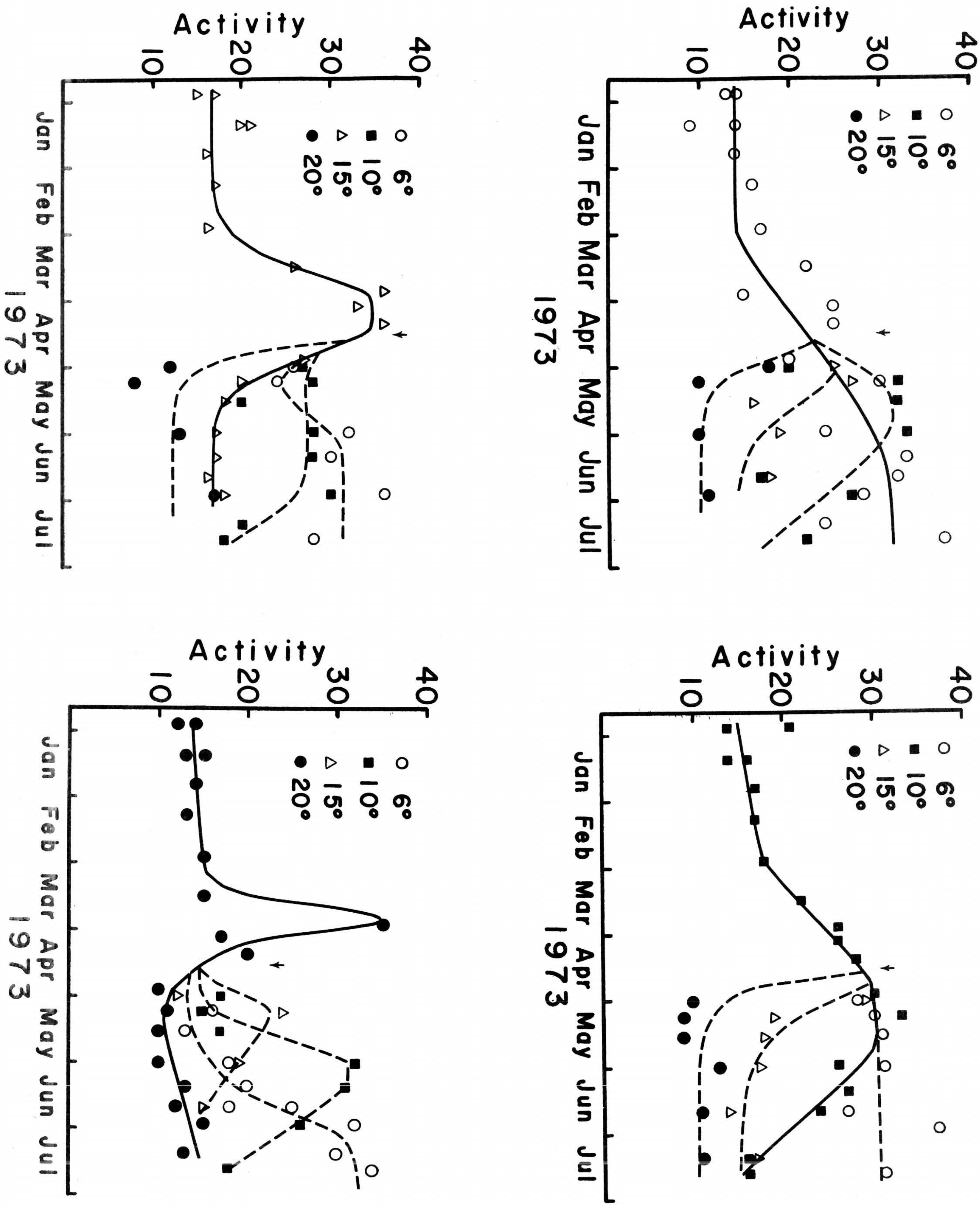
15°
20°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SOME SMOLT CHARACTERISTICS IN SUMMER STEELHEAD

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The Oregon Wildlife Commission became involved in a summer steelhead study on the Deschutes River in July 1969. One of the objectives of the study was to determine the most efficient method of rearing Deschutes summer steelhead under hatchery conditions. In the past all juvenile steelhead released into the Deschutes River have been reared at hatcheries with constant temperature water supplies. Laboratory and rearing programs were designed to provide information on age, growth and water temperature requirements for the parr-smolt transformation in summer steelhead.

Size at time of release appears to be one of the most important considerations in releasing summer steelhead smolts. Fish smaller than 15 cm fork length reared in variable or constant water temperature hatcheries do not migrate downstream. A decrease in coefficient of condition occurs during the spring prior to migration. The magnitude of the change in coefficient of condition is controlled by rearing regime. Fish reared under variable or normal water temperatures had a mean coefficient of condition of 0.960 prior to migration as compared to 1.030 for fish reared in constant water temperature. Siletz, Rogue, Umpqua and Skamania runs of summer steelhead also display the vernal decrease in coefficient of condition prior to downstream migration.

The optimum time to release Deschutes summer steelhead smolts is mid-April through the first week in May. Downstream migration patterns for Deschutes hatchery-reared summer steelhead reared under variable and constant water temperatures were similar. Peak movement occurred the first week in May coinciding with that of wild smolts in the Deschutes system. Siletz, Rogue, Umpqua and Skamania summer steelhead had similar migration patterns.

Saltwater survival does not appear to be a good indicator of smolting in summer steelhead because of variability from month to month. Deschutes summer steelhead reared in constant and variable water temperatures displayed 60 and 70 percent survival respectively in full strength seawater prior to peak migration. Other races of summer steelhead had survival values of 70-95 percent during the same period. The osmotic concentrations of plasma for Deschutes fish reared under the two regimes were similar but concentrations were always higher than those of Alsea winter steelhead, indicating that they were poorer regulators in full strength seawater. During the period of downstream migration to the ocean, gradual transition through the estuary to higher salinities could be an important phenomenon for summer steelhead smolts.

In the Deschutes River approximately five percent of the hatchery-reared steelhead smolts remain in the stream as residuals. These fish rear and spawn with the native rainbow population. Genetic studies could not differentiate the Deschutes rainbow and steelhead. The progeny from the resident rainbow population could be contributing to the steelhead run. Preliminary studies indicate that progeny of resident rainbow and summer steelhead reared under similar conditions exhibit similar characteristics. Although the mean condition factor of the Deschutes rainbow is higher than for summer steelhead, both display the vernal decrease in coefficient of condition and similar migration characteristics. The resident rainbow display a high gill ATPase activity during the spring months.

In summary, there are many unanswered questions about smolting in summer steelhead. Rearing regime does not seem to be an important factor in downstream migration and the subsequent return of adults. In the last few years we have experienced consistent returns of 3.5 to 5.0 percent from large smolts (4-6 fish/lb) released in late April.

A CONTROLLED TEMPERATURE FACILITY FOR FISHERY RESEARCH

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Testing of a controlled temperature facility at the Oregon Wildlife Commission's Research Division laboratory is nearing completion. The facility was designed to test effects of fluctuating temperature cycles on cutthroat trout (Salmo clarki clarki Richardson) as a part of a study of the effects of logging on aquatic resources.

Five Honeywell dual temperature controller-recorder units (Model #604 P43DD-74-III-896) and ten three-way mixing valves (Research Model 6A-711-35M) comprise the basic core of the facility and provide tempered water to ten 140 liter fiberglass aquaria. The facility was designed to utilize existing air, water and power supplies at the laboratory.

Plexiglas cams control the programmed temperature cycle for each controller-recorder unit. Temperature cycles are plotted on thermograph charts which in turn are pasted on to the 9 x 9 x 1/10 in. cam blanks. The blanks are then cut on a band saw and finished with a high speed sander. Any combination of cyclic and mean temperature rate changes may be used as long as rate changes do not exceed 5.5°F/hour or 66°F in any 12-hour period. The cam motors complete one revolution every seven days before a cam change is necessary.

The thermograph portion of the controller-recorder unit records the temperature regime experienced in the aquaria via feedback from a mercury filled capillary sensor. The controller portion of the unit can detect differences between the desired temperature on the cam and the temperature of the water in the aquaria and cause pressure changes to the diaphragm of the 3-way mixing valve. A change of pressure to the mixing valve adjusts the ratio of hot and cold water mixture. Compensation takes place between the output temperature and the cam program temperature until the difference is eliminated. Accuracy of $\pm$0.5°F of set point is maintained by the controller-recorder unit over a range of 44°F to 120°F.

Proper operation of the controller-recorder and three-way mixing valves is dependent on a clean dry air supply of 20 psi delivered to the controller unit plus supplies of 44°F and 120°F water at 24 psi to the mixing valves.

Tempered or mixed water enters the aquaria through a stainless steel spray nozzle at a rate of six liters/minute. The exchange rate is one change every 23 minutes. A 3/4 in. diameter PVC inner standpipe and a slotted 1½ in. diameter outer standpipe aid in removing waste materials and maintain a constant head within the tank. A tygon tube ring with 4 airstones encircling the bottom of the tank assists in aerating the water. Each tank is equipped with a 15 x 15 in. plexiglas viewing port for observing the experimental animals. An automatic Nielsen trough type feeder provides food to the animals through a slot in the top of the tank lid.

The total cost was approximately $9,300 and includes 5 dual controller-recorders, 10 three-way mixing valves, 10 fiberglass aquaria, two insulated aquaria cabinets, PVC plumbing fixtures and a fiberglass lined hot water heater.

Within the next six months, plans will be carried out for constructing a more efficient degassing system to eliminate supersaturation as a factor in testing animals under various fluctuating temperature regimes.

AN EVALUATION OF TECHNIQUES FOR AUGMENTING THE NATURAL PHOTOPERIOD TO ADVANCE THE ONSET OF MIGRATION IN WINTER STEELHEAD

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The role of photoperiod and temperature in the parr-smolt metamorphosis has been studied at the behavioral, morphological and physiological levels in steelhead trout (Salmo gairdneri) for many years by Dr. H. H. Wagner. Photoperiod was the main environmental factor controlling the onset of metamorphosis, but did not determine whether or not the event occurred. Wagner found that fish reared under an accelerated or advanced annual photoperiod were migratory earlier than control fish regardless of the temperature cycle. Similarly, those receiving a decelerated annual photoperiod had a delayed and extended migratory period.

His data suggested that the rate at which the length of the daily photoperiod increased was the information most utilized by the fish for synchronizing the metamorphic response, rather than length of daily light or dark period per se or accumulated hours of exposure. He observed that some fish under constant photoperiod and temperature regimes exhibited migratory behavior and normal smolt characteristics. Therefore, he concluded the transformation has an endogenous mechanism.

Wagner's previous work involved the complete control of photoperiod cycles and required tanks equipped with hoods and artificial light sources. This past year's experiments involved rearing fish under natural light conditions with periods of artificial light, thus extending the normal day length in an attempt to advance the time of parr-smolt transformation. Artificial light of varying intensity was added either prior to sunrise or after sunset.

Smolting was assayed by examination of changes in migratory behavior, coefficient of condition and Na+, K+-stimulated gill ATPase activity.

Fish under a natural photoperiod plus artificial light and a simulated normal temperature regime (ASL-NT) showed a rise in enzyme activity in late February and March. The controls, however, showed an increase in enzyme activity during April.

The results of this study indicate that the length of hatchery residence can be shortened by photoperiod manipulation. However, the effect that early migration into the sea will have on survival, growth and life history remains to be determined.

PROGRESS OF COHO SALMON GENETIC STUDIES AT BIG CREEK

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INTRODUCTION

The Fish Commission of Oregon and the Oregon Cooperative Fishery Research Unit are engaged in a study of coho salmon genetics at Big Creek Salmon Hatchery near Astoria, Oregon. The study was initiated to determine the heritability of several traits in coho salmon (Graybill, 1972). The experimental design in these studies included mating adult males and females to produce a series of 60 families of known genetic relationship. Families were kept separate until the fish were large enough to receive a coded wire tag plus adipose mark. Once marked, the families were combined and reared in the common environment of a single rearing pond. This procedure was followed for the 1967, 1968, and 1969 broods. Analysis of variation in selected traits for individuals in these families enabled separation of genetic and environmental components of the observed variability.

In 1970, significant differences were noted in the numbers of returning adults in the 1967 brood families. In 1971 percentage returns of fish with a specific serum protein phenotype were greater than fish with other phenotypes.

The objective of this report is to describe two experiments that have been initiated to increase adult production of Big Creek coho salmon. The first experiment was to select individuals for breeding from families with the highest percentage survival of adults. The second experiment was to select individuals for breeding so as to maximize the frequency of the serum protein phenotype producing the highest percentage adult survival.

EXPERIMENTAL PROCEDURES

In November 1971 the 1968-brood adults returned to Big Creek. During sorting operations adipose marked adults were separated from production fish. Those that were overripe or green prior to a predetermined spawning time were sacrificed, their tags removed, and decoded. During the spawning operation gametes obtained from each adult were placed in an individual container identified by a number corresponding to a numbered disc tag applied to the parent carcass. Gametes were stored at 40°F. The wire tag from each spawned out carcass was removed and decoded, and gamete containers and disc tagged carcasses were assigned their respective sib group. Numbers of adults returning to the hatchery from each sib group were then added to the numbers recovered in the 1971 ocean and Columbia River fisheries and the percentage return for each group was determined. Average survival in the families was 0.8 percent of the number released and ranged from 0.1 to 2.1 percent. Individuals from families with a return greater than 1.0 percent were then used as broodstock for the 1971 brood. Average survival of these "select" fish was 1.5 percent. All matings were completed within 8 hours of gamete removal.

Adults selected at random from the "production fish" 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 eggs and juveniles were reared as in previous years.

Blood samples have been obtained from several of the experimental groups that have been available during the course of these studies. These samples provide the raw material to study the character of serum proteins. One such protein, transferrin, is polymorphic in Big Creek coho salmon, in that two different types can be identified by starch-gel electrophoresis. Each type appears to be inherited in a predictable manner.

The two types of transferrin are thought to be produced by separate alleles that, by convention, are labeled A and C. Therefore, three different electrophoretic patterns (phenotypes) are observed in these fish. The patterns observed are as follows:

Transferrin phenotypes of the 1968 brood, at time of their release and as returning adults were determined. The percentage return for each phenotype was:

	AA	AC	CC
females	1.04	1.18	--
males	0.47	1.08	--

These data represent the proportion of juveniles in each transferrin phenotype that returned as adult males or females. In that individuals of the AC phenotype appear to return in greatest proportion, we have initiated an experiment with the 1973 brood in which this phenotype has been maximized. This was accomplished by taking blood samples from the available brood fish, determining their transferrin phenotypes, and choosing appropriate brood fish to maximize the production of AC types.

PROGRESS TO DATE

Although our experiments cannot be evaluated at the present time, some important preliminary results can be examined. In artificial selection programs, changes in desirable characteristics are often correlated with changes in other characteristics. The number of jacks produced by select families was of concern in these studies. Would we increase the number of jacks as a result of our selective breeding program? The jacks from the 1971 brood returned to Big Creek this year. The percentage return of the total release returning as jacks in select and control groups was as follows:

	Select	Control
Percentage return as jacks of the total released	0.29	0.37

Based on these results, we have tentatively concluded that selection of our brood stock from families with the greatest survival will not increase the numbers of jacks produced.

In addition, it was of interest to explain the low number of males of the AA transferrin-type that returned as compared to the AC-type. One hypotheses suggested that the AA males tended to return as jacks. To test this possibility, we obtained blood samples from the returning jacks in October 1973. Determination of their transferrin phenotypes gave the following results:

	AA	AC	CC
number	47	35	1
frequency	0.56 (0.64)	0.42 (0.32)	0.02 (0.04)

Accordingly, the hypothesis was rejected. The selective disadvantage of AA males remains unexplained.

The expected frequencies, in parentheses, were estimated from the gene frequencies of the 1971-brood parents. Comparison of the observed and expected frequencies shows a preferential survival of the AC-type, a result that parallels earlier results with the 1968-brood parents.

ACKNOWLEDGMENTS

Several individuals that are not directly involved with the program at the time, but assume major roles in any success attained to date are: Mr. J. Graybill, Mr. V. Knowles, and Dr. R. Simon. Mr. R. Sheldon and personnel at Big Creek Hatchery, Mr. L. Brown, Mr. M. Solazzi, and several others, continue to make significant contributions to the program.

REFERENCES

Graybill, J. R. 1972. Heritability estimates for several traits in coho salmon (Oncorhynchus kisutch). (Unpublished manuscript)

GROWTH RATE, FEED EFFICIENCY, AND REPRODUCTION RESPONSES OF RAINBOW TROUT (DONALDSON STRAIN) FED MOIST AND DRY DIETS

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There is considerable literature on the effects of diets on growth of salmonid fishes. Most of these studies, however, deal with young fish (fry and fingerlings). The effects of diets on brood fish have not been looked at extensively. In view of increased interest in salmonid aquaculture, diet-growth and reproduction relationships of brood fish are of singular importance. Because, sound nutrition is a determinant for growth, maturation and reproduction; and to an extent it is life itself.

This investigation was therefore undertaken for the purpose of determining whether or not a dry commercial diet, a moist commercial diet, and the standard University of Washington hatchery diet, modified by incorporating either shrimp wastes or crab wastes, are equally satisfactory for brood stock rainbow trout developed at the University of Washington.

