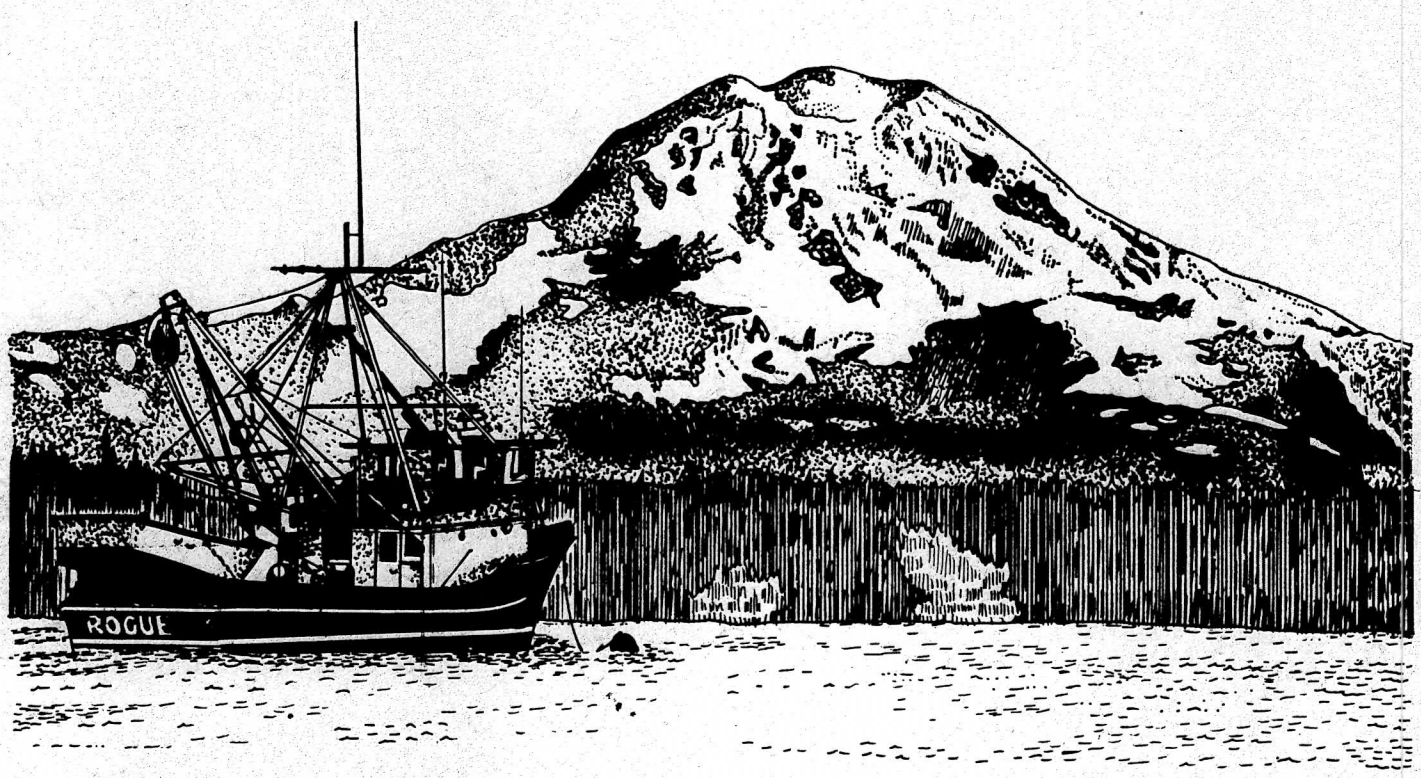
PROCEEDINGS OF THE

32 ND. ANNUAL NORTHWEST FISH CULTURE CONFERENCE



Tumwater, Washington

Dec. 1, 2, 3 1981

PROCEEDINGS

of the

Thirty-second Annual

Northwest Fish Culture Conference

December 1-3, 1981

Tumwater, Washington

Chairman

W. C. Ashcraft

State of Washington Department of Fisheries

The Northwest Fish Culture Conference

Northwest Fish Culture Conferences are informal workshops for exchange of information and ideas concerning all areas of fish culture. Current progress reports of hatchery management practices and problems, new developments in fish culture technology and results of research studies are presented. Active discussion and constructive criticism are encouraged and contribute significantly to the information exchange that takes place. All persons interested in or associated with fish propagation are invited to attend and participate. Presentations are limited to topics that have direct application to fish culture.

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

PREFACE

The 32nd Annual Northwest Fish Culture Conference was held at the Vance Tyee, Tumwater, Washington, from 1:00 P.M., December 1st through noon December 3rd, 1981.

Rolland Schmitten, Director of Washington State Department of Fisheries gave the keynote address.

Jim Wood, Kevin Amos, Bill Hopley and Bob Hager served as panel leaders and ably directed the presentations for the 285 registrants. Registration was handled by Diana Malmin and Sharon Sato.

My personal thanks to Bob Foster who was responsible for the program development, hotel arrangements, and preparation of the proceedings.

The 1982 conference will be hosted by National Marine Fisheries Service in Portland and in 1983 will be hosted by Idaho Fish and Game and University of Idaho.

Wilbur C. Ashcraft

TABLE OF CONTENTS

PRODUCTION AND TRANSPORTATION TECHNIQUES OF GAMETES COLLECTED FROM REMOTE FRESHWATER AND SALTWATER LOCATIONS IN S.E. ALASKA.

by

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Southern Southeast Regional Aquaculture Association in Alaska, a private non-profit fishermans co-operative has been in the process of developing its hatchery program by collecting eggs from wild broodstocks since 1978.

The coho and chum adults are caught by trapping or seining operations in fresh or salt water and held to maturity.

Due to the high costs of maintaining salmon hatcheries in remote locations in S.E. Alaska, we spawn in the field and the eggs and sperm are separately transported by plane or helicopter to the centrally located hatchery in Ketchikan for fertilization and incubation. Direct flights may only last one hour, but due to unpreidctable weather patterns along this coastline, gametes may be delayed from six hours to three days after collecting before fertilization at the central incubation hatchery.

Large production lots of eggs (25 million) have been taken from isolated remote locations.

Egg costs are very high due to transporting to and from several field stations, therefore we have concentrated a lot of effort on collecting

information and experimentation in order to improve gamete survival from both saltwater and freshwater broodstock holding areas Graph 1.

Capture and holding of adults

Since 1978 many egg-takes have been attempted at several locations in S.E. Alaska.

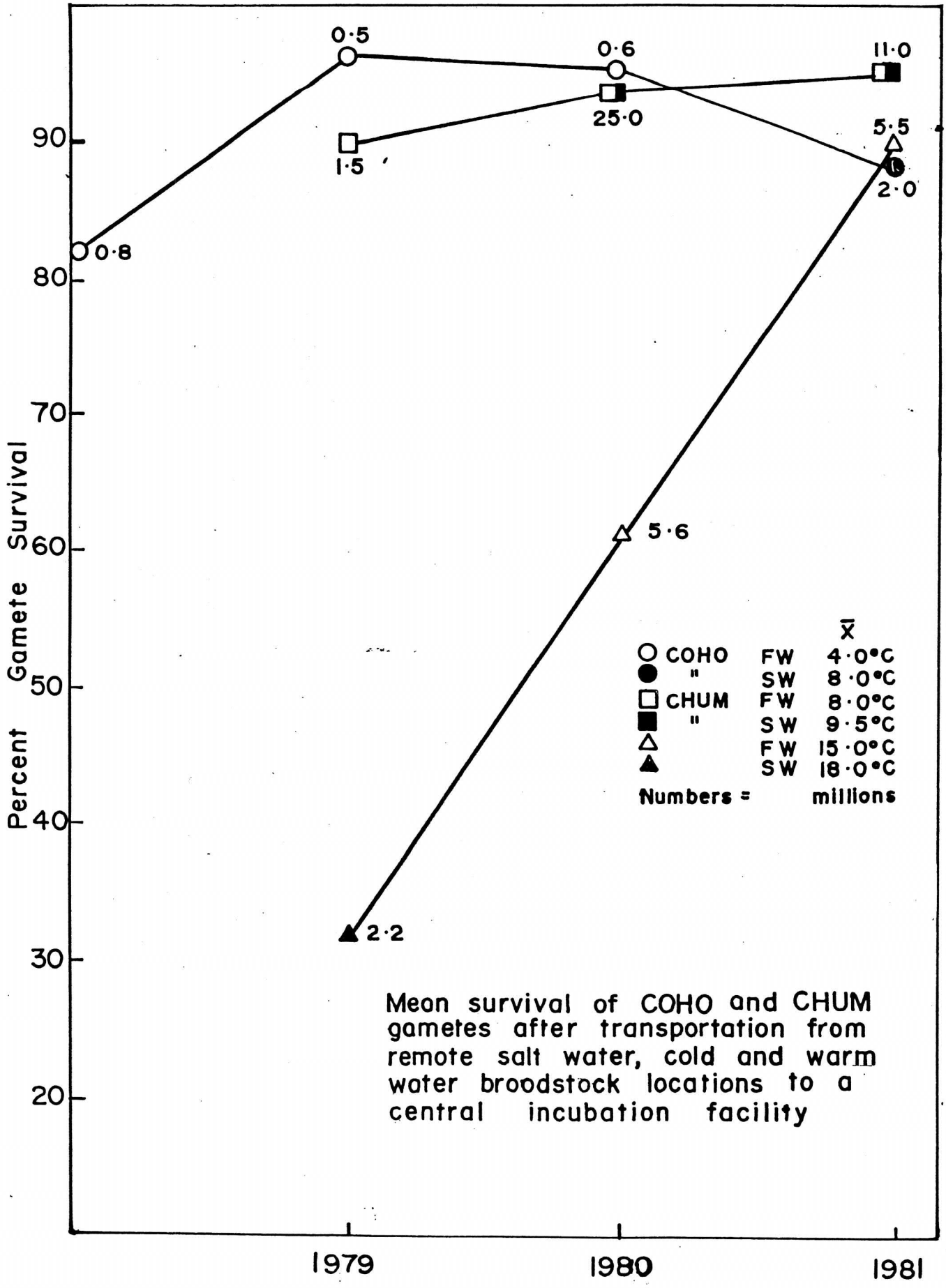
Extreme variations in weather patterns and wild conditions make egg takes difficult. Numerous rules and regulations implemented by the Alaska Fish and Game and other state departments were adhered to, making it very difficult to work effectively.

Freshwater weirs have a tendency to wash out with flash floods and holding pens for the containment of a few thousand adults are almost impossible to maintain in S.E. Alaskan streams, where floods and bears go unchecked and regulations demand that nothing of a permanent nature can be installed.

It is for these above reasons that brakish saltwater holding and ripening of broodstocks are attempted to make large egg takes easier.

The fish are seined in the estuary and held in net-pens until ripe. At first the ripening of summer chum in brakish saltwater net-pens during July and August in warm water (up to 18^{o}C) at the surface proved disastrous with poor egg fertility and high adult mortalities. The slow ripening of the males and extremely lively conditions of the green fish made checking for ripeness an almost impossible chore.

We soon found that stress during the holding of adults decreases fertility, so we reduce saltwater densities to less than 1 lb/cu.ft. to avoid excessive adult mortalities, we also reduce stress by checking the ripeness of fish under anaesthia. We now use CO_2 introduced from a high pressure bottle into a sorting box which is suspended in the net-pen. The box is filled to capacity with fish and the people sorting the females



Mean survival of COHO and CHUM gametes after transportation from remote salt water, cold and warm water broodstock locations to a central incubation facility

stand in the box among the partly anaesthetised fish. We do not buffer the pH in a saltwater environment and regulate the amount of Co_2 flow into the box according to the effectiveness of the anaesthetic to slow the fish down.

Spawning and Transportation

Ripe fish are killed and bled by cleaving through the main vertibrae across the back of the head between the eyeball and the gill plate. The cleavered fish are carefully laid on a bleeding grate. The spawning shed is accomodated on a float which can be moored to close to the net-pens for ease of access. Carcasses are thrown from the shed into an attached boat for quick removal.

The eggs from freshwater sites are taken in much the same fashion with the exception that fish are kept for ripening in holding pens at densities of 5lbs.per cu.ft. and crowded towards the spawning area for sorting, killing and spawning without anaesthetic.

The eggs of 5 females are spawned into a container according to normal, careful spawning practices, checked for water hardened eggs or other contamination and put on ice for cooling.

We consider this cooling of the egg very necessary in order to slow down respiration.

We have found that at temperatures near 15°C it is to our advantage to spend considerable time making sure that each batch of eggs of five females is cooled down to 4 or 5°C before these eggs are massed together into bulk containers with waterproof snap-on lids. These pails with unfertilized eggs (4°C-6°C) are filled to the top with eggs from approximately 30 females, tightly sealed and further iced down in styrofoam coolers.

Plane loads of coolers have at times been delayed without apparent losses for up to 3 days due to poor flying conditions.

The sperm of males from salt or fresh water, we finally found out it didn't make any difference, is taken from live or unbled killed fish. Sperm from up to three males may be collected in one small plastic "whirl pak" and cooled down quickly among ice. To accomodate transport delays the plastic bags may be blown up with pure oxygen from a high pressure bottle. Each sperm bag is laid down flat to allow for maximum area penetration of the oxygen into the sperm layer to allow for maximum respiration and cooling.

Sperm and egg temperatures are checked upon arrival at the hatchery, sub-sample of sperm are checked for motility under the microscope before pooling. Sperm motility checks are done by putting a drop of sperm on a concave counting chamber slide (hemacytometer) under a cover slip. While focusing in on the sperm a drop of ovarian fluid from the eggs is squirted under the cover slip, showing an immediate burst of activity, this makes it possible to estimate the percent of motile sperm.

Fertilization and Incubation

Sperm bags with questionable motility are thrown out.

The eggs are measured in our central incubation hatchery into lots of approximately 12,000 eggs and fertilized with 10-20mls. of sperm. Gametes are mixed by stirring each lot and allowed to sit for one minute before activation takes place, by pouring the eggs into a water filled Heath tray.

Immediate change of temperature from the stored gametes at 4°C to the temperature of the incubation water which is about 10°C does not seem to effect survival. After 1 hour of water hardening the inner

Heath tray baskets with eggs are disinfected in a 1.150 solution of buffered Wescodyne before final placement into the main incubation room.

Checking fertilization

12-16 hours after fertilization, depending upon the temperature each shipment of eggs is checked for fertility.

A random sample of eggs is removed and placed in "Stockards" solution (or plain white vinegar with a pinch of salt) within twenty minutes the germinal discs turn white and the two or four stage cell division of fertilized eggs can easily be observed at the surface of the egg with the naked eye for 30 minutes and compared with the non-divided germinal discs of unfertilized eggs.

This will immediately identify potential problems after each spawning or transport for rectification before attempting the next spawning.

Gonadotropin Hormone Tests

An additional technique for the improvement of gamete collections was tested. We controlled the time of maturation by a Gonadotropin Hormone which was purified from chum pituitaries. In an experiment carried out this fall with broodstock held in both saltwater and freshwater, 35% of the fish that received an injection of G.T.H. had ovulated 5 days after and 95% 10 days after injecting.

Controls that received an injection of saline had ovulated 27% by day 5 and 57% on day 10.

Percent of fish that ovulated after injecting purified Gonadotropin Hormone.

	Day 3-5	Day 7-10
G.T.H. injection	35%	95%
Control	27%	57%

Injection of males with G.T.H. will accelerate the maturation process and yield a higher amount of sperm.

Fertility of eggs and sperm collected after hormone injections was not different from the egg fertility of controls.

FREESTYLE INCUBATORS FOR EYEING EGGS: FALL 1981

Bob Rogers
McKernan Salmon Hatchery

Salmonid eggs can be eyed in mass in freestyle incubators with little time and energy spent for placement into and removal from each unit.

The freestyles used at the WDF George Adams and Donald McKernan salmon hatcheries are constructed of 6.35mm (1/4") PVC. All seams were hot air welded and glued. The dimensions of each unit are as follows:

Total length: 101cm (39.75")
width: 74cm (29.25")
depth: 55cm (21.50")

Egg containment section:
length: 79cm (31.00")
width: 63cm (24.75")
depth: 50cm (19.75")

The base egg support is made of 31.75mm X 2.38mm (1-1/4" X 3/32") slotted screen.

Five units are placed in each stair-step series. Well water flows from the uppermost unit, upwelling through the egg mass throughout the series of incubators. Each unit will safely eye 500,000 chum or coho eggs or 400,000 chinook eggs. Depending on egg sizes, this approximates 136kg (300lbs) of green eggs. Heavier loadings were tried this year with fall chinook. Into each of two units was placed 160kg (360lbs) of green eggs. The results were very satisfactory; no egg loss increase.

Flows required to incubate 2,500,000 chum eggs is 60 lpm (16gpm). At water temperatures of 9.5^{o}C (49^{o}F), dissolved oxygen readings through eyed eggs held at 8.0 ppm.

Incubation capacity at George Adams is 60 million chum. Total flow required is 1450 lpm (385gpm). At McKernan Hatchery, 15 million chum can be eyed in freestyles utilizing 380 lpm (100 gpm). Though it has not been tried

here, we feel confident that 600,000 chum per freestyle (3 million per series) would produce satisfactory results.

For the last two years at McKernan Hatchery, egg losses through the eyed stage have approximated 3.5 to 4.0%. Last year at George Adams Hatchery, loss to the eyed stage was 4.0%. By comparison, in previous years egg loss on pond trays at George Adams approached 8%.

Man-hours spent placing and removing eggs from the units is notable. Two persons can weigh down 500,000 eggs in 10-15 minutes, and can remove, shock and transport to the hatchery building the same in approximately 25 minutes.

To reduce fungal growth, the eggs are treated with malachite three times weekly. The flush method is used at both facilities; 230ml of solution per each series of freestyles.

The eggs are shocked at approximately 500 T.U. and allowed to sit 24 to 48 hours before salt dipping (epsom salt) and picking. After removal of dead eggs, chum are weighed down into bags in deep troughs; 100,000 per bag, 1 million per trough. Chinook are weighed down at 750,000 per trough. The eggs are then ready for placement in the hatching units (gravel boxes, raceways, or heath trays) or for transfer to other facilities.

When purchased last year, cost per unit approached $300.00.

Efficacy of Two Fungicides on Eggs of Chinook Salmon and Subsequent Effects on Saltwater Survival

John L. Dentler
Oregon Dept. Fish & Wildlife

ABSTRACT

Chitosan (the deacetylated derivative of chitin), malachite green, and a control were evaluated for their effectiveness at inhibiting infestations of Saprolegnia sp. on the incubating eggs of chinook salmon. Approximately 1,000 eggs (Rogue River, Oregon Spring Chinook Stock) were placed in each tray of a Heath-Techna egg incubator. Two trays were utilized for each treatment. Malachite green was applied at 2, 10, and 100 mg/l and chitosan was applied at 42, 83, and 166 mg/l. A control received no chemical treatment. Experimental trays were treated a total of nine times before inspection (Table 1). In general malachite green was superior at inhibiting fungus than chitosan (Fig. 1). Chitosan actually appeared to stimulate Saprolegnia incidence over that of a control. However at the greatest concentration of chitosan there appeared to be some abatement in the incidence of Saprolegnia. Survival to the fry state revealed no outstanding differences except at the highest concentration of malachite green (Fig. 2), where mortality was complete.

A total of 350 fish from selected treatments were reserved for subsequent tests on saltwater survival. Each month (June through December) a total of twenty fish from each treatment were transferred directly into $35^0/_{00}$ and $40^0/_{00}$ seawater. Each day mortalities were removed and

enumerated. Seawater was replaced on day 7 of the 14 day challenge or as soon as fecal material accumulated. A row x column χ^2 ($35^0/_{00}$ June through October) test revealed that there were no significant differences in the ability to survive seawater in any of the treatment groups ($\chi^2 0.05$, 12df=21.03,χ^2= 16.56).

Table 1. Date of treatment.

MG (mg/l) 2 10 100	Chitosan (mg/l) 42 83 166	Control
19 October	19 October	---
24 October	24 October	---
27 October	27 October	---
31 October	31 October	---
4 November	4 November	---
10 November	10 November	---
14 November	14 November	---
17 November	17 November	---
21 November	21 November	---

Table 2. Percent Survival

Treatment	Month	June	July	Aug.	Sep.	Oct.
Malachite green 2 mg/l	35 PPT	20	30	70	60	95
	40PPT	--	0	0	5	45
Malachite green 10 mg/l	35 PPT	50	15	50	85	75
	40 PPT	--	0	5	5	40
Chitosan 166 mg/l	35 PPT	60	5	70	75	95
	40 PPT	--	0	0	5	40
Control	35 PPT	45	0	80	50	100
	40 PPT	--	0	0	0	5

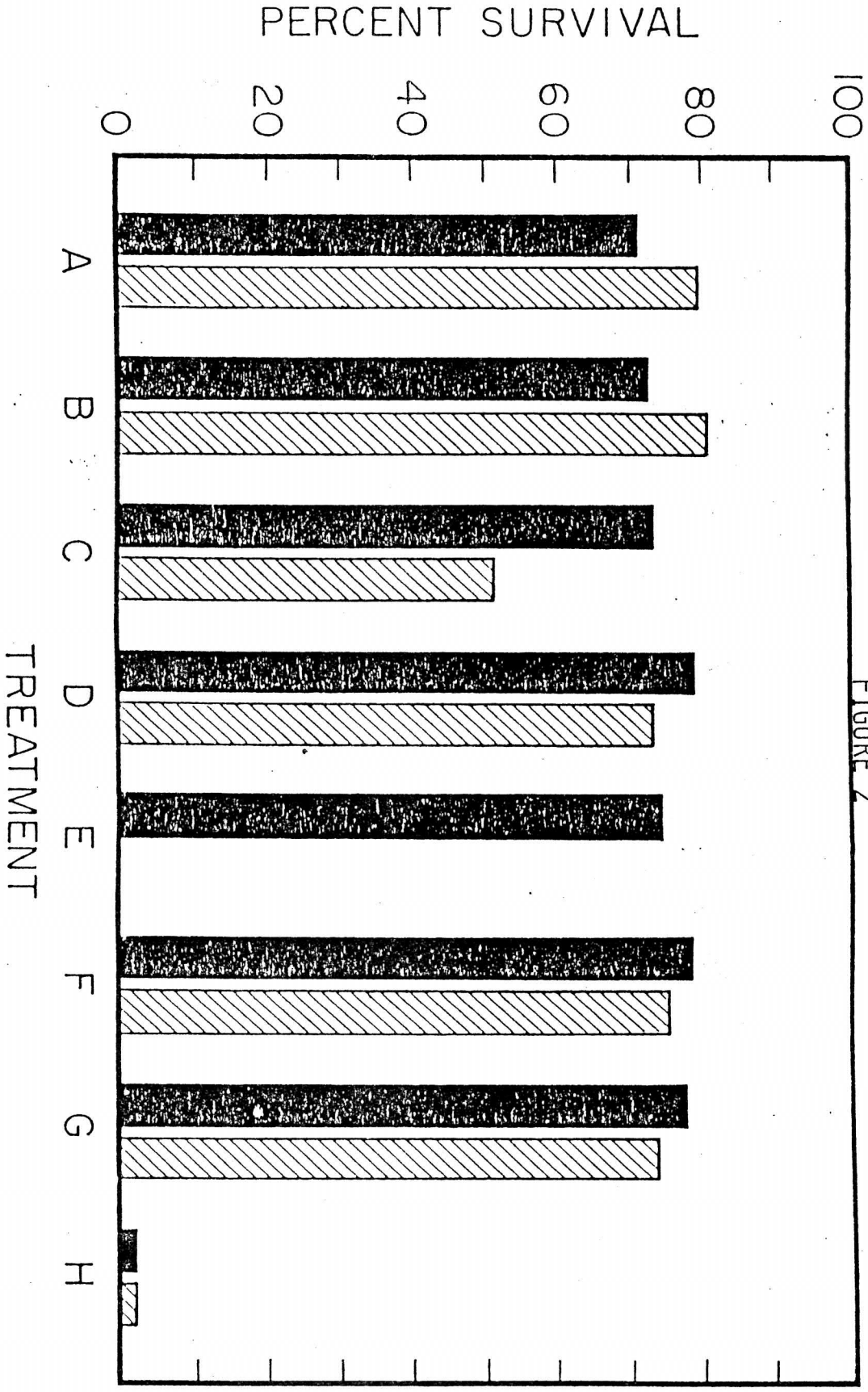


FIGURE 2

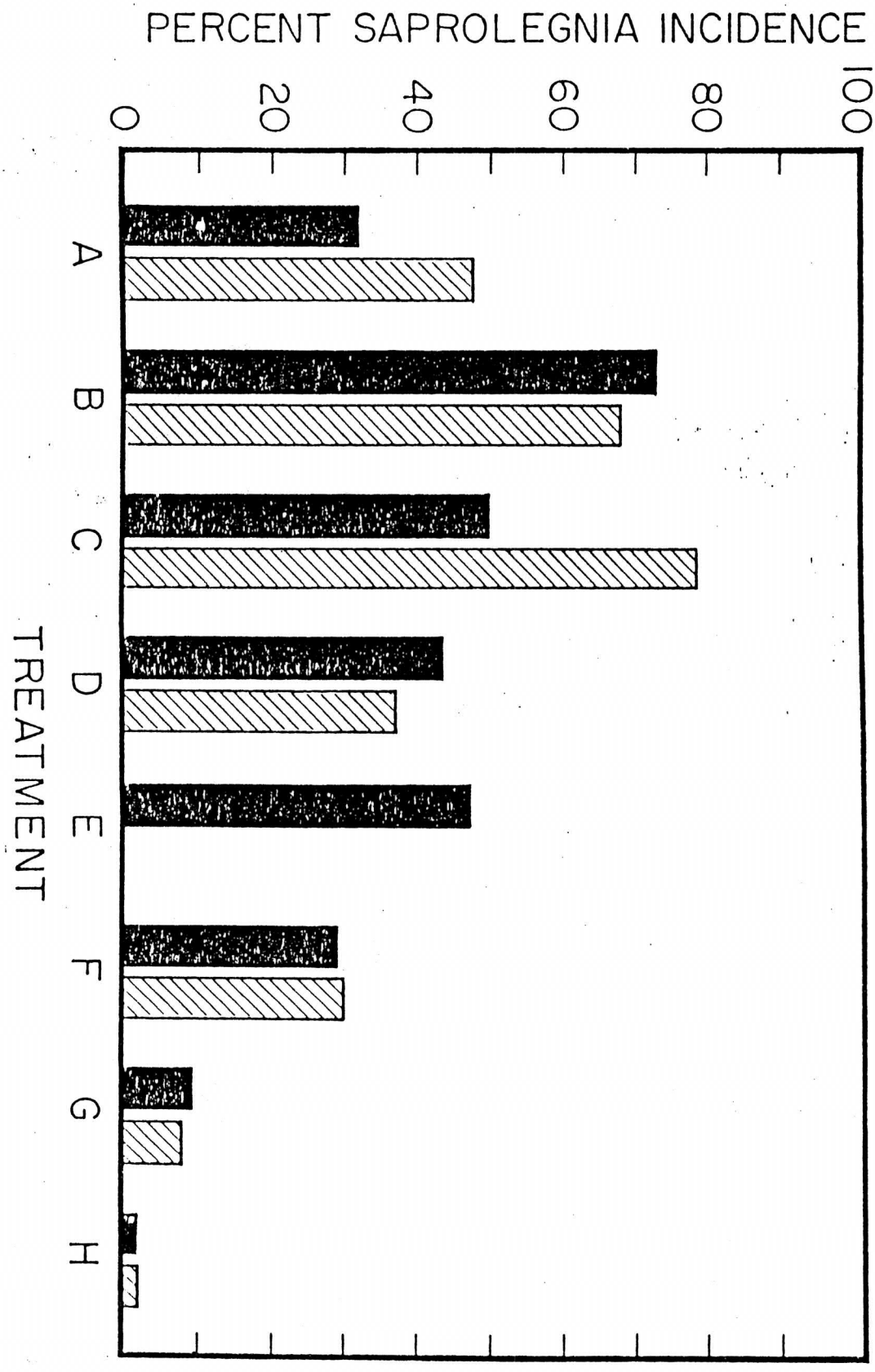

PERCENT SAPROLEGNIA INCIDENCE
0
20
40
60
80
100
A
B
C
D
E
F
G
H
TREATMENT

FIGURE 1

Figure Legends

Figure 1. Percent Saprolegnia infesting eggs of various treatments. Treatments: A=Control, B=Chitosan 42 mg/l, C=Chitosan 83 mg/l, D=Chitosan 166 mg/l, E=Control, F=Malachite green 2 mg/l, G=Malachite green 10 mg/l, H=Malachite green 100 mg/l.

