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26th ANNUAL NORTHWEST FISH CULTURE CONFERENCE

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Newport, Oregon

26th ANNUAL NORTHWEST FISH CULTURE CONFERENCE

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CHAIRMAN'S REMARKS

An effort was made this year to bring about a change in the conference format. There was a growing feeling that the scheduling of short technical papers delivered back to back in a single room crowded with all the participants was not conducive to a spirited exchange of ideas. Therefore, since the spirit of the conference has always been to remain informal in our quest for the new information available during the year the format was altered by using split sessions and longer time for questions and answers.

Several panel discussion sessions were added to expose the group to a broader range of issues. Present and future operational and technical needs of fish culture were brought out simultaneously in three split sessions and then shared with the combined assembly.

The response from the participants to the format change was most favorable. I would highly recommend further attempts at inovating new ways in which we can get at the general issues and specific problems so important to the continued improvement of fish culture in the Pacific Northwest.

Over 300 persons attend this years conference on the rugged Oregon coast. Even though the weather put on a spectacular winter storm the participants enjoyed the setting and the facilities at the Inn at Otter Crest.

Next year G. W. "Bill" Klontz will host the function somewhere in Idaho. Bill's usual talents and spirit will no doubt bring about a good show.

Thank you to all who helped make the 26th conference a good one.

John R. Donaldson

DISEASES

A PRELIMINARY REPORT ON THE CONTROL OF BACTERIAL KIDNEY DISEASE IN CHINOOK SALMON

by

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and
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Abstract

The Rapid River Hatchery in Idaho, owned by the Idaho Power Company and operated by the Idaho Fish and Game Department, was built in mitigation for chinook runs lost due to hydroelectric dams. Since the hatchery's construction in 1968, annual losses caused by bacterial kidney disease (BKD) increased annually until 1973 when the mortality in the adult holding ponds was 37%.

This study is based upon the utilization of subcutaneous injections of Erythromycin phosphate (a water-soluble Erythromycin derivative) into the adult chinook when they are removed from the hatchery trap. Efficacy was evaluated by: 1) gross lesions in the spawned fish, 2) gross lesions in the pond mortalities, 3) presence of BKD organisms in the spleens of all the adult fish, 4) condition of the eggs and fry from injected females, and 5) incidence of BKD in the progeny from injected females.

Progeny from the Erythromycin phosphate injected females were brought to the University of Idaho wet lab as pre-feeding fry. A control group of fry was also brought to the lab and each group was kept in separate tanks. The number and cause of mortalities was recorded for each tank and bi-weekly samples of clinically healthy fish were taken. A similar experiment took place at the hatchery. The results from both locations are very similar.

The project has been funded for the past two years and the following data have been evaluated to date.

Table 1. 1974 - Adult Salmon Data

	Injected	Control
Total fish	71	1,433.
Pre-spawning mortalities (% total)	8.45%*	21.84%
Fish with lesions (% morts)	16.66%	44.88%
Total Spawned	65.	769.
Spawners with lesions (% spawned)	4.61%	16.25%

*Some morts. unaccounted for due to lost tags

Table 2. 1975 - Adult Salmon Data

	Injected	Control
Total fish	2, 305.	1, 108.
Pre-spawning mortality (% total)	5. 63%	5. 07%
Fish with lesions (% morts)	8. 89%	37. 20%
Total Spawned	2, 175.	1, 065.
Spawners with lesions (% spawned)	1. 56%	10. 80%

Table 3. 1974-75 Fry Data - U. of I. Wet Lab

	Fry from Injected Females	Control Fry
Fish on hand (12/1/74)	1, 180	1, 155
Morts. to date (11/1/75)	54	132
Morts with kidney disease	0	28

EFFECTS OF INCREASING TEMPERATURES AND BACTERIAL DISEASES FOUND NATURALLY IN THE WILLAMETTE RIVER TO FOUR STOCKS OF STEELHEAD SMOLTS

by

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A live-box experiment in the Willamette River was begun on April 10, 1975 to analyze the effects of temperature and naturally occurring bacterial diseases (Aeromonas salmonicida, Aeromonas liquefaciens and Flexibacter columnaris) to the following stocks of steelhead smolts: Rogue (summer), Deschutes (summer), Skamania (summer) reared at Roaring River Hatchery, Skamania (summer) reared at Oak Springs Hatchery, and Willamette (winter). All fish were fin marked for positive identification and exposed continuously for 133 days. This included a period of acclimation of 85 days at water temperatures 62°F. Over 90 percent of each group survived the initial 85 day exposure.

As water temperatures increased, the Skamania stocks and the Willamette stock became infected with bacterial diseases and died, while the Rogue and Deschutes stocks were more resistant. Only 37 and 24 percent of the Skamania stocks reared at Roaring River and Oak Springs, respectively, survived the exposure while only 12 percent of the Willamette winter steelhead survived. A total of 84 and 81 percent of the Rogue and Deschutes smolts, respectively, survived the exposure. Most of the mortalities (79 to 88 percent) were infected with either A. salmonicida or A. liquefaciens. Only one fish was infected with F. columnaris. All the stocks appeared to be resistant to the myxosporidan, Ceratomyxa shasta.

IMMUNIZATION OF FISH FOR CONTROL OF INFECTIOUS HEMATOPOIETIC NECROSIS

by

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Infectious hematopoietic necrosis is a highly infectious viral disease of salmonid fish which has caused losses in populations of sockeye (Oncorhynchus nerka) and chinook salmon (Oncorhynchus tshawytscha) and rainbow trout (Salmo gairdneri). The morphology has been described (Amend and Chambers, 1970), and many of the biological and physical properties are known (Wingfield, et al., 1969 and McCain, et al., 1971 and 1974).

Early in 1972, experiments were undertaken in an attempt to attenuate a highly virulent strain of infectious hematopoietic necrosis virus (IHNV). The strain selected for attenuation was isolated from rainbow trout in 1971 and was designated RBT-IHN-71-NSL. The method of attenuation consisted of multiple passage of the cirus in a cell line derived from steelhead trout (STE-137) at 18 C. Virus was subcultured either every 10 days or when cytopathogenic effects (CPE) were observed, depending on which occurred first. Subcultures were made by removing the infected cell culture fluid (Hanks MEM 5%), centrifuging it at 2,200 x g for 20 minutes, diluting it 1:1000 in Hanks MEM 5%, and then reinoculating 0.1 ml of this dilution onto fresh cell cultures. After 41 passages a strain was shown to be reduced in virulence by calculating the LD_{50} in sockeye salmon and relating this to the number of plaque forming units (PFU) of virus present. This LD_{50} was then compared to the LD_{50} of the wild-type virulent IHNV from which the attenuated strain was derived. From these experiments is has been determined that this attenuated virus strain experienced approximately a 100-fold reduction in virulence during the course of 41 passages. A second attenuated strain was obtained by 34 serial passages in the same cell line at 9.5 C.

These two serially passed IHNV strains have been tested extensively for immunizing potential in small sockeye salmon. Both strains were introduced to fry of this species by one of two methods: (1) intraperitoneal injection or (2) direct addition to the aquaria water. After an immunization period of 25 days, the fish were challenged with intraperitoneal injections of the original wild-type virulent IHNV. Results of this experimental work indicated that both strains of passed virus had remained antigenic. The IHNV passed 34 times showed best immunization potential when injected intraperitoneally, and the strain passed 41 times was an effective vaccine when added directly to aquaria water containing fish. The relative ease of administering this water-borne vaccine offers the best potential for use in fish culture.

The effectiveness of the attenuated IHNV water-borne viral vaccine as an immunizing agent is shown in Table 1. The vaccine preparation consisted of infected cell culture fluid that had been centrifuged at 2,200 x g for 20 minutes to remove cell debris. Dilutions of the supernatant were then added directly to the aquaria water for a period of 48 hours. The immunization period prior to challenge was 25 days at 18 C. Data from this laboratory experiment clearly indicates the protective nature of the water-borne virus vaccine to sockeye salmon subsequently challenged either by intraperitoneal injection or by direct addition of the virulent wild-type virus to the water at 18 C.

Table 1. Efficacy of immunization of sockeye salmon fry with attenuated IHNV water-borne viral vaccine after intraperitoneal or water route challenges with virulent IHNV.

	Survivors of Challenges with Virulent Wild Type IHNV[b,c]		
Immunizing dose pfu/ml aquaria H_2O[a]	intraperitoneal challenge of 40 LD_{50} units	virulent wild type virus added to aquaria water at a concentration of 2000 pfu/ml	virulent wild type virus added to aquaria water at a concentration of 4000 pfu/ml
6200/ml	19/20	20/20	19/20
12,400/ml	20/20	16/20	20/20
Non immunized controls	0/20	3/20	2/20

[a] Exposure period to attenuated IHNV-71 was 48 hrs.

[b] Immunization period before challenge was 25 days.

[c] Experimental animals were sockeye salmon (mean weight 0.9 gm).

This experiment was followed by a second conducted with a similar design, but employing immunizing doses of 1,500, 7,500, and 15,000 pfu/ml of aquarium water. Twenty-five days after immunization the experimental lots and a nonvaccinated control group were challenged by ip injection of 48 LD_{50} of wild type virus. The results (Table 2) again reflected the highly protective nature of the attenuated IHNV water-born viral vaccine.

In the previous two experiments, the period between immunization and challenge was 25 days. In a third test, this interval was expanded to 110 days to determine if the vaccinated animals maintained immunity for this extended time. Experimental fish were immunized with 7,000, 14,000, and 21,000 pfu/ml of aquarium water for 48 hours. They were subsequently challenged with 2,400 pfu wild type virus/ml of aquarium water. The exposure period for challenge was also 48 hours. The data

indicate (Table 2) that high levels of immunity were maintained. Experiments concerning the nature of this immunity and its potential use in fish culture are continuing.

Table 2. Efficacy of immunization of sockeye salmon fry[a] with attenuated IHNV water-borne viral vaccine after an injected ip challenge with 48 x LD_{50} of virulent wild type IHNV.

Immunizing dose[c] (pfu/ml aquarium water)	Number of survivors / Number tested	Percent survivors
1,500	39/40	98
7,500	39/40	98
15,000	40/40	100
Controls[d, e]	1/40	3

[a] Mean weight of fish was 0.4 g.

[b] Challenge contained 60 pfu in 0.02 ml of HBSS injected ip 25 days after immunization

[c] Immunization dose consisted of undiluted tissue culture fluid added to ten liters of aquarium water for an exposure period of 48 hours.

[d] Non-immunized control fish were challenged with 48 x LD_{50} of wild type IHNV injected ip.

[e] Another control group received an immunization dose of 15,000 pfu/ml aquarium water but was not challenged - all fish survived exposure to this immunization dose.

Table 3. Efficacy of immunization of kokanee salmon fry[a] with attenuated IHNV water-borne vaccine to a water route challenge[b] containing wild type IHNV 110 days after immunization.

Immunizing doses[c] (pfu/ml aquarium water)	Number of survivors / Number tested	Percent survivors
7, 000	26/36	72
14, 000	30/35	86
21, 000	31/36	86
Non-immunized controls[d]	1/18	6

[a]Mean weight of fish used was 0. 77 g.

[b]Challenge level consisted of undiluted tissue culture fluid added to ten liters of aquarium water at a concentration of 2, 400 pfu/ml for an exposure period of 48 hours, 110 days after immunization.

[c]Immunizaing dose consisted of undiluted tissue culture fluid added to ten liters of aquarium water for an exposure period of 48 hours.

[d]Another control group received an immunization dose of 21, 000 pfu/ml aquarium water but was not challenged - all fish survived exposure to this immunization dose.

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INCREASE IN KNOWN DISTRIBUTION OF INFECTIOUS HEMATOPOIETIC NECROSIS VIRUS IN ALASKAN SOCKEYE SALMON

by

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Infectious hematopoietic necrosis virus (IHNV) disease has caused further loss of sockeye (Oncorhynchus nerka) salmon artificially propagated in Alaska. Substantial mortalities of juveniles occurred in Auke Creek Hatchery, Sitka estuarine rearing pens in Southeast Alaska and in Kitoi Bay Hatchery on Afognak Island near Kodiak. At Auke Creek Hatchery most sockeye fingerlings died as a result of an IHNV epizootic during July in the manner of an unsolicited benefit from an elevated water temperature rearing experiment. Sockeye smolt died, approximately 66.6% of 1,110 in Sitka estuarine rearing pens, primarily during July. These smolt had been transported from Auke Creek to the salt water pens in June and held at salinities of 5 °/oo initially and 23 °/oo early in June. Ten percent of 43,600 alevins present as controls during an IHNV vaccination trial at Kitoi Bay died from the disease during June and July.

In order to better define the distribution of IHNV in wild stocks and to use this information in hatchery site selection, a survey of Alaskan sockeye stocks was undertaken in 1975.

MATERIALS AND METHODS

Sampling of sockeye salmon was restricted to mature males and females that had returned to parent streams or beach locations in the summer and fall of 1975. The sampling goal was 150 fish from each location with 75 males and 75 females represented in 5-fish pools of gonadal fluids to achieve an overall 2 percent incidence of disease carriers based on a 95 percent confidence level. Included in this report are 12 feral stocks. Sample processing at Biometrics, Inc. was similar to that used and reported by Grischkowsky and Amend at this conference last year. One major exception is that the present use of multiwell plates (Falcon or Linbro).

RESULTS

Results of the 1975 IHN virus survey are given in table 1. No virus was found in Lake Nerka beach spawners and Tustumena Lake fish. Five locations, Little Togiak River, Bear Lake and Chignik Lake on the Aleutian chain, Becharof Lake on the Alaskan Peninsula, and Akalura Lake beach spawners on Kodiak Island, showed virus in 6.7 to 13.3% of females only. In the Karluk Lake system of Kodiak Island, Karluk Lake and O'Malley River sockeye contained 20-26.7% positive female pools only. Fish from four locations displayed IHN virus in male as well as female pools, including Upper Russian Lake system (Upper Russian Creek and Bear Creek), Lily Lake of the Big Lake system and Auke Creek near Juneau. In the Upper Russian Lake system, females from both creeks sampled showed 100% of pools positive for virus and male pools between 20-45% positive. Beach spawning populations in Lily Lake contained 6.7% and 20.0% positive pools for males and females respectively. Auke Creek sockeye upstream from the Auke Creek Hatchery which had a major sockeye IHNV mortality exhibited 60.0% female pool indicence and 6.7% male pool incidence. Tentative positives (6.7% for female pools and 6.7% for male pools) recently have been found in Klawak Lake samples near Ketchikan.

DISCUSSION

Of particular interest in this survey are the expansion of the prevalence to Chignik on the Aleutian chain and to Klawak Lake in Southeast Alaska near Ketchikan and the failure to find virus at Lake Tustumena and Lake Nerka of the Wood River system. The latter site also was low during 1974, 6.7% female pools positive. The differential percentages between males and females pools is striking. Combining all samples, 5.2% of male pools (191 total) and 30.1% female pools (196 total) contained IHNV.

Table 1. 1975 Alaskan Sockeye Salmon IHN Virus Survey

Location	Month Sampled	Male		Female	
		Number 5-fish pools	% Pools with IHNV	Number 5-fish pools	% Pools with IHNV
Lake Nerka (beach)	August	15	0	15	0
Little Togiak R.	August	15	0	15	13.3
Bear L. (Chignik)	September	15	0	15	13.3
Chignik L. (beach)	September	15	0	15	6.7
Becharof L.	August	15	0	15	13.3
Akalura L. (beach)	October	15	0	15	13.3
Karluk L.	July	15	0	15	26.7
O'Malley R. (Karluk L.)	July	15	0	15	20.0
Upper Russian Creek	August	11	45.5	16	100.0
Bear Creek (Upper Russian L.)	October	15	20	15	100.0
Tustumena L.	August	15	0	15	0
Lily L. (beach)	August	15	6.7	15	20.0
Auke Creek	August	15	6.7	15	60.0

DISTRIBUTION OF FISH VIRUSES IN OREGON

by

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Following the Infectious Pancreatic Necrosis Virus (IPN) epizootic in brook trout at Fall Rivery Hatchery, reported at the 1973 Fish Culture Conference, a survey was initiated to determine the distribution of fish viruses in lakes and trout hatcheries in the state of Oregon. Previous to this investigation IPN virus had been isolated from Elk and Lava Lakes and Marion Creek (North Santiam River drainage) in the Central Oregon Cascades and Fish Lake in South Central Oregon. During this survey samples were collected from 23 lakes. IPN virus was isolated from two of these lakes, Sparks and Cache Lakes in the Central Oregon Cascades.

Infectious Hematopoietic Necrosis Virus (IHN) which had previously been isolated from Nan-Scott Lake (North Santiam River drainage) was also found in kokanee spawning in the Upper Metolius River.

IPN virus was isolated from spring chinook salmon at the Oregon Fish and Wildlife Commission, Corvallis Research Laboratory and from one group of rainbow trout broodstock samples collected at Roaring River Hatchery. Repeated sampling at this hatchery have been unable to reisolate any virus.

In 1974 IPN virus was isolated from brook trout fry at Wizard Falls Hatchery and brown trout fry at Ft. Klamath Hatchery.

Previously the only IHN virus isolated at an Oregon hatchery was in 1958 from kokanee at Willamette Hatchery. Since then no virus has been isolated at this location. This year an IHN epizootic in steelhead occurred at Round Butte Hatchery with the resultant loss of about one million fry.

During the spring of this year an IHN epizootic also occurred in kokanee and rainbow trout at Wizard Falls Hatchery. The rainbow trout were found to be doubly infected with both IPN and IHN viruses. Laboratory tests indicated that both viruses were present in individual fish. This is the first report of double infection by both viruses in a single host.

No virus was isolated from the other eleven hatcheries sampled. Since the IPN epizootic and disinfection of Fall River Hatchery during the summer of 1973, over two years of intensive sampling has occurred at this location. No virus has been isolated from any of these samples. This hatchery is currently back in full production.

SALMONID HERPESVIRUS: A NEW ISOLATE FROM RAINBOW TROUT

by

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Since 1971, I have isolated an agent on RTG-2 cell cultures from ovarian fluid of apparently normal rainbow trout broodstock at the Winthrop hatchery. Cytopathic effects are normally observed about six days after inoculation with ovarian fluid when the incubation temperature is about 12°C. Subsequent passages of culture grown isolates usually produce cytopathic effects in two to three days.

For many years at Winthrop, rainbow trout broodstock have suffered high post spawning losses. Usually slight loss occurs before and during spawning, but is excessive during a two-month post-spawning period. Three-year-old fish spawning for the first time suffer the heaviest losses with mortality rates normally from 30 to 50%. Males tend to suffer higher losses than females. At Winthrop, the problem is insidious since the small daily losses that occur over a prolonged period of time in limited populations add up to large percent losses.

In view of a suspect virus, I had electron micrographs of infected cell cultures made in a cooperative effort with a research facility of the Veteran's Administration. The initial film did not show direct evidence of a viral agent, but did show suspect areas and indicated the need for additional pictures. Therefore, electron micrographs of infected cells at different stages of incubation were made the following year. These pictures clearly showed particles suggestive of Herpesvirus. At the same time, suspect isolates and histologic samples were sent to Ken Wolf, Eastern Fish Disease Laboratory, for analysis and characterization. The agent was determined to be a previously undescribed virus and has been provisionally named Herpesvirus salmonis. It is heat, either, chloroform, and acid labile. In cell culture, respective optimal temperature and pH values are about 10°C. and 7.3. Infectivity passes through 220 nm membrane filters, but is retained on 100 nm membranes. The size of the particle is estimated at 175 nm.

Infectivity experiments at the Eastern Fish Disease Laboratory have shown that this virus is pathogenic for rainbow trout. When rainbow fry--50 mm long were inoculated with culture isolates, the first loss occurred after 33 days and loss was 100% after 43 days. The incubation period appears to be prolonged, but the final result is lethal. At the time of initial mortality fry inoculated with the virus weighed 40% of the controls

inoculated with heat inactivated virus. The symptoms included dark coloration, popeye, distended abdomens, anemia (the gills were a gray, pinkish color), and edema of the liver, spleen, kidney, and heart. Since then, inoculation of fry and fingerlings 100 mm long have caused initial loss after 38 days and a 50% loss the next 20 days. Brook and brown trout as well as Atlantic salmon inoculated with 1.4×10^3 PFU's/ml did not show symptoms.

In rainbow trout broodstock at Winthrop, there were essentially no overt symptoms at the time of spawning. Moribund post-spawners typically show darkened coloration and sometimes contain small amounts of ascitic fluid. Hyperemia was sometimes noted in the liver and visceral fat and other visceral components. The fish were lethargic and often show extensive saprolegnia. An outstanding gross symptom is the flaccid condition of the liver, spleen, digestive tract, and skeletal muscle. This would support histologic findings which indicate generalized edema.

Herpesvirus causes a distinct cytopathology on RTG-2 cell lines. After about 48 hours, focal points of cell fusion, rounding of cells, and multinucleation occur. The foci gradually enlarge and necrosis of the entire cell sheet occurs.

At the present time, it is now known where the virus originated, Asiatic salmon were reportedly introduced to the Northwest in 1971, but I am not yet familiar with the details. On the other hand, Winthrop fish have been shipped to Japan in past years. The viral presence in ovarian fluid would suggest a likelihood that H. salmonis is egg transmissible. It would appear that the virus is latent for indeterminable periods of time and that stress would elicit a productive response. Stress during the spawning period may very well elicit a change from a latency to the active, pathogenic state.

As of now, the Winthrop broodstock program has been closed out, and stocks from clean stations will be used for the program in the future.

INCIDENCE OF CERATOMYXA SHASTA IN SELECTED HATCHERY STOCKS OF COHO AND GENETIC CROSSES OF FALL CHINOOK SALMON

by

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The progeny from genetic crosses between Trask and Big Creek fall chinook were tested to determine their susceptibility to Ceratomyxa shasta infections. Previous experiments have shown that Trask fall chinook are highly susceptible to C. shasta infections while Big Creek fall chinook are quite resistant to this parasite. Four hatchery stocks of coho salmon were also examined for levels of resistance to this myxosporidan.

The genetic crosses were made at Big Creek Salmon Hatchery and eggs were held there until the eyed stage. Eyed eggs were then transported to the Oregon State University Fish Disease Laboratory and reared until experimental size. The four hatchery stocks of coho salmon fingerlings were also held at the Fish Disease Laboratory prior to exposure. To help prevent bacterial infections, all groups of fish were placed on a diet of medicated Oregon Moist Pellet (3% Tm50) ten 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 72 hours in the Willamette River. The fall chinook groups were exposed from July 30 to August 2, 1975 with a mean water temperature of 17°C. Coho stocks were exposed from June 20 to June 23, 1975 with a mean water temperature of 15.5°C. After the exposure period, all lots of fish were transferred to the Fish Disease Laboratory and maintained at 18°C for the remainder of the experiment. Each group 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.

Results from the genetic crosses are presented in Table I. Conforming to previous experiments, the Trask fall chinook were highly susceptible to C. shasta infections and the Big Creek fall chinook were resistant. However, both crosses, Big Creek male with a Trask female, and Big Creek female with a Trask male produced progeny which were more resistant to Ceratomyxosis than Trask fall chinook.

The levels of infection varied widely among the different coho stocks. The results shown in Table II indicate that coho stocks derived

from coastal locations are more susceptible to ceratomyxa infections than Columbia River strains. These results are in agreement with previous data reported at these meetings with fall chinook and steelhead.

Table I. Incidence of Ceratomyxa shasta in Genetic Crosses of Fall Chinook[1]

Cross	No. of Fish Exposed	Total Deaths	Deaths Due to C. shasta	Percent Loss from C. shasta	Mean Day of Death
Big Creek Male x Big Creek Female	75	8	0	o	--
Trask Male x Trask Female	80	77	74	92.5	27
Trask Male x Big Creek Female	75	8	3	4.0	41
Trask Female x Big Creek Male	75	31	25	33.3	30

[1] These fish were exposed for 72 hours in the Willamette River at a mean temperature of 17°C. After the exposure period all groups were transferred to well water and maintained at 18°C for the remainder of the experiment.

Table II. Incidence of Ceratomyxa shasta in Four Hatchery Stocks of Coho Salmon[1]

Source of Fish (Hatchery)	No. of Fish Exposed	Total Deaths	Deaths Due to C. shasta	Percent Loss from C. shasta	Mean Day of Death
Alsea	85	71	71	83.5	37
Big Creek	85	2	0	0	--
Nehalem	75	45	45	60	42
Bonneville	100	13	13	13	56

[1] These fish were exposed for 72 hours in the Willamette River at a mean temperature of 15.5°C. After the exposure period all groups were transferred to well water and maintained at 18°C for the remainder of the experiment.

ENVIRONMENTAL CONTROL

USE OF SODIUM THIOSULFATE DECHLORINATED MUNICIPAL WATER IN SALMON CULTURE

by

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One problem commonly facing a fisheries researcher is obtaining adequate and suitable water. For various reasons, obvious sources are inaccessible or impractical.

A solution to this problem is the use of a chlorinated municipal water source as the sole aqueous media. This has special significance in light of interest in heated water from industrial processes for aquacultural use. These waters are often chlorinated

The addition of chlorine gas to water forms hypochlorous and hydrochloric acid:

$$Cl_2 + H_2O \rightleftharpoons HOCl + H^+ + Cl$$

Hypochloric acid dissociates to yield hydrogen and hypochloride ions:

$$HOCl \rightleftharpoons H^+ + OCl$$

hydrogen and hypochlorite ions quantities vary with pH and temperature

Most municipal water sources aim for a chlorine residual of 0.3 ppm at the consumer. This is in excess of toxic limits for fish culture.

Various workers have reported on low levels of chlorine necessary to produce a toxic response (Holland, et al., 1960; Zillich, 1972).

While carbon absorption has been used for dechlorination during rearing of all life stages of salmonids, Brungs (1973) stated that it is inadequate to remove chloramines and thus may be an unsuitable dechlorination method for sensitive ogranisms. Carbon absorption is also prohibitive on very large scale implementation.

The technique for dechlorination using $Na_2S_2O_3$ is well documented. In fact, chlorine toxicity studies utilize this method as a control in

laboratory conditions (Coventry, et al., 1935; Zillich, 1972).

There is substantial evidence that sodium thiosulfate, unlike carbon absorption, removes both chloramines and free chlorine.

The reaction by which sodium thiosulfate neutralizes the toxic effect of chlorinated water is as follows:

$$4Cl_2 + Na_2S_2O_3\ 5H_2O = 8Cl^- + 2SO_4^{2-} + 2Na^+ + 10H^+$$

Thus, it may be said that

$$1 \text{ molecule } Na_2S_2O_3\ 5H_2O = 4Cl_2$$

And:

$$1 \text{ ppm } Na_2S_2O_3 = 1.143 \text{ ppm } Cl_2$$

$$1 \text{ ppm } Cl_2 = 0.875 \text{ ppm } Na_2S_2O_3$$

A bioassay was run during June through September 1975, assessing growth, freshwater survival, blood chemistry, Gill ATP-ase levels and saltwater survival for coho reared in $Na_2S_2O_3$ dechlorinated water and a common source unchlorinated control.

Sodium thiosulfate addition was through Wallace and Tiernan dry chemical feeders. Water flow varied from 3-7 cfs for the dechlorination site. Control was in a lacustrine environment.

On July 8 and 9, four groups of 1,200 coho fingerlings and a single group of 1,200 coho presmoltes were placed in separate nylon net pens at the dechlorination site. Single control groups of 600 fingerlings and 1,200 presmolts were similarly held at the common source control.

Two of the four groups of coho fingerlings were held in 4' x 4' x 6' nets while the others were held in 8' x 8' x 6' nets. In both treatment groups, two diets were adminstered. Two percent of body weight per day for one pen and four percent of body weight per day for the other. Coho smolts were fed two percent per day body weight, as were control groups. These levels were revised biweekly, based on growth sample data. All populations were fed Silver Cup, a commercial dry salmon feed, in the appropriate size. No initial mortalities occurred, and on July 15, the bioassay began.

Results

Gill ATP-ase Analysis

Adaption of salmon to saltwater should result in an increase of Na^+ and K^+ activated gill ATP-ase activity. This activity is associated with removal of Na^+ and other ions from the blood (Zaugg and McLain, 1970). It is this extra-renal active transport enzyme triggered phenomena which allows salmon to adapt from a freshwater to a saltwater environment. The adaption process is termed smoltification.

In an effort to understand the effects of sodium thiosulfate dechlorination and deliberate chlorine exposure upon gill ATP-ase levels, three groups of coho smolts were transported to the U.S. Fish and Wildlife Service, Cook, Washington, Nutrition Lab. There, W.S. Zaugg and L.R. McLain performed assays to determine the levels of gill ATP-ase. (See Table 1.)

Table 1. Mean weight in grams, fork length in mm, pooled gill weight grams and moles Pi/(mg protein per hour) for three groups of coho smolts.

	W	F	Gill Wt.	moles Pi / mg protein per hour
Group 1	39.8	137	.2	18.35
Group 2	34.1	137	.14	11.05
Group 3	28.0	129	.18	17.83

Group Number 1 represents smolts reared in $Na_2S_2O_3$ dechlorinated water. This population suffered nine percent mortality upon short term exposure to chlorinated water.

Group Number 2 are smolts reared at the control site, which were deliberately exposed to 0.2 ppm chlorine in city tap water for 1-1/2 hours.

Group Number 3 are smolts from the control.

While levels for groups 1 and 3 were similar and near the range shown for this time period (August), high water temperatures retard gill ATP-ase formation (Zaugg and McLain, 1970; Zaugg et al, 1972). (Group 2 levels were below both 1 and 3, possibly due to chlorine exposure and gill damage).

Survival

Coho fingerling survival averaged 91.5 percent for the dechlorinated group and 71 percent for control. Coho smolt survival was 91 percent for dechlorinated groups and 66 percent for controls. Control mortality is attributed to bird predation and elevated temperatures (66°F at control site). Principle cause of mortality in the dechlorinated group was due to chlorine toxicity, caused by a halt in sodium thiosulfate introduction. The hydroscopic nature of sodium thiosulfate allowed a crust to halt introduction, and chlorine concentration reached toxic levels.

Mortality peaked three hours after malfunction and continued for two days.

An effort was made to capitalize on this incident and a series of bioparameters were collected on the affected population and the unaffected controls.

HEALTH

Blood Chemistry

Biweekly blood samples were taken from each population and analyzed for plasma chloride, plasma glucose, hematocrit, calcium and osmolality.

Glucose, chloride and hematocrit levels were within normal ranges for coho as stated by Wedemeyer and Chatterton, 1970 and 1971.

During accidental and subsequent experimental deliberate exposure to chlorine, however, glucose levels were elevated and chloride levels were depressed. This fits the classic stress reaction of salmonids. Blood calcium and osmolality showed no response to chlorine exposure.

Gill Histology

Biweekly gill samples were taken. A single gill arch was excised, fixed, H&E stained, and mounted for examination.

The gills of fish reared in $Na_2S_2O_3$ dechlorinated water showed no evidence of hyperplasia or erosion.

In chlorine damaged gills, the gill lamella and secondary lamella appear severely eroded.

Smolt Adaption to Saltwater

On August 2, two groups of 200 coho smolts were transported from the test and control site to the Henderson Inlet pen culture facility in south Puget Sound. After 21 days of rearing in saltwater, survival was 96% and 75% for the dechlorinated group and the control group, respectively.

Low survival of the control group and post introduction mortalities in general may be attributable to Vivriosis, a saltwater disease, and stress directly related to transport which accounted for 14% of mortality in the control group.

Growth

Coho fingerlings reared in dechlorinated water grew at a rate of 2%/day while control fingerlings grew at a rate of 1.3%/day. Coho smolts reared in dechlorinated water grew at a rate of 0.95%/day, while controls grew at a rate of 0.65%/day. The difference reflects feed regime, 6 times daily vs. 2 times daily at the remote control site and variation between site temperatures. There is a growth advantage to a 4% feed rate as opposed to a 2% feed rate, as well as to populations reared in 8' x 8' x 6' nets vs. numerically equal populations reared in 4' x 4' x 6' nets.

CONCLUSIONS

Sodium thiosulfate dechlorinated water provides an acceptable medium for the rearing of salmonids.

No detrimental effects have been observed on fish survival, growth, health, saltwater survival, or gill ATP-ase levels when compared to a common source control.

Sodium thiosulfate dechlorination is practical at any flow rate, low in cost and uses known technology for introduction (5#/day @ 2 cfs and 0.3 ppm Cl).

Blood chemistry, especially plasma chloride and glucose, and gill examination provide an index of health in regard to chlorination/dechlorination regime.

Credits

I would like to thank Gary Wedemeyer and Tosh Yasatake of the Fish & Wildlife Service Sandpoint, Washington, Fish Disease Laboratory for information and aid concerning blood chemistry and histology; and W. S. Zaugg and L. R. McLain of the Fish & Wildlife Service Cook, Washington, Nutrition Laboratory for aid in ATP-ase assays.

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EFFECTS OF HOLDING TEMPERATURES ON REPRODUCTIVE DEVELOPMENT IN ADULT SOCKEYE SALMON (ONCORHYNCHUS NERKA)

by

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ABSTRACT

Wild adult sockeye salmon (Oncorhynchus nerka) were captured and placed into tanks supplied with Columbia River water so that the effects of four temperature treatments could be determined. Treatment included an initial acclimation period wherein temperatures changed about 2C per day until they reached test temperatures of 10, 16.5, 20, and 22C on day eight, and remained there until day 32 when cooling to 10C began. All surviving fish were sacrificed and examined on day 44. The results indicate that 22C was rapidly and directly lethal to all of the fish and while equally lethal, 20C resulted in complete mortality more slowly by infection rather than thermal death. Comparisons of fish surviving the 10C and 16.5C treatment revealed that 10C was associated with less frequent ventilation of the gills, smaller livers, larger gonads, less geriatrophy and both a lower incidence and a lower antibody titer against Columnaris disease. The authors conclude that 10C would be more favorable for sexually maturing adult sockeye salmon than 16.5C.

INTRODUCTION

Several hatcheries already heat their water for fish culture and other hatcheries anticipate doing this in the near future. These hatcheries are typically located on streams or springs that are exceptionally clean, but so cold that the embryos develop and juvenile fish grow at less than optimal rates for mass production. If the water is heated, the fish gain weight at a substantially higher rate. However, bio-temperature effects probably vary between different life stages and it is not safe to assume that temperatures optimal for juvenile growth are necessarily safe for adults or eggs. Some examples will clarify this point.

Fryer and his coworkers have admirably demonstrated the potential danger to fish from infectious disease agents, when water is heated excessively. For example, Holt et al. (1975) reported no mortality among salmonids from Flexibacter columnaris when the temperature was at or

below 9.4 C (49F), but mortality increased progressively with increasing temperature. Likewise, Udey, Fryer and Pilcher (1975) reported that the geometric mean time to death of salmonids infected from ceratomyxosis was definitely a direct function of temperature. These examples illustrate the concept that excessive heat can promote infectious disease.

Another potential concern is non-infectious, nonlethal pathology which may result from adverse but tolerated high-temperatures that otherwise seem acceptable. In such insidious cases, the pathology is instituted at the molecular level and ramifies to higher levels of organization such as cells, tissues, and organs. Thus, fish exposed chronically to sublethal but adverse levels of heat might show aberrant organ changes as one result. This possibility seemed especially relevant to Pacific salmon on their spawning migration, because they are terminal animals that do not feed, yet they undergo extensive reproductive development and geratic tissue changes prior to spawning and subsequent death.

Adult sockeye salmon (Oncorhynchus nerka) were selected for use in this study for several reasons. Operational costs and special requirements are considerable for adult salmon. Indeed, these primary factors have precluded the use of adult salmon and other large fish in other water quality testing programs. The the relatively small size of the adult sockeye salmon favors it over other available salmon species. Another important factor is that sockeye salmon undergo considerable reproductive development during July and August, which is a period of high water temperatures. Thus this work could indicate the relative impact of river temperatures management practices and might have implications in a hatchery operation.

METHODS

Wild adult sockeye salmon were trapped on July 1, 1969 when the Columbia River was about 16 C. After anesthesia each fish was tagged, weighed, and measured before being assigned randomly to one of four holding tanks (8000 l, 3.6 m diameter, 90 cm deep, with a 1.2 m soft wall surmounting the tank wall.) During the first day, temperatures were cooled to 13 C in all tanks as a precautionary measure. Thereafter water temperatures were adjusted at about 2 C per day to provide different temperature treatments and this was done in a sequence such that on day eight, the four tanks reached 10, 16.5, 20 and 22 C respectively. These temperature treatments were maintained automatically for 24 days and the average daily temperatures are depicted in Figure 1. After day 32 the heated tanks were returned to Tanner Creek temperatures (10-11 C). Reference to a particular tank temperature therefore identifies the entire 44-day treatment.

The water supply to each tank was about 38 l/m and at this rate, it would fill a tank in about 3.5 hours. Columbia River water was the supply

from day 1-20; thereafter Tanner Creek was used. Water quality in the tanks is summarized in Table 1 for the first 20 day period. Water quality between days 20-44 was monitored, but is ommitted here because it was very similar, although less turbid and slightly softer. A recycle pump was used to maintain a current in each tank at about 2.5 cm/sec (at the outside diameter). This also maintained high levels of dissolved oxygen, equilibrated other dissolved gases and provided a disturbed water surface which helped keep the fish quiet.

The fish were observed several times each day and those which died during the experiment were given a necropsy examination. This consisted of determining weight, length, and photographing its general appearance. Various tissues were cultured for Aeromonis salmonicida and Flexibacter columnaris.

All surviving fish were killed and inspected on the 44th day after their capture. Individual fish were reweighed and remeasured before blood and tissues were collected for examination. The total weight and volume of livers and gonads were determined and used to estimate the total number of eggs per female. Agglutinating antibodies against F. columnaris and A. salmonicida were determined according to the methods described by Evans (1957).

RESULTS AND DISCUSSION

Lethal Effects

All of the fish that were heated to 22 or 20 C died prior to termination (Figure 2). Survival at 22 C and 20 C averaged 3.2 days and 11.7 days respectively. The sudden onset and rate of death at 22 C indicated that physical effects of temperature were directly lethal to adult sockeye salmon. However, at least some of the fish survived for a month at 20 C and this implicates a more complex response than just direct thermal lethality. Coutant (1969) reported similar results for adult coho salmon (Oncorhynchus kisutch) and adult chinook salmon (Oncorhynchus tshawytscha). Pathogens were identified from most but not all of the dead fish and probably most of the mortality at 22 and 20 C was influenced by these pathogens whose effects are intensified at warm temperatures (Fryer and Pilcher, 1975).

Mortality reached 33 percent in the 16.5 C tank by the end of the experiment, but most of this occurred during the period of exposure to this temperature. At 10 C, all the fish survived for 21 days; mortality reached a total of about 20 percent by termination.

Sublethal Effects

This section deals with those events which occurred during the life of the test organisms and is based primarily upon the observations of fish which survived the test exposures at 10 and 16.5 C.

Body length and weight changes: Body length and weight changes are listed in Tables 2 and 3. At 10 C the unfed fish increased their body length during the course of the 44 day period and this was due primarily to the development of secondary sexual characteristics, i.e., development of a kipe (hooked snout) in males. Conversely, unfed fish that survived the 16.5 C treatment had a net loss of body length which was statistically significant.

Body weights also declined during the 44 day treatment and this is normal because adult Pacific salmon rarely feed during their spawning run. Body weight losses for males averaged 7.0 percent at the 10 C treatment and 10.5 percent at 16.5 C treatment; this difference in weight loss was statistically significant. Females lost significantly more weight than males in the same temperature treatments, reflecting their higher metabolic costs for egg development. Females lost an average of 8.5 percent of their body weight in the 10 C treatment, but they lost an average of 13.2 percent in the 16.5 C treatment.

These changes appear to reflect the metabolic demands of the fish. Based upon average weight loss of individuals, a temperature rise from 10 C to 16.5 C increases the metabolic demand of males by 150 percent and of females by 155 percent. Also based on weight loss, the metabolic demands of females averaged 121 percent higher than males at the 10 C treatment and averaged 125 percent higher than males at the 16.5 C treatment.

Weight loss per 100 degree days permitted a comparison of the metabolic demands at each temperature and permitted the use of weight loss data from mortalities. Again, the average rate of body weight loss per 100 degree days was progressively higher as temperature increased from 10 C to 22 C (Table 4). Compared to fish at 10 C, the fish at 20 C were losing about twice as much weight and this shows a close conformity to the Q_{10} effect.

Ventilation activity: Ventilation of the gills by the bucal pump was influenced by the temperature as indicated in Table 5. Ventilations averaged 1.20 per second at 11 C (sic) and increased to 1.45 per second at 16.5 C, to 2.07 per second at 20 C. Ventilation rates were thusly following the Q_{10} effect and were essentially doubled by a 10 C rise in temperature.

Changes in liver and GI tract: Liver weights averaged smaller for males than for females (Table 6). Liver weights were directly and significantly correlated to total body weight among females, but this was not true among the males; we have no explanation for this disparity.

The effect of higher temperature on livers of adult sockeye salmon was an increase in size that parallels our observations of metabolic demand. Females lost even more body weight and had even more enlarged livers than males at the 16.5 C treatment or males or females at the 10 C treatment.

Gastrointestinal tracts were not studied quantitatively, but showed several obvious differences. Fat reserves were abundant in the 10 C group at termination, but these were absent among the 16.5 C treatment group. Histological and visual examinations indicated that the GI tracts were more atrophied and less functional among the 16.5 C treatment group. For example, GI tract size had declined considerably among the 16.5 C treatment group compared to fish from the 10 C group which had only slightly shrunken GI tracts.