The two commercial diets used in the study are readily available and both are extensively used for growing salmonid fishes in the Pacific Northwest and in the intermountain zone of the United States. Shrimp wastes and crab wastes constituted 25 percent in total weight of the modified University of Washington diet.

Two hundred yearlings of the 1971 brood year were divided into four groups of 50 fish each. Each group of fish was fed one of the above diets at the rate of 2 percent of their body weight every other day for 8 months before spawning. Adjustments in feeding were made following monthly weighings. Water temperatures during the growth period ranged between 7^{o} and $25^{o}C$, with a mean of $13.5 \pm 6.3^{o}C$. Spawned eggs were held in a vertical flow incubator, with the water temperature maintained at $9.5 \pm 1.3^{o}C$. The eggs were attended daily until they hatched and the yolk sac was absorbed. Weight gain, condition factor, feed conversion, gross growth efficiency, and kcal of metabolizable energy required per kg of flesh were measured. Egg production, egg weight, egg size, egg survival (hatchability) and the chemical composition of the green eggs and sac fry were determined.

Growth rates per month were not constant over the experimental period, but the average growth curves (Figure 1) were sufficiently different to distinguish the effects of the various dietary treatments in a meaningful manner. Significant differences due to diet were found among the groups in terms of growth responses (Table 1). Mean egg production, egg weight, and egg size were not significantly different, but the green eggs and sac fry differed significantly ($P < 0.05$) in their contents of protein, lipid, ash, moisture, and iodine number. Hatchability was not affected by the weight or size of the egg *per se*, but was affected by the quantity and quality of protein, lipid, and ash in the egg. Approximately 53 percent of the protein and 33 percent of the lipid stored in an egg were used during embryonic development. Sac fry contained about 20 percent more water than the green eggs. Egg survival ranged from 45 percent for the dry commercial to 81 percent for the standard University of Washington diet modified by incorporating shrimp wastes (Table 1). Differences in egg survival (hatchability) among treatments were highly significant ($P < 0.01$).

The rank order of the diets according to performance for growth and reproduction in the ascending order was the dry commercial diet, the moist commercial diet, and the standard University of Washington diet with the addition of crab or shrimp wastes. Shrimp wastes apparently contain some unidentified factors that are responsible for good growth, high egg production, and hatchability of rainbow trout eggs.

TABLE 1. Summary on growth rate, feed efficiency and reproduction responses of rainbow trout - Donaldson strain - fed dry and moist diets (mean±SD).

G R O W T H	Shrimp Wastes	Crab Wastes	Commercial Moist Diet	Commercial Dry Diet
Initial length (cm)	40.73±2.36	34.12±1.02	41.04±2.25	40.79±2.19
Final length (cm)	55.70±2.45	55.07±3.12	55.93±4.32	54.07±3.04
Percent gain in length	36.75	34.25	36.28	32.56
Initial weight (kg)	1.13±0.26	1.14±0.25	1.13±0.24	1.12±0.23
Final weight (kg)	3.32±0.50	3.23±0.56	3.20±0.53	2.68±0.41
Percent gain in weight	193.81	183.33	183.19	139.29
Initial condition factor	1.67	1.65	1.63	1.65
Final condition factor	1.92	1.93	1.83	1.70
Percent gain condition factor	14.79	16.97	12.27	3.03
Kcal per g of diet	2.00	2.35	2.70	3.50
Protein-energy ratio	1.70:1.00	2.70:1.00	1.40:1.00	1.60:1.00
Kcal required per g flesh	3.00	3.50	4.30	6.20
Total food fed (dry wt kg)	153.00	158.00	163.19	220.00
Food conversion	1.42	1.50	1.60	2.77
Lb of food per lb flesh	2.21	2.27	2.36	3.01
Gross growth efficiency (%)	66.00	62.00	59.00	43.00
No. of fish lost (mortality)	2	3	3	2
Percent mortality	4.00	6.00	6.00	4.00
R E P R O D U C T I O N				
FEMALES				
Length (cm)	57.05±2.36	54.80±7.16	56.66±2.47	54.39±2.19
Wt before spawning (kg)	3.44±0.36	3.44±0.78	3.22±0.56	2.85±0.45
Wt after spawning (kg)	2.99±0.31	3.05±0.36	2.80±0.46	2.35±0.35
Percent difference in wt	13.06	11.33	13.19	17.75
No. of fish spawned	24	19	18	18

REPRODUCTION (Continued)	Shrimp Wastes	Crab Wastes	Commercial Moist Diet	Commercial Dry Diet
MALES				
Length	59.99±2.36	59.08±4.10	59.51±3.37	54.44±4.77
Weight (kg)	3.42±0.15	3.44±0.16	3.44±0.13	2.74±1.52
No. used	24	19	18	18
EGG PRODUCTION				
No./female	10,019±1,735.73	9,317±1,839.07	9,574±2,117.71	10,999±548.50
No. in 6-inch trough	33.58±1.09	34.12±1.02	34.46±1.05	35.22±2.25
Size of eggs (mm)	4.46±0.19	4.38±0.28	4.44±1.89	3.37±1.87
Wt of 100 eggs (gm)	4.47±0.32	3.89±0.41	4.40±0.34	3.90±2.48
Egg production efficiency	3.36±0.97	3.09±0.79	3.42±1.13	4.69±0.92
Coefficient variation (egg no.)	17.32	19.74	22.12	32.26
EMBRYONIC MORTALITY (%)				
Initial pick mortality	0.30±0.05	0.71±2.53	0.01±0.02	0.58±2.10
Eyed stage mortality	10.60±4.36	20.71±11.69	19.09±9.97	25.42±12.79
Hatching stage mortality	8.32±5.57	14.63±10.21	19.46±12.16	29.28±10.89
Total embryonic mortality	18.95	36.05	38.56	55.28
Percent survival	81.05±6.50	63.95±10.30	61.44±12.27	44.72±11.56
fficient variation (survival)	8.02	16.12	19.97	25.85

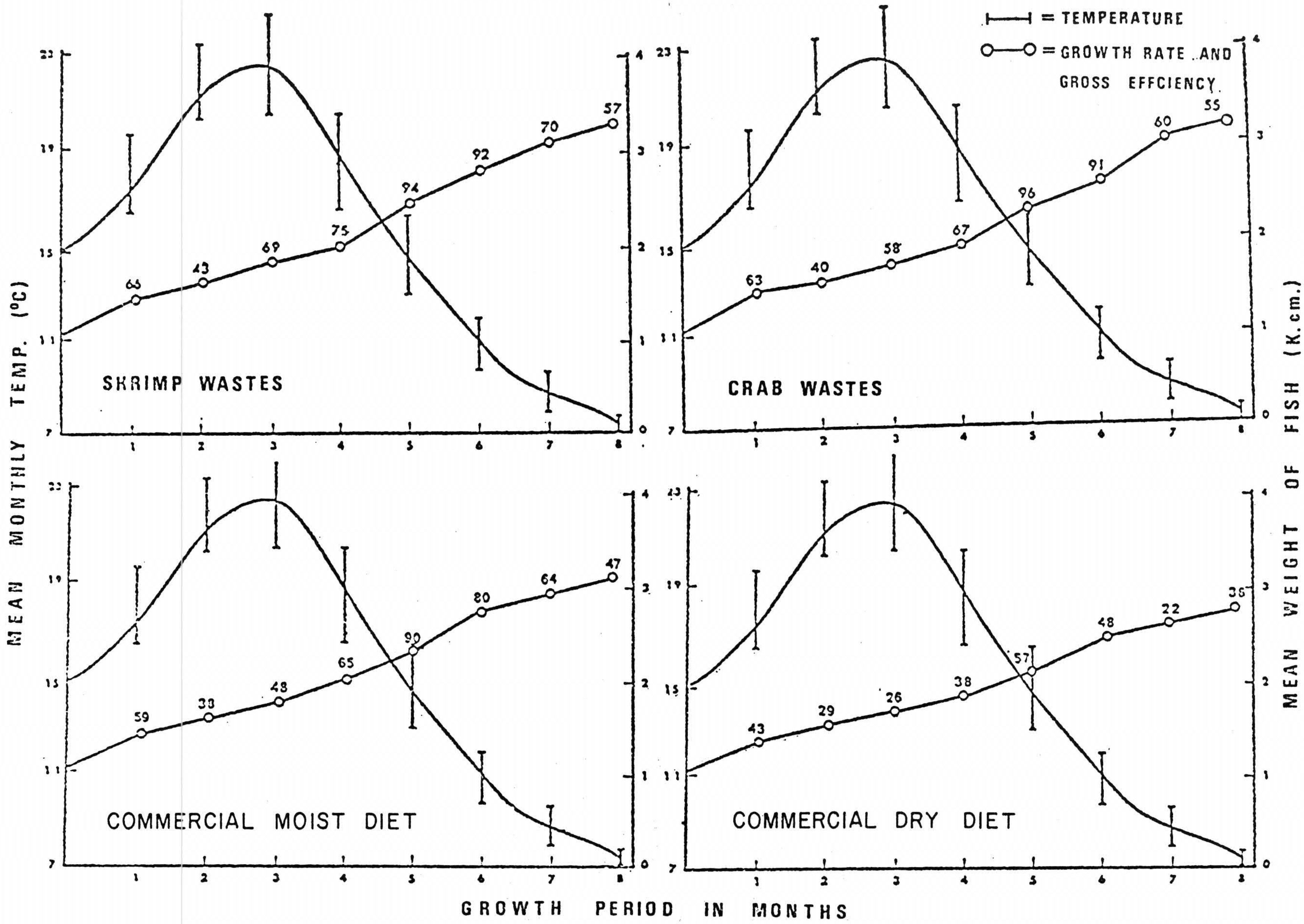

Figure 1. Water temperatures, growth curves and gross growth efficiencies for rainbow trout brood fish fed commercial and laboratory diets for 8 months before spawning.

RESPONSE OF CHINOOK SALMON TO DIETARY PROTEIN/FAT RELATIONSHIPS[1,2]

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and

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ABSTRACT

The sparing action of dietary herring oil on protein was investigated in spring Chinook salmon (*Oncorhynchus tshawytscha*) fed rations containing herring meal and raw, round turbot as a source of protein for 16 weeks at 12°. Diet protein levels were adjusted by replacing herring meal with cellulose. The experiment included levels of 35, 44, 52 and 59 percent protein each fed at 12, 17, 22 and 26 percent fat dry weight. The minimum requirement of fish protein for growth was shown to be 44 percent dry weight in the presence of 26 percent herring oil. Protein conversion was optimum at 17 percent fat and was limited by protein levels above 52 percent regardless of energy supplied. While adequate energy in excess of 17 percent fat was critical in achieving optimum gain at the minimum protein level required, salmon readily utilized excess protein for energy at higher protein levels to compensate for fat energy deficiencies. Body fat levels and to a lesser extent, protein levels reflected ration composition. Liver fat and carbohydrate content was not significantly affected by the wide range of ration compositions.

NITROGEN METABOLISM AND FEEDING IN DONALDSON STRAIN RAINBOW TROUT

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One has only to visit the catfish farms of the south or the salmon rearing areas in Puget Sound to realize that aquaculture is on the rise. However, the economic conditions within this country and abroad are forcing closer examination of the overall efficiency in aquaculture. The connections between appetite, feeding level, and maximum and most efficient growth are just being investigated. Many aquaculturists feed to near satiation, as often as possible. This would lead to maximum growth, but poor efficiency, and would waste protein, expensive at today's prices.

One of the more frequently used commercial fish foods, Moore-Clark's Oregon Moist Pellet, can be assumed to be high in protein, moderately high in fats, and lower in carbohydrates. Providing that the caloric level of the diet is adequate to allow normal metabolism, and O.M.P. can be assumed to fit that description, feeding a fish at levels above where most of the amino acids from the protein in the food are turned into growth is wasteful. This level changes with diet, age of the fish, sex, temperature, and many other parameters.

The fish used in this experiment were Donaldson strain rainbow trout from the University of Washington. They were approximately 0.9-1.5 years old and weighed approximately 1 kg. They can, because of their growth characteristics, be considered prime candidates for aquaculture.

A fish was selected at random from a pool of fish and was placed in a respirometer. The fish was starved 96, 48, or 24 hours and then fed with 0.5 percent body weight of O.M.P. Oxygen consumption and the amount of ammonia excreted from the gills were constantly monitored. The ammonia is the result of determination of protein in the fish.

Figure 1 shows an example of one of the excretion rate figures, this one is for 10°C. As indicated, the excretion rates were higher for the immature females than for the mature males, and those fish starved 24 hours excreted more ammonia than those starved 96 hours. As can be seen, several features vary, including the timing of the beginning of the excretion, the peak, and the end of excretion. The area under the curves also varies. By knowing how much ammonia was excreted, the protein retention can be calculated.

Table 1 shows the percentage of the fed protein retained at the end of the experimental period (24 hours). The calculations are based on a protein assimilation factor of 80 percent. This table shows that at 15°C more protein is retained than at 10° and 20°C, and that fish starved 96 hours retain more protein than fish starved shorter intervals. Mature males retain more protein than do immature females at 10° and 15°C, but at 20°C the differences are indistinct. The table also indicates that at 10°C the mature male gonad consumes 30 percent of the assimilated protein for the formation of sex products. This drops to approximately 20 percent at 15°C and less than 10 percent at 20°C. Immature males examined showed retentions like those of the females.

The differences in retention with temperature and starvation interval help account for inefficient growth at high dietary levels. It is known that the cells building tissue protein can only work up to a maximum rate, and that amino acid levels above those needed to supply that system are deaminated.

TABLE 1. Percent nitrogen (of that assimilated[1/]) retained by the fish.

Experimental Temperature		10°C	15°C	20°C
Starvation				
96 hours[2/]	male	74.8%	78.2%	64.2%
	female	41.3%	59.3%	56.2%
48 hours	male		74.8%	56.5%
	female		47.0%	33.1%
24 hours	male	21.2%	66.8%	45.8%
	female	-18.5%	44.8%	31.4%

1/ assuming 80 percent of all ingested nitrogen was assimilated (see text).

2/ hours of starvation prior to feeding of experimental meal.

Thus, the excess protein above the maximum growth requirements of the fish is lost to deamination, and released as energy. Energy which is excess to the fish and does not build tissue. The mature males had higher retention than did the immature females, because of the additional tissue, the gonad, which was utilizing amino acids to build tissue, in this case the sex products.

Another point is that the process or rate of growth is closely temperature controlled. The deamination of amino acids for energy is less temperature controlled and may act as a buffer against high amino acid levels in the blood.

These hypotheses agree with work on growth and growth physiology by workers such as Brett, and Davis and Warren. The data also suggest that the most efficient way to feed these fish in terms of protein retention efficiency might be to feed small amounts constantly. It would have to be ascertained that the constant feeding would not cause the fish an energetic hardship. The amount of diet fed would have to be calculated physiologically and checked with quantitative growth measurements.

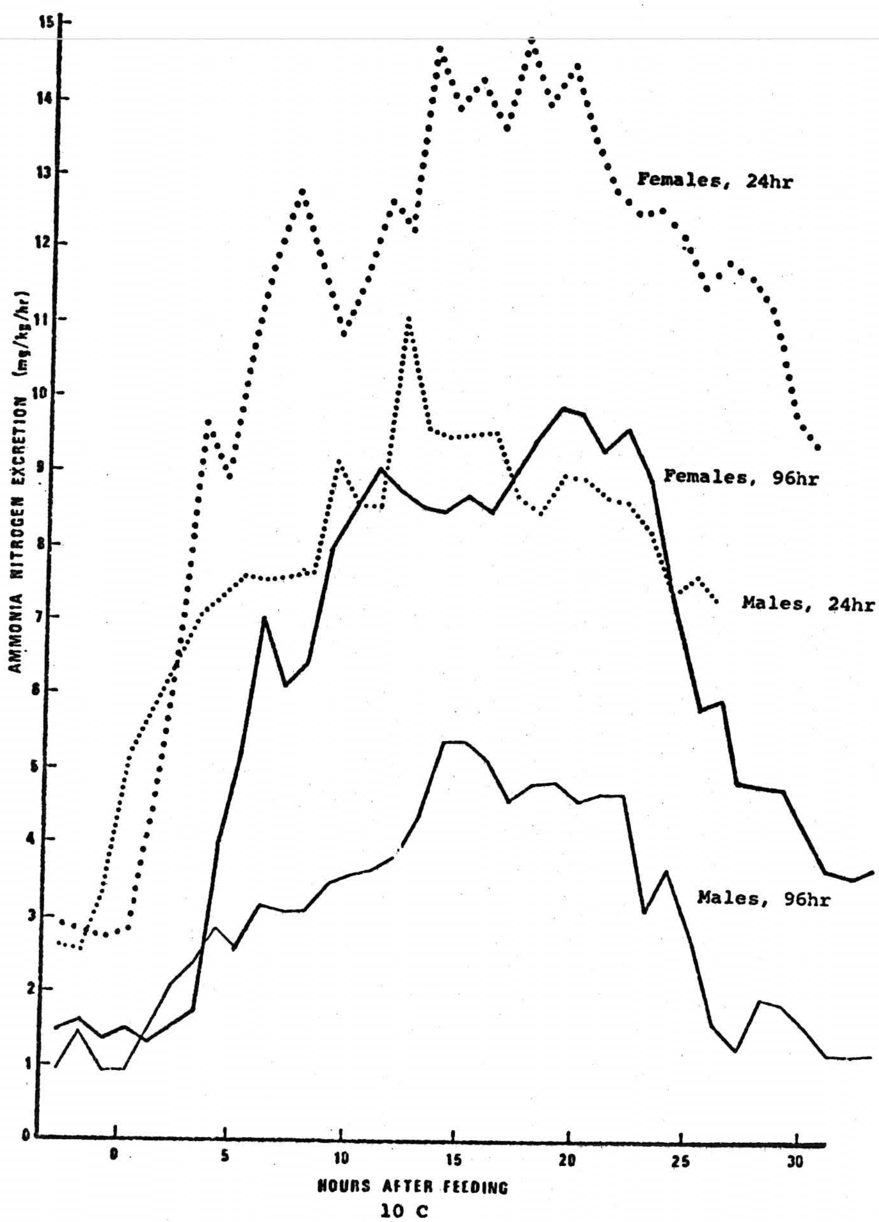

Figure 1. Ammonia nitrogen excretion at 10°C in Donaldson strain rainbow trout.