Figure 2. Percent surviving to swim-up stage. Treatments: A=Control, B=Chitosan 42 mg/l, C=Chitosan 83 mg/l, D=Chitosan 166 mg/l, E=Control, F=Malachite green 2 mg/l, G=Malachite green 10 mg/l, H=Malachite green 100 mg/l.

Settling of Water Borne Solids Using Readily Available Materials

Rich Kolb
Washington Department of Fisheries

The Washington State Department of Fisheries, Green River Hatchery, located on Soos Creek just northeast of Auburn, is commonly referred to as a "dirty" water station. On occasions we have measured the incoming water and found it as high as 3.5 ml/L settlable solids. Many problems are associated with dirty water at hatcheries, but nothing is more immediately impacted than newly hatched coho fry in shallow troughs.

At Green River, a mechanical sandtrap was constructed and installed in a section of the intake pipeline. This seemed to help a little, but during dirty water periods the fry continued to require many extra man hours of attention to ensure survival. To further alleviate the sand problem, the crew came up with an economical but relatively effective settling box.

Utilizing plastic pipe and rigid plastic fish boxes, that the Department had on hand, individual settling boxes were made for each set of shallows. Each box is 43" X 48" and 30" high and furnishes water to eight shallow troughs. Eight 1½" holes were drilled about 3" down from the top and spaced to supply one trough per hole. When the boxes are filled with water, the sides tend to bow out. This was corrected by using 2 threaded rods joining the opposite sides.

To facilitate cleaning, a 2" gate valve was attached to the bottom. A wire basket is suspended under the inflow to the boxes to catch larger debris while a filter box catches finer materials before they enter the troughs. Light gauge aluminum was bent to fit over the edge of the boxes and act as a flow control for the outlets.

The plastic boxes are light weight, relatively strong and easy to work with. The setup procedure is simple, but care must be taken to ensure the boxes are level so that all troughs will get the same amount of water. The price per unit is about $150: box, pipe and fittings.

The Use of Plastic Substrate in the Incubation of Coho Salmon at a Cold Water Hatchery

Howard Fuss and Charles Johnson
Washington Department of Fisheries

Introduction

The use of artificial plastic substrate as a substitute for gravel in hatchery incubation systems has been increasing over the past few years. Gravel substrates were shown to produce larger sockeye salmon (Oncorhynchus nerka) fry with greater swimming stamina and more ability to avoid predators (Brannon, 1965; Bams, 1967). Bams (1972) also showed that hatchery reared pink salmon fry (O. gorbuscha) incubated in gravel, survived to the adult stage similarly with pink fry incubated in the natural stream.

Because of the labor involved in handling gravel, a lightweight substitute with similar or greater incubation advantages was needed. The artificial substrate requirements included void space similar or greater to that of gravel and a tactile surface for the alevins. Both these requirements allow a sufficient quality and quantity of water to the alevins as well as providing some measure of darkness.

Astroturf was apparently the first artificial substrate used (Bailey and Taylor, 1974). Later, plastic intalox bio-saddles (Leon, 1975) and plastic bio-rings (Snyder, 1979) were used. All three substrates produced fry of similar size and quality as gravel. The latter two had at least two major advantages over astroturf; 1) greater density potential and 2) greater adaptability to various incubation systems. In Alaska, 97 percent of the total eggs incubated on substrates, during 1980, were

incubated in bio-saddles and bio-rings. The use of artificial substrates in Washington salmon hatcheries has been increasing steadily over the past three years. The substrate in primary use today is multi-layered vexar netting and bio-rings.

The use of artificial substrates has centered primarily around pink and chum salmon (O. keta). Its use with chinook (O.tshawytscha) and coho salmon (O. kisutch) has been somewhat limited. This study dealt with the effects of artificial substrate on coho salmon incubated in shallow troughs at a cold water hatchery. The study objectives included: 1) the effect substrate has on alevin size at button up; 2) if a potential size advantage would be maintained during rearing through release; 3) if substrate had an effect on disease susceptibility, and 4) if substrate had an effect on consequent ocean survival. The study was conducted at Dungeness Hatchery, located near Sequim, Washington. Eggs originated from the 1977 brood coho that were spawned at the hatchery in October.

Methods and Materials

The study was conducted at the Dungeness Hatchery and replicated on a smaller scale at Green River Hatchery. Coho eggs from a common egg take were eyed and randomly distributed in shallow trough baskets. A total of 20 troughs were utilized at Dungeness and eight troughs at Green River. Each trough was divided into three sections. The upper section serves as a settling basin for particulate matter. Three baskets of eggs (25,000 eggs/trough) were placed in the remaining two sections. Five layers of 1.9 cm vexar were placed in the bottom of each trough. The vexar was cut to conform to the length and width of the trough and was held together by plastic

ties. A length of 1.3 cm rebar or lead net weights was used to weight the vexar down. At Dungeness, the fry were allowed to drop through the egg baskets after hatching. However, at Green River the fry were placed in the appropriate troughs after hatching. Densities of fry in the troughs are given in Table 1.

Two treatments were tested: covered substrate and uncovered substrate with corresponding covered and uncovered controls. At Dungeness, five troughs for each treatment were used (20 troughs total) and at Green River, two troughs for each treatment were used (eight troughs total).

Fish were sampled for length and weight immediately prior to ponding. This was accomplished after removing the substrate by sampling at intervals along the entire length of the trough. The fish were then placed in a bucket of water and a sample of approximately 50 fish was removed by hand and sacrificed in a concentrated solution of MS-222. Fifty fish from each treatment were measured to the nearest millimeter and weighed to the nearest 0.01 g on a Mettler PN1210 balance.

After ponding fifty fish from each treatment and control were similarly weighed and measured. The fifty fish were drawn from a larger sample that was randomly sampled from each pond.

The fish were ponded on May 1, 1981, in four 6m x 24m concrete ponds at an initial density of 1533 fish/m^3 (0.02 lbs./ft^3/inch of body length). Each treatment and control pond was split to another pond (two ponds per treatment) when density reached 500 fish/m^3 (0.09 lbs./ft^3/inch of body length). All fish were fed OMP II at a ration level of 3.4% (May-October), 0.5% (November-March) and 2.5% (April-June).

Two-way analysis of variance tested the hypothesis of equal fish size in relation to substrate. Differences in mortality rates between the substrate and control groups were tested using Shep's relative difference test:

$$Ps = Pc + Pe\ (1\text{-}Pc) \qquad (1.0)$$

where Ps = mortality rate of the study group
Pc = mortality rate of the control group
Pe = excess risk, applied to the group that would not have otherwise have had the event (1-Pc)

By simple algebra:

$$Pe = \frac{Ps - Pc}{1 - Pc} \qquad (2)$$

which Sheps suggests be used as the measure of added or excess risk, termed the relative difference. The standard error (s.e.) is approximately

$$\text{s.e. } (Pe) = \frac{1}{Qs}\sqrt{\frac{PcQc}{Nc} + (1\text{-}Pe)^2\ \frac{PsQs}{Ns}} \qquad (3)$$

A t-test accomplished by dividing Pe by s.e. (Pe), determines the significance level.

Results

Size of Alevins and Fry

Fry in the substrate groups were significantly larger ($P < 0.005$) in both mean weight and length than fry in the control groups (Table 2). Additionally, there was a significant ($P < 0.05$) interaction effect of substrate and covering on mean weight. To determine the cause of the interaction, condition factors were calculated for all four groups. Fish in the control groups had significnatly higher condition factors ($P < 0.005$). The raw data was re-examined and it was found that the control groups had a larger

percentage of fry with visible yolk (8% and 4% for the control and substrate groups, respectively). The uncovered control group had the highest percentage of fry with visible yolk of any of the groups.

Fry in the substrate groups were significantly larger ($P < 0.05$) one month after ponding (Table 2). There was no statistical difference in either mean weight or length due to covering nor was was there a statistical difference in condition factors between any of the groups. The substrate fish maintained a slight size advantage over the control groups for the remaining four months. Both control groups were larger than the uncovered substrate group in July. However, this is probably due to sampling error because the size difference between the two substrate groups is many times higher than the difference between the two substrate groups in either June or August, where the uncovered substrate fish were larger than the covered substrate fish. Also, sampling error probably accounted for the larger size of the covered control group in August.

Freshwater Mortality

The mortality rates of the substrate and control groups differed significantly ($P < 0.001$; Table 3). The mortality rate of the control groups was four times higher in May and nearly nine times higher in June. The mortality rate in all groups dropped in June due to the addition of TM-50 to the diets. The cause of the mortality was cold temperature disease (*Cytophaga psychrophilla*) a common problem in coho at Dungeness Hatchery during the early summer. Also, the mortality rates in the production groups and control groups were similar and higher than the substrate groups. The production groups were incubated (without covering) and ponded in a similar manner as the control groups.

Discussion

The use of vexar as a substrate during the incubation of coho salmon alevins produced significantly larger fry compared with fry incubated without substrate. However, the size differences between the substrate and non-substrate fish were small and decreased gradually during the rearing period. It is difficult to predict whether these size differences would be maintained up to release or if they would be greater at release under a more controlled feeding regime. Leon (1975) found that Atlantic salmon (Salmo salar) fry incubated on a plastic substrate maintained a size advantage over fry incubated without substrate for 225 days post hatching. However, Leon used small lots of fish and small rearing containers and as such, had a more controlled feeding regime than this experiment. Shroder (1976) found that chum salmon incubated on artificial substrate maintained a size advantage over non- substrate incubated chum for five weeks of controlled feeding. The growth rates between the two lots of fish were not different, indicating that the substrate only imparted an initial size advantage. In species such as chum and pink salmon, an initial size advantage is probably beneficial because of the short freshwater rearing period. In coho, which are reared up to 16 months in some facilities, any size advantage at ponding can be minimized later, due to less controlled feeding practices in production scale hatcheries. If the small size differences reported herein were maintained at release there would probably be very little difference in survival due to size.

Perhaps of greater importance to the fish and the fish culturist is the apparent reduction of disease incidence due to substrate. Stressing of fish has been recognized as an important mediator of many diseases. It is conceivable that fish incubated on a substrate lacking rugosity suffer enough stress to make them susceptible to certain pathogens. Also, once exposed to these pathogens, the fish may suffer chronic stress that is not detectable by poorer food conversion rates or higher mortality. Yet, this long term stress may ultimately effect ocean survival in several ways. One, the fish may be carrying the pathogen in a latent or non-epidemic form and because of the stress during saltwater transition succomb to the pathogen, or; 2) the long term stress associated with disease occurrence or exposure might effect the osmoregulatory ability of these fish.

Incubating coho salmon in shallow troughs utilizing vexar netting as as a substrate is feasible in a production scale hatchery. The fry incubated on substrate are not only larger at ponding, but they also appear to have an increased resistance to cold temperature disease (Cytophaga psychrophillia). The substrate itself is both easy to install and remove for cleaning. However, there are at least three criteria that should be considered for its use in production scale facilities: 1) moderately clean water, 2) reduced disease incidence and, 3) increased ocean survival.

Table 1. Fry densities in shallow troughs with and without substrate.

	Number of fry	Number of fry/cm^2	Number of fry/cm^3
Without	75,000	5.6	0.7
With	75,000	5.6	0.8

Table 2. Mean weight of fry at ponding (April 26, 1981) and subsequent rearing periods.

Treatment	April	June	July	August	September	October
Covered substrate	0.34	0.97	2.12	4.33	9.15	14.40
Uncovered substrate	0.32	0.93	1.89	4.41	8.64	14.14
Mean	0.33**	0.95*	2.01	4.37	8.90	14.27
Covered control	0.30	0.91	1.92	4.13	8.34	14.73
Uncovered control	0.31	0.86	1.95	4.17	8.44	12.66
Mean	0.30	0.89	1.94	4.15	8.39	13.69

* significant at = 0.05
**significant at = 0.005

Table 3. Mean monthly mortality rates for control, substrate and production groups. Covered and uncovered groups within treatments were combined.

	May		June	
Group	No.	Percent	No.	Percent
Substrate	340 / 246,000	0.34	85 / 245,075	0.035
Control	3,200 / 246,000	1.31	749 / 242,780	0.31
Production	18,313 / 1,888,240	0.97	4,500 / 900,000	0.50

Range: (0.68-1.41)

Literature Cited

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Evaluation of Three Plastic Substrates in the Incubation of Chum Salmon

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Introduction

Chum salmon (Onconhynchus keta) are incubated in Heath incubators at some Washington Department of Fisheries hatcheries. It was noted by hatchery personnel and biologists that the quality of fry produced in Heath incubators with the normal flat screen tray was very poor. To remedy this situation, artificial plastic substrate was used. Three types of substrate were compared against the control (normal screen) and data on weight, length and condition factors taken. The study took place at George Adams Salmon Hatchery located near Shelton, Washington.

Materials and Methods

Chum salmon eggs from a common egg take were randomly fertilized and placed in four stacks of Heath Techna incubators. Three stacks (16 trays per stack) were randomly designated as one of three experimental treatments; 1.9 cm PVC vexar, 2.5 cm PVC Intalox saddles or 3.8 cm PVC bio-rings. The fourth stack was designated as the control and consisted of 14 mesh/cm fiberglass screen trays. The uppermost tray in each stack was not utilized. Experimental group trays were filled with substrate to a depth of 3.8 cm and loaded at a density of 7.05 alevins/cm^2 (Table 1). The incubators were supplied with well water at 10^{o} C and 5 gpm flow. After 88 days (880 T.U.'s C^{o}) of incubation, 50 fry from each of four randomly selected trays per stack were weighed to the nearest dg. The hypothesis of equal fry weights between the four groups was tested using one-way analysis of variance. Positional differences within each stack were tested using one-way analysis of variance

and the Student-Newman-Keuls procedure for differentiating non-homogenous groups.

Results

Fry incubated in any of the three substrates were significantly larger in both mean weight and length ($P < .001$) than fry incubated without substrate (Table 2). Additionally, fry incubated with bio-rings were larger than fry incubated in either vexar or saddles. This difference amounted to only 0.1g and is probably not biologically significant. Mean fry size also varied due to tray position. There were significant positional differences in mean weight for the vexar ($P < 0.001$) bio-rings ($P < .0025$) and control ($P < .014$) groups. As determined by SNK analysis, fry in the lower trays were larger than fry in the upper trays for the forementioned groups (Fig. 1). Although these differences were statistically significant, the mean difference in weight between any one tray did not exceed 0.03g and are probably not biologically significant in terms of weight.

Condition factors (Kf) were computed to determine the degree of yolk absorption. Since the fry had not begun feeding, the condition factor would be expected to continually fall below unity as the yolk is absorbed. The mean Kf's of the substrate groups were below that for the control group (Table 3). Among the substrate groups, the vexar groups had the lowest Kf, indicating that these fish were utilizing yolk reserves at a higher rate.

Discussion

The three artificial substrates used in this study provided a more favorable incubation environment than bare screen substrate. The difference among the three substrates was minimal and probably not biologically significant. Shroder (1976) found that fry were significantly larger when incubated on gravel or astroturf as opposed to bare screen. When subjected to a controlled feeding

regime of five weeks, the fry incubated on either of the two substrates were still larger than fry incubated on bare screen. However, the actual growth rate did not appear to be different. Leon (1975) found that Atlantic salmon (Salmo salar) fry incubated on plastic substrate were 45% larger than control fish. The substrate incubated fry maintained a size advantage for 25 days post hatching. Although no controlled feeding trials were done in this experiment, one can postulate, based on Shroder's and Leon's findings, that the chum incubated on substrate were larger at release (65 days average rearing period).

The difference in fry size among the three substrate groups was minimal, yet, there appears to be other benefits attained using substrate rather than bare screen in Heath incubators. One example is the potential for earlier feeding and more uniform fry dispersal at ponding. Leon (1975) mentioned that several investigators had noted a more rapid yolk absorption in fry reared on substrate. Data collected at Green River showed this to occur with coho, (WDF, unpublished data). Also, dispersal of chinook salmon fry incubated on vexar was noted to be more uniform at ponding, than fry incubated on bare screen (Chuck Johnson, personal communication). These fish were also feeding more readily than the bare screen fish at initial feed introduction. The potential advantages are obvious; a larger fry that can be ponded earlier and will feed more readily at initial food introduction.

An additional potential advantage is reduction or elimination of certain diseases. The incidence of coagulated yolk disease was greatly reduced in chum fry incubated in substrate compared with chum fry incubated on bare screen trays (Dennis Popochock, personal communication). Although no quanitative data exists at present, the reduction in coagulated yolk disease was substantial. Leon (1975) found that the incidence of constricted Atlantic salmon yolks was reduced substantially when fry were incubated on substrate

Because there were no discernible differences among the substrate groups, some criteria must be developed to evaluate which substrate should be used. There are at least three important considerations when using substrate in a large production scale hatchery: 1) the man-hour requirement for placement of the substrate, 2) working with the eggs in conjunction with the substrate; and, 3) cleaning dead eggs and fry from the substrate. The three plastic substrates require little extra labor during placement in an incubation system. However, prior to placement, the vexar must be cut in strips, folded into the desired layer configuration and then fastened. This procedure is not required with either the bio-rings or saddles.

If the average WDF hatchery has a hatching capacity of 11 million eggs (in Heath incubators) this would require the assemblage of 1,375 Vexar units. It has been estimated to take one person approximately three minutes to assemble one vexar unit. This would require approximately 69 man-hours to supply the hatchery's needs. This operation occurs only once, since the vexar units become permanent units. At this stage, the installation considerations are similar to the other substrate types. Perhaps then, the most important considerations are the man-hour requirements after egg picking and clean up after the fry have been ponded. In large production facilities, eggs are shocked and picked en masse. The substrate must be placed in the incubator when the eggs are replaced for subsequent incubation. Both the bio-rings and saddles are more labor intensive for two reasons: 1) they cannot be handled as a single unit, and 2) they are more difficult to clean of dead eggs and fungus. The substrate must be cleaned and stored after ponding the fry. The bio-rings are more labor intensive at this stage than either the saddles or vexar because dead eggs and fry and associated fungus tend to form mats in the interstitial spaces. This material is difficult to remove with high pressure water jets, and requires that the individual pieces be washed en masse. Soaking large quantities of either bio-rings

or saddles in a solution of LLMO (Live Liquid Micro Organisms) is satisfactory, but this solution will not dissolve unbroken eggs, (Denis Popochock, personal communication) and therefore, additional cleaning is necessary. Cleaning vexar is much easier. Shaking dead eggs and fry from the substrate and then hosing each unit off is all that is usually required. A cost comparison is included in Table 3.

Conclusions

1. Larger fry are produced when incorporating an artificial plastic substrate with Heath Techna vertical incubators.
2. Alevins incubated on substrate might complete yolk absorption sooner and more efficiently than alevins incubated on bare screen.
3. Fry incubated on substrate might be dispersed more evenly at ponding and take food more readily than fry incubated on bare screen.
4. Coagulated yolk and other diseases might be significantly reduced or eliminated when substrate is incorporated in incubation.
5. Vexar substrate is a less time-consuming and more cost efficient substrate (after initial assembly) than either bio-rings or saddles and produces fry of equal quality.

Table 1. Alevin densities for each substrate.

Substrate	Substrate size(CM)	Alevin Density No./cm^2	Alevin Density No./cm^3	Adjusted[1/] Alevin Density No./cm^2	Adjusted[1/] Alevin Density No./cm^3
Control	14/cm	7.05	1.39	7.05	1.39
Bio-rings	3.81	7.05	1.39	7.67	1.51
Saddles	3.81	7.05	1.39	7.58	1.51
Vexar	1.91	7.05	1.39	7.58	1.49

[1/] Adjusted using void space of substrate: bio-rings and saddles: 92%; Vexar: 93%.

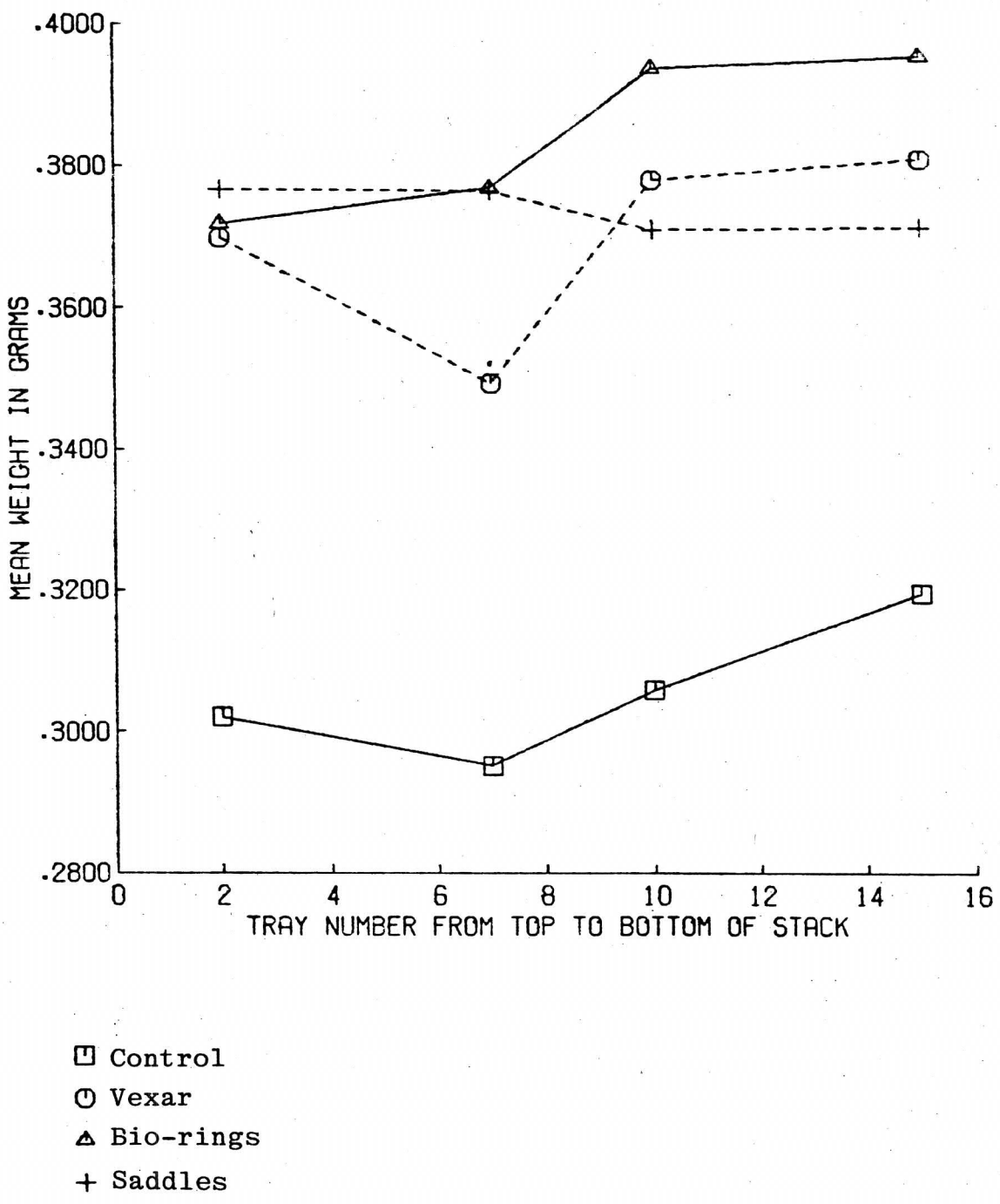
Table 2. Mean fry sizes for each substrate.

Substrate	Mean Weight(g)	SD	Mean Length (mm)	SD
Control	0.31	0.038	3.5	0.14
Bio-rings	0.38	0.036	3.8	0.13
Saddles	0.37	0.035	3.8	0.13
Vexar	0.37	0.035	3.8	0.14

Table 3. Cost comparison of the three substrates.

Substrate	Handling & Installation Hours	Handling & Installation Cost	Total Cleanup Hours	Total Cleanup Cost	Grand Total Hours	Grand Total Cost
Bio-rings	17	97.00	27	153.00	44	250.00
Saddles	17	97.00	27	153.00	44	250.00
Vexar	5	28.00	17	97.00	22	125.00
			Difference		22	125.00

Fig. 1. Mean weight of chum alevins from top to bottom of Heath incubator stack.



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RESULTS OF A TEST OF A RECIRCULATING SALMON INCUBATOR FOR ALASKAN VILLAGES WITH LIMITED WATER SUPPLIES

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ABSTRACT

Few sites in Northern Alaska are suitable for conventional salmon hatcheries. The main reasons for this are (1) surface water temperatures remain close to 0°C for 7 months of the year, (2) permafrost and high mineral contents in ground water rule out wells in most areas and (3) access to sites with adequate water (where most of the wild salmon spawn) is severely limited.

An attempt to overcome these problems by incubating salmon eggs in a recirculating incubator was made. Approximately 7,400 fall chum salmon, Oncorhynchus keta, eggs were placed in an upwelling incubator. The supply of new water was usually kept in the range 20 to 55 ml/min. These flows were roughly 1% to 3% of the total flow through the incubator (1% to 3% "make-up"). Survival to the eyed stage was 86.5%. Survival to the stage just prior to emergence was 54.6%. About 5% of the alevins showed signs of stress suggesting that water quality had worsened after hatching. However, growth of the alevins appeared normal. Total ammonia levels, initially high because of an external ammonia source, were later reduced to safe levels with an ion-exchange column. pH gradually decreased from about 8.3 to about 7.0 during the incubation period. Temperature was kept between 3.0° and 4.0°C. A biofilter appeared to be only weakly effective at removing ammonia in this temperature range. A pump failure terminated the experiment about 1 week before the fry were to be released.