Secondary sexual development: Surviving male sockeye salmon from the 16.5 C group generally had more advanced secondary sexual characteristics than males from the 10 C treatment group. Snouts (kipes) were more pronouncedly hooked, backs were more humped, and skin was either darker or redder at the higher temperature. Females from 10 and 16.5 C showed no clear cut differences that were evident from external examination.

Changes in gonad and eggs size: Male and female gonad parameters are listed in Table 7. At 10 C, male gonads averaged about 80 g, but at 16.5 C they averaged only about 59 g. Thus higher temperatures were associated with advanced development of seconary sexual characteristics and diminished development of gonads. (It should be noted that increased development of secondary sexual characteristics, such as the darkening of the skin and kipe formation, are also associated with decreased fish quality and desirability among fishermen.)

Male gonad weight showed a significant but inverse correlation to body weight loss. In other words, higher body weight losses were associated with smaller male gonads in this study.

Females bore similar numbers of eggs in both groups but the average weight of those eggs was 33.1 mg in the 10 C treatment group; eggs weighed about 11 percent less weight in the 16.5 C treatment group. This difference in egg weight was not statistically significant. However, regression analysis revealed that the average egg weight was significantly but inversely correlated to percentage body weight loss (Figure 3) both

at 10 C (r -0.59) and at 16.5 C (r -0.76). Since female sockeye salmon lost nearly twice as much weight at 16.5 C than at 10 C, this relationship may explain, in part, why the 16.5 C treatment produced eggs weighing about 11 percent less than at 10 C.

We have no way of predicting the final size that gonads or individual eggs would have achieved had these fish been allowed to live and reach spawning condition in October. Possibly the differences noted here might not have been discernable at spawning time; however, it is also possible that the observed differences would have been enlarged. In either event, the most important concern would be the resultant impact upon the progeny and this is not known.

Pathogens and antibodies: F. columnaris was cultured from only one of twenty-five surviving fish in the 10 C treatment group and was not isolated from the surviving 16.5 C group. A. salmonicida was cultured from two of twenty-five fish in the 10 C treatment group and from five of twenty-one fish in the 16.5 C group.

Agglutinating antibody titers against two diseases are listed in Table 8. Titer levels against A. salmonicida average 1:36 and 1:47 respectively in the 10 C and 16.5 C treatment groups at termination. Both of these levels are relatively low and they are not significantly different. Titer levels against F. columnaris averaged about 1:2 in the 10 C group and averaged about 1:65 in the 16.5 C group at termination. Equally important, the incidence of this antibody was only 8 percent at 10 C but occurred in 91 percent of the 16.5 C treatment group.

While the acquisition of antibody against F. columnaris undoubtedly provided some measure of protection to the survivors, it was accrued through an infectious process which probably killed many fish.

Acquisition of antibodies in fish by live pathogens is a risky proposition and seems no more acceptable here than in human health.

Other Observations

Eye damage: Eye pathology became evident among all lots of fish during the course of the experiment (Table 9). This has been described by Bouck et al. (1976).

CONCLUSIONS

Adult sockeye salmon can survive temperatures between 16 and 20 C for a few weeks if necessary, but such exposure entails a serious threat of extensive mortality, either due to direct thermal death or due indirectly to pathogens. At the 10 C treatment, fish ventilated less frequently, lost

less of their body weight, had smaller livers, larger gonads, larger eggs, less atrophied GI tracts, and fewer thermophillic infectious diseases. The sum of these observations indicate that sexually maturing adult sockeye salmon are favored by temperatures near 10 C and disfavored by temperatures of 16 C or above.

ACKNOWLEDGMENTS

All microbiological and immunological data were collected by Mr. Paul Fujihara as provided by an agreement and transfer of funds from the Federal Water Quality Commission to the Atomic Energy Commission.

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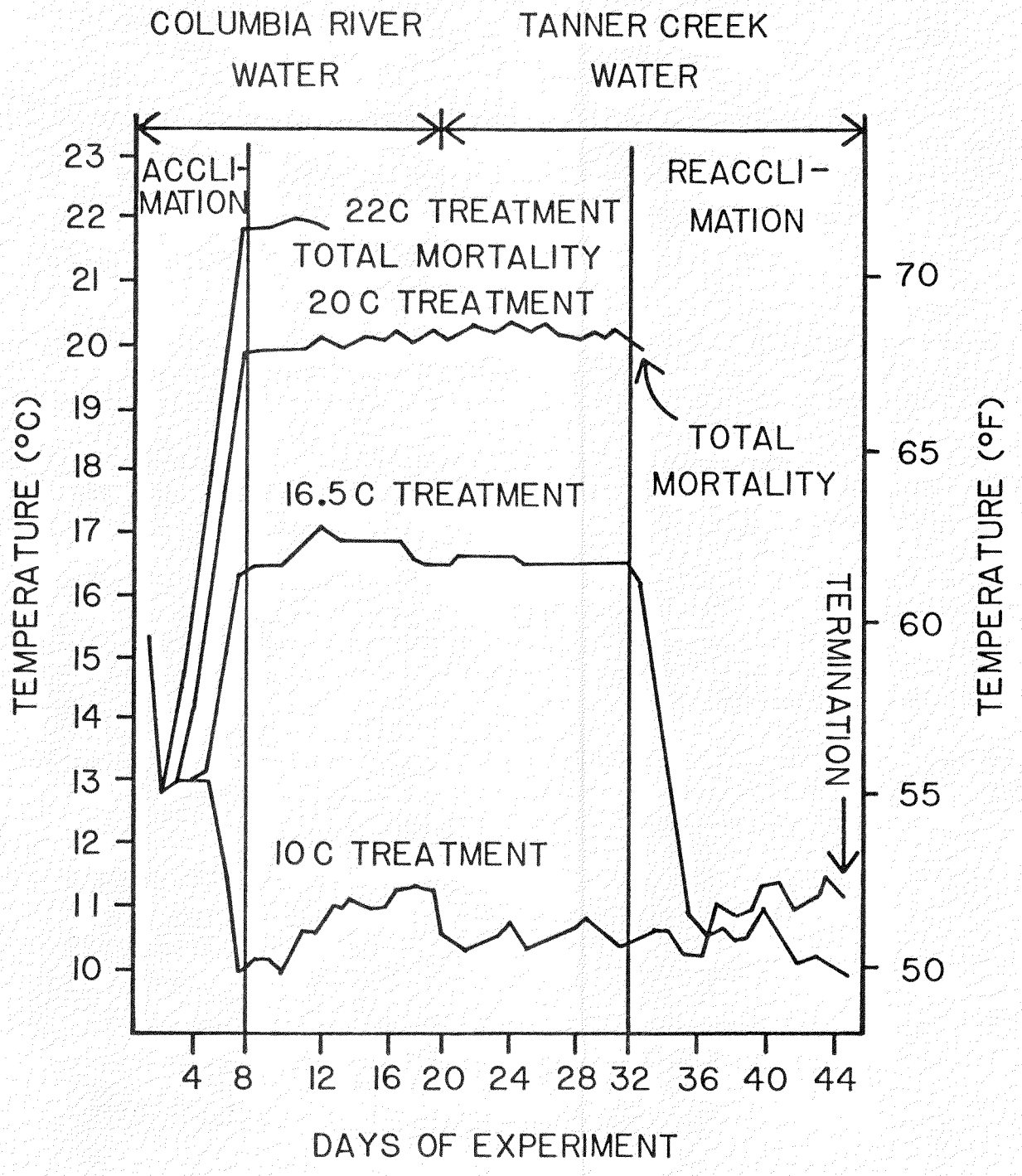

Figure 1. Average daily water temperatures.

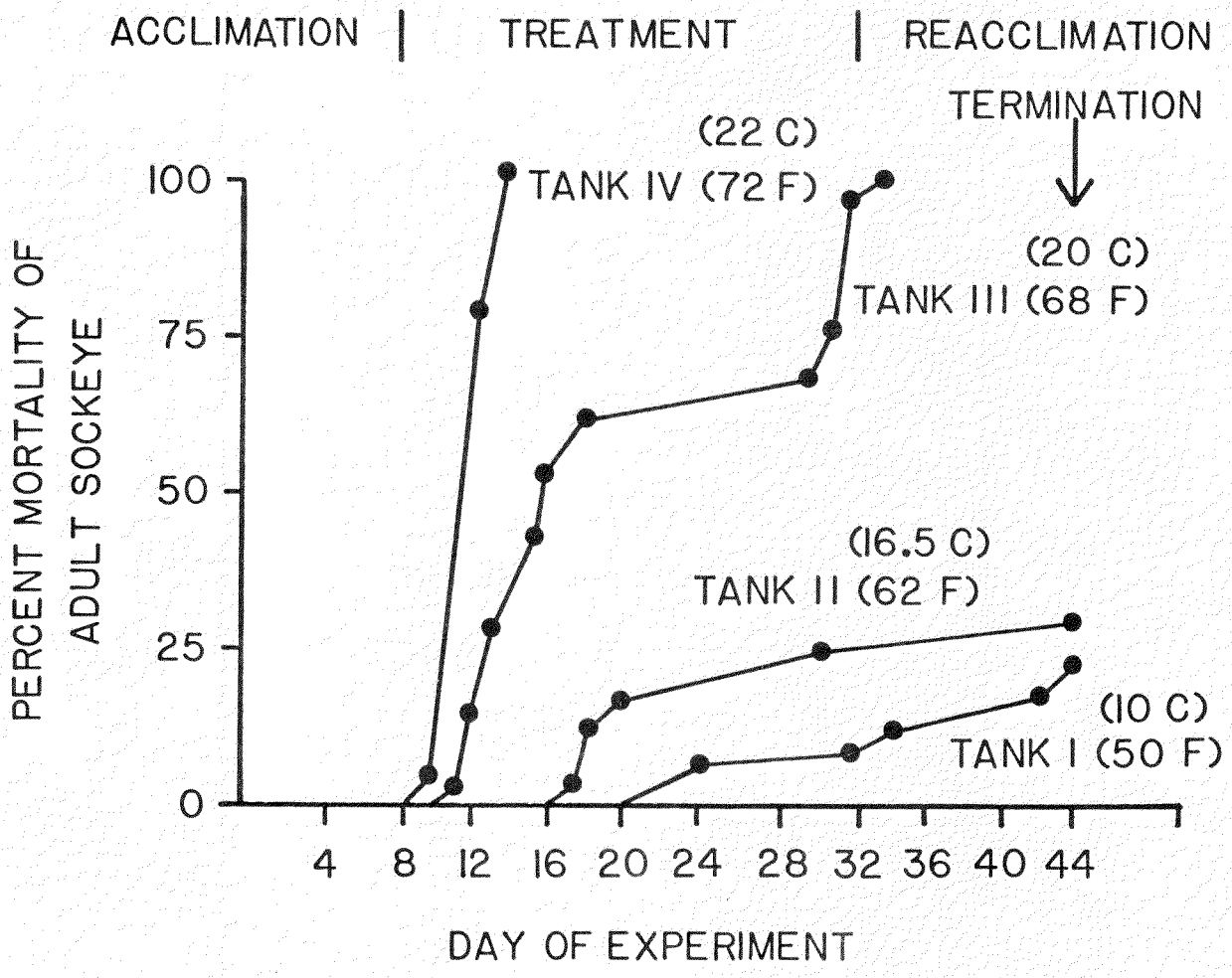

Figure 2. Cumulative mortality of adult sockeye salmon (Oncorhynchus nerka) during four temperature treatments.

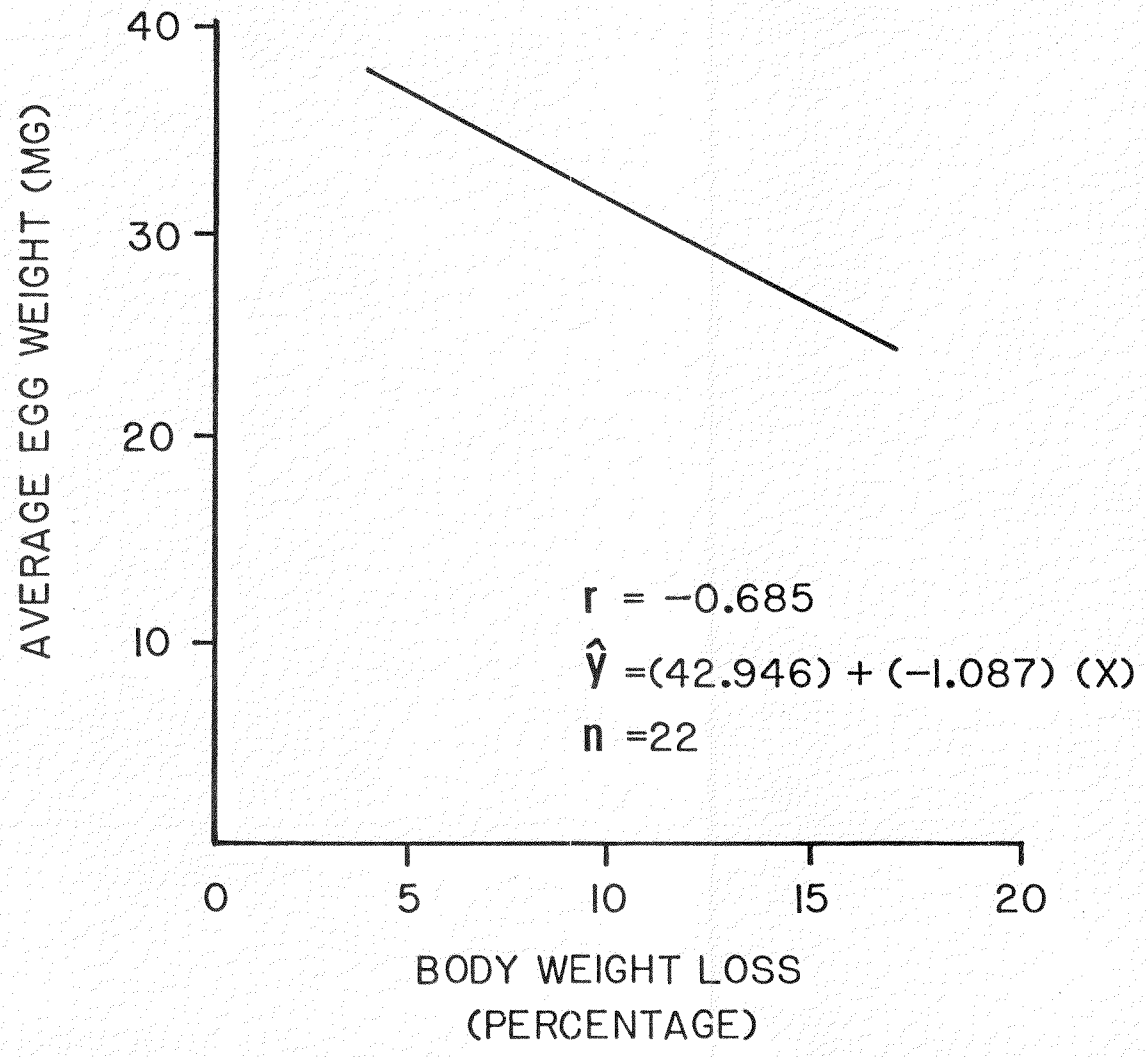

Figure 3. Relationship between body weight loss and resulting average egg weight in adult sockeye salmon (Oncorhynchus nerka).

Table 1. Water quality in adult sockeye salmon (Oncorhynchus nerka) tanks during July 1 - July 19, 1969.1/

Location	Dissolved oxygen (ppm)	pH	Total alkalinity (as ppm of $CaCO_3$)	Total hardness (as ppm of $CaCO_3$)	Ammonia (as ppm N)	Nitrate (as ppm N)	Nitrite (as ppm N)	Cu (as ppb)	Fe (as ppb)	Pb (as ppb)	Mn (as ppb)	Zn (as ppb)
Tank I												
Average	10.1	8.0	57	60	0.08	0.07	< 0.01	5.8	385	15	26	10.0
Range	9.2-10.9	7.7-8.4	53-66	57-67	0.04-0.15	0.04-0.11	< 0.01-	3.8-7.0	280-450	12-18	25-26	7.9-13.2
N	48	45	43	40	13	8	8	3	3	3	2	3
Tank II												
Average	9.2	8.0	57	61	0.12	0.10	< 0.01	4.2	342	13	22	9.0
Range	8.8-9.7	7.7-8.4	53-67	57-66	0.04-0.57	0.05-0.26	< 0.01	3.2-5.3	220-434	11-16	19-24	4.6-13.8
N	48	45	43	40	13	7	7	3	3	3	2	3
Tank III												
Average	8.7	8.0	57	62	0.09	0.08	< 0.02	4.3	330	11	21	10.7
Range	7.9-9.9	7.6-8.5	53-66	57-67	0.02-0.15	0.05-0.12	< 0.01-0.03	4.0-5.0	210-455	9-12	17-24	10.4-11.0
N	48	45	44	40	13	7	7	3	3	3	2	2
Tank IV												
Average	8.3	8.0	57	61	0.17	0.10	< 0.01	4	445	7.5	24	14.4
Range	7.4-9.8	7.8-8.5	54-61	57-65	0.05-0.66	0.06-0.15	< 0.01	4	445	7.5	24	14.4
N	34	31	31	27	9	3	3	1	1	1	1	1
Columbia River Supply												
Average	9.5	8.3	57	61	0.05	0.06	< 0.01	5	710	9	--	18
Range	8.6-10.0	8.1-8.5	53-60	59-64	0.05	0.04-0.09	< 0.01	5	710	9	--	
N	21	21	21	21	8	8	8	1	1	1	--	1

1/ Water supply = Columbia River, Tanner Creek used thereafter.

Table 2. Fork length of adult sockeye salmon (Oncorhynchus nerka) before and after 44-day temperature treatments. 1/

Initial Length	Assigned temperature treatments			
	10C	16.5C	20C	22C
Average (cm)	53.0	53.5	53.5	53.3
95% confidence limits	±0.69	±0.47	±0.77	±0.76
Range	49-59	50-56	50-60	50-60
N	31	31	30	31

Final length change 2/ of surviving fish	10C treatment		16.5C treatment	
	Males	Females	Males	Females
Average (cm	+0.50*	+0.50*	-0.17*	-0.58*
95% confidence limits	±0.29	±0.06	±0.19	±0.35
Range	0-+4.2	0-+2.0	0--0.5	0-2.0
N	14	10	9	12

*Significantly different from initial length.
1/ See Figure 1 for description of temperature treatments.
2/ All fish assigned to migrate at 20 and 22C died.

Table 3. Summary of initial total weight and percentage body weight loss of adult sockeye salmon (Oncorhynchus nerka) during 44-day temperature treatments. 1/

Initial total weight	Assigned temperature treatments			
	10C	16.5C	20C	22C
Average weight (grams)	1764.4	1765.7	1799.6	1773.8
95% confidence limits	± 35.35	± 26.21	± 42.85	± 41.31
Range	1364-2327	1535-2122	1362-2603	1501-2500
N	31	31	30	31

Percentage body weight loss 2/	10C temperature treatment			16.5C temperature treatment		
	Males & females	Males	Females	Males & females	Males	Females
Average	7.6*	7.0*	8.5*	12.0*	10.5*	13.2*
95% confidence limits	±1.25	±1.78	±2.02	±1.44	±2.27	±1.86
Range	1.8-11.9	1.8-11.5	4.0-11.9	3.9-18.3	3.9-13.8	8.0-18.3
N	22	13	9	21	9	12

*Significantly different heterogeneous at the 0.95 level.

1/ See Figure 1 for description of temperature treatments.

2/ Total mortality precluded data at 20 and 22C.

Table 4. Summary of percentage weight loss rate among adult sockeye salmon (Oncorhynchus nerka) during four temperature treatments. 1/

Parameters	Assigned temperature treatment			
	10C	16.7C	20C	22C
Average percent body weight loss per 100 degree days 2/	1.73*	2.20*	2.63*	2.98*
95% confidence limits	±0.250	±0.323	±0.600	±0.553
Range	0.93-3.27	0.60-5.24	0.37-6.26	0.47-6.00
N	31	31	29	29
Sex ratio (F/N)	0.45	0.54	0.48	0.48

*Significantly heterogeneous at the 0.95 level.
1/ See Figure 1 for description of temperature treatments.
2/ Calculations based on weight losses of all fish at time of mortality. A Degree day equals the average daily temperature above 0C for one day, summated during a given period.

Table 5. Summary of ventilation rates of adult sockeye salmon (Oncorhynchus nerka) at different temperature treatments. 1/

Ventilations/second	Temperature treatment		
	11C	16.5C	20C
Average	1.20*	1.45*	2.08*
95% confidence limits	±0.25	±0.15	±0.15
Range	1.00-1.66	1.23-1.86	2.00-2.17
N	5	7	6

*Significantly heterogeneous at 0.95 level.
1/ See Figure 1 for a description of temperature treatments.
2/ Observations on fish maintaining their position in a current of about 2.5 cm/sec. at the outside edge of tanks 4 meters in diameter.

Table 6. Summary of liver characteristics from adult sockeye salmon (Oncorhynchus nerka) that survived a 44-day simulated migration at two temperature regimes. 1/

	10.0C		16.5C	
	Males	Females	Males	Females
Liver weight (grams)				
Average	15.29*	21.75*	23.04*	26.38*
95% confidence limits	1.30	2.45	2.32	2.14
Range	12.5-23.9	16.3-32.0	18.0-28.6	22.1-32.9
N	15	10	9	12
Liver weight as percent of total body weight				
Average	0.94	1.40	1.42	1.76
Range	0.77-1.92	1.18-1.77	0.99-1.83	1.51-2.05

*Significantly heterogeneous at 0.95 level.
1/ See Figure 1 for a description of temperature treatments.

Table 7. Summary female and male gonad parameters from adult sockeye salmon (Oncorhynchus nerka) after 44-day temperature treatments. 1/

	10C temperature treatment		16.5C temperature treatment	
	Total number of eggs	Weight per egg (mg)	Total number of eggs	Weight per egg (mg)
Female:				
Average	2973	33.1	3048	29.4
94% confidence limits	±258	±4.9	±213	±3.1
Range	2405-3679	27.5-45.3	2659-3744	19.8-35.6
N	10	9	12	12

	10C temperature treatment		16.5 temperature treatment	
	Total weight of both gonads (g/Kg body wt)	Percentage of body weight	Total weight of both gonads (g/Kg body wt)	Percentage of body weight
Male:				
Average	80.03*	4.71	58.52*	3.53
95% confidence limits	±35.26	±2.60	±49.69	±2.80
Range	16.2-124.1	1.03-6.60	29.2-91.6	1.87-5.02
N	15	15	9	9

*Significantly different at 0.95 level.

1/ See Figure 1 for a description of temperature treatments.

Table 8. Summary of antibody titers against Flexibacter columnaris and Aeromonas salmonicida in sockeye salmon (Oncorhynchus nerka) after 44-day temperature treatments. 1/

Parameters	Temperature treatment	
	10C	16C
Fish surviving to termination	25/31	21/31
Percentage survival	80.5%	67.7%
Average titer against *A. salmonicida*	1:36	1:47
Range	0-1:80	0-1:80
Titer incidence	92%	86%
Average titer against *F. columnaris*	1:1.6*	1:64.8*
Range	0-1:20	0-1:320
Titer incidence	8%	91%

*Significantly different

1/ See Figure 1 for a description of the temperature treatments.

Table 9. Incidence of eye damage among adult sockeye salmon (Oncorhynchus nerka) during 44-day temperature treatments. 1/

Parameters	Temperature treatment			
	10C	16.5C	20C	22C
Number of fish	31	31	30	31
Incidence of eye damage (%)	35	29	53	65
Left eye only	19	10	33	36
Right eye only	3	0	7	10
Both eyes	13	19	13	19

1/ See Figure 1 for a description of temperature treatments.

HOLDING AND SPAWNING SPRING CHINOOK IN REDUCED PHOTOPERIOD

by

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A study was conducted at Dexter holding ponds in 1975 to determine if a reduced daily photoperiod would advance the maturation rate of spring chinook, and through earlier spawning reduce prespawning mortality and egg losses. Prespawning mortalities and high egg losses have been chronic problems at this location for many years. It is suspected that water quality and/or temperature are the primary cause of these losses.

One of the two 40' x 160' holding ponds was subdivided into two equal volume 20' x 160' units, one covered (#1A) to exclude natural light and one uncovered (#1B). All fish arriving prior to July 15 were randomly divided between units #1A and #1B. A total of 703 fish entered unit #1A and were thereafter exposed to a daily 6-hour photoperiod produced with incandescent lamps. In the control unit #1B a total of 550 fish were collected and these experienced natural lighting and photoperiod. Fish arriving after July 15 were diverted into the remaining 40' x 160' holding pond (#2).

A breakdown of the number of fish, mortalities, and spawning data for each holding unit is presented in Table 1. The fish held in reduced photoperiod, unit #1A, spawned earlier (August 21-September 9) than those in unit #1B and pond #2 (September 9-October 15). However, the prespawning mortality of females in #1A was 55% and only slightly less than the 64 and 66% female losses in unit #1B and pond #2. Egg losses, to eye up, were 22.5% from #1A, 25.3% from #1B, and 21.8% from pond #2. The early spawning period caused another problem, all early eggs had to be transported to South Santiam Hatchery for incubation because water temperatures at Willamette were in excess of 57 F until mid-September.

It was concluded that an earlier spawning period could be accomplished by reducing the photoperiod. However, an earlier spawning period does not appear to be the solution to the problem of prespawning mortalities or high egg losses at Dexter.

Table 1. Number of spring chinook held, mortalities, and spawning summary for each of three holding ponds at Dexter, 1975.

Pond #	Covered #1A	Control #1B	Late Fish #2
Total Fish:	703	550	839
No. Females	389 1/	283	398
No. Males	316	267	441
Mortalities:			
No. Females	210	182	263
% Females	55	64	66
No. Males 2/	156	127	150
Spawned:			
No. Females	171	101	135
% Females	45	36	34
Egg Take:			
Date Start	8/21	9/9	9/9
Date Finish	9/9	10/15	10/15
H_2O Temp:			
Start	5	57	57
Finish	57	58	58
Max	57	60	60
Min	54	57	57
No. Eggs (x 1, 000)	785	444	646
Egg Loss (%)	22.5	25.3	21.8

1/ Eight females killed green.
2/ Males handled differently than females; some reused, some classed surplus and killed.

THE USE OF LOW-GRADE HEAT EFFLUENT FROM NUCLEAR POWER STATIONS IN AQUACULTURE

by

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ABSTRACT

The presentation made at the 26th Annual Fish Culture Conference highlighted a study recently completed by The UMA Group in assessing the feasibility of utilizing low-grade heat effluent from a nuclear generating station in aquaculture. The terms of reference for this study specifically centered around the intensive culture of Salmonids in a production-scale facility as applicable to a Fisheries Rehabilitation Program for the Great Lakes. (A four agency Steering Committee including representatives from Environment Canada, Atomic Energy of Canada, Ontario Hydro and the Ontario Ministry of Natural Resources provided study direction and review).

At the present time, there are no nuclear power plants in Canada which make use of low-grade heat effluent for freshwater aquaculture. Beyond Canadian borders, four pilot plant facilities in Scotland, Sweden, Japan and USA are operational, but these relate almost exclusively to mariculture.

Three sites, Pickering, Bruce and Darlington, were assessed in the study and it was demonstrated that it is feasible to construct a production type facility at each site. The Bruce site on Lake Huron, however, provides considerable cost advantage, primarily associated with the cold water supply. Seasonal projections of effluent temperatures fall within the range desired for salmonid rearing except for the summer months. These summer temperatures exceed optimal and even lethal limits, hence the need for a cold water source for blending and/or direct use during summer rearing.

Definition of a production level for a fish-culture facility cannot be based on poundage alone; both the number and size by species must be identified in conjunction with a definitive rearing schedule which reflects stocking or market demands. For facilities with a production level varying from 100, 000 lbs. /year to 500, 000 lbs. /year, unit costs including both operating and capital, were shown to vary from $10.68/lb. to $5.99/lb. for a fish of 27 gm. size. These unit costs are competitive with those advanced by the Ontario Trout Farmers Association for a facility with a production capacity greater than 150, 000 lbs. /yr. However, for larger size fish (e.g. 225 gms) these unit costs are not competitive.

The rearing water demands for even a large-scale freshwater fish-culture operation (say 500, 000 lbs. /year) represent only a fraction (1-1/2%) of the actual condenser flows available from a nuclear station.

FACTORS WHICH INFLUENCE SMOLT DEVELOPMENT AND SALTWATER ADAPTATION OF SALMONIDS

by

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Studies over the past several years on some of the physiological processes involved in parr-smolt transformation and saltwater adaptation of salmonids have shown that we can now think in very practical terms about how we might use environmental and dietary situations to better prepare young salmonids to meet the challenges encountered after release.

Laboratory and other tests accurately demonstrate when smolt transformation occurs and migratory behavior emerges, thus permitting more accurate determination of proper release times. When these tests are properly employed it is possible to avoid premature releases, when fish may experience delays in outmigration, or late releases which can be unnecessarily costly in terms of excees feed and handling, and which might also cause the outmigrant to encounter unfavorable river conditions en route (especially those migrating several hundred miles).

During the past several years we have been studying the relationship of Na, K-ATPase activity in the gills of steelhead trout, coho and chinook salmon, to parr= smolt transformation. In all of our studies we have found good correlation between an increase in this enzyme activity during the spring months and transformation to smolts as determined by changes in coefficients of condition, migratory behavior, and saltwater adaptability. Other investigators have confirmed our observations, finding the level of ATPase activity an effective measure of migratory behavior in coho and Atlantic salmon.

We have observed in several instances that factors affecting the level of gill ATPase activity also affect migration. In steelhead trout, for example, outmigration of juveniles and the seasonal rise in ATPase activity can be induced in experimental fish about 6 weeks prior to controls by an advanced photoperiod schedule. We have found that the smolting process can be completely inhibited or reversed in water at 55°F or warmer. On the other hand, water temperatures of 59°F greatly accelerated the smolting of coho salmon compared to controls at 42°F. However, cold water exposure is necessary if the smolt stage, developed in warm water, is to remain for an extended period of time.

In addition to these environmental factors which influence the smolting process, increases in dietary salt intake significantly elevate

gill Na, K-ATPase activity and improve saltwater survival rates. Chinook salmon at the Oregon Fish Commission's Sandy Hatchery fed diets containing 2 and 4% added NaCl survived exposure to saltwater (33-34 ppt) in greater numbers than controls, especially early in the spring. The salt-fed fish also had higher gill Na, K-ATPase activity than controls. Salt-fed (4 and 8%) coho salmon developed elevated gill ATPase activity.

In summary, we have worked with three methods of altering either the timing of parr-smolt transformation or activity of the gill ATPase enzyme. These methods are:

1. Changing photoperiod schedules
2. Altering environmental temperature
3. Feeding salt

Advanced photoperiods will cause early smolting in steelhead in water not warmer than about 54°F. Coho smolting can likewise be accelerated in sufficiently cool water. The upper limit is not known for coho but may well be below that for steelhead since higher temperatures alone, in absence of advanced photoperiods, cause early smolting. This may tend to mask any effect by the advanced photoperiod. Photoperiod and temperature effects on smolting in chinook salmon have not yet been studied in detail.

Salt feeding appears to have a beneficial effect on the ability to adapt to saltwater and can be employed as a means of reducing the stress of acclimation, especially in young salmon and steelhead that reach saltwater within one month of release.

The methods discussed above have potential for use either singly or in combination, in preparing juvenile salmonids for maximum survival when released.

GENETICS

SOME EFFECTS, ON RAINBOW TROUT BROODSTOCK, OF REDUCING WATER TEMPERATURE FROM 59°F. to 52°F.

by

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INTRODUCTION

The Hagerman, Idaho National Fish Hatchery is one of approximately twenty trout hatcheries located adjacent to the Snake River in the Hagerman-Twin Falls vicinity. The constant 59°F. spring water provides near ideal trout rearing conditions but is too warm for the production of viable trout eggs. To our knowledge there are no successful egg-producing operations in the area utilizing the 59°F. water.

The Hagerman National Fish Hatchery is currently classified as disease-free and outside sources of disease-free eggs have become increasingly difficult to obtain in recent years. Therefore, a decision was made to embark on a broodstock program utilizing chilled water for holding broodstock. A 50-ton water chiller was installed which is capable of cooling 150 gpm of water from 59°F. to 52°F.

METHODS

Three strains of rainbow trout broodstock are currently held at the hatchery, covering the following spawning periods:

(1) August - October
(2) November - December
(3) January - March

As the required length of time in the chilled water to produce viable eggs was unknown, the August - October spawners were placed in the chilled water for two different periods of time prior to anticipated spawning.

(1) 100 female and 30 male 3-year old rainbow trout were placed in chilled water as soon as the chiller was installed (April 16, 1975).
(2) 100 female and 30 male 3-year old rainbow trout were placed in chilled water July 8, 1975.
(3) The remainder of the lot (114 females and 113 males) were retained in the 59°F. water. It was known that these females

would produce poor quality eggs but the quality of sperm from the males was not known.

RESULTS

Spawning of females placed in chilled water April 16, 1975 commenced August 8, 1975 (114 days in chilled water) and terminated October 14, 1975; or a spawning period extending over 67 days. Overall eyeup for eggs from this group was 91%.

Spawning of females placed in chilled water July 18, 1975 commenced September 3, 1975 (57 days in chilled water) and terminated October 14, 1975; or a spawning period extending over 41 days. Overall egg eyeup from this group was 84%.

Numerous males from the 59°F. water were utilized to fertilize eggs stripped from females held in the chilled water. Eyeup percentages for these eggs compared favorably with those resulting from males and females held in the chilled water (as high as 99% in certain instances). Therefore, it is evident that the males can be held in 59°F. water; thereby increasing the number of females that can be placed in the chilled water system.

The spawning period for females held in chilled water four months prior to initial spawning extended over 67 days whereas the spawning period for females held in chilled water two months prior to initial spawning extended over 41 days. For this particular lot of fish, then, the shorter time in chilled water prior to spawning resulted in a more nearly even ripening of the overall group; thereby necessitating less handling during the spawn-taking process.

SUMMARY

Holding of females in chilled water for 57 days prior to initial spawning did produce viable eggs. It is not necessary to hold males in chilled water as egg fertilization success was excellent utilizing males held in unchilled 59°F. water.

FUTURE PLANS

We are currently involved with spawning of the November - December spawners which have been in chilled water seven months. These are 4-year old rainbow trout and as we have only thirty females in this lot we will not obtain any significant data from this group.

The January - March spawners have been split into three groups and will be in chilled water one, three, and five months, respectively,

prior to anticipated time of spawning. These are 2-year old fish and number two hundred in each of the three groups. It is anticipated that data from these groups will provide further information to aid in planning a broodstock program based on the utilization of chilled water.

To date, our chilled water system has consisted of a meager 150 gpm of single-pass water. We are currently involved with construction of a reuse system which will utilize the 150 gpm as the makeup water; thus providing a chilled water system of 1,000 to 1,500 gpm.

The reuse system will include a bio-filter of the up-flow type; utilizing polystyrene beads as the media. Water from the raceways will flow by gravity through the filter, then pumped to an aeration tower, and gravity flow return to the raceways.

Current plans call for an annual egg program of two to three million eyed rainbow trout eggs and two million eyed Lahontan cutthroat trout eggs. It will likely be four to five years before this projected program is attained.

FIRST SPAWNING OF MATURE CULTURED COHO IN THE REGION OF BRETAGNE (FRANCE)

by

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Centre Oceanologique de Bretagne, Brest, France
and
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ABSTRACT

Coho salmon were cultured to maturity in both a freshwater hatchery and a saltwater, diked, tidal pond in the region of Bretagne (France) as a part of the CNEXO-COB coho salmon farming studies. The annual temperature range of the streamfed hatchery is 4°C to 18°C, and the pH ranges from 6.7 to 7.0. Seawater temperature range from 9°C to 18.5°C, with salinities as high as 34%.

Coho salmon cultured from eyed eggs of 1974 Puget Sound brood parents reached first maturity in freshwater in 1973 as 2-year fish. The fish were reared entirely on dry-pelleted diets of French manufacture. The mortality during egg incubation was high, and the survival rate through swim-up was only 0.3%. However, the surviving fry were normal and subsequent growth was excellent. The average weight in July, 1974, was 10 g. At 10 months post swim-up, 52% of the fish were smolted with an average weight of 156 g, and 48% (averaging 38 g) remained as parred fish.

The remaining coho of the 1971 brood that did not mature at 2 years were transferred in December 1973 to a diked, tidal, seawater pond, where they were cultured in floating net-pens. All fish were fed on dry pellets, and 29% matured in 1974; 82% of these adults were males. The size for both sexes ranged from 1 to 2.5 kg. Although the size and general condition of these maturing fish adults was good, they did not exhibit the usual sexual characteristics of mature coho cultured in seawater pens at the NMFS Manchester station. The majority of the ovaries were either atrophied or only partially developed. The few loose eggs obtained from those females were transparent with centrally-located oil droplets. This could possibly be due to water entering the vent. It is thought that a combination of adverse environmental conditions in the pond during the summer months may have contributed to this condition. At times seawater temperatures were as high as 18.5°C, and dissolved oxygen levels dropped as low as 5 ppm.

Eyed coho eggs from Columbia River 1972 broodstock were cultured in the same freshwater hatchery. In December 1974, approximately 20% of the progeny reached first maturity as 2-year olds. The average length and weight of the females was 35.7 cm and 600 g, and the males, 31.7 cm and 447 g. The eggs appeared to be normal in color, but of small size. Approximately 43% of the females spawned were considered to have eggs in the proper state of maturity. The rest were either tight or over-ripe with water-hardened eggs. The survival of the eggs through the swim-up fry stage was approximately 20%, all of which appeared normal. In spite of a late fry feeding start, the progeny of this spawning reached an average weight of 43 g by November (1975), with sizes ranging from 10 g to 180 g. This growth was better than that of coho progeny from eyed eggs obtained from U.S. stocks in December, 1974.

RETURNS FROM MARKED SUMMERRUN STEELHEAD HIGH GRADE PROGRAM

by

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The summerun steelhead report last year in Seattle was for the 1973 brood year and the 74 spawning which is the same group of fish. This report is on the following two brood years. To prevent confusion and show the terminology that has developed a sequence of two possible consecutive summerrun steelhead cycles would be:

	1965 adults to freshwater peaking July	
	1966 spawn and rear	
	1967 plant + 1/2 in ocean	
1 Salt -	1968 all year in ocean	Five year
2 Salt -	1969 all year in ocean	
3 Salt -	1970 brood year	
	1971 spawn and rear	
	1972 plant + 1/2 in ocean	
1 Salt -	1973 all year in ocean	Five year
2 Salt -	1974 all year in ocean	
3 Salt -	1975 brood year	

Normally the current year brood is not checked till spawning and after the December N W Fish Culturist meeting. This year there was a need to check the sizes for a possibly new criteria to use in the high grade program. The long awaited return of the 1972 plant of the 1970 brood high graded smolts with a right maxillary mark as a 3 salt cycle had arrived. These were the first of sufficient numbers as fingerlings to keep separate under maximum production operations.

As a result of our early sorting and for the first time a size number peak was discovered for our 3 salt fish. It is 32" for females and 34" for males. Judging from the 2 salt and the 1 salt returns over the years this size peak will not change readily in the same environment. The percentage to the size peak seems to increase with the program. Whether possible advances are real within the same salt cycle remains to be seen. With the evidence produced in the return this year it is felt reasonable to state the desired larger steelhead has been achieved (see Fig. I.)

It is a sloppy run and far from homogenesis. The different year classes are also heterogenesis. That the slower maturing and larger adult trend will continue is encouraged by the dramatic and unexpected

harvest of large summer run steelhead in all the tributaries of the Columbia River planted from this hatchery. The same increase occurred in returning adults to the Cowlitz Hatchery from our later eggs of the same season. The same trend is in our current no-marks (See Table 1).

This means the selection standard for the high grade stock was more severe than the biological differences. The later spawning large fish and/or some smaller early spawners of that brood year also responded to a degree to the 3 salt 5 year cycle potential. The first marked 3 salt 5 year cycle to the hatchery with superior size was in 1967. They were too scarce to suggest a peak size. Figure 2 compares size changes two generations apart or 1965 with 1975.

The hatchery has had marked returns of a 3 salt 6 year cycle adult. This happened again in the current 75 brood with the right ventral mark (See Table 1). Previous returns of this 3 salt 6 year cycle were in 63 and in 65 broods. None of the specimens of this cycle were or are superior to other specimens without the mark and in the same spawning season. This suggests that the slower growing fingerling while it may or may not be slower maturing did not demonstrate the larger size potential which did develop within the overall run of fish.

SMOLTS:

The primary reason for the two year freshwater plant of fingerling is insufficient size in the first year to make a smolt plant for good return. This right ventral mark was the latest check to see if there is a biological break off between maximum size of smolt and desired return in size and numbers of adults. At 2-1/2 per pound these were the largest smolts ever planted here and the percentage return clearly was superior to the balance of the same years plant (See Table 2). In fact the best correlation relates to poundage rather than numbers. Size wise more returned in the 1 salt cycle and less in the 3 cycle than of the yearling smolt high grade of the same planting season. However the statement that the larger the smolt the better the return is still valid.