A NOTE ON WINTER STARVATION AND FEEDING OF CULTURED JUVENILE COHO SALMON

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Many hatcheries, like the fish culture facilities at the Pacific Biological Station at Nanaimo, feed juvenile coho salmon according to a temperature-related schedule. Wild juvenile coho salmon generally have a low food intake during winter season due to reduced metabolic rates in cold water.

The experiments carried out during the winters of 1972 and 1973 at temperatures below 8°C answer the question: will coho salmon survive long starvation periods, and what is the rate of recovery?

1971-72

In December 1971, 500 age 0+ coho were selected at random with a mean weight of 8.2 g ± 1.0 g from a basic stock of fry. Ten replicated groups of 50 fish each were held in randomized 10-gallon fiberglass tanks with a flow of 1/3 to 1/2 gallon min dechlorinated city water supply. Due to tank shortage the two starved groups were "doubled up" in a 100-gallon tank with a 3-gallon per minute flow. From January 6 to April 13, 1972 (a period of 98 days) the fish were given the following Oregon Moist Pellet rations:

Group I	twice daily
Group II	once daily
Group III	one feeding every 3 days
Group IV	one feeding every 6 days
Group V	starved

Each feeding was at least 4 percent wet weight of ration of Oregon Moist Pellet. Fish were sampled every 2 weeks.

As seen in Figure 1, growth during the experimental feeding was related to ration. With resumption of excess feeding, the severely rationed fish approached in weight but did not catch up with the well fed coho of Groups I and II.

Figure 2 shows that the growth rates for coho juveniles fed once and twice daily (Groups I and II) were about .4 percent except for a cessation of growth 2 weeks into the experiment that might be related to extremely low temperature (2.6°C). The groups fed once every 3 days (Group III) and once every 6 days (Group IV) showed growth rates of about .2 percent. The starved coho salmon (Group V) lost weight, with a mean daily rate of -.1 percent.

From April 13, 1972 all groups were fed twice daily in excess. During this increased feeding schedule the daily growth rate increased slowly to about .6 percent in Groups I and II. The growth rate of the other three groups increased very rapidly during the first 2 weeks of increased feeding followed by a decline. The starved coho of Group V had the highest growth rate in weight of 1.9 percent per day, followed by Group IV (fed once every 6 days) of 1.6 percent, and Group III (fed once every 3 days) of 1.1 percent per day. This fast daily growth did not continue for very long, although growth rate remained higher than the better fed fish.

1972-73

In November 1972, 750 age 0+ coho were selected with a mean weight of 7.0 g $\pm$ 1.0 g. Six replicated groups of 125 fish each were held in 100 gallon 3 ft diameter fiberglass tanks with a water supply similar to that of the 100-gallon tank the previous year (3 gal/min). From November 26, 1972 to April 14, 1973 (a period of 140 days) the six tanks were assigned to three ration schedules:

Group I	twice daily
Group II	starved below 5.5°C and fed once every three days between 5.5°C and 8°C
Group III	starved

The Group II schedule was included to simulate a feeding regime of wild coho in the winter stream. The fish, when fed, were given an excess of 4 percent wet weight ration. Fish were sampled once a month.

Figure 3 shows that the overall growth pattern in 1973 was roughly similar to that of the 1972 experiment. However, in 1973 there was no tendancy for the starved fish to catch up with the well fed fish. Spring growth in the two years was confounded by up to 3°C difference in temperature (Figures 1 and 3).

In Figure 4, the wet weight of coho fed twice daily (Group I) increased roughly .4 percent per day, while the coho starved for 140 days decreased by -.2 percent per day. Group II, which more closely approximates the fish's experience in the stream, showed an increased daily growth rate of .2 percent when feeding was resumed once every three days between temperatures of 5.5°C and 8°C.

When feeding was resumed to excess in April 1973, the highest growth rate occurred in the starved groups. After 2 months of feeding on excess rations, the daily growth rate of the starved fish had declined to a level somewhat above that of well fed coho of Group I.

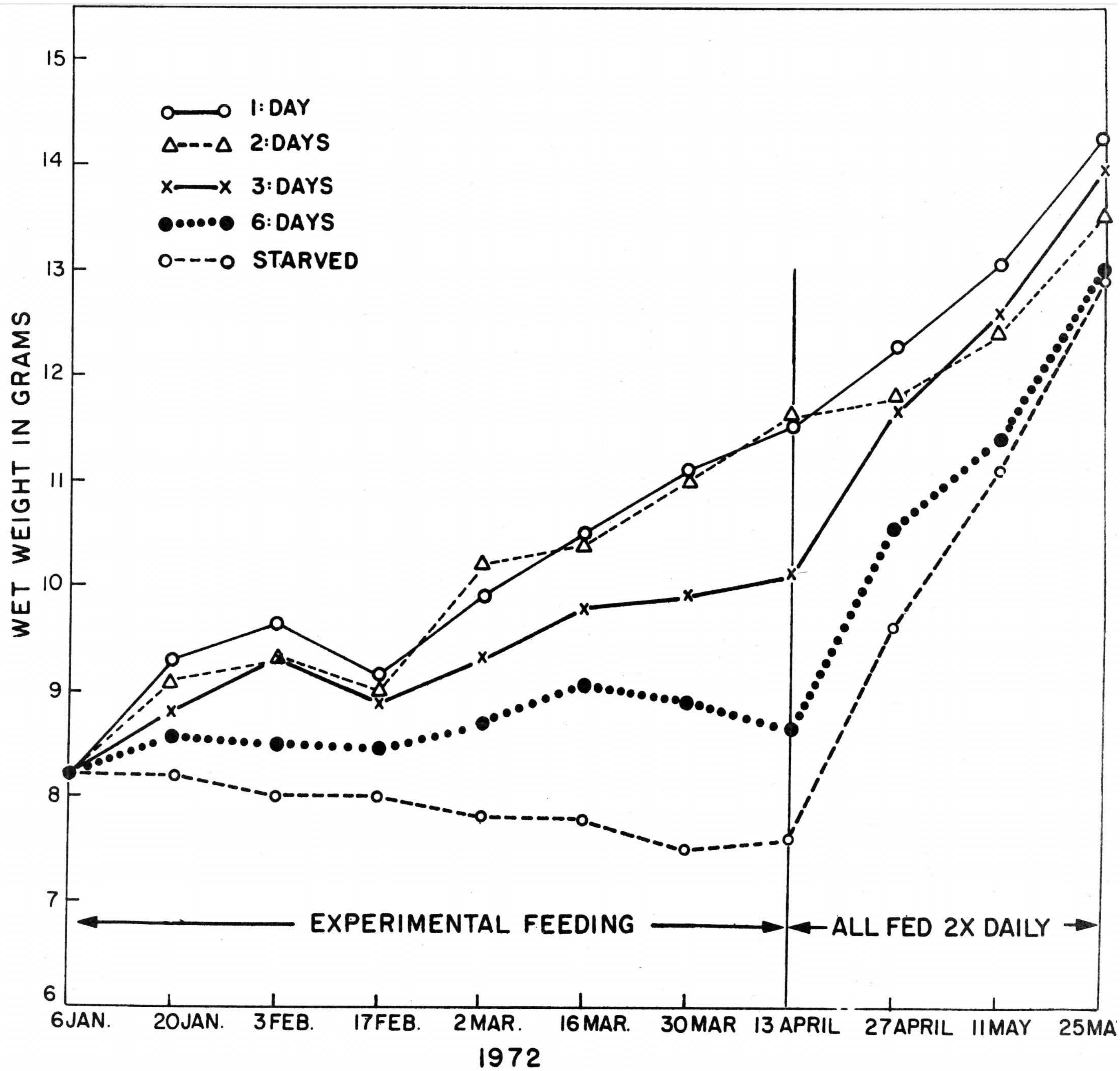
Figure 5 shows lipid content, expressed in percentage of wet weight of coho, dropped from 5.5 percent to 0.6 percent in the starved fish of Group III. Only in late winter, after the prolonged 5 months of starvation, did the fat content approximate that of wild coho in streams.

All fish readily accepted food when it was offered and it took only a few days for the starved fish to readjust to a regular feeding regime. Total mortalities in the two years were 18 with only 2 occurring in the starved group.

It seems that coho survive and recover from drastic food reductions during the winter although the only definitive test of satisfactory recovery is in adult return. Such food reductions may be advantageous in terms of a more economic hatchery operation but of course have to be balanced in the attempt to produce smolts of optimum size ($\approx$ 22 per pound). In many hatchery operations the production of large numbers of jacks is a problem. Severe reduction in winter rations may be a useful tool in regulating smolt size.

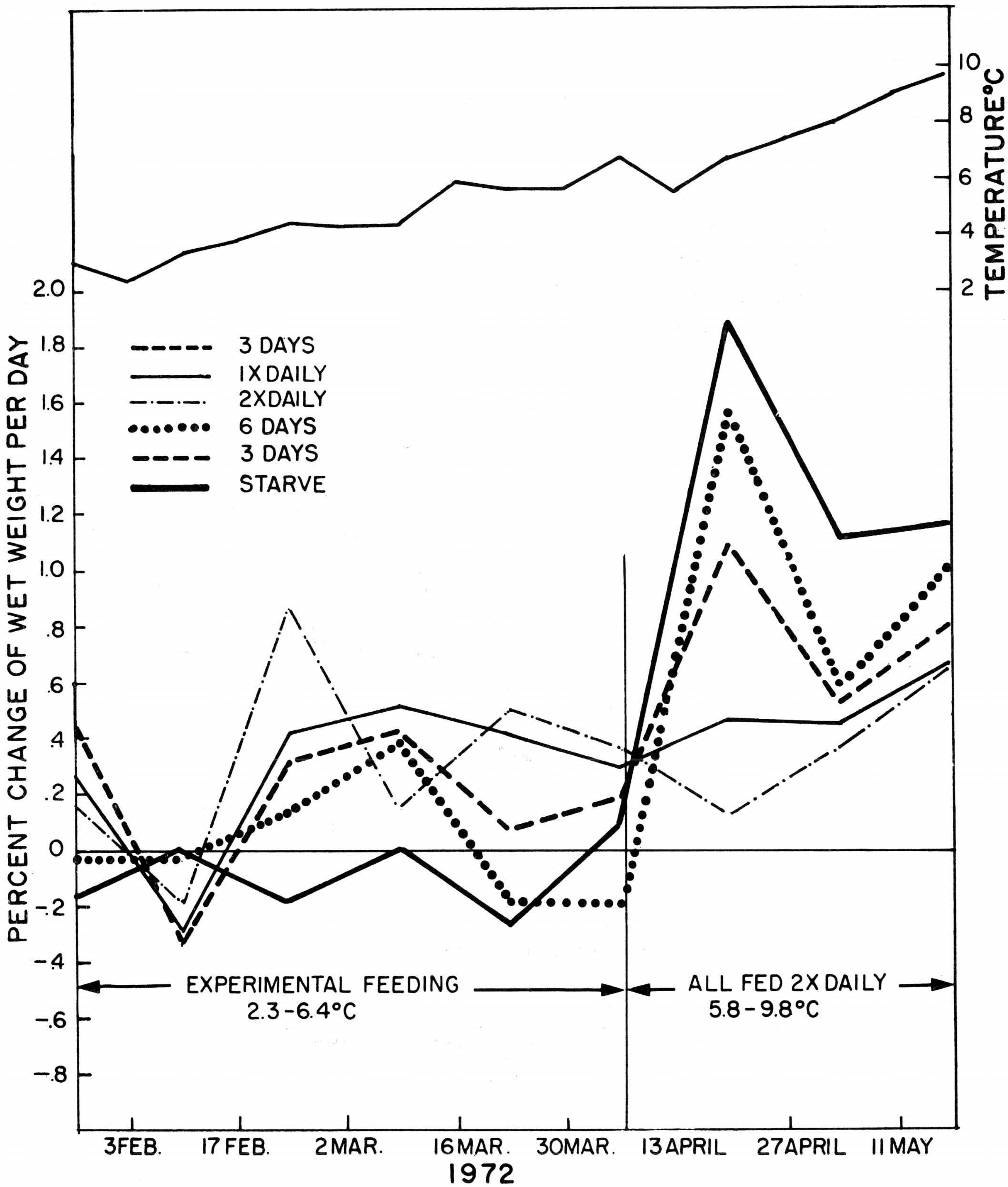
Figures

Figure 1.



I: DAY
2: DAYS
3: DAYS
6: DAYS
STARVED
WET WEIGHT IN GRAMS
15
14
13
12
11
10
9
8
7
6
EXPERIMENTAL FEEDING
ALL FED 2X DAILY
6JAN.
20JAN.
3FEB.
17FEB.
2MAR.
16MAR.
30MAR
13 APRIL
27APRIL
11MAY
25MA
1972

Figure 2.



10
8
6
4
2
TEMPERATURE°C
2.0
1.8
1.6
1.4
1.2
1.0
.8
.6
.4
.2
0
-.2
-.4
-.6
-.8
PERCENT CHANGE OF WET WEIGHT PER DAY
3 DAYS
1X DAILY
2XDAILY
6 DAYS
3 DAYS
STARVE
EXPERIMENTAL FEEDING
2.3-6.4°C
ALL FED 2X DAILY
5.8-9.8°C
3FEB.
17 FEB.
2MAR.
16MAR.
30MAR.
13APRIL
27APRIL
11 MAY
1972

Figure 3.

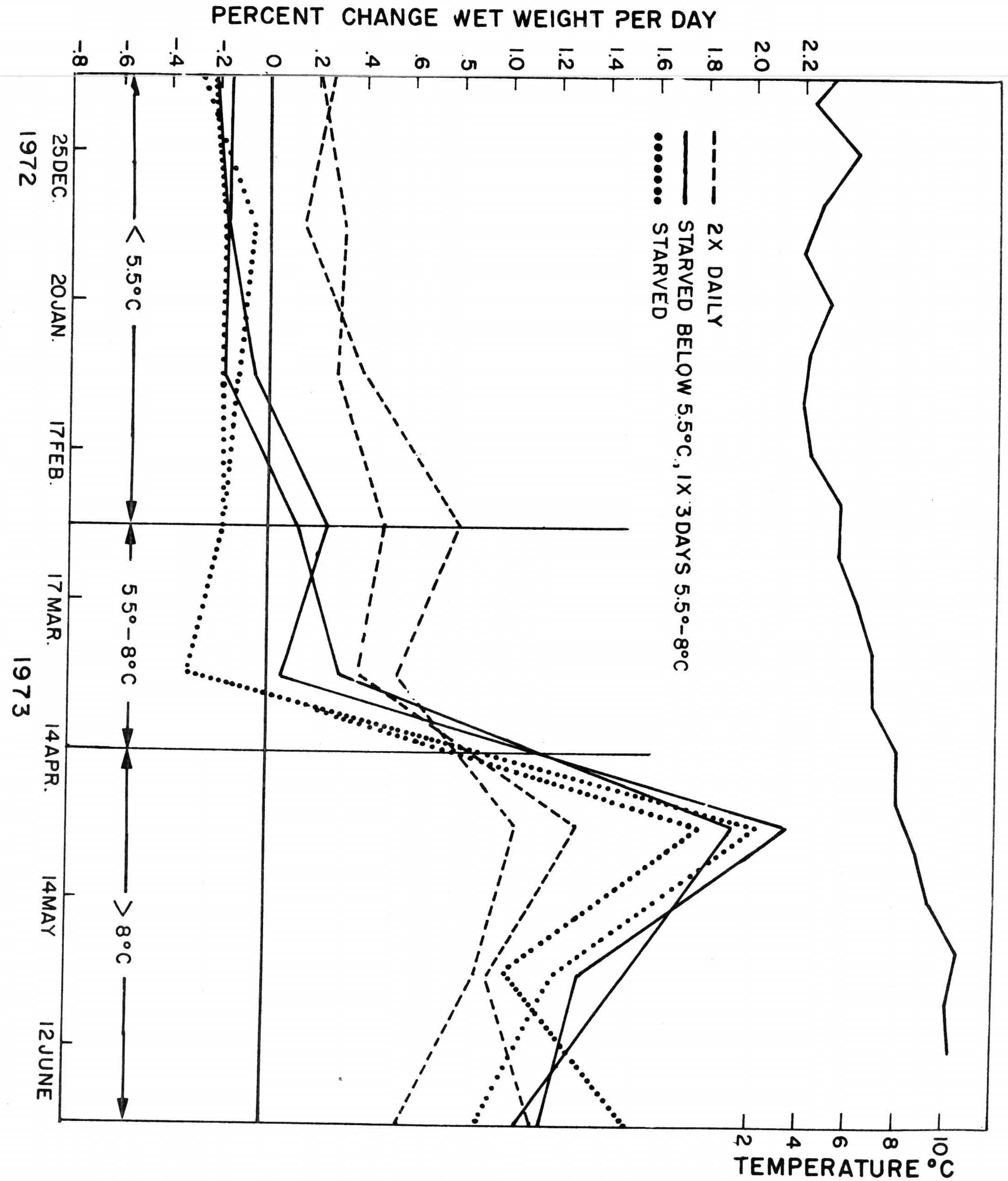

PERCENT CHANGE WET WEIGHT PER DAY
-.8
-.6
-.4
-.2
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2X DAILY
STARVED BELOW 5.5°C, 1X 3DAYS 5.5°-8°C
STARVED
25DEC.
1972
20JAN.
17FEB.
17MAR.
1973
14APR.
14MAY
12JUNE
< 5.5°C
5.5°-8°C
> 8°C
2
4
6
8
10
TEMPERATURE °C

Figure 4.