Storage of salmon sperm by cryopreservation.

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INTRODUCTION

Cryopreservation of gametes, i.e. storage for indefinite periods at extreme low temperatures, is a technique used for genetic work. In some salmonids, cryopreservation was performed rather successfully (for review see Scott and Baynes, 1980). However, in Pacific salmon, in particular, variable success has been reported so far. The availability of a reliable technique could have major implications: (i) in management of wild fish populations, (ii) in selective breeding programs for cultured fish, or (iii) in general for controlled reproduction.

Stored gametes can be regarded as an insurance against the loss of stocks. Further, they can help to maintain original stocks that may be subjected to rapid changes due to high selection pressure from the environment (acid rain).

Finally, genes (frozen gametes) from previous generations could be reintroduced to rather small populations. Thus the genetic variability would be maintained and inbreeding and loss of genetic information - a consequence of using a small number of adults for reproduction - would be prevented. These reasons justify the establishment of a gene-bank.

In cultured fish, frozen gametes would increase the efficiency of selective breeding and provide a time and location independent propagation and distribution of desirable genetic material. In this regard, trade of gametes from tested strains/populations, as practiced in other domestic animals, appear likely to happen in the near future. The technique of producing all-female offspring by "female sperm" (see paper by G.A. Hunter and E.M. Donaldson) is much more efficient by cryopreserving this sperm.

MATERIAL, METHODS AND RESULTS

The techniques of freezing and storing sperm was described earlier (Stoss and Holtz, 1981). Unless otherwise mentioned, an extender consisting of 300 mmol glucose plus 10% DMSO was used. Sperm pooled from at least 5 males was frozen within one hour of collection, and fresh eggs were used to test the fertility of the frozen-thawed sperm. Storage periods varied between 4 h to 1 1/2 yr. Tests were carried out with milt from pink, chinook and sockeye salmon.

Pink salmon

In pink salmon the procedure of thawing the frozen sperm was altered (compare Table 1). Thawing was done either in an artificial ovarian fluid (Stoss and Donaldson, in preparation) or in a 120 mmol $NaHCO_3$-solution. Each thawing solution was supplemented with either 0,1 or 5 mmol of 3-isobutyl-1-methylxanthin (IBMX). This substance is a phosphodiesterase-inhibitor and thus provides a more continuous level of cyclic AMP to the sperm cells (Benau and Terner, 1980; Billard, 1980).

This means simply that the usual very brief period of sperm motility is prolonged, which possibly would have a beneficial effect as well on the sperm-fertility.

Using artificial ovarian fluid, there appeared to be a tendency of increasing fertility with increasing concentrations of IBMX. However, this trend was not statistically significant. In contrast, a clear decrease in fertility was observed, when IBMX was added to $NaHCO_3$, indicating an interaction between the various thawing solutions and IBMX.

Chinook salmon

In this experiment sperm from sex-controlled fish was used which

produced only female offspring. The suitability of the thawing solutions, $NaHCO_3$ (120 mmol) and artificial ovarian fluid with and without the addition of 1 mol IBMX was tested. Furthermore, various amounts of sperm and three different thawing rates were applied (compare Table 2).

Increasing the sperm concentration from 0.125 mol per 77-104 eggs by two- or three-fold did not change the fertility. Results averaged between 54-56%. Using the two-fold sperm volume and increasing the thawing rate from 600°C/min to 1400 or 1700°C/min increased the fertility significantly to 76 and 78%, respectively.

Artificial ovarian fluid with or without the addition of IBMX was not different from $NaHCO_3$-solution.

Sockeye salmon

In sockeye salmon sperm we studied the effect of three factors on sperm survival after thawing (compare Table 3).

Two diluents to extend and freeze sperm were tested, one as described by Stoss and Holtz (1981) and the second consisting of 30 mmol glucose and 10% DMSO as used in the previous experiments. Since DMSO may have a toxic effect on sperm cells, three different procedures of addition were applied to reduce a possible toxic effect.

Firstly, sperm was exposed to the full strength of DMSO in one step and freezing was carried out subsequently. This had been done in the previous experiments. Secondly, DMSO was added slowly in two or four steps - each step lasting five minutes. Finally, thawing was done at a slow or a fast rate.

In agreement with the findings in chinook sperm, the faster thawing resulted in high fertility, regardless of the sperm extender or the mode of

adding DMSO. In the case of the first extender, slow addition of DMSO had no effect when thawing was done at 600°C/min and fertility results were in the range of 60%. At the higher thawing rate however, slow addition of DMSO was beneficial and resulted in 87% fertility.

This finding was not shown in the glucose extender where slow addition of DMSO at the lower thawing rate decreased the fertility substantially from 81 to 47%, whereas no effect was evident at the high thawing rate (82-90%).

In summarizing the results, fertilization rates between 80-90% can be reliably obtained with cryopreserved sperm from pink, chinook and sockeye salmon. Although fertility identical to fresh sperm has not yet been reached, the present techique is adequate for use as a tool in salmon genetics and stock management.

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TABLE I - FERTILITY % ($\bar{X} \pm SD$) OF PINK SALMON SPERM AFTER FREEZING AND THAWING.

FOUR REPLICATES PER TREATMENT WITH 77-104 EGGS EACH. THAWING WAS DONE AT A RATE OF 600°C/MIN IN AN ARTIFICIAL OVARIAN FLUID (STOSS AND DONALDSON, IN PREPARATION) OR A $NaHCO_3$-SOLUTION. THAWING SOLUTIONS WERE SUPPLEMENTED WITH 3-ISOBUTYL-1-METHYLXANTHIN (IBMX) TO PROLONG SPERMATOZOAN MOTILITY. FERTILITY DATA REFER TO EYED STAGE.

	THAWING SOLUTION					
	ARTIFICIAL OVARIAN FLUID			120 MMOL $NaHCO_3$		
IBMX (MMOL)	0	1	10	0	1	10
	75.6 ± 9.5	77.7 ± 4.6	85.1 ± 4.7	75.7 ± 2.2	65.8 ± 5.7	62.0 ± 5.9

*, **, $P < 0.05, 0.01$ (T - TEST)

FRESH SPERM CONTROL = 100

TABLE 2 - FERTILITY OF CHINOOK SALMON SPERM AFTER FREEZING AND THAWING.

FOUR REPLICATES PER TREATMENT WITH 77-104 EGGS EACH. A 120 MMOL $NaHCO_3^-$ SOLUTION AND AN ARTIFICIAL OVARIAN FLUID (STOSS AND DONALDSON, IN PREPARATION) WERE USED AS THAWING SOLUTIONS. THE EFFECT OF 3-ISOBUTYL-1-METHYLXANTHIN (IBMX) WAS TESTED. SPERM QUANTITY AND THAWING RATE WERE ALTERED.

THAWING SOLUTION	SPERM QUANTITY (ML)	THAWING RATE (°C/MIN)	EYED EGGS (%) $\bar{X} \pm SD$
$NaHCO_3$	0.125	600	54.7 ± 10.0
$NaHCO_3$	0.250	600	55.7 ± 7.1
$NaHCO_3$	0.375	600	54.3 ± 11.7
$NaHCO_3$	0.250	1400	76.4 ± 7.9**
$NaHCO_3$	0.250	1700	77.5 ± 9.0**
ARTIFICIAL OVARIAN FLUID	0.250	600	54.0 ± 9.7
ARTIFICIAL OVARIAN FLUID + 1 MMOL IBMX	0.250	600	44.0 ± 12.4

** DIFFERENT FROM ALL TREATMENTS WITH THAWING RATE 600°C/MIN ($P < 0.01$, T-TEST).
FRESH SPERM CONTROL = 100

TABLE 3 - FERTILITY % ($\bar{X} \pm SD$) OF SOCKEYE SALMON SPERM AFTER FREEZING AND THAWING.

FOUR REPLICATES PER FERTILITY TEST, EACH REPLICATE WITH 131-153 EGGS, FERTILITY CHECK AT 230 DAY °C. FREEZING WAS DONE WITH TWO DIFFERENT EXTENDERS. THE CRYOPROTECTANT DMSO WAS ADDED IN ONE STEP OR SLOWLY IN TWO STEPS OVER 10 MIN OR IN FOUR STEPS OVER 20 MIN. TWO THAWING RATES WERE APPLIED.

		SPERM EXTENDER			
		STOSS AND HOLTZ (1981)		GLUCOSE (300 MMOL) + 10% DMSO	
THAWING RATE (°C/MIN)		600	1400	600	1400
MODE OF	1 STEP	62.4 ± 4.6	75.9 ± 3.8	80.8 ± 8.1	89.5 ± 4.4
ADDING DMSO	2 STEPS	59.3 ± 13.0	73.8 ± 4.7[A]	65.7 ± 15.2	84.1 ± 8.5
TO SPERM	4 STEPS	60.8 ± 11.0[A]	87.4 ± 1.9[A]	46.8 ± 17.8	82.3 ± 4.5
	$\bar{X}$	60.4	79.0	64.4	85.3

**: 1 STEP 600 vs 1400 (STOSS AND HOLTZ); 1 STEP 600 vs 1400 (GLUCOSE + 10% DMSO); 2 STEPS 600 vs 1400 (GLUCOSE + 10% DMSO); 4 STEPS 600 vs 1400 (GLUCOSE + 10% DMSO)

*: 4 STEPS 600 vs 1400 (STOSS AND HOLTZ)

**: 1 STEP vs 2 STEPS (GLUCOSE + 10% DMSO); 1 STEP vs 4 STEPS (GLUCOSE + 10% DMSO)

**: 2 STEPS vs 4 STEPS (GLUCOSE + 10% DMSO)

**: 1 STEP vs 2 STEPS (STOSS AND HOLTZ); 1 STEP vs 4 STEPS (STOSS AND HOLTZ)

**: 2 STEPS vs 4 STEPS (STOSS AND HOLTZ)

[A] N = 3

*, **, $P < 0.05, 0.01$ (T - TEST)

FRESH SPERM CONTROL = 100

MCCALL SUMMER CHINOOK SALMON HATCHERY

by

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McCall Summer Chinook Salmon Hatchery was built in 1979 on the site of an old Idaho Fish and Game Department hatchery on 15 acres of land in McCall, Idaho. It was the first hatchery constructed under the Lower Snake River Fish and Wildlife Compensation Plan which was authorized to compensate for losses of salmon and steelhead caused by construction of the four lower Snake River dams (Ice Harbor, Lower Monumental, Little Goose, Lower Granite). The plan will eventually provide hatchery capacity in Oregon, Washington and Idaho to rear over 9 million chiook salmon smolts, 6.7 million steelhead smolts and 93,000 pounds of resident fish.

Construction was funded by the U.S. Army Corps of Engineers and to date has cost approximately $6 million for the hatchery and an associated trapping facility. Operation of the facility is funded by the U.S. Fish and Wildlife Service and the hatchery is operated by Idaho Fish and Game Department.

McCall Hatchery is designed to rear and release one million summer chinook salmon smolts into the South Fork Salmon River. We also rear various trout species for planting mountain lakes and other waters throughout central Idaho. We also redistribute approximately 100,000 catchable rainbow trout reared at Hagerman State Hatchery.

McCall Hatchery consists of a hatchery building, two outdoor raceways, collection basin, settling pond, visitor center, office/dormitory building and three employee residences.

Normal hatchery operations require 20 cfs of water which is supplied from Payette Lake. Two inlets draw water - one at the surface of the lake and the other 50 feet deep. Surface inlet temperatures range from frozen to 75^{o}F and deep inlet temperatures range from 38 to 45^{o}F requiring the two sources be mixed to yield usable temperatures in the hatchery. However, for only three months in the summer is the water temperature the optimum of 50 - 55^{o}F while for five months in the winter the temperature is less than 40^{o}F. A 36 inch transmission line supplies the hatchery with water drawn from the lake.

Incubation of eggs at McCall occurs in 26 half-stack Heath incubators with a capacity of 1.4 million salmon eggs. Incubation and early rearing water is sterilized by Aquafine ultraviolet light sterilizers. Incubation of salmon occurs from mid-August, when the first eggtake occurs, until January when the last fry are ready for transfer to the indoor vats.

Prior to button-up, the fry are transferred to our indoor vats. We have 14 of these measuring 40'x4'x2', each having a capacity of approximately 100,000 fry. Feeding is performed by hand at least once every hour. Fry are reared in these tanks until June, when approximately 250/lb, at which time they are transferred to the outdoor raceways.

Our two outdoor raceways measure 200'x40'x4' and each has a capacity of holding 500,000 fry to smolt size. These ponds are gravel-bottomed and so cannot be cleaned. Due to this and because of disease problems, we plan to cement the bottoms this spring. After this is accomplished, cleaning will be performed with the use of a swimming pool vacuum.

Each pond is covered with a metal sunscreen roof to eliminate sunburn problems in the fish. These roofs eliminate light to such an extent, however, that it is very difficult to see the fish. We plan to remove some of the roof panels to allow us to observe the fish yet still protect against sunburn.

Each pond also is equipped with nine Nielson automatic rotary pan feeders designed to be loaded in the morning and activated automatically by a time clock. At this time we do not use these and feed strictly by hand since we feel better results are achieved.

In April, the salmon are 18 months old and approximately 20/lb and ready to smolt. At this time, we seine them down into the collection basin and load them into tankers for transport to the South Fork Salmon River. We plant the smolts at a location approximately two miles upstream of our adult trap location. In 1980 we planted 128,000 smolts, in 1981 275,000 smolts were planted, and for 1982 we have 148,000 fry on hand. Obviously, we are quite far from our target of one million smolts released.

Our adult trap and holding facility is located on the South Fork Salmon River approximately 25 miles east of Cascade, Idaho and approximately 50 highway miles from McCall. This facility is used to trap and hold the migrating salmon and take eggs to supply McCall Hatchery. This facility consists of a conduit picket weir, fish ladder, trap, holding ponds, spawning platform, vault toilet and travel trailer.

The weir is only temporary and must be installed in early July and removed

in mid-September after the run is completed. Blocking the entire river, the weir forces the fish to climb the ladder and enter the trap. Fish are removed from the trap daily and placed in the holding ponds (which have a total capacity of 750 fish) or returned to the river to spawn naturally. Approximately 1/3 of the run is returned to the river in an attempt to maintain somewhat of a wild run.

Spawning is by the incision method with fertilization using randomly selected males (including jacks). Eggs are water hardened in a 2ppm solution of erythromycin phosphate for one hour to combat possible vertical transmission of bacterial kidney disease. Eggs are shipped green back to McCall for hatching and rearing.

The run into the South Fork Salmon River is very small. In 1980 we trapped only 380 salmon and in 1981 trapped 524 fish. Historically the South Fork Salmon River was a prime salmon stream and probably was the best stream for salmon sportfishing in Idaho. However, in the early 1960s poor logging practices combined with rapid runoff and heavy spring rains to produce largescale washout of roads in the area. Tremendous amounts of sand entered the river and destroyed most of the spawning habitat resulting in drastic declines in the number of returning adult salmon. Hopefully, our efforts at McCall Hatchery will restore the run of summer chinook salmon into the South Fork Salmon River.

HATCHERY SITE SELECTION
OR
"WHY DOES IT HAVE TO BE THIS WAY"

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During the past decade or so, many state and federal agencies have been and are involved in the process of attempting to turn around the decline in fishery stocks by constructing hatcheries. I suppose to be semantically correct I should have said that the decline in fishery stocks will be turned around with hatchery-raised fish; but my first observation probably carries more truth.

This presentation, done with 35mm slides, indicated the process of selecting new hatchery facility sites beginning with the problem definition and ending with the first release of fish.

Although the presentation is rather light hearted - sort of designed to comfort the afflicted and afflict the comfortable - I sincerely believe that the process is often more directed towards edifying the design engineering firm than it is towards enhancing the stock of fish in question. One of my pet peeves with hatchery design is that the motto "Never duplicate - always originate" seems to prevail at all times. Is the construction - or reconstruction, as it were - of an existing productive facility or pond against some unwritten engineering rubrics?

One final note for those of you who have been through an unfortunate set of bureaucratic manipulations, the first manager of a new facility. Would it not be nice to take over a new hatchery that worked the first year like it was supposed to? Why do we have to spend years and countless thousands of dollars redesigning the design? I rest my case....

TOWARD CONTROL OF IHNV

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The primary limitation to the culture of sockeye salmon *Oncorhynchus nerka* in Alaska is infectious hematopoietic necrosis virus (IHNV). The constant presence of IHNV in hatchery and wild sockeye stocks has influenced all phases of sockeye culture. Recent research has not solved the problems caused by the presence of the virus, but results of this work may provide the culturist with a clearer view of which methods might be applied toward the control of IHNV.

Heat treatment (18C) of fry during IHNV epizootics (1980) at both Kitoi Bay and East Creek Hatcheries accelerated mortality. Heat-treated fry which died were characterized by different histopathological signs and had a significantly lower mean concentration of IHNV than untreated fry. The death of these fish could have been related to the treatment as well as to the virus. Both water-sampling (for IHNV) from incubators holding later-emergent fry and the isolation of each incubator and its resultant fry were important steps in avoiding infection among more than half of these later-emerging fish at Kitoi Bay in 1980.

Vaccination of adult female sockeye, followed by only short-term holding prior to spawning, resulted in a slight increase in the

ability of serum to neutralize IHNV. Ovarian fluids from the same females had no significant IHNV-neutralizing ability. Holding adult sockeye at 18C for four days in an attempt to reduce virus titers was not successful. The experiment was complicated by the fish not ripening for 19 days after the temperature was returned to ambient. When spawned, treated fish had significantly higher titers than untreated.

Disinfection of eggs. Eggs were water-hardened in iodophor to both inactivate virus taken into eggs during water-hardening and expedite disinfection procedures. There was no significant difference between the survival of eggs water-hardened in Betadine and those disinfected with Betadine after water-hardening.

Individual egg lot incubation. In an attempt to relate vertical transmission of IHNV to the quantity of virus in individual female ovarian fluids, individual egg lots from 100 female sockeye salmon were isoltaed from egg-taking through incubation. Neither the virus nor a mortality characteristic of IHN occurred among any eggs or offspring.

Quantitative virology has been used as a tool to examine IHNV infectivity among different stocks. The quantitative distribution of IHNV among spawning and spawned-out fish differs with the maturity of samples, stock of fish, and the time of run.

These results provide both actual and potential tools for the culturist who must learn to cope with IHNV. Predictive water sampling and isolation of incubators can minimize the impact of IHNV outbreaks among hatchery fish. Vaccination of adults and a subsequent sufficient

period of incubation might provide offspring with passive antibody as well as control of the infection among vaccinated females. However, this procedure would generally prove impractical as the sufficient imunization period has not been determined and could exceed any practical holding period. Since the amount of infectivity in a stock varies with the time of run, a careful mapping of this change and subsequent selection of eggs from the least infected portions of the run might reduce the risk of IHN in the hatchery.

We feel that the two most important results of this work were that (1) water-hardening in iodophor did not significantly increase mortality of eggs or fry; and (2) that when eggs are removed, fertilized, and incubated as isolated lots from individual females, IHNV is rarely transmitted to offspring despite sometimes large quantities of virus in ovarian fluids of these fish.

UPDATE: Bacterial kidney disease control 1979 - 1981 activities at the University of Idaho.

by

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ABSTRACT

Experiments were conducted at spring chinook salmon facilities in Idaho and Washington to assess: 1) the effectiveness of prespawning injections of erythromycin phosphate in reducing prespawning mortalities to and the carrier state of bacterial kidney disease (BKD); 2) the effectiveness of water-hardening fertilized eggs in erythromycin phosphate to reducing presmolt mortality to and carrier state of BKD; 3) the uptake of erythromycin phosphate by fertilized eggs during water-hardening; and 4) the effectiveness of the water-hardening process in reducing the number of viable BKD organisms in newly fertilized eggs.

Preliminary results from these experiments indicate that: 1) erythromycin injections reduce clinical lesions due to BKD but do not eliminate the carrier state of this disease in spawning adult salmon; 2) returning jack salmon, previously water-hardened in erythromycin phosphate, possess a lower carrier incidence of BKD than do spawning adults of the same year class; 3) water-hardening in erythromycin phosphate can be effective in reducing the carrier incidence of BKD in presmolting populations of spring chinook salmon reared at facilities using untreated river water of relatively low to moderate total hardness; 4) total hardness of rearing water may be less significant than previously believed in determining the carrier incidence of BKD in presmolting populations; 5) spring chinook salmon eggs can absorb up to 1.5ppm erythromycin phosphate during the water-hardening process and the erythromycin may be inactivate within 24hours following this process; 6) eggs obtained from females that had been injected with erythromycin phosphate may contain therapeutic levels of this drug up to 30 days post-injection; and 7) water-hardening in erythromycin is effective in reducing the number of vialble BKD organisms present on the surface of newly fertilized eggs.

ENVIRONMENTAL GILL DISEASE (EGD): WHAT IT IS AND WHAT TO DO ABOUT IT

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Description and Significance

Environmental gill disease (EGD) is a subacute to chronic noninfectious disease of juvenile fish being raised under intensive culture conditions. It has a complex etiology with the direct cause considered to be accumulations of sufficient levels of free (undissociated) ammonia and/or suspended organic or inorganic solids to cause chemical and physical irritation of the gill tissues. Indirect causes of disease are feeding rate (lbs of feed/100 lbs of fish), fish density (lbs of fish/ft^3), dissolved oxygen levels, alkalinity, temperature and pH of the water.

Histopathologically, the lesions are restricted to the lamellar epithelia unless the condition is further complicated by an infectious process. According to interpretation of available information, the pathologic process is initiated with hypertrophy of the lamellar epithelial cells. The sequence of subsequent changes is obscure, but the following changes have been recorded: separation of the lamellar epithelium from the capillary endothelium with accumulations of fluid; local hyperplasia of the lamellar epithelium; general hyperplasia of the lamellar epithelium with partial to complete occlusion of the interlamellar spaces; bulbous engorgement of the lamellae with subsequent rupture and frank hemorrhage.

Clinically, the fish exhibit increased respiratory activity, anorexia and lethargy. The mortality rate in uncomplicated EGD is seldom very high. Its main effects are reduced growth rates, reduced dietary effi-

ciencies, and increased production costs. However, uncomplicated EGD is more the exception than the rule. The condition (often undetected) frequently is the harbinger of infectious processes caused by cutaneous and systemic bacteria and by external protozoons and metazoons. All of which are frequently typified by extremely high morbidity and mortality rates.

The foregoing description of EGD is based upon a collation of the observations and interpretations of Klontz et al. (1980), Wood and Yasutake (1957), Smith and Piper (1975), Burrows (1964), Smart (1976), Bullock (1972), Wales and Evins (1937), Eller (1975), Hartman (1979 unpublished), Westers and Pratt (1977), Larmoyeux and Piper (1973), Wood (1968, 1974) and Snieszko (1974).

The major pathophysiological alteration resulting from the thickened gill lamellar epithelium is reduced oxygen uptake which decreases the ability of the affected fish to withstand the rigors of a stressful situation, no matter what the cause. Wedemeyer (1970) and Snieszko (1974) have independently and comprehensively described the potential of stress-activated clinical disease caused by infectious agents.

In a survey of public and private salmonid hatcheries in Idaho, Klontz (1973) documented that more than 50% of the facilities visited reported having had significant stress-related occurrences of infectious diseases. It was estimated that 40-50% of the annual mortality (often as high as 50% from eyed egg to release or processing) in fish hatcheries was directly attributable to the existance of EGD prior to the onset of the infectious process.

Treatment Methods

At this time in our research, we think the best way to control an

occurence of uncomplicated EGD is to withhold feed from the fish for at least 48-72 hours, that is if the fish are large enough to permit this practice. Fish smaller than 200-300/lb should not have feed withheld for more than 24 hours. This method markedly decreases both solids and ammonia-N generation -thought to be major causes of EGD. It also reduces the oxygen demand by the fish.

The next step is to either increase the water flow to the pond or reduce the biomass in the pond or both. In our experience major contributing causes to EGD are overloading ponds and insufficient water flows.

If the outbreak of EGD is complicated with one or more infectious agents - protozoa or bacteria - then specific therapy should be instituted. With respect to chemotherapeutic measures for EGD, we in the fish-raising business are caught between the rock and the hard spot. To our knowledge, only salt has been approved by the FDA for external use in fish. As anyone who has treated gill diseases in fish will relate, several chemotherapeutants not on the list of approved chemicals are used routinely in treating gill diseases of food fish. So, we are not going to recommend any specific "wonder drugs" to add to the water to treat gill disease. But, we will recommend a way by which the chances for therapeutic efficacy will be enhanced.

The first task is to make an assessment as to the nature of the gill disease; i.e., is it simple EGD or is it complicated with an infectious agent? If it is uncomplicated EGD then withholding feed, reducing the biomass and increasing the water flow will often suffice. There are no chemicals, to our knowledge, which will accomplish this task.

If there are infectious agents present, then a chemical treatment

is warranted; however, the treatment for EGD must still be instituted. After choosing a particular chemical and selecting a dosage and time of exposure, it is strongly recommended that a bioassay be run to verify that the particular chemical and exposure time are effective in resolving the problem. Thus, fish must be examined before the bioassay and afterwards - preferably at the termination of the exposure period and 2-4 hours later - to determine the antimicrobial effect. The bioassay method should indicate positive results before the method is applied to the entire lot. In our collective opinion, groups of fish are continually being treated and retreated without any regard for the efficacy. A decreasing mortality rate is not sufficient evidence by itself to demonstrate efficacy.

Prevention Methods

The most effective method to prevent EGD that we know of is to keep pond loadings so that critical levels of oxygen tension (pO_2 = > 90 mmHg) are not present. In addition, feeding rates and feeding frequencies must be kept at levels where ammonia-N and fecal solids, plus uneaten feed, do not accumulate at tissue damaging and growth restrictive levels. Finally, water replacement times in raceways should be between 20-30 minutes. This provides for adequate water velocity to help reduce the ammonia-N and solids levels plus providing oxygen make-up.

With respect to pond loadings, the simplest and perhaps safest method to determine pond carrying capacity is that derived by Piper (1972). By using a temperature-elevation compensated table, the factor obtained is multiplied by the average fish length in inches and the water inflow in gpm, and allowable (maximum) weight of that sized fish in the pond is derived. Other methods have been presented by Klontz et al. (1978).

Appendix I: Literature Review

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OCCURENCE OF BOTULISM IN SALMONID-REARING FACILITIES

by Dr. Mel Eklund

Type E botulism was first recognized as a major cause of fish mortality in the United States in 1979. This outbreak caused an estimated loss of 1 million juvenile coho salmon reared in an earth bottom pond at the Elokomin Hatchery in the state of Wahington.

