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PROCEEDINGS OF THE

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NOVEMBER 30 -
DECEMBER 2, 1982

PROCEEDINGS

of the

Thirty-third Annual

NORTHWEST FISH CULTURE WORKSHOP

November 30 - December 2, 1982

Chairman

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THE NORTHWEST FISH CULTURE WORKSHOP

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

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

PREFACE

The thirty-third Annual Northwest Fish Culture Workshop (Conference) was held at Salishan Lodge, Gleneden Beach, Oregon on November 30 - December 2, 1982.

In an attempt to return the Fish Culture Workshop to the working fish culturist, the agenda was structured to provide the latest fish culture techniques and advancements. According to the reception by the workshop participants, this thrust was appreciated and endorsed.

I sincerely thank all who participated in the workshop. I particularly appreciate the efforts of Bob Smith, Roy Wahle, and Mike Delarm, who kept the program on schedule and running smoothly.

Papers submitted by speakers as well as several transcripts submitted but not discussed during the session are included in these proceedings. Discussions following presentations were recorded and are included where appropriate.

A subject/author index for the proceedings of previous conferences/ workshops was prepared and provided to all participants. Those people who could not attend the workshop but ordered copies of the proceedings will also receive copies of the index.

Drawings were held during the workshop and prizes donated by several companies were distributed to the following lucky workshop participants:

Prize	Donated by	Winner
Salmon Charter Trip for 2	Bioproducts, Inc.	Mike Blanchard
Salmon Charter Trip for 2	Becker Industries & Newport Tradewinds	James Wood
Rod & Reel	Moore-Clark Co.	Donald Ratliff
Mid-Winter Escape Pkg	Salishan Lodge	Larry Wimer

The Idaho Fish and Game Department and the University of Idaho will co-host the 1983 workshop at the Best Western University Inn in Moscow, Idaho, on December 6-8, 1983. Evan Parrish and George Klontz will be Co-Chairmen. The Washington Department of Game will host the 1984 workshop.

Einar Wold

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BULK EYEING IN DEEP TROUGH SECTIONS

by

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Oregon's involvement in bulk incubation appears to have started from an idea brought back from the Washington Department of Fisheries, who picked it up from Japan, who in turn got the idea from the New England States at the turn of the century. There are many variations of the technique which include the use of buckets, boxes, barrels or troughs. Apparently the only new ideas are those using innovations for specific needs. This paper deals with the eyeing-up of Chinook eggs at the ODFW Bonneville and Big Creek Hatcheries. Prior to its full scale use at these stations, testing was done by Bill Nyara, ODFW Hatcheryman at the Sandy Hatchery, upon the suggestion of George Smalley, past ODFW Hatchery Co-ordinator.

The system at ODFW stations utilizes a .090 thick aluminum plate of 5052-H32 alloy with 1/8" holes on 3/16" centers allowing 1/16" metal between holes. For our use, the plates were cut 15 1/8" X 16 3/16".

After receiving the plates from the metal shop, holes were drilled in each corner and 1 1/4" X 1/4" stainless steel machine screws were attached to serve as legs to hold the plate off the bottom of the trough. The plates were then inserted between the dam and riffle tin to create a container out of each deep trough section.

Water flows to each trough were set at 6 GPM which allows eggs to be poured into the section without spilling over the dam tin. It should be noted that a clean water source is required for this system. Sediment or debris can plug the holes causing the flow to run over the trough wall rather than through the plates.

Having used various loading capacities for a season, it was determined that 100,000 eggs/section was an acceptable number. Spawning was accomplished so that three buckets would fill one section and all eggs were washed prior to placing them in the troughs. On the day following spawning, water flows were increased to 10 GPM and held there until the eggs were ready to be shocked. During this period, eggs were treated three times a week with a 1:600 Formalin treatment.

Shocking is accomplished by siphoning the eggs into buckets, which are then poured into baskets. Each section of 100,000 is split into four baskets and held for salting, picking, counting and finally tray down.

The first consideration in evaluating the process was to compare egg mortalities with prior years. The results showed that there was no increase in egg loss due to eyeing-up eggs in this manner. Resulting fry showed no effects or increased mortality.

The other thought was what effect this technique had on the normal work load through the eyeing-up period. At the stocking rate of one million eggs per trough the number of troughs used was 25% of the usual holding method. It also resulted in 1/4 the amount of water usage, egg treatment time, amount of chemical used and general time spent caring for the eggs. More effort was expended at the time of shocking due to transferring the eggs to baskets for thinning purposes, however this extra effort did not offset the amount of time saved during the eyeing-up stage.

SUBSTRATE INCUBATION WITHOUT SHOCKING OR PICKING

by Ladd Macaulay, fish culturist
Douglas Island Pink & Chum, Inc.
November 16, 1982

For several years the Kowee Creek and Sheep Creek hatchery operations, located in Juneau, Alaska, have been incubating pink and chum salmon eggs without shocking or picking. The green/egg to fry survival rates have averaged above 90%. With the thought of never having to pick another dead egg or the little effort required to clean substrate due to the lack of dead egg clusters, little reason remains not to recommend for those considering raising large numbers of salmon that require substrate incubation, the following:

Equipment

1. NOPAD incubators, (Zenger box $695/box) 4 or 5 per stack.
2. Plastic substrate (Bio-rings or saddle loops $25-50/incubator).
3. NOPAD egg tray (4 mm for pinks & 6 mm for chums, $30/tray).
4. 1000 cc IV bottle.