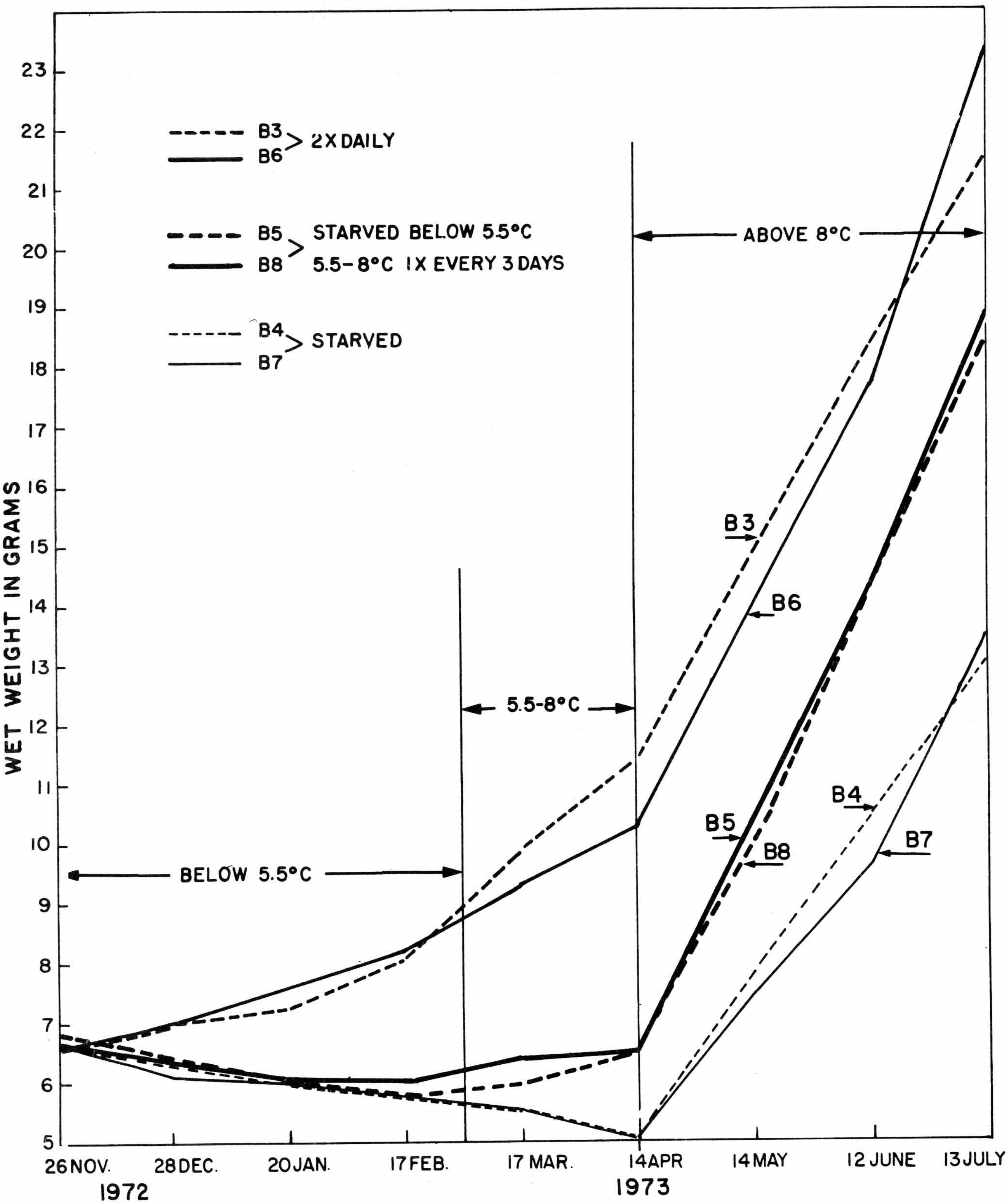
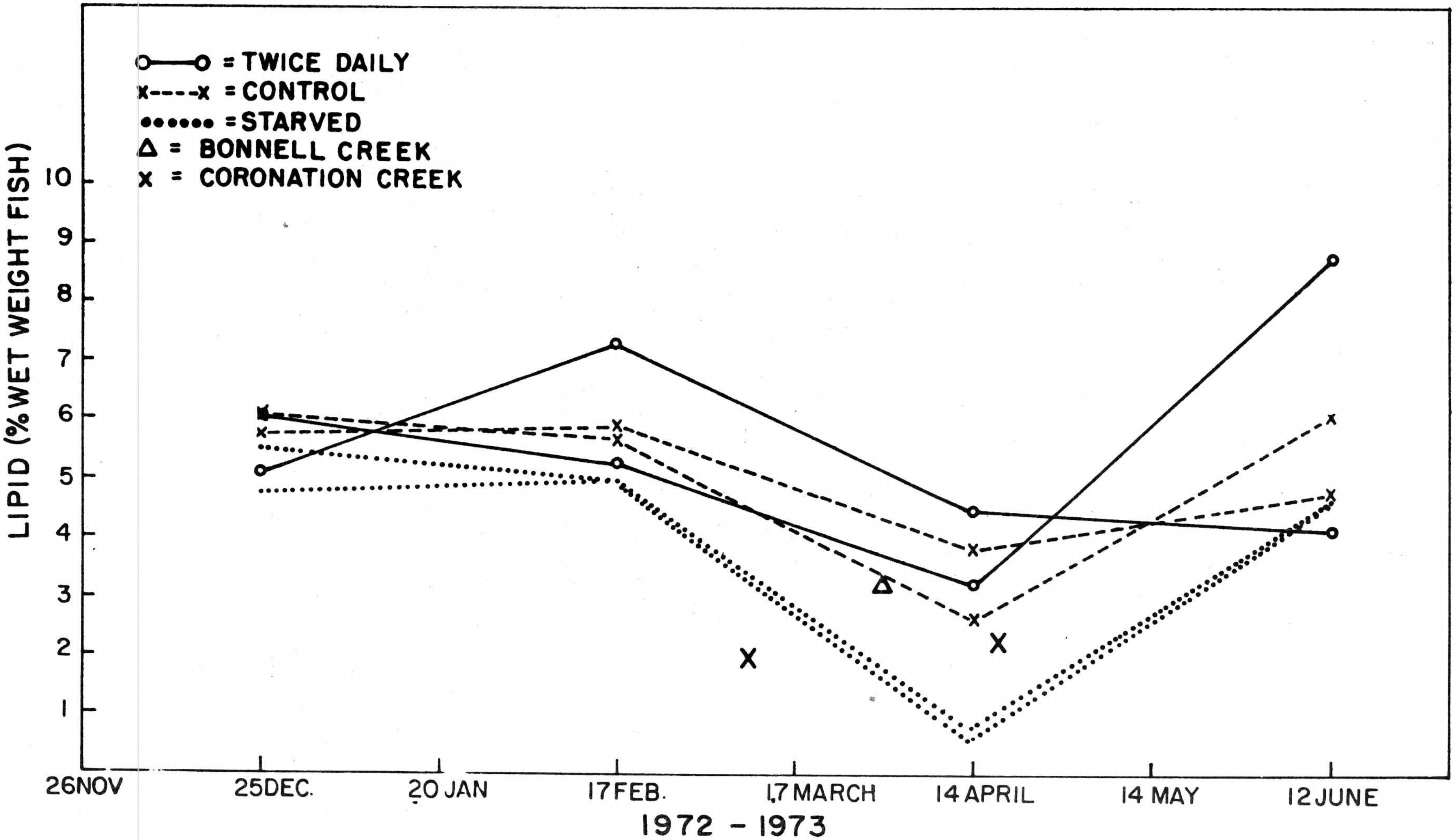

B3 > 2X DAILY
B6
B5 > STARVED BELOW 5.5°C
B8 5.5-8°C 1X EVERY 3 DAYS
B4 > STARVED
B7
ABOVE 8°C
5.5-8°C
BELOW 5.5°C
WET WEIGHT IN GRAMS
B3
B6
B5
B8
B4
B7
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
26 NOV.
28 DEC.
20 JAN.
17 FEB.
17 MAR.
14 APR
14 MAY
12 JUNE
13 JULY
1972
1973

Figure 5.



o—o = TWICE DAILY
x----x = CONTROL
•••••• = STARVED
Δ = BONNELL CREEK
x = CORONATION CREEK
LIPID (% WET WEIGHT FISH)
10
9
8
7
6
5
4
3
2
1
26NOV
25DEC.
20 JAN
17FEB.
17 MARCH
14 APRIL
14 MAY
12 JUNE
1972 - 1973

RAISING TROUT WITHOUT ANIMAL PROTEIN

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This report gives the data to 18 weeks on feeding rainbow trout diets containing no animal protein. Four soybean products were tested at 80 percent of the diet with four amino acid supplements in a latin square design. The diets contained 80 percent soybean products, 10 percent dried brewer's yeast, 3 percent cod liver oil, 6 percent vitamins and minerals and 1 percent amino acid supplement. Methionine and/or cystine were added at 0.5 percent and the nonessential amino acid aspartic acid was used to make the diets iso-nitrogenous. All groups had initial starting average weights of 0.64 gms. The data at 18 weeks are given in the table. The upper figure is average weight at 18 weeks and the lower figure is feed/gain ration. Soybean meals no. 2, 3 and 4 were processed in our laboratory.

Gain and feed conversion were better on many of the soybean diets than they were on the PR-6 control diet. Mortality has been within acceptable limits and the general appearance of the fish is good.

It should be emphasized that this is as yet a short term test with a limited number of fish. Tests will continue to study the long range effects. These tests indicate, however, that rainbow trout can be reared successfully on feeds made from properly processed soybeans. Conversion data indicate that enough food can be grown per acre of agricultural land to produce 1,000-1,500 pounds of fish. This figure compares very favorably with beef production per acre. The use of domestically grown crops could also make us independent of imported fish meal.

	No. 1	No. 2	No. 3	No. 4
	Commercial SBM 50% Prot.	232°C 8 min.	204°C 12 min.	204°C 8 min.
Met. 0.5	Lost	16.36	12.54	9.26
Cyst. 0.5		1.36	1.51	2.16
Met. 0.5	15.66	15.00	12.59	8.16
Asp. 0.5	1.53	1.43	1.52	1.99
Cyst. 0.5	10.76	11.42	9.93	6.33
Asp. 0.5	1.97	1.95	1.77	3.88
Asp. 1.0	11.87	10.21	9.84	1.47
	1.93	1.89	1.79	105.50

Control Diets:

PR-6	Ave. wt.	12.60	feed/gain	1.61
H-440	Ave. wt.	18.08	feed/gain	1.00

TESTS OF FISH MEALS IN OREGON PELLETS

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Clackamas, Oregon

Potential alternative fish meals were evaluated in laboratory feeding trials. These included herring, Peruvian and California anchovy, menhaden, hake, tuna scrap, salmon scrap, and fillet scrap meals. Our first trial included two batches of meal from the same fish species, and the second included meal combinations. Oregon Pellets were formulated to contain equal amounts of fish meal protein within each trial, and were fed on an appetite basis to chinook salmon at 53°F.

Final results of the first trial after 22 weeks (Table 1) indicated the effect of meal batch was limited to feed conversion with Hake Meal B. Herring and Peruvian anchovy meals as a group yielded comparable weight gain and feed conversion, superior to menhaden and hake. Weight gain with menhaden and hake meals was comparable, but feed conversion with menhaden was superior to that of hake due to Hake Meal B.

Results at the end of the second trial after 11 weeks (Table 2) indicated weight gain and feed conversion with hake meal, and feed conversion with Peruvian anchovy, menhaden, and fillet scrap meals, were superior to those with herring meal when fed individually in Oregon Pellets. Only three of the 24 meals or meal combinations produced weight gain and feed conversion significantly inferior to herring meal, and all three contained salmon scrap meal.

Hatchery feeding trials with Peruvian anchovy meal in Oregon Pellets indicated no problems with attaining desired fish sizes; however, feed conversions compared with those of herring meal were not as favorable as in the laboratory trials.

Anticipating that herring meal will continue in short supply, the Fish Commission's next feed contract (January 1 to June 30, 1974) will permit 50 percent of the fish meal in 3/32-inch and larger Oregon Pellets to be anchovy, menhaden, or hake meal. Herring meal will be required as the other half, and at 100 percent in smaller pellets and mash.

TABLE 1. Results of first fish meal feeding trial.

Fish Meal	Meal Batch	Weight Gain (%)	Feed Conversion (Wet)
Herring	A	409a	1.40a
	B	378abc	1.41a
Peruvian	A	355bcd	1.42ab
Anchovy	B	395ab	1.38a
Menhaden	A	320d	1.50c
	B	354bcd	1.45bc
Hake	A	340cd	1.48bc
	B	334cd	1.62d

Values in a column with same exponent letter did not vary significantly (P .05) from each other.

TABLE 2. Results of Second Fish Meal Feeding Trial.

		Fish Meal	Weight Gain (%)	Feed Conversion (Wet)
(19.6% protein)				
		Herring	493defg	1.38def
		Peruvian Anchovy	503cdefg	1.30bc
		Menhaden	533abcdef	1.26ab
		California Anchovy	529bcdefg	1.36cdef
		Hake	580a	1.20a
		Tuna Scrap	480g	1.38ef
		Salmon Scrap	318i	1.82h
		Fillet Scrap	504cdefg	1.28ab
13.6%	Herring	(6% protein)		
13.6%	Herring	Hake	549abc	1.28ab
13.6%	Herring	Tuna Scrap	486efg	1.39ef
13.6%	Herring	Salmon Scrap	417h	1.58g
13.6%	Herring	Fillet Scrap	493defg	1.29bc
13.6%	Peruvian Anchovy	Hake	509bcdefg	1.31bcd
13.6%	Peruvian Anchovy	Tuna Scrap	503cdefg	1.33bcde
13.6%	Peruvian Anchovy	Salmon Scrap	415h	1.51g
13.6%	Peruvian Anchovy	Fillet Scrap	515bcdefg	1.29bc
13.6%	Menhaden	Hake	538abcd	1.26ab
13.6%	Menhaden	Tuna Scrap	540abcd	1.28ab
13.6%	Menhaden	Salmon Scrap	483fg	1.42f
13.6%	Menhaden	Fillet Scrap	541abcd	1.26ab
13.6%	California Anchovy	Hake	537abcd	1.29bc
13.6%	California Anchovy	Tuna Scrap	535abcde	1.28ab
13.6%	California Anchovy	Salmon Scrap	492defg	1.40ef
13.6%	California Anchovy	Fillet Scrap	556ab	1.28ab

Values in a column with same exponent letter did not vary significantly (P .05) from each other.

HATCHERY WASTE WATER TREATMENT AS VIEWED BY THE BUREAU OF SPORT FISHERIES AND WILDLIFE

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Bureau of Sport Fisheries and Wildlife
Washington, D. C.

The Bureau of Sport Fisheries and Wildlife became actively involved in the abatement of fish hatchery pollution when President Nixon issued Executive Order 11507 in February 1970.

It became apparent to us that at that time we were in an era of environmental awareness and that the Bureau should take the lead in carrying out the Executive Order which stated that federal installations would not only cease to pollute, but would show the way to pollution abatement.

We approached the Environmental Protection Agency and asked for assistance in identifying the pollution problems of fish hatcheries. It was decided that we would set a one-year monitoring program at 30 of our trout and salmon hatcheries to measure the levels of hatchery pollution. In all some 20 water quality parameters were measured at five sampling points. In addition, bottom fauna samples were also taken and analyzed. All of the chemical data has been entered into the EPA Storet System and is available to anyone having access to the system.

Early in the monitoring program it became apparent that a fish hatchery does not really have a pollution problem as such. The problems that fish hatcheries create are for the most part aesthetic. On the average a hatchery effluent contains 10 mg/L BOD and the same level of settleable solids. These levels meet State water quality standards. The pollutional problem in most cases arises from the solids settling out below the hatchery outfall and forming shoals which under certain conditions can become offensive.

Another fact that we are all aware of is that fish culture is self limiting; that is a water supply may be utilized only to the point that the oxygen level is lowered to 5 mg/L or the ammonia level is increased to 0.5 mg/L.