In the years 1979-1981, botulism was confirmed as a major cause of fish mortality in four salmon and three steelhead hatcheries in the state of Washington and one salmon hatchery in the state of Oregon. These outbreaks have resulted in losses of approximately two million juvenile salmon and steelhead. Earlier records indicate that botulism may have caused major fish mortality in some of the hatcheries as early as 1960.

Results from laboratory and field experiments indicate that Clostridium botulinum type E, the bacteria causing type E botulism, grows and produces toxin in dead fish that remain on the bottom of rearing ponds. Live fish cannibalize the decomposing fish and consume lethal levels of type E toxin. Fish with botulism die and become additional substrate for type E organisms and sources of toxin for other live fish.

In order to prevent botulism from occurring, or to stop a botulism outbreak dead fish must continuously be removed from the rearing ponds. In some ponds, it is impossible to collect all decomposed toxic fish or fish parts. In these cases, the live fish may have to be moved to other ponds away from the toxin source and subsequent dead fish collected and disposed of daily.

Type E toxin is also very lethal to humans, animals, and birds. Dead fish should be handled with care to prevent the spreading of C. botulinum type E bacteria and toxin. The carcasses of the fish should be incinerated or buried, away from domestic water supplies under a layer of quick lime and soil.

Foodborne, infant, and wound botulism are three clinical forms currently recognized. Infant and wound botulism are associated with the growth and toxin production of the Clostridium botulinum bacteria in the intestines of children (1-13 months old) or in damaged tissue. Foodborne botulism is caused by the ingestion of food in which the Clostridium botulinum bacteria has grown and produced the lethal toxin. Employees should therefore practice good hygiene in order to prevent the introduction of the type E bacteria or the toxin into themselves, the home, and the food supply. Type E can grow and produce toxin in contaminated foods within 1 to 2 days at room temperature, 1 week at 50°F, and 3 weeks at 38°F. Heating foods to internal

temperatures of 212°F for 15 to 20 minutes will inactivate the type E toxin. However, when in doubt, discard the food. A mere tasting of an unheated food containing botulism toxin could be fatal to humans.

Sediments of ponds in which botulism has occurred often contain high numbers of C. botulinum spores. It is recommended that the sediments not be used as fertilizer for home gardens or other purposes, but handled in a similar manner as described for dead fish.

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A SIMPLE MODEL TO DESCRIBE ZINC STATUS IN TROUT

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Monitoring the whole body zinc concentration and "total" body zinc of a group of hatchery-reared rainbow trout as they grew from fry to 1200 grams indicates that body zinc concentration (wet wt) is constant and that total body zinc is proportional to size.

A model is presented which predicts the effect of various levels of dietary zinc on total body zinc and zinc concentration. The model predicts that zinc deficiency can occur more rapidly in smaller fish than in larger fish when a zinc-deficient diet is fed. Zinc deficiency can also occur more rapidly in fish being fed a deficient diet which produces a low food conversion ratio than in a diet with the same zinc concentration giving higher food conversions. The model also suggests a means to check the efficiency of zinc uptake in fish diets.

Data are presented from experiments currently in progress which suggest that the model accurately predicts zinc bioavailability and the effect on zinc body concentration of a low zinc diet.

Cataracts in Washington State

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A large number of lens cataracts were first seen in fall chinook in late March or early April, 1981, when the fish were about 1.3 g (350 fish/pound). During the first few weeks only a few hatcheries reported the disease so non-nutritional causes were initially considered. However, as time went by, the disease was found at more and more hatcheries and their satellites. The final count was 32 out of 50 stations had cataracts in coho and/or chinook salmon. It was not possible to accurately determine the incidence and severity of cataracts at this many stations because: (1) these factors were changing with time; (2) there were sampling problems because the fish with cataracts were not uniformly distributed in the pond; (3) there was bird predation on the light colored fish with mature cataracts; and (4) there were assessment differences among the investigators. However, it would be accurate to say that the 1980 brood fall chinook at Puget Sound stations were the most severely effected.

The cataracts appeared to begin as a small point opacity near the center of the anterior surface of the lens. In many fall chinook the area of involvement increased rapidly until

the entire lens was opaque (mature cataract) and there was liquefaction of the lens cortex (hypermature cataract). In many other fish cataract development was limited to a diffuse cloud with small areas of greater opacification, or to the formation of a spider's web. Cataract can be defined morphologically as any disturbance of the optical homogeneity of the lens. This may involve only a region of the lens, and a partial cataract may develop. In many coho the cataract never developed beyond the small point opacity of the central anterior area, which was probably due to proliferation of the central epithelial cells heaping up in layers and forming a pyramid with the apex toward the center of the lens and the base resting on the capsule. In the majority of affected Puget Sound fall chinook this regional cataract progressed further and became total. Damage to the lens fiber membranes represents the initial pathogenesis of this progression. There is a progressive loss of K^+ ions, amino acids, inositol, and glutathione coupled to Na^+ and Ca^{2+} ion gains which creates an adverse physiochemical environment for the lens proteins. This causes abnormalities in the molecular organization of lens proteins that eventually leads to protein aggregation and the loss of transparency. Liquifaction of the lens cortex follows complete opacification, and the liquified lens protein leaks out of the lens capsule and triggers a local immune response which may destroy the eye.

Because of the ubiquitous nature of the lens cataracts, and the appearance of an otherwise healthy eye and lack of a systemic disease, a nutritional cause was considered. The potential

diet related causes considered were: (1) lack of the vitamin riboflavin; (2) lack of the amino acid methionine; (3) a zinc deficiency; and (4) the presence of a toxic substance known to cause lens cataracts, i.e., 3-aminotriazole. Disease symptomatology, chemical analysis of the food and fish, and a review of the literature suggests that the lens cataracts seen in fall chinook and coho salmon were due to a zinc deficiency in the fish, and that the probable cause was the use of high ash (bone) fish meal, crab meal and cottonseed meal in the diet. It appears that calcium decreases the physiological availability of zinc and that this effect is mediated through an interaction with phytate and/or fiber, both of which are present in cottonseed meal. Analysis of fish and Oregon Moist Pellet (OP-2) from affected and nonaffected stations found that fish with cataracts had the lowest whole body zinc concentrations which were approximately 40 mg/kg (dry weight basis). The results suggest that when the calcium to zinc ratio in the diet (OP-2) exceeds 600:1 the fish will develop lens cataracts. Eyes with lens cataracts were examined histologically and were found to be quite similar to those seen in rainbow trout fed diets containing white fish meal (20% ash) as the primary protein source, and to those induced by the chemical thioacetamide which ties up zinc, making it physiologically unavailable to the fish.

In early June all fish in State hatcheries started receiving OP-2 supplemented with 150 mg/kg zinc as $ZnSO_4$ (monohydrate), and crab/shrimp meal was deleted from the diet. At this time a comparative diet study was started at Skykomish Hatchery in

an attempt to induce cataracts in coho salmon, and to see what effect supplemental dietary zinc would have. An "old" 3/32-inch OP-2 suspected of causing cataracts in Skykomish summer chinook was fed to one group of coho, zinc supplemented OP-2 (low calcium) was fed to another group, the third group was fed 50/50 "old" and zinc supplemented OP-2, and the fourth group received a non-supplemented OP-2 which had a calcium to zinc ratio of less than 500:1. The fish were examined every two weeks for the presence of cataracts and samples were taken for the determination of whole body concentrations (dry weight basis) of various metals including zinc. The food suspected of causing cataracts in the Skykomish summer chinook produced the same (or slightly lower) whole body concentration of zinc in coho as was seen in chinook from groups with a high incidence of cataracts. However, there was not a diet related increase in the incidence of cataracts. Analysis did show, however, that the level of dietary zinc or the calcium zinc ratio has a marked affect on the whole body concentration of zinc in the fish (Figure 1).

Therefore, I was not able to prove that the high calcium diets suspected of causing lens cataracts in the 1980 brood chinook, and in the 1979 and 1980 brood coho actually did. I do not feel; however, that this possibility can be ruled out. It may have been necessary to feed the test diets at Skykomish for a longer period of time to induce the cataracts in coho salmon. The ability of these diets to cause lens cataracts may depend on some physiological factor(s) and may be partially fish size dependant. Even though I assume the zinc supplemented,

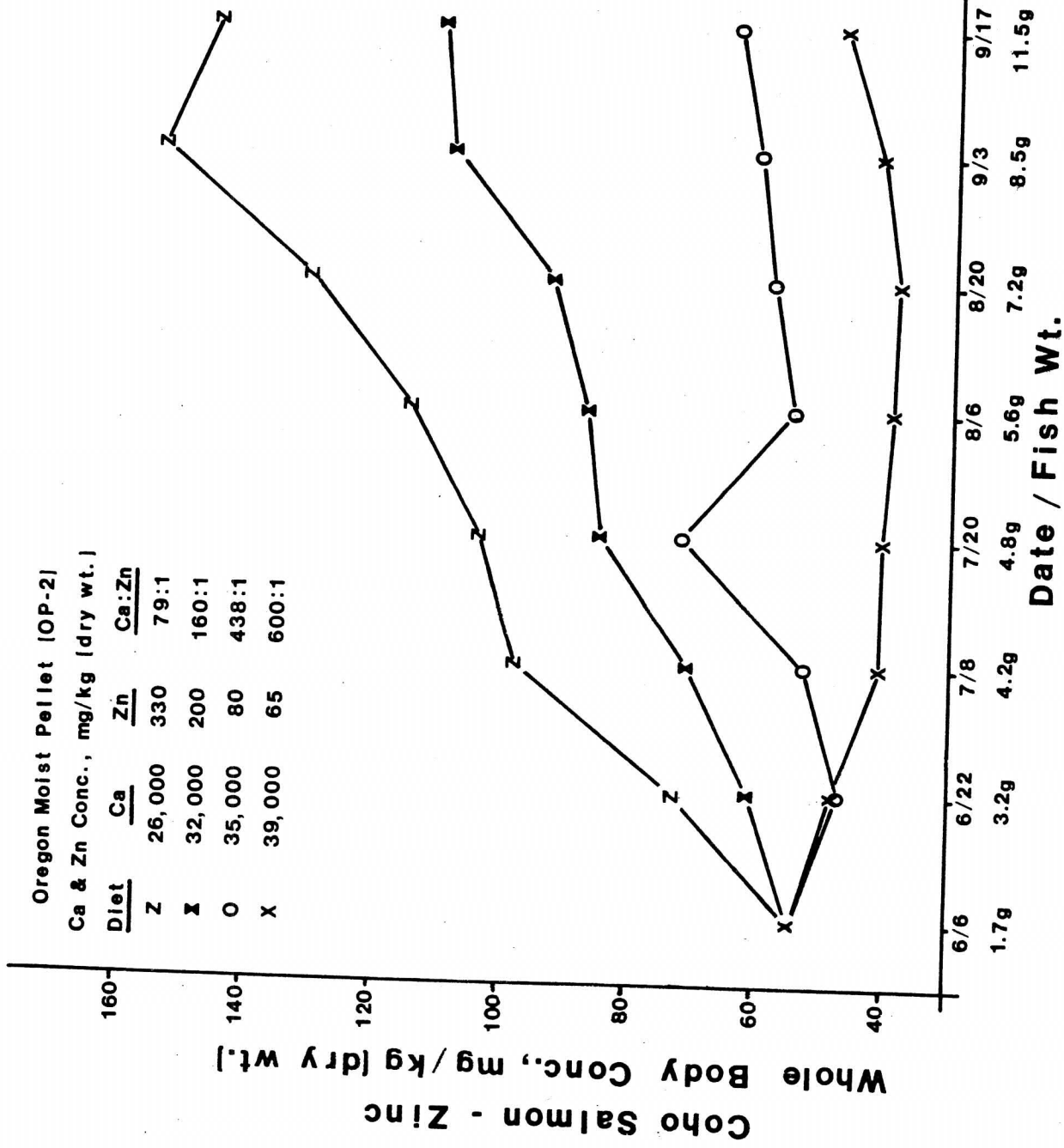

Figure 1. Whole body zinc concentration (mg/kg, dry wt.) of Skykomish coho salmon fed OP-2 with different calcium and zinc levels.

low calcium diets (250+mg/kg zinc, 2.5% calcium, dry wt. basis) did arrest cataract development, this is not conclusive since there were no control groups (not receiving the zinc supplemented diet) which developed mature cataracts.

There is a possibility that the cataracts were caused by something other than a zinc deficiency. This is suggested because the development of lens cataracts seems to have occurred in the absence of caudal fin and skin erosion and poor growth, symptoms which reportedly precede the appearance of cataracts induced by a zinc deficiency. This observation plus the apparent rapid progression of degenerative changes in the lens, i.e., from a small point opacity to lens cortex liquefaction in less than two weeks, suggests that a toxic substance was involved.

The specifications for the OP-2 formulation of Oregon Moist Pellets have been changed to ensure that the diet does not produce a zinc deficiency in the fish. Crab or shrimp meal has been eliminated from the diet, a minimum fat level for fish meal has been added which will limit the amount of ash the meal can contain, and the diet will be supplemented with 75 mg/kg zinc as zinc sulfate (as fed basis).

CATARACTS IN B.C. CHINOOK AND COHO: COSTS AND CURES

by

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Introduction

This year a major occurrence of cataract or opacity of the lens was observed in B.C. chinook and coho hatchery stocks for the first time. Affected chinook were reported at Big Qualicum Hatchery on May 17, and subsequently at the Puntledge, Quinsam and Little Qualicum facilities. Other chinook stocks did not develop cataracts prior to release. Most of these fish were released by mid-June as typical "90-day" smolts.

Cataract amongst coho fry of the 1980 brood was found at Puntledge Hatchery in late May and has since been reported at Chilliwack, Capilano and Quinsam hatcheries. As for chinook, other hatchery populations appear free of the disease. These fish are scheduled for release in spring 1982.

Efforts have failed to produce any evidence that pathogenic organisms, water quality or stress during early rearing are related to the outbreak of cataract in B.C. Only nutritional factors have been implicated. However, nutrition and disease diagnostics specialists remain unconvinced that the cause is simply nutrition; instead they feel a complex interaction between any or all of these factors may be responsible.

The evidence implicating nutritional factors is circumstantial - cataracts occurred only in Washington and B.C. hatcheries supplied Oregon Moist Pellet fish food from Washington. Oregon stocks raised on feed from a different manufacturer did not contract the disease. The only dietary factor identifiably abnormal in some feed samples taken from affected hatcheries is a zinc deficiency in relation to unusually high calcium content. This condition has been linked to cataract development in trout. No evidence of vitamin deficiency or toxicants in the feed which may account for the outbreak has been found.

Production Costs

Approximately 2.4 million chinook smolts released in 1981 had cataract. Fifty percent of these fish had pinpoint or partial lens opacity while the remainder were severely affected. There seems to be no doubt that fish with complete lens opacity will not survive. They are unresponsive to visual stimuli and unable to find food. Unhealthy chinook transferred from Big Qualicum to saltwater pens for 30 days at the Pacific Biological Station failed to improve, although the problem did not get noticeably worse. A control group of unaffected chinook also did not suffer any major development of cataract over the 30 day period. During this trial, the mortality rate was 1% amongst the healthy fish and 10% among the unhealthy fish.

On the other hand, 5000 fall chinook held for 3 months beyond normal release date at Puntledge Hatchery in troughs showed a marked increase in the number of severely affected fish and a corresponding decrease in the number of healthy fish despite the fact they were fed OMP supplemented with vitamin C and zinc (Table 1). This suggests chinooks released in a healthy condition may have degenerated during ensuing months.

The susceptibility of fish with cataracts to predators was illustrated rather dramatically in the Big Qualicum system. Post-release loss of chinook smolts in the Qualicum estuary was estimated to be approximately 300,000 in both 1979 and 1980. But, in 1981, predation increased to 1,000,000 (Pamela Mace, pers. comm.). Heavier losses were linked directly to the absence of predator avoidance behaviour in blind smolts which made them prey to normally ineffective bird species and which resulted in failure to use refugia available at greater water depths on high tidal cycles.

Given this information, it is probable that chinook smolts with severe cataract will not contribute to production and those with partial cataract may not contribute. In the worst case, delayed cataract development may reduce viability of some "healthy" smolts.

Preliminary data suggests that up to 800,000 of the 3.5 million coho rearing at Puntledge, Quinsam, Chilliwack and Capilano hatcheries may have experienced some degree of lens opacity. The incidence of severe cases is relatively low compared to chinook with pinpoint or partial opacity accounting for over 95% of all cases. Another difference between the coho and chinook outbreaks is the high incidence of one eye cataract in coho - virtually all affected chinook had bilateral lens cataract.

The prognosis for coho is uncertain. Groups of fish with no cataract or with pinpoint cataract isolated in troughs at Quinsam have shown significant degeneration over a two month period despite feeding with a zinc and vitamin C - enriched diet (Table 2). However, repetitive sampling at monthly intervals in a larger rearing unit (standard Burrows pond) has failed to demonstrate a significant change in cataract incidence over a four month period. Hatchery managers have observed that fingerlings with pinpoint or partial cataract seem to be equal to healthy fish in terms of in-pond holding locations, feeding activity and growth.

It is probable that most blind coho will perish before release. At Puntledge, for example, a furunculosis outbreak amongst fry with cataract resulted in loss of 70,000 fish leaving the balance of the population free of the disease. Less severely affected coho may well survive and contribute to production with the net result of very little impact on 1980 brood yield.

Cures

Prevention seems to be the only solution to cataract disease. Diet enrichment or a change in rearing environment does not appear to reverse disease development after initiation. Since diet has been most clearly implicated in the cataract problem, the Department of Fisheries and Oceans will implement an intensive feed quality control program in 1982.

This program will be improved over similar earlier programs:

- ingredients and finished diet will be tested before the feed is used
- chemical analysis will be more intensive

Samples of marine oils, fish meal and processed diet will be obtained during manufacture and returned directly to Vancouver. A verbal report on critical quality control parameters will be available within four days at which time feed of the tested production lot en route to B.C. or stored at the plant will be cleared for use.

Thorough chemical analysis (Table 3) is considered a prerequisite to a successful quality control program. The program previously in place in B.C. would not have identified the metals problem which occurred this spring and there is little point in running a skeleton program which gives only false assurance.

All agencies using OMP (and other feed types) should work together to determine parameters necessary for quality control of meals, oils and processed diet (ie., upgrade Table 3) and to develop reasonable specifications for these parameters. Ingredients could then be tested prior to purchase by the manufacturer and all processed feed could go through a single quality control laboratory. This would relieve the pressure on each agency to sample and test feed lots produced for their requirements and make the manufacturer's job easier by eliminating the need to satisfy multiple sets of standards.

Conclusion

Production lost to the fishery due to the 1981 cataract outbreak in B.C. will be at least 30,000 chinook. Coho losses will be substantial if cataract formation continues in partially affected fingerlings but the likelihood of further degeneration is uncertain.

There have been costs other than those related to production. The results of some chinook marking experiments carried out in spring 1981 will be invalidated and planned coho rearing/release studies have been discontinued at one hatchery. Most important, the cataract problem has demoralized hatchery staff and has definitely not been good for public relations. Prevention of a future outbreak is a top priority, and can be achieved most efficiently through cooperative development of diet quality control specifications and procedures.

TABLE 1. Cataract incidence amongst fall chinook salmon held at Puntledge River Hatchery. (100 fish were sampled weekly from a population of 5000 - data from H. Genoe).

Condition	Frequencey (%) in Samples Taken During	
	May/June	July/August
Normal	36	16
Partial cataract	38	28
Severe cataract	26	56
TOTAL	100	100

TABLE 2. Change in cataract incidence and severity amongst segregated healthy and pinpoint cataract subpopulations of coho fingerlings at Quinsam Hatchery. (Data from J. Van Tine and G. Hoskins).

Group	Date	Incidence (%)			
		Healthy	Pinpoint	Partial	Severe
Healthy	Sept. 18	100	0	0	0
	Nov. 11	54	42	4	0
Pinpoint	Sept. 18	0	100	0	0
	Nov. 11	0	36	63	1

TABLE 3. Parameters for quality control of fish meals, marine oils and fish feed. (Developed in co-operation with the West Vancouver Laboratory.)

Sample	Parameter	Sample	Parameter
Fish food	crude protein	Marine oil	peroxide value
	crude lipid		iodine number
	moisture		free fatty acids
	ash		
	crude fiber	Fish meal	crude protein
	gross caloric content		moisture
			ash
			minerals
	peroxide value		available lysine
	iodine number		
	vitamin C (ascorbic acid)		
	vitamin E (α tocopherol)		
	riboflavin		
	vitamin A		
	minerals (Ca, Mg, P, Zn, Fe, Cu, Na, Cd, Se, K, Mn, I, Hg, Pb)		

Control of sex in salmonids: pilot release of sterile and all-female groups of coho salmon Oncorhynchus kisutch from the Capilano Salmon Hatchery.

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INTRODUCTION

A recent series of experiments at the West Vancouver Laboratory of the Resource Services Branch have led to the development of techniques for the control of sex differentiation in Pacific salmon. The specific goal of this work has been the production of all-female and sterile groups of salmon. The anticipated benefits of releasing all-female groups of salmon include the elimination of precocious male development, an increase in the value of the catch where roe has an additional value and an increase in the number of females available for broodstock. Similarly, sterile salmon do not undergo precocious male development. Further, steriles do not undertake the normal anadromous migration. By remaining in the ocean and continuing to grow, these fish will provide benefits to both commercial and recreational fisheries through an increase in average individual size. Also, the deterioration in flesh quality associated with sexual maturation is eliminated.

The technique involves the administration of sex steroids, either androgen or estrogen at the appropriate dose to juvenile fish at a time when their gonads are undifferentiated. By choosing the appropriate steroid the course of sex differentiation can be redirected towards the desired sex. Sterilization is achieved by treatment with a dosage of androgen higher than that required to produce males.

Fish which are feminized by treatment with estrogen produce viable ova. However, these females may not be used for broodstock. As half of these female salmon are genetically male (XY), fertilization of their ova with normal milt (X or Y) would result in an 3:1 male female ratio in the offspring. All-female groups (XX) whose offspring occur in a normal 1:1

male:female ratio can however, be produced by initially masculinizing genetic females (XX) and subsequently using their milt on normal ova.

This latter technique has been successfully developed at the West Vancouver lab for both coho and chinook. The first all-female group of salmon produced by this method are to be released from the Capilano Salmon Hatchery in 1982. Groups of sterile and all-female salmon produced by direct steroid treatment have already been released. The object of this presentation is to describe the preliminary results of this first pilot release of sterile and all-female coho salmon from the Capilano Salmon Hatchery (Hunter, Donaldson and Stone, unpublished) and suggest possible applications of sex control techniques to salmonid aquaculture and resource management.

Treatment

In the spring of 1979, two groups of approximately 40,000 coho salmon were treated with either 17β estradiol or 17α-methyltestosterone as eyed eggs, alevins and fry. Both groups were nose tagged and fin clipped at 6 mo of age. Before release in May 1980 a sample of 1000 of each type were transferred to net pens at the Pacific Biological Station, Nanaimo, to observe their adult performance.

Net pen control

The groups held in net pens were examined periodically to determine growth and sex type. No fish matured precociously. Survival to adulthood was similar for both groups. The all-female groups began to mature in September 1981. The results from this study indicated that the treatments were nearly 100% effective. Sterile fish grew at a slower rate than female fish, but remained 'silver bright' and continued to grow through the period

of sexual maturation while female growth ceased.

Contribution to fishery - Preliminary results

Coded wire tag recoveries indicated that to August 1981 both groups contributed at similar rates to the troll and net fisheries. Sports fisheries recoveries to June 1981 indicated that the female group contributed twice as many fish. Approximately 500 fish from the female group had returned to the hatchery by Nov. 5, 1981 compared with 20 from the sterile group.

Adult returns to hatchery - Preliminary results

The fish returning to the Capilano hatchery were examined for sex type, length, body weight and gonad weight. All of the fish from the female group returned as maturing females. No differences were observed between these fish and normal production females.

Summary and conclusions based on preliminary results

1. Treatment for the direct production of steriles and females is essentially 100% effective.
2. Precocious male development is eliminated.
3. Survival to adulthood is similar for both groups.
4. Fish from both groups contribute to the commercial fishery at similar rates.
5. Steriles up to 3 yr contribute at a lower rate to the sport fishery.
6. Steriles held in net pens; grow at a slower rate than females; remain 'silver bright' and continue to grow during the period in which the females are maturing and have ceased growth; reach the same carcass weight as the females by the end of the spawning season.
7. Steriles do not undergo the normal anadromous migration.

8. Females which return to the hatchery are similar to normal production fish in body and gonad size.

Applications to salmon management

The preliminary results of the pilot release of all-female coho indicate that these fish perform as expected. While further studies are required to completely assess the performance of the sterile fish, it is possible to suggest possible applications of these techniques. The production of sterile fish could provide a means of reducing excess hatchery escapement in favor of the saltwater catch. Alternatively, where a stock is harvested at a time when sexual maturation has resulted in a deterioration in flesh quality, the production of steriles which remain "silver bright" would improve the value of the catch. If as anticipated, the prolonged seawater residency of sterile fish leads to an increased average size with the potential for trophy sized fish, the technique could be applied to advantage for stocks which contribute to the sports fishery. The production of all-female fish by direct estrogen treatment increases the number of females resulting in an increase in the value of the catch where the roe is of additional value. Using the alternative method for producing all-female groups described earlier, an increase in the proportion of brood females in a given escapement could be achieved. Alternatively, the escapement could be reduced while maintaining the required egg take. The production of either sterile or all-female fish increases the adult harvest through the elimination of precocious male development.

In addition to those benefits already listed, sterilization would allow the aquaculturalist to market adult sized 'silver bright' fish on a year-round basis.

PINK SALMON RETURNS TO THE QUINSAM HATCHERY FROM UNFED FRY AND SALT WATER REARED FRY RELEASED

by:

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Introduction: The escapement of pink salmon to the Quinsam River has declined dramatically. We have released unfed fry from upwelling gravel boxes directly to the Quinsam River and released salt water reared fry in the estuary in an attempt to enhance this run. I reported on these methods at last year's conference.