There are other factors involved such as pond space and water volume in late summer or the cost of feed which could affect limits in applying. Holding fingerling for an extra growing season does salvage a fatal undersize smolt situation. After starting with 12 per pound minimum size we are now down to 9. If the fingerling are not 8+ per pound by mid May they are not part of that years smolt program.

fig.2

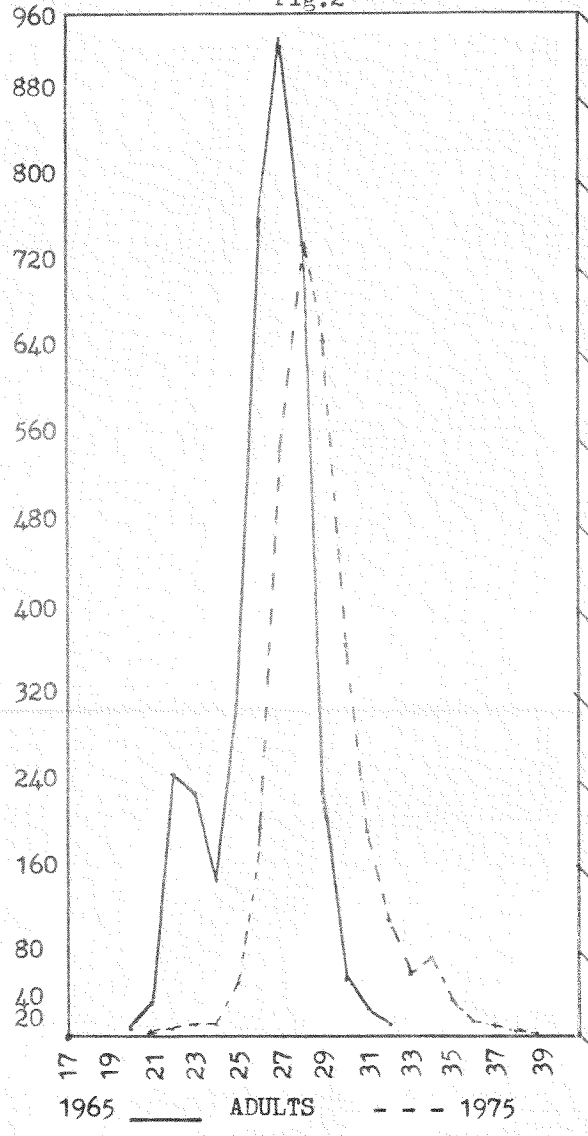
960
880
800
720
640
560
480
400
320
240
160
80
40
20
17 19 21 23 25 27 29 31 33 35 37 39
1965 ADULTS 1975

fig.1

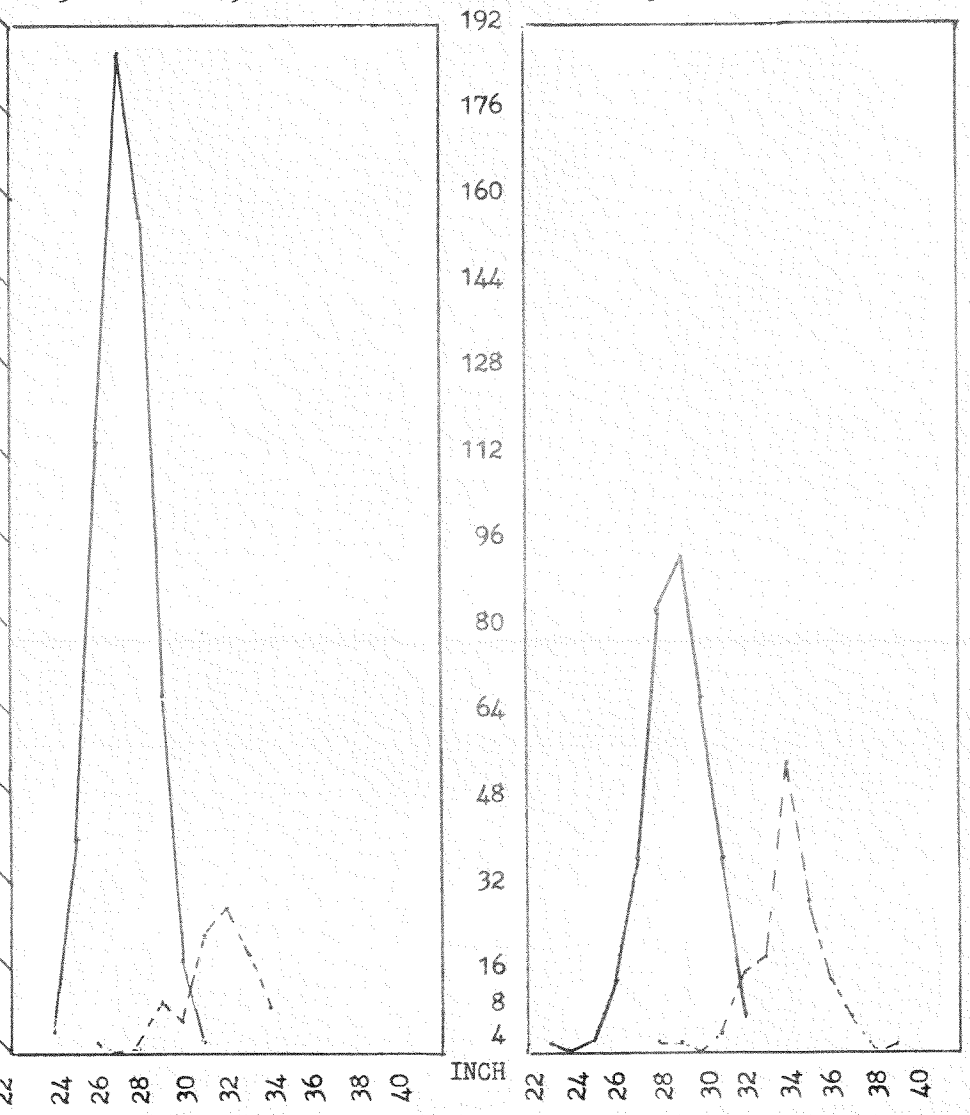
FEMALE
2 SALT 74
3 SALT 75
RIGHT MAXILLARY
CLIP
MALE
2 SALT 74
3 SALT 75
192
176
160
144
128
112
96
80
64
48
32
16
8
4
INCH
22 24 26 28 30 32 34 36 38 40
22 24 26 28 30 32 34 36 38 40

TABLE I
BROOD 1975

INCH	NO-MARK		LF-PECT		RT-PECT		RT-MAX		RT-VEN	
	m	f	m	f	m	f	m	f	m	f
	MIXED		1 SALT		2 SALT		3 SALT		3 SALT	
17	1									
21	2									
22	7	1	1							
23	9	1	3	1						
24	2	5	1	2	1	4				
25	5	28	1			17				1
26	3	93			8	91		2		
27	34	211	X	X	32	272				
28	82	262		X	107	287	2	1		1
29	112	202	X		140	159	2	9	1	4
30	123	61			132	43		5	1	
31	75	35			54		4	22	1	
32	25	13			25		15	27	1	1
33	7	12			3		18	18	1	1
34	9	4					54	8		
35	9	1					28			
36	3						13			
37	-						7			
38	2						-			
39	-						1			

X - errors marking Rt-Pect

TOTAL 3077

TABLE II

PLANT YEAR	AGE	MARK	LBS	#	NUMBER	DATE	$\frac{1}{2}$ or NON	Salt Water Period $1\frac{1}{2}$	$2\frac{1}{2}$	$3\frac{1}{2}$	TOTAL
71	1	Lf-Ven	1530	$5\frac{1}{2}$	10,000	4/19	3	19	71	17	110
72+	1	Rt-Max	9370	$6\frac{1}{2}$	60,000	5/3-11-26		2	926	236	1164
72	1	-	5885	$6\frac{1}{2}$	38,000	"					
72	2	Rt-Ven	8400	$2\frac{1}{2}$	21,000	4/17		361	544	14	919
73+	1	Rt-Pect	6700	$7\frac{1}{2}$	50,000	4/14		37	1375		
73+	1	-	7095	$7\frac{1}{2}$	50,000	5/1					
74+	1	Rt-Pect	4165	6	25,000	4/19-22		13			
74+	1	-	11,600	6-7	78,000	"					

+ selected high grade

MOVEMENTS AND ANGLER CATCHES OF TWO STRAINS OF HATCHERY-REARED RAINBOW TROUT IN A SMALL OREGON STREAM

by

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Studies in 1974 with two strains of rainbow trout and their hybrids indicated some potential differences in angler catches and movements from a small stream, Mill Creek, Oregon. Facilities were designed in 1975 to accurately measure the downstream movements of groups of planted trout. A concurrent, intensive creel census was utilized to determine angler catches of each group.

A weir and fish trap were operated on Mill Creek from 14 April to 18 July 1975. The weir consisted of removable sections bolted to a permanent concrete sill. The study section extended upstream from the weir a distance of 15 km (9.3 miles). Fish were planted at each of six bridges within the study section. Equal numbers of four rainbow trout groups (Roaring River, Cape Cod, RR male X CC female, CC male X RR female) were planted at each of five planting dates. The Roaring River strain was originally from Idaho, and is the stock source for most catchable plants in the Willamette Valley. The Cape Cod strain arrived in Oregon via Washington. The brood stock has been isolated at Roaring River Hatchery, and plants have been restricted.

The research work on Mill Creek had several results apropos to management decisions. Among these were:

1. Test groups of fish were planted at the upper end of the study area 12 days before opening day. Results indicate high percentages of fish moved 15 km out of the system prior to opening day, but the number of Cape Cod trout moving was significantly lower, at the 95% level: a minimum of 13.0% RR male X CC female, 12.6% Roaring River, 10.1% CC male X RR female, and only 2.5% Cape Cod trout leaving the system.

2. Angler catches for those fish released 12 days prior to opening day were significantly higher (90% confidence level) for Cape Cod trout.

3. Of the 2000 fish planted just two days prior to opening day, less than 1% moved out of the system in those two days.

4. Of the 2000 fish planted for opening day, 29.0% of the Roaring River fish, 44.2% of the CC male X RR female, 47.6% of the RR male X

CC female, and 71.4% of the Cape Cod fish were ultimately caught by anglers. The catches of Cape Cod fish were significantly higher than other groups, at the 95% level. All catches of Roaring River fish occurred in the first week of the season.

5. Plants later in the season indicated that when streamflow is low, restricting active downstream movements, angler catches of each group were similar. When flow was adequate for downstream movement, there were active movements of Roaring River fish, and, to a lesser extent, hybrid groups.

Acknowledgements

I wish to acknowledge the assistance of Mr. William Wingfield and his staff at Roaring River Hatchery, and Mr. David V. Buchanan of the Oregon Department of Fish and Wildlife. This project was partially financed by Federal Aid in Fish Restoration funds, Oregon Project F-94-R.

THE EFFECT OF PARENTAL AGE-CLASS ON THE CONTRIBUTION OF CHINOOK SALMON TO THE WASHINGTON FISHERY

by

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In 1971 a selective breeding program began at the University of Washington to determine the effects of parental age-class on growth and survival of chinook salmon. The purpose was to evaluate parental age-class as a basis for selection in a selective breeding program.

In 1973 the following five inter-year crosses were made, indicating female first: 4x4, 4x3, 4x2, 3x3 and 3x2. Early life histories of these fish were evaluated prior to smoltification. Before release each fish was tagged with a binary coded wire tag indicating the particular group and making information on the contribution of the various groups to the fishery available through tag recovery. Numbers and size at release are indicated in Tables 1 and 2.

Recoveries of the fish first appeared in August 1974, three months after release in mid-May. Information is now available for the first year of these fish in the Washington fishery, August 1974 through July 1975.

Analysis indicates that the two groups with two year old male parents entered the fishery in greater numbers than those with three and four year old male parents (Table 1). Number of recoveries seems not to be affected by the age of the female parent to the same degree.

Age of the parents appears to have an effect on growth rate. In the two groups with three year old male parents, 4x3 and 3x3, the effect of the female parent is particularly apparent (Table 2). The larger size at recovery and return of the 4x2, 3x3 and 3x2 groups suggests however, that there is a growth effect by both parents.

The fish caught in the first year were primarily in the sport fishery of Puget Sound. Figure 1 indicates the various locations of capture. Fish from the 4x3 group occurred with the most frequency in the Seattle area, while fish from the 4x2, 3x3 and 3x2 groups appeared most often in southern Puget Sound.

The differences of occurance of these groups in these two areas is significant at the 95% confidence level by Chi-square analysis. The 4x4 group was not recovered frequently enough for a valid analysis of location of capture.

Evaluation of the adult returns of these fish can only be made at this point on jack returns. Percent returns to date of the 4x4 and 4x3 groups is approximately 0.03% and that of the 4x2, 3x3 and 3x2 is approximately 0.2%. Average size of the 4x4 group in 1975 was 45.5 cm and slightly over one kilogram. Average size of the 4x2, 3x3 and 3x2 groups was 55 cm and approximately two kilograms. All returns to date of the 4x3 group occurred in 1974. The early return of the 4x2, 3x3 and 3x2 groups and the greater occurance of these fish in southern Puget Sound indicates that more of these fish are remaining throughout their life cycle in the Puget Sound area.

Analysis of the differences of these inter-year crosses will continue until 1977 when the adult returns should be complete. Possible outcomes from this research are to develop methods to produce faster growing and maturing fish, thus yielding quantitative gains in a particular stock; the shortening of generation time increasing the number of cycles over a period of years to facilitate selective breeding and possible manipulation of stock location and behavior for desired results in a particular fishery.

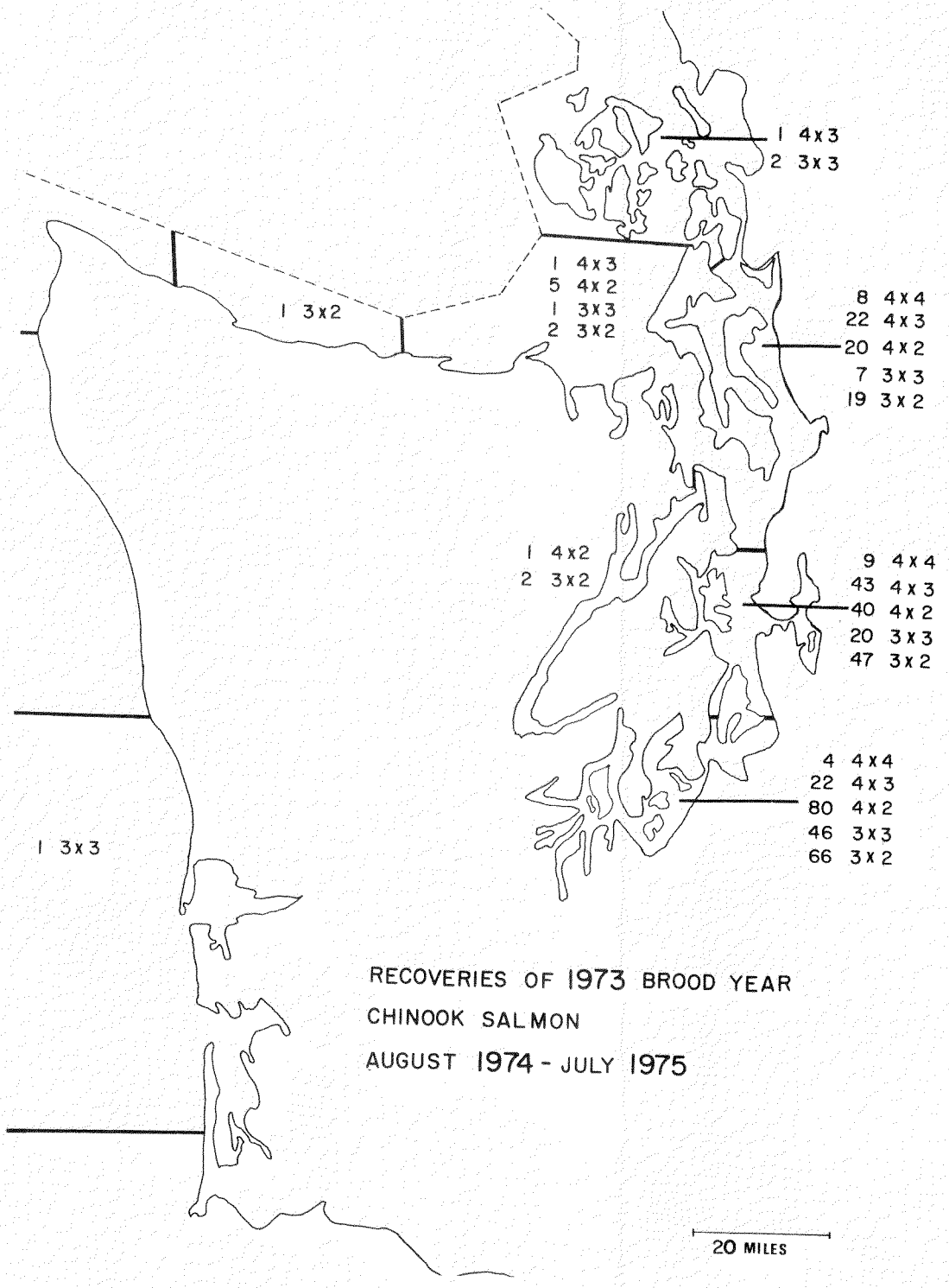
Table 1. Number of releases, recoveries in the fishery and jack returns to the hatchery of the 1973 brood year chinook salmon inter-year crosses.

Cross ♀x♂	Number Released	Number Recovered in Fishery	Percent Recovered	Number of Jack Returns 1974-1975	Percent Returns	Total Number Recoveries & Returns	Total Percent
4x4	35,894	21	0.06	12	0.03	33	0.09
4x3	32,077	89	0.28	11	0.03	100	0.31
4x2	41,956	146	0.35	81	0.19	227	0.54
3x3	41,730	77	0.18	83	0.20	160	0.38
3x2	38,430	137	0.36	77	0.20	214	0.56

Table 2. Average length (cm) at release, recovery and jack returns 1975 of the 1973 brood year chinook salmon inter-year crosses.

Cross ♀X♂	Average Length at Release	Average Length Recovery, July 1975	Average Length Return 1975
4x4	10.6	40.5	45.5
4x3	10.2	37.0	-*
4x2	10.1	45.1	54.7
3x3	10.3	48.8	55.8
3x2	9.9	44.6	53.7

*All returns of the 4x3 cross to date occurred in 1974.


1 4x3
2 3x3
1 4x3
5 4x2
1 3x3
2 3x2
1 3x2
8 4x4
22 4x3
20 4x2
7 3x3
19 3x2
1 4x2
2 3x2
9 4x4
43 4x3
40 4x2
20 3x3
47 3x2
4 4x4
22 4x3
80 4x2
46 3x3
66 3x2
1 3x3
RECOVERIES OF 1973 BROOD YEAR
CHINOOK SALMON
AUGUST 1974 - JULY 1975
20 MILES

EARLY LIFE HISTORY STUDY OF THREE WASHINGTON DEPARTMENT OF FISHERIES COHO SALMON (ONCORHYNCHUS KISUTCH) POPULATIONS BY INTERRACIAL HYBRIDIZATION

by

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The purpose of this study is to evaluate all possible crosses between three hatchery strains of coho salmon on the basis of their performance during early life history, i.e., fertilization of the eggs to smoltification.

The 1974 brood year coho salmon were collected at each of three Washington Department of Fisheries hatcheries (Green River, Simpson, and Skykomish). Sex products from 30 males and 30 females were taken at each hatchery and transported to the Green River hatchery where crosses were made according to a 3x3 factorial design; in addition a sample of each cross was taken to the U. W. College of Fisheries for hatching and rearing.

Experimental design

Females \ Males	Green River	Simpson	Skykomish
Green River	Green River x Green River	Simpson x Green River	Skykomish x Green River
Simpson	Green River x Simpson	Simpson x Simpson	Skykomish x Simpson
Skykomish	Green River x Skykomish	Simpson x Skykomish	Skykomish x Skykomish

After the crosses were made, data were taken on various aspects of the early life history. These included♀

1. Average egg size
2. Temperature units to 50% and 100% hatching
3. Mortality at eyeing, hatching
4. Rate of yolk absorption
5. Food conversion efficiency
6. Differences in disease susceptibility
7. Electrophoretic analysis of selected enzyme systems

After the fish reached a size adequate for marking, the various crosses were tagged with individual Bergman-Jefferts tags and are being grown for a spring release.

Adult data can then be analyzed, based on returns to the hatchery and contribution to the fishery.

Results at this time are still preliminary. In order to insure observed differences are genetic differences associated with each stock, replication of at least one additional year-class is needed.

The most interesting results to date are associated with food conversion efficiency. Egg size varied among the various stocks. The Simpson stock had the largest eggs (0.83 cm), while Green River stock eggs were intermediate (0.80 cm) and Skykomish stock eggs were the smallest (0.78 cm). This resulted, as would be expected, in a differential fry size at "button-up." The fry resulting from Simpson stock averaged 0.58 gm, the fry from Green River stock averaged 0.53 gm, and the fry from Skykomish stock averaged 0.51 gm.

At the College of Fisheries hatchery, each cross was reduced to 850 fry for the food conversion experiment, while at the Green River hatchery each cross was reduced to 20,000 fry. All crosses at both locations were fed a fixed ration, depending on their size. Final results indicate some significant differences in growth and conversion efficiency. Hybrid vigor is evident in all inter-hatchery strain crosses when compared with the pure lines.

The most striking data are those on fry derived from the Skykomish stock, both males and females. The fry from this stock were initially the smallest, but became the largest. Also, fry from crosses where the Skykomish males contributed sperm are the largest in the other groups. In addition, the conversion factors are the best in all cases where parents from the Skykomish stock were used. This trend is the same at both the College of Fisheries and the Green River hatchery. Skykomish fish appear to have a superior ability to convert food. This appears to be a genetic difference which could be exploited in management schemes.

A replicate of the experiment is being performed, utilizing 1975 brood year coho.

Results of food conversion experiments at College of Fisheries hatchery

Cross Female	Male	Initial weight (g)	Final weight (g)	Conversion	% gain	% mortality
Sim.	x Sim.	0.57	3.05	1.42	435.1	0.94
Sim.	x G. R.	0.60	3.53	1.35	488.3	1.76
Sim.	x Sky.	0.58	3.59	1.28	519.0	1.18
G. R.	x Sim.	0.56	3.07	1.31	448.2	0.82
G. R.	x G. R.	0.53	2.53	1.56	377.4	1.05
G. R.	x Sky.	0.52	3.20	1.26	515.4	0.82
Sky.	x Sim.	0.51	3.53	1.21	592.2	1.41
Sky.	x G. R.	0.49	3.54	1.21	622.4	1.18
Sky.	x Sky.	0.51	3.44	1.25	574.5	0.94

Results of food conversion experiments at Green River hatchery

Cross Female	Male	Initial weight (g)	Final weight (g)	Conversion	% gain	% mortality
Sim.	x Sim.	0.58	2.11	1.46	263.8	2.9
Sim.	x G. R.	0.59	2.24	1.47	279.7	2 5
Sim.	x Sky.	0.57	2.41	1.28	322.8	3.2
G. R.	x Sim.	0.52	2.08	1.30	300.0	0.9
G. R.	x G. R.	0.55	2.04	1.46	270.9	0.9
G. R.	x Sky.	0.55	2.12	1.34	285.5	0.9
Sky.	x Sim.	0.51	2.44	1.10	378.4	0.8
Sky.	x G. R.	0.49	2.36	1.14	381.6	0.5
Sky.	x Sky.	0.51	2.28	1.22	347.1	0.5

PERFORMANCE OF THREE CROSSES OF DESCHUTES SUMMER STEELHEAD AT ROUND BUTTE HATCHERY MADRAS, OREGON

by

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Introduction

The objective of this experiment was to evaluate the performance of progeny from crosses of wild x wild, wild x hatchery and hatchery x hatchery adult summer steelhead under hatchery conditions and subsequently evaluate the adult returns from each group.

Experimental Design

To evaluate the brood stock selection program, eggs were obtained from 1974 brood hatchery and wild steelhead returning to the Pelton trapping facility. Eggs were incubated in Heath incubators and fry reared at Round Butte Hatchery. The three crosses consisted of hatchery males x hatchery females, wild males x hatchery females and wild males x wild females. Progeny from the three crosses were handled in a similar manner throughout the experimental period.

The wild x hatchery and one half of the wild x wild eggs were spawned Feb. 26, 1974, the rest of the wild x wild eggs were taken March 8, 1974 and placed in 58^{O} water to increase temperature units so the entire group would be ponded at the same time. The hatchery x hatchery eggs were spawned March 6, 1974 and placed in 54^{O} water. All three groups were ponded within a three day period.

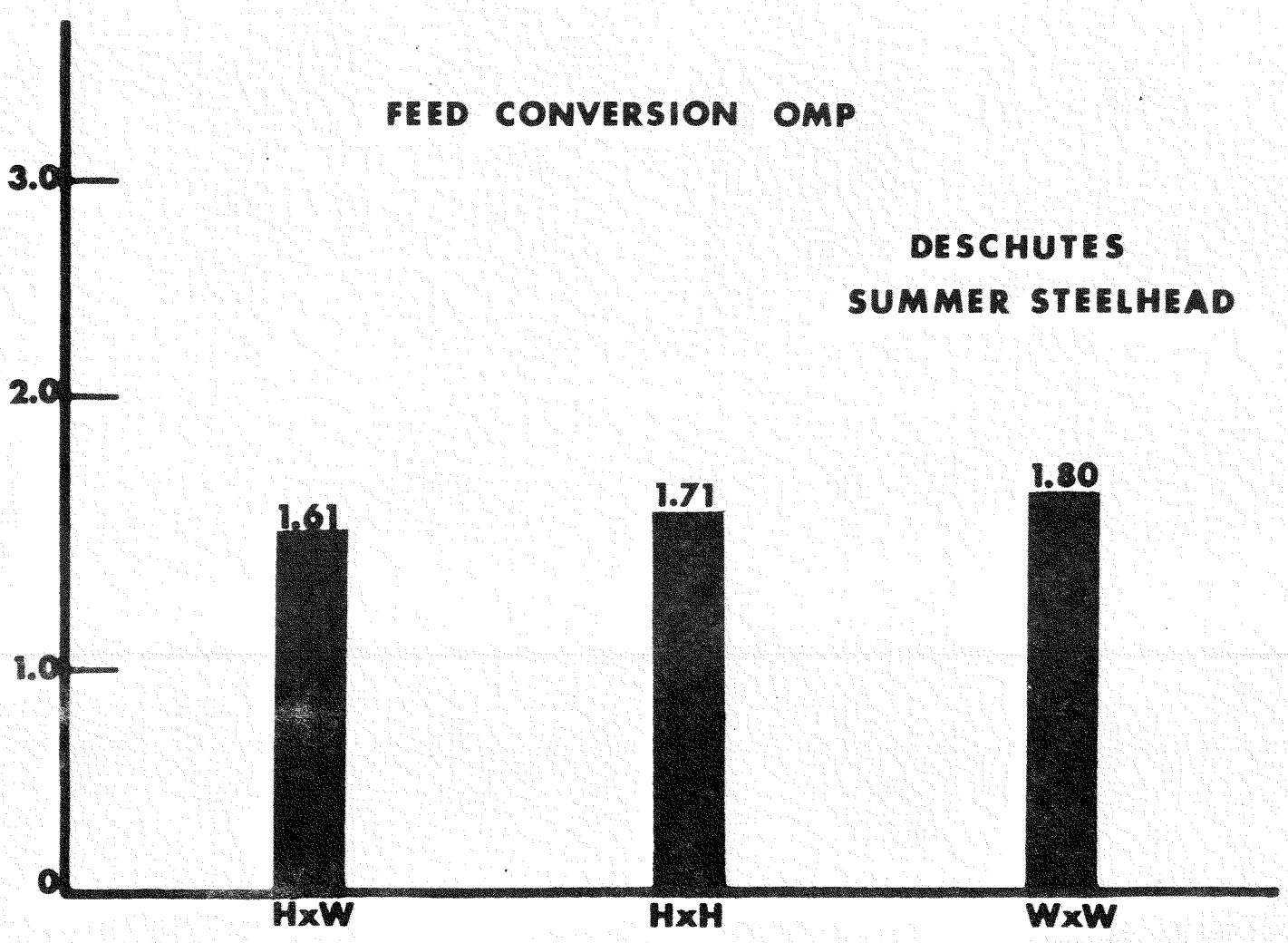
Initially the hatchery x wild and wild x wild fry were started in six-foot circular tanks. The hatchery x hatchery cross was started in a 10 x 30 ft. oval pond. Each group was stocked at a similar density to insure similar treatment. Later the three groups were marked and ponded in 16' x 75' x 3' rectangular rearing ponds. The hatchery x hatchery cross experienced some loss due to gill disease while in the oval pond. In September 1974 the same group contacted another disease which was never identified. The growth rate of this group was retarded because of the disease and/or toxicity problem. All three groups were hand-fed every half hour during normal working hours until they reached 800 fish per pound and then they were fed every hour. Automatic feeders were installed in October 1974 and each group was fed a small amount of feed every 20 minutes from daylight until dark.

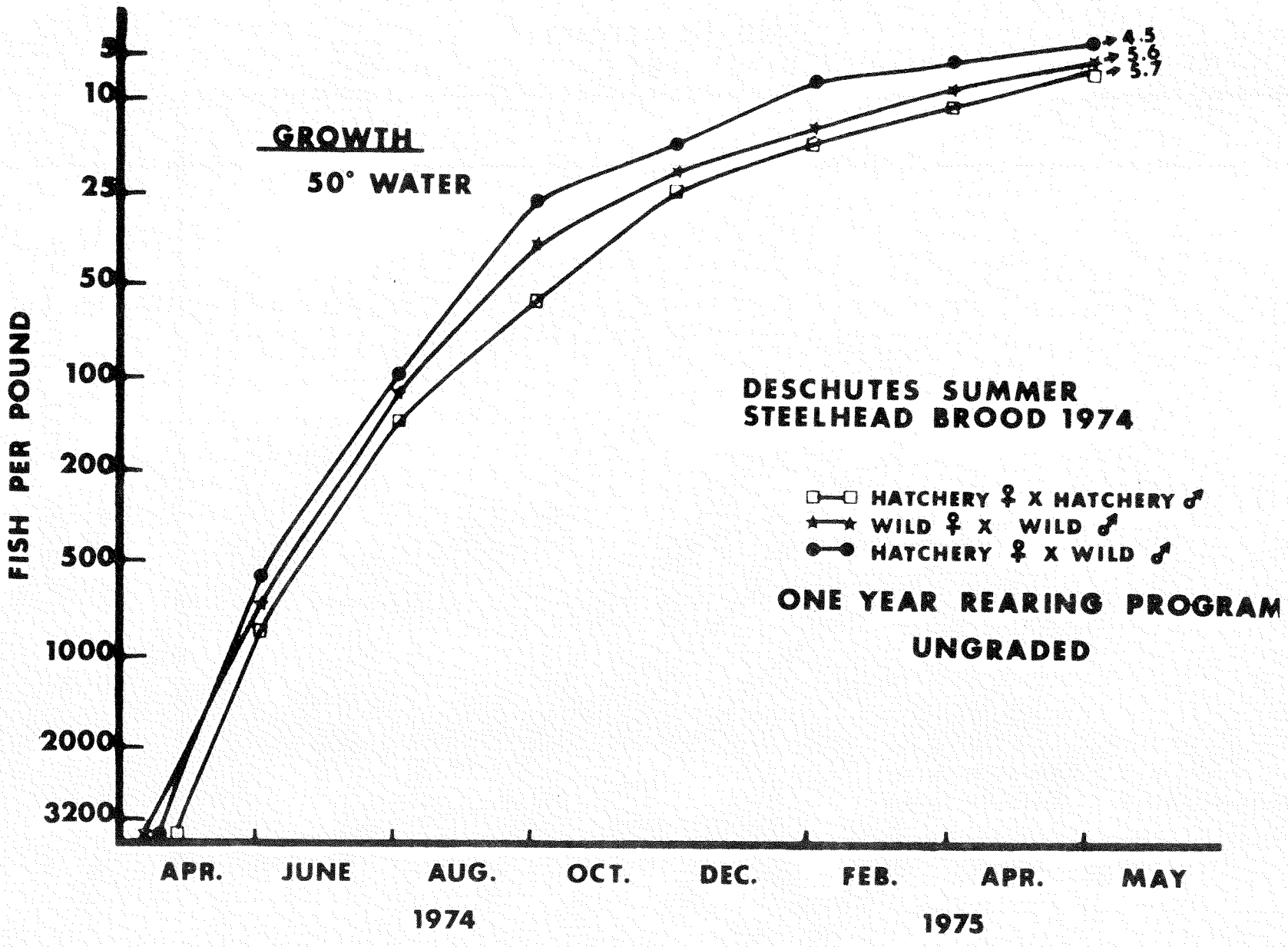
Results and Discussion

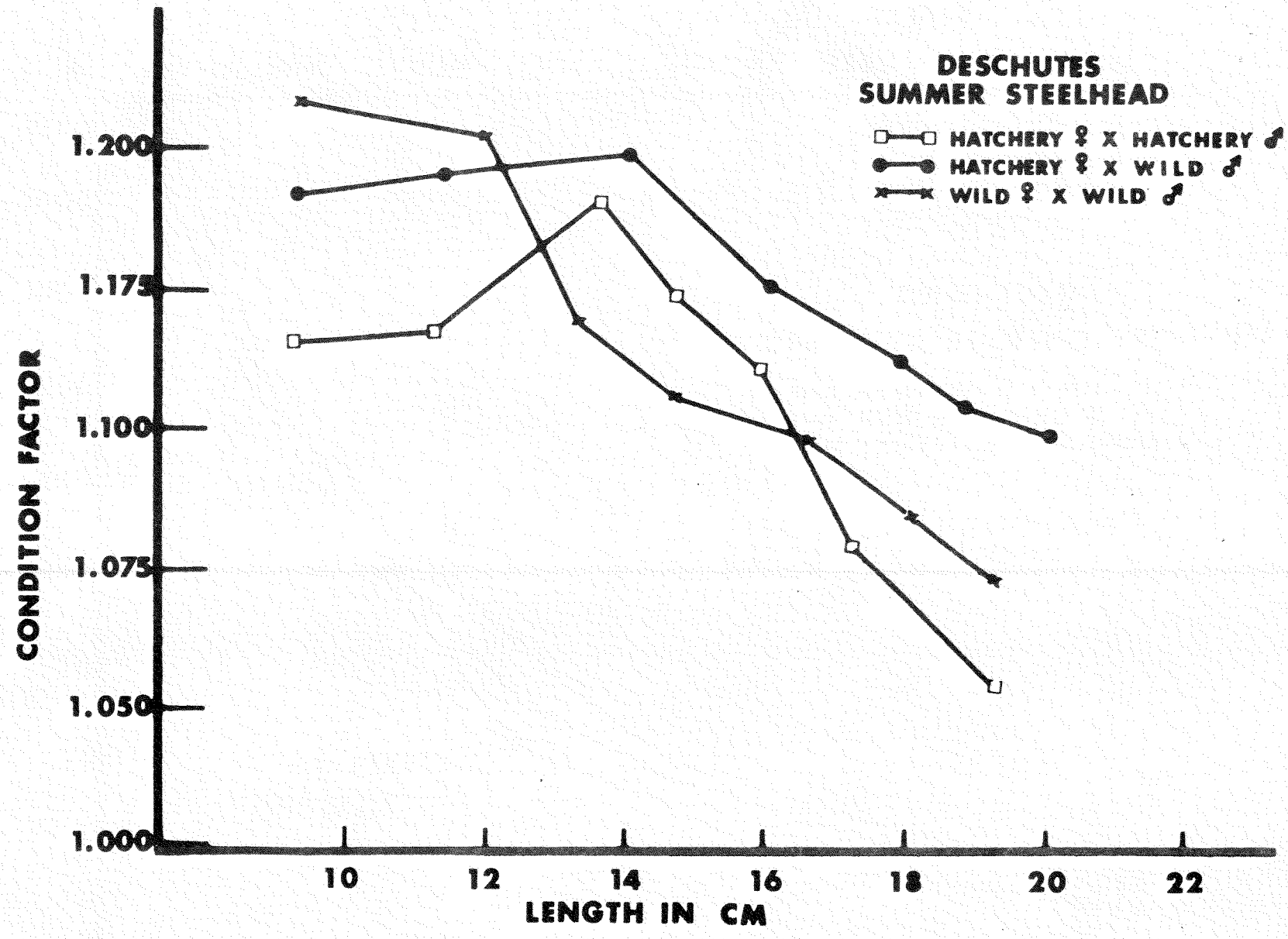
The hatchery x wild cross had a food conversion of 1.61 throughout the experimental rearing period (Figure 1). This group seemed to feed more actively or voraciously than the other two groups. The hatchery x hatchery cross had a food conversion of 1.71 even though they had a disease or toxicity problem for two months. Possibly they would have grown as well or better than the hatchery x wild cross if the problem had not been encountered. The wild x wild cross had a food conversion of 1.80.

At time of release in May 1975, the H x H, H x W and W x W crosses were 5.6, 4.5 and 5.7 fish per pound respectively (Figure 2). The mean length of the H x W group was 20.0 cm at time of release while the H x H and W x W groups had a mean length of 19.2 and 18.7 cm respectively (Figure 3). Mean coefficient of condition was 1.101 for the H x W cross, 1.050 for the H x H cross and 1.074 for the W x W cross at time of release. (Figure 4).

In conclusion, preliminary findings indicate that summer steelhead progeny from parents of hatchery origin will out-perform progeny from wild-type parents under hatchery conditions. However, the subsequent return of adults from each group is the most important consideration in evaluating a brood stock selection program.


FEED CONVERSION OMP
DESCHUTES
SUMMER STEELHEAD
3.0
2.0
1.0
0
1.61
1.71
1.80
HxW
HxH
WxW


GROWTH
50° WATER
FISH PER POUND
5
10
25
50
100
200
500
1000
2000
3200
4.5
5.6
5.7
DESCHUTES SUMMER
STEELHEAD BROOD 1974
HATCHERY ♀ X HATCHERY ♂
WILD ♀ X WILD ♂
HATCHERY ♀ X WILD ♂
ONE YEAR REARING PROGRAM
UNGRADED
APR.
JUNE
AUG.
OCT.
DEC.
FEB.
APR.
MAY
1974
1975


DESCHUTES
SUMMER STEELHEAD
HATCHERY ♀ X HATCHERY ♂
HATCHERY ♀ X WILD ♂
WILD ♀ X WILD ♂
CONDITION FACTOR
1.200
1.175
1.100
1.075
1.050
1.000
10
12
14
16
18
20
22
LENGTH IN CM

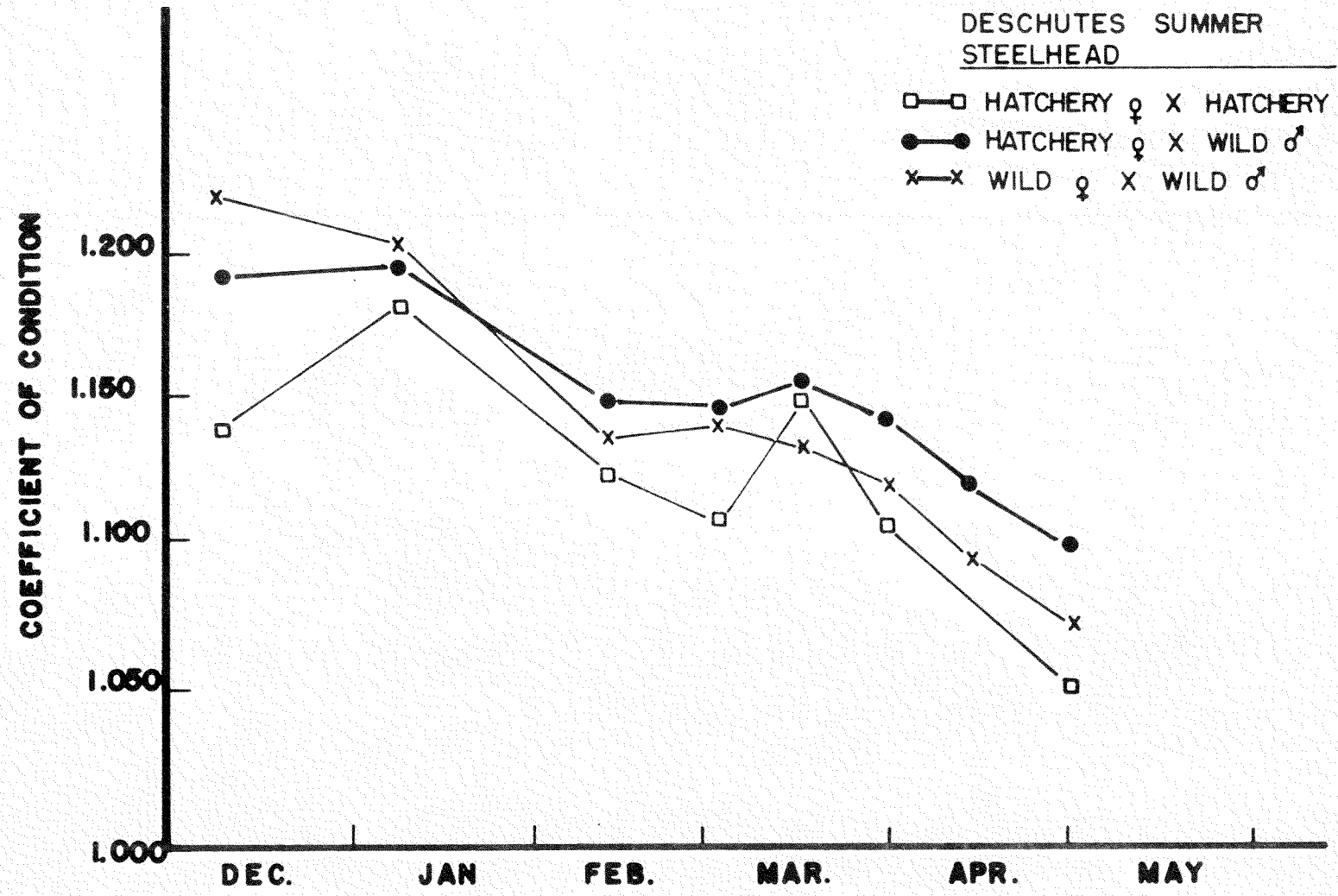


FIGURE 4. MEAN COEFFICIENT OF CONDITION OF THREE CROSSES OF SUMMER STEELHEAD FROM DEC. 1974 TO MAY 1975

METHODOLOGY

METHODS OF HANDLING AND TRANSPORTING GREEN FALL CHINOOK EGGS

by

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Longview, Washington

An experiment was conducted at the Abernathy Salmon Cultural Development Center to study some of the causes of high mortality encountered when transporting green fall chinook eggs from one hatchery to another. Eggs from eight fall chinook salmon were combined and randomly split into nine groups (about 4, 300 eggs) to form one replicate. Four of the groups were transported to Little White Salmon National Fish Hatchery for incubation, four groups were hauled to Vancouver, Washington and returned to Abernathy, and the ninth group remained at Abernathy to serve as a control. The experiment was replicated five times and all eggs were hauled approximately 120 miles by automobile on the same day. The following experimental variables were established: (1) Control, eggs fertilized immediately, not hauled; (2) Eggs fertilized before shipment; (3) Eggs fertilized after shipment; (4) Eggs fertilized after shipment and treated with Wescodyne at recommended levels after one hour of water hardening; and (5) Eggs fertilized after shipment with milt diluted with water less than 15 seconds prior to fertilization. A composite milt sample from four fish was randomly split and used to fertilize all groups within replicates. Eggs were hauled in 1-gallon, lid-covered freezer cartons lined with small plastic garbage bags. Milt was transported in similar 1-quart, lid-covered cartons with an air to milt volume of at least 10 to 1. The cartons were packed in crushed ice and were transported at temperatures ranging from 47 to 53° F. Each group of eggs were incubated separately in vertical stack incubators.