Combining these two factors - aesthetic pollution and biological limiting factors - we proposed, in 1971, the following guidelines:

1) To stay within the biological limitations, no more than 0.2 of a pound of feed per gallon per minute water flow should be fed.

2) State water quality standards must be met.

3) An aesthetic problem does not occur below the outfall.

If any of the above guidelines is violated then the settleable solids must be removed. In doing so a proportional amount of the BOD will also be removed.

These guidelines apparently were not acceptable to EPA. Their initial reaction was that the effluent of a fish hatchery must meet the standards set for a secondary sewage treatment facility which call for a 90 percent reduction in solids and an 80 percent reduction of BOD.

The quantitative allotment level in a fish hatchery effluent are however, already lower than that of a secondary sewage treatment facility. We have found that conventional secondary treatment of hatchery effluents with these low levels of pollutants is prohibitively expensive.

After the passage of the Water Pollution Control Act Amendment of 1972 (PL-92-500) we began working with EPA on the formulation of effluent guidelines for fish hatcheries and the regulations for the National Pollution Discharge Elimination System (NPDES).

When the draft NPDES regulations were issued we held meetings with EPA officials to:

1) Exclude pond culture from the permit program on the basis that a fish pond by its very nature is a tertiary treatment facility. This point was won.

2) Gain an exemption for trout and salmon hatcheries which produce less than 100,000 pounds per year. On this point EPA decided that any hatchery which produces over 20,000 pounds must apply for a permit and comply with the provisions of the permit program.

Concerning the effluent guidelines, we provided all data and information we had about the fish culture industry to EPA. This included an assessment of fish produced, and data from the literature and our monitoring study.

The first document we were provided was entitled "Draft Interim Effluent Guidance" and was an internal document designed for in-house reviews by the Regional Offices of EPA. The interim guidance was used as a basis for the effluent limitations for a proposed NPDES permit for the Eagle Creek National Fish Hatchery. After 1976, the hatchery would have been allowed to discharge an effluent which contained no more than 0.52 ppm suspended solids. We understand that EPA has issued an interim permit which will allow additional time to study treatment processes.

The 1972 amendments contain a unique provision to allow "approved aquaculture projects" to discharge specific pollutants under controlled conditions. The purpose is to encourage the utilization of pollutants through aquaculture and to develop new aquaculture crops. We have had an opportunity to review proposed regulations under which the "approved aquaculture projects" will operate and conclude that they are so restrictive that at best, only a very few can qualify for a permit.

All in all, we have reached the conclusion that EPA has not yet developed a sufficient catalog of information to provide meaningful, reasonable standards.

FEDERAL LAWS AS THEY RELATE TO HATCHERY WASTE WATER TREATMENT

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Prior to the early 1970's the pollutional effect of fish hatcheries and the treatment of hatchery wastewaters was given little consideration in Federal laws and regulations. In fact in July 1966 an Executive Order on Prevention, Control, and Abatement of Water Pollution by Federal Activities specifically exempt federally operated fish hatcheries from providing definite levels of treatment and control. In February 1970 another Federal Order superseded that Order and removed the exemption for fish hatcheries and required all Federal facilities to conform with water quality standards. This order only really affected a few fish hatcheries located on small streams which were causing water quality problems.

In 1971 the Refuse Act Permit Program was established by Executive Order based on Section 13 of the 1899 River and Harbor Act. The program was administered by the Corps of Engineers and technical expertise was provided by EPA. Under the Refuse Act all industrial dischargers, including fish hatcheries, needed to apply for permits to discharge wastewaters to navigable waters. To implement this program EPA introduced the use of effluent guidelines to establish specific levels of allowable discharge based on the type of facility involved. These guidelines were prepared by EPA during 1971 and 1972 but were not extensively used and in some cases did not go beyond intra-agency review because of court actions against the Refuse Act. During this period the first draft of effluent guidelines identifying hatchery wastewater treatment needs for salmonid fish hatcheries was prepared by EPA.

On October 18, 1972 Congress passed the Federal Water Pollution Control Act Amendments of 1972. The Act abolished the Refuse Act Permit Program and established a national permit program called the National Pollutant Discharge Elimination System (NPDES). The name comes from the goal of the Act, which is to eliminate the discharge of pollutants by 1985.

The NPDES program is administered by EPA and can be delegated to an approved State agency. To date in Region X, Washington and Oregon permit programs have been approved. EPA continues to be responsible for preparing permits for Idaho and Alaska and for all Federal installations.

Any permit issued under the National Permit Program will impose on a discharger certain requirements designed to attain the goals of the Act:

1. Must make an application and provide the permitting authority with data on the discharge.

2. Each issued permit will insure that the discharge will meet effluent limitations, including schedules of compliance, and water quality standards.

3. Each permit will require the effluent to be monitored and records to be kept of monitoring activities.

4. Throughout the permit issuing process public participation is encouraged, including providing public notice designed to inform all interested parties.

One of the major features of the new Act as related to fish hatchery wastewater treatment is that the new Act provides for uniform effluent limitations for categories of waste sources and uniform dates for their achievement. Congress set two dates - July 1, 1977 and July 1, 1983 - by which different levels of treatment are to be reached. It is a timetable based on advances in technology.

By July 1, 1977 all point source dischargers, other than publicly-owned treatment works, are to achieve effluent limitations that represent the application of the "best practicable control technology currently available". By July 1, 1983 effluent requirements must be met which represent the "best available technology economically achievable". In addition, the Act provides that more stringent levels of control must be required if these levels of technology will not adequately protect water quality standards.

The terms "best practicable control technology currently available" and "best available technology economically achievable" must be defined in terms of "Effluent Guidelines". An effluent guideline will essentially establish the quantity of allowable pollutant to be discharged per unit of production. For fish hatcheries this could be the quantity of BOD and suspended solids per pound of fish produced or per pound of fish feed or any other unit deemed to be meaningful in quantifying the waste load.

In defining effluent guidelines for best practicable control technology several factors must be taken into account, including:

Age of equipment and facilities involved.

Processes employed.

Engineering aspects of the application of control techniques.

Process changes.

Degree of effluent reduction achievable by various control measures.

Non-water quality environmental impact (including energy requirements).

In assessing best practicable control technology there must be a balance between total cost and effluent reduction benefits. In some cases this may eliminate the application of technology which is high in cost in comparison to minimal reduction in pollution which might be achieved. Best available technology is the highest degree of technology that can be demonstrated as capable of being designed for plant scale operations. The same considerations must be given as for best practicable, although the cost may be much higher for providing best available technology. For either case cost effectiveness is to be confined to consideration of classes or categories of point sources and will not apply to an individual point source within a category.

At the present time EPA is in the process of developing these effluent guidelines for fish hatcheries. A rough draft of EPA Interim Guidance on fish hatcheries was prepared in April 1973. This report is an internal document for intra-agency review and has been made available for comment by most fisheries agencies. The wastewater treatment level in this interim guidance called for an 80 percent reduction in effluent BOD and suspended solids by July 1, 1977. This level of treatment would represent the "best practicable control technology economically achievable" and was essentially based on providing sedimentation for the entire hatchery wastewater. "Best available technology economically achievable" as defined in the interim guidance was based on 90 percent reduction in effluent BOD and suspended solids. The treatment system necessary to meet this effluent level would likely involve biological treatment and/or recirculation.

The initial response of fishery agencies and commercial hatcheries was that these levels of treatment were not attainable both from the standpoint of technology and economics. EPA is presently participating with the fishery agencies and commercial hatchery operators to review the interim guidance and to establish effluent guidelines which are reasonable and attainable.

EPA is under a very tight time schedule for developing the final guidelines. The final draft development document on the guidelines is scheduled for completion by the end of this year and the proposed guidelines are to be published in the Federal Register by the spring of 1974. EPA is under a final court order to promulgate the fish hatchery guidelines by October 25, 1974.

It will take a considerable effort by all involved parties to meet these deadlines and EPA is looking forward to continued cooperation with the fisheries agencies in identifying fish hatchery wastewater treatment needs.

AN ENGINEERING FIRM LOOKS AT HATCHERY WASTEWATER TREATMENT

Written by
Ron Mayo
Kramer, Chin and Mayo
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Presented by
Cecil Fox

I thank you for the opportunity to express some of our thoughts on hatchery wastewater treatment. I am not going to labor the technical details. Instead, I would like to speak briefly about where this question has been and where we think it is going.

First I would like to make one thing perfectly clear (where have I heard that before). Kramer, Chin & Mayo did not invent fish hatchery pollution. It has been with us for some time, only no one had ever assembled in one place a recitation of the problems across the country. In 1967, with the support of New York, Wisconsin and Michigan, we made what probably was a mistake in assembling this information in a single report. Many of you contributed to that report and have since probably regretted it.

Starting with that study, we have been involved in a number of research and planning studies and project designs which resulted in decisions relative to water treatment and/or pollution control facilities for hatcheries. The criteria we used were based on our judgment as to the most reasonable answer to the problem of a particular hatchery. No written standards were available. The planning and design criteria we used were in general terms:

1. Do not locate hatcheries where the effluent must be discharged into a very small stream.

2. Avoid locating hatcheries above a small lake with a relatively high detention time.

3. Provide in hatcheries a separate drainage system that will allow individual hatchery ponds to be cleaned and then have the overflow carried into some type of treatment pond, clarifier or filter system.

4. In siting a new hatchery, it is necessary to assume that some type of effluent treatment ponds will eventually be required, thus avoid restricted sites.

5. In considering the pollution control at existing hatcheries, we generally (1) tend towards the idea of providing separate drainage for individual ponds for the pond cleaning waste, (2) suggest the acquisition of land for future treatment facilities and (3) suggest that the hatchery operators carefully watch their feeding procedures (especially during periods of low water) to avoid the visible signs of the hatchery caused pollution.

Recently, however, the Environmental Protection Agency has proposed interim guidelines to put numbers on hatchery pollution control requirements. These numbers in simpliest terms provide for removal on the order of 90 percent of the BOD and 90 percent of the suspended solids.

In considering their proposal, we should consider what "interim guidelines" are. As we understand it, they are (1) to be applied to new facilities and (2) subject to change after they have received comments, criticisms and input.

Along the line of input, the National Marine Fisheries Service is about to initiate a study of their existing Columbia Basin hatcheries to determine the economic impact of various levels of pollution control. A similar study is now being completed for the Portland Corps of Engineers on six hatcheries. Similar studies are also being conducted in California, Ohio, New York, Wisconsin, Michigan and probably many other areas. We hope that when these studies are brought together with the EPA's requirements, there will result appropriate pollution control requirements.

As engineers, we must look ahead at what we think these final requirements will be for there are those who look to us for judgment. In general, we believe that the EPA will eventually publish standards as follows:

<u>For new hatchery facilities</u>:

1. BOD removal of 75 to 80 percent.

2. Suspended solids removals of 75 to 80 percent.

<u>For existing hatcheries</u>:

1. A common standard - a separate drain system for pond cleaning waste and an aeration or detention pond to treat that waste to an 80 to 90 percent BOD removal condition.

2. A special standard (for those hatcheries clearly affecting the receiving water by their effluent after a separate pond cleaning waste system has been installed) - further control through the construction of an aeration/detention pond providing 50 to 60 percent BOD and suspended solids removal <u>or</u> some other method of treatment as necessary to protect the receiving water <u>or</u> closure of the hatchery.

<u>The standard for the future?</u>:

1. Achieve a "zero" discharge goal (full nutrient removal) by the mid-1980's.

It is this last condition, based on current Federal legislation, which raises in our minds the largest question of substance. Is "zero" discharge in the 1980's (or ever) really in the cards either for hatcheries or for people?

We do not believe so. In the first place not enough money is being spent. Estimates place the cost on the order of 100 billion dollars nationally. To meet this Congress authorized five billion dollars for this year's pollution control projects. It appropriated two billion dollars to these projects. The President impounded all but 850 million dollars. We believe when the full summary of expenditures is made, that less than half of the unimpounded 850 million dollars was actually appropriated to projects.

In the second place other parts of the pollution control legislation require such things as regionalization studies, complex facility studies and any number of other studies all to be done quickly. Not all of these studies have been started and few completed. In our opinion, studies are doing more to stop the construction of pollution control facilities than they are to start them.

Finally a study type of special concern is the ever changing environmental impact studies. We believe firmly in the validity of the goals of environmental studies. We also believe that given the constraints of the inadequate appropriation, planning, and public involvement, these studies are holding back many pollution control projects.

Taken in total, we feel that there is little likelihood that secondary treatment will be achieved throughout the United States by the mid-1980's let alone the "zero" discharge goal. Thus to expect "zero" discharge hatcheries throughout the United States is not being realistic.

Okay, is this probable failure of hatcheries to meet a "zero" discharge goal bad? Once again "it ain't necessarily so".

The nutrient in the discharge streams from most hatcheries is in a form well suited for assimilation into, and enrichment of, the aquatic environment. Much work is being done throughout the country learning how to balance nutrients in the environment to achieve maximum productivity of fish and crustaceans. One example is Dr. Ryther's new Environmental Systems Laboratory at Woods Hole.

From this work, we might find ourselves building hatcheries which meter out nutrients rather than sewage treatment plants which remove them. We think that is where the future is.

HATCHERY EFFLUENT STANDARDS IN CALIFORNIA

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INTRODUCTION

This afternoon I will give a brief explanation of the California Department of Fish and Game's involvement in hatchery effluent standards.

In early 1971, the Department's Water Quality Biologists recommended that a study be initiated to assess the nature of the waste effluent emitting from all 22 Department of Fish and Game hatchery facilities. We had indications that the State (SWRCB) and Regional Water Quality Control Boards (RWQCB) would probably establish waste discharge requirements on hatchery effluents. We were also aware of the closure of the Rifle Falls hatchery in Colorado due to water quality considerations.

As a result, a year-long study plan was developed and implemented statewide. The study sought to answer the following questions:

1. What is the magnitude of the hatchery waste load?
2. What is probable impact on beneficial uses?
3. Is the effluent subject to waste discharge requirements?
4. Are treatment facilities required?
5. What are the design features to be incorporated in the treatment system?

METHODS

The study began in June 1971 and carried through June 1972, under the direction of the Department's Nimbus Water Pollution Control Laboratory. Minimum observations taken on-site at hatchery inflow and outflow included:

1. daily temperature
2. weekly D.O.
3. weekly pH
4. weekly settleable solids
5. weekly turbidity

Other records included food fed and flow.

Grab samples of both inflow and outflow were collected monthly and forwarded to the Nimbus laboratory for analyses which included:

1. BOD - 5 day
2. Ammonia N
3. Total Organic N
4. Nitrate N
5. Nitrite N
6. Total N
7. Total dissolved and suspended PO_4 as P
8. Dissolved solids
9. Suspended solids

Analyses were performed in accordance with procedures outlined in Standard Methods, 13th Edition.

RESULTS

Results were quite variable between hatcheries and time of year. The following ranges were noted:

Parameter	Range	Notes
Temperature	35°F - 74°F	Outflows average about a 2°F increase over inflow
D.O.	4 mg/1 - 14 mg/1	Generally well above 6 mg/1
pH	6.5 - 8.9	Generally around 7.3
Settleable Solids	0-1.73 mg/1	Mostly less than 0.1 mg/1
		Pounds/Day (Maximum)
Ammonia	0.00 - 2.03 mg/1	172
Organic N	0.00 - 2.00 mg/1	-
Nitrate	0 - 10.3 mg/1	-
Total N	.1 - 10.5 mg/1	389
PO_4	0 - 3.01 mg/1	286
Dissolved Solids	4 - 1,660 mg/1	-
Suspended Solids	0 - 1,660 mg/1	60,702
BOD	0.2 - 23.0 mg/1	2,943

Most of the time BOD increases were less than 5.0 mg/1.

INTERPRETATION

About the time we finished our study we were directed to file a report of discharge to the Corps of Engineers. We did this. Later, the responsibility was transferred to EPA and we were directed to file again, this time under the NPDES permit program.

Concurrent with this, we filed with the RWQCB for waste discharge requirements. Under California law, we were required to submit a filing fee based on volume of flow discharged. The maximum amount was $1,000 for a flow of 1 mgd or higher. Thus, we paid $21,250 just for filing.

A few months ago the RWQCB's requested the SWRCB to develop standard hatchery effluent limitations in accordance with Section 402 of P.L. 92-500.

The SWRCB has prepared guidelines for the RWQCB's to follow. The guidelines spell out daily effluent limitations based on unit mass emission rates of certain constituents applied to a defined amount of food fed at the hatchery.

The constituents and their limit factors are:

Constituent	Unit Mass Emission Rate* (UMER)
Ammonia	0.0115
Total Nitrogen	0.0225
Total Phosphate	0.0175
Biochemical Oxygen Demand (BOD)	0.100
Nonfiltrable residue (suspended solids)	0.120

*Units are pounds constituent/lb. fish food fed.

The mass emission rate for each constituent included in the permit effluent limitations is determined as the product of the unit rate and the average daily feeding rate during the month when the monthly feeding rate was at a maximum (i.e., $\text{UMER X } \frac{\text{Max. Food Fed}}{\text{Days in Month}}$). The values obtained are compared to mass emissions determined as the product of the constituent (in mg/1) and the effluent flow (in mgd) converted to pounds per day (i.e., mg/1 constituent X mgd X 8.34).