Methods:

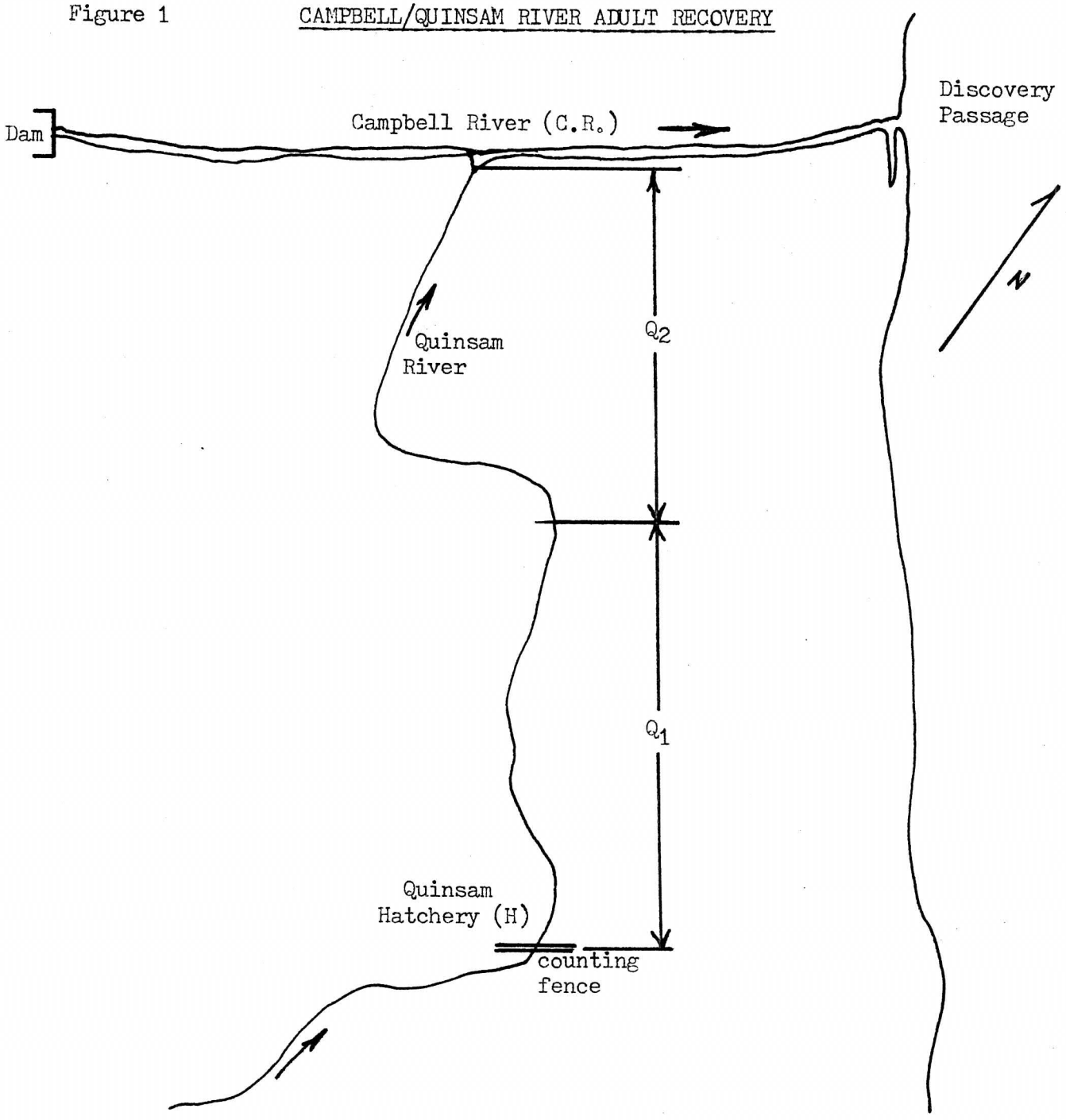
Release - Three groups of fry, two of which were marked, were released during the spring of 1980 (Table 1).

Table 1 SUMMARY OF MARKING & RELEASE OF PINK FRY, 1979 BROOD

Group	Number Released	Mark Type	Number Marked	Date Released	Release Size (g)
Unfed Fry	1,500,000	Right Ventral	96,400	Apr 4/80 (range: Feb 28- Apr 16)	0.225
Fed Fry	290,000	Left Ventral	87,700	May 15/80 (50 days rearing)	0.83 (range: 0.70- 0.94)
Natural Migration	1,550,000	N/A	0	Apr 15/80 (range: Mar 19- Apr 26)	0.220

Returns - Adult pink salmon were enumerated and examined for marks at the hatchery counting fence and holding ponds from August 5 to October 5, 1981. Adult escapement below the hatchery was determined by river swims during the period of August 5 to September 23, 1981. Dead recoveries were conducted below the hatchery from September 29 to October 15, 1981 (Figure 1).

Figure 1 CAMPBELL/QUINSAM RIVER ADULT RECOVERY



Results - 21,500 adult pink salmon returned to the Quinsam River from August 5 to October 5, 1981. A total of 357 marks were recovered indicating a total return of 979 marks (Table 2).

Table 2 ESTIMATED MARKED PINK SALMON ADULT RETURNS TO THE QUINSAM RIVER - 1979 BROOD

Area	Population	Sample Size	Marks Recovered L.V.	R.V.	Estimated Return L.V.	R.V.
H.	19,000	7,007	159	151	431	409
Q_1	2,200	741	28	14	83	42
Q_2	300	110	4	1	11	3
C.R.	N/A					
TOTALS		7,858	191	166	525	454

Preliminary estimated adult survival from fed and unfed fry releases were calculated by comparing the number of marks released to the number of marks that returned. The adult survival from natural fry was calculated by subtracting the estimated total survival of adults from unfed and fed fry releases from the total escapement and comparing them to the natural fry migration (Table 3).

Table 3 PRELIMINARY SURVIVAL ESTIMATES FOR PINK SALMON ADULTS TO THE QUINSAM RIVER - 1979 BROOD

Group	Marks Released	Total Release	Est. Mark Returns	Est. Total Return	% Return
Unfed	96,400	1,496,400	454	7,047	0.47
Fed	87,700	277,700	525	1,662	0.60
Natural	~~0~~	1,550,000	~~0~~	12,791	0.83

Recovery data was adjusted for a differential mortality due to marking of 1.18 which was estimated by comparing the overall mark rate in the juveniles to the overall mark rate in the adults. Potential sources of errors may originate from the accuracy of the estimate of natural fry migration (Table 1) and because it was not possible to calculate a different survival rate for marked fish from the unfed and fed fry groups. In studies conducted on the Tsolum River pinks (Bams, 1976) a differential of 1.24 was considered to be low. An extensive fishery occurred in Johnstone Strait for Fraser River pinks and sockeye during the 1981 season. The exploitation rate of 3:1 for the Quinsam stock was extremely high.

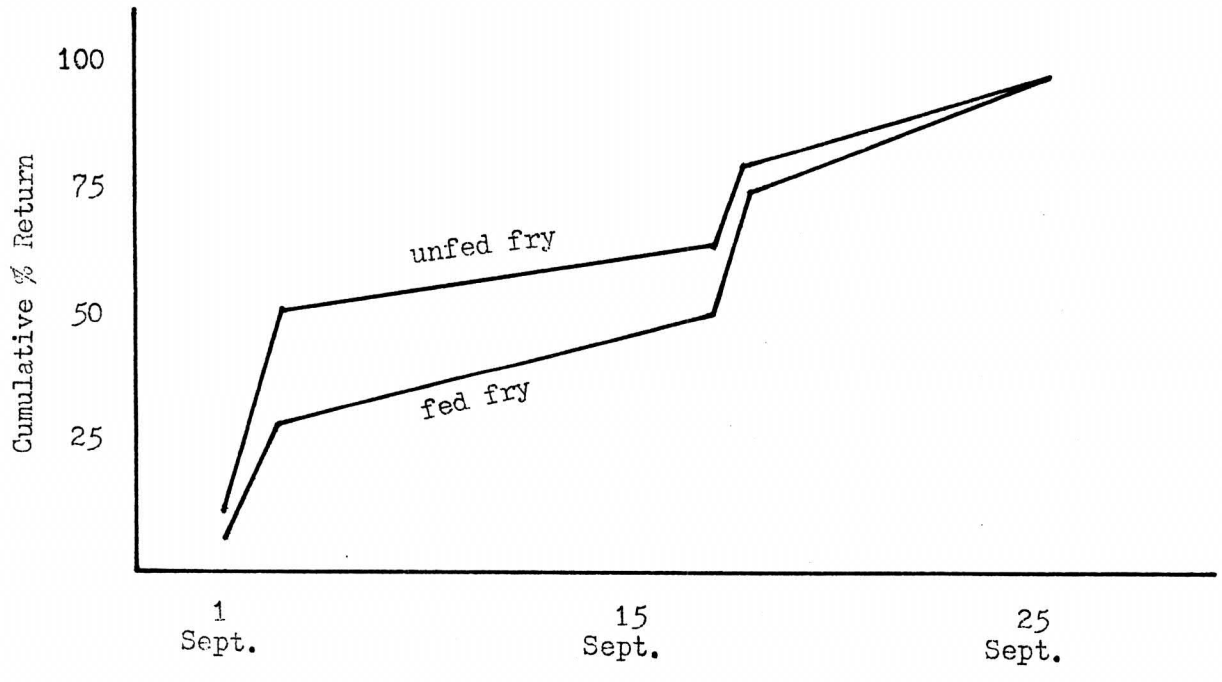
Table 4 SURVIVAL ESTIMATES FOR PINK SALMON ADULTS ADJUSTED FOR DIFFERENTIAL MARK MORTALITY

Group	Est. Mark Returns	Adj. Mark Returns	Adj. Return To River	Adj. % Return	Adj. Total Survival *
Unfed	454	553	8,584	0.57	2.28
Fed	525	639	2,023	0.73	2.92
Natural			10,893	0.70	2.80

* catch to escapement 3:1 , DFO management biologist

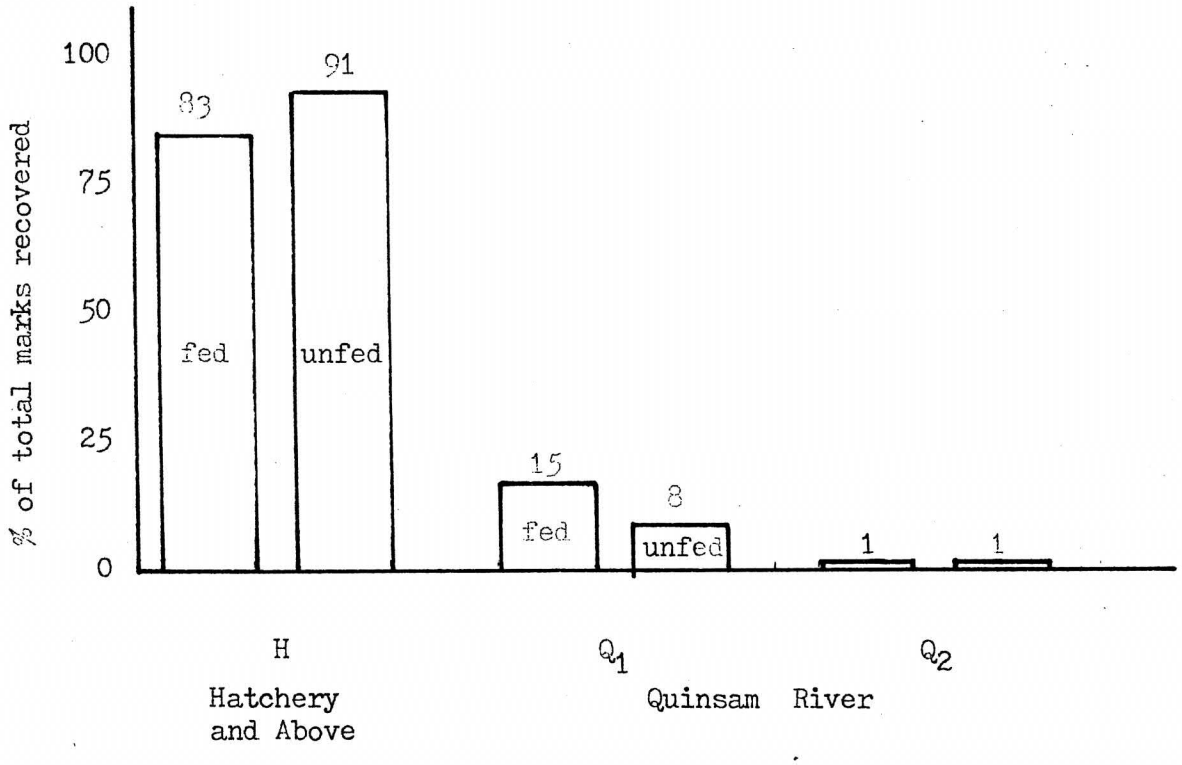
There was a dramatic trend for adults from the unfed fry release to return to the hatchery earlier (Figure 2).

Figure 2 DATE OF RETURN FOR ADULT PINK SALMON - 1979 BROOD (HATCHERY AND ABOVE COUNTING FENCE)



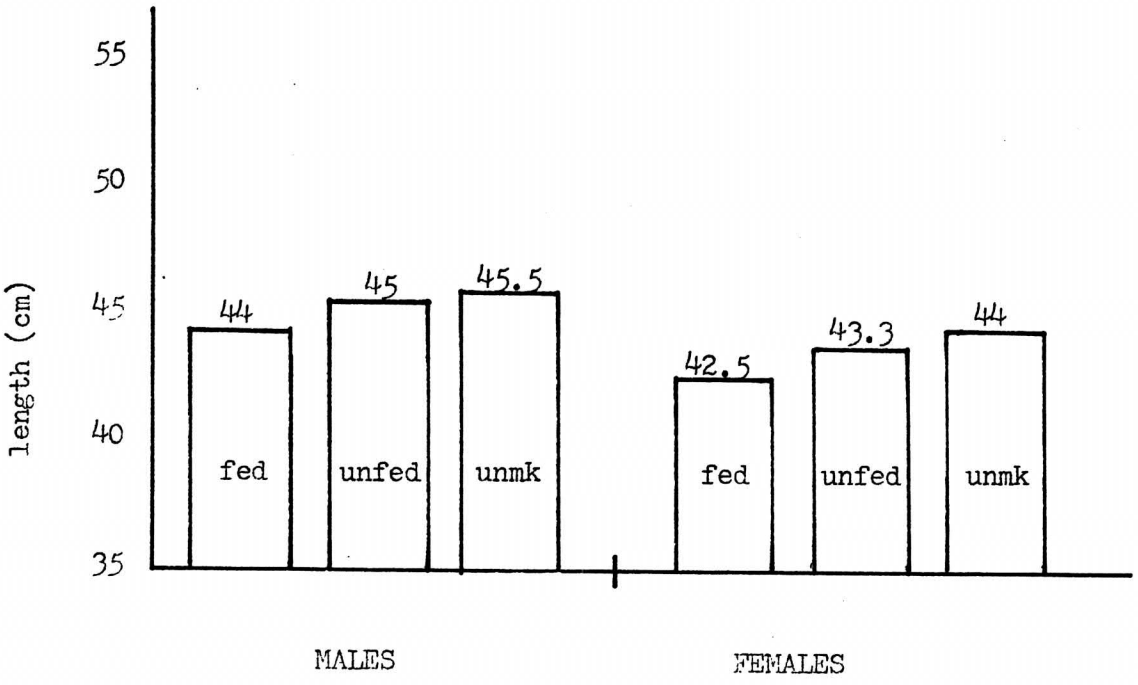
There was a stronger tendency for adults from the unfed fry release to migrate to the hatchery and above compared to the adults from the fed fry release. The question of where the adults from the reared fry release would return to spawn was of considerable interest. The adults from the fed fry group may have held in the estuary where they were reared thereby delaying their migration upstream. However, no visual evidence of this was observed. The number of marked adults spawning in the lower 1.5 miles of the Quinsam (area Q_2) and in the Campbell River below the Quinsam confluence was insignificant (Figure 3).

Figure 3 DISTRIBUTION OF MARKED RECOVERIES IN THE QUINSAM RIVER SYSTEM - ADULT PINK SALMON 1979 BROOD



A consistent trend in size of returning adults, although not significant, was observed and is consistent with findings in Alaska (Martin et al. 1981) (Figure 4).

Figure 4 COMPARISON OF LENGTHS OF RETURNING ADULT PINK SALMON 1979 BROOD



The sex ratio of returning adults was not examined extensively. Of the approximately 8,000 adults handles, 52 % were females.

In the final analysis, by rearing fry we obtained a survival rate very similar to that of natural fry. The unfed gravel box fry survived at a lower rate (initial analysis indicates that these rates are statistically significant). However, when we compare the females used to adults returning to the river we find that a female used in the hatchery will produce 2.75 times as many adults as a female that is allowed to spawn naturally (Table 5).

Table 5 ADULTS RETURNING TO THE QUINSAM RIVER PER FEMALES USED

	Hatchery	River
females used	1,200	3,400
adults returned	10,607	10,893
adults produced/ females used	8.8	3.2

Concerns:

The fry released from the upwelling boxes (unfed group) preceeded the natural fry migration by approximately 11 days.

The salt water reared fry were released approximately one month later than the peak of the natural migration.

The natural fry were not marked.

Contributions to fisheries for specific groups is unknown.

Future Studies/Plans:

This work was repeated with the 1980 brood at the Quinsam, Bear, and Puntledge River Hatcheries. Eggs have been taken at the Quinsam and Puntledge Hatcheries from the 1981 brood. In addition, 2 million fry from the Quinsam will be released into the Bear River which at present has only an even-year run.

Acknowledgements:

I wish to thank Ted Perry for his invaluable assistance in preparing this paper and my staff at the Quinsam Hatchery who did all the work.

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Martin, R.M., W.R. Heard, and A.C. Wertheimer. 1981. Short-term rearing of pink salmon fry : effect on survival and biomass of returning adults. Can.J.Fish. Aquat.Sci. 38 : 554-558.

A SYSTEMS APPROACH TO HATCHERY PRODUCTION
OR
EVERYTHING YOU WANTED TO KNOW ABOUT FISH BUT WERE AFRAID TO ASK YOUR COMPUTER

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An aquaculture system consists of a number of biotic and abiotic factors which act along and/or interactively in defining systems behavior and impacting the allowable growth rate (AGR) of the fish (Table 1). The bioenergetics approach, as presented, provides the necessary common denominator linking the quantitative effects of the biotic and abiotic dependencies of systems operation (Figure 1).

Computer implementation of the mathematical model of quantitative relationships in aquaculture systems is a dynamic process which provides a conceptual framework for understanding systems behavior (Figure 2). This model can provide useful information on variable significance to systems functioning, thereby directing research resources into areas which will most benefit further understanding of the system. Furthermore, as aquaculture systems research progresses, the model can be modified to incorporate new technology. Modelling therefore, is a cyclic process, a means for understanding the system, evaluating the system, and using the model to incorporate the new technology.

The conceptual framework of the model is not only applicable to rainbow trout, but is an acceptable conceptual model for all aquaculture systems. Reparameterization of specific components results in valid models for other species.

Table 1. Factors affecting the productivity of trout and salmon raising facilities (Klontz et al. 1979).

A. Fish Associated	
1. Ammonia-nitrogen	7. Infectious disease history
2. Behavior	8. Length-weight relationship
3. Nutritional requirements	9. Cannibalism
4. Environmental requirements	10. Oxygen uptake
a. physical	11. Oxygen demand
b. chemical	12. Fecal solids
5. Product definition	13. CO_2

B. Water Associated	
1. Dissolved oxygen	12. Municipal contaminants
2. Nitrite-nitrogen	13. Natural contaminants
3. Alkalinity	a. N_2
4. pH	b. CO_2
5. Inflow	c. H_2S
6. Suspended solids	d. Fe
7. Settleable solids	14. Utilization
8. Temperature	15. Salinity
9. Carrying capacity	16. Hardness (Ca^{++})
10. Agricultural contaminants	17. B.O.D.
11. Industrial contaminants	18. Viscosity

C. Container Associated	
1. Water volume	5. Water replacement time
2. Water velocity	6. Outfall design
3. Composition	7. Shape
4. Water flow pattern	

D. Nutrition Associated	
1. Feeding rate	4. Nutritional quality
2. Feed efficiency	a. proximate analysis
3. Feed style	b. metabolizable energy
	5. Feed Storage

E. Management Associated	
1. Fish sampling techniques	5. Pond cleaning
2. Feeding frequency	6. Fish size grading techniques
3. Feeding techniques	7. Management programming
4. Record keeping	8. Management objectives

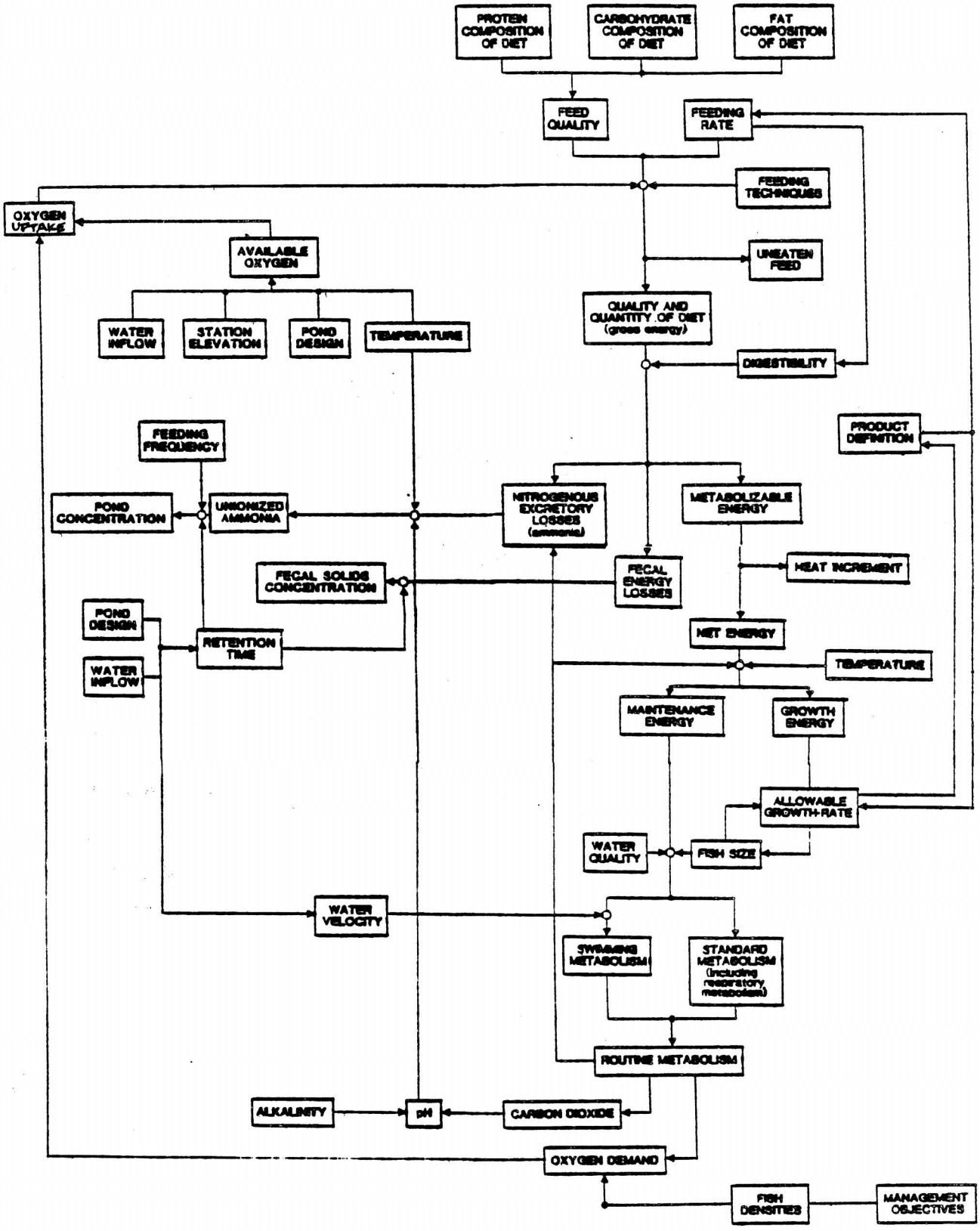

Figure 1. Diagrammatic representation of variables and interrelationships within an aquaculture system.

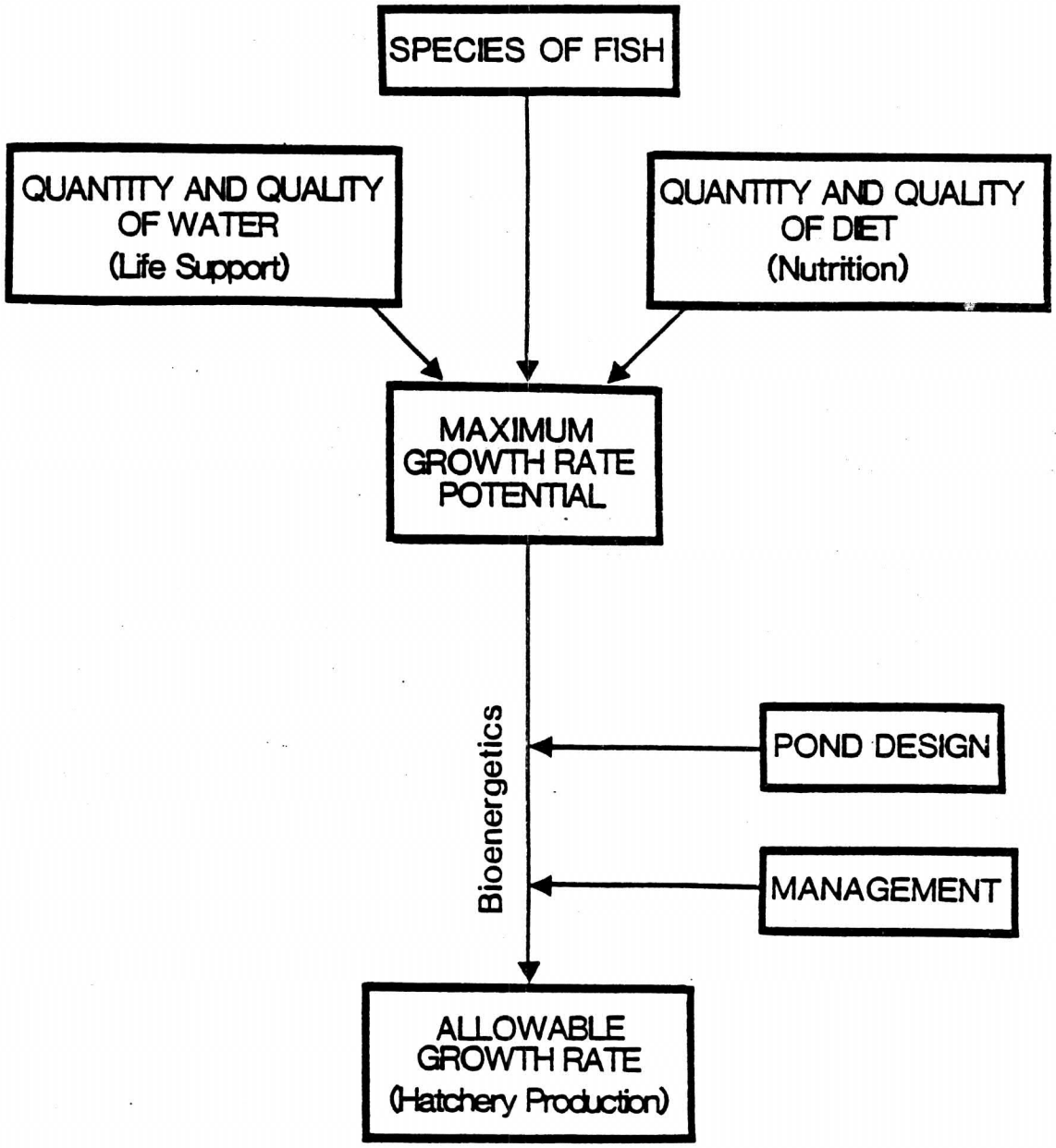

Figure 2. Relationships of major components defining allowable growth.