Three levels of mortality were found at eye-up as shown in the table. Lowest mortalities were found in the control or unhauled groups. All groups fertilized prior to transportation showed consistently high mortality. Slightly elevated mortalities were found in all groups within the remaining four variables. Wescodyne apparently had no effect on mortality, and water dilution had no effect on egg fertility. No mortality differences were found between eggs incubated at Abernathy and Little White Salmon hatcheries. Although acceptable techniques for transporting green eggs may vary between species or even between different stocks, the policy of transporting fertilized green fall chinook eggs appears questionable.

Percent Green Egg Mortality

Replicate	Control	Fertilized		Unfertilized		Wescodyned		Diluted Sperm	
	Abernathy	Abernathy	L. White	Abernathy	L. White	Abernathy	L. White	Abernathy	L. White
1	2.33	64.61	72.51	6.03	5.69	5.56	5.72	5.35	4.89
2	2.62	48.93	59.29	6.66	8.82	6.63	4.68	6.37	8.26
3	6.73	53.18	59.32	7.66	9.14	12.24	9.72	8.74	16.59
4	4.25	53.84	58.50	6.86	6.27	5.92	4.21	6.82	6.95
5	1.66	54.92	64.13	7.73	6.22	7.27	10.49	10.33	9.26
$\bar{X}$	3.52	55.10	62.75	6.99	7.23	7.52	6.96	7.52	9.19

THE EFFECT OF ACCELERATED GROWTH AND EARLY RELEASE ON TIMING, SIZE, AND NUMBERS OF RETURN OF QUINAULT SOCKEYE SALMON

by

Cary Feldman
and
Martin Figg
Quinault Project
Moclips, Washington

A group of 154,734 sockeye salmon in a program of accelerated growth and early release were released into the Quinault River at a size of 200/lb. in July of 1974. Their downstream migration was monitored by river fyke net capture of a portion of the 86,404 adipose clipped smolts. The estimated migration was 21% or 18,144 fish. The remainder extended residence in Lake Quinault and migrated in 1975.

In the spring of 1975, 9-11 months after release, 216 marked adults, .25% of the total marked release or 1.19% of the estimated migration, were caught in the Quinault River net fishery. The 17 month old adults showed a 2 to 1 female to male ratio and averaged 3.7 lbs. each which approached the 4.4 lb. average of wild adults 2 to 3 years older. These initial results are very encouraging as the largest portion of the returns is expected in 1976.

PERCIVAL COVE DELAYED CHINOOK PROGRAM

by

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INTRODUCTION

A new concept in rearing juvenile chinook has recently been developed by the Washington State Department of Fisheries to increase the salmon catch by Washington anglers. The idea involves the rearing and release of large yearling chinook, a technique which causes them to deviate from their normal migration patterns and remain for the most part, in local areas throughout their saltwater life. An extended rearing project in Percival Cove, an arm of Capitol Lake near Olympia, was begun in September of 1973 with a transfer of over one-half million 1972 brood yearling chinook from nearby hatcheries. It was anticipated that these fish, liberated approximately nine months past their normal release, would contribute greatly to the Southern Puget Sound sport catch of resident blackmouth. The program was repeated the following year with over 300,000 fish.

The physical layout of the cove shown in figure 1 is ultrasimplistic in nature utilizing a 3/8 inch stretch mesh suspended from boom logs to entrap the yearlings and prevent entry of predatory fish, a polyvinyl-chloride (PVC) diversion curtain to divert the flow of Percival Creek into the cove, a landing area for the feed barge, and a shed for feed storage.

In September 1973, 650,000 fall chinook averaging 20 fish/pound were transferred from Simpson and Minter Creek hatcheries. Additionally in November, 30,500 spring-fall chinook hybrids were transferred from Hood Canal hatchery. These fish were reared until March 1974 when the net was removed and the level of Capitol Lake was fluctuated greatly forcing outmigration of 616,000 fish at 5.6 fish/pound. A total of 128,950 pounds of Oregon Moist Pellet were fed and a weight gain of 77,715 pounds and a conversion of 1.65:1 were estimated. Feeding was accomplished from an outboard powered barge 2-3 times per day depending on dispersal of the fish. One attractive feature of this technique is a cost per pound of $0.47.

In September and October 1974, 349,602 fall chinook averaging 14.4 fish/pound were transferred from Simpson and George Adams hatcheries. These fish were reared until March 1975, at which time the net was removed and the lake level fluctuated forcing 284,220 fish at 3.4 fish/pound from the rearing area. Approximately 60,000 fish residualized and a special freshwater sport fishery was initiated to crop this population before the planting of 74 brood chinook in the cove. The fishery was relatively

relatively successful with approximately 50,000 being caught. A total of 128,350 pounds of OMP were fed and a weight gain of 73,921 pounds and conversion of 1.7:1 were estimated. Feeding was accomplished as before and cost per pound of fish was $0.51.

The measure of success of this venture would be identification of the fish in the fishery. To this end 64,037 of the 1974 release and 37,841 of the 1975 release were adipose clipped and wire-tagged using the Bergman-Jefferts microtag.

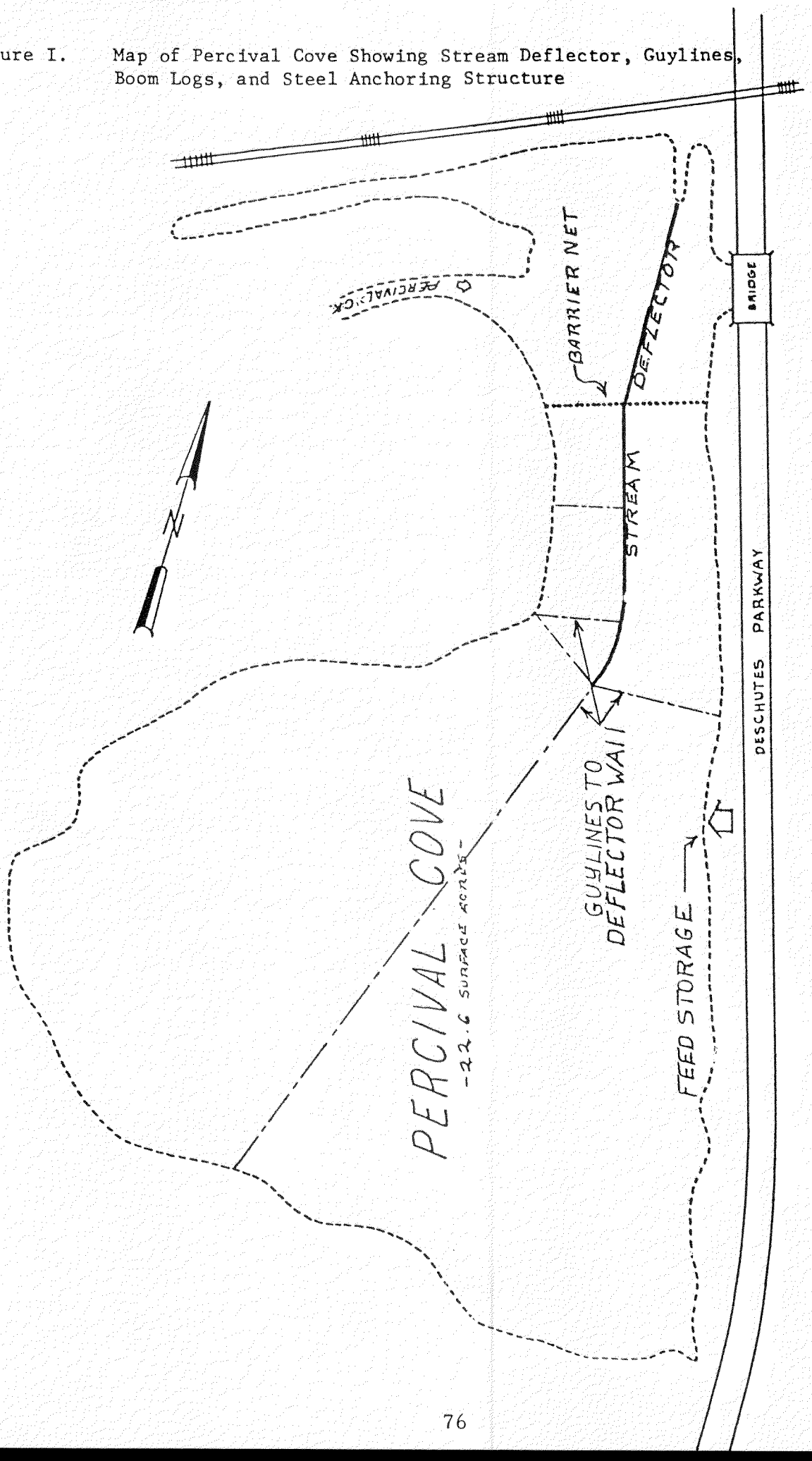
Puget Sound is utilized as a sport fishing area by large numbers of persons due to ready accessibility and areas of protected water making possible year-round fishing. Fishing is done primarily from smaller boats and the size of chinook caught is 3-5 lbs.

The sport fishery for resident chinook in southern Puget Sound was depressed during the 1960's and early 1970's. The average total yearly chinook catch in the years 1968 through 1973 was 24,081 and chinook salmon/trip ratio was .14. In 1974 the chinook catch in southern Puget Sound had risen to 57,066 and chinook/trip was .41. Southern Puget Sound catches attributable to Percival Cove delayed release in 1974 totaled 8,906 fall chinook and 136 spring-fall hybrids. Total catches of this release, in 1974, primarily in Puget Sound, is estimated at 15,530 fall chinook and 408 springs-fall hybrids. The total catch of this group in the 20 months since release is estimated to be 41,987 of 7% of the release.

The group released in March 1975 has also shown markedly in the fishery in the 8 months since release 4.4% or 12,528 have been estimated to have been caught.

The delayed chinook release appears to be a program with definite advantages from both a user and grower basis.

Figure I. Map of Percival Cove Showing Stream Deflector, Guylines, Boom Logs, and Steel Anchoring Structure



COMMERCIAL FISH REARING ON CAPE BRETON ISLAND

by

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Underwood McLellan & Associates Limited
UMA Group
Calgary, Alberta

Introduction

This paper is about the development of Salt Water Commercial Fish Rearing on Cape Breton Island in the Province of Nova Scotia, Canada, and deals specifically with the results obtained by Cape Breton Primary Production Limited in experimental and pilot commercial operations.

The first slide shows the geographic location of Cape Breton Islands in relationship to the USA and the rest of Canada.

Cape Breton Development Corporation

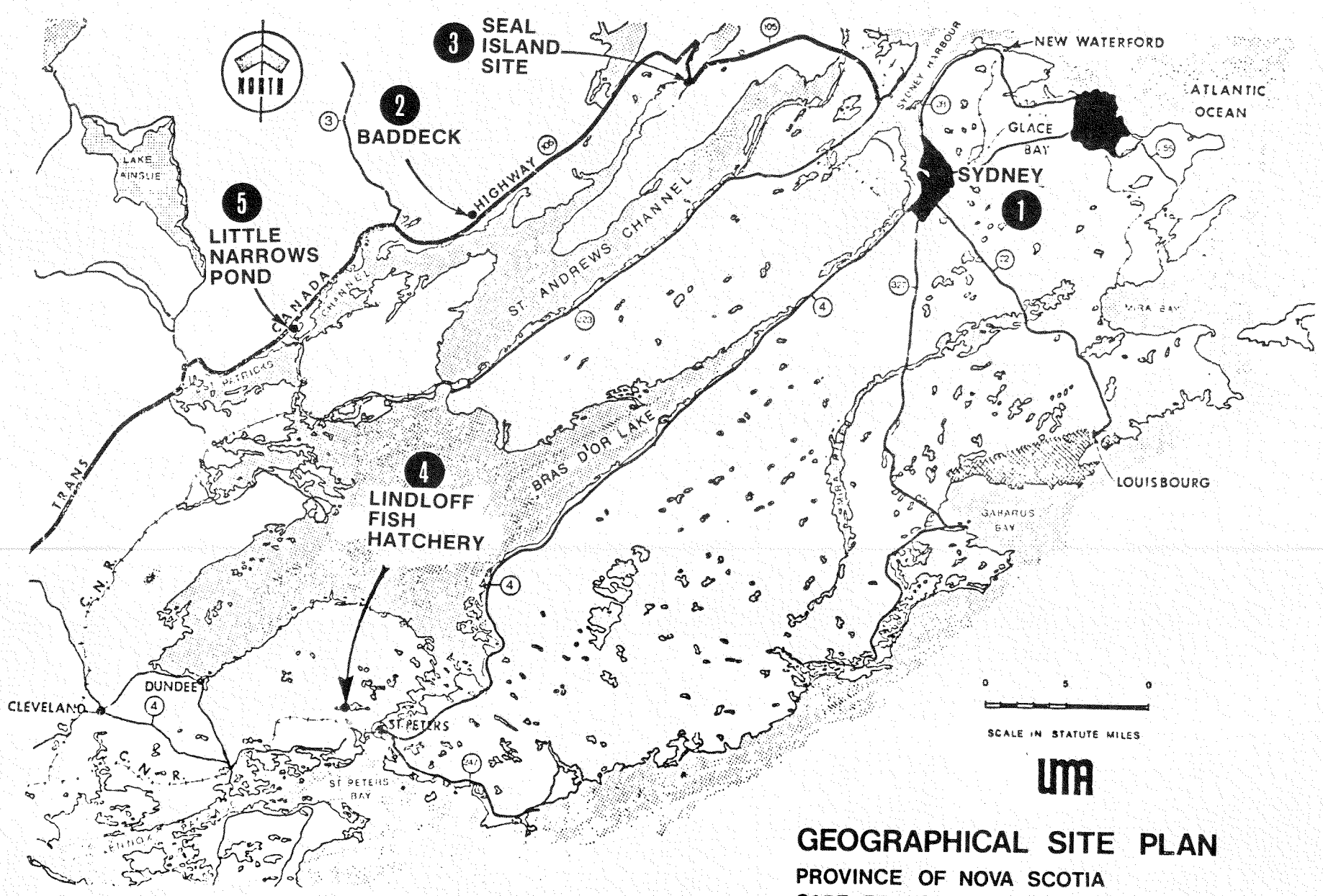
The fish farming methods and techniques under discussion are employed by Cape Breton Primary Production, which is one division of the Cape Breton Development Corporation, locally known as DEVCO.

The Cape Breton Development Corporation headquartered in Sydney, Nova Scotia, is a Crown Corporation funded by the Federal Government. The prime purpose of this corporation is to further the economic growth of Cape Breton Island through the development of commercial and industrial ventures, thus providing additional employment opportunities for the people of the Island whose main occupations were traditionally mining and fishing. Formed in the early 1960's to render assistance to the ailing coal and steel industry, DEVCO has since diversified into financing, manufacturing and related industrial services, tourism and community services, and primary production.

The Cape Breton Primary Production Division was organized as a company to facilitate the eventual transfer of the operational responsibility to a producers co-operative, and at the present time is engaged in such diverse activities as experimental oyster farming, sheep ranching, vegetable growing and fish farming.

Fish Farming

The fish farming program has been the successful rearing on an experimental basis of some 5000 pounds of Rainbow Trout in both 1972 and 1973, which led to the development of a pilot commercial operating rearing 30,000 lbs. of fish in 1974. The success of the pilot commercial operation



GEOGRAPHICAL SITE PLAN

PROVINCE OF NOVA SCOTIA
CAPE BRETON ISLAND

Plate: 1

has initiated a program to produce a readily acceptable market size fish at a competitive price.

Rainbow trout fingerlings for the 1974 pilot commercial operation were purchased in May from a commercial trout hatchery in Ontario at a 4-inch (40/lb.) size then transported to sites where they were acclimated to salt water for a short time. From the acclimation sites located near the fish farming operations centre at Baddeck, the fish were moved to salt water rearing cages located near Seal Island on Bras d'Or Lake, where the fish were reared from a 4-inch (40/lb.) size to a 10-inch (2/lb.) size in 105 days.

As part of the total program for the development of this fish rearing program, Cape Breton Primary Production Limited has concluded that a fish hatchery facility is required to supply the large number of fingerlings necessary for a commercial scale salt water cage rearing program, provided that the proposed facility is able to supply fingerlings at a price competitive with other commercial suppliers, and as part of these objectives has taken over the operation of the Lindloff Fish Culture Station located near St. Peters.

Experimental fish rearing work has also been carried out at Little Narrows Pond. As shown on Plate 1 the areas under discussion are:

1. Cape Breton Development Corporation
   Headquarters - Sydney
2. Cape Breton Primary Development
   Field Operations and Laboratory - Baddeck
3. Seal Island cage rearing site on Bas d'Or Lake
4. Lindloff Fish Culture Station on Long Lake
5. Little Narrows Pond experimental winter rearing location

Sydney

The slides were taken during visits in November 1974 and January 1975. Not too much imagination is required to determine which slides were taken in January. The next 3 slides show Sydney, Nova Scotia from the air and on the ground.

Bras d'Or Lake Cage Rearing

The Brad d'Or Lake is actually a large inland sea with a salinity range of 20 to 24 parts per thousand, a surface area of some 450 square miles, an average depth of 65 ft. with a maximum depth of approximately 3,000 ft. Rainbow Trout as well as other species are native to the lake.

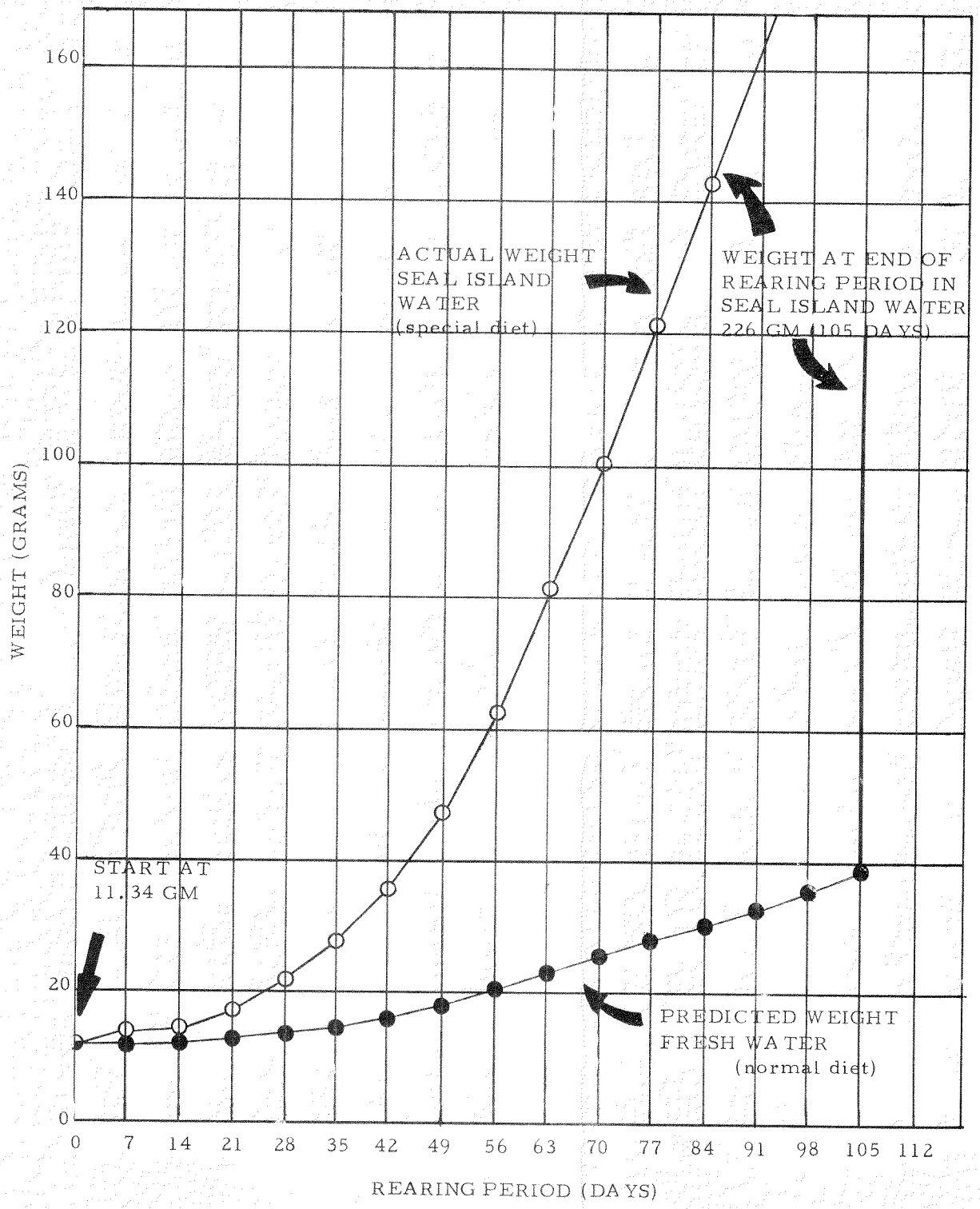


PLATE 2. GROWTH RATE COMPARISON

The next group of slides show Bras d'Or Lake as seen from Nova Scotia Provincial Highway No. 4.

The Seal Island site was selected because of:

1. The good flow of water through the narrows as a result of wind and tidal action.

2. The complete mix of the water which provides for a uniform summer temperature and oxygen profile from top to at least 50 ft. below the lake surface.

3. Because of the good accessibility by road.

After acclimation in early May at sites near Baddeck which allows mixing of salt and fresh water, the 4" 40/lb. fish are transported to Seal Island and placed in net rearing cages of two sizes, 16' x 16' x 16' deep and 20' x 20' x 16' deep, along finger rafts which are held in place by steel cables secured to the shore and anchored at the water end with 3 - 200 lb. anchors. The nets are fastened to wooden frames which are bolted to PVC buoys. Nets are replaced every month as a measure of insurance against abrasion to prevent the possible loss of the fish in a cage.

Fish density is kept to a maximum of 1 lb. per cubic foot of cage. Fish are fed by hand on a special diet of moist pellets, the formulation of which was developed and is produced by Cape Breton Primary Production at Baddeck. The fish food is approximately 10 to 15% moisture and contains about 45% protein. Food conversion is approximately 2 lb of food per lb. of fish.

Mortalities over the three years of operation range from 2 to 5% for rearing from the 4" to 10" size. A number of the missing fish can be accounted for by the presence of two legged varmits in the area.

In September at the 10" size the fish are taken to a fish eviscerating facility and then to market in either the USA or Eastern Canada. Development of markets for the limited production to date has not been difficult. The next group of slides show the Seal Island rearing site.

Baddeck

The Cape Breton Primary Production facilities at Baddeck include laboratory and office space for people engaged in research and operations as well as a workshop for the manufacture of the special gear required for the fish farming and oyster culture operations.

Lindloff Fish Culture Station

The Lindloff Fish Culture Station was operated by the Federal Government from the time of construction in the early 1900's until 1972 when the facility was given to the Provincial Government of Nova Scotia, who subsequently handed over the facility to the Cape Breton Development Corporation. The next group of slides show the extent of this facility.

The existing facilities consist of 9 - 25 ft. diameter concrete ponds, a hatchery and storage building as well as residence and garage for the manager. The water source is from Long Lake which has an average discharge of 1500 Igpm (1800 USgpm) lake temperature varies from a winter low of 1°C to a summer high of 18°C.

A 250 ft. deep well was drilled in 1974 to hopefully increase the available supply of water and to modify the lake water temperature range. Subsequent pump testing and an aquifer evaluation by the UMA Group resulted in a calculated long term safe yield of 50 Igpm (60 USgpm) which was far below Cape Breton Primary Productions expectations, at a temperature of 8°C, which did not appreciably help the water supply capability, but can be used when heated for an incubation supply.

Little Narrows Pond

In November, 1974 approximately 800 of the 10" (2/lb. size) fish were placed in cages in Little Narrows Pond, where the cages were allowed to freeze over. Because of the peculiarities of the water flow and/or fresh water seepage into the pond, the winter water temperature after freezeup measured at the mid depth of the cages, ranged from a high of 6°C to a low of 3°C. Fish were fed twice a day on the same diet as at Seal Island. The fish grew from 2/lb. size in November to 1/lb. size in May. Mortalities at Little Narrows Pond were only five fish. The Little Narrows fish were then moved back to Seal Island in May where at the present time at an age of 2 years they have an average weight of 4 to 4.5 lbs. with the largest at 7 lbs. The largest fish are presently being stripped as brood stock.

UMA Group Involvement

Our involvement in this project was to conduct a study of the existing Lindloff Fish Culture Station to determine the feasibility and related costs to supply the necessary number of 4" (40/lb. size) fish in May to meet the objectives for Seal Island as set by Cape Breton Primary Production Limited. This study resulted in the development of the following alternatives.

1. A single pass system using unheated lake water to produce 720,000 fish per year at a cost of 18¢ per fish.

2. A double pass system using unheated lake water to produce 1, 080, 000 fish per year at a cost of 16¢ per fish.

3. A recycle system operating at a constant temperature using lake water for makeup, to produce 2, 250, 000 fish per year at a cost of 26¢ per fish.

All costs per fish include amortization of capital and yearly operating costs.

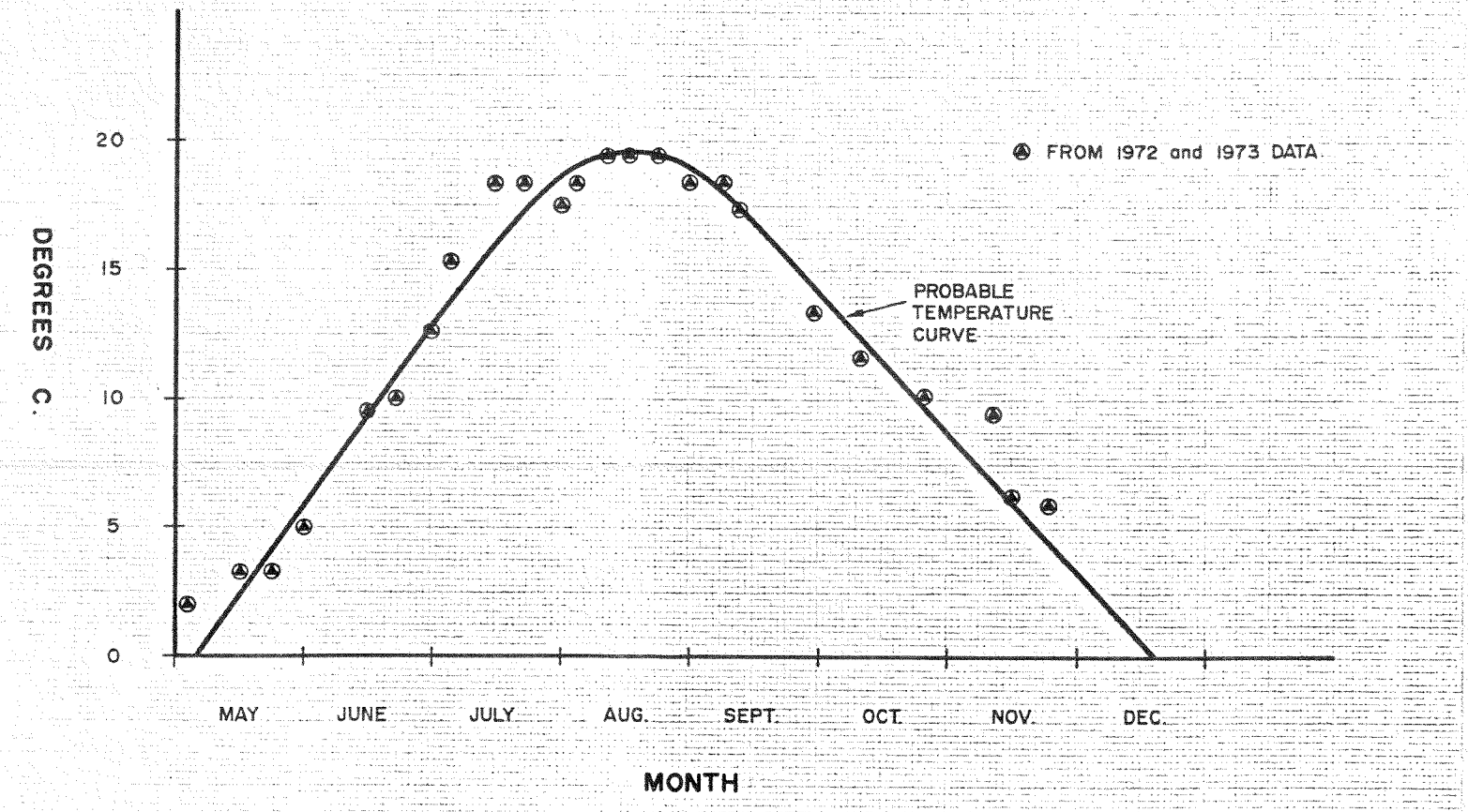
Summary

In summary one of the most interesting aspects of the fish farming operation operated by Cape Breton Primary Production at Bras d'Or Lake is the remarkable growth rates they have achieved through diet and salt water rearing at the temperatures available at the Seal Island Site which are shown on Figure 1.

A conservative projection based on accepted growth rates of Rainbow Trout at Published feed rates in fresh water at temperatures similar to Seal Island starting in May at the 11 gm (40/lb.) size would result in a growth to 39 gm (12/lb.) size 105 days later in September, whereas the actual growth at the Seal Island Site using the special diet has resulted in an increase in size from 11 gm (40/lb.) size in May to a 226 gm (2/lb.) size in the same 105 day period. The results of these growth rates are shown graphically on Plate 2.

Recent experiments at the St. Andrews Research Station at St. Andrews, New Brunswick has indicated that the Cape Breton Primary Production Limited fish food formulation will achieve a growth rate for Rainbow Trout in sea water almost twice as high as the growth rate available when using commercial fish food. However, conversion rates were not as good as the results obtained using the commercial fish food. This experiment has been carried out and published by Arnie Sutterlin at St. Andrews. The purpose of the experiments were to test growth rates in salt water using different types of food and did not consider the economics of the food supply.

Cape Breton Primary Development in keeping with their objectives, is presently advancing the technology and upscaling the fish farming project to a size where the economics will permit the gradual development of private or co-operative operated salt water rearing facilities supplied with fingerlings and fish food produced by Cape Breton Primary Development Limited.



TEMPERATURES AT SEAL ISLAND SITE - SALT WATER STATION

FIGURE: 1

FIRST RESULTS OF COHO SALMON FARMING IN FRANCE

by

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ABSTRACT

The coasts of Bretagne in France offer many suitable sites for salmon aquaculture. Seawater temperature varies from 9 to 18.5°C, but unusual climatic conditions may induce peak temperatures of 20°C.

Coho salmon research was induced in France in 1971 by the CNEXO-COB research team, in close relationship with NOAA-NMFS specialists. The results in freshwater-rearing were excellent with high survival and good growth under natural conditions, leading to a large percentage 0-age smolts.

The first year of operation of an experimental saltwater, diked, tidal pond produced 6.2 metric tons of coho salmon in 1974, and 30 tons in the first 6 months of 1975. Another pilot plant using net pens in the Rade de Brest was achieved by June, 1974, and produced about 4 tons of salmon.

Late spring and summer adaptation of smolts to seawater showed heavy mortalities over the summer in 1974 and 1975, possibly due to high temperatures associated with high salinities. No evidence of bacterial infection was found in 1974, but Vibrio sp. was isolated from dying fish in 1975. However, the surviving fish showed an excellent growth. Part of 0-age 26 g smolts adapted in July, 1974, reverted to parr condition with a poor growth, while the other part of the population reached an average weight of 397 g by December 31 (1.58% daily weight increase) and 735 g by April 10, 1975. Large, 1-year smolts (70 g) transferred to floating pens in July, 1974, reached an average weight of 522 g by December 31 (1.25% daily weight increase) and 1050 g on April 9, 1975.

Actual saltwater production is scheduled from October to May when the sea temperature is below 13 C. The coho are marketed in France, fresh, whole, and in the size range of 0.3 - 0.8 kg. Market prices and acceptance are excellent. Total production should approach 40-50 metric tons by the end of 1975 and new facilities should be able to produce 100 - 120 tons in 1976 in three operating farms.

TRANSFERRING MODERN ADVANCES IN TROUT CULTURE TO COHO SALMON CULTURE

by

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Introduction

Trout culture has been undergoing steady changes over the past 40 years in a search for greater understandings. Currently, we are thinking in terms of load factors instead of changeovers per hour, hatchery constants, instead of feed charts, inches per month gain vs. percentage gain, density factors as opposed to pounds per cubic foot. Temperature units per inch gain have emerged as a measure of the metabolic heat use. Most important of all is the realization that these are all part of an interrelated system. This system is tied together with length as the common denominator. "Managing Hatcheries by the Numbers" by Robert Piper, published in the American Fishes and Trout News, September 1972, gives insight into this system. It also gives some information about procedures used in these tests.

Most of the work leading up to the present level of understanding has been done with rainbow trout. The ultimate growth rates, conversions, feed levels, temperature units per inch gain, and load factors for rainbow in an integrated system have not yet been totally worked out. The principle of the system apply everywhere, but not the actual levels. Each hatchery, species, strain of fish, water chemistry, and diet formulation is different so universal guidelines are impossible. A maximum load factor of 1.3 at one hatchery will not necessarily apply at another. Every fish culturist must apply the principles of the system to his own particular situation. Only then can it become possible to compare results, locate problems, and improve performance.

The work reported here was done on coho salmon at three different locations and temperatures. It was not intended to establish a universal standard of achievement, but it is, however, intended to demonstrate that the trout principles are applicable to salmon. It was also intended to establish a base line for comparing future performance of cohos at these and other similar locations.

Methods

The method was relatively simple. We conducted a series of growth study tests in which one parameter was varied while the others were held

constant. When constrained by a given diet, water supply, species of fish, etc., there remains three primary growth-affecting parameters: (1) feed levels; (2) load factors; and (3) density factors (the traditional pounds per cubic foot was not tested as it is actually a combination of the last two). Four growth-efficiency indicators were used to tell when the fish were growing at their best: (1) total length; (2) conversion; (3) inches per month gain; and (4) temperature units per inch gain.

The first parameter measured was feed level. Variation of this factor produces the most radical and immediate effect on growth. Four hatchery constant feed level tests were set up at the three locations, each having a different constant water temperature: 41°F, 48°F, and 53°F, respectively. The feed levels were established at 10 percent increments above and below normal (-10, 0, +10, +20). The load factor was held to 0.5 and the density factor to .4. The percentage to feed was determined by using the following formula: $\frac{\text{Hatchery constant}}{\text{Length of fish}}$ = percent to feed on a daily basis

Each test was conducted for a 14 day period. The gain was estimated for that period and feed levels were increased daily to reflect the gain of the fish. At the end of the 14 day period, the fish were reweighed and sample counted. Adjustments in flow, total weight, and numbers were made to maintain the original load and density factors. The feed requirement was projected for the next 14 days. The tests continued in this manner until the fish reached a weight of approximately 15/pound.

After the maximum feed level was established, we set up four similar tests to determine the maximum allowable load factors. During these tests we used the maximum feed levels as determined in test 1 and maintained a density factor at 0.4. Since there was absolutely no data upon which to establish the range for these tests we performed a preliminary test that indicated that a load factor of 2.0 at 46°F was close to maximum. After adjusting for metabolic differences the tests were set up accordingly:

Temperature (Fahrenheit)	Load Factors			
41°	2.0	2.5	3.0	3.5
48°	1.5	2.0	2.5	3.0
53°	1.0	1.5	2.0	2.5

A third set of studies were set up to determine the maximum density factor at 41°F:

$$\text{Density factor} = \frac{\text{lbs. per cubic foot}}{\text{length of fish}}$$

The levels tested were .25, .50, .75, 1.0, and 1.25, respectively. The optimum feed levels and load factor as determined by tests 1 and 2 were used.

Results

Table I shows the data and conditions were the maximum or optimum growth was obtained for the various temperatures. Due to limited space we cannot include all the results of each test. However, the optimum growth was easily determined by comparing the levels obtained with the four growth indicators. We looked for (1) the highest total gain in inches; (2) the greatest inch per day gain; (3) the lowest conversion; and (4) the lowest temperature units per inch gain. In this process we let the fish tell us when he is performing at its best. Even though fish do not speak in words, they talk very clearly if we know how to listen.

Table I

COHO SALMON GROWTH DATA at 14-day intervals, OMP open formula diet, at various constant temperatures

41°F

Hatchery Constant: 4.2
Load Factor: 3.5

Month	Length	Inch/Month Gain	Conversion	TU/inch
1	1.35			
	1.40	.16	2.81	31.3
2	1.49	.22	1.98	22.7
	1.65	.29	1.52	17.2
3	1.80	.33	1.19	15.2
	1.95	.32	1.19	15.6
4	2.01	.33	1.19	15.2
	2.27	.39	1.14	12.8
5	2.48	.37	.78	14.3
	2.60	.38	1.08	13.9
6	2.79	.34	1.14	15.5
	3.98	.40	1.29	13.2
7	3.15	37	1.11	14.3
8	3.30	.36	1.14	14.7
	ND	ND	ND	ND
9	ND	.33	ND	16.7
	3.68	ND	ND	ND
	3.77	.19	2.02	28.6
10	3.85	.17	2.14	33.3
	3.89	.08	4.89	65.5
11	3.94	.11	2.68	50.9
	4.00	.10	3.51	53.9
	4.06	.12	3.19	45.8
12	4.11	.10	3.26	50.9
	4.19	.17	2.45	31.6
1	4.27	.17	2.81	31.6
	4.37	.21	2.17	26.2
2	4.44	.23	1.96	24.2
	4.68	.44	1.20	13.4
3	4.85	.39	2.60	21.4
	4.99	20	1.20	10.5
4	5.22	.43	1.50	15.7
	5.43	.41	1.40	12.8

Table I

COHO SALMON GROWTH DATA at 14-day intervals, OMP open formula diet, at various constant temperatures

53°F

Hatchery Constant: 9.3
Load Factor: 1.0

Month	Length	Inch/Month Gain	Conversion	TU/inch
1	1.35			
	1.61	.50	1.82	24.0
2	1.84	.57	1.57	21.1
	2.17	.64	1.30	18.8
3	2.57	.70	1.17	17.1
	2.82	.69	1.20	17.4
4	3.14	.69	1.20	17.4
	3.18	.73	1.18	16.4
5	3.84	.75	1.20	16.0
	4.19	.75	1.23	16.0
6	4.53	.84	1.24	14.3
	5.02	.84	1.25	14.3
7	5.37	.84	1.28	14.3
	5.70	.66	1.44	18.2
8	5.95	.62	1.55	19.9
	6.24	.39	1.66	31.8

48°F

Hatchery Constant: 6.6
Load Factor: 1.5

1	1.35			
	1.44	.27	4.56	32.9
2	1.65	.44	1.65	20.2
	1.91	.59	1.27	15.1
3	2.20	.63	1.18	14.1
	2.46	.61	1.07	14.6
4	2.79	.64	1.05	13.9
	3.07	.66	1.01	13.5
5	3.37	.78	.94	11.4
	3.80	.61	1.16	14.6
	3.90	.62	1.18	14.3
6	4.19	.49	1.25	18.1
	4.47	.62	1.15	14.3
7	4.73	.63	1.28	14.1
	4.92	.45	1.45	19.8

Table II

Feed Chart and Anticipated Results for Coho Salmon on Federal Open Formula Diet

Feed Chart				Results		
F^{o}	C^{o}	Hatchery Constant	Inch/Month	Conversion	TU	LF
53	11.7	9.30	.75	1.32	17.1	1.0
52	11.1	8.76	.73			
51	10.5	8.22	.70			
50	10.0	7.68	.68			
49	9.4	7.14	.67			
48	8.9	6.60	.65	1.27	16.1	1.5
47	8.3	6.23	.58			
46	7.8	5.91	.50			
45	7.2	5.57	.47			
44	6.7	5.23	.44			
43	6.1	4.89	.41			
42	5.5	4.54	.38			
41	5.0	4.20	.35	1.19	15.1	3.5
40	4.4	3.90	.31			
39	3.9	3.60	.26			
38	3.3	3.30	.20			

Notes:

(1) These results do not hold true when fish grow beyond 15/lb.

(2) These results do not apply beyond September of the first year when coho's enter the "slump". Table II at 41^{o} indicates more closely what can be expected thereafter.