The SWRCB expects that the effluent limitation standards can be met by retaining normal hatchery wastes in sedimentation basins for at least 2 hours prior to discharge and segregating concentrated pond cleaning wastes in separate catch basins. Where lack of space precludes sedimentation ponds, a treatment system providing equivalent performance will suffice. The comparative values to determine compliance with the standards are based on the average (designated 30-day) of at least four weekly samplings in which not more than one sample may exceed the standard by a factor of two (designated maximum).

The unit mass emission rates have received tentative acceptance by EPA. It is similar to the rates provided in the proposed Coleman NFH permit by Region IX, EPA (San Francisco).

To comply with the NPDES program the Department must 1) provide significant funding for necessary waste treatment facilities and 2) maintain a monitoring program. At this time we do not have an estimate of the cost of constructing the treatment facilities. We have, however, an indication of the cost of conducting the analytical portion of the monitoring program based on weekly inflow and outflow samples from each hatchery (2,288 samples and 11,440 analyses per year). Our estimates do not include costs related to collection and transportation of the samples to the laboratory or other work conducted in the Regions, such as on-site analyses, recording daily flows, etc.

1. If all week samples are sent to the nearest certified private laboratory. Cost per year $128,000

2. If all analyses are performed at WPCL using SWRCB and EPA approved analytical techniques. Cost initial year . . . .$ 29,900
   Annual cost following initial year . . . .$ 20,360

Overall, we are meeting most of the constituent levels most of the time under present operations. However, some problems are noted and will require attention as follows:

HATCHERIES HAVING IDENTIFIED WATER QUALITY PROBLEMS

Hatchery	BOD	Ammonia	Total Nitrogen	Phosphate
Iron Gate	X			
Pit River	X	X	X	
Trinity River	X	X	X	
Darrah Springs	X			
Nimbus	X	X	X	X
American River	X	X	X	X
Central Valley	X	X	X	X
Mokelumne River	X	X	X	X
San Joaquin	X			
Moccasin Creek	X		X	X
Fish Springs	X	X	X	X
Filmore	X		X	X

Suspended solids have not been included here as we are in the process of evaluating this.

Our move in the future is to construct the necessary waste treatment facilities and demonstrate compliance with the effluent limitation standards through the monitoring program.

A STUDY OF THE EFFECTS OF A CENTRIFUGAL WASTEWATER CONCENTRATOR ON FISH HATCHERY REARING WATER

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1. INTRODUCTION

This study, initiated in October 1973, was jointly sponsored by Domsea Farms, Inc., Bremerton, Washington, the Stephen Thurlow Company, Seattle, Washington and Kramer, Chin & Mayo, Inc., Seattle, Washington.

It is essentially the continuation of a study conducted in February 1973 at the Green River Salmon Hatchery through the efforts of the Washington State Department of Fisheries, the Stephen Thurlow Company and Kramer, Chin and Mayo, Inc. The results of this preliminary look at the centrifugal wastewater concentrator were promising, indicating removals of 41.7 percent and 42 percent for COD and suspended solids, respectively.

A formal report on the study will be available after the first of the year, however it is the intent of the author that this presentation describe the study in sufficient detail to introduce the centrifugal wastewater concentrator as a possible tool for controlling water quality.

The unit analyzed was a 12" Sweco centrifugal wastewater concentrator. It utilizes high flow rates and fine mesh centrifugal screening to remove suspended solids. The process also aerates the filtered effluent by unit with approximately 10 feet of hydraulic head. This flow travels up through the center of the unit and onto two horizontal flighted distributors. These distributors direct the influent against the inner top surface of the screens in a series of overlapping thin layers of liquid. The influent is traveling at an impingement velocity of 5 to 10 feet per second when it meets the screen that is revolving at about 11 to 14 feet per second. The combination of the screen's rotational velocity and the impingement velocity of the influent results in a vector triangle that allows the screen to remove particles smaller than the wire opening. These particles are caught in a continuous slough-off concentrate stream that washes down the inside of the screen with 5 to 20 percent of the hydraulic flow to the concentrator. Both the filtered water and the concentrate leave the unit by gravity.

The purpose of the study was to evaluate the physical operating characteristics of the centrifugal wastewater concentrator and to determine its effect on the quality of fish hatchery rearing water.

The system was tested at the Domsea Farms Salmon Hatchery in Bremerton, Washington, by Krámer, Chin & Mayo, Inc.

The system consisted of,

1. a 12" Sweco centrifugal wastewater concentrator
2. a pump
3. piping
4. domestic water supply for backwash water
5. a 110 volt electrical service for the drive motor
6. a raceway (100' x 16' x 4') containing 300,000 coho salmon weighing approximately 12,300 pounds
7. a tank used for holding pond cleaning wastes

The intake for pumping normal hatchery effluent was located roughly one foot below the water surface, six feet upstream of the raceway stoplogs. Pond cleaning water was pumped directly from the raceway bottom or from the holding tank.

Samples were removed from the system at (a) the influent line after passage through the pump, but before entering the unit, (b) the concentrate effluent pipe, (c) the filtered effluent pipe. The samples were removed simultaneously during testing to insure that they were characteristic of what was occurring in the system at that time. A sample of the hatchery's water supply was removed twice daily to establish a control.

Four screen sizes were available for testing. Their characteristics are described below.

SCREEN CHARACTERISTICS

Type	Material	Opening Size Micron	Percent Open Area
PE 33	Polyester	33	25.25
PE 43	Polyester	43	28
400 mesh	Stainless Steel	37	36
165 mesh	Stainless Steel	105	47.1

Each screen was to be tested at three flows (100, 150 and 200 gpm) for each of four rearing water conditions; before feeding, during feeding, after feeding and during pond cleaning. Samples were collected for each of the above operating conditions and analyzed for pH, temperature, dissolved oxygen, suspended solids, alkalinity, turbidity, BOD, COD, ammonia, nitrate, nitrite and phosphate.

3. Being creek water, the quality and quantity entering the raceway was affected by weather conditions which at one point stopped the testing program.

4. Obtaining a representative sample from the concentrate effluent pipe was difficult because the concentrate flows were so low.

5. Test results for pond cleaning wastes were generally more consistent. This was probably reflective of the fact that the influent concentrations were fairly consistent.

6. By the nature of the screening process, it is unlikely that a system with concentrators in series will improve the removal efficiencies significantly.

7. Removal and replacement of the screens in the centrifugal concentrator can be accomplished quite easily in 15 minutes.

8. Should the backwash system or drive motor malfunction, the majority of the incoming flow is discharged from the concentrate effluent pipe. This condition normally will not damage the screens.

9. The type of feed and size of pellet may have an affect on the removal efficiency of the centrifugal concentrator.

3. CONCLUSIONS

The Sweco centrifugal concentrator is an effective way to remove suspended solids and associated elements. At its design flow of 150 gpm, the centrifugal concentrator removed an average of 70 percent and 42 percent for suspended solids and COD, respectively. In addition to its primary function, the concentrator also aerates the incoming water and shows probable reductions in CO_2.

These characteristics should make the centrifugal wastewater concentrator a candidate for use in water reuse systems and pollution control systems associated with fish culture facilities.

4. ACKNOWLEDGEMENTS

This study was partially supported by Domsea Farms, Inc., the Stephen Thurlow Company and Kramer, Chin & Mayo, Inc. Special thanks are due to Ken Ferjancic of Domsea Farms, Don Trandum of the Stephen Thurlow Company, and Skip Tezak and Steve Lusk of KCM for their assistance throughout the study.

In addition, a series of blinding tests for each operating condition was run to determine how fast the screens "blinded" (reached a 75 percent filtered -25 percent concentrate flow split) with the backwash water turned off. Then the backwash was turned on and the recovery time to the original split was measured.

2. DISCUSSION

The test results indicate that the centrifugal concentrator will remove up to 80 percent of the suspended solids associated with fish hatchery rearing water. This, however, is affected by the concentration of suspended solids entering the system. At suspended solids concentrations below 4 mg/1, removals were generally less than 50 percent; from 4 to 10 mg/1, removals of 50 to 70 percent were experienced; and above 10 mg/1, removals ranged from 70 to 80 percent. The removal of suspended solids decreased with an increase in flow as illustrated on Figure 1. Figure 1 also illustrates COD removal versus flow.

As anticipated there was a correlation between suspended solids removal and the removal of COD, BOD, ammonia, nitrate, nitrite and phosphate. The weighted averages with respect to initial concentrations for the above parameters are indicated below.

Parameter	Weighted Average* Percent Removal
Suspended Solids	61
COD	50
BOD	46
NH_4-N	25
NO_3-N	48
NO_2-N	40
PO_4-P	17

* Based on influent concentrations

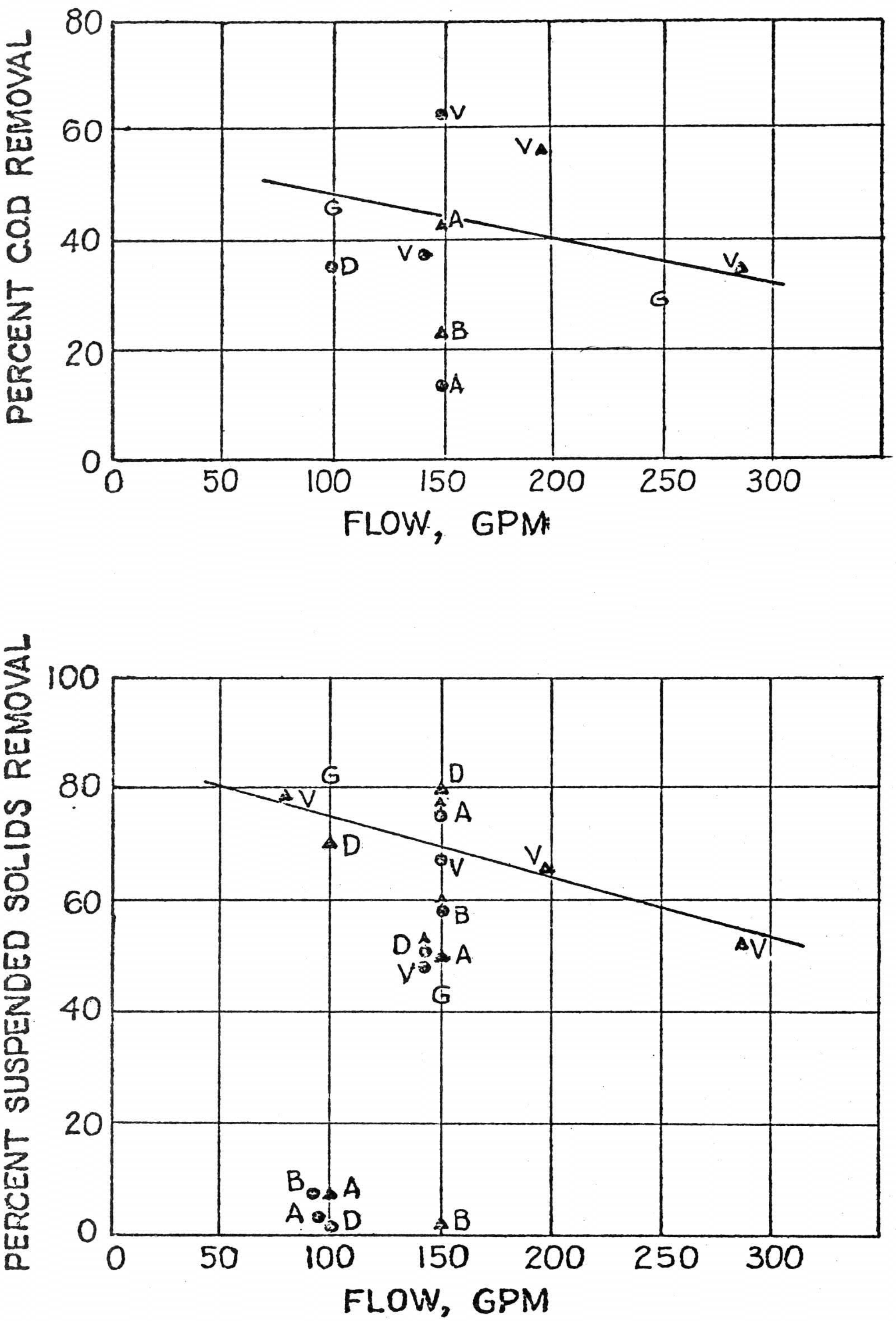
The test results indicate further that aeration occurs in the concentrator and the pH of the water increases. This increase is assumed to be the result of a decrease in CO_2, however CO_2 was not measured.

Analysis of the blinding and recovery times indicated that continuous backwashing is required and that it effectively removes the fish wastes.

During the study several observations were made regarding the system and test conditions. These are mentioned briefly below.

1. Suspended solids visually apparent in the raceway during feeding either settled out or passed out of the raceway within an hour and a half after feeding was stopped.

2. Concentrations of suspended solids before the first feeding in the morning were very low.



LEGEND

△ 37y
● 43y

CONDITIONS:

B Before feeding
D During feeding
A After feeding
V Cleaning wastes
G Green River Hatchery (37y)
↑ Greater than value indicated

FIG. 1

WISCONSIN'S BAYFIELD HATCHERY UTILIZES SOME NEW TECHNIQUES

A Slide Presentation

Cecil L. Fox, Vice President
Kramer, Chin & Mayo, Inc.
Seattle, Washington

DISCUSSION

Our work in hatcheries is a constantly changing effort to apply the latest technology to our clients' needs to produce the best facility within the limitations of the program.

My thought today is to show you how we are doing this in one example in a project now under construction in the State of Wisconsin. The DNR required a hatchery in an area of limited resources and hired us to help them plan and build a modern facility. Some of the details of this planning will be of interest to you, I believe and these are the main subject of my presentation.

New applications and techniques to old problems. To start with, we'll talk about the energy crisis or at least a method of conserving some energy in the form of a heat exchange system for water, a full scale water conditioning reuse system, second and finally, another raceway design that may prove interesting to you.

To give you a better understanding of the overall scope of the project, the following may help:

The hatchery is in northern Wisconsin on Lake Superior near Bayfield.

The temperature of the air can get to the 90's in summer and 40 below in winter.

The water supply for the hatchery comes from two sources, wells at 1,000 gpm to produce water at 46 degrees F year around and an open watershed, wild fish creek at 2,200 gpm that varies from 33 degrees F in winter to the high 60's in summer.

The fish raised are lake trout, brown trout, brook trout and rainbow.

By careful programming, it is expected to produce in excess of 75,000 pounds per year.

The entire hatchery will be enclosed. The plan of the building and the components we'll be discussing are shown on this first slide.

Slide #1 - Floor Plan

The portions we'll be interested in are shown and consist of:

1. Water supply sources of Pikes Creek on left and the wells at the top.

2. The heat exchanger channel in the center,

3. The headbox area on the right, and

4. The raceways.

The filters and mechanical spaces also serve the process we'll be talking about.

Slide #2 - Schematic Flow Diagram

This shows what a two water source, 4 zone hatchery looks like schematically. This was the drawing that the hatchery was designed around.

The first thing to note is the "Heat Transfer Channel" at the top of the page.

The Pikes Creek water enters from the left, travels in a pipe through the channel to the sand filters then back to the channel where it is released as open channel flow where it travels back to the left around the end and then to the creek water sump where it is pumped into the system.

The well water is pumped via the well water headbox and into the well system as indicated. We'll discuss this flow pattern in more detail in a moment.

The water from these two systems is introduced into the raceway systems by flow to the individual headboxes as shown.

Each headbox and piping system has been designed to provide for a minimum of 3 reuses of the water by use of the Sweco concentrator that removes the floatables and solids larger than the 400 mesh screens, with the solids removed being discharged by the concentrated waste drain. The reused water is aerated and put back in the system. Each of the systems is independent with an intermix of water only in case of emergency or as desired by valving.

The hatchery effluent consists of the concentrated waste from the Sweco units and recirculated water as displaced by the incoming water as will be explained later.

This then is a brief discussion of the flow patterns through the hatchery.

The heat exchange system can better be shown on the next slide.

Slide #3 - Heat Exchange System

The building section at the top of the slide shows the relationship of the channel in the building.

The technique of heating and cooling is shown in the two sections underneath.

The one on the right showing the summer mode shows how we heat the well water in the summer by cooling the Pikes Creek water in the channel. The water surface is lowered to operate out of contact with the warm drain systems thus cooling the Pikes Creek water and warming the well water.

In the winter, the effort is to warm the Pikes Creek water. We do this by utilizing the summer well water piping for wastewater to provide as much contact time with the cool water as possible. Also, we raise the water level to surround all of the water leaving the building to remove the heat from the water and add it to the Pikes Creek water. Studies indicate that we'll be able to change the temperatures in the Pikes Creek water by approximately 2 degrees F. This may not sound like much but the fuel savings for heating this amount of water will pay for all the added cost in less than 5 years using last year's oil prices.

So much for the heat exchange system. Next I'd like to show you a closer look at the typical headbox system indicated on the schematic.

Slide #4 - Headbox

Simply described, the water from the raceways will return to the sump by gravity, where it is pumped to the concentrator and to the headbox aerator and there on to the headbox supply to make another cycle.

On the plan to the right you can see the method of introducing all of the supply systems into the system.