This computer implemented mathematical model has addressed one of the significant limitations of aquaculture systems management; namely, production forecasting, by providing a method of using current technology for the predictions of allowable growth rates and systems production forecasting. The use of the model in hatchery operations would serve as a valuable aid to production forecasting, resulting in more efficient and profitable aquaculture systems operations.

'78 Brood Green River Coho Pond Loading/Size at Release Study

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Introduction

This study was designed to address the issue of coho rearing strategies in Puget Sound hatcheries. Questions were brought out by several studies including Sandercock and Stone (Capilano), ODFW and earlier WDF time size studies.

The Capilano study, simply stated, showed the possibility of producing a comparable number of adults from a smaller number of smolts, if these were reared at lower density.

The WDF '78 brood Green River study took this one step further by incorporating a size at release factor into the study.

Methods and Materials

Eight 10' X 80' flow through raceways were set aside at Green River Hatchery; four were programmed for 25 fish/lb. at release and four for 15 fish/lb. Within each size group four densities were tested based on pond volume. The densities, expressed in lbs/ft^3/inch of body length, range from .25--$>$.40 were duplicated in each size group.

The ponds were randomly populated on May 24-25, 1979. The original intent was to use fish from a common egg take. This proved to be impossible at ponding time and fish from a different egg take were supplied proportionally to all the eight ponds. The final populations were 90% from one egg take and 10% from the other.

The randomization process was accomplished by assigning 20 lbs. of fish per bucket to the pond with the highest population and then adjusting the weight downward, proportionally for each of the remaining ponds. Using this method each pond received fish regularly with the final round of buckets (#24) finishing off all pond populations.

Pond populations were set on a "no split basis" and overpopulated by 10% to compensate for mortalities.

Tags were applied (approximately 20,000/pond) in December 1979 and the fish were released on April 23, 1980. One week prior to release, condition factors from 100 fish/pond were calculated. No significant differences were found although the large fish did have slightly higher condition factors than the smaller fish.

Conclusions

Survival figures and catch data are comprised of Washington ocean troll and sport catch and Puget Sound sport catch through September 30, 1981. They have been expanded for sampling rate and pond population. With such a small percentage of the total returns it is unfair to make definitive statements concerning the results.

It can be seen, however, from the large size fish that density did appear to alter survival as expected. That is, the lower the density the better the survival.

When returns for the smaller fish are examined, the picture is not so clear cut. Survivals are not significantly different from density to density. This may suggest that smaller fish are not as sensitive to density, in terms of decreasing survival, as larger fish.

When the catch figures are looked at overall, it becomes clear that size at release interacts with the density at which the fish is reared. With this

in mind, you can see the potential of a larger release of fish to overcome any decrease in survival associated with a higher density and produce more fish to the catch. The key is to derive the rate at which survival decreases when density increases, to achieve maximum contribution.

In reality, because the survival figures for all groups are close, it is possible to say that we never really challenged the ponds in terms of density, even though five out of the eight ponds contain densities higher than any tested in Canada.

It is easy to imagine that each style of pond (burrows, raceway, etc.) has its own criteria for density and size of fish release to obtain maximum contribution.

GREEN RIVER COHO 78 BROOD

POP.	58,800	69,800	81,600	90,700
size fish/lb.	17	15	18	19
lbs/gpm/in	1.10	1.49	1.47	1.60
lbs/ft^3/in	.21	.29	.28	.31
lbs/gpm	5.77	7.75	7.55	7.95
FISH/M^2	791	939	1098	1220
pond	5	6	7	8
pond	4	3	2	1
POP.	79,300	92,800	107,500	119,400
size fish/lb.	24	25	25	25
lbs/gpm/in	1.15	1.32	1.53	1.71
lbs/ft^3/in	.22	.25	.30	.33
lbs/gpm	5.50	6.19	7.16	7.95
FISH/M^2	1067	1248	1446	1606

GREEN RIVER COHO 78 BROOD

Wash. Ocean sport & troll; Puget Sound sport catches though Sept. 30th

POND	SIZE	POP.	SURV.%	CATCH	CAT/lb	COST RATIO	
1	25	119,400	2.0	2385	.50	.66	HD
2	25	107,500	2.2	2310	.53	.65	↑ Increasing density
3	25	92,800	1.9	1765	.47	.81	
4	24	79,300	1.9	1390	.42	1.00	LD
5	17	59,800	2.6	1560	.45	.90	LD
6	15	69,800	2.3	1605	.34	.97	↓ Increasing density
7	18	81,600	2.1	1715	.37	.90	
8	19	90,700	1.8	1635	.35	.96	HD

Eagle Creek National Fish Hatchery Density Study

by

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Introduction

We are now in the third year of similar studies at Eagle Creek National Fish Hatchery in Estacada Oregon. The first year two populations were set up in January at densities that would reach density factors of .15 and .30. These were released in May of 1980, with a right and left ventral clip respectively. Similar tests were set up in February of 1980 and 1981 and eggs have already been allocated for starting in a test in 1982. The test in these three years will extend over the entire lenght of the time the fish are held at the hatchery. Space and water limitations require that we split the fish three times during the fingerling pre smolt time leading to release, thus reaching maximum densities four times prior to release. The fish will be coded with wire tags and results will primarily judged on the percent return to the hatchery and later to total return to the resource as data is accumulated. A complete description of the test proceedures were reported in the 1980 proceedings of the Northwest Fish Cultures conference held at Courtenay British Columbia. Table I shows the comparison of the program at Eagle Creek. Table II is the basic results of the test program at Eagle Creek. Table III lists some comparison data looked at for indication of what might explain a difference in returns. Table IV shows results to date.

Table I

Canadian vs Eagle Creek Loading Data

Canadian Test
Fish Size
5.0171
22.6/lb
Pond Size
17'x75'x2.5'
90.3M^3
3188 ft^3
118.4M^2
1275 ft^2

Eagle Creek Test
Fish Size
5.8868
14/lb
Pond Size
8'x80'x2.5'
45.3M^3
1600 ft^3
59.5M^2
640 ft^2
K Factor
.0003500

	#/M2	#/M3	lbs/cu ft	Density Factor	lbs/gal	Load Factor
Canadian Test Levels						
Low 59,200 fish	500	666	.83	.16	4.40	.87
med/Low 78,618 fish	664	885	1.11	.22	5.80	1.16
Med/ High 86,550 fish	731	975	1.24	.24	5.38	1.27
High 106,678	901	1201	1.50	.30	7.87	1.57
Eagle Creek Test Levels 1980, 1981, 1982 and 1983						
Low 4 ponds 21,400 fish	353	464	.94	.16	3.15	.53
High 2 ponds 42,800 fish	720	945	1.91	.32	6.41	1.09
Eagle Creek Additional Test Levels 1981, 1982 and 1983						
Very High 62,100	1043	1371	2.59	.47	9.30	1.58

Table II

Eagle Creek

	Approx. Split Date	Size	D.F. Start/End	lbs/cu ft	lbs. Start/End	#/lb	Number	L.F. Start/End
Initial Ponding	Feb.	1.45"	.075/.15	.109	177/496	943	164,082	.25/.51
			.15/.30	.218	349/994	943	329,107	.50/1.02
			.22/.45	.326	523/1490	943	493,189	.75/1.52
First Split	April	2.05"	.075/.15	.154	246/679	331	81,426	.25/.50
			.15/.30	.308	492/1357	331	162,852	.50/1.0
			.225/.45	.462	738/2036	331	244,278	.75/1.5
Second Split	June	2.87"	.075/.15	.215	344/939	120	41,395	.25/.5
			.15/.30	.43	688/1878	120	82,790	.50/1.0
			.225/.45	.645	1032/2817	120	124,185	.75/1.5
Third Split	Sept.	3.92"	.075/start	.29	470/start	44	20,700	.25/start
			.15/start	.59	940/start	44	41,400	.50/start
			.255/start	.88	1411/start	44	62,100	.75/start
Release	April	5.75"	.15/end	.86	1380/end	15	20,700	.50/end
			.30/end	1.73	2760/end	15	41,400	1.0/end
			.45/end	2.59	4140/end	15	62,100	1.5/end

Table III

Group Comparisons for 1981 Release

Density Factor	.15	.30	.45
ATP Ase	12.6 ± 0.6	12.6 ± 0.6	12.6 ± 0.6
Cortisol	Near 0	Near 0	Near 0
Interrenal cell size	not complete	not complete	not complete
Mortality for each split			
To 5/15	5.0	3.4	3.5
To 8/26	.6	1.3	17.3*
To 9/15	.9	.7	.6
Conv. Total for Study	1.47	1.51	1.64*
K Factor	.0003350	.0003360	.0003431
O_2 Range	8.0 to 10.9	8.0 to 10.4	7.0 to 9.5
NH_4 Range	0.1 to .05	.15 to .05	0.3 to .05
Lenght at Release	5.86	5.86	5.77
Lenght Gain	4.01	4.01	3.92
Lenght of Study	383 days	383 days	383 days

* Furunculosis loss from 7.15 to 7/30. Fish were treated with Terramycin and water flows increased from 570 gpm to 785 gpm. Water flows were reduced on 8/25 to 530 gpm with no further loss to Furnunculosis.

Table IV

A. Returns from 1980 Release

1) Jack Returns Oct. 1980

Density Factor	# Released	# Returned	% Returned
.15	84,785	41	.049
.30	84,239	31	.036
Non clip production held at D.F. .30	1,406,397	1,792	.127

2) Adult Returns Oct. 1981

.15	84,785	67	.080
.30	84,239	57	.068
Non clip production held at D.F. .30	1,406,396	1,808	.129

Conclusion:

1) Ventral clip resulted in half the return of non clipped fish.

2) D.F. .15 returned at a higher rate than D.F. .30.

3) % return was not inversely proportional as the Canadian test showed.

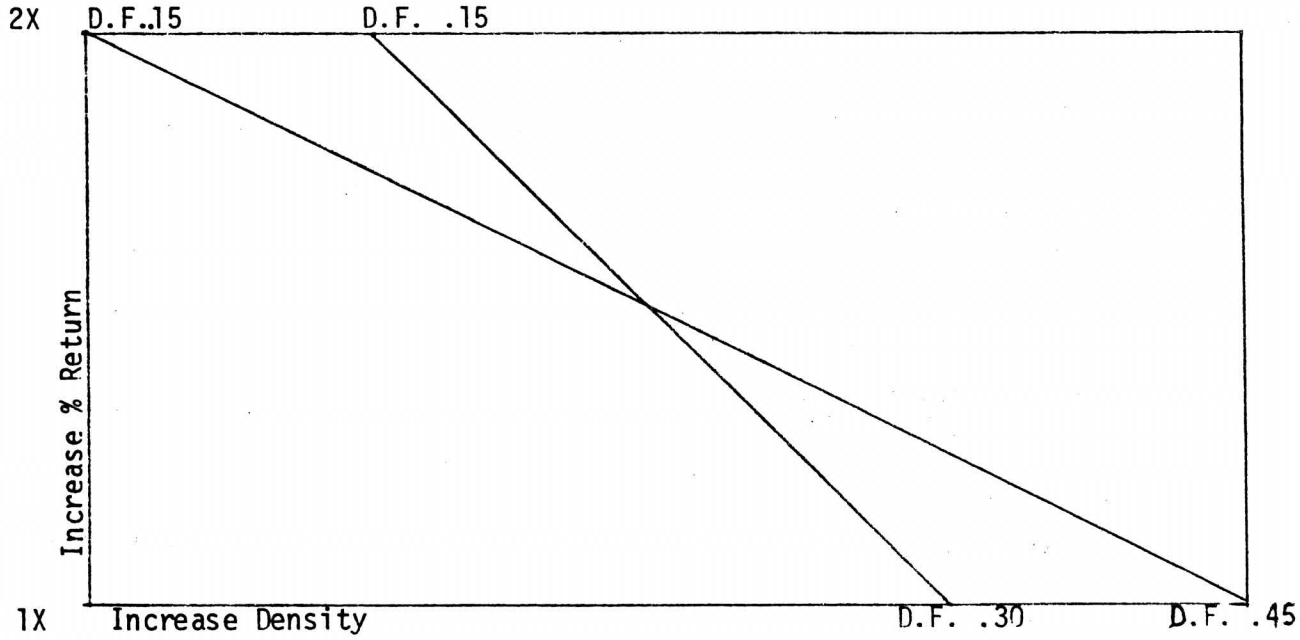
B. Returns from 1981 Release

1) Jack Returns Oct. 1981

Density Factor	# Released	# Tags Read	% Returned
.15	43,545	125	.29
.30	83,715	165	.20
.45	126,753	203	.16
.30 non tagged	685,718	1,199	.17

Conclusion:

1) This % return curve tends to substantiate the results that were reported by the Canadians at the 1979 NW Fish Culture conference.



This graph shows the relationship and slope of the Canadian study vs the Eagle Creek study. (Jacks only)

THE OREGON STEELHEAD DEMONSTRATION PROJECT

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Leslie Schaeffer
Drew Schaeffer

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This report summarizes the production data acquired during the period 24 September 1980 through 20 April 1981, the grow-out period for steelhead presmolts being reared at the site proposed for constructing a major steelhead production facility near Irrigon, Oregon.

In summary, 48,000 steelhead weighing approximately 200-300/lb from the Wallowa ODFW hatchery were rais-d to 5-7/lb in 6-7 months. The rearing conditions were three raceways (8' X 80' X 3') arranged in two single-pass systems and one double-pass. The water was 59^{o} F (constant) and the pond replacement times were approximately 30 minutes. Other than an oversight mishap, there were no problems encountered during the grow-out period. The overall feed conversion was 1.8:1 for all groups. There were occurrences of infectious or noninfectious diseases. The daily mortality was 0.013%, less than the figure considered to be acceptable for most operations.

Among the more significant interpretations of the data collected were: (1) a method validating the inventory sample as being representative of the population; (2) a method of preventing the size distribution in the population from becoming statistically cumbersome; (3) a method of achieving a predicted biomass increase within the population; (4) a method of predicting an achievable dietary efficiency (or its reciprocal, feed conversion).

Early vs. Late Release of Steelhead
or What a Difference a Month Makes

The Washington Department of Game, following the Boldt Decision, embarked on a research program to improve returns of steelhead. We hoped that we could fine tune our procedures and thereby lessen the impact of the Indian fishery on the sport fishery. As a part of this effort a time of release study was done on the Puyallup River system. The experiment was done on two successive years to provide duplication and provide validity to the results.

In the fall of 1976 two groups of Chambers Creek stock winter steelhead fingerling were coded wire tagged at the Puyallup Trout Hatchery. One group containing 43,518 smolts was released April 4, 1977. These fish were 5.8 and 6.0 per pound at release. A second group containing 39,354 fish at 4.8 and 5.2 per pound were released May 11 and 12, 1977. An effort was made at the time the fish were tagged to select fish graded in such a manner so that the two groups of fish would be equal in size at the time they were released. Although we were not completely successful I think that the size at release was not a major factor affecting the test results.

The same procedure was followed the following year. The early group was released April 4th and 6th. This group contained 47,725 fish at 6.0 and 7.3 per pound. The second group of 46,424 fish at 5.2 and 6.7 per pound was released May 16 and 17, 1978.

Both groups were checked for tag retention prior to release. The samples in the 1977 release showed a 99% tag retention in the April group and 100% in the May group. The 1978 groups showed 97.1% tag retention in the April group and 93.14% in the May group.

Approximately equal numbers of fish were planted at the same sites in both April and May. Figure 1 shows the planting sites used for both the early and late releases both years. Also shown is the trout hatchery site and the site of the Puyallup Salmon Hatchery. No steelhead were planted directly from the trout hatchery. The salmon hatchery released coho and chinook into the drainage both years. The largest salmon releases in 1977 were 47,000 pounds of coho yearlings April 26 - 30, and 4600 pounds of 0 age fall chinook May 9 and 11. Largest releases in 1978 were 35,000 pounds of yearling coho May 4

and 13,400 pounds of 0 age fall chinook May 17, 23, and 30. These large releases were into Voights Creek directly from the salmon hatchery. These salmon releases are mentioned since there is a possibility that salmon and steelhead releases could impact one another particularly as the fish pass through the estuary.

Figure 2 shows the numbers of tags recovered from the fishery in 1978-79 and 1979-80. These figures have not been corrected for tag retention percentages or the slight difference in the numbers in the April and May groups. As the figure shows, the May release returned at much higher rate than the April release. The May 1977 release returned at twice the rate of the April release and the May 1978 release returned at seven times the rate of the April release.

From this information it appears that it would definitely pay to hold steelhead into May for the best return.

References - Washington Department of Fisheries Progress Reports No.'s 77 and 93, Statistical Reports of Production and Plantings for 1977 and 1978.

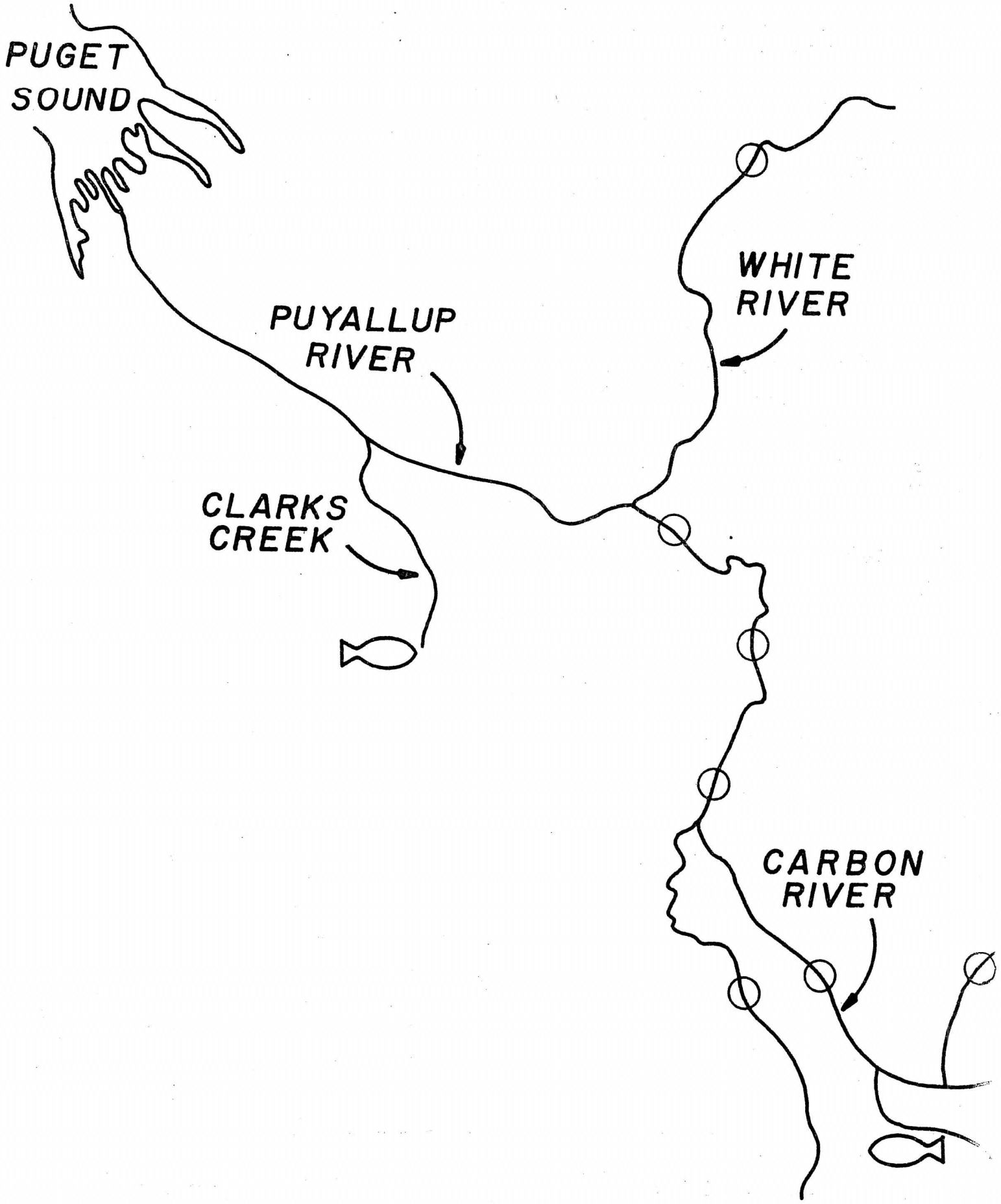
PUGET
SOUND
WHITE
RIVER
PUYALLUP
RIVER
CLARKS
CREEK
CARBON
RIVER

FIGURE 1

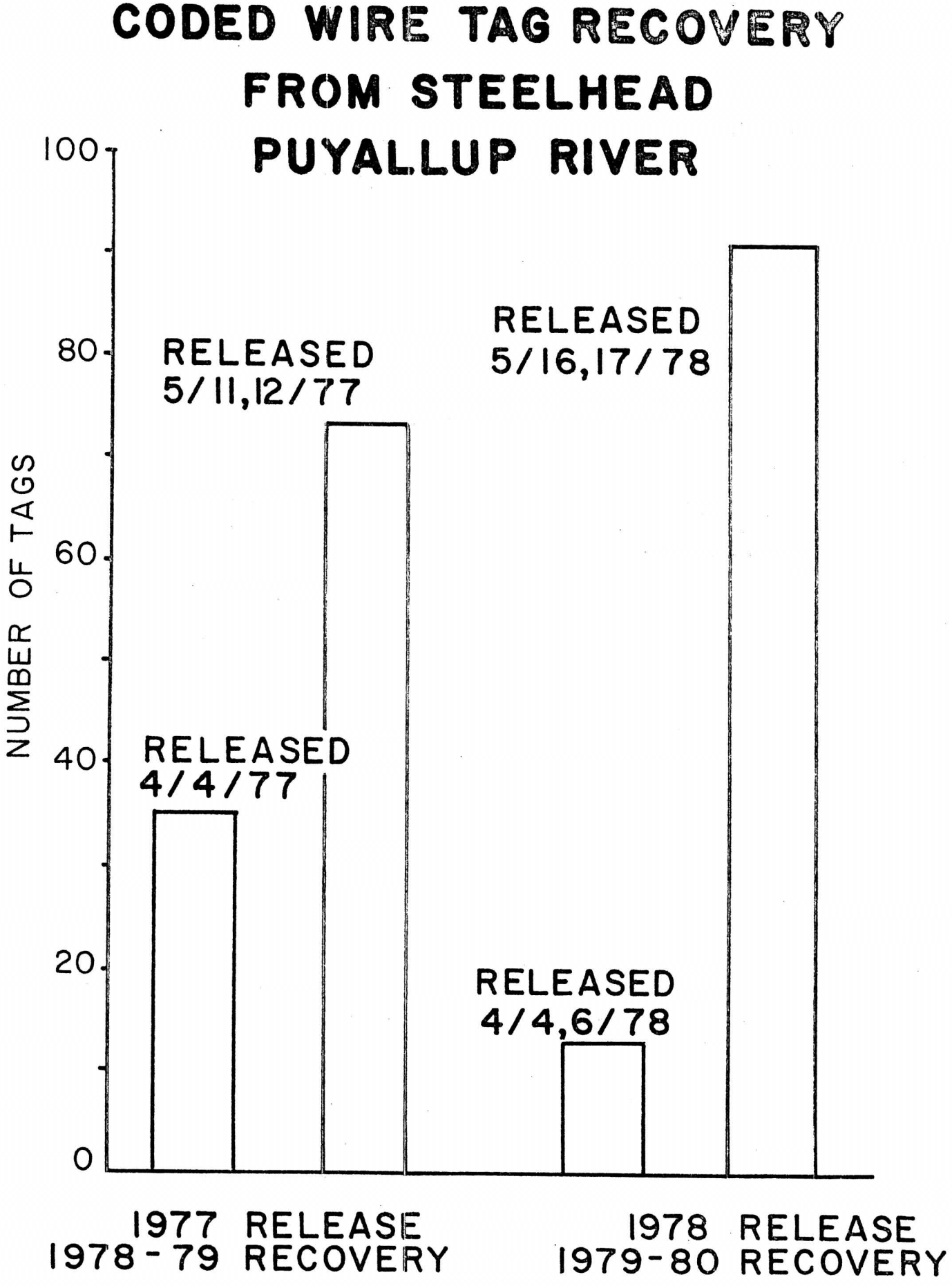
CODED WIRE TAG RECOVERY
FROM STEELHEAD
PUYALLUP RIVER
NUMBER OF TAGS
100
80
60
40
20
0
RELEASED
5/11,12/77
RELEASED
4/4/77
RELEASED
5/16,17/78
RELEASED
4/4,6/78
1977 RELEASE
1978-79 RECOVERY
1978 RELEASE
1979-80 RECOVERY

FIGURE 2

THE SECOND B.C. COHO SIZE AND TIME OF RELEASE EXPERIMENT: PRELIMINARY RETURNS TO THE QUINSAM HATCHERY

by

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Introduction:

The first size and time of release experiment was conducted at the Rosewall Creek experimental hatchery. The results were reported at last year's conference. The second experiment was conducted at the Quinsam Hatchery, using 1978 brood coho. These preliminary results deal with only marked fish which returned to the hatchery.

Methods:

Release - During the spring of 1980, four ponds of coho smolts were released at different times. Each time of release was comprised of three size categories achieved by grading the population in each pond. Each size category was marked in triplicate but the results are pooled in this report. Each of the 12 groups released were comprised of approximately 11,000 marked smolts (Table 1).

Table 1 Tagged Coho Smolt Release Information

Release Date 1980	Size Category	Average Weight (grams)
April 20	Small	14.3
	Medium	18.7
	Large	23.7
May 10	Small	17.8
	Medium	21.5
	Large	26.0
May 30	Small	19.8
	Medium	23.9
	Large	29.5
June 19	Small	20.0
	Medium	24.7
	Large	29.3

Return - All the coho jacks and adults that returned to the Quinsam Hatchery were examined and all the marks were sampled.

Results - Of the approximately 20,000 coho jacks that returned to the Quinsam system from the 1978 brood releases, 13,270 were examined to recover 1,858 marks. Of the approximately 30,000 adults that returned, 19,900 were examined to recover 2,725 marks (Table 2).