(3) These results are averages. Table II shows changes as fish mature.

UPDATE ON LUMMI INDIAN AQUACULTURE

by

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Abstract

Lummi Indian Aquaculture has been operating for the past six years. The goals were for the production of pan sized coho salmon and oysters by Lummi 82 members of the Lummi Tribe are employed in aquaculture. Administration of aquaculture is handled by Lummi Indian Tribal Enterprises (LITE), the business arm of the tribe.

Physical facilities of Lummi Aquaculture include a fresh water salmon and steelhead hatchery, Skookum Creek Fish Hatchery, located on the South Fork of the Nooksack River. This hatchery is supplied with water from Skookum Creek and adjacent springs and has water reconditioning filters. Its annual capacities include 1,500,000 coho salmon smolts, (yearling); 250,000 fall chinook; 800,000 chum; and 25,000 steelhead. Annual releases of all four species have been made since 1970. The 750 acre Lummi Sea Pond was created in 1970 by extending an encircling dike within Lummi Bay. This is the site where pan sized coho salmon are reared during spring, summer, and fall months; and where sea-ranched salmon are released and subsequently recaptured. The rearing system consists of four large anchored net pens. Currently, production for pan sized coho is about 50,000 pounds and 550,000 released coho and chum salmon. The method of capture for returning salmon consists of traps located within the tidal gates of the dike.

Pacific oysters (Crassotrea gigas) have been produced at the oyster hatchery since 1971. The operations undertaken at the location on Lummi Bay include spawning mature oysters, feeding the resultant larvae for about 25 days, allowing them to set on cultch material, and grow until the oysters can be set out on tidelands within the Lummi Reservation. Production tests were made on cultchless (free) oysters for rapid growth but due to higher handling costs, this method of production was deemed undesirable and oyster production now concentrates on cultch oysters. Currently, 8,000 cases (4 cu. ft. each) of oyster spat is produced annually from the oyster spat is produced annually from the oyster hatchery, and 250 acres of tidelands are seeded annually. Growth to marketable oyster takes three years and harvest on a production scale will begin in 1976.

A PHILOSOPHY OF FISH CULTURE

by

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Abstract

Any fish-raising facility consists of the following elements: fish; water; container; nutrition; management. Of the five, management is the most difficult to define. However, by taking into account the interrelationships of fish: container: water: nutrition, a workable definition of management is evolved.

Relationships		Consideration
Water:container	-	water velocity and exchange rate
Water:Fish	-	dissolved oxygen, ammonia, standard environmental temperature, growth rate (ΔL) Load Factor
Container:Fish	-	Density Index, water flow pattern
Water:Nutrition	-	Carrying Capacity (based upon Permissable Pounds of Feed), water velocity
Fish:Nutrition	-	Feed conversion, growth rate (ΔL). Hatchery Constant, ammonia and solids production, oxygen depletion

To accurately determine the foregoing relationships, the following data must be available: number of days of growth, number and length of fish, fish/pound, pounds/pond, expected pounds of gain, expected inches of gain, pounds of feed fed, pond volume, water inflow rate, dissolved oxygen, pH, temperature, and geographic elevation.

We have quantified the interrelationships of fish: container: water: nutrition in several programmed test situations. The results have been highly rewarding from the standpoints of fish condition, cost of production and predictability of product.

A HISTORY OF THE WASHINGTON DEPARTMENT OF FISHERIES, PINK SALMON REARING PROGRAM

by

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Abstract

The pink salmon (Oncorhynchus gorbuscha) artificial rearing program for Washington began in earnest in 1953 when the Hood Canal Hatchery went into operation. This hatchery is unique in Washington because it has both fresh - and salt-water rearing capabilities. This report follows the development of the pink salmon run at Hood Canal citing both successes and failures and gives a detailed enumeration of the adult returns, egg takes and station releases.

The report also covers the rearing of pinks at the Skagit River Hatchery, where from an initial release of 475, 000 fingerlings in 1974, over 3, 000 adults returned to spawn in 1975.

Pink Salmon Rearing in Washington

The pink salmon (Oncorhynchus gorbuscha) rearing program in Washington became a reality in 1953 when the Hood Canal Hatchery was built. This station, located on Finch Creek at Hoodsport, is unique in that it has both fresh-water and salt-water rearing capabilities. Pink salmon had been reared previous to this time, but with no real determined effort to keep them going. Pink salmon are the only species of salmon to mature and spawn in a two year cycle with no variations. In Washington, pinks (humpbacks or humpies as they are also called) occur on the odd years only, while in parts of Canada and Alaska they occur on even years only.

Even-Year Pinks at Hood Canal

The first release of even-year pinks from Hood Canal, were of the 1952 brood from the Skeena River in Canada. A total of 159, 000 fingerlings at 110 fish per pound were released into Hood Canal tributaries, and an additional 56, 000 fish were released into Finch Creek itself. A return of 64 adults from the latter group were spawned in 1954, producing approximately 43, 000 even year pink eggs.

This relatively poor success with even-year pinks was believed partly attributed to the dietary problems prior to release. The "production diet"

at that time was made up of 70% salmon viscera and 30% beef liver.

The alleviate the possible dietary weakness, brine shrimp (Arthma gracilias) were substituted for the production diet in a test group of the 1954 brood. The hatchery crew cultivated and fed brine shrimp for the 105 day rearing period test with the production diet used as a control.

This experiment was conducted on a small scale using four 75-gallon acquarium.At the time of release the test and control lots had similar average length frequencies, but the standard deviation of the two groups showed a marked difference (Brine diet $\bar{x} = 42.0$, $s = 2.4$; production diet $\bar{x} = 43.7$, $s = 7.3$). Another parameter of import was that during the study the first fed Brine shrimp survived at twice the rate of the controls with little or no "pinheads" present. The weight comparisons were not felt to be valid as the quantity of Brine shrimp available was limited.

The 1954 pink liberation consisted of 163, 000 fingerlings and resulted in a return of 121 adults in 1956. These were from 43, 000 eggs from local stock and the remainder again imported from the Skeena. The adaptability of the even-year pinks to Washington State waters was again proving to be relatively unsuccessful. The following 2 sudcessive even-year broods were reared with diminishing returns and then this phase of the pink salmon program was abandoned.

Odd-Year Pinks at Hood Canal

1953 Brood

The first release of native odd-year pinks occurred at Hood Canal in 1954 from eggs of the 1953 brood Dungeness stock. The plant consisted of 182, 730 pinks weighing 1, 757 pounds (104 fish/lb.). This group resulted in the return of 1, 813 adults in 1955. They were a total result of a transfer as the Hood Canal station had never experienced a run of odd-year pink salmon.

1955 Brood

A total of 650, 000 eggs were taken in 1955 and the resultant fry were reared using two differing diets. As with the studies on even-year pinks a diet of brine shrimp was thought to be a better starting food than the standard production diet. Two lots of 100, 000 were reared identically, except that one group was fed brine shrimp while the other received the "control" diet. The experimental groups were reared 73 days before the first release which consisted of 45, 600 marked LV of the brine shrimp group and 27, 800 marked RV of the "production" group; an additional 80, 725 standard reared pinks were released without marks. Those remaining were reared to 105 days before release; with 45, 120 of the brine shrimp Lot marked LV, 20, 680

marked Ad RV from the "production" group. The total plant of all pinks at the hatchery was 280, 500.

1957 Brood

The returning adults in 1957 totaled 3, 628 fish of which 1, 478 were marked: 354 LV, 318 RV, 452 Ad RV. The survival rates from release to adults were better for the production diet, but this is attributed to the larger release size of these fish (see Table 1 for details). The fresh water rearing was a duplicate of the previous experiment conducted with the 1954 brood Skeena River pinks. It was believed that the reason for the lower overall survival and smaller size at release of the brine shrimp group was that it was not possible to feed an adequate amount of such a small organism and therefore was discontinued as a total diet. The natural feed appeared to have a high potential and was later used in subsequent programs as a starting diet followed by the production diet as soon as the fish got large enough to eat it. This system greatly reduced the number of pinheads which constituted a major portion of the mortalities.

1959 Brood

The 1957 returns produced 2, 469, 764 eggs of which 385, 480 fry were retained at Hood Canal for a final liberation of 254, 850 fish at 200 per pound. The total survival from fry to liberation was 66%, none of which were marked. The returning adults to Hood Canal (1, 529) accounted for 913, 527 eggs for the 1959 brood. This egg take was transferred to Minter Creek for hatching and then returned to Hood Canal for final rearing and liberation (Minter Creek retained 106, 700 fry for release at that station). The final release at the original station was 663, 687 fingerlings ranging from 200-250 fish/pound.

By this time, results from various experiments with local stocks of odd-year stocks handled in the same manner as imported even-year stocks gave significantly higher returns when transplanted from one area to another. Transplants of odd-year local stock showed a profit in adult population gains; transplants of even-year stock showed a loss in adult populations. Therefore, it was decided to concentrate the pink salmon effort on odd-year stocks only.

1961 returns of 2, 952 adults back to Hood Canal produced an egg take of 2, 369, 216. From these eggs, 300, 729 fingerlings were released at Hood Canal and due to exceptionally high marine survival produced an all time high of 6, 636 adults for the 1963 brood. Starting with the 1961 brood, the pink salmon program at Hood Canal became a standard operation. In 1963 the production diet was changed to OMP; this helped to solve the pinhead problem and increase the hatchery survival rate. The fry are routinely started in fresh water and converted to salt water when the fish reach 40-55 days and then reared until approximately 90 days old.

Table 1. Summary of Pink Salmon Rearing Procedures and Resulting Returns of Adults - Hood Canal Hatchery 1955-1957.

Diet	Original Stock In Ponds	Rearing Conversion	Percent Survival to 73 Day Total Total Rearing	Number, Mark and Disposition After 73 Days Days of Rearing	Percent Survival to 105 Days Total Rearing	Number, Mark and Disposition After 105 Days of Rearing	Adult Return	Percent Survival Plant to Adult	Percent Survival Fry to Adult
SHRIMP DIET	GROUP A: 100,000	14-day freshwater 16-day conversion to salt water	93.8%	45,601 marked LV and released 1,123/pound			354 LV marked	0.776%	0.728%
			GROUP A 1:	48,190 held for additional rearing in salt water	87.70%	45,119 marked AdLV and released 563/pound	354 AdLV marked	0.785%	0.688%
CONTROL DIET	GROUP B:	14-day freshwater 16-day conversion to salt water	60.90%	27,801 marked RV and released 546/pound			318 RV marked	1.144%	0.697%
			GROUP B 1:	33,134 held for additional rearing in salt water	38.0%	20,678 marked AdRV and released 192/pound	452 AdRV2, marked	186%	0.831%
CONTROL DIET	230,800	14-day freshwater 16-day conversion to salt water	75.0%	80,725 released unmarked 635/pound	49.0%	60,568 released unmarked 220/pound	2,144 no marks	Avg. 1.517%	0.743%

Pinks at Skagit

In 1973, the pink salmon program was expanded to the Skagit River Hatchery. Brood stock was obtained by netting in the Skagit just below Hamilton on the north side of the river about 30 miles downstream from the hatchery. The stress of handling the fish was high and this, of course, was reflected in the mortality rate (1, 181 ponded and 629 dead before spawning). Enough survived to take 675, 000 eggs and approximately 617, 000 fry were ponded and reared 101 days. The final plant totaled 401, 486 pinks at 394 fish/pound for a survival rate from egg to release of 59%. Along with this plant of Skagit River stock was a plant of 75, 000 pinks of Stillaguamish origin.

This year was the first return to the Skagit hatchery for pinks, and the department was anxiously awaiting the results of the work done in 1973. The run was over 5 1/2 times as large as the parent brood, 552 adults in 1973 and 3, 070 adults in 1975. The 1975 brood pink egg take was 2.8 million so it looks as if the pink program is off to a good start at Skagit.

BROOD YEAR	NO. EGGS	POUNDS PLANT	NO. PLANT FINCH CREEK	NO. ADULT RETURN
1952	200, 000	1, 445	56, 039	64
1953	357, 000	1, 757	182, 730	1, 813
1954	464, 000	1, 255	162, 959	121
1955	632, 500	682	280, 492	3, 628
1956	1, 266, 025	335	707, 053	284
1957	2, 467, 764	1, 274	254, 850	1, 529
1958	139, 470	180	32, 400	14
1959	913, 527	2, 515	563, 687	2, 952
1961	2, 369, 216	989	300, 729	6, 636
1963	5, 175, 850	1, 506	922, 961	430
1965	472, 328	1, 283	420, 958	2, 236
1967	615, 000	1, 416	602, 820	2, 256
1969	1, 983, 463	2, 399	773, 702	2, 390
1971	1, 960, 000	3, 462	1, 488, 970	1, 509
1973	841, 422	2, 104	708, 624	2, 349
1975	1, 790, 000			

EVALUATION OF RETURNS FROM HATCHERY-REARED KOKANEE SALMON AT ODELL LAKE, OREGON

by

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ABSTRACT

A creel census program was conducted at Odell Lake from 1964 to 1975 to evaluate returns of hatchery-reared kokanee salmon in relation to size, timing of release and racial origin of stocks. The annual catch of hatchery-reared kokanee averaged 7,700 representing 11 percent of the total fish harvested. Returns of hatchery kokanee to the fishery averaged 5.4 percent of the total fish released. Both size at release and timing of releases appeared to be important factors determining survival and return to the fishery of hatchery kokanee. Best returns were realized from fish 100 per pound released in June and July. Evaluation of racial stocks revealed differences in age at maturity and harvest pattern but little difference in total return to the fishery. Cost per hatchery fish creeled averaged $0.18 and ranged from $0.06 to $0.35.

INTRODUCTION

The Oregon Department of Fish and Wildlife annually releases between 1.1 and 2.9 million kokanee salmon fingerlings into Oregon lakes. Little evaluation of releases of hatchery-reared kokanee has been conducted to determine stocking procedures that would maximize returns to the fishery Therefore a creel census program was conducted at Odell Lake, Oregon from 1964 to 1975 to evaluate returns of hatchery-reared kokanee in relation to size, timing of release and racial origin of stocks.

STUDY AREA

Odell Lake is an oligotrophic lake located 60 miles east of Eugene, Oregon in the central Cascade Mountains (Fig. 1). The lake lies at an elevation of 1,459 m (4,788 ft) and encompasses 1,454 hectares (3,593 acres). Kokanee salmon (Oncorhynchus nerka) is the predominant fish species present in the lake. Odell Lake is one of the most popular fishing waters for kokanee in Oregon supporting 34,000 angler days annually (Lewis, 1975). The lake is easily accessible along Oregon State Highway 58 and has well developed recreational facilities including three major U. S. Forest Service campgrounds, two resorts, a marina and 67 summer homes.

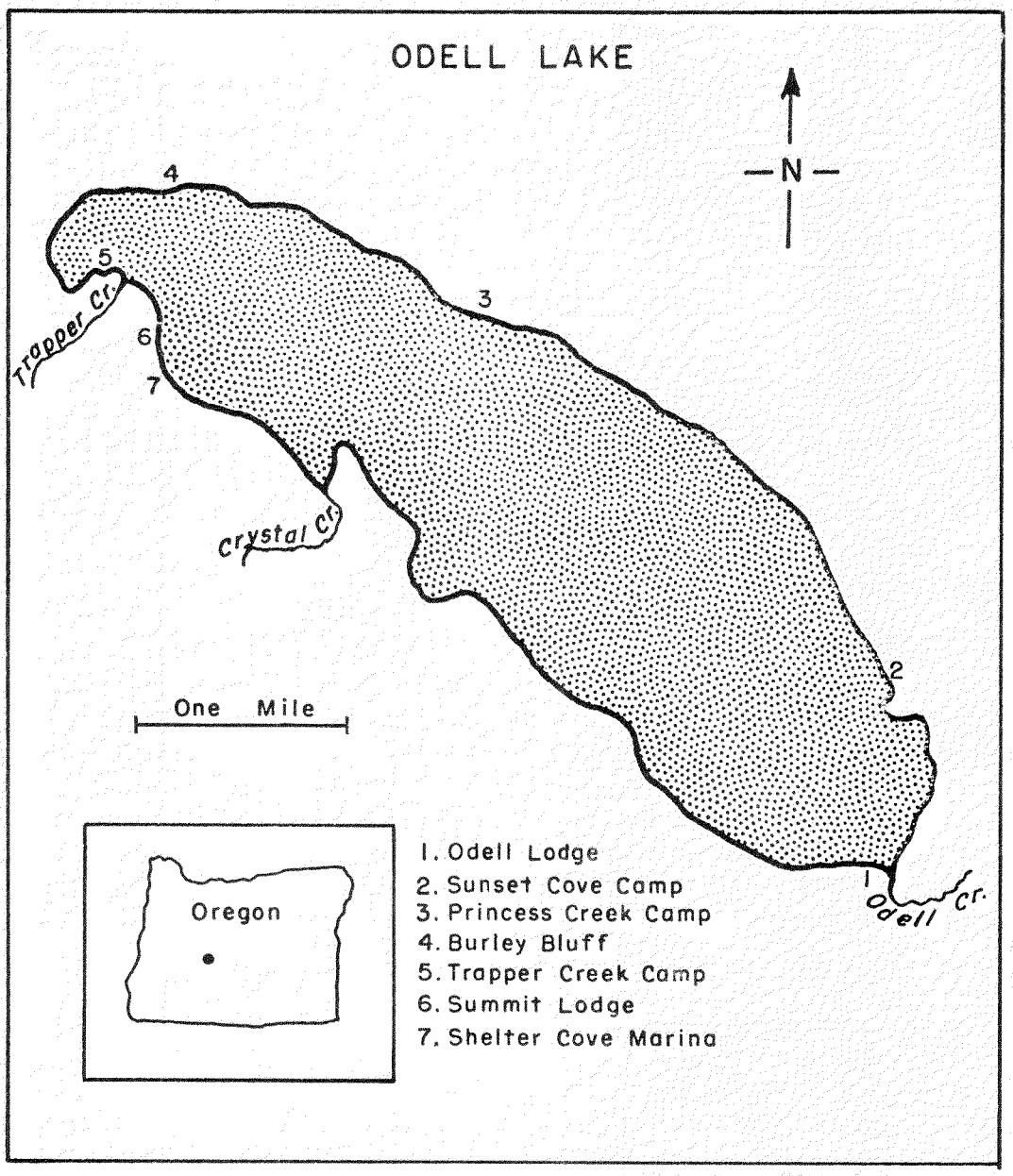

Figure 1. Map of Odell Lake showing location of recreational facilities.

METHODS

Hatchery-reared kokanee were evaluated in relation to size, time at release and racial origin of stocks. From 100,000 to 300,000 fish were released annually between 1963 and 1971 (Table 1). All releases of hatchery-reared kokanee were terminated after 1971. Size at release varied from 450 to 84 per pound (46 to 79 mm) while timing of releases ranged from May to September. The sources of eggs were: Kootenay Lake, British Columbia; Flathead Lake, Montana; and Whatcom Lake, Washington. The fish released were marked utilizing adipose and ventral fin clip combinations for later identification in the fishery. A statistically designed creel census was conducted from 1964 to 1975 to obtain estimates of catch and effort. Details of the creel census design are described by Lewis (1975). The survival and return to the fishery of hatchery-reared kokanee were determined from estimates of total harvest.

RESULTS

The annual harvest of kokanee salmon at Odell Lake from 1964 to 1975 averaged 69,545 ranging from 20,318 to 128,385 (Fig. 2). The catch of hatchery-reared kokanee averaged 7,693 representing 11 percent of the total fish harvested. Hatchery contributions varied from none in 1975 to 23 percent in 1965. Returns of hatchery kokanee to the fishery have averaged 5.4 percent of the total fish released and ranged from 1 3 to 14 6 percent (Table 2).

The harvest of the 1963 to 1971 year classes of hatchery kokanee between 1964 and 1974 points to the relative success of hatchery releases in relation to size of fish, timing of release and racial origin of stocks. Although variable angling pressure and environmental conditions make it difficult to compare returns, certain relationships are nonetheless evident. Both the 1965 and 1969 release groups were eliminated from detailed analysis of returns because of problems with low fishing pressure and disease, respectively, both of which abnormally reduced harvest levels.

Size at Release

Size at release appeared to be an important factor determining survival and return to the fishery of hatchery kokanee (Fig. 3). The size range of fish tested varied from 195 to 84 per pound (63 to 79 mm). Larger fish (80 to 120 per pound) generally provided better returns than releases of smaller fish.

Time of Release

Timing of release also appeared to be an important factor. Best returns were generally realized from fish released between June and July, while May, August and September releases resulted in lower catches (Fig. 4).

Table 1. Kokanee hatchery release groups, Odell Lake, 1963 to 1971.

Release date	Hatchery	Race	Number released	Number per pound	Mean length (mm)	Percent marked	Mark
5/15/63	Wizard Falls	Kootenay	150,246	198	--	20	LV
6/17/63	Wizard Falls	Kootenay	149,607	112	--	20	RV
5/22/64	Wizard Falls	Kootenay	150,083	133	--	20	RV, LV
6/7/65	Wizard Falls	Kootenay	125,410	164	--	20	LV
7/8/65	Wizard Falls	Kootenay	124,293	91	--	20	RV
7/21/66	Wizard Falls	Flathead	99,558	193	--	20	RV, LV
6/21/67	Rock Creek	Kootenay	50,260	195	63	50	Ad, LV
6/29/67	Wizard Falls	Flathead (Colorado)	50,300	176	--	50	Ad, RV
9/11/67	Fall River	Whatcom	48,008	188	63	50	Ad, RV, LV
8/22/68	Oak Springs	Flathead	101,680	136	75	100	RV, LV
6/30/69	Oak Springs	Flathead	50,288	450	46	100	RV
7/30/69	Oak Springs	Flathead	50,400	240	59	100	LV
8/28/69	Oak Springs	Flathead	50,903	109	74	100	Ad, RV
7/20/70	Wizard Falls	Flathead	75,180	84	79	100	Ad, RV, LV
7/20/70	Klamath	Kootenay (Crescent L.)	75,050	158	68	100	Ad, LV
7/1/71	Wizard Falls	Flathead	150,000	122	73	100	RV

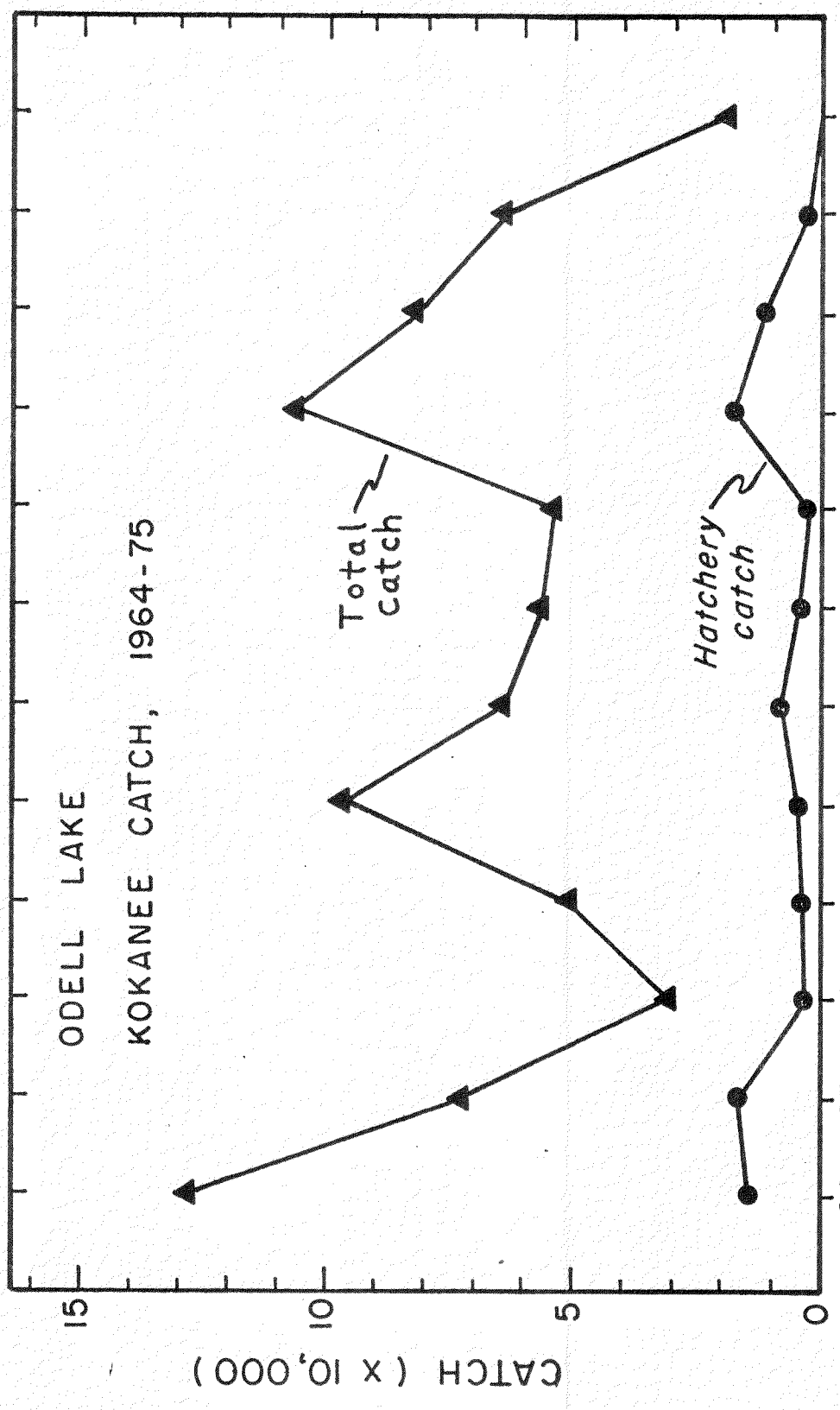

Figure 2. Catch of kokanee salmon at Odell Lake from 1964 to 1975.

Table 2. Harvest of hatchery-reared kokanee by age group from Odell Lake, 1964-1974.

Release date	Race	No. per pound	I+	II+	III+	Total catch	Percent[a] return
5/15/63	Kootenay	198	2,964	2,834*	---	5,798	3.9
6/17/63	Kootenay	112	9,266	12,502*	---	21,768	14.6
5/22/64	Kootenay	133	1,334	1,918*	---	3,252	2.2
6/7/65	Kootenay	164	227	1,520*	1,053	2,800	2.2
7/8/65	Kootenay	91	379	1,875*	1,073	3,327	2.7
7/21/66	Flathead	193	190	1,604	1,632*	3,426	3.4
6/21/67	Kootenay	195	546	2,548*	18	3,112	6.2
6/29/67	Flathead	176	532	2,156	779*	3,467	6.9
9/11/67	Whatcom	188	24	1,027	401*	1,452	3.0
8/22/68	Flathead	136	478	3,161	1,060*	4,699	4.6
6/30/69	Flathead	450	37	136	584*	757	1.5
7/30/69	Flathead	240	68	80	492*	640	1.3
8/28/69	Flathead	109	91	661	584*	1,336	2.6
7/20/70	Kootenay	158	515	6,861*	37	7,413	9.9
7/20/70	Flathead	84	871	4,854	886*	6,611	8.8
7/1/71	Flathead	122	4,872	11,556	3,208*	19,636	13.1

[a]Percentage of total fish released.

[b]Peak year of maturity designated with asterisk.

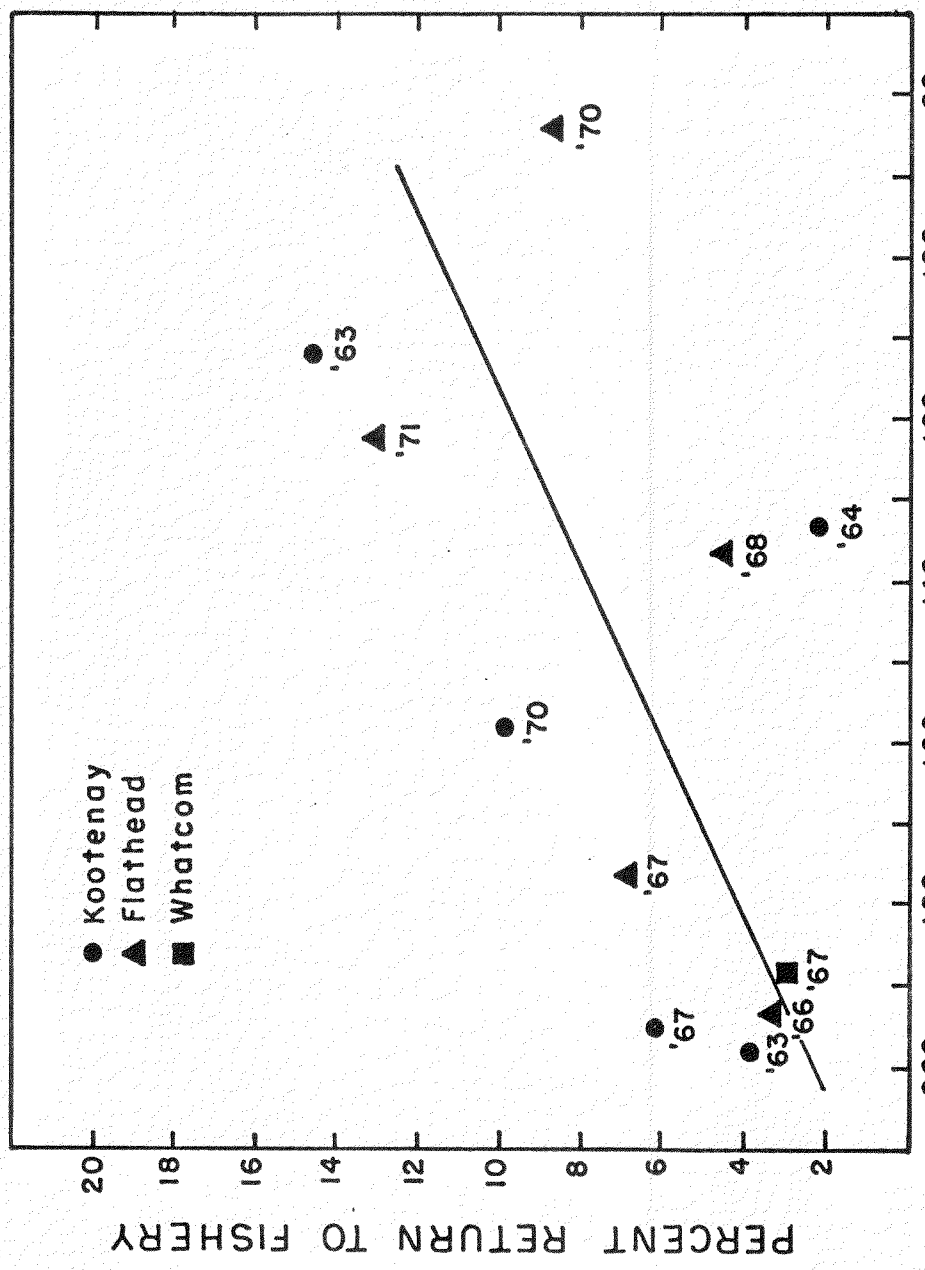

Figure 3. Relationship between size at release and percent return to the fishery for hatchery-reared kokanee salmon at Odell Lake from 1964 to 1974.

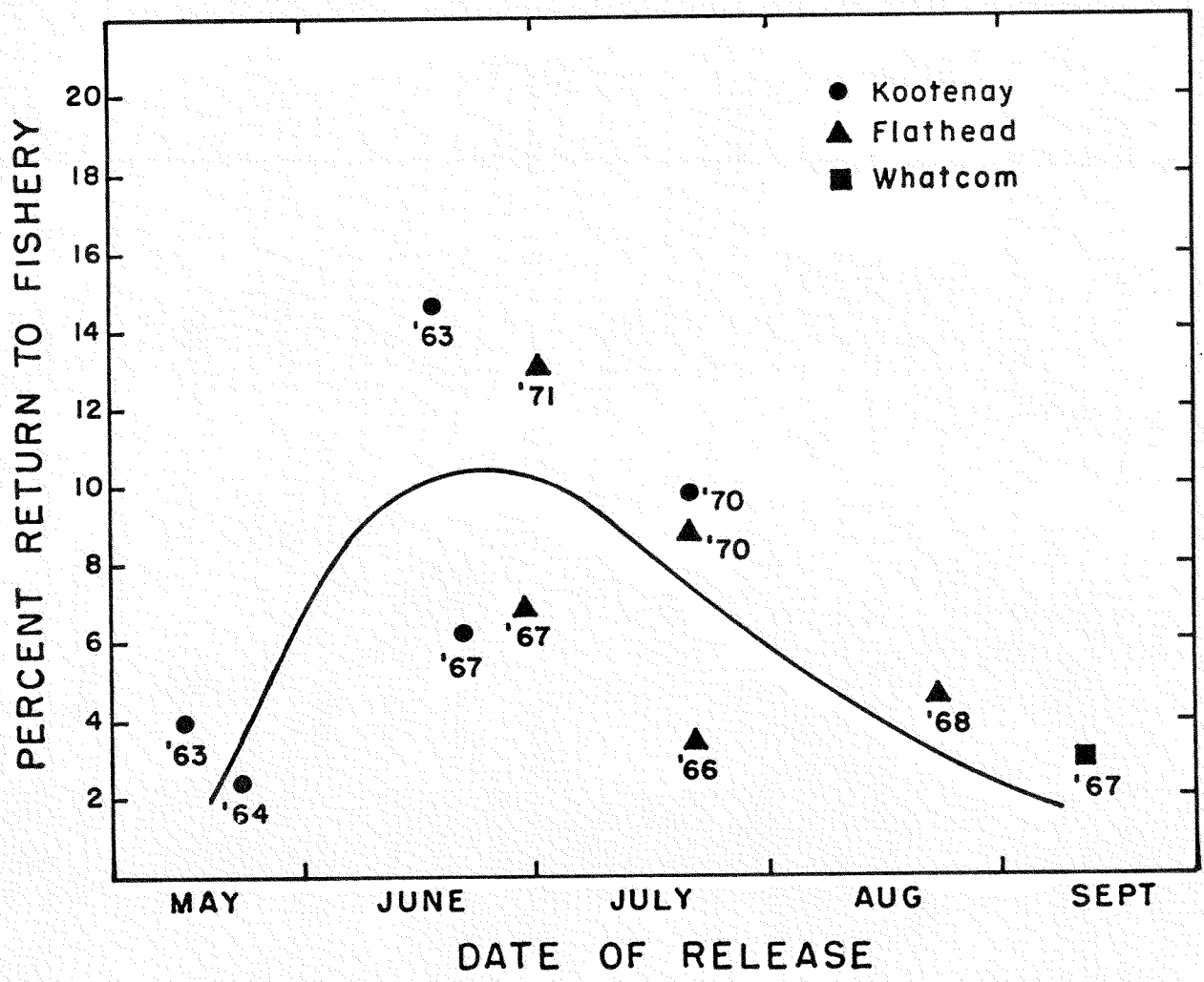

Figure 4. Relationship between time of release and percent return to the fishery for hatchery-reared kokanee salmon at Odell Lake from 1964 to 1974.

Zooplankton abundance at time of stocking appears to be the key to survival and growth. Releases should be timed to correspond with the increase of the zooplankton cycle which is normally June through July for Odell Lake.

Racial Origin of Stocks

Evaluation of racial stocks revealed differences in age at maturity and harvest pattern but little difference in total return to the fishery (Fig. 5). The Kootenay Lake race was harvested in the second and third year of life and matured primarily in the third year (Age II+). The extended life cycle and harvest of the 1965 release groups was attributed to slow growth. The Flathead Lake race was caught predominantly during the third and fourth year of life and matured in the fourth year (age III+). Although harvest of the late-maturing Flathead race extended through the fourth year, the total return was comparable to that of the earlier-maturing Kootenay race. Characteristics of the Whatcom Lake race were similar to the Flathead race. Although detailed growth analyses were not conducted on the hatchery groups it appears that the differences in age at maturity reflect inherent differences in growth rates with the Kootenay Lake race growing more rapidly than the Flathead Lake fish. Little difference was observed in size at maturity between races despite differences in age at maturation. The results generally support the findings of an earlier evaluation of kokanee salmon races (Lewis 1970).

Cost Analysis

The cost per fish creeled of hatchery-reared kokanee salmon introduced into Odell Lake from 1963 to 1971 averaged $0.18 and ranged from $0.06 to $0.35 (Table 3). These values were computed on the basis of an Oregon Fish and Wildlife Department estimate of $1.00 per pound to raise kokanee fingerling and return data from Odell Lake. The above cost was realized in a fishery where hatchery fish made up only 11 percent of the total harvest and returns on hatchery fish averaged 5.4 percent of the fish released. Much higher returns and lower cost per fish creeled could be anticipated from intensive fisheries supported primarily by hatchery fish.

DISCUSSION AND RECOMMENDATIONS

Results of the Odell Lake evaluation provide the basis for better utilization of hatchery-reared kokanee salmon. Stocking procedures for lakes managed with hatchery fish must take into account both size and time at release. Fish released should be approximately 100 per pound (70 mm) and releases should be timed from June through July. Fish may be released earlier in the period for lakes containing the Copepod Diaptomus and later where the Cladoceran, Daphnia is the principal zooplankter. Little difference in total return to the fishery or size at maturity can be anticipated between early or late maturing races. A mixture of early and late fish is recommended until seasonal pattern of harvest can be adequately assessed. Based on cost analyses it appears that a kokanee fishery can be maintained

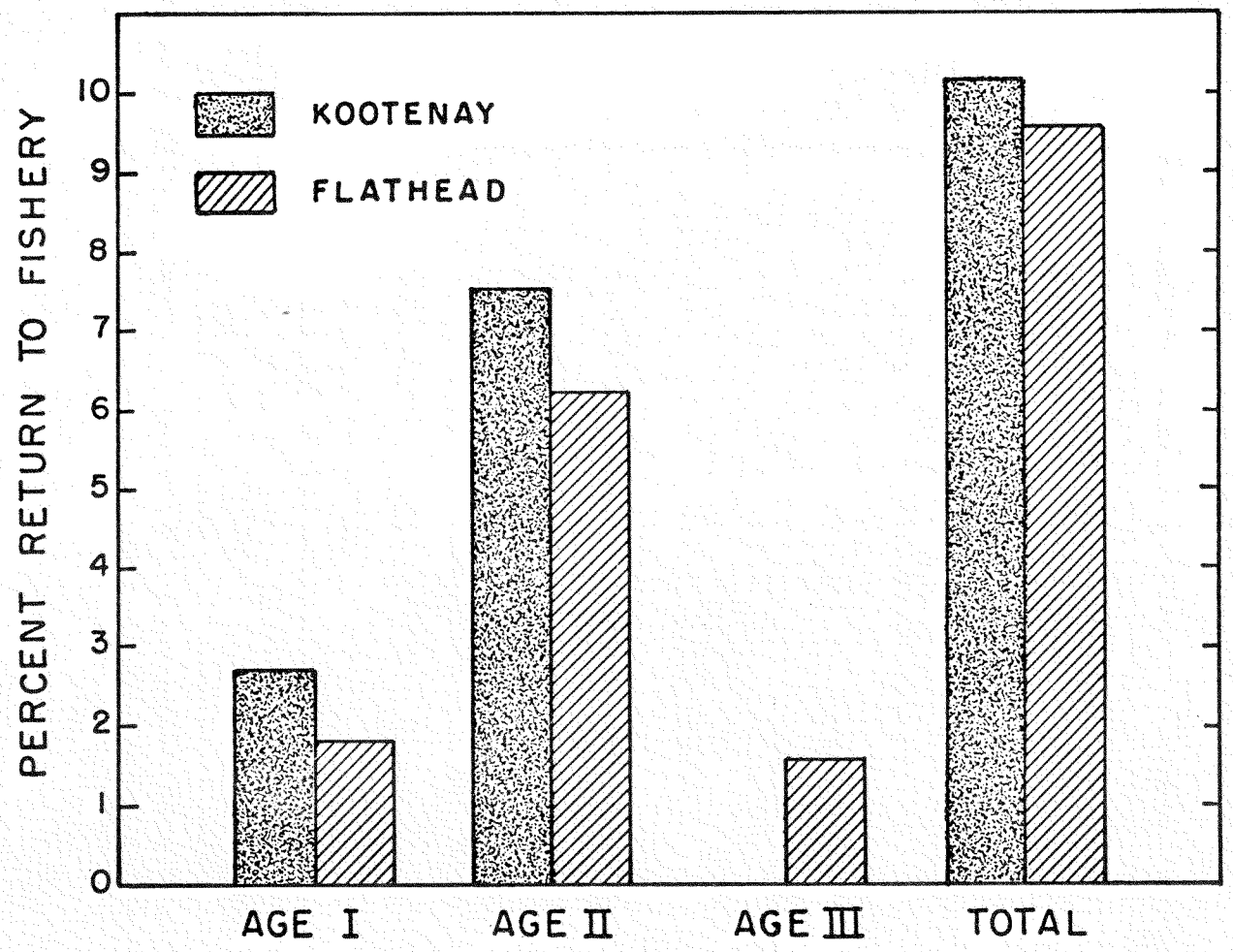

Figure 5. Comparison of the mean percent return to the fishery by age class of Kootenay and Flathead Lake races of kokanee salmon at Odell Lake. (Groups outside the optimal size or time at release were eliminated from comparison).

Table 3. Cost analysis of hatchery releases of kokanee salmon introduced into Odell Lake from 1963 to 1971.

Year of release	No. released	Cost[a] of release	Return to fishery	Cost per fish creeled
1963	299,853	$2,095	27,566	$0.08
1964	150,083	1,128	3,252	0.35
1965	249,703	2,131	6,127	0.35
1966	99,558	516	3,426	0.15
1967	148,568	799	8,031	0.10
1968	101,680	748	4,699	0.16
1969	151,591	789	2,733	0.29
1970	150,230	1,370	14,024	0.10
1971	150,000	1,230	19,636	0.06
Mean	--	$ --	--	$0.18

[a] Based on Oregon Department of Fish and Wildlife estimate of $1.00 per pound for kokanee fingerling.

in large bodies of water at a lower cost than fisheries managed for large fingerling or catchable rainbow trout.