One little devise that is of interest is the floating wier that regulates the amount of water discharged to the drain system. The recirculated water is pumped to the chamber adjacent to the floating wier. When the water level is at its normal level, the wier is raised and the pumped water tops the fixed wier and on to the drain. If insufficient water is in the headbox the floating wier drops allowing the recirculated flow to enter the headbox via the aeration grid. This devise allows the system to operate for a period of time as a closed system if necessary.

The last item is a hybred raceway that I believe will warrant your attention. It is shown on this next slide.

Slide #5 - Raceway Plan and Section

As you can see, it has the inlet distributor we developed with Washington Game for the Cowlitz, a mid point screened drain with tilt pipe level control and a similar end drain with pipe.

It also has a number of screen and stop log slots or baffle slots as indicated.

The reasons for all these variations you probably know. However, for those who may have come in late, they are an attempt to provide all those things often requested by hatchery people. They are:

1. Higher velocities in raceways. These raceways are piped to flow 550 GPM through each raceway.

2. Better bottom cleaning. With the higher flows, and the use of baffles as shown, it is expected the bottoms will be kept much cleaner.

3. Reduced stress on fish during cleaning. When it is necessary to agitate the bottom to remove the settleables, the flow to the nearest drain can be controlled by adjustment of the stand pipe drains. Thus the stirred up material doesn't travel the whole length of the raceway.

4. Ability to divide the raceway.

5. To provide varying degrees of water quality and velocities within the raceway. We've heard varying ideas about the quality and velocity in some of the circulating type ponds. This design may answer some of these complaints. It has the flexibility to allow a degree of experimentation so we'll keep you informed of the results after use.

This concludes my prepared presentation. If we have time, I'd be happy to answer any questions now, or later. Thank you for your attention.

Chairman's Note:

Drawings of the facilities shown in the slides are available from the author.

FISH CULTURE PROGRAM AT MT. HOOD COMMUNITY COLLEGE

Jim Graybill
Mt. Hood Community College
Gresham, Oregon

The Fish Culture Program at Mt. Hood Community College trains students to become fish culturists with a broad technical background in fish husbandry and fishery techniques. The program is supervised by an advisory committee composed of professional fish culturists and fishery biologists whose input is largely responsible for the success of the program. The program intends to provide to the field, graduates with an academic background enriched with a great deal of practical experience in widely varied husbandry oriented skills. The emphasis of the program is to produce a husbandryman that can get the job done and not one that must always be intimately involved in research.

Being a community college with the doors open to everyone, the program attracts all types of students. They may range in age from 17 to 50, usually are a veteran, like the outdoors, like small towns, are not interested in getting rich, and prefer working outside rather than working at a desk. Most of the students have part time jobs and some have full time jobs which may include work as a mechanic, landscaper, truck driver, or builder.

Formal training is arranged so that a broad base is given in the first year. At Mt. Hood Community College we are fortunate in that our base courses such as mathematics, writing and public speaking are adapted to working with fishery problems giving the students more practical experience doing those sorts of things they will be doing when they are working in the field. Related courses are taught by professionally experienced instructors in welding, small gas engines, first aid, small group supervision, and consumer economics. The core fisheries courses include maintenance and operation of hatchery type equipment, building maintenance and repair, fisheries organizations and their administration, data collection and analyses, and current issues in natural resources.

The freshmen are introduced to fisheries through a two-term sequence in fish biology and a three-term sequence in fishery techniques which covers such topics as boats and outboard motors, methods of fish capture, population estimation, aging of fish, management practices, surveying, identification of aquatic organisms, and water chemistry analyses. We have two streams and a 5 acre lake on the campus.

This gives the students the background for their sophomore courses in field projects and in fish husbandry. In field projects the students are given an opportunity to show their initiative on projects of their own choosing. The year long fish husbandry class covers such topics as handling of adult salmonids, spawning techniques, egg incubation, fry rearing, hatchery design, reuse systems, nutrition, fish pathology and treatment, liberation techniques, loading and completing management reports. Many of the students take part time and summer jobs in fish hatcheries with the Fish Commission of Oregon and the Oregon Wildlife Commission whose cooperation is greatly appreciated. At present, a small fish hatchery is located on the campus.

A new fisheries building will be completed December 1974 which will include a classroom, storage area, workroom, laboratory, and a hatchery equipped with representative examples of incubators, troughs, and 38 three-foot-diameter circular tanks. The hatchery will be operated with a reuse system. This facility will provide the students with ample experience in fish cultural practices.

THE QUINSAM RIVER FISH HATCHERY

W. P. Truch
Underwood McLellan & Associates Limited
(A member of the UMA Group)
Calgary, Canada

The second major fish rearing facility constructed by Fisheries Service, Government of Canada, on the West Coast of British Columbia near Campbell River, offered several engineering challenges in design, somewhat different from the norm:

1. The primary water supply (Cold Creek) required the construction of a diversion structure and a 3,800-foot pipeline through cuts up to 36 feet, and with controls and appurtenances to handle a head differential of 115 feet, at a flow of 36 cfs.

2. A somewhat unstable river regime demanded careful selection of site and construction details related to a diversion fence on the Quinsam River. This fence is considered a necessary adjunct to the hatchery operation.

3. Two (2) 70' diameter clarifiers providing for a 25 percent reduction of suspended solids and BOD were considered as necessary to establish a practical precedent for "nonexistent standards" in the province related to discharge of hatchery wastes.

4. The hatchery building required the accommodation of five major operational units, viz: Incubation, Service Facilities, Administration, Fry Marking and Visitors Display, such that desired internal movements would be a complement to the outside activities.

5. Site conditions including protection for a 1-in-100 year flood, adverse soils and difficult terrain for access road construction posed physical limitations on available space and required a compact arrangement of all facility components.

A conservative benefit-cost ratio of 3 to 1 was determined for this facility on the basis of a capital expenditure of $4.3 million, and a yearly operating cost of $250,000. Its completion in September 1974 will represent a major contribution towards advancement of a positive fish management program on the Canadian West Coast.

PROGRESS REPORT
ON
DWORSHAK NATIONAL FISH HATCHERY

John R. Parvin
Dworshak National Fish Hatchery
Ahsahka, Idaho

The first phase of construction of the Dworshak National Fish Hatchery was completed in 1969. Dedication was in August of that year. Since that time, alterations of one type or another have been in progress culminating with the present contract.

The original construction included one reuse system of 25 recirculating type ponds. The filters of this system are the gravel, oyster shell type. The present contract which is substantially complete was for the purpose of converting the balance of the ponds to two reuse systems. These use an upflow filter design with plastic rings for the media. These two additional systems were placed in operation during the summer of 1973.

Some of the problems encountered included a higher than desirable nitrite buildup in system III and the introduction of Ichthyophthirius into the systems possibly by failure of the sand filters in the new construction and possibly aggravated by vectors (birds).

At the present time the systems II and III which have the upflow filters are operating satisfactorily with adequate metabolite removed. In these systems it was possible to treat the Ichthyophthirius. The incident of infection is lessening and the fish appear to be in good health. The steelhead in system I were removed from the system and treated with the classical treatment for Ichthyophthirius. At times other diseases were diagnosed within the system but were of no apparent consequence. It appears that the upflow filters have some inhibiting effect on the progress of the Ichthyophthirius epizootics.

The initial egg collection of steelhead trout was made in the spring of 1969. The first smolts numbering approximately 1,400,000 were released in the spring of 1970. These were reared in the reuse system which is now the No. I system. The first returns of 813 fish from this release appeared as one ocean fish in the 1972 spawning stock. 8,542 of the returns for the 1973 season were from this release as two ocean fish. An additional 906 fish appeared from subsequent releases. 376 wild fish were present. A total of 9,824 returned, of which 96.17 percent were of hatchery origin.

The Dworshak National Fish Hatchery was also involved in the management of the Dworshak reservoir in cooperation with the Idaho Fish and Game Department. The initial releases into the reservoir in the spring of 1972 included rainbow and kokanee. These fish have produced a highly satisfactory fishery. In the fall of 1973 the kokanee appeared as a spawning population estimated to be in excess of 50,000.

CHUM SALMON HATCHERIES OF JAPAN

Lauren R. Donaldson
Professor Emeritus of Fisheries
College of Fisheries
University of Washington
Seattle, Washington

The salmon hatchery system in Japan has evolved over the past hundred years from the early practice of collecting and incubating the eggs and releasing unfed fry to the integrated management program now in use. The responsibility for management rests with the federal Fisheries Agency in the Department of Agriculture, the prefectural fisheries departments and local fisheries associations.

The salmon rivers are located in northern Honshu and Hokkaido Islands. The rivers are small by our standards and very polluted. Chums make up the great bulk of the salmon reared, but pinks and kokanee are receiving more attention.

There are 41 "operational centers" on Hokkaido, where the adults are trapped, eggs harvested, and fed fry planted into the rivers. Table 1 presents a summary of the Hokkaido Prefecture chum salmon fry plants and recoveries.

The chum fry are fed in the hatcheries until they reach a weight of 1.6 to 2.0 grams (290 to 230) per pound) before release into the rivers at a time when the temperature of the rivers is optimal and the food in the adjacent sea is at the springtime peak.

The fish return over a five-year span, with the great majority returning as four-year-olds. Returns since 1952 have varied from a low of 0.53 percent for the 1958 brood to 1.85 percent for the 1963 brood year, an average of 1.15 percent. Incomplete records indicate that the 1966 brood year will be even better, with about 7 million adults back from a release of 272 million fry.

The largest of the chum salmon hatchery complexes is on the Tohachi River in south central Hokkaido. The return of chum salmon to this small river in 1972 numbered over 250,000 fish and produced 200 million fed fry with a weight of approximately 800,000 pounds.

Economic feasibility studies indicate a very favorable cost-benefit ratio for the salmon hatchery program, so the present policy is to expand the program by developing more efficient operations, making better use of the limited water supplies, and improving the quality of the fry at release. Positive steps are being taken to maintain the quality of the adults through spawning, for the carcasses are sold by the fisheries associations.

Chinook and coho salmon are being worked into the program. The limiting factors most frequently mentioned are the shortage and high price of good quality fish meal so essential in the production of the food for feeding the one billion fry planned for annual production.

TABLE 1. Hokkaido Prefectural Chum Salmon Program Data, 1952-1969

Year Released	No. of Fry Released	No. of Return of Each Age Group — Age 2	3	4	5	6	Total Return	Percent Return Each Year	Percent Return of 3-year-old Fish
1952	159,557,000	35,900	583,600	931,800	201,200	1,600	1,754,100	1.15	0.37
1953	170,606,000	32,100	659,800	1,135,900	161,800	1,400	1,991,000	1.17	0.39
1954	269,338,000	44,800	1,233,900	1,900,400	133,900	100	3,313,100	1.23	0.45
1955	247,922,000	34,400	850,900	1,043,700	77,800	2,100	2,008,900	0.81	0.34
1956	140,454,000	45,100	570,700	992,400	286,400	12,100	1,906,700	1.36	0.41
1957	361,608,000	30,700	637,500	1,829,500	554,800	15,000	3,067,500	0.85	0.18
1958	417,238,000	22,100	765,900	1,279,500	160,000	400	2,227,900	0.53	0.18
1959	313,549,000	58,000	895,400	1,846,300	379,100	1,000	3,179,800	1,01	0.29
1960	203,413,000	17,800	1,601,800	1,581,900	195,200	2,000	3,398,700	1.67	0.79
1961	359,489,000	144,700	1,836,300	3,516,000	538,800	3,700	6,039,500	1.68	0.51
1962	280,743,000	14,300	997,000	1,506,300	405,400	8,000	2,931,000	1.04	0.36
1963	272,106,000	41,000	1,658,200	3,103,100	230,000	200	5,032,500	1.85	0.61
1964	334,463,000	98,900	971,900	913,900	75,500				
1965	549,278,000	15,900	816,900	1,707,600					
1966	272,036,000	175,900	2,310,100						
1967	434,729,000	79,400							
1968	207,438,000								
1969	361,571,000								
Average age composition (%)		1.41	33.35	56.08	9.02	0.14	100.0		
Average								1.15	0.38

Data from Fisheries Agency Report, 1971

RESUME ON THE REPORT "COMMERCIAL TROUT HATCHERIES OF SOUTHERN IDAHO"

Don Nelson
Murray Elevator
Salt Lake City, Utah

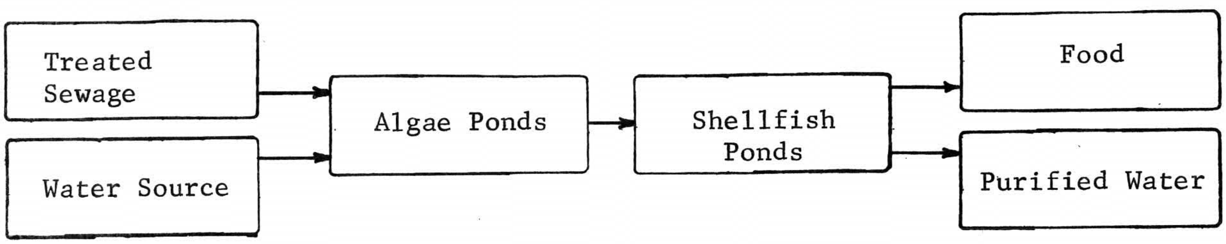
An informative sound, colored movie of fifteen minutes duration which presented helicopter views of many of the commercial trout hatcheries of Southern Idaho. Also shown were feeding techniques, trout processing procedures and production figures. The various feed ingredients used in many dry trout foods were also depicted by photograph.

DESIGN OF AN AQUACULTURE FACILITY FOR
WOODS HOLE OCEANOGRAPHIC INSTITUTE

Ernest Lewis
Kramer, Chin & Mayo, Inc.
Seattle, Washington

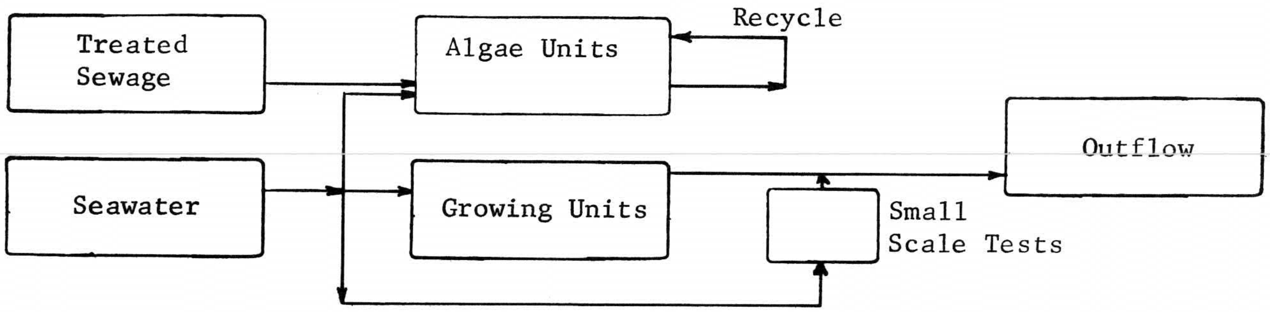
ABSTRACT

This article describes the objectives, setting of requirements, approaches adopted as well as the unique physical plant evolved in developing the Environmental Systems Laboratory for the Woods Hole Oceanographic Institution. This seawater complex is intended to be capable of performing a wide spectrum of research in the fields of marine water pollution control, aquaculture and coastal biology. The initial emphasis will be to further develop and "productionize" the secondarily treated domestic sewage-marine phytoplankton-shellfish food chain systems for tertiary sewage treatment and aquaculture currently under investigation at Woods Hole.