Table 2 Percent Return of Jacks & Adults From The 1978 Brood Coho Releases

Release Date 1980	Size Category	Ave. Weight (grams)	% Marked Returns to Hatchery Jacks	Release Mean	Adults	Release Mean
April 20	Small	14.3	0.12		0.86	
	Medium	18.7	0.33	0.32	0.65	0.64
	Large	23.7	0.52		0.40	
May 10	Small	17.8	0.18		1.13	
	Medium	21.5	0.42	0.57	0.87	0.86
	Large	26.0	1.12		0.57	
May 30	Small	19.8	0.05		2.01	
	Medium	23.9	0.64	0.88	1.75	1.77
	Large	29.5	1.94		1.55	
June 19	Small	20.0	~~0~~		0.45	
	Medium	24.7	0.35	0.20	0.53	0.45
	Large	29.3	0.25		0.38	

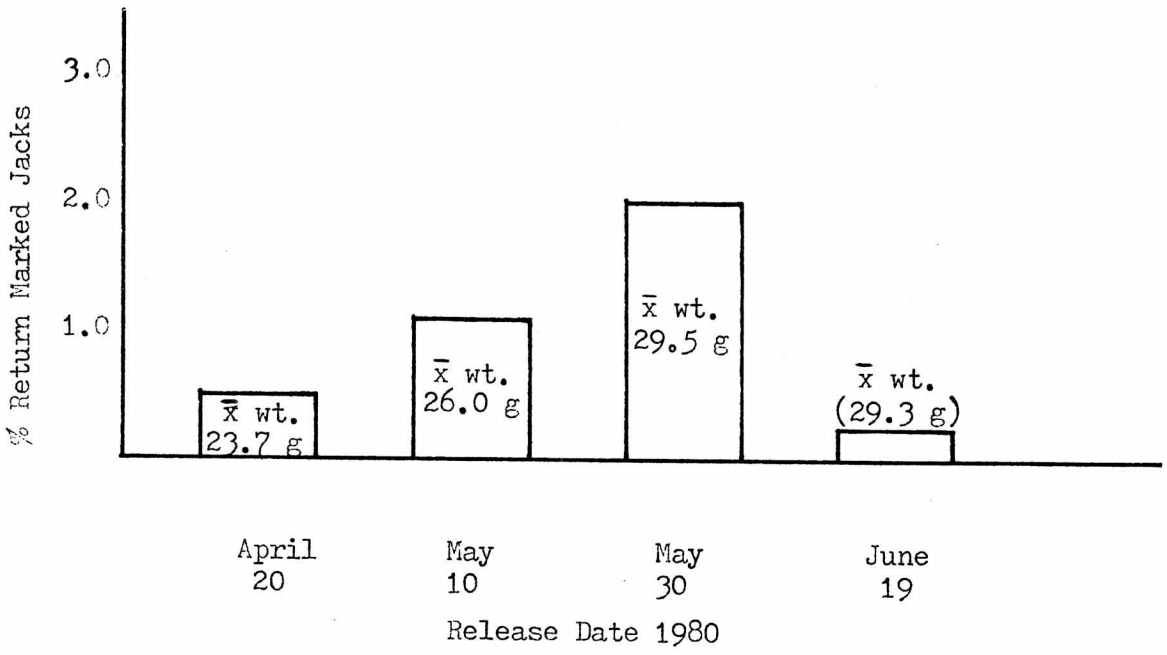
Jacks:

Size of Release - The largest smolts released at each time consistently yielded the highest percent of jack returns with the exception of the June 19 release. This group had a 30 % incident of furunculosis at release. This general deterioration of smolt health as time of release is delayed is consistent with past experience at Quinsam.

The smallest smolts released consistently yielded the lowest percent of jack returns (Table 2).

Time of Release - A comparison of only the largest smolts from each time of release indicates that the May 30 release produced the highest percent of jack returns (Figure 1).

Figure 1 Percent Return of Marked Jacks From The Large Smolt Releases



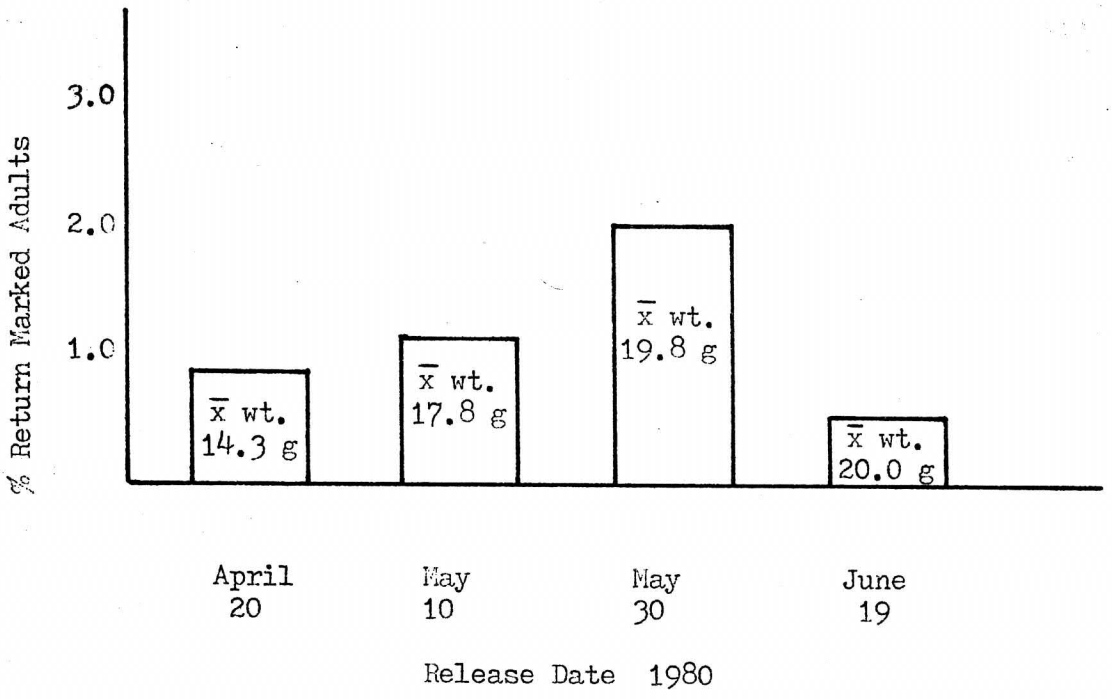
Adults:

Size of Release - For each time of release, the smallest smolts consistently yielded the highest percent of returning adults with the exception of the June 19 release (Table 2).

The largest smolts released consistently yielded the lowest percent of returning adults (Table 2).

Time of Release - A comparison of only the smallest smolts released for each time of release indicates that the highest percent of returning adults resulted from the May 30 release (Figure 2).

Figure 2 Percent Return of Marked Adults From The Small Smolt Releases



Discussion:

Grading for size has been examined extensively and no significant statistical bias has been found to date (Alderdice, Bilton, pers. comm. 1981).

A comparison of the Rosewall and Quinsam results indicates that the best time of release at Quinsam is approximately 10 days earlier, May 30 versus June 10. The best size of smolts to release is approximately 20 grams for both locations.

At Quinsam, our normal strategy has been to release 25 gram smolts approximately mid May. The results of this experiment indicate that we could expect approximately 0.6 % adult returns to the hatchery. This is confirmed by past results. By delaying our releases two weeks and by decreasing the size of smolt by 5 grams from 25 grams to 20 grams, our percent return to the hatchery should triple to approximately 2 percent.

A data report (Bilton et al. 1981) has been published which provides information on this experiment until the time of smolt release including length, weights, sex composition, health, and ability of released fish to adapt to salt water.

A complete report of the experiment is planned and will contain information on survival, biomass return, catch, distribution in the catch, age and sex composition, and health.

This experiment was repeated with the 1979 brood coho and plans are now being developed to undertake a similar experiment on 1981 brood chinook at Quinsam.

Acknowledgements:

The author wishes to express his appreciation to Mr. H.T.Bilton and Mr. A. Coburn for their efforts and sincere cooperation in designing and carrying out this experiment, and for permission to report these preliminary results. Thanks are also extended to Mr. D. Barrett and Mr. T. Perry for their assistance in preparing these results.

References:

Bilton, H.T., and A.S. Coburn. 1981. Time and Size at Release Experiment: Four Releases of Three Size Categories of Juvenile Coho Salmon From The Quinsam Hatchery in The Spring of 1980. Can. Dept. Fisheries & Oceans. R.S.B. Can. Data Report of Fish and Aquatic Sc. No. 252.

HOW 'YA GONNA KEEP 'EM UP AT THE HATCHERY ONCE THEY'VE SEEN YOUNGS BAY

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ABSTRACT

We conducted this study to determine the feasibility of creating or enhancing a fishery in a specific area by releasing hatchery salmon into the area. We examined the homing ability and contribution to the fisheries of coho salmon, Oncorhynchus kisutch, released at two locations.

In 1973, two groups of approximately 100,000 1971-brood coho salmon were marked with differentiating fin clipping at Willard National Fish Hatchery near Cook, Washington. We transported one group to Youngs Bay, near Astoria, Oregon, for release, and the other group was released at Willard Hatchery.

In 1973 and 1974, major salmon fisheries in Washington, Oregon, California, the Columbia River and Youngs Bay, and returns to Columbia River hatcheries were sampled for marked coho salmon. Analysis of the results indicated the two groups homed to their respective areas of release with very little straying.

Two Youngs Bay release and twenty-six Willard release coho salmon returned to Little White Salmon Hatchery, the return site for fish released at Willard Hatchery. One Youngs Bay release coho salmon strayed to Klaskanine Hatchery, on a tributary to Youngs Bay.

In addition, we estimated 199 fish from the Youngs Bay release and none from the Willard release were captured in the Youngs Bay gillnet fishery. The Youngs Bay release group contributed 23 fish to the Pacific salmon fisheries per 1,000 fish released. The Willard Hatchery release group contributed 5.6 fish per 1,000 releases.

SMALL SCALE SALMON ENHANCEMENT PROJECTS IN NORTHERN PUGET SOUND

A Presentation by Jim Humphreys

In 1776, when the U.S. was fighting the revolution for our independence, the streams of the Pacific Northwest and northern Puget Sound were very pristine. Salmon ran in large numbers in most streams, and the water quality was good. Also, the watersheds were in good shape. However, two hundred years later, by the time of the U.S. Bicentennial in 1976, a number of things had changed. Dams, construction, logging, pollution, urbanization, and other factors led to many changes in the streams of northern Puget Sound. Changes to the point where these streams no longer produced salmon in large numbers.

That was the situation in 1976 when the Sea Grant Office in Bellingham was approached by commercial and sport fismermen who suggested that we help them initiate some activities to improve the situation. Specifically, they wanted to start streamside salmon incubation box projects on streams on northern Puget Sound. The Sea Grant Office was more than happy to assist these people, and we helped them to work cooperatively with the Washington Department of Fisheries. In the 1976-77 season, two salmon incubation box projects were started as educational projects. The boxes were on Oyster Creek and on Dakota Creek with 60,000 chum salmon in each box.

Within the last five years, this project has grown considerably from the two small eggbox projects that started in 1976. Today in

northern Puget Sound we have two private, nonprofit, enhancement associations that are made up of commercial fishermen, sports fishermen, and interested citizens. We have students from three area high schools involved in projects. We have had two different classes being taught on salmon enhancement techniques. We have seen the development of Bellingham's Maritime Heritage Center, which is a hatchery, an educational facility, and a park that five years ago was a "white elephant" of an old sewage plant. In 1981-82, these volunteers in northern Puget Sound have proposed 13 different projects that will be hatching close to two million chum and coho salmon eggs.

You may be asking yourself at this point how a program like this works, one that can go from nothing to working on 13 different projects with two million eggs within five years. Organizationally, there are three major groups involved in the program: the Washington Department of Fisheries, the Sea Grant Office, and the volunteers. The Washington Department of Fisheries is a very important organization in a program of this nature, and their role has really been vital. They have supplied the eyed eggs for the projects and provided most of the technical expertise. They have helped to determine which streams are suitable for projects and which streams are not. The WDF District biologist, the Samish hatchery crew, and the State office staff have all been extremely cooperative. The role of the Sea Grant Office has primarily been one of coordination. In addition, we provided some technical assistance and education (informal as well as formal education). The volunteers are probably the most critical link in the organization of a program

like this, and they tend to be the backbone of the operation. To make a cooperative-volunteer program successful, you need people who are extremely committed to seeing salmon return to these streams. People are commited to projects like this for various reasons, such as: aesthetics, money, or recreation. However, the important point is that they need to be committed to improving the resource. The volunteers do most of the work. They run the day-to-day operations of the projects. They also help select the sight and look at its suitability to see what fish stocks are currently in the stream, what fish stocks were there historically, what is the condition of the watershed, and is the landowner cooperative. The volunteers also have to make sure once the eyed eggs are in the boxes that they are checked daily. This is very important and can be a weak link in the program.

Technically, the project is primarily one of obtaining eyed eggs from the Washington Department of Fisheries and placing the eggs in upwelling gravel incubation boxes along streams. The water source for these boxes comes from upstream, either directly out of the stream or, in some cases, from small reservoirs. The eggs are mixed with gravel in the upwelling incubation box or placed in trays; however, we may be using biorings in the future. The boxes are checked daily for problems, and the dead eggs are removed. When the eggs hatch out, chum salmon in all but one project are not fed and go directly into the stream and into the estuary. However, one project near Blaine has a chum feeding pond and instead of releasing chum at about 1,000 per pound as most of the projects do, these chum are released at about 400 per pound. When

coho hatch out, again, the only feeding that is done is at Blaine, where there is a small reservoir of about two acres which is 18 feet deep. In this reservoir, coho are held and fed as opposed to the other projects where the coho go directly into the stream until they smolt and migrate.

Let me briefly review what has been done to date and what is being proposed this current year as far as numbers and release sites. The area where the projects are located goes from Whitehall Creek in the northern Skagit County area to the Canadian border. In 1976-77, Oyster Creek and Dakota Creek were the first two projects. In 1977-78, Oyster Creek and Dakota Creek chum eggs were doubled, and Chuckanut Creek was added at 120,000 chum also. Deer Creek came on with 60,000 coho, and the Blaine Reservoir ponds received 120,000 coho fry to be fed. In 1979, the program continued to grow. The number of eggs increased, and the numbers of projects increased to eight. In 1979-80, we saw more growth yet. For 1981-82, thirteen different projects on 11 different bodies of water have been proposed. Whitehall Creek, Oyster Creek, Chuckanut Creek, Baker Creek, Blaine Reservoir, Whatcom Creek, Deer Creek, Samish Lake, Padden Creek, Squalicum Creek, and Haynie Creek all have projects proposed for the 1981-82 season.

With these fish being released, one has to wonder what the return rate has been. Yet, with any low-budget, volunteer-run program, it is very difficult to provide a good numerical estimate of the returns. However, through observation, the returns appear to be fairly good. Deer Creek, near Blaine, has seen a tremendous increase in the number of coho coming back, and there has been a large increase in sport fishing activity

in that area. Commercial fishermen had a three-day opening for chum salmon this fall, and a considerable amount of fishing activity took place off the mouth of Chuckanut Creek. Interestingly enough, Chuckanut Creek still had a good return, and reports from fishermen were that their catch was quite good as well. Also, there was a very good return this year to Oyster Creek. I have also had a report that there was a good coho return to Haynie Creek.

Any program where you are working with volunteers can have some problems, and this program has three major problems. The first is labor. There have been several cases where because of lack of labor and poor organization there have been some loss of eggs. The second major factor is weather. Freezing of the pipes and flooding can both be serious problems, and these problems are magnified if the group is also having problems with its labor supply. The third major problem is the urban guardianship of the streams. In other words, protecting the stream from urban pollutants and stream habitat alterations.

To summarize, I am very excited about this project in the northern Sound area primarily because it has a lot of pluses. First, it has gotten people very enthusiastic about spawning salmon and developed a tremendous amount of community support. These projects have gotten people involved in raising salmon, and it has given them an interest in the resource. Also, it has led to the development of some very interesting and innovative projects. For example, Bellingham's Maritime Heritage Center five years ago was a sewage treatment plant. Now it is being used as a fish rearing facility, as an educational facility, and it is

being turned into a city park. At the same time, just to give another example of people and local government's commitment to stream resources, Bellingham has a person working full time on assessing stream habitat within the city of Bellingham, who is looking at ways to improve the stream habitat. It appears that the City of Bellingham is moving towards a clearing ordinance to protect the habitats that they have available. Also, through the use of volunteers, it has allowed an Agency to maximize the use of the dollars as much as possible.

In closing, I would like to thank the Department of Fisheries, particularly, for their cooperation and participation in the small stream salmon enhancement programs in northern Puget Sound. Without their help, the programs never would have gone. Thank you all for allowing me to speak here today. If there are any questions, I would be more than happy to try and anwswer them.

F. I. S. H.
or
Micro-Computers in Hatcheries

by Cameron West

A computerized data management system is operating on-site at major production facilities of the Salmonid Enhancement Program. F.I.S.H., (Fishculture Information System for Hatcheries) contains data entry and report generators for incubation, rearing and adult sampling data. As aids to facility and office staff, F.I.S.H. also includes utility programs for statistical, bio-engineering, physical modelling and fishculture related calculations.

F.I.S.H. has been custom designed for use by hatchery staff. The data content was determined after surveying the records of all major SEP facilities, and fishculture terminology is used whenever possible. Development during the one-year pilot project involved a close working association with hatchery personnel. The resulting system is suitable for practical use in production facilities.

The adult data programs were operated in a production mode this past fall, and the coming winter and spring will be the first full-scale test of the incubation and rearing sections. The major advantage of processing the adult data has been the extremely fast reporting, along with fast editting and re-reporting of sampling summaries. This includes formatted tables and descriptive statistics.

The utility programs have proven to be valuable assets for such things as calculating mark-recovery effort for assessment programs, designing aeration towers or safe procedures for mixing and heating water supplies, preparing feed tables and calculating dosages of chemical treatments for fish diseases. Benefits of the utility programs lie in their ease of use and the speed and precision with which the above reports are produced. They also provide a collection of expertise in many fields which may not otherwise have been readily available to the user. Most of the utility programs have been developed in co-operation with experts in the fields of fish-culture ,disease diagnostics, fish physiology, physical chemistry and statistics.

Alternate uses for micro-computers are facility-based financial accounting systems, inventory data base management, and word processing.

Development of the F.I.S.H. system has been a success. Acceptance of the Apple micro-computers has been very good, due to the benefits of electronic data processing and to the effort in developing user friendly programs. SEP Operations currently uses 12 Apples and will be purchasing additional systems for new facilities in the near future.

A SAND BIO-FILTER FOR REMOVAL OF AMMONIA NITROGEN

by

R.W. MacMillan, Fish Culturist
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As Fraser Valley Trout Hatchery is located on Fraser River drainage, approximately 50 river miles from tide-water, we have become quite involved in the rearing of steelhead and sea-run cutthroat trout under the Salmonid Enhancement Program. This added production is made possible by using a few off-site rearing facilities within 30 miles of the main hatchery. These are fish culturally supervised by our own designated people.

The subject of this talk involves a small, privately owned commercial fish farm, now exclusively devoted to rearing sea-run cutthroat and steelhead for us, under contract.

This hatchery consisted of 6 earthen raceways arranged in series. An artesian well provided a flow of 110 Imp.gals./min. with D.O. of 0-3 p.p.m. This water at first flowed through a small head pond that contained a few domestic rainbow brood fish. There were some problems with an algae bloom during the first year, but we did produce a small crop of smolts.

On setting up for year #2, the domestic rainbow were removed and the small head pond was filled in. The artesian water was piped directly to the head of pond #1. A flow-operated splash wheel was used for some aeration. Sea-run cutthroat at 150/lb. were placed in pond #1.

Problems with a shortage of D.O. soon occurred. This was supposedly corrected by erecting an aeration tower and pump. Problems then started with clubbing of gills and heavy concentrations of myxobacteria. Further testing showed that the artesion water contained 0.40 p.p.m. ammonia nitrogen. This, combined with a pH of 8.1 and a temperature of 11^{o} C resulted in an un-ionized ammonia level of 0.012 p.p.m.

A bio-filter for bacteria to convert ammonia to nitrite and nitrate was constructed using a 10' diameter 4' high fibre-glass pond and P.V.C. piping. A 2.5' layer of sterilized crushed granite chicken grit, 80% being 1-2 mm in size on top of 1.3' of drain rock and pea gravel served as the filter media. Water enters the downflow filter through a spray bar by gravity from the base of the aeration tower. This water passes downward through the media and is picked up by collector pipes below the gravel, and flows by gravity to the head of pond #1.

The 1976 printing of Leitritz, pages 18 and 19, explains quite well the bacterial action that takes place within this type of filter. These bacteria cannot become established or remain functioning without a carbon source for nutrition. We set up to provide this by dripping diluted molasses into the water at the well head. Probably we were not diluting it enough, as the filter would quickly clog with a brown, furry growth.

Our main hatchery operates successfully on recycled, bio-filtered water, so staff who monitor water quality reasoned that this system might work with small amounts of recycled water. A small submersible pump was placed in the foot of pond #1 and returns 2 g.p.m. back to the sump.

Nitrification commenced in 5 weeks and was in full operation at 6 weeks. With a half hour weekly back wash, ammonia - N levels were below detectable concentrations and nitrite was present in trace amounts. The system is now trouble-free and our fish are thriving.

During the last year, another artesian well has been added, bringing the total water supply to 170 Imp.gals./min. We have installed a second aeratian tower and bio-filter. The ponds are still arranged in series, but we have added some by-pass plumbing so that any pond carrying fish is supplied with some additional fresh water.

Gas Bubble Disease Research: Progress in 1981

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Extended Abstract

The research continued along three lines, namely the development of better means to measure and monitor dissolved gas pressures, methods for small scale de-centralized degassing at fish tanks, and testing of factors which influence susceptibility to gas bubble disease in rainbow trout.

The development of the Gasmometer improved the measuring and monitoring of dissolved gases. This instrument is operated by water flow and pressure instead of human or electrical assistance and can be connected to the water supply system or to a small submersible pump. Dissolved gases are monitored continuosuly, hence Gasometers can be connected to the hatchery alarm system. Gasometers can be constructed at home and costs are relatively inexpensive.

Efficiency of degassing was compared between several methods including simple plunge (jetting), drop thru incubation trays (screens) and with combinations of two packed column degassers filled with four sizes of packing. Dropping the water thru a series of 12 screens (1/8" mesh) was only slightly better than allowing its direct plunge into a tank. Degassing is a function of total column height and packing size, regardless of whether a single column or a series of short columns was used. Hyperbaric gas pressures (ΔP) of treated water can be predicted easily from column height and input ΔP. Packed column degassing can be used continuously, usually without any operational cost. Degassing should take priority over gas monitoring.

Biological testing by others has generally indicated that dissolved gas levels as low as 101% of atmospheric pressure can have serious, but protracted effects on larval fish, such as herring and striped bass. Larval stages of some salmonids (lake trout and Atlantic salmon) apparently tolerate very little supersaturation compared to rainbow trout and Pacific salmon. Non larval stages tolerate higher levels of supersaturation.

Intermittent (diel) exposure to supersaturation allows fish to degas and increases the length of their survival. This may be useful in emergencies; fingerling rainbow trout has no mortality at ΔP = 150 mm Hg (120% of barometric pressure) when exposed either 8 or 16 hours per day for over 3 weeks, but over 50% died in the same period when they were exposed continuously.

Compression to an equivalent depth of 10 m did not improve survival during subsequent exposure to supersaturation. However, fish on restricted rations of food died twice as fast as fish fed *ad lib*. A given level of supersaturation, either in fresh water or seawater, caused approximately equal mortality and similar times to death in steelhead smolts.

VOLUNTEER HELP AS A MEANS TO AN END

Fred Norman
Washington State Game Department

With today's money problems causing cutbacks in personnel and fish production, the Department of Game has sanctioned a program where individual citizens or groups of citizens can donate both time and money to Department programs. This can include ongoing or new programs.

In 1979, from the need of more fish and places to rear them, the regional biologist of the Aberdeen Region asked the community business leaders for help. From this start the Citizens Wildlife Heritage Program was founded. It now operates as a program of the Game Department.

It derives benefits from four areas:

1. Sport Club Production Projects

   These projects raise rainbow and steelhead for lake and stream plants.

2. Foundation Grants

   This has accounted for $60,000.

3. Estate Planning Deferred Giving Program

   Irrevocable trusts worth $10,000,000 have been received so far. Upon the decease of the donor, the Department of Game receives complete ownership.

4. Outright gifts of $150,000, land gifts of 700 acres and wildlife easements.

As of the end of 1981, the Department of Game has received a total of 1,000,000 free fish ranging from 6" to 2-1/2 pounds with 900,000 committed for the future.

"FLUIDIZED BEDS"
The Latest Technology in Reuse Systems

ABSTRACT

Fluidized beds are high-rate biological processes which utilize the surface area provided by very small media. The wastewater is passed upwards through a reactor which is partially filled with a media such as sand.

The small media produces a specific surface area approximately 40 times greater than some currently used media. The hydraulic loading of a fluidized bed is a magnitude of 5 to 15 times greater than conventional biological systems. The increase in hydraulic loading decreases the filter bed area requirements by the same factor.

Fluidized beds have been tested and are being used to treat municipal wastewater. The efficiency of the fluidized beds exceeds all other types of biological treatments.

After careful studies, a full-scale production system is presently being installed at Dworshak National Fish Hatchery. This is the first application of a fluidized bed system in a hatchery production situation.

--David E. Owsley, U.S. Fish & Wildlife Service, Dworshak National Fish Hatchery, Ahsahka, Idaho

"FLUIDIZED BEDS"
The Latest Technology in Reuse Systems

by

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Dworshak National Fish Hatchery, located along the Clearwater River in north central Idaho, was constructed as a reuse hatchery in order to produce a steelhead trout smolt in 1 year. Using raw water, the process would take 2 years. Reuse would increase the production of the hatchery over raw water with the same number of ponds.

Under Phase I construction, System I was completed in 1968. System I consists of 25 Burrows ponds and 8 oyster shell-rock biological filters. The system was designed for a total flow of 15,000 gpm and 10 percent makeup water. The biological filters were operated at 1 gpm/ft^2 in a downflow operation.

Although the oyster shell filters offered good buffering to the deficient North Fork water, the system was shut down in 1978 because the design did not meet the NPDES discharge permit specifications.

Under Phase II construction, Systems II and III were completed in 1972. System II consists of 25 Burrows ponds

and 4 upflow biological filters using 3½-inch Koch rings for the filter media. The system was designed for a total flow of 15,000 gpm and 10 percent makeup water. These biological filters were rated at 2 gpm/ft^2.

System III consists of 34 Burrows ponds and 6 upflow biological filters. The media for these filters was the 3½-inch Koch rings. The system was designed for a total flow of 20,400 gpm and 10 percent makeup water. These biological filters were rated at 2 gpm/ft^2.

Based upon (what was considered at the time) poor ammonia removal efficiency, System II was modified in 1978. The 3½-inch Koch rings were removed and a polyethylene bead material was installed in all four filter beds. The new bead media was smaller and had more surface area than the Koch rings (see Table 1). The smaller media with more surface did improve the ammonia removal efficiency. With this concept in mind, a new biological filter was tested to replace the oyster shell filters in System I.

In late 1978, a fluidized bed pilot system was tested by the Corps of Engineers. Fluidized beds are high-rate biological processes which utilize the surface area provided by very small media. The wastewater is passed upwards through a reactor which is partially filled with a media such as sand.

The small media produces a specific surface area approximately 40 times greater than some currently used media. The

hydraulic loading of a fluidized bed is a magnitude of 5 to 15 times greater than conventional biological systems. The increase in hydraulic loading decreases the filter bed area requirement by the same factor.