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PRESSURE SPRAY MARKING OF FISH WITH GRANULAR DYES

by

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A technique for marking large numbers of fish quickly, efficiently and inexpensively is needed. Pressure sprayed dyes could be the answer if a permanent mark is not required.

The major advantages are: 1) the cost per marked fish is low when compared with fin clipping or coded wire tagging; 2) the equipment needed is relatively simple and requires no training to operate; 3) the dye is available in three basic colors, which can be combined to provide seven possible color codes; 4) the process does not disturb the fish by excision of fins or mouth parts; 5) individual fish need not be handled; and 6) anesthetizing is not required.

This marking technique has been utilized on projects where mark retention of about two years was required. Spray mark retention studies for longer time have not been made. Since its initial use by C. F. Jackson in 1958, pressure spray mark techniques have been used to evaluate the movement of several aquatic organisms, including salmon, trout, perch, sticklebacks, whitefish, flounder, sole, sea anemones, clams, abalone, starfish, shrimp and sculpins. This list should include most of the organisms of concern to the Department of Fish and Wildlife (see references). Consult the literature before using this technique since there may be information specific to the species you are planning to mark.

Efficiency of marking and retention by species

The marking rate is dependent upon the size and species involved. Smaller fish (6-10 cm) can be marked more rapidly than larger fish ($\geq$ 10 cm). The table below provides some guidelines to the number of fish that can be marked per hour:

Species	Mean fork length (cm)	Spray operation	Fish/ hour	Fish/pound of dye
Spring chinook	16	single pass[1]	35,000	3,000
Rainbow trout	10	single pass[1]	40,000	6,000
Summer steelhead	10	double pass[2]	18,000	3,000

[1] Fish are subjected to the spray operation one time.

[2] Fish are subjected to the spray operation twice (fish are dipped from the raceway, sprayed and placed in a live box. They are then dipped from the live box, sprayed again and released into the raceway).

As a general rule, fall and spring chinook salmon seem to retain the dye better than coho, rainbow or steelhead. No information is available on cutthroat trout. For this reason, it is advisable, if a high retention rate is required, to double spray coho salmon and trout. Double spraying decreases the efficiency of the spray-marking operation as shown in the table above.

Mark retention

The retention of the dye should be evaluated about one week after marking. In the spraying operation, much of the dye is imbedded in the external mucous of the fish, while relatively little of it penetrates beneath the scales. The fish resemble Christmas tree ornaments immediately after spraying, but they rapidly slough the mucous covering which contains most of the dye. By the end of a week, the fish retain only those granules imbedded beneath the scales; they look normal, usually with no visual evidence of the dye. Mark retention is determined in a darkened area or a field viewing box. The number of fish checked for mark retention will depend on the desired precision of the estimate. The mark retention of the groups of fish described previously were:

Species	No. checked	Percent mark retention	Spray operation
Spring chinook	800	93	single pass
Rainbow trout	400	70	single pass[1]
Summer steelhead	200	100	double pass

[1] The spray gun was malfunctioning due to moisture in the dye.

Effects of granular dyes on fish

To evaluate the effects of spray-marking on growth and survival of coho juveniles, Phinney and Mathews (1969), placed three groups of fingerlings (6.3 cm mean fork length) in a mud-bottom pond with 192 yearling coho salmon (15-20 cm in length) and 29 rainbow trout (21-36 cm in length). One group of fingerling coho was spray marked, the second fin-clipped (left ventral-right maxillary), and the third group was an unmarked control. The control and spray marked fish had 1.25 times greater survival than the fin-clipped fish. Phinney and Mathews found that control and spray-marked fish grew equally well, while the growth of the fin-clipped fish was significantly reduced. Their conclusion, based on this study, was that spray-marking had no effect on either the growth or survival of coho fingerlings while fin-clipping had an adverse effect on both traits.

Expected mortalities

Mortalities which occur during spray-marking are caused primarily by stepping on the fish rather than by injury resulting directly from spraying. The loss due to mechanical injury will be approximately 0.1% of the fish

handled. In fingerling rainbow, the loss was 0.2% (400 deaths/200,000 fish handled).

Due to the abrasions and stress imposed by handling, the fish should be given a malachite green or similar treatment after marking to inhibit fungal infections. The treatment time will vary from hatchery to hatchery.

Detection of the spray mark

Unless a fish is overmarked, the fluorescent pigment imbedded under its scales is not visible when viewed in normal light. When illuminated by long-wave ultraviolet light (black-light) in the dark, the pigment will fluoresce, and be readily visible.

If a 100 volt A. C. source is available, such as at a hatchery or at a counting station, the UV illumination can best be provided by a small fluorescent fixture (about $10) fitted with a tube type black-light (poster light) (also about $10). It is advisable to locate the black-light tubes first (buy several if possible), then locate the fixture to fit the bulbs. This method of procurement is desirable since the fixtures are easier to find than the black-light tubes.

A word of caution! It is best to wear eyeglasses with glass lenses when checking for marks. Although long-wave ultraviolet rays will not damage the eyes, it is conceivable that some short-wave rays escape the tube envelope, however, the short-wave rays will not penetrate glass. Also fabricate a shield around the fixture so that bulb doesn't shine directly into the eyes. This will make the marks appear more intense, and facilitate detection.

Field detection of the spray marks can be accomplished by constructing a viewing box. A good light source is a fluorescent tube-type camping lantern fitted with black-light tubes. The camping lantern sells for about $15 ($10-$20) while the bulbs cost about $7 ($5-$10).

Dimensions at the box can vary with the size fish to be checked. For fish about 18 cm or less in length, a box 18" long, 12" wide and 12" high is sufficient. The box can be fabricated with 3/8" plywood except for a portion of the side panels which is sheet rubber. The inside of the box should be painted black. Two slits in the form of an (x) or (+) should be made in the rubber panel so the anesthetized fish can be inserted into the box for viewing while maintaining a relatively light-tight seal around the wrist. Once the fish and arm are inserted, viewing is accomplished by looking through a hole in the top of the box. The diving mask attached over the hole will provide a light-tight seal around the face while viewing. Allow a few seconds for eye adjustment to the low light levels.

Spray marking technique

The marking system is composed of a compressed air source, spray equipment and dye, a chute or trough, and various nets and live boxes (optional). The fish are crowded into a small area of the hatchery pond, scooped up in hand nets and deposited in the trough. The fish are sprayed with the dye as they pass down the trough and back into the pond.

Efficient spray marking requires four persons deployed in the following manner: two fish dippers, one cannister filler and one sprayer. The fish are loaded into an inclined chute (6" wide bottom, 4" sides, 8' in length), covered with plastic and sprayed just prior to their exiting the chute. The chute should be of sufficient length and width to allow the fish to distribute themselves so one surface of each fish is exposed to the spray. Tilt the chute at about a 20° angle so the fish will slide easily into the pond.

Orient the gun at a 45° angle to the bottom of the chute. Spray distance can vary from 8 inches to about 12 inches. Maximum spray efficiency can be obtained if the nozzle is moved rapidly back and forth across the fish.

Equipment required for spray marking (see equipment suppliers)

Equipment needed for spray marking consists of: 1) spray gun; 2) air hose; 3) a compressed air source; 4) dip nets; 5) live boxes (only if double spraying; and 6) fluorescent pigment. Each of these is discussed below.

Spray gun. The gun utilized to apply the pigments is a sand blast gun modified for spray application of the dye. Substitutions may work equally well, however, we have not evaluated any other type of spray gun. The gun (with canister) can be purchased for about $40. A spare canister for the gun can be purchased for about $5. The extra canister will save time since one can be loaded while the second is in use.

Air hose. Any air hose (1/4" diameter) capable of withstanding 150-200 pounds pressure can be used to attach the spray gun to the compressed air source. The cost, on a per foot basis, varies from $.50-$1.30, depending on the length purchased and the supplier.

Compressed air source. The air source used for propelling the pigment may be an air compressor or compressed air bottles. Whatever the source, it should be capable of delivering 100 psig continuous pressure. That is, the pressure applied to the gun while in operation should not be less than 100 psig, or more than 120 psig. A lower pressure will result in decreased mark efficiency. Large compressors may be obtained from rental agencies.

Electrically powered compressors (110-120 v AC) cannot handle the load requirement of this spray operation. Gasoline powered compressors

(4 hp) have worked well. Compressors operating on 220 v AC are best suited for heavy duty work, and should be used if available. Fast recovery compressor systems are preferable.

For small scale spraying operations or if the system needs to be portable for use in the field, commercially bottled air can be used The tanks must be fitted with a standard two-stage regulator so that the desired spray pressure can be obtained. Fittings are also available for adapting SCUBA tanks to standard air hose fittings.

Glow-mark fluorescent pigment. The fluorescent pigments used in spray-marking come in two forms: powdered and granular. Published literature indicates that better mark retention is attained using the granular (50-350 μ) pigment. Dyes are available in four colors: red, yellow, green and blue. The blue pigment, however, decomposes rapidly in sunlight, and is not recommended. The dyes can also be obtained in various color combinations: red-yellow, red-green, yellow-green, and red-yellow-green. In total, seven color combinations are available for use.

The cost of the pigments varies with color: red being least expensive ($7.25/lb) and green being most expensive ($7.75/lb) (11/30/75 prices for 11-50 lbs.). As with most commodities, the larger the order, the less the price per pound.

The pigments are biologically inert, and pose no threat to the fish. It should be mandatory, however, that personnel in the immediate vicinity of the spray operation wear protective face masks to prevent inhalation of the dye. The only supplier for these dyes is Scientific Marking Materials, P. O. Box 24122, Seattle, Washington 98124.

Helpful hints

1) Occasionally the dye intake stem for the spray gun will become clogged. To clear the stem, press the nozzle of the spray gun against the side of the trough and pull the trigger. This will force air back through the stem and into the canister. A spray of pigment will be emitted from the breather hole in the canister when the stem is cleared.

If that doesn't work, the stem should be unscrewed from the spray handle and cleaned with a wire and acetone. Ream out the stem with the wire, then immerse the end of the stem in acetone and pull the trigger on the gun. Directly the spray away from all personnel.

2) When cleaning up the equipment, use the spray gun body and nozzle. Immerse the intake stem in the water and use the air pressure to generate a high pressure washer.

3) Wear old clothing, a face mask (spray painting type), and gloves. The fine granules will penetrate practically anywhere, especially in the wrinkles of skin and between the fibers in clothing. It generally takes several days forthe dye to "wear off" your skin, so you might want to avoid "black light joints' for several days after spraying.

4) Use a large funnel to load the canisters with dye. Pour the powder in the funnel at an even rate to prevent clogging of the funnel. If the becomes clogged, use a pencil or stick to push the dye through the orifice. Don't hit the funnel on the edge of the canister to unclog it - that will compact the powder in the canister and clog the stem when spraying.

The listing of a possible vendor does not constitute an endorsement by the author or the State of Oregon.

Acknowledgements

I wish to thank the following individuals for their advice and assistance in this project: Ray Culver, Hatchery Superintendent, Cole Rivers Hatchery; Jan Adkins, John Adkins, Doug DeHart, Steve Johnson and William Noll, all of whom were biologists working on the Rogue Basin Evaluation Program.

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MODIFICATION OF THE CODED-WIRE NOSE TAG MARKING PROCEDURE

by

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The coded-wire nose tag mark has, in the past several years, become the mark of choice for anadromous fisheries experiments on the Pacific Coast. Federal agencies including National Marine Fisheries Service and U. S. Fish and Wildlife Service, fishery agencies in Alaska, California, Idaho, Oregon, and Washington, and the province of British Columbia are all currently identifying experimental groups of fish with binary coded-wire nose tags and adipose fin clips. With the large numbers of fish marked each year, any change in the procedure reducing costs becomes very significant.

In 1973, a four year hatchery evaluation study was initiated by the U. S. Fish and Wildlife Service at Spring Creek National Fish Hatchery. During this period a total of 4, 000, 000 fall chinook, Oncorhynchus tshawytscha, will be marked. With a marking experiment of this size, it was desirable to maximize output per marker day. This necessitated a change to the marking procedure as practiced at that time. The usual method was to have one group of women, remotely located from the marking machines, anesthetize and clip the adipose fin off the dorsal surface of the fish. These fish were allowed to recover, moved to the area of the marking machines, and then reanesthetized and nose tagged. With some exceptions, one fin-clipper could supply fish for one woman operating a tagging machine. This meant that if the number of fish marked for a day by one machine operator was 4, 000, the number per marker day would be half, or 2, 000.

By rearranging the physical set up of the machinery and making slight modifications, one woman can both clip and tag without slowing down the process. The extra step adds nothing to the time for tagging. Working with a supply of anesthetized fish to her left and the machine directly in front, the fish marker secures a fish right side up with her left hand, the adipose fin is clipped with scissors held in the right hand, the fish inverted and placed against the head mold, the cycle switch is operated with the scissors hand, and the fish is released to pass through the quality control detector.

An additional advantage for the modified method concerns the amount of handling the fish undergoes. In this method the fish is only handled and

anesthetized once versus handling and anesthetizing twice in other methods.

Table I shows a comparison between fall chinook marked by the two different methods in fish per marker day. The fish per marker day varied between 1, 899 and 2, 572 when two women were involved. Themodified method ranged from 4, 844 to 6, 179. This is a significant difference, and would result in a reduction in the cost per fish marked. It should be noted that in 1975 the 4, 844 fish per marker day at Spring Creek was adversely affected by machine problems. This also applies to the low figure at Alsea Hatchery. In 1974, 250, 000 fish group was marked by 5 women in approximately 7 days, an average of almost 7, 000 fish per marker day. To mark a group of this size using the two woman method would require an output of 14, 000 fish per machine per day. The results with spring chinook were similar (Table II). On fish of equal size 2, 222 per day were marked with the two woman method and over twice as many, 5, 057, with the one woman method.

The purpose of this paper is not to criticize the methods by which fish have been marked in the past, but rather to provide a money saving alternative. Reductions in cost may open the way for many new marking experiments. The figures for Oregon hatcheries were supplied by Oregon Department of Fish and Wildlife. These fish received high quality marks and had exceptional tag retention.

Table I - Fall Chinook Marking

Hatchery	Agency	Method	Fish/Marker Day
Quinault 1974	USFWS	Standard - 2 women	2, 572
Quinault 1975	"	"	2, 342
Klaskanine 1973	ODF&W	"	2, 455
Klaskanine 1974	"	"	2, 294
Alsea 1973	"	"	2, 207
Alsea 1974*	"	"	1, 889
Trask 1974	"	"	1, 977
Elk River 1974	"	"	2, 566
Spring Creek 1973	USFWS	Modified - 1 woman	4, 526
Spring Creek 1974	"	"	6, 179
Spring Creek 1975*	"	"	4, 488

* Machine breakdowns frequent.

Table II - Spring Chinook Marking

Hatchery	Agency	Method	Fish/Marker Day
Marion Forks 1973	ODF&W	Standard - 2 women	2, 222
Willamette 1973	"	"	2, 222
Carson 1975	USFWS	Modified - 1 woman	5, 057

NUTRITION

THE EFFECT OF EARLY FEEDING ON THE RATE OF YOLK ABSORPTION IN CHINOOK SALMON (ONCORHYNCHUS TSHAWYTSCHA) ALEVINS

by

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Washington Department of Fisheries
Artificial Production
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Introduction

It has been previously shown that hatchery-reared chinook salmon are able to convert food to growth prior to completion of yolk absorption. Of interest is the effect, if any, that early feeding of alevins has on the rate of yolk absorption. In order to establish any change in rate of yolk absorption that is associated with early feeding, a comparison study was initiated at the experimental hatchery at the University of Washington, Seattle.

Methods

The fertilized eggs from one chinook salmon female were incubated to hatching in one compartment of a vertical Heath incubator. Incubation was monitored daily after the eggs began to hatch and when hatching was virtually 100% complete (1/27/75) samples of 20 alevins were taken at intervals of two or three days and preserved in a solution of 10% formalin. After one week in formalin, yilks were removed from the alevins and weighed to the nearest .1 mg. On the twelfth day after complete hatching (2/8/75) the lot of alevins was divided randomly into two groups and placed in two 27" x 12" sections of a standard shallow hatchery trough. Those alevins in one section were offered the standard University of Washington salmon diet at least hourly, eight hours per day, over the following five weeks. During this period, the second section remained unfed. At intervals of from one to five days, 20 alevins were removed from each section, preserved in 10% formalin, and later analyzed for yolk weight. When growth gains were visually apparent, fork length and whole weight measurements of preserved fish were included. Fork length was recorded to the nearest mm and weight to the nearest .01 g. The study was concluded when fish with no yolk remaining appeared in each of the sections (2/12/75), a feeding period of five weeks after separation of the groups.

Water flow in the trough was 5-6 gpm and the trough temperature averaged 52.1°F and ranged from 51.0 to 55.0°F.

Results

As has been demonstrated previously, the chinook salmon alevins were able to convert food to growth prior to yolk absorption. Initial mean length when alevins were placed in the hatchery trough was approximately 33 mm. After five weeks of separate rearing, the unfed group reached an average length of 37 mm while the fed group averaged 44 mm in length, 119% of the unfed mean length and a net difference of 7 mm (Figure 1).

Weight at initial separation averaged .55 g. After the five weeks of separate rearing, the fed group averaged 1.15 g while the unfed group averaged .56 g, the fed group average being 205% of the unfed group mean weight, a net difference of .59 g (Figure 2).

Figure 3 shows the rates of yolk absorption from the time of 100% hatching to the end of the five week feeding period. The rate of yolk absorption for the fed group was 6.11 mg/day and the rate for the unfed group was 6.08 mg/day. Statistical testing of the hypothesis of no difference in the slopes representing yolk absorption rate resulted in a t-value of .417, $p > .50$, indicating no difference in yolk absorption rate between the two groups.

The data support previous evidence that chinook salmon alevins are able to convert an exogenous food supply to growth prior to the time of yolk absorption. In addition, it was shown that the conversion of an exogenous food supply by the alevins does not significantly alter the rate of yolk absorption when compared to unfed alevins.

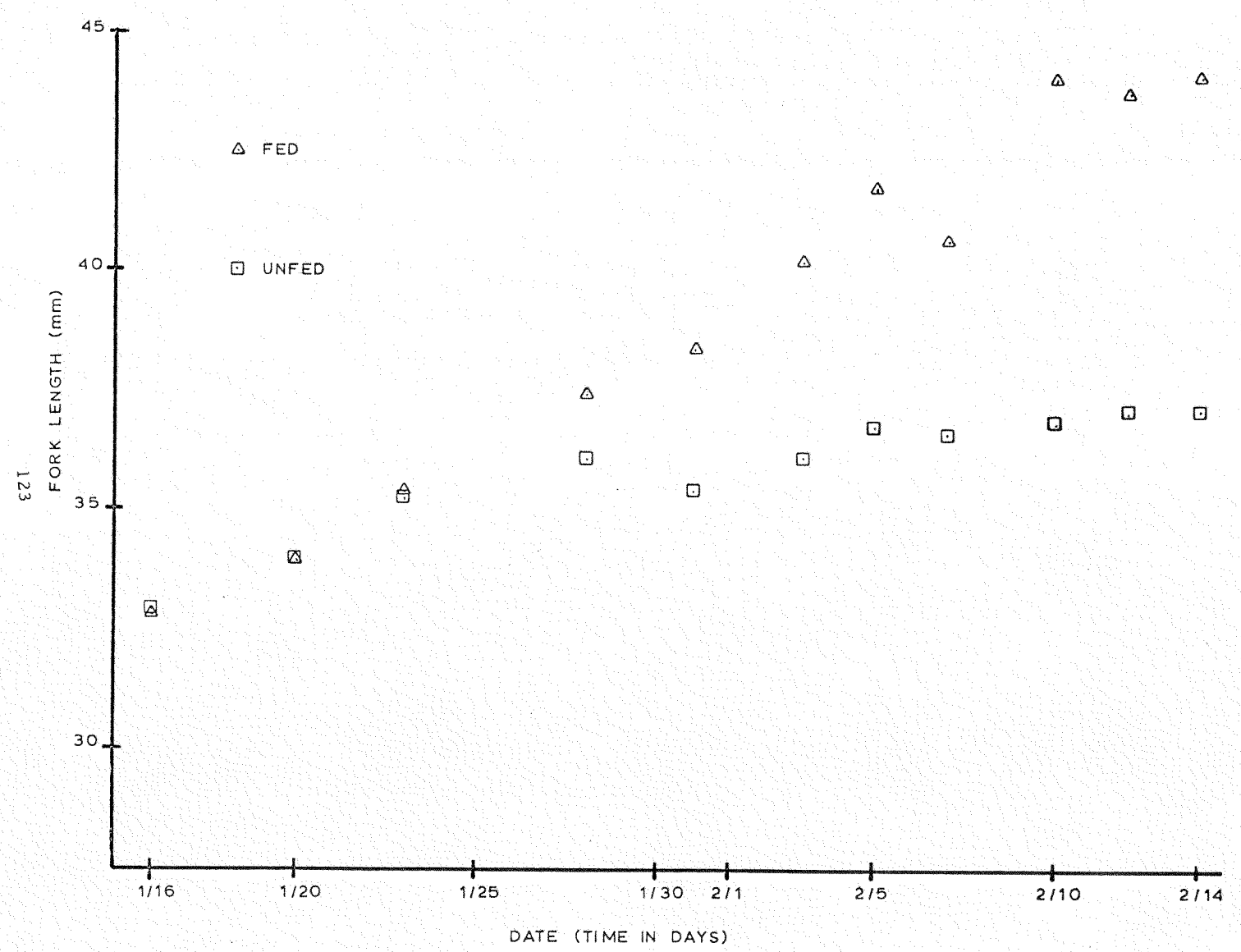

Figure 1: Change in fork length, chinook alevin yolk absorption experiment

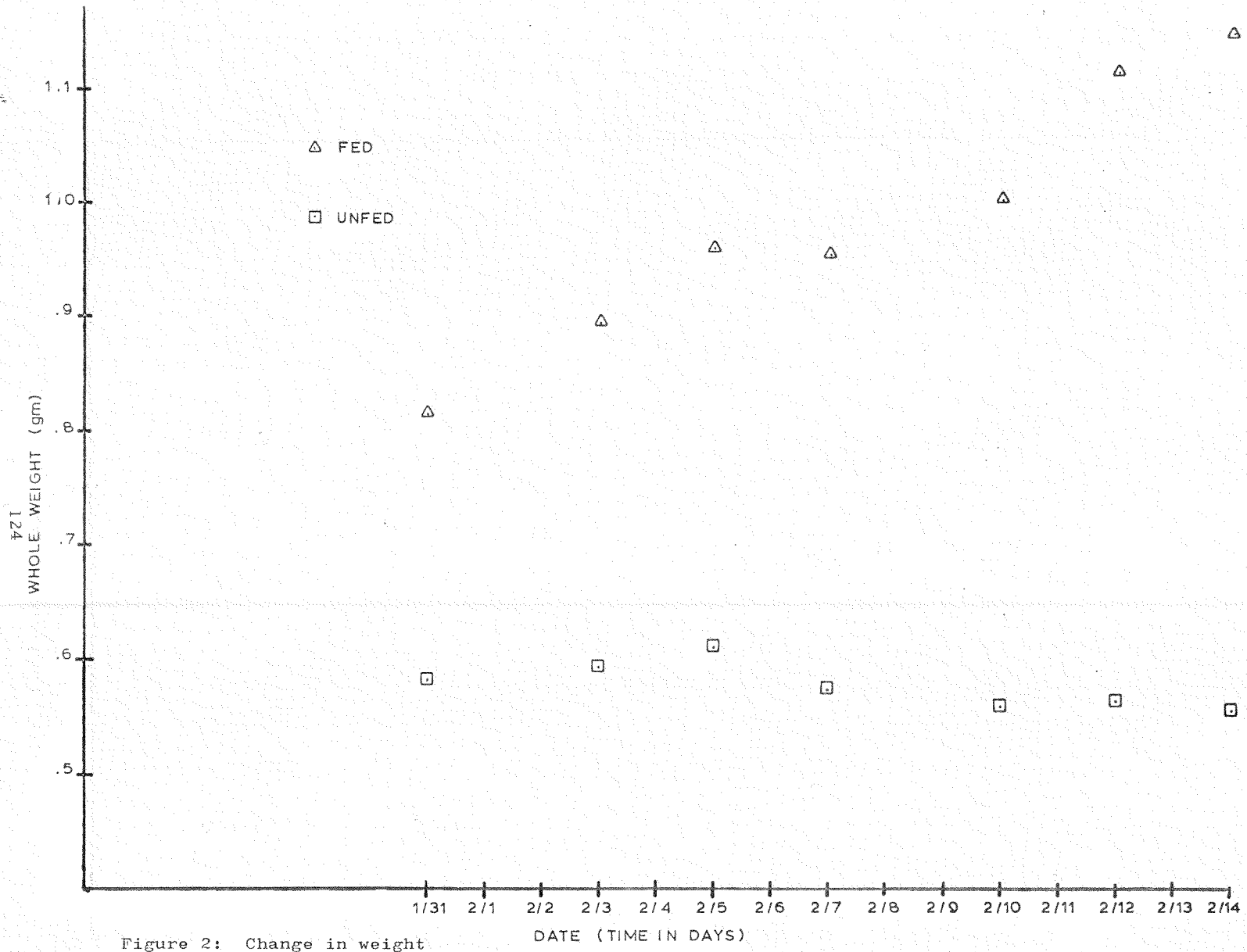

Figure 2: Change in weight

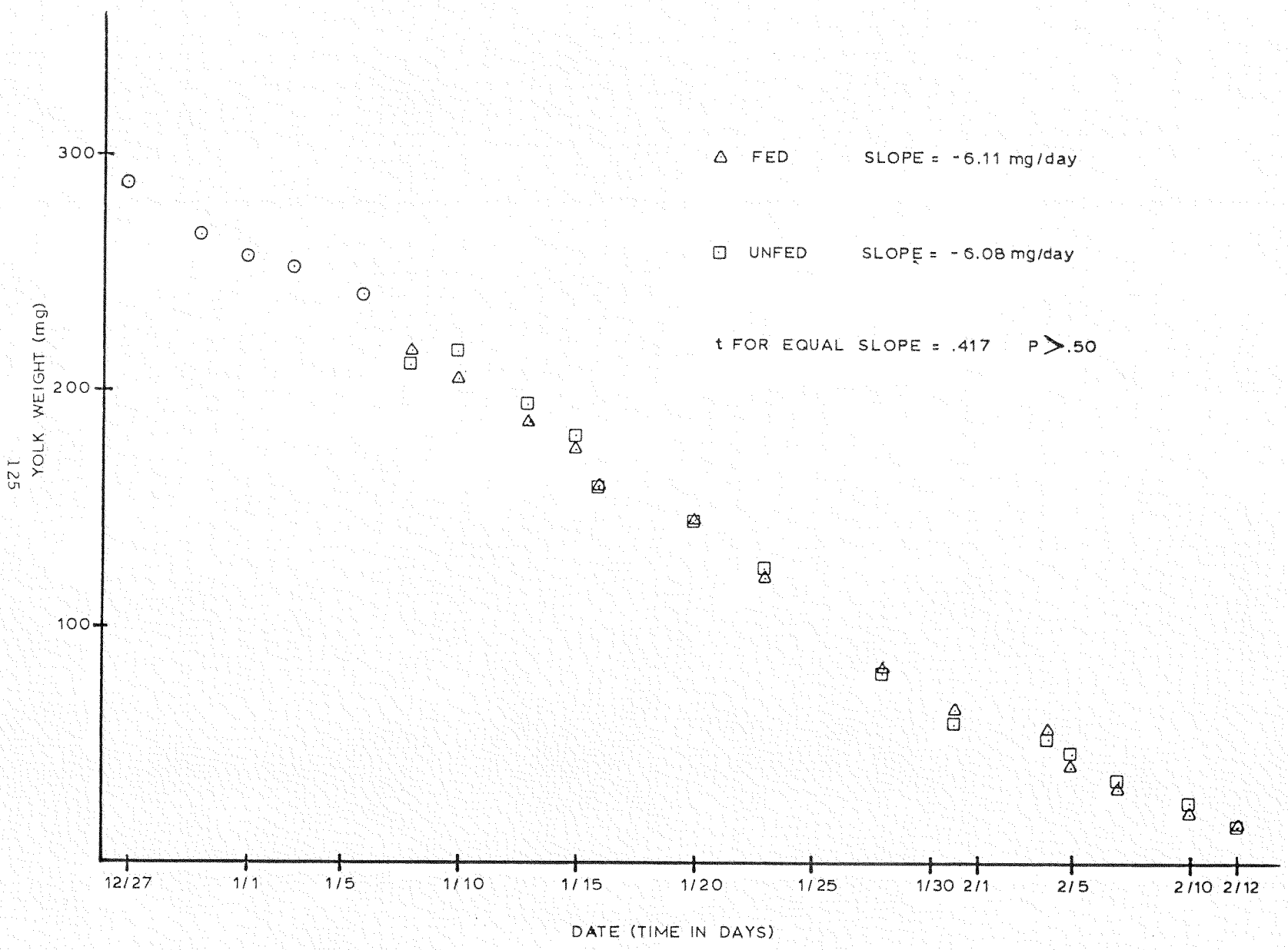

Figure 3: Yolk absorption rate, fed and unfed chinook alevins

EFFECTS OF LIPID NUTRITION ON POST-RELEASE SURVIVAL OF COHO SALMON

by

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ABSTRACT

Since about 1969 the Oregon Department of Fish and Wildlife has been studying lipid nutrition and it's possible effects on fish fitness and survival. We became interested in this subject because results obtained at the USF&WS Abernathy Salmon Cultural Laboratory suggested that increased fat stores might be beneficial to fall chinook fingerlings after liberation (Burrows, 1969). Our work has been directed toward confirming those results and extending the research to other species of salmon.

To date, our studies have concentrated on coho salmon and we have conducted three survival experiments; one each with 1969-, 1970-, and 1972- brood fish. In each trial, duplicate lots of about 80,000 to 90,000 fingerlings were fed Oregon Pellets (OP-2) containing "low" and "high" amounts of supplemental lipid from June or July until the fish were released in April the following spring. The "low" supplements ranged from 0.0% to 0.5% of the diet (about 10-11% total fat, dry weight) and the "high" supplements ranged from 5.8% to 6.5% (about 17-18% total fat, dry weight). Soybean oil was used as the lipid supplement in the first experiment, herring oil in the second, and both soybean and herring oils were employed at two different levels in the third trial. All experiments were performed at the ODF&W Cascade Salmon Hatchery located about 2 miles upstream from Bonneville Dam. In each study, representative groups of fish were marked with distinctive fin-clips to permit identification in fisheries catches and hatchery recoveries.

Results to date indicate: (1) the amount of dietary lipid used during was significantly correlated with increased rates of survival to adulthood ($P < 0.01$); (1) diets containing herring oil supplements were associated with significantly higher survival rates than those using soybean oil ($P < 0.01$); and (3) fingerling fat content at liberation is not a dependable indicator of survival potential for coho salmon.

ACKNOWLEDGEMENTS

These experiments were made possible by the diligent work of hatchery personnel at ODF&W Columbia River Gorge Hatcheries. Mr. Daniel B. Romey, now with the Alaska Department of Fish and Game, was intimately involved in planning and conducting the first two field tests.

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SOME OBSERVATIONS ON THE USE OF FISH PROTEIN CONCENTRATE IN EXPERIMENTAL TROUT DIETS

by

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ABSTRACT:

Semipurified diets containing varying levels (40, 50, 60 and 70 percent) of casein-gelatin and fish protein concentrate (FPC)-gelatin were fed to duplicate groups of rainbow trout for nine months. Poor growth resulted from trout fed FPC at the two highest protein levels (60 to 70 percent and from trout fed casein at the lowest protein level (40 percent). Skeletal aberrations (scoliosis, lordosis, and deformed operculas and hypural plates) occurred in trout fed FPC at the two highest protein levels (60 and 70 percent), but not in any casein fed fish. Mortalities in the FPC fed trout increased proportionately (3.8 to 18.1 percent) with the FPC level in the diet, but mortalities remained low (0-3.1%) in the casein fed trout. The factor(s) in these FPC diets which are causing the pathological conditions are unknown at present and will be the object of further study.

USE OF "BIOPOND SLUDGE" AS A FEED INGREDIENT FOR PEN-REARED COHO SALMON

by

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Over the years fish culturalists have seen continuing increases in the price of fish meal and a subsequent rise in feed costs. As a result, salmonid diet research has included experimentation with alternate sources of protein for fish food, including dairy by-products, grains and yeasts. The paper industry also has a proteinaceous by-product, nicknamed "biopond sludge" or "biosludge." Effluent from part of the paper making process, containing sugars, carbohydrates, lignins and other materials, is retained in large settling ponds. Various microorganisms grow in these bioponds, including bacteria and protozoans. As they grow and collect, a foamy brown sludge is formed which can be scooped up and dried. After drying, this black crunchy granular material contains from 30 to 40% protein. This preliminary study was designed to test the suitability of this material as a feed ingredient for salmon. In particular, we wanted to determine if salmon could eat, survive and grow on a diet which included biopond sludge.

The location for this study was at the Weyerhaeuser Salmon Aquaculture Research Facility, a salt water pen rearing site in southern Puget Sound, at Henderson Inlet. The experimental rearing units were a series of 8' x 8' x 8' nylon net pens, located in a plank and log float. Each net contained approximately 1000 zero-age coho salmon (Kalama stock, 1974 brood year), with an average initial weight of 21 grams.

The biopond sludge was incorporated in a dry diet following the Abernathy formulation (Fowler et al, 1971). The feed was prepared at Washington State University in Pullman, in cooperation with Dr. I. A. Dyer. The experimental diets contained two different levels of biopond sludge - at 7% ("Biopond-7") and 14% ("Biopond-14") by weight. "Silver Cup" Salmon feed (Murray Elevators, Utah) was used as the control diet; this was the same feed the fish had been reared on, both in fresh and salt water, prior to experimentation.

After six weeks, the experiment was rearranged due to short feed supply; replicate pens were canceled. Biopond-7 was fed for 10 weeks, and Biopond-14 and the control diet continued for 12 weeks, from August to October, 1975.

RESULTS AND DISCUSSION

Basic Diet Formulation

Ingredient	% by Weight
Biopond Sludge	7-14
Fish Meal	50
Wheat Germ	13-15
Whey	13-15
Wheat Middlings	5-8
Herring Oil	4
Vitamin Pack	1

Proximate Analysis of Feed

	Protein	Fat	Ash	Moisture
Biopond-7	41.9	10.6	10.8	8.3
Biopond-4	41.2	10.7	10.7	8.4
Silver Cup	>48	>8	<17	

Comparative Biological Parameters

	Initial Size (Grams)	Final Size (Grams)	# Days	Growth Rate %/Day	% Mortality Overall	Conversion
Biopond-7	21	63	71	1.6	10.1	1.3
Biopond-14	21	68	85	1.4	14.9	1.8
Silvercup	21	80	85	1.6	11.0	1.6

The results of this study indicate that salmon can eat and grow on a diet which incorporates biopond sludge. Growth rate for fish on Biopond 7 was the same as the control; growth on Biopond 14 was slightly less. The fish fed Biopond 14 had the highest percent mortality and highest conversion rate, while the Biopond 7 diet produced a relatively lower percent mortality and the lowest conversion rate.

In conclusion, it appears biopond sludge deserves continued research. The material needs to be analyzed chemically more thoroughly, and fed to other salmonids as well as other animals. Plans are underway for a study at the Abernathy Salmon Cultural Station in Longview, Washington, incorporating the sludge at different levels in diets for chinook salmon.

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QUANTITATIVE PROTEIN REQUIREMENTS OF THE UNIVERSITY OF WASHINGTON RAINBOW TROUT BROOD STOCK

by

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Isocaloric[1] diets of approximately 27%, 37%, 47% and 55% protein[2] were fed to the 1973 brood during the eight months prior to their first spawning as two-year-olds to determine their quantitative protein requirements. Growth to spawning and fecundity, egg size, gamete viability and egg survival were evaluated.

The results (Table 1) indicate that under the particular set of environmental conditions experienced, University rainbow brood stock require a diet containing between 37% and 47% protein for maximum growth. Although statistical analysis did not detect a significant difference (alpha is .05) it appears that there was an increase in fecundity and egg size with an increase in percent protein to the 47% level (Table 2). Also, the females which received the 27% protein diet were significantly delayed in reaching ripeness. However, the level of protein did not appear to have a significant or consistent effect on gamete viability, egg survival to the eyed stage or egg hatchability (Table 2). Possible egg survival differences may have been masked due to high pre-hatching and hatching mortality, which I feel can be attributed to some physical aspects of our incubation system combined with small egg size.[3]

These problems will be investigated with the 1974 brood rainbow trout spawn.

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[1] 3.90 kcal/gm (dry weight)

[2] dry weight

[3] approximately 4.2 mm or 0.164 inches

Table 1.

Protein level (%)	Female			
	Length (cm)		Weight (kg)	
	Mean	SD	Mean	SD
27	53.2	2.8	2.47	0.44
37	53.0	3.3	2.46	0.41
47	56.0	3.1	2.84	0.36
55	55 7	2.4	2.87	0.38

Table 2.

Protein level (%)	Number of eggs/oz		Number of eggs spawned		Percent eyed eggs		Percent Hatch	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
27	501.9	70.1	8993	1677	75.9	18.8	45.5	29.1
37	491.5	101.3	8700	2278	74.7	18.4	54.0	27.0
47	465.1	81.2	9896	1950	80.6	12.0	48.9	20.9
55	468.0	48.6	10001	2771	75.2	24.2	54.0	27.4

THE EFFECT OF DIETS CONTAINING DOGFISH MEAL (SQUALUS ACANTHIAS) ON THE MERCURY CONTENT AND GROWTH OF PEN-REARED COHO SALMON (ONCORHYNCHUS KISUTCH)

by

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ABSTRACT

The use of dogfish meal as a complete replacement for herring or other low mercury (Hg) content fish meal in rations intended for rearing cultured salmon introduces the risk of producing fish that exceed the current U. S. FDA tolerance of 0.5 ppm Hg. The amount of Hg that accumulates in the muscle is not only related to the total Hg content of the fish, but is probably also related to the form in which it is present in the diet and to other constituents that may react with the Hg in the diet. The results indicate that dogfish meal may be used as a partial (<50%) replacement for the fish meal portion of the diet without encountering Hg values (in the muscle) that exceed 0.5 ppm Hg. No evidence was found that naturally occurring chelating agents in dehydrated orange peel or polygalacturonic acid-cellulose complexes (PG) have the ability to chelate and prevent the deposition of Hg in either the muscle or the liver of the fish.

It was observed that growth is significantly decreased in coho fed OMP-type diets in which 50% or more of herring meal was replaced with dogfish meal. Results of experiments are summarized in Figure 1. Details will be published in the August (1976) issue of the Journal of the Fisheries Research Board of Canada.

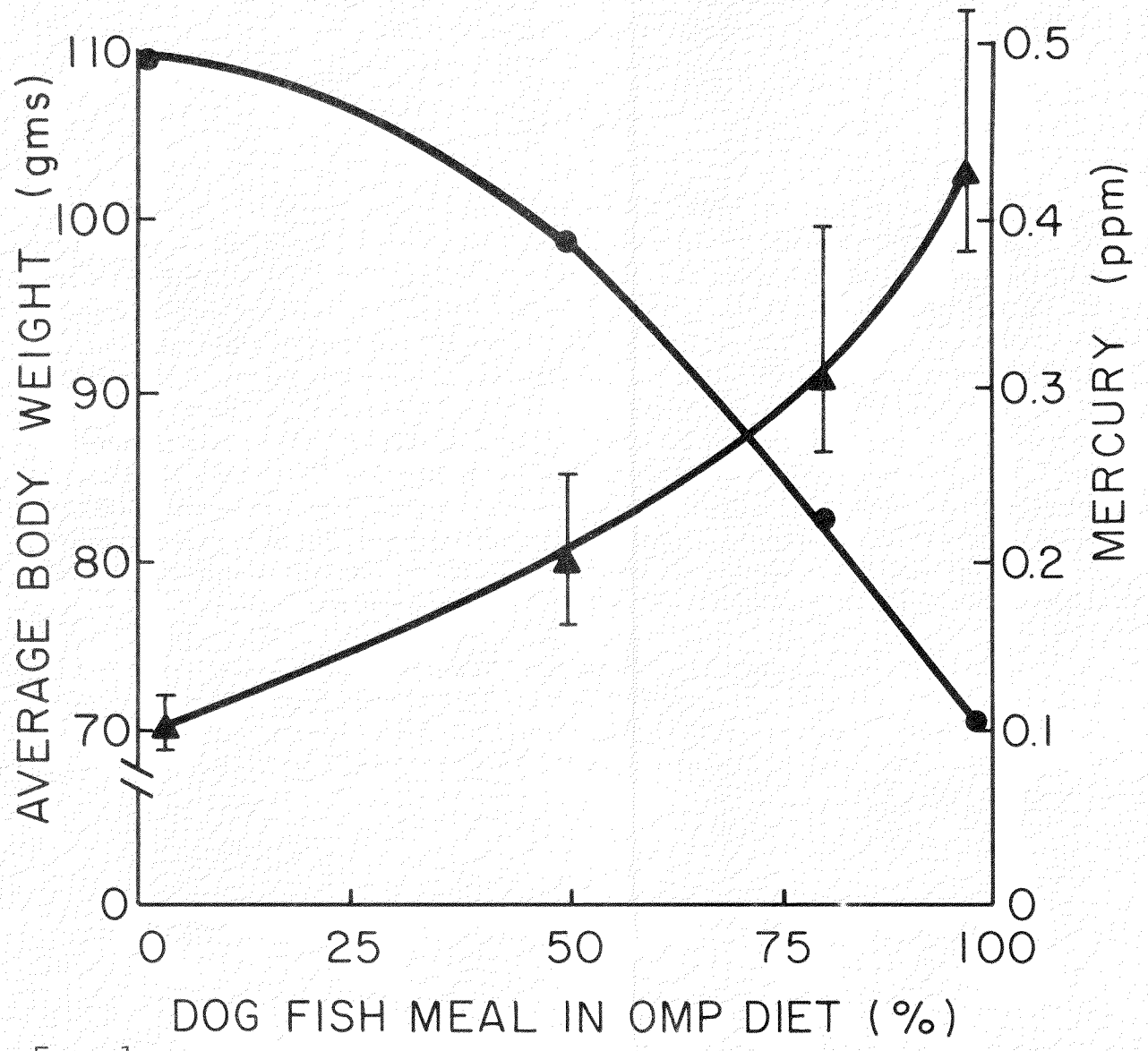

FIG. 1

Average body weight and mercury content of coho salmon fed 180 days with OMP diets containing 0–100% of the fish meal portion replaced with dog fish meal.