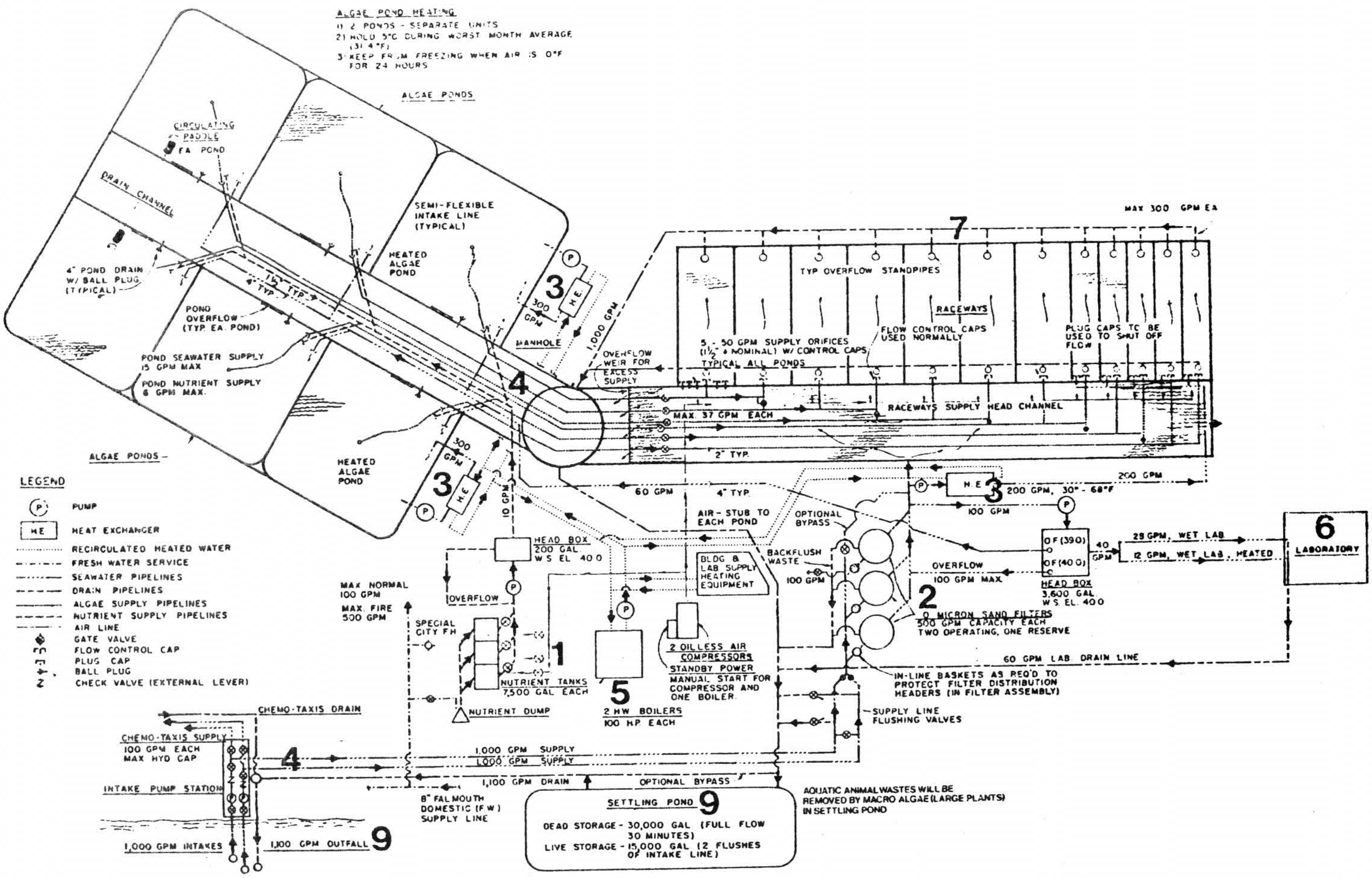
CONCEPT

Coastal-zone eco-systems naturally transform bio-chemical components of waste to protein animal (food) tissue. Small-scale laboratory studies conducted by life scientists under the leadership of Dr. J. H. Ryther at Woods Hole Oceanographic Institute, Massachusetts, over the past 10 years, indicate that this food-chain process might be controlled in a full-scale facility to provide an economical tertiary sewage system. Seafood (oysters and other bivalves) would be a byproduct of the intensive-aquaculture portion of such a system that could be marketed to offset the cost of tertiary treatment. If this system could be proven, it might provide a significant economic and environmental application for municipalities not only in the United States but throughout the world. Essential to the proof of this theory, is a laboratory of a scale sufficient to simulate natural conditions and realistic treatment capacity that would demonstrate feasibility. Although study would begin with bivalves, future research with carnivores, such as lobsters, is contemplated as are symbiotics (multi-animal communities) and the use of heated effluent from the cooling systems of thermal power plants for temperature control. The concept is that of Dr. Ryther. The design is that of the entrant.



PROBLEM

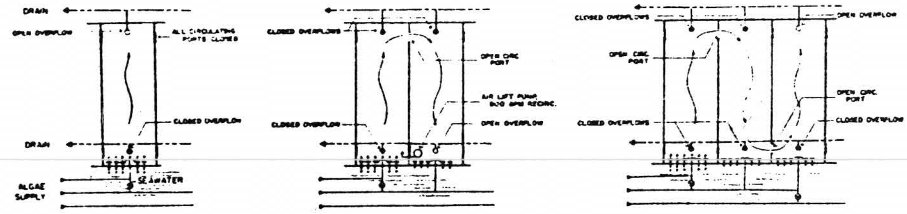
For the designers, the problem essentially was a lack of criteria, as the client-generated diagram indicates. The installation will establish criteria for second-generation prototype. Numbers were suggested for each element, but all were changed by the engineer, except the algae-pond surface area. In virtually no instance could established fish hatchery and aquaculture techniques be directly applied, nor could laboratory data be safely projected. Need was apparent for screening oxygen/nutrient-competitive organisms for intake seawater, for noncorrosive piping, for purgin invading organisms, for temperature control facilities to simulate seasonal variations, for determining oyster oxygen consumption and toxic metabolic waste production, for adjustable-length raceways, for observing specimens, for reuse recirculation of algae-rich water at optimum rates of flow and for efficient product (bivalve animal) handling equipment. All of these needs represented minor, easily obtained set-ups in a small-scale laboratory, but they presented a massive collection of assumptions for full-scale application. Basis for design was largely conceptual for herbivores (oysters) and more so for carnivores (lobsters, crabs) and symbiotic (multi-animal) communities. Flexibility was designed in for unknown variables.



SCHEMATIC FLOW DIAGRAM

SOLUTION

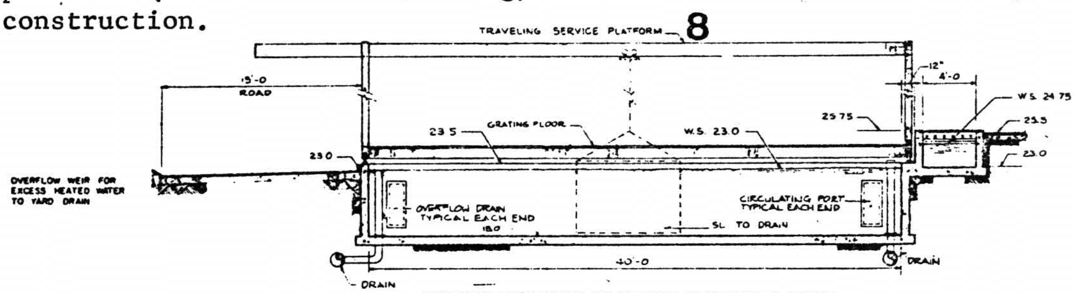
Reasonably reliable conventional criteria were derived from site and weather data, architectural requirements, target capacities, budget limitations, scheduling requirements and Vinyard Sound seawater quality analysis. To obtain secondarily treated sewage with most uniform characteristics, effluents from communities throughout eastern Massachusetts were analyzed. 1) A supply will be trucked to the site daily. 2) a 1,000 GPM, 10-micron sand filtering system was proposed and designed for influent seawater, with backflushing. 3) Heating controls, far more elaborate than any known in aquaculture, will allow a variation from 31°F to 80°F in winter, with gradations provided by heating, and/or bypassing intake water, mixing intake and recycled water, and raceway storage with retrieval. To avoid corrosion, and as a precaution against toxidity, bio-assays were conducted for a variety of likely metalic and synthetic materials, such as polyvinyl chloride pipe, epoxy fiberglas, high-density polyethylene. Few met all requirements. Some products were noncorrosive and nontoxic to oysters but toxic to algae. 4) Tough, flexible high-density polyethylene was chosen for intake piping. Fortunately, it was most economical. 5) Valving and layout was designed to allow the introduction of hot water at periodic intervals, or to allow some pipes to stand empty, so invading organisms could be destroyed and flushed away. 6) In its own wet laboratory, the engineer experimented with oysters to determine the rate of oxygen consumption and production of toxic ammonia derivatives. 7) The client requested four raceways with given dimensions, but the counter-proposal was to design a configuration with new dimensions, gates, drains, piping and air-lift pumping to increase the number of raceways to an eventual 12 with flexibility within each.



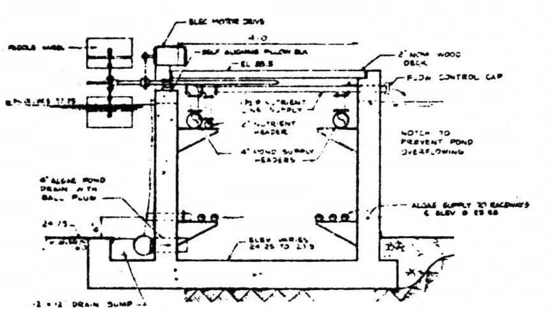
SINGLE RACEWAY 2 RACEWAYS 3 RACEWAYS

REUSE – THROUGH THE USE OF CIRCULATING PORTS IN ALL COMMON WALLS (ONE EACH END) VARIOUS REUSE ARRANGEMENTS ARE POSSIBLE.

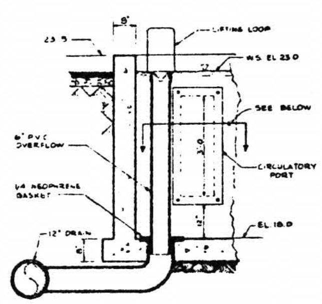
Possibilities for simultaneous individual experiments were increased thereby from 4 to 12 or more so that such things as optimum volume, length and loading density could be determined. Another plus was an ability to give bivalves any number of passes at the algae-seawater mix with controls for oxygen induction and toxics removal. 8) Both a means for scientists to observe specimens and to hoist and move about racks of specimens was obtained by design of a unique traveling crane-bearing platform (shown in the rendering) that is scheduled for second-phase construction.



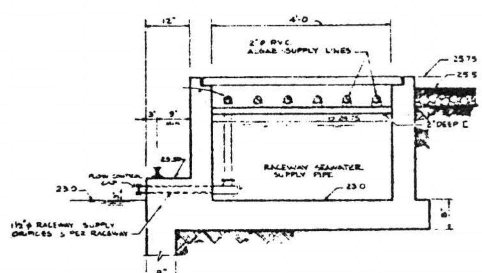
TYPICAL REARING RACEWAY SECTION (LONG.)



ALGAE POND CHANNEL



RACEWAY OVERFLOW DRAIN

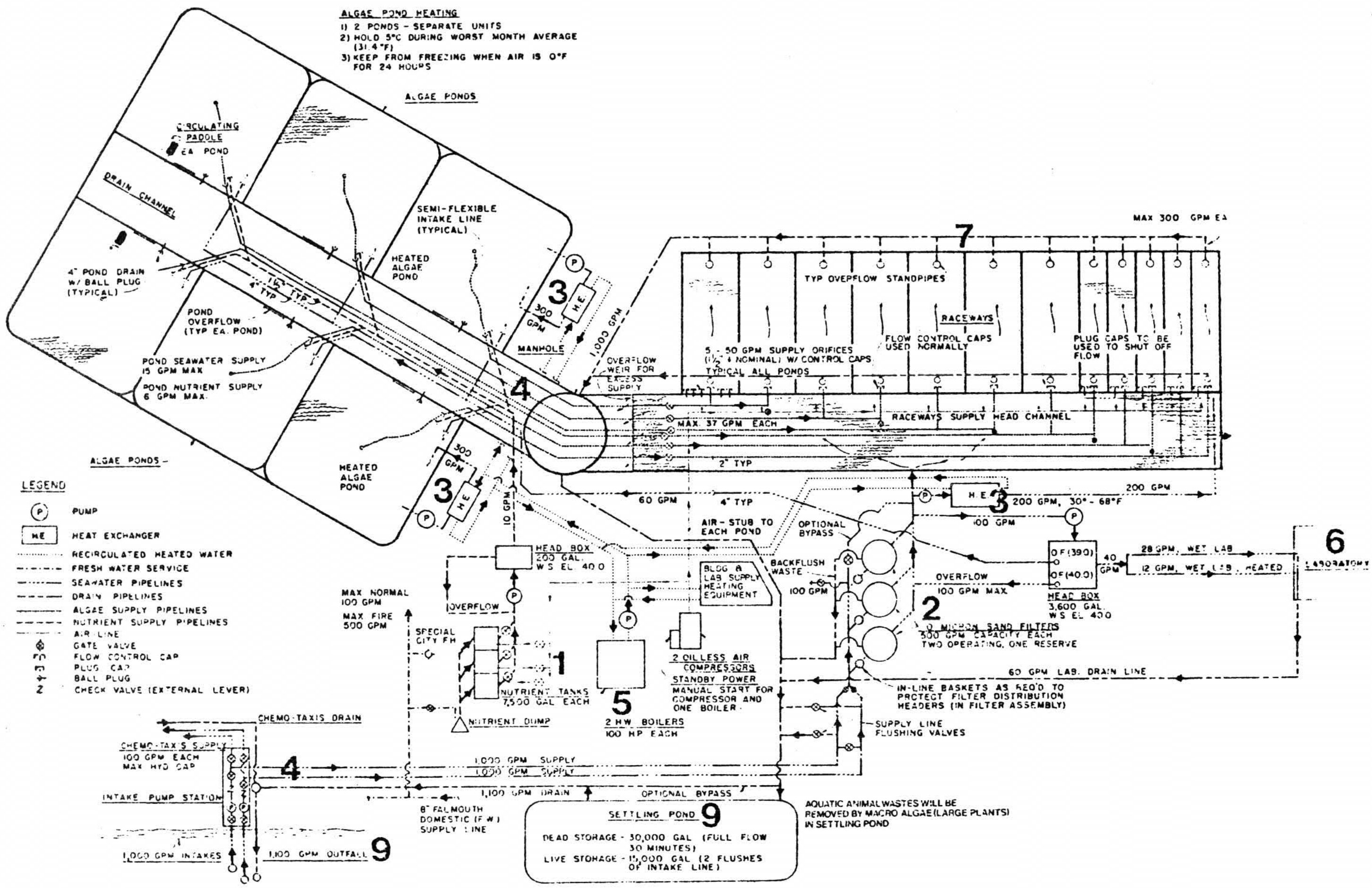


RACEWAY SUPPLY CHANNEL

Lack of specific criteria necessitated that design work proceed with assumptions. Therefore, cost estimation became a critical exercise within the confines of a limited budget. Priorities were established for various technological features so that it could be ascertained early in preliminary design whether a basic facility, in terms of the scientists' conceptual requirements, could be realized and, if so, what features could best be left for later addition. The most advanced state of the art in bio-engineering for all essential elements was accommodated in the final design. 9) Solid wastes will be removed with sedimentation and seawater will be returned to Vinyard Sound in a condition virtually identical to that of intake water. In its present state, the design will allow for future treatment of effluent with macro-algae and the use of herbivores reared in the system to provide food for carnivores.

In application, W.H.O.I. scientists envision a symbionic relationship with secondary sewage treatment plants and thermal power-generation plants; the former supplying the nutrients and the latter heated effluent from cooling system so as to eliminate the use of energy for temperature control.

It is estimated that with the use of this system a town of 11,000 would provide sufficient nutrient to produce 1,000,000 pounds of food per year.



SCHEMATIC FLOW DIAGRAM

SUMMARY OF
UNIVERSITY OF WASHINGTON
AQUACULTURE WORKSHOP

Terry Nosho
Ernie Brannon
Ernie Salo
University of Washington
Seattle, Washington

On September 21, 1973, the Sea Grant program of the University of Washington sponsored a 1-day aquaculture workshop to discuss the problems common to persons involved in aquaculture. Forty-seven people representing 17 agencies and companies registered, and of this group, 8 were in some stage of active production of salmon for sale.

A report will be available through the Sea Grant offices of the University. In summary:

1. Salmon farming has grown enormously in Washington within the last 5 years. At present, five species of salmon and steelhead trout are being farmed for commercial markets and recreational use. (Table 1)

TABLE 1. Species by method being reared in Washington by commercial groups attending workshop. Numbers are given in thousands of fish.

	Coho	Chinook	Pink	Chum	Sockeye	Steelhead	Total
Net-pen	1,720	310			1		2,031
Ocean Ranch	500	500	350	250		600	2,200
Lagoon	960	—	—	—	—	120	1,080
Totals	3,180	810	350	250	1	720	5,311

2. Pen-rearing salmon provides a potential for intensively cultivating high-quality market fish. It can also be used as an intermediate rearing phase for certain species, such as coho, prior to ocean release.

3. Ocean ranching appears attractive in that it offers a wide range of species for cultivation, relatively low initial capital, established market outlets, and diversification in the total salmon farming picture. It has minimal pollutional or aesthetic problems.

4. Lagoon rearing has been reported as being successful, but the required capital appears to outweigh the advantages unless natural bodies of water are utilized. Then, social problems may become insurmountable.

5. The development of new sources of protein for fish needs is imperative. For fish meal purposes, using underutilized species will have a relatively short-term impact. Finding new stocks and fishing them down, as history indicates will occur, will only alleviate the problem on a short-term basis and, in some cases, may cause new problems. However, this idea is worthwhile until something more permanent is developed. The long-term lasting effect required by industry may come from development of single-cell protein. If this material can be incorporated into fish diets, then studies on its adequacy are needed immediately.

6. Much more research into disease prevention, as well as treatment of symptoms, is needed. Cooperative experiments between disease experts and industry may help provide insights and solutions for all. The status of Vibrio was discussed in detail.

7. Although salmon farming is technically a reality, its economic feasibility is still not clear. Many questions remain in the marketing area.

8. The legal-political aspects of pen-culture and fish-ranching are not clear at this time.

Attendees were sent a questionnaire to evaluate the workshop, give a preference of subject topics for future workshops, and give suggestions where improvements might be made in format. Results are based on 15 returns, or 30 percent of the attendees.

All respondents said the workshop was worthwhile and apparently favored follow-up workshops. For the purposes of the intial meetings, 66 percent felt that the subject material was covered in sufficient detail; however, for the future, they favored fewer subjects with greater in-depth discussion.

Topics suggested for future meetings included:

1. fresh vs. saltwater rearing
2. pen vs ocean ranching
3. closed vs. open systems
4. multipurpose systems
5. pen vs. raceway rearing
6. hatchery vs. pen systems
7. open range systems