The operation of the fluidized bed consists of introducing the wastewater with a velocity sufficient enough to impart motion, or fluidize the bed. After the bed becomes activated with nitrifying bacteria, a biomass will begin to grow on the sand particles. As this biomass grows, the bed will expand to twice the original bed depth. These coated sand particles will decrease in density and rise to the surface of the bed. Once the coated sand particles reach the top of the bed, they are diverted into a separator. The separator shears the biomass from the sand particle and the clean sand is returned to the reactor to start a new process. Because of this process, the fluidized beds are self-cleaning; and once they are in operation, there is no need to take a filter out of operation for cleaning. The cleaning of biological filters has been a severe problem in current reuse systems.

The biomass that is sheared from the sand particle is directed to a waste treatment operation for further disposal.

Fluidized beds have been tested and are being used to treat municipal wastewater. The efficiency of the fluidized beds exceeds all other types of biological treatments. The

pilot study at Dworshak substantiated this efficiency using System II reuse water.

System I is currently being modified to utilize fluidized beds in a hatchery production situation. The new system will undoubtedly have some start-up problems.

Once these problems are overcome, the fluidized beds may prove to be the best biological system available to the fish culturist at today's standards.

The new fluidized bed system at Dworshak is expected to be on line for the 1982 steelhead broodyear. The system will be closely monitored, and those results will be made available after the first year of operation.

Table 1

Media Type	Void Space %	Specific Surface Area ft^2/ft^3	Bed Depth	Hydraulic Loading gpm/ft^2	Efficiency* % Ammonia Removal
Oyster Shell	80	75	5	1	50
1½" Koch Rings	97	40	6	2	40
3½" Koch Rings	98	27	6	2	25
Polyethylene Beads	40	140	3	2	85
Styrofoam Beads	60	120	3	2	50
Expanded Shale	80	65	3	1	50
Flex Pac Waffle Media	96	50	6	2	35
Fluidized Bed (sand)	40-50	1200	2	15	92

*Based on Dworshak NFH water

REDESIGN OF THE PRIEST RAPIDS SALMON HATCHERY*

Vic Kaczynski--CH2M HILL
Bob Hager, Jim Wood--Washington State Department of Fisheries

The Priest Rapids salmon hatchery is located on the east side of the Columbia River, below Priest Rapids Dam. The facility was recently redone as a conventional raceway hatchery for fall chinook salmon. Previously, the raceway facilities were large, serially connected, concrete-lined spawning channel sections with intermittent deeper resting pools.

Five of these spawning channel sections were used to create five independent raceway vessels. The intermediate drop sections were used to create independent drain boxes by installing a transverse concrete wall across them, and by installing drain lines from each drain box to a common drain manifold. Screening and drop boards were also provided to retain the chinook fry and to control raceway water levels, respectively. A common intake manifold supplied water to the raceways from an existing siphon through Priest Rapids Dam (e.g., river water) and from three ground-water wells tapping the Moran Slough aquifer. A separate supply line provides the ground water. Individual, adjustable raceway headers supply water to each raceway independently. Various blends of ground and surface water can result. Initially, the fry are reared on ground water; river water is gradually blended in as the fry grow and, subsequently, their water demand increases. Water is not reused. This is a one-pass system to minimize potential disease problems. Very conservative biological criteria are used (see Table 1).

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*Project modifications performed for Public Utility District Number One of Grant County.

The facility has the capacity to rear 125,000 pounds of actively feeding chinook fry at a release size of 100 per pound (12,500,000 fry).

Ground water (up to 6 cfs) was also supplied to the existing adult holding pond and to the existing egg and alevin incubation building. This ground-water supply should improve adult holding survival and health, egg and alevin survival and health, and general fry quality.

Slides were shown of biocriteria, construction activities, facility components, and initial startup.

Table 1

BIOLOGICAL CRITERIA FOR THE PRIEST RAPIDS SALMON HATCHERY

	Fry	Smolt
Transfer Size/Release	250/pound	100/pound
Maximum Load Density	0.67 lb/cu ft	0.76 lb/cu ft
Maximum Load Rate	2,160 lb/cfs	2,385 lb/cfs
Cross Section (trapezoidal)	25'x41'x4'	25'x41'x4'
Cross Sectional Area	132 sq ft	132 sq ft
Sectional Length	250 ft	250 ft
Sectional Volume	33,000 cu ft	33,000 cu ft
Maximum Carry per Section		
Fish	5,556,000 fry	2,500,000 fry
Pounds	22,224 lb	25,000 lb
Type of Limitation (individual section)	Volume	Volume
Maximum Flow per Section	10.3 cfs	10.5 cfs
Maximum Velocity	0.08 fps	0.1 fps
Water Detention Time	53 minutes	52 minutes
Water Turnover Rate	1.1 times/hour	1.1 times/hour
Total Carry--5 Sections		
Fish	13,888,889 fry	12,500,000 fry
Pounds	66,672 lb	125,000 lb
Sections Required	3	5
Flow Required	30.9 cfs	52.5 cfs

Relationships between sex, coloration and migration tendency in steelhead trout.

R. D. Ewing, M. D. Evenson, E. K. Birks

Parr-smolt transformation in salmonids has been postulated to compete with processes leading to sexual maturity. There have been few studies, however, which have examined indices of parr-smolt transformation in relation to the sex of the fish involved. During the past year, we examined relationships between size, coloration, sex and migration tendency in 2-year-old winter steelhead trout reared at Cole River Hatchery on the Rogue River, Oregon. These fish were part of experimental release groups testing the feasibility of volitional releases in steelhead juveniles.

The original population was graded before the beginning of the experiment on April 2. The precocious males and runts under 6" were removed from the population. The final population consisted of 12,522 fish marked LVRM which had 31% males, 66% females, and 1% precocious males.

These fish were permitted to voluntarily migrate from the raceway from April 2 to June 15 by passing through two openings at the surface of the downstream end of the raceway. The first opening, 6" deep and 3' wide, permitted the fish to pass behind the raceway screens. The fish then passed through a 6" diameter hole onto a trough where they were dewatered, passed by an automatic counter, and were captured in a trap. The fish were then hand counted and permitted to escape into the river.

Peak outmigration occurred on May 11 (Fig. 1), very similar to peaks in previous years. By June 15, emigration had dwindles to almost nothing, leaving 33% of the population still in the raceway.

Samples were taken at two week intervals throughout the migration period for data on lengths, weights, sex and a number of other smolting characteristics for migrant and non-migrant groups designated parrs, partial smolts, and smolts, as estimated visually.

Estimates of percentages of smolts in the population showed a peak in non-migrant populations on April 13 (Fig. 2), fully a month before peak outmigration. With time, this percentage decreased. This decrease could not be accounted for by outmigration of smolts. The most likely conclusion is that they were regressing to a partially-smolted form before emigration occurred.

Since a high percent of females were of a dark color on April 2, we hypothesized that male fish became silvery early and began outmigration before the females. To test this, the sex of each fish was determined after classifying them as parrs, partial smolts or smolts in migrant and non-migrant categories.

If males and females became silvery at the same rates, then the ratio of males/females for smolts should be the same as the male/female ratio of the entire population. When male/female ratios of smolts were compared with that of the population, however, (Fig. 3) the ratio for smolts was always significantly higher than that for the population except on June 8 when migration had all but stopped. This suggests that males were in general more silvery than females.

Secondly, when male/female ratios of migrants were compared with ratios expected from the population, regardless of smolting category, a very large ratio occurred initially in the migrants (Fig. 4), followed by a decline which remained significantly higher than the ratio which would be expected if males and females were migrating equally in proportion to their abundance.

This may also be seen by looking at the percent males and females in the migrant population (Fig. 5).

These results were not due to differences in length between males and females. There were no significant differences between males and females in either migrant or non-migrant categories. The only significant differences in lengths occurred between smolting categories where, in general, smolts were larger than partial smolts which were larger than parr.

We have interpreted this data in terms of a hypothesis suggested by Thorpe (1981) in Atlantic salmon. He postulated that early in development, males make a choice between smolting and becoming precocious and that these states were mutually exclusive. We suggest that in steelhead the females have also made this choice, although development of the gonads is much slower. The females which have taken this option become residuals, taking up residence in the stream after liberation.

If this choice were made equally for the sexes numbers of precocial and residual males should equal that of residual females. Actual ratios indicated that nearly twice the number of males as females became either residual or precocious.

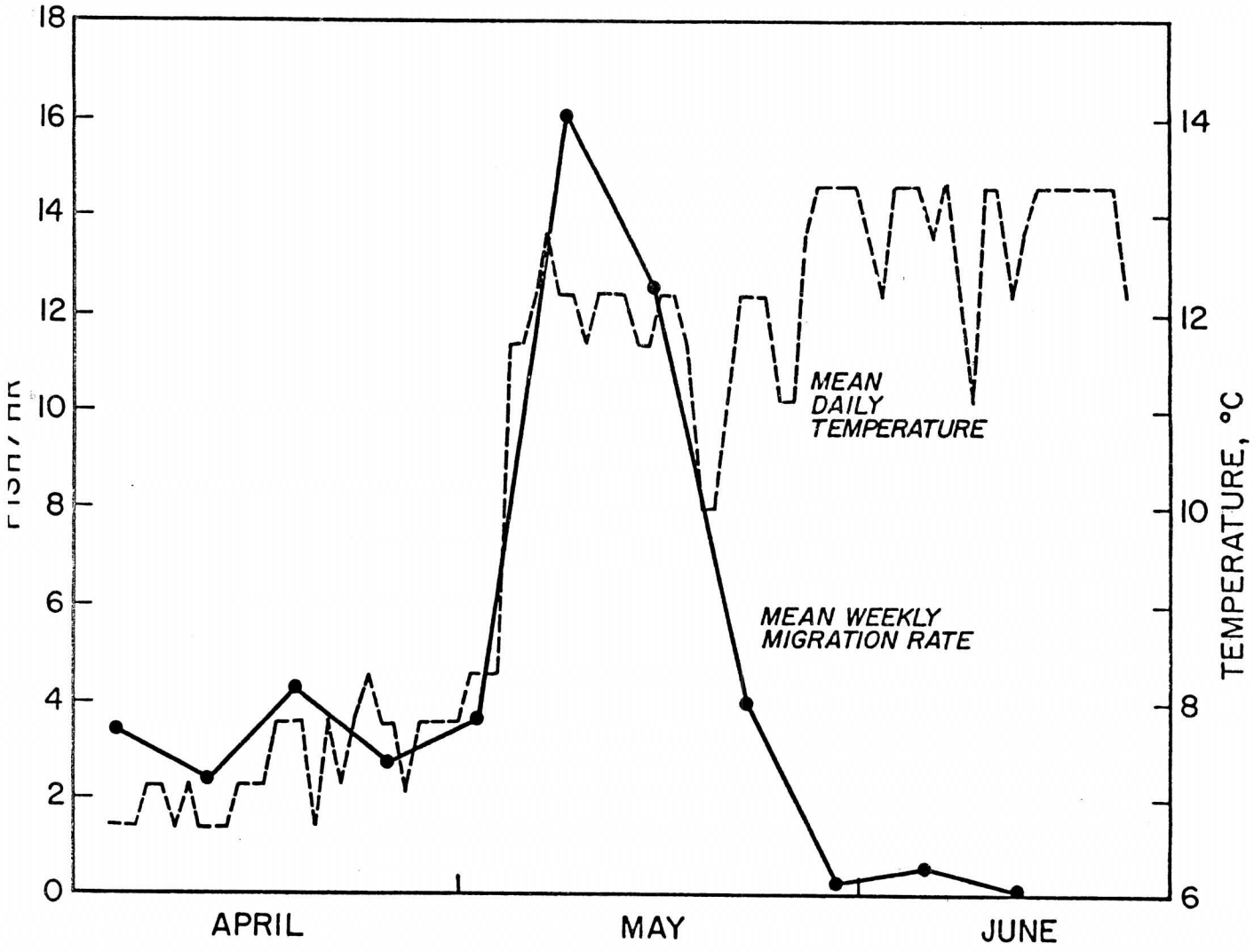

Figure 1 Outmigration of juvenile steelhead with time. Dashed line represents mean daily temperature.

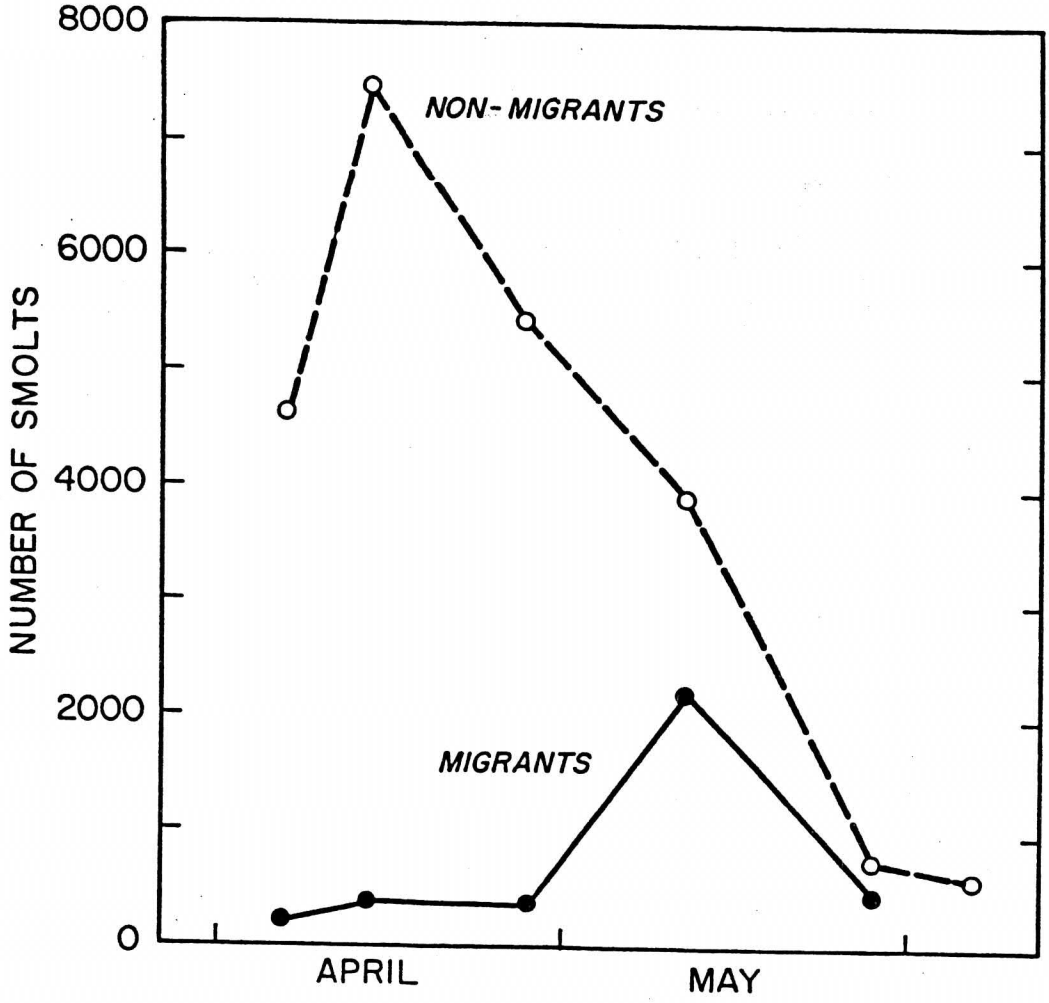

Figure 2 Total number of steelhead smolts in both migrant (o—o) and non-migrant (o--o) population.

COMPARISON OF MALE / FEMALE RATIOS
OF THE POPULATION WITH THAT OF SMOLTS

DATE	POPULATION	SMOLTS
4/13	0.47	0.54
4/27	0.43	0.55
5/11	0.41	0.98
5/27	0.25	0.56
6/8	0.41	0.41

Figure 3 Comparison of male/female ratios of the population of steelhead with those of smolts.

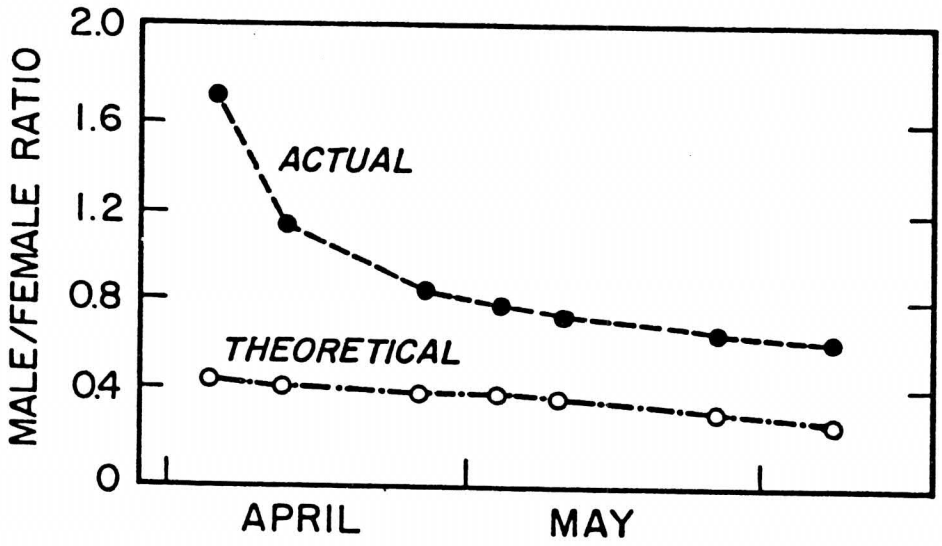

Figure 4 Comparison of male/female ratios of migrant steelhead with those of the total population.

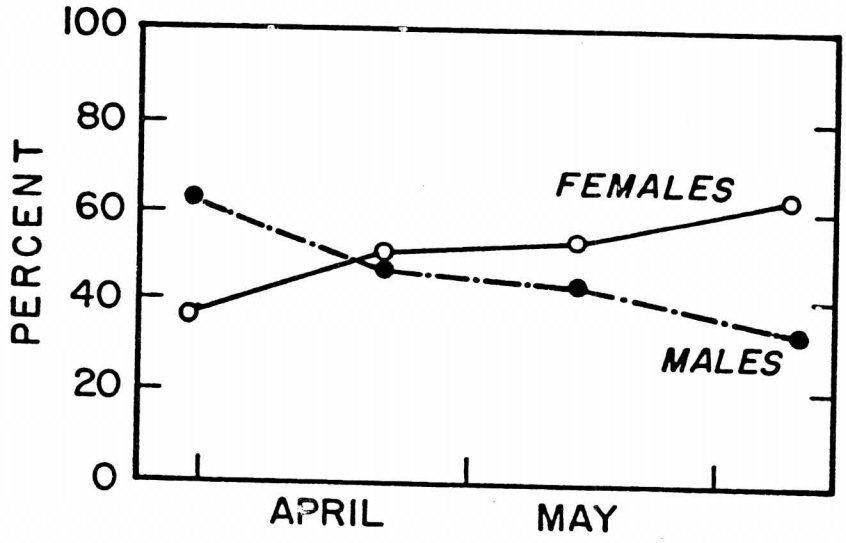

Figure 5 Percentage of males and females in the migrant population with time.

ADEQUATE VITAMIN C IMPROVES RESISTANCE TO STRESS

Barbee Tucker, J.E. Halver and Gary Wedemeyer
University of Washington & U.S. Fish & Wildlife Service

Coho salmon (15gm) were prefed for 3 months with H440 Test Diet containing 1/10 or 2X CTD levels of vitamin C. After 2 months part of low C fed fish were transferred to the high C diet. Resistance to stressors was measured for fish fed different levels of C. The sealed jar test was used to measure time required for anoxia. Hours to loss of equilibrium ranged from 8.3 for low C fed group to 11.5 for the high C fed group. Ascorbate remaining in livers and anterior kidneys reflected most recent dietary intake. Remaining fish were exposed to unexpected laboratory infection which killed most fish in entire wet laboratory, except for one dietary treatment group. Mortality was: low C--100%; low then high C--33%; and high C fed group--0%.

RESPONSE OF MARINE FISH LARVAE TO ARTIFICIAL DIETS

J.R. Villalon, G.M. Pigott and J.E. Halver
University of Washington

A new flow through system was designed and tested with Pacific herring larvae fed Artemia nauplii and two formulated artificial diets. The system consisted of two plastic pails glued together at rims with bottoms removed and container hinged at center with nylon bolt fastened to carrier. Friction rings held Nitex screen on either end. Container was suspended in water bath and provided with small water jet at surface to slowly rotate water cylinder. Daily cleaning was facilitated by covering open end with Nitex held with ring, then slowly rotating container on carrier until bottom Nitex with absorbed debris and mortalities was at surface to be removed and cleaned. System allowed removal of debris with minimum handling and stress on larvae.

Two artificial diets and Artemia nauplii were compared for growth and survival. Diet HP 813 failed to support adequate growth for 6 week test. Survival was also low. Diet HP 815 which contained supplementary amounts of vitamin C_2 (ascorbate-2-sulfate) produced better growth and survival. Artemia nauplii produced best growth but only intermediate survival. Survival on HP 815 was best in these preliminary larval feeding trials.

A MINIMUM THRESHOLD SIZE FOR HATCHERY STEELHEAD SMOLTS IN THE WILLAMETTE RIVER SYSTEM

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Corvallis, Oregon 97331

A hypothesis was first proposed in 1978 that hatchery steelhead smolts less than 18 cm in fork length at release will not be as successful in their freshwater emigration as larger smolts. The minimum threshold size hypothesis, while not an answer to all the size at release questions, reasons that smolts not found emigrating through the freshwater system will not subsequently return as adults. Studies were conducted in Oregon's Willamette River system on an introduced Skamania stock of summer steelhead and a native stock of Willamette winter steelhead.

Over 500,000 Skamania smolts and 80,000 Willamette smolts were released into the upper Willamette tributaries in 1977. Lengths were sampled prior to release on 1,002 Skamania smolts from 11 marked groups and on 1,236 emigrating smolts captured 200 to 340 km downstream at Willamette Falls. Over 46% of all Skamania smolts sampled prior to release were less than 18 cm, yet this size group comprised only 4% of the Skamania smolts sampled at Willamette Falls. A sample of 200 and 241 Willamette winter steelhead smolts from two marked groups were measured prior to release and at Willamette Falls, respectively. Over 20% of the Willamette smolts sampled prior to release were less than 18 cm, yet only 1.2% of this size group appeared at Willamette Falls.

Hatchery smolts may grow from release to the time of their freshwater capture thus confusing the minimum size concept. We conducted studies in 1978 with

Skamania smolts that were captured at Willamette Falls only 7 to 10 days after release. Measurable growth probably could not have occurred during this brief period. When medium sized Skamania smolts (modes of 18 to 20 cm) were compared with small smolts (modes of 17 to 18 cm) the medium group survived significantly better (X^2 = 16.10, d.f. = 1 at 99.5%). Also, few of the fish in the small group that were less than 17 cm emigrated. We conducted studies in 1980 with Willamette winter steelhead that were captured only 25 to 35 km downstream from their release sites on the South Santiam River. Emigrating smolts were captured by trapping a concrete spillway with an incline plan trap and with electroshocking gear. Peak capture was 7 to 10 days after release. Lengths sampled from a marked group prior to release found 15% less than 18 cm, yet only 1% of this group were captured downstream.

Discussion with Earl Dawley of the National Marine Fisheries Service supports our hypothesis. Seining of juvenile salmon and steelhead on the Lower Columbia River near Jones Beach found few marked fish from either Skamania or Willamette stocks less than 18 cm in fork length. However, his studies did indicate that some upper Columbia River stocks may have lower threshold sizes than for those released into the Willamette River. We conclude the following: 1) A minimum threshold size of less than 18 cm significantly reduces freshwater emigration in the Willamette River for Skamania and Willamette steelhead stocks. 2) Managers should be aware that a minimum size may exist for each of the many steelhead stocks released on the Pacific Coast. 3) Samples of individual lengths taken at or near the release time will better describe the actual size of a release group than samples of average weights. Average weights will not describe the variance of a population or the percentages less than a given desired size. 4) Sampling individual lengths throughout the rearing period will better help managers select the time and size to grade a given population.

ANNUAL NORTHWEST FISH CULTURE CONFERENCES
HISTORICAL RECORD

Year	Location	Host Agency	Chairman
1950	Portland, Oregon	U.S. Fish & Wildlife Servcie	Perry, T.
1951	Wenatchee, Washington	U.S. Fish & Wildlife Service	Burrows, R.
1952	Seattle, Washington	Wash. Dept. of Fisheries	Ellis, B.
1953	Portland, Oregon	Oregon Fish Commission	Cleaver, F.
1954	Seattle, Washington	U.S. Fish & Wildlife Service	Rucker, R.
1955	Portland, Oregon	Oregon Game Commission	Rayner, J.
1956	Seattle, Washington	Wash. Dept. of Game	Millenbach, C.
1957	Portland, Oregon	U.S. Fish & Wildlife Service	Johnson, Harlan
1958	Seattle, Washington	Wash. Dept. of Fisheries	Ellis, R.
1959	Portland, Oregon	Oregon Fish Commission	Jeffries, E.
1960	Olympia, Washington	Wash. Dept. of Game	Johansen, J.
1961	Portland, Oregon	Oregon Game Commission	Jensen, C.
1962	Longview, Washington	U.S. Fish & Wildlife Service	Burrows, R.
1963	Olympia, Washington	Wash. Dept. of Fisheries	Ellis, B.
1964	Corvallis, Oregon	Oregon State University	Fryer, J.
1965	Portland, Oregon	U.S. Fish & Wildlife Service	Halver, J.
1966	Portland, Oregon	Oregon Fish Commission	Hublou, W.
1967	Seattle, Washington	University of Washington	Donaldson, L.
1968	Boise, Idaho	Idaho Fish & Game Department	Cuplin, P.
1969	Olympia, Washington	Wash. Dept. of Game	Johansen, J.
1970	Portland, Oregon	Oregon Game Commission	Jensen, C.
1971	Portland, Oregon	U.S. Fish & Wildlife Service	Smith, M.
1972	Seattle-Tacoma, Wash.	Wash. Dept. of Fisheries	Noble, R.
1973	Wemme, Oregon	Oregon Fish Commission	Jeffries, E.
1974	Seattle, Washington	University of Washington	Salo-Brannon
1975	Newport, Oregon (Otter Crest)	Oregon State University	Donaldson, J.
1976	Twin Falls, Idaho	University of Idaho	Klontz, B.
1977	Olympia, Washington	Wash. Dept. of Game	Morrow, J.
1978	Vancouver, Washington	U.S. Fish & Wildlife Service	Leith, D.
1979	Portland, Oregon	Oregon Dept. of Fish & Wildlife	Jeffries, E.
1980	Courtenay, British Columbia	Fisheries and Oceans	Sandercock, K.
1981	Tumwater, Washington	Wash. Dept. of Fisheries	Ashcraft, W.
1982	Portland, Oregon	National Marine Fisheries Service	Wold, E.
1983		Idaho Fish & Game and University of Idaho	