PHYSICAL FACILITIES

OXYGEN CONSUMPTION OF COHO SALMON IN A PUMPED SALTWATER RACEWAY

by

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INTRODUCTION

The water requirements of most salmon rearing units depend primarily on the rate of removal of oxygen from that water. The minimum dissolved oxygen levels necessary to maintain fish life put a limit on these water requirements. The test described here was an attempt to measure the change in oxygen levels as water passed through a pumped saltwater raceway that contained coho salmon. These oxygen levels were observed as fish were put through several standard fish cultural activities. The experiment was designed to model the saltwater acclimation and release of salmon. It was conducted at the Weyerhaeuser Company's experimental net pen culture site at Henderson Inlet in southern Puget Sound.

METHODS AND MATERIALS

The oxygen consumption of two populations of different sized fish was measured over a ten-day period (in August 1975) following their introduction to raceways. Measurements were taken at 8 a.m. (before feeding), 12 noon, and 4 p.m. Consumption was measured by taking dissolved oxygen readings at the inlet and outlet of the raceways. On the fifth day the densities of the raceways were reduced by thinning due to low dissolved oxygen levels.

Dissolved oxygen was measured with the Y.S.I. model 57 meter. Fish were held in 36.5' x 6' x 6' aluminum raceways. Two hundred gallons per minute of saltwater was pumped to each raceway, giving a water exchange rate of 1.5 times per hour. Water was pumped from a depth of 12 feet. It had a temperature of from 13.5°C to 15°C and a salinity of from 25 to 30 parts per thousand. The two groups of fish were 5/lb and 17/lb.

OBSERVATIONS

Oxygen consumption was determined by measuring the difference between incoming and outgoing dissolved oxygen levels. This part per million figure was then changed to pounds of oxygen per 100 pounds of fish per day by multiplying times the water flow (converted to pounds per day) and then dividing by the pounds of fish (times 100). This data is presented in Table 1. RW 1 here denotes raceway 1 (5/lb fish) and RW 2 is raceway 2 (17/lb fish).

1. Oxygen consumption following pumping:

   The fish were pumped from nylon net pens into the raceways with a 6" fish pump to begin the experiment. Oxygen consumption directly following this pumping was not excessive. Consumption did not reach the normal high values until the morning following the start of the experiment, 16 hours later. Pumping, then, does not seem to represent an undue stress, as measured by fish oxygen consumption.

2. Oxygen consumption as fish acclimated to raceways:

   Consumption per pound of fish over the first five days remained the same. However, over the following four days the average oxygen consumption decreased by 30%. This could be due to the fish becoming acclimated to their surroundings and thereby reducing their metabolic rates.

3. Oxygen consumption versus time of day:

   The average oxygen consumption was higher at noon than either 8 a.m. or 4 p.m. in all but one case. It was 25% greater at noon than the average for all three times. This is probably due to the increased metabolic rates encouraged by feeding activities beginning about 9 a.m.

4. Oxygen consumption following thinning:

   After thinning, oxygen consumption increased significantly in both raceways. Raceway 1 was thinned by 54% and O_2 consumption increased by 70%. Raceway 2 was thinned by 54% and O_2 consumption increased by 86%. In both cases, the lower fish densities consumed much larger amounts of oxygen per pound of fish.

   It has been reported in the literature that oxygen consumption rates increase with the ambient oxygen levels, especially at these low values. Thinning increased the 12 noon readings from roughly 3 ppm to 4 ppm. An increased consumption due to these ambient levels is one possible explanation. Another may involve a behaviorial response to decreased densities.

5. Oxygen consumption versus fish size:

   The 17/lb coho consumed 57% more oxygen per pound of fish than the 5/lb coho before thinning and 71% more following thinning.

Calculation of carrying capacity:

The following formula was developed by writing a conservation of mass equation for oxygen. It states that the amount of oxygen entering the system from the incoming water IN, equals the amount leaving, OUT, plus fish oxygen consumption, F, and metabolic by-product consumption, M.

$$IN = OUT + F + M$$

It was assumed that M was negligible compared to the other terms. This assumption was tested by measuring the oxygen change through the raceway after fish had been removed and wastes were still present on the raceway bottom. The oxygen change was very small between incoming and outgoing water. It should be generally true that for a well cleaned raceway the fish waste oxygen consumption is small compared to direct fish uptake.

The equation now reads:

$$IN = OUT + F$$

Using the following definitions:

O_{in} = Dissolved oxygen level of incoming water in ppm

O_{out} = Minimum dissolved oxygen level allowed in the unit

Q = Flow in gallons per minute

C = Maximum oxygen consumption of fish in pound of O_2 per 100 pounds of fish per day

.012 = Conversion factor $\left(\frac{\text{pounds}}{\text{gallon}} \frac{\text{minutes}}{\text{day}} \times 10^6 \right)$

P = Pounds of fish

We can write (using the dimension pounds of O_2/day):

$$IN = (Q)(O_{in})(.012)$$

$$OUT = (Q)(O_{out})(.012)$$

$$F = (P)(C)/100$$

or, $$.012(Q)O_{in} = .012(Q)O_{out} + (P)C/100$$

To determine the pounds of fish that can be held in a rearing system we solve for P:

$$P = (1.2)\frac{(O_{in} - O_{out})Q}{C}$$

All the numbers on the right hand side can be determined prior to a raceway being stocked with fish. O_{in} and Q are already known, O_{out} is determined (usually a criteria of 5 ppm or greater is used for the outgoing dissolved oxygen level), and C must be found for the particular fish being used.

In this experiment, the oxygen consumption of coho salmon at two different sizes and under various fish cultural activities was determined. In using the above formula to predict how many pounds of fish can go in a rearing unit, the average oxygen consumption for the particular size fish to be used would be determined. Consideration should be given to various factors affecting that consumption, such as the possibility of acclimation, the effects of stocking densities, fish cultural activities, time of day, fish

size, species, water dissolved oxygen level, temperature and velocity.

The oxygen consumption data presented here is compared with existing consumption data given in the literature in Table 2. This information shows that the oxygen consumption rates are generally higher than the standard rates presented in the literature. In fresh water then, fish may be stocked at a somewhat higher density than salt water.

CONCLUSION

In the future, work must be done to include the atmosphere and bio-communities as sources and sinks of oxygen in other rearing systems, particularly large low density ponds. However, for raceways the formula presented will work after the fish oxygen consumption is calculated.

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Table 1

Oxygen Consumption (in Pounds O_2/100 lb Fish/Day)

Period 1 - before thinning, first 5 days:

RW1,	8:00 a.m.	Average	= 0.22
	12:00 noon	Average	= 0.28
	4:00 p.m.	Average	= 0.34
		Overall Average	= 0.28
RW2,	8:00 a.m.	Average	= 0.45
	12:00 noon	Average	= 0.54
	4:00 p.m.	Average	= 0.34
		Overall Average	= 0.44

Period 2 - following thinning:

RW1,	8:00 a.m.	Average	= 0.39
	12:00 noon	Average	= 0.57
	4:00 p.m.	Average	= 0.47
		Overall Average	= 0.48
RW2,	8:00 a.m.	Average	= 0.76
	12:00 noon	Average	= 1.00
	4:00 p.m.	Average	= 0.70
		Overall Average	= 0.82

TABLE 2

LITERATURE SURVEY

	AUTHOR	SPECIES	TEMPERATURE	5/LB FISH	17/LB FISH
Stocking Density in lbs./gal./min.	Liao (1971)	Salmon	55°F	18	14
	Piper (1970)	Salmon	55°F	11.25	8.25
	Westers (1970)	Coho	55°F - 54°F	7.90 - 5.6	7.70 - 3.7
	Ferguson, Allee	Coho (saltwater)	55°F - 59°F	8.20 - 5.8	8.00 - 3.7
Stocking Density in lbs./cubic feet	Burrows (1968)	Salmon	---	---	1.45
	Hastel (1955)	Brown Trout	54°F	---	4.5
	Nicholls (1963)	---	---	---	4.0
	Westers (1970)	Coho	50°F - 54°F	---	2.2
	Ferguson, Allee	Coho (saltwater)	55°F - 59°F	1.48 - 1.05	1.45 - 0.7
Oxygen Consumption in lbs./100 lbs. of fish/day	Alexander (1970)	Salmon	50°F	.38	.50
	Brett (1973)	Sockeye			
		Standard	55°F	.18	.22
		Active	55°F	1.92	2.10
	Elliot (1969)	---	---	---	.31
	Liao (1971)	Salmon	55°F	.33	.42
	Ferguson, Allee	Coho (saltwater)	55°F - 59°F	.28 - .48	.44 - .82

AN AIRLIFT FLOATING FISH TANK

by

Charles J. Hunter
National Marine Fisheries Service
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BACKGROUND

Apparent increase in demand for salmonid culture caused by declining runs, saltwater pen culture, increased Indian fishing and the recent interest in ocean ranching, will probably strain the capacity of the present hatchery systems. Many of the sites with good quality running water are presently being utilized for hatcheries, and much of the other running water resource in the Northwest is being used for recreation, homesites, etc.

Because of this possible shortage in good quality running water, we are in the process of developing a rearing system that will utilize an untapped water resource -- our still water -- lakes, ponds and reservoirs. Many of these contain good quality water and would provide adequate siting for fish rearing.

DESCRIPTION OF REARING SYSTEM

This system consists of round floating tanks and an air pump (Figure 1). Models were built of plexiglass but the production tanks were standard 4 foot fiberglass tanks made bouyant by attaching styrofoam to the exterior surface. These models, about 21" in diameter, were subsequently used for egg incubation.

The air pump supplied a water flow of about 5 gpm which entered the tank at the top in a circular motion and left the tank through a drain in the center of the bottom (Hunter, 1975).

EGG INCUBATION

The models were tested as egg incubators during the winter of 1974-1975. These tanks were 21 inches in diameter, 9 inches deep and held about 5 gallons of water. An aircraft system supplied 1.6 gpm of water exchange. This system took very little care except for occasionally checking the air supply and treating them once with malachite green dye at 2 ppm for 1 hour to discourage the growth of fungus.

Loading densities of 1.5 layers (4, 050) and 5 layers (13, 500) of chinook salmon eggs were tested. Approximately 99% of eyed eggs hatched absorbed their yolk sac and began feeding as swim-up fry, which we believe is as good or better than conventional systems.

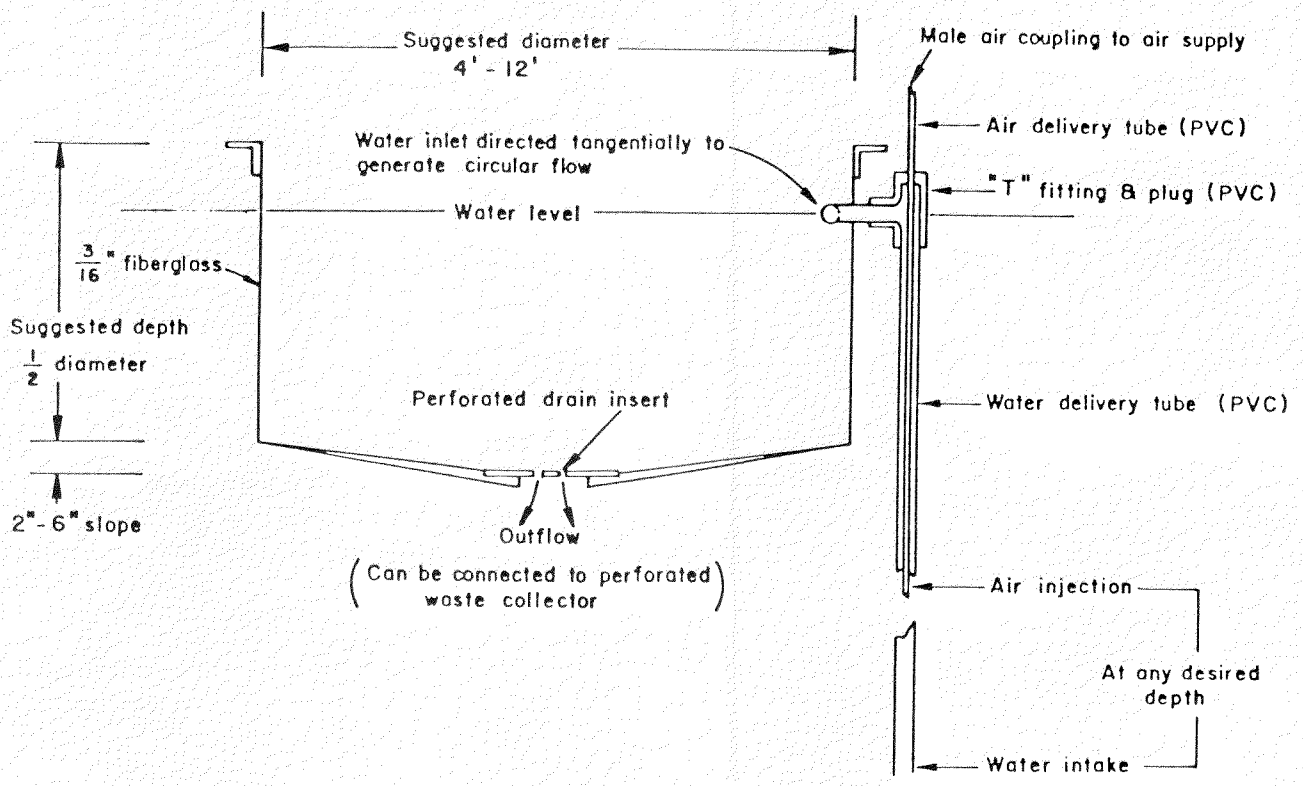


Figure 1.--Airlift floating fish tank.

These preliminary tests indicate this system, using water from lakes, ponds or reservoirs, has considerable promise.

REARING JUVENILE SALMON

During the spring of 1975, 8 groups of chinook salmon were reared in airlift floating tanks at Portage Bay, a 40 acre appendage to Lake Union, adjacent to the Northwest Fisheries Center in Seattle. These tanks were the standard 4 foot round fiberglass type commonly used in fisheries. Floating in the lake, they could accommodate 18 inches of water and contained about 140 gallons. An airlift pump was adjusted to supply a 5 gpm exchange rate although greater flow was possible from the same air system.

This study included 4 densities and 2 age groups (Table 1). The older fish were started at 329 per pound and the younger fish at 632 per pound. They were fed Oregon Moist Pellet Feed at a maximum useable rate. The study was conducted over a four week period and then had to be terminated because of an untimely power failure. Mortality and growth rates of the various loading densities and age groups are shown in Figures 2 and 3. The younger fish were judged to have a poorer condition factor which may have been partly responsible for the lower performance in that group.

Based on these preliminary data it seems reasonable to expect that at least 5,000 chinook salmon could be reared to the smolt stage in a 4 foot tank with a mortality rate of 2% per month and a growth rate of 2.8% per day.

CONCLUSION

Use of still water for incubating salmon eggs and rearing juveniles to the smolt stage has been shown to be a practical system and may provide valuable supplemental space for our present hatchery system.

Table 1. Loading density, mortality and growth rate of chinook salmon in airlift floating tanks during the period April 30 to May 28, 1975.

Density (pounds/ cubic ft.)	Total Pounds	Estimated number of fish (329/pound)	Estimated number of fish (632/pound)	Mortality No. of fish	Mortality %	Growth rate (%)
1.6	30.34	9,982	--	474	4.7	71
1.0	17.50	5,757	--	117	2.0	83
0.5	8.74	2,875	--	43	1.5	104
0.25	4.37	1,438	--	46	3.2	150
1.6	30.34	--	19,175	12,200	63.6	-7
1.0	17.50	--	11,060	1,295	11.7	29
0.5	8.74	--	5,524	202	3.6	84
0.25	4.37	--	2,762	113	4.1	76

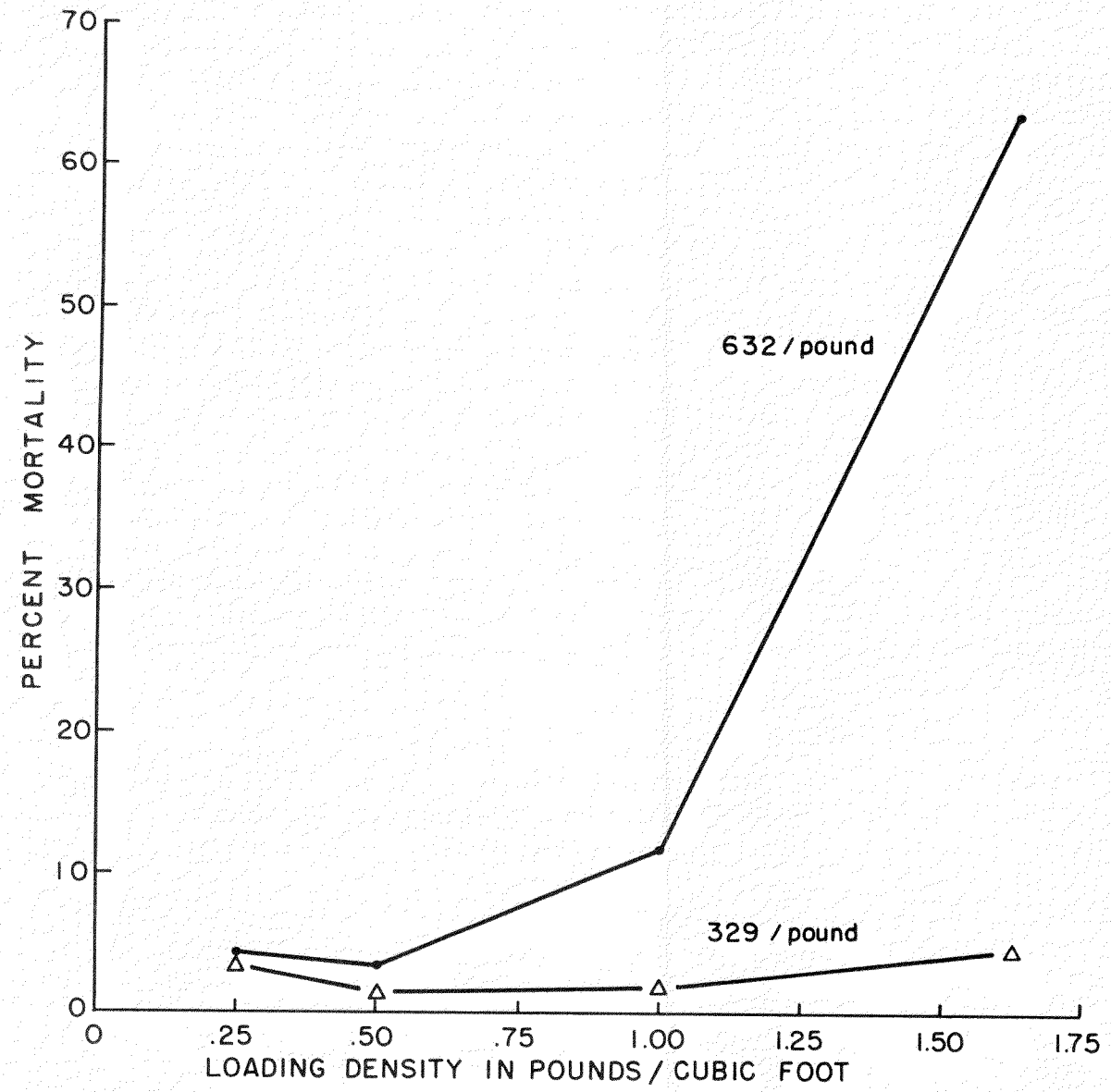


Figure 2.--Mortality of chinook salmon in airlift floating tanks during the period April 30, 1975 to May 28, 1975.

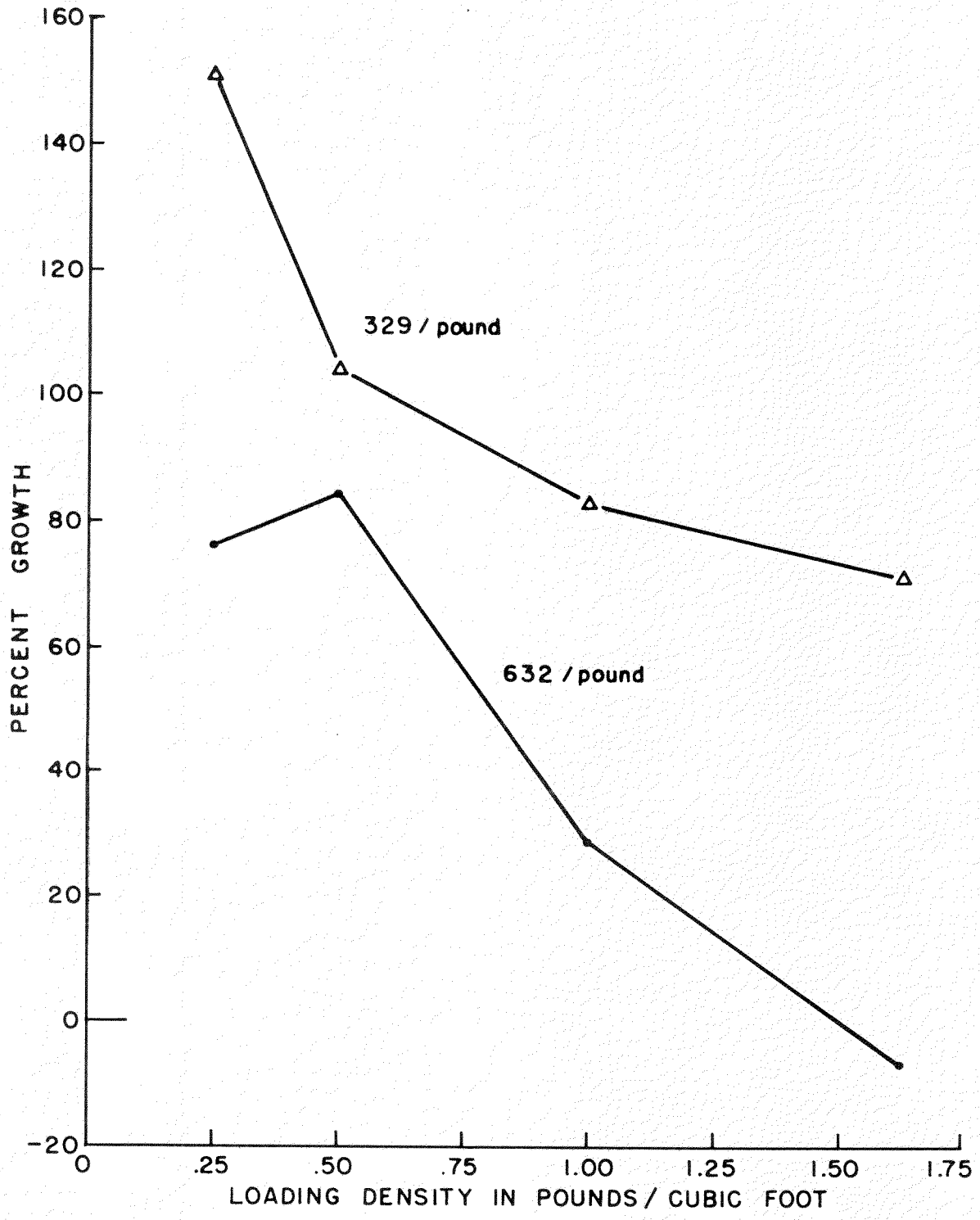


Figure 3.--Growth rate of chinook salmon in airlift floating tanks during the period April 30, 1975 to May 28, 1975.

LITERATURE CITED

Hunter, C. J., and T. Joyner. 1975. A self-cleaning floating fish tank. The Prog. Fish-Cult. 37(2): 115-116.

UP, UP, AND AWAY IN A FISH LOCK WITH SPECIAL EMPHASIS ON THE NEW BONNEVILLE SALMON HATCHERY SPAWNING FACILITIES

by

A. Kenneth Johnson
Oregon Department Fish & Wildlife
and
Dan Barrett
Oregon Department Fish & Wildlife
Bonneville, OR

The excessive handling requirement of sorting mature from immature fish during the spawning season is alleviated by a method whereby sexually mature adults are allowed to "drop out" of a holding pond during their spawning migration. The method described by Burrows (1960), has been successfully used with fall chinook and coho at the ODFW Bonneville (Sheldon, 1970) and Big Creek hatcheries, and with spring chinook at the Dexter Holding Pond.

To accommodate the "drop out" method, prototype mechanical handling facilities were installed at Dexter Holding Pond in 1971. These included a crowder, anesthetic tank, and a power driven brail for lifting adults to a sorting table. From an elevated position ripe and green fish are easily distributed, by inclined chute, to the spawning deck or holding pond, respectively. Experience has shown, however, that lifting ripe adults in brails can result in mechanical injury to fish and loss of eggs. To circumvent the problem, the "fish lock" has been incorporated in recent spawning facility development at the ODFW Marion Forks (Minto), McKenzie, and Bonneville salmon hatcheries.

The Bonneville Hatchery fish lock chamber has a cross-section of 28.6 square feet. The differential elevation between the surface level of the entrance channel and lift apex is 15 feet. Entrance to the chamber is through a submerged orifice and is regulated by electrically operated barrier and bulkhead gates. Fish are forced to remain at or near the surface of water as it rises in the chamber by a brail which also forces them to leave the top of the chamber where they enter an anesthetic tank. The lock is supplied with 11 cfs water. Capacity of the brail is approximately 165 adults with an ascent rate of 0.21 foot per second.

With this introduction, a description and slide presentation of the new Bonneville Hatchery spawning facilities were presented by Dan Barrett, Production Foreman, Bonneville Hatchery.

Literature Cited:

Burrows, Roger E. 1960. Holding ponds for adult salmon. U. S. Department of Interior, Fish and Wildlife Service, Special Scientific Report. Fisheries No. 357, 13 p.

Sheldon, Ray. 1970. "Drop Back" method for sorting fall chinook. Fish Commission of Oregon. Proceeding 21st Annual Northwest Fish Culture Conference pp. 65-68.

THE ELWHA CHANNEL

by

Roy K. Pigott
Washington State Department of Fisheries

This is a descriptive presentation of the Washington State Department of Fisheries salmon rearing facility. I start with a brief history of the Elwha river watershed. Fifteen slides will follow showing the channel. Accomplishments and goals for the project will terminate the presentation.

Time: 15 minutes

THE TEHAMA-COLUSA SALMON SPAWNING CHANNELS

"A Summary of the First Four and One-half Years of Operation"

by

Thomas Richardson
USFWS, Red Bluff, California

The Tehama-Colusa Fish Facilities are located on the Sacramento River near Red Bluff, California. The Facilities include a number of structures associated with the Tehama-Colusa Irrigation Canal that are designed for fish enhancement, namely: fish ladders, counting stations, a fish trap and selector system, and a large king salmon spawning channel complex. Construction of the channels was completed in 1971, and they were put into operation that fall. This report summarizes the first four and one-half years of channel production of fall chinook salmon at the Tehama-Colusa Fish Facilities.

The channels include two basic structures: The dual purpose irrigation-spawning canal, and the single purpose channels.

The dual purpose canal consists of the upper three miles of the Tehama-Colusa Canal. It is designed to provide spawning habitat for over 30, 000 adult salmon and also convey irrigation flows in excess of 2, 000 c.f.s. The gravel lined bottom measures 100 feet wide and 2 1/2 feet deep.

The dual purpose canal has not been used for fish production yet except on a very limited basis. This is due to several factors, namely:

1. Incompletion of the Tehama-Colusa Canal resulting in reduced flow capabilities and therefore marginal spawning velocities.
2. E. P. A. restrictions on use of the gravel cleaning rig.
3. Insufficient numbers of spawners available.
4. Difficulty in evaluating production.

The single purpose channels have been used for nearly all salmon production to date. These channels are each one mile in length, 30 feet wide at the gravel surface, and provide spawning area for approximately 5, 000 adult salmon.

Spawning stock is obtained from the fish trap at the Red Bluff Diversion Dam or from volunteers attracted to the channel discharge at Coyote Creek. Coyote Creek is a small tributary to the Sacramento River and, except for winter run off, is usually dry.

Numbers of adult salmon placed in the spawning channels since 1971 are outlined in Table 1 and illustrated in Figure 1. Figure 1 shows both numbers of salmon trapped and volunterring each fall. The upper line graph shows the total fall run of king salmon enumerated at the Red Bluff Diversion Dam. By agreement with the California Department of Fish and Game, we have limited the annual number trapped to 1,000 females or five percent of the fall run, whichever is greater, in order to reduce impact on up-river spawning stocks.

Table 1

Year	No. of Spawners Volunteering	No. of Spawners Trapped	Total Spawners	Total Fall Run Counted at R. B. D. D.*
1971	295	4,741	5,036	63,918
1972	110	1,671	1,781	42,503
1973	886	2,491	3,377	63,891
1974	843	2,234	3,077	54,128
1975	1,994	1,973	3,967	64,542

(*) California Department of Fish and Game's adjusted figures.

Total numbers placed in the channels have varied from a high of 5,036 in 1971 to a low of 1,781 in 1972. Very few salmon volunteered from Coyote Creek in 1971 (295) or 1972 (110). In 1973 and 1974, the numbers of volunteers increased to approximately 850. This past fall, over 2,200 spawners volunteered into the terminal facility from Coyote Creek; of which 1,994 were selected and placed in the channels. Many of these fish were quite large, weighing 50 to 60 pounds. Also included with the volunteers were marked jacks from the 1973 brood year, our first tagged releases. It appeared that this seasons returns included fish from brood years 1971 through 1973.

One of the problems initially encountered with the adult phase of channel operations was a high female prespawning mortality. As shown in Figure 2, over one-third of the females died prior to spawning during 1971. Subsequent modifications in selecting, hauling and stocking techniques have resulted in an average female prespawning mortality during the past three years of about eight percent. Following egg salvage from those females capable of being artificially spawned, the actual unspawned loss now averages less than five percent.

Spawners are now sorted from an anesthetic tank instead of being visually selected as they slide down a chute. The number of fish and duration of time held in the fish hopper is limited. Trucked fish are treated

Figure 1. Total Fall Run Counted at the Red Bluff Diversion Dam

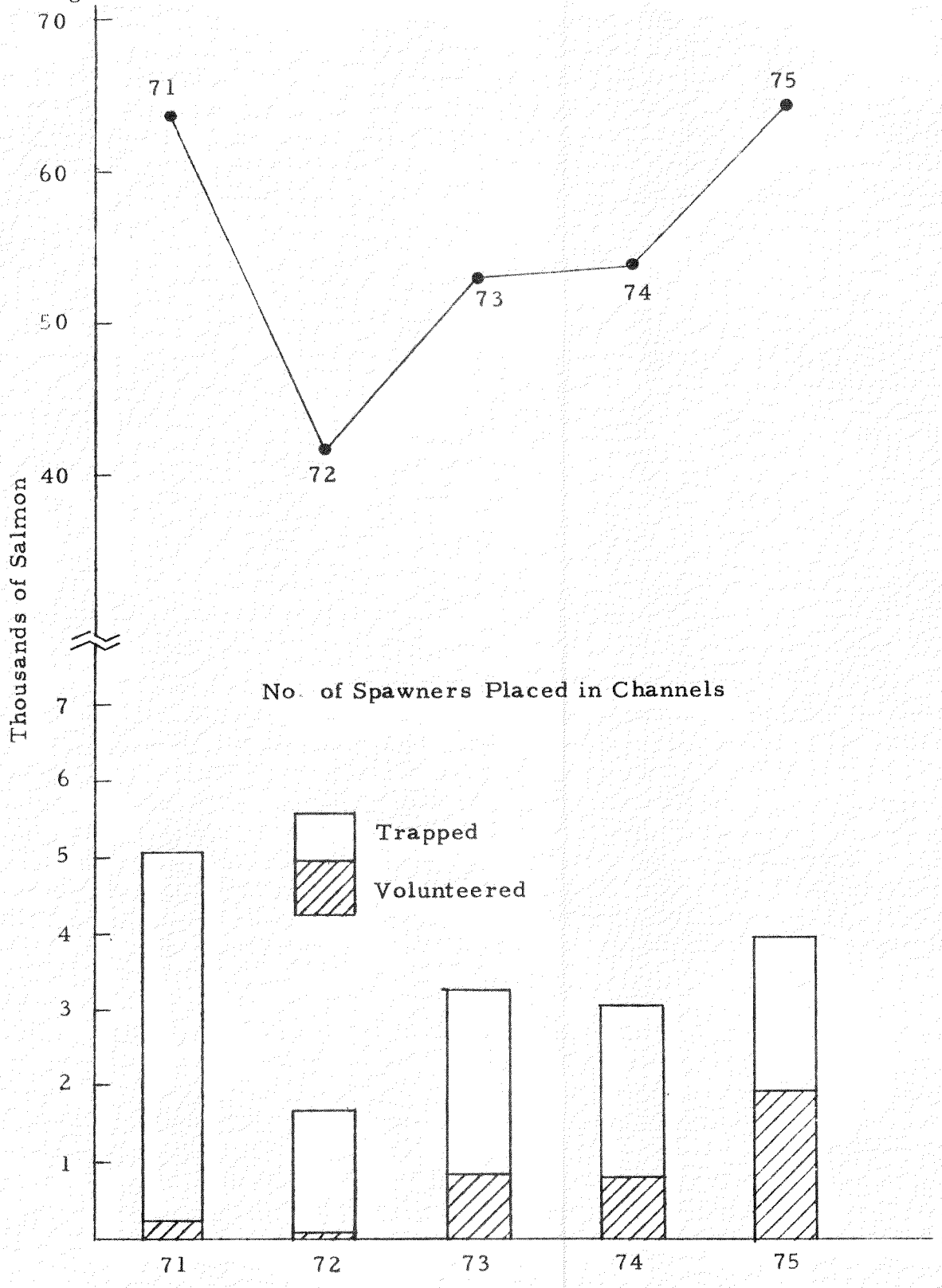
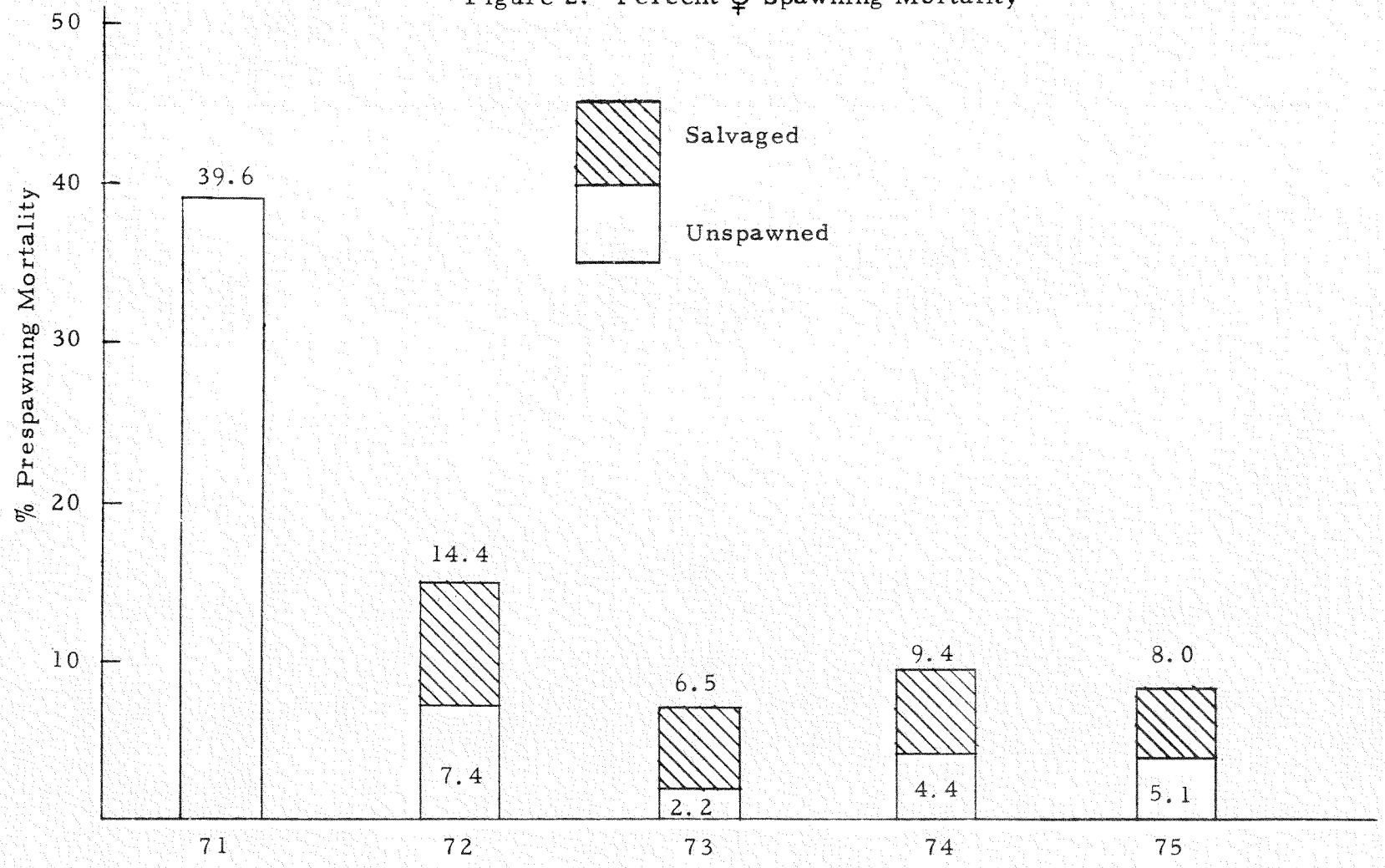


Figure 2. Percent ♀ Spawning Mortality



with malachite to reduce fungusing and are planted directly into the channels by section instead of being released in a ripening pond. Vertical wire mesh weirs have been replaced with inclined pipe racks. A small incubation station has been built to hatch salvaged eggs.

Figure 3 outlines the annual production released from the channels in comparison to the estimated egg deposition. Total numbers of juveniles released have varied from 1/2 to 4 1/2 million each spring representing survivals from 6 to 60 percent.

Table 2

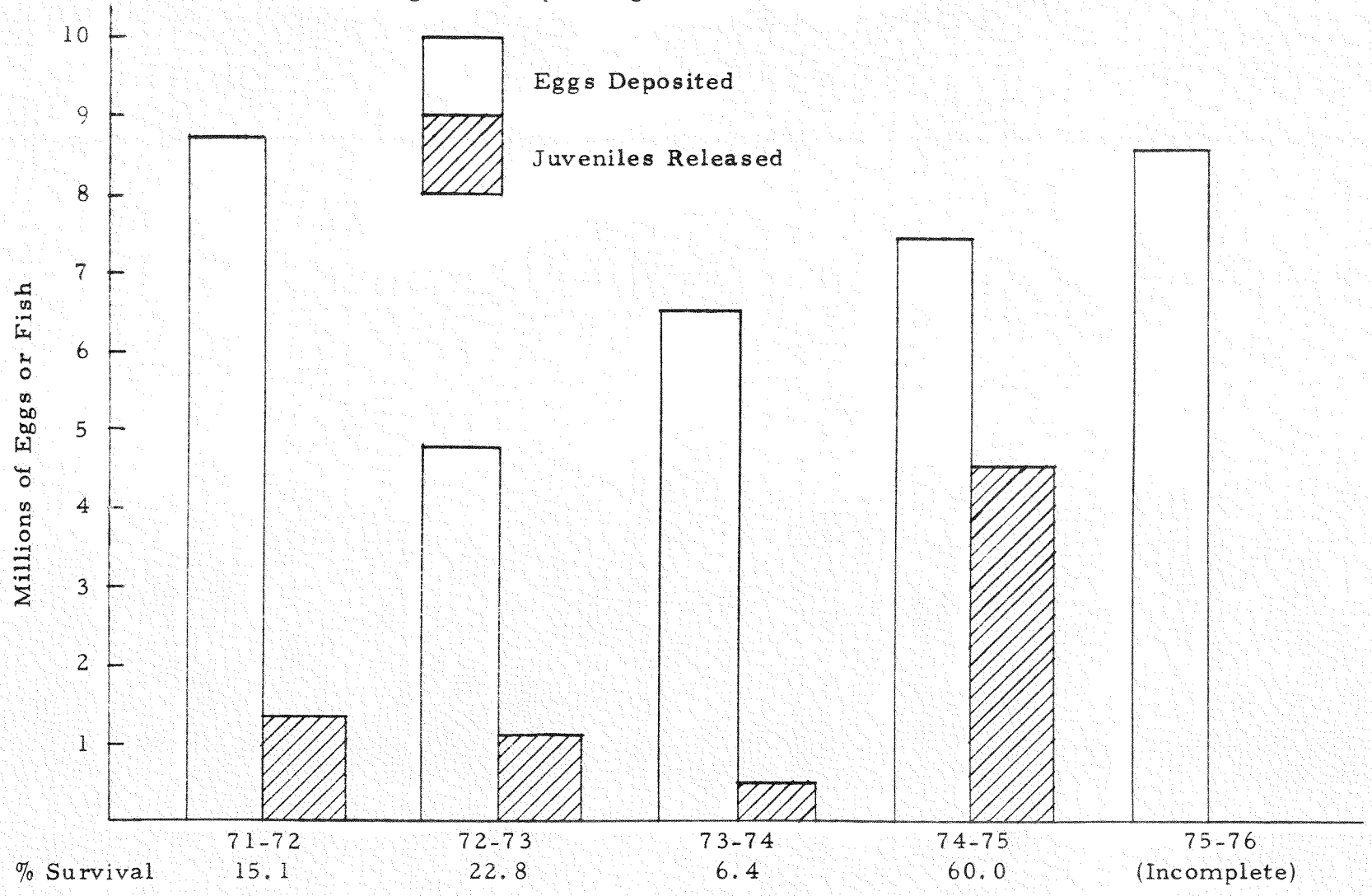
Year	Estimated Egg Deposition	Juvenile Outmigration	Percent Survival
1971-72	8,748,000	1,320,000	15.1
1972-73	4,789,000	1,093,000	22.8
1973-74	6,571,000	418,000	6.4
1974-75	7,418,000	4,448,000	60.0
1975-76	8,750,000		

The survival from brood year 1971 appeared to be greater than the fifteen percent shown, as extensive screen leakage occurred during the first year of operation. The actual numbers released that year probably approached two million or twenty percent of the estimated egg deposition. Survival of the 1973 brood year was extremely poor due to extended flood conditions in the Scaramento River and resulting high siltation levels recorded in the gravel. The total river flow during the winter of 1973-74 was the greatest ever recorded since monitoring began in 1972.

Juvenile salmon are allowed to egress from the channels at will and vary in release size from button-up fry in February to as large as sixty per pound by June. Previous attempts to confine early outmigrants in the channels and access canal above the counting station have been unsuccessful. Extensive screen leakage and loss from predation and canabalism has occurred, especially during periods of high water turbidity. A small rearing area, constructed at the terminus of the channels, will be used to rear a portion of the early outmigrants during the spring of 1976.

The techniques developed in four and one-half years of operation of the single purpose channels will be applied to the large dual purpose canal when this structure is eventually brought into production. Last fall, approximately 400 spawners were stocked in the upper section of the canal where satisfactory flows and gravel conditions were provided. It is anticipated that additional spawners will be placed in the facilities annually as returns increase and the dual purpose canal is gradually brought into full operational capacity.

Figure 3. Spawning Channel Production



A CONTROLLED INCUBATION SYSTEM FOR MULTIPLE CROP SALMONID PRODUCTION

by

Richard Severson
Oregon Aqua-Foods, Inc.
Newport, Oregon

INTRODUCTION

Since the advent of commercial salmon culture, the basic thrust of production efforts has been to develop techniques that will allow harvesting throughout most or all of the year. One of the greatest constraints which faces the private aquaculturist is the biological limitation imposed by the salmon's normal life history. However, by manipulating variables such as species, stocks, genetic selection, timing of egg take, incubation temperature, temperature and photoperiod during rearing, etc., production can be expanded beyond the usual biological time frames. Programs can be carried out that include both intensive culture, fish reared to market size in containment, and extensive culture, smolts released to the ocean and recaptured as returning adults.

INCUBATION SYSTEM DESIGN AND OPERATION

A system was developed, incorporating the vertical incubation concept, with the capacity to heat and/or cool water during egg incubation for the purpose of accelerating or decelerating growth of the salmonid embryo and of the alevin through fry stages. This system is applicable only to those facilities not having the advantage of naturally warm and/or cold water temperatures. The system consists of three bays which allow three different temperature regimes to be used simultaneously. A single bay is shown in Fig. 1. It includes an upper reservoir containing biological filter media (oyster shell bagged in nylon mesh netting, Fig. 1a) which is also the site of water heating. The reservoir receives water both from an outside source (make-up water) and from the lower reservoir (recirculated water). This water is distributed over the oyster shell and the accompanying bacterial flora.

The reservoir is plumbed with a make-up water source and a float-valve. In the center of the reservoir is the recirculating water return which distributes the water over the filter media. In the bottom of the reservoir tank are four incubator water supply valves. An overflow standpipe and drain maintains water height and a float alarm located just below the water surface is activated in the event of a water loss to the system. A thermostatically controlled heating element equipped with an alarm completes the upper reservoir. In the event of loss of water due to pump failure, the float valve

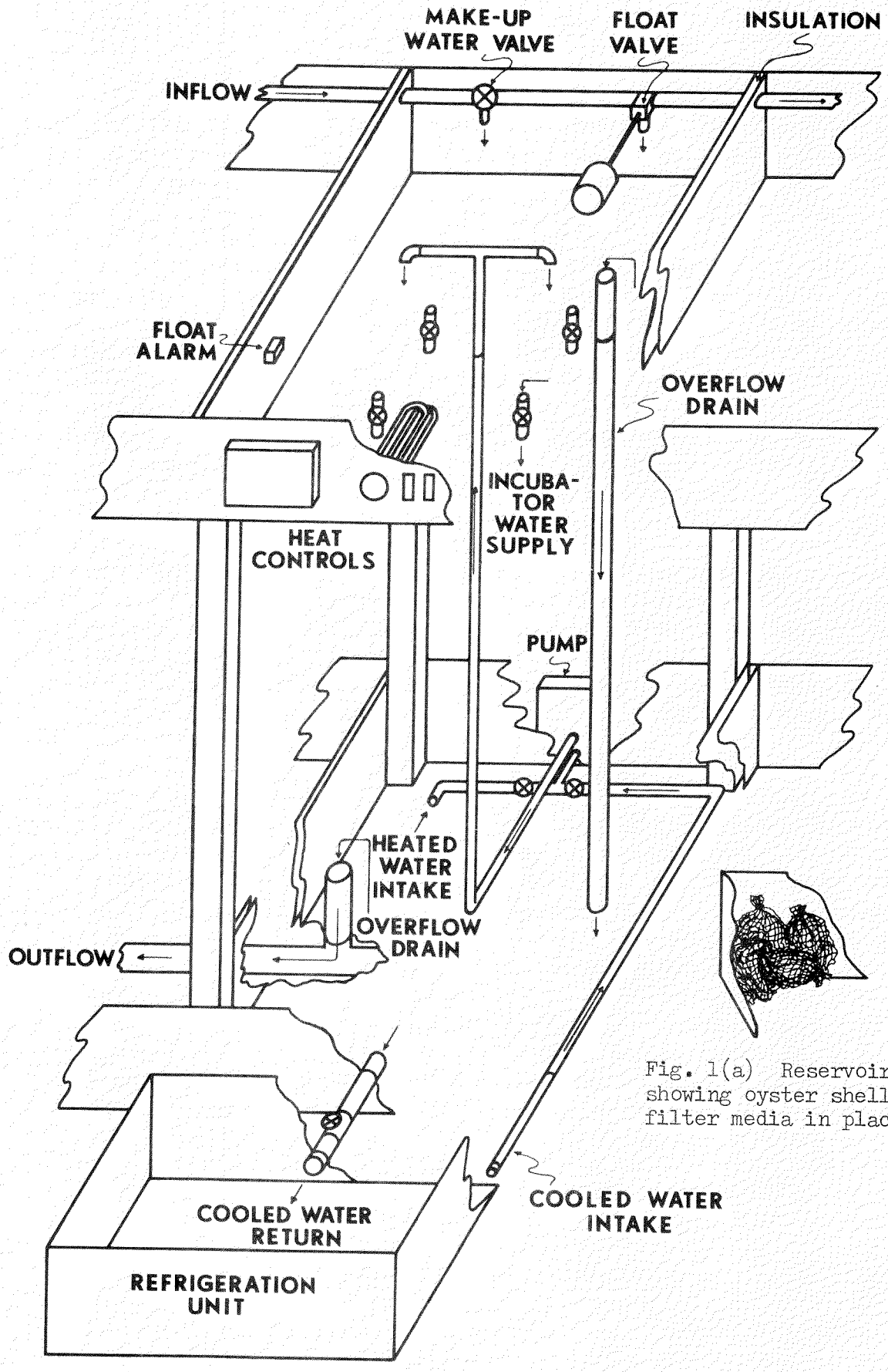


Fig. 1(a) Reservoir corner showing oyster shell biological filter media in place.

Fig. 1 Schematic drawing of controlled incubation system.

is activated and the unit then becomes a flow through system. The drop in water level also activates the float switch malfunction causing the water to warm beyond the thermostat setting, a similar temperature sensing device activates which sounds an alarm.

The lower reservoir functions primarily as a sump, catching the used water which has passed through the four incubator stacks and provides the water storage needed for pumping back to the top reservoir. It also serves as a container for biological filter media. A 1/3 hp pump featuring plastic parts is mounted outside the reservoir and provides the recycling capability. A standpipe controls water depth and also serves to drain the system. An additional reservoir which operates independently is used for chilling water and is plumbed to all three bays. Three 1 hp thermostatically controlled chiller units can be operated independently or together depending upon the water temperature desired.

When in operation a single bay contains 350 gallons of water, 90% of which is recirculated and 10% that is added new as "make-up" water. Each bay is segregated by 1.5 inches of styrofoam insulation preventing heat transfer between the reservoirs. The reservoirs are constructed of 0.75 inch plywood laminated with fiberglass and all plumbing and valves are constructed of PVC.

When the system is operating, all incoming water passes through one of three rapid sand filters. This removes the majority of solids and reduces secondary ammonia production before the water enters the system. (Kramer, Chin and Mayo, 1972). Recirculated water is pumped from the lower reservoir to the top where it filters through the biological filter media before it is discharged through one of four incubator supply valves. Each valve is metered to deliver 6 - 8 gpm to each of the four 16-tray vertical incubator stacks. After leaving the incubators it again passes through the biological filter media in the lower reservoir before it is pumped back up to the top. When chilled water is desired to retard fish growth, water is routed from the refrigeration reservoir (Figure 1). When heated water is desired for accelerated growth it is obtained by activating the heating element in the upper reservoir. When ambient temperatures are desired, they are obtained by one of two ways: (1) by using recycled water in the absence of heating or chilling or (2) by turning off the recirculating pump and increasing the filtered make-up water to the flow level needed to maintain incubation.

DISCUSSION AND RESULTS

Biological filtration is a critical link in any recirculating system. Ammonia nitrogen samples analyzed during the last two years have shown the need for a "run-in period" to allow time for nitrification on the filter media to begin prior to the introduction of eggs into the system. Ammonia

levels were observed to rise and fall depending upon the stage of egg and fry development. Values ranged from 0 1 mg/l to 1.2 mg/l and the sharpest increases occurred during time of hatching.

Ammonia nitrogen toxicity appears to be correlated with pH. (Burrows, 1964) pH in our system varied slightly from 6.9 to 7.1 which could account for the fish being in good condition during times of high ammonia levels. The pathological effects of high ammonia nitrogen levels have been reported as including hyperplasia or clubbing of the gill filaments, hemorrhaging of gill lamellae and inflamed liver to name a few. None of these symptoms have been observed in fish incubated in our system. We have not observed any sublethal effects of ammonia nitrogen build-up with respect to growth, physical stamina, disease resistance or the salt water entry of our fish although no controlled experiments have been conducted.

It is possible that seeding the filter bed with an organic substance in advance of the introduction of eggs could reduce high ammonia nitrogen levels.

The relationship of biomass to surface area of filter media is unknown but may be an important consideration in using biological filtration during incubation. In our system each bay contains approximately 15,000 sq. ft. of filter media and each bay has the capacity to incubate 600,000 eggs.

When biological filtration is used, care must be taken when treating eggs with chemical compounds since many can inhibit nitrification (Holmes, 1968). Prophylactic and disease treatment can be done without harming the biological filter by pulling the plug on the bottom tray in a stack and diverting the water out and away from the system. A flush method can then be used by adding the chemical to the top tray and replacing the plug in the bottom tray when the water has cleared.

CONCLUSION

The use of controlled temperature in egg incubation with a water re-use system has proven to be an important management tool in commercial salmon farming (intensive) and ranching (extensive) operations. The advantages are: (1) provides an economical means of controlling temperature for acceleration and deceleration of fish growth to fit a production plan; (2) provides a controlled environment favorable for disease control; (3) reduces suspended solids on eggs and early life history stages; (4) provides for greater facility utilization by staggering hatching times; (5) provides a technique for managing around undesirable rearing periods, i.e. low flows, poor water quality, seasonal disease problems and (6) reduces time to harvest in both farming and ranching programs.

PHYSIOLOGY

EFFECTS OF DETERGENTS ON GILL (Na+K)-ATPase ACTIVITY IN CHINOOK SALMON

by

Richard D. Ewing and S. L. Johnson
Oregon Department Fish & Wildlife
Corvallis, Oregon

Detergents have been routinely used in fishes to examine gill (Na+K)-ATPase activity in relation to seawater adaptation and smolting. Deoxycholate increases the activity of (Na+K)-ATPase in gill microsome preparations. The concentration required for optimal solubilization to the microsomal fraction, however, is dependent upon the protein concentration in the homogenate. Substantial losses in total activity are observed both after centrifugation and after detergent treatment. These effects indicate that extreme care must be taken in analysis of detergent-treated gill microsomes for (Na+K)-ATPase activity.

A SIMPLIFIED PROCEDURE FOR MONITORING (Na+K)-ACTIVATED ATPase IN GILL TISSUE

by

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Corvallis, OR

ABSTRACT

Increase in (Na+K)-activated ATPase activity in gill tissue of anadromous salmonids has been used as an indicator of the smolting process. The enzyme assay might be an important tool in determining optimal release times for hatchery reared salmonids. A simplified procedure has been developed for analysis of (Na+K)-activated ATPase in gill tissue of spring chinook salmon. The assay is short, enabling large sample sizes to be obtained, and inexpensive, requiring only a standard spectrophotometer for analysis. Characterization of the enzyme has been accomplished to obtain optimal conditions for activity in the spring chinook gill tissue. Variability analysis was completed to assess variability within the gill homogenate, between different gill arches of individual fish and from a homogeneous population of fish. Results indicate considerable variation between individual fish within a given population, requiring the use of a large sample size to obtain meaningful data.

EFFECTS OF COPPER IONS IN FRESH WATER ON GILL ATPase ACTIVITY, MIGRATION AND SEA WATER ADAPTATION OF JUVENILE COHO SALMON

by

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Corvallis, Oregon

Exposures of yearling coho for 144 h to sublethal concentrations of zinc in fresh water had little effect on the enzyme activity of Na^+, K^+-activated ATPase in gill microsomes or on the survival of fish transferred to sea water. Acute and chronic exposures (maximum of 4128 h) of juvenile coho to sublethal concentrations of copper in fresh water had deleterious effects on downstream migration in a natural stream, gill ATPase activity and subsequent survival in sea water. Chronic exposures had more severe effects than did 144 h exposures on downstream migration and survival in sea water but not on gill ATPase.

Coho juveniles given a 120 hour "rest" (non-extoxicant exposure in fresh water) following toxicant exposure showed somewhat higher survival when transferred to sea water than their counterparts which were transferred immediately. However, juveniles that were given a 15 day "rest" showed survival almost equivalent to the controls when tested in sea water.

PANEL DISCUSSIONS

THE ROLE AND CHALLENGE OF FISH CULTURE IN THE NORTHWEST

Lauren R. Donaldson (Leader)
College of Fisheries
University of Washington
(paper included)

Earnest R. Jefferies
ODFW, Portland
(paper included)

Brian J. Allee
Weyerhaeuser Company, Seattle

PAST: HISTORICAL DEVELOPMENT OF FISH CULTURE IN THE NORTHWEST

Lauren R. Donaldson
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PRESENT: ROLE AND CHALLENGE OF FISH CULTURE IN NORTHWEST

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OSU, Corvallis

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USFWS, Portland

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PAST: HISTORICAL DEVELOPMENT OF FISH CULTURE IN THE NORTHWEST

by

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Artificial propagation of salmon started with the establishment of the McCloud River hatchery in northern California by the U.S. Fish Commission in 1870. Oregon's first salmon hatchery was established on the Clackamas River in 1877. Washington followed with the construction of the Kalama River hatchery in 1895. By 1900 a network of salmon and trout hatcheries spread over the Pacific Northwest, and the annual egg takes numbered in the hundreds of millions. In early years the eggs obtained by seining the natural spawning areas were hatched and released as unfed fry. This practice of robbing the streams and lakes of eggs for hatching and release contributed little to the salmon stocks--in fact may have been a detriment.

Gradually hatchery techniques improved. Pond rearing, especially in the State of Washington, increased survival to a level high enough to enable hatcheries on some streams to become donors, supplying eggs to other stations such as the Kalama and Green River hatcheries. Trout brood stocks also were developed at the California and Oregon Game Commission hatcheries to provide stocks for planting in lakes and streams.

To provide food to feed the salmon and trout in the expanding rearing programs, the early hatcheryman had to be opportunistic and take advantage of every possible food source. Spawned-out salmon carcasses, cannery wastes, scrap fish, horse meat, liver, lungs, spleen, etc., etc., etc., were used. Food procurement and processing were involved in every hatchery operation.

The 1930's were years of real progress in fish culture. Facilities were improved, brood stocks were developed, better diets became available, and Dr. H. S. Davis and others were providing information on disease diagnosis and treatment.

Leaders in the field of fish culture began to concentrate on the problem areas, to question unproductive practices, stimulate an interest in research, and increase the flow of information. Perhaps most important, they developed a feeling of pride of accomplishment in the rank and file workers.

A host of fisheries workers have contributed to the rapid development of fish culture in the past three decades. It would be difficult, maybe impossible, to recognize all the individual contributions, so I have selected three of our decreased co-workers for special comment.

Matt Ryckman, Superintendent of Hatcheries for the Oregon Game Commission, was one of the first to recognize the need for better communication among hatchery workers. Starting in the early thirties, "Uncle Matt" annually assembled his "boys" in the Corvallis Hotel for three days between Christmas and New Year's to, as he said, "talk fish." These sessions, where hatchery personnel could talk about successful programs (and failures), learn about the latest research developments, and generate enough enthusiasm to carry them through the cold, wet months ahead, were the real forerunner of the present Northwest Fish Culture Conference.

During his entire career, Fred J. Foster, starting in Maine, and later in Florida, Missouri, Utah, Oregon, Washington, and other western states, worked for closer cooperation among the federal government programs and state and private operations. In the area of fish culture he continually pushed for expanding experimental work in nutrition and fish disease studies. The development of an adequate dry diet for hatchery use was one of "Fred J.s" pet programs.

One of the first employees in 1933 of the newly created Washington State Department of Game was Clarence F. Pautzke. With the State Department of Game, "Pots" pushed programs of lake rehabilitation and stocking, access for fishermen to state-managed lakes and streams, and developed a successful steelhead management program. I feel, however, that the greatest contribution Pots made to fisheries was the great "humanizing" effect he had on fisheries workers. In all his positions as Chief Biologist for the Department of Game, Assistant Director of the Washington Department of Fisheries, Assistant Commissioner of the Alaska Department of Fish and Game, and as U. S. Commissioner of Fisheries, Pots carried the unflinching belief that every employ was important and made a great contribution to the team. He was so convincing that those associated with him would "break their butts" trying to justify the faith Pots had in them.

I hope the present and future generations of fish culturists will learn from the experiences of the past 100 years and not insist on trying to "reinvent the wheel," for to "ignore history is to be condemned to repeat it."

PRESENT: ROLE AND CHALLENGE OF FISH CULTURE IN NORTHWEST

by

Ernest R. Jeffries
Oregon Department of Fish and Wildlife

In fiscal year 1973, seven state agencies in the west operated 89 installations rearing anadromous salmonids. There were also 31 detached large-sized rearing ponds. Of these 120 facilities, 80 percent were located in Washington and Oregon. During this same period the U. S. Fish and Wildlife Service operated 12 hatcheries with 9 on the Columbia River and 1 other major facility - the large Tehama-Colusa spawning channel in California.

In this same fiscal year, 1973, the state agencies produced in these facilities 250 million anadromous fish weighing about 8 million pounds, 64 percent by number were chinook and 35 percent by weight. In addition to the production from the 89 installations and 31 rearing ponds, the Washington Department of Fisheries released another 1.2 million salmon (200, 000 lbs.) from pens in fresh and salt water. The federal agencies released 70 million anadromous fish weighing 1, 560, 000 lbs. Total production then is about 321, 000, 000 anadromous fish, weighing almost 9.7 million pounds. Production has increased since 1973. The production from British Columbia is not included.

In addition to the anadromous fish, there are almost 4 million pounds of trout produced by state and federal agencies. In Idaho, private trout producers reared 20 million pounds in 1975 or 4/5 of the nation's private trout production. The production of salmon and trout in state or federal hatcheries and ponds is a major industry in the Northwest.

Since I am most familiar with anadromous fish, most of my remarks will be directed towards programs with these fish.

Private interests are becoming involved in a major way in salmon production. In Washington, salmonids reared by private capital cannot be released to the ocean; in Oregon, California, and Alaska they can. The American Salmon Growers Association has as one of their goals, legislation in Washington to allow release and recapture by the private grower. I would expect totals of fish released to be further increased by private hatchery activity.

In Oregon we have issued 8 permits for private chum hatcheries, 2 for coho and 2 for chinook. We have pending 9 applications for chums and 4 for chinook.

I am not well acquainted with the extent of the pen rearing program in Washington, other than it is extensive and growing. I understand the Lummi Indians have a $10 million facility to rear salmon and oysters, and Union-Carbide has extensive facilities, recently acquiring Pacific Ocean Farms to add to the Domsea Farms. Weyerhauser is getting involved in a big way in both Oregon and Washington.

State and federal agencies here in the northwest have continuing plans for major expansion. The FWS has two hatcheries under construction, one in Oregon and one in Washington. They also have funds for modernization and expansion of 3 hatcheries on upper Columbia River tributaries. Washington Department of Fisheries has an $8 million expansion program underway this year which includes two new hatcheries, construction of satelite ponds and purchasing a trout hatchery to be converted to salmon rearing. In Oregon we have 3 new hatcheries under construction, two more in the planning stages, and other expansion proposed. (British Columbia and Alaska are also expanding their fish culture operations.)

One of the major expansion programs that is being considered is one recommended to the Corps of Engineers by fishery agency personnel. This is the hatchery construction program to compensate for losses of salmon and steelhead caused by construction of 4 dams on the lower Snake River. The Corps is attempting to develop federal financing for the program to cost an estimated $46 million. It will include the construction of 8 hatcheries; two in Washington, two in Oregon, and 4 in Idaho.

Those hatcheries in Oregon must be re-use systems since we have no large-sized water supplies of suitable quality available in the areas of need. When you consider the complexity of design and operation of large-sized re-use systems, the high annual operating expenses (Dworshak National Fish Hatchery costing annually almost $1 million), the high losses of juveniles moving downstream over or through 8 dams, then the major loss of adults coming back estimated to be 20 percent at Bonneville, 10 percent at The Dalles, 20 percent at John Day, and so on - the problem becomes one where we need people with experience, initiative, and commitment.

There are 20 federal agencies now with programs committed to some phases of aquaculture. In the Department of Commerce, the National Oceanic and Atmospheric Administration Sea Grant program is spending $3.8 million with $2.2 million as matching from other funds ($6.0 million) annually on aquaculture programs. Also in the Departmentof Commerce, the NMFS now has an Aquaculture Coordinator - John Glude in the Seattle Regional office. NMFS personnel are now developing a National Fisheries Plan. The U. S. Fish and Wildlife Service in the Department of Interior has extensive facilities for fish research and production, developmental facilities, fish disease labs, and funds cooperative fishery units at colleges. In addition, several land grant colleges are using State Agricultural Experimental funds for work with fish.

In the 1940's and 1950's, hatcheries were having a difficult time producing quality fish. Diets were poor, pathological services were almost non-existent and many of the techniques of operation needed improvement. Many biologists were very critical of the operations, the expenditure of funds and the product. Unfortunately very few had constructive criticism. In our organization, and I suspect in others, there were real conflicts between biologists and fish culturists. Fish culturists were not highly regarded.

Due to the programs of many agencies and many people (biologists, physiologists, fish culturists, pathologists, nutritionists, geneticists, engineers, and administrators) things began to change for the better in the early 60's. The pendulum has reversed and now fish culture-type programs are of major dimension in most conservation agencies. Hatchery-reared fish are making significant contributions to both the sport and commercial fisheries. Fishing is so good in the Lake Michigan area, they have a 5 per day sport salmon limit compared to 3 per day on the west coast.

As I was mulling over the great expansion of fish culture in the northwest, and in the midwest, I was reminded that in the report of Chum Salmon Hatchery Rearing in Japan, by Harry Senn and Steve Matthews, Japan is now producing about 500 million chum salmon fingerlings. In the Northwest, we are producing 321 million salmon; however, very few of our total are chum salmon with a short rearing period. Most of ours are coho, chinook, and steelhead with extended rearing. Japan is reported to be considering the doubling of their production to 1 billion fingerlings.

As I have thought about the role and challenge of fish culture in the Northwest, I am convinced that both the role and the challenges are great. Some questions come to mind.

1. How many fish can the ocean support? Are we rearing to the limits of production? (In some of the recent good salmon years, 1970, 1973, for example, I am told that if we added up the ocean and Columbia River catch, the total volume of production from the Columbia River may be approaching that of the early years (1880's). The species, races, etc., are now much different than they were in the earlier years.) How can we determine what are the limits of production? How much more expansion should be allowed? Is the commercial and/or sport harvest increasing proportional to the increase in production? Should it? If production should be restricted, should it be for private, state, or federal? What effect are all these hatchery fish having on wild stocks?

   Three graphs were shown which compared the catch of coho with hatchery returns, smolts released and spawning ground counts

of wild coho. In general, the data shows that the increased hatchery production from 1960-66 resulted in increased catch and hatchery returns. After 1966, the catch and returns have fluctuated rather widely and are not consistent with hatchery releases. The counts of wild coho appear to be going down.

2. Where is all the fish food to come from to feed these hatchery fish? A couple years ago, when the Peruvian Anchovetta and the east coast herring fisheries failed, there was great concern as to a source of fish meal.

3. How serious are the pollutional aspects of hatcheries? Is the money for correction worth the results? If not, can we change the requirements?

4. How much care should we exercise in transferring fish as related to disease and genetics? Does the time, size and area of release effect the migration more than genetic characteristics?

5. Since the fish migrate past state and national boundaries in the ocean, what should be the role of federal agencies in the total picture?

6. Probably most important! Who is going to answer these questions and make the necessary decisions?

We in fish culture are part of a dynamic, important, and intensely interesting program. We each have a part, no matter what our specific job, to use all the initiative and desire we can muster - to use and operate the facilities we have - "wisely".

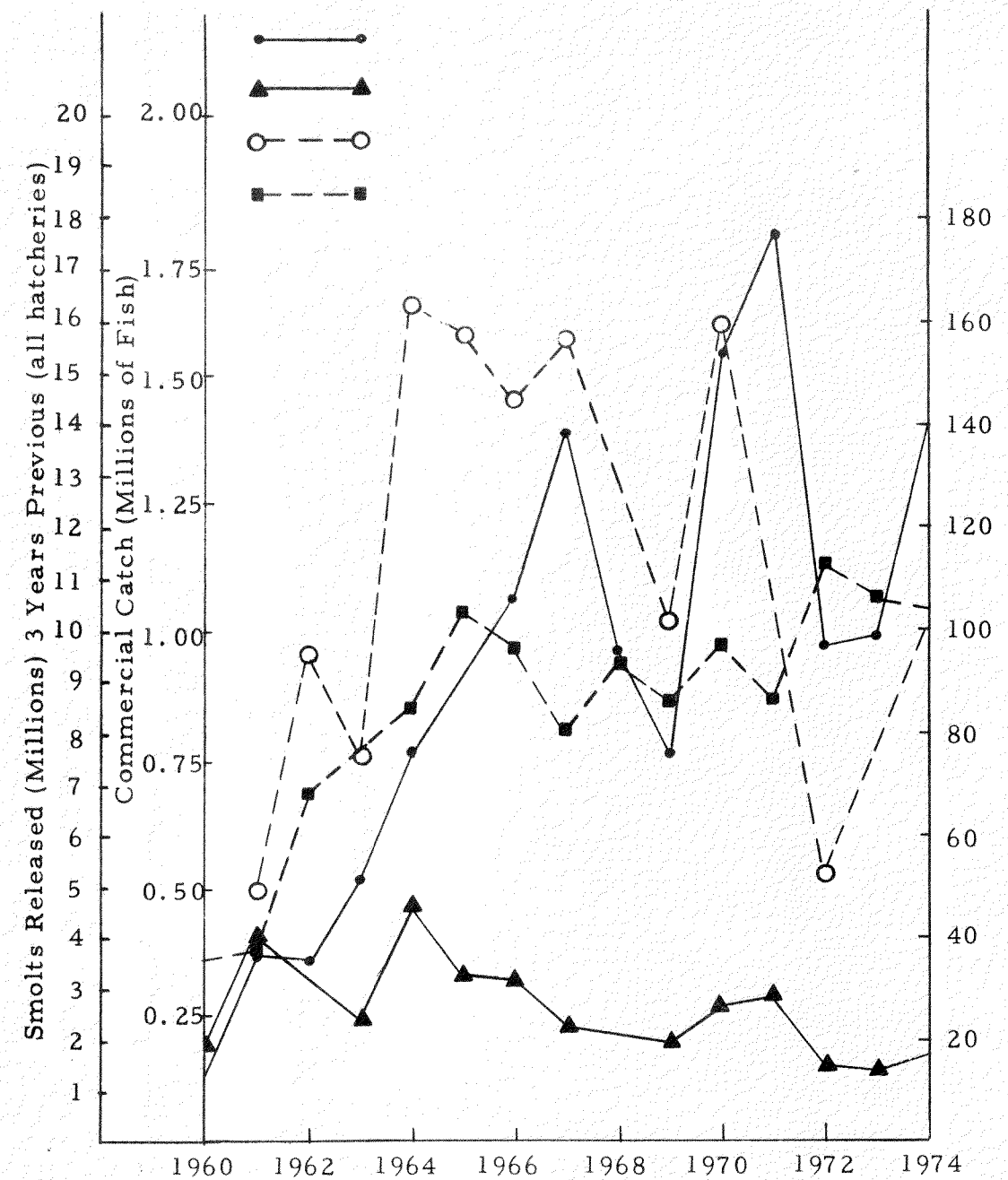
I have been a proponent for many years of building more hatcheries, since more hatcheries automatically mean more fish. I am changing my thinking! I now question if building more hatcheries is the correct way to proceed. We might be better off to spend more money learning how best to operate those we have.

Ten years or so ago, the NMFS (BCF) had a moratorium of the use of their funds to construct any more hatcheries on the Columbia River until we could show hatcheries were producing enough adults to really make a contribution. Possibly each agency should have a self-improved moratorium (with coordinated study programs) until we know how to use the hatcheries we have. This would be difficult because we have done such a good job convincing sports, commercial and legislators how great hatcheries are.

Present studies show we may be able to substantially increase survival by nitritional changes, genetic manipulation, or control of diseases. We

need more money for this work. It is ironic that in our agency, we have major amounts of dollars for construction, but have had to reduce work on nutrition and disease.

Preparing this talk has made me do some thinking about where we should be going. I hope it has made you think also.



Coho Survival Trends

Oregon

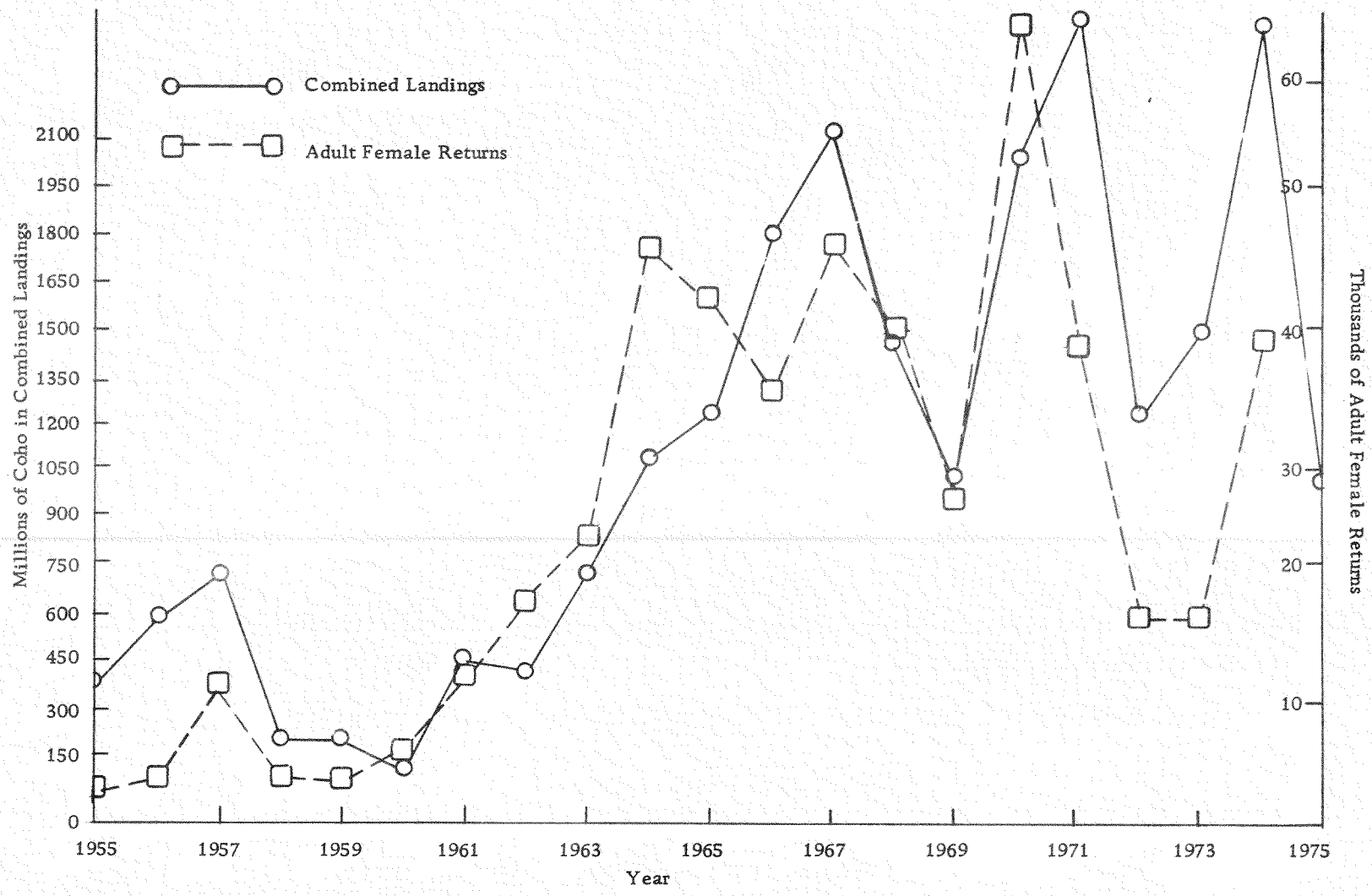
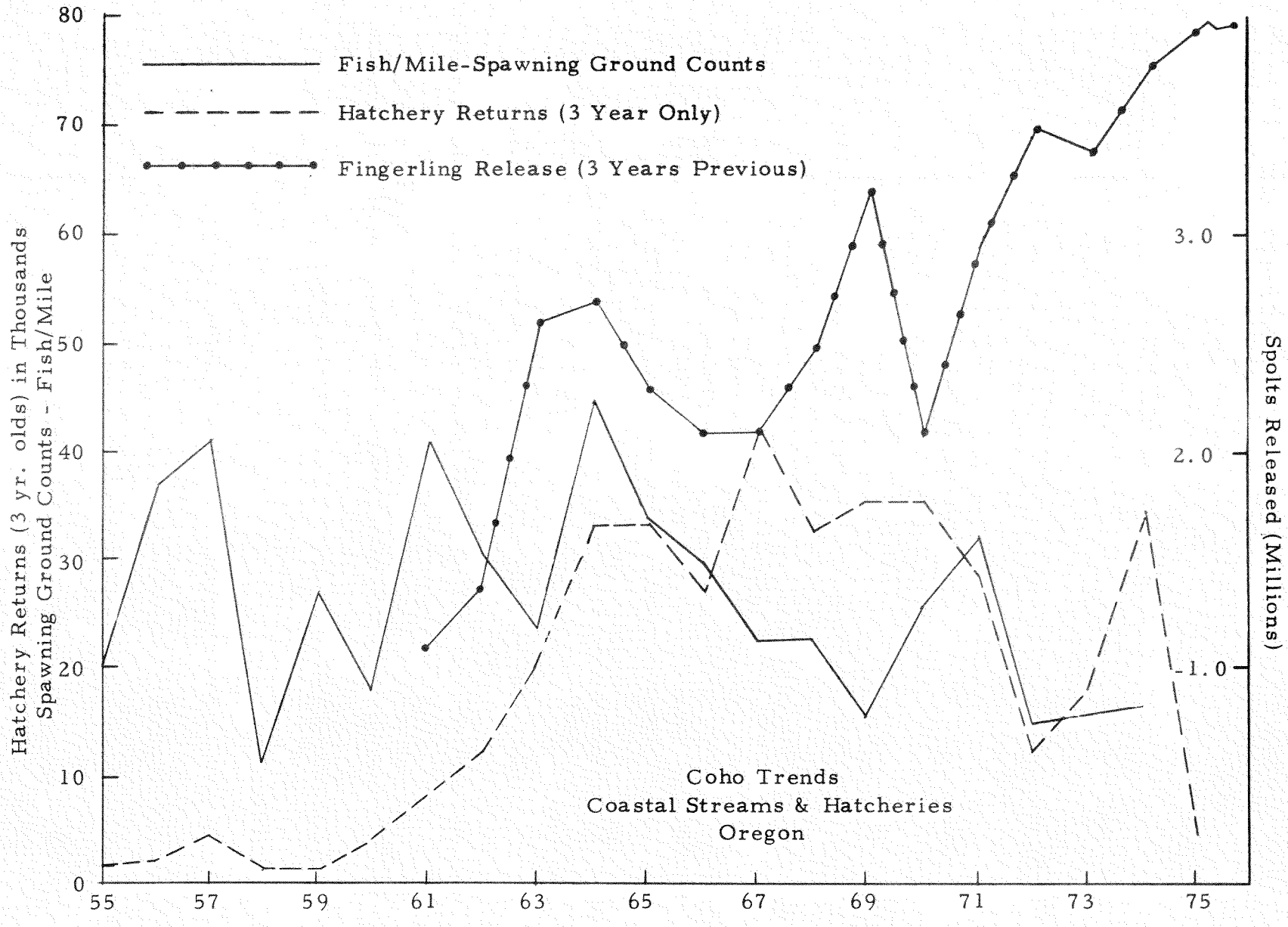


Figure 2. Combined California Troll, Oregon Troll and Columbia River Gillnet Coho Landings and Adult Female Coho Returns to Oregon Hatcheries.


Fish/Mile-Spawning Ground Counts
Hatchery Returns (3 Year Only)
Fingerling Release (3 Years Previous)
Hatchery Returns (3 yr. olds) in Thousands
Spawning Ground Counts - Fish/Mile
Spolts Released (Millions)
80
70
60
50
40
30
20
10
0
3.0
2.0
1.0
55
57
59
61
63
65
67
69
71
73
75
Coho Trends
Coastal Streams & Hatcheries
Oregon

OPEN DISCUSSIONS ON THE OPERATIONAL AND TECHNICAL NEEDS OF FISH CULTURE

Split Session Leaders

Dick Noble
WDF, Olympia

Wally Hublou
ODFW, Clackamas

Roger Burrows
UMA, Longview

General Session Summary

The following items were summarized by the panel leaders:

Operational Needs

1. More efficient utilization of existing water supplies.
   a. Reuse of all water by some degree.
   b. Loading limits in reuse systems.
   c. Develop presently unusable water supplies.

2. Improve hatchery design for cost control and quality fish production.

3. Continuous training and education of hatchery personnel.

4. Evaluate success of operations in terms of quantity and quality of fish produced and harvested.

5. Develop means to stimulate and encourage hatchery personnel.

6. Obtain the necessary funding to achieve the goals.

Technical Needs

1. Prevention and control of fish diseases.

2. Improved fish nutrition.

3. Time, size and condition of release fish.

4. Stock selection

5. Establish criteria for defining the quality of fish for intended uses.

6. Improvement of the hatchery equipment for more efficient operations.

7. Continued development of marking and tagging systems.

8. Improved communications within the profession and with the public.

Participants Written Responses

1. Increase use of present facilities before building new ones.

2. Improve stocks through genetic selection.

3. Accelerate the development of vaccines for disease control.

4. The ultimate diet has not been developed we need further improvements.

5. Seek means of regulating the fisheries that optimizes the harvest.

6. What are the disease problems in the ocean?

7. Is there enough natural feed in the ocean to support an increase in foraging young salmon?

8. Develop and "10-year plan" that will set goals and develop coordination within and between agencies.

9. Develop diversity into our cultured stocks of salmon to meet a broader resource demand.

10. Stimulate a vigorous public relations program.

11. Increase survival from release to recapture of our cultured salmon stocks.

12. Improved training and communications.

13. Strive for quality instead of quantity in release fish.

14. Establish equitable allocation of the harvestable resource among all the user groups.

15. Work more closely with the public so they can be informed and responsive citizens to the problems of the fisheries.