Technique

1. 10 gpm of water per incubator stack.
2. 300,000 pink eggs/tray, 180,000 chum eggs/tray.
3. Formaldehyde 37% (15 minute drip method).

The Sheep Creek hatchery uses NOPAD incubators with egg densities of 300,000 pinks/incubator or 180,000 chums/incubator and has been stacking them four high with excellent results. The aluminum incubator is designed as a vertical stack substrate incubator. It measures 4 feet square and 14 inches high. The incubator has an aluminum up-welling plate that provides even water flow through the plastic substrate. Not more than 8-10 gallons per minute of water is required by each stack until fry release. At that time one may wish to increase the water flow as a means of flushing the fry out. The water temperatures have varied under the heavy loading densities from 33' to 48' F with no ill effects noted. The DO readings on the lowest incubator have not varied 1-2 ppm from the readings taken from the top incubator. DO saturation or near saturation levels are the usual operating norm.

Plastic saddle loop substrate is considered the Cadillac of substrate as it packs well under the NOPAD egg trays but it is also the most expensive. The bio-rings cost less, do not cut and scratch as much when handling but require more time and effort getting their "heads down" in order to lay the egg tray over them. Either substrate works well and either is recommeded.

The NOPAD egg trays are sized specifically to lay on top of the substrate inside the NOPAD incubators. The trays are available with either 4 mm plastic screen for pinks or 6 mm plastic screen for chums. The aluminum egg tray frame measures approximatly 40 inches square and is held in place by two fry-release gates. The egg trays can be removed from the incubators easily and at any time.

The 4 mm screen has been sucessfully used with chum eggs; however, the time it takes for the alevins to fall through the screen is longer. This in turn requires a lower density of seeding to be recommended; therefore, the switch to the 6 mm screen is preferred. The maximum density levels experienced using the egg trays and experiencing no mortality problems is:

A. 4 mm egg tray, 300,000 pink eggs/tray at 10 gpm.
B. 6 mm egg tray, 180,000 chum eggs/tray at 10 gpm

At the above densities the incubators have been stacked four high with no problems. The incubators have been stacked five high in previous years but the egg trays were not in use at the time. I am convinced one could go higher; however, it is easier to look into the top incubator of a stack of four and necessity has not required us to go higher at this time.

The technique for incubation is thus quite simple. Either fertilized or eyed eggs are placed on an egg tray, treated with formaldehyde by the drip method once a week until hatching, then the egg tray is removed once the alevin have passed through the screen. The dead or non-fertile eggs are rinsed, counted and disposed of, leaving the alevins in a clean substrate environment. Thus no shocking or egg picking.

INITIAL RESULTS OF USING HEATED WATER TO ADVANCE GROWTH OF FISH AT MARION FORKS HATCHERY

by

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97330

Based on adult return per smolt released, Marion Forks Hatchery has been the least successful of the ODFW's Willamette River Spring Chinook Hatchery complex. Only about 0.1% of the spring chinook smolts released, on the average, return to the release site as adults.

We believe that these rather poor adult returns may be at least partly associated with smolt size. Incubation and rearing water at Marion Forks is cold during much of the year. As a result, smolts from Marion Forks rarely exceed 20 fish/lb after one year of intensive hatchery rearing. Most of our marking and tagging studies have shown that adult return is directly correlated with smolt size; that is, bigger smolts usually bring back more adults than small smolts.

In the mid-1960's, attempts were made to increase smolt size at Marion Forks by incubating the Marion Forks eggs at another Willamette River hatchery, starting the fish at this station with warmer water, and then bringing the fish back to Marion Forks for finish rearing and release. While this operation did increase average smolt size, it did not improve returns of adults to Minto. In fact, adult returns dwindled. This may be the result of importation of diseases or reduced numbers of smolts released. While smolt size was increasing, fewer adults were

returning.

In 1980, we decided to try heated water at Marion Forks to advance sizes of young fish in their early development. We theorized that we could achieve larger fish within the existing hatchery regime while avoiding the problems of imported diseases. We wanted to know:

1. Could we get a practical design for the heated-water facilities?
2. How much would it cost?
3. How much improvement in growth would we get?
4. Will the cost of advancing fish growth provide adequate adult benefits to be justified?

In 1981 we built the water-heating facilities and started test groups of 1981-brood spring chinook. We now have preliminary information on equipment, costs and effects on fish sizes. The purpose of my talk today is to discuss these initial results.

Methods and Materials

Upon approval from staff and the Corps of Engineers, in 1980, blue prints were drawn up by our Engineering Section after input from Marion Forks Hatchery personnel. The system is relatively simple, consisting of a 90 KW electric water boiler, a packed column for gas removal and aeration, cold water and hot water PVC piping and valves, a ½ Hp booster pump and flow switch, 24 single stacks of Heath incubators, two fiberglass rearing tanks, and a low water alarm system (Fig. 1). Detailed plans and specifications are available from the Oregon Department of Fish and Wildlife.

Incubator

Our experiments were conducted from December,1981 to October,1982. Two groups of eyed North Santiam stock spring chinook eggs with 611 temperature units were placed in Heath incubator trays at 4000 eggs/tray through

hatching. The first group consisted of 55,000 eggs and the second group 50,000 eggs. Water was heated and mixed to maintain a continuous 10 to 13 degree F temperature above the raw water.

Intake water passed through the electric boiler by use of a ½ Hp booster pump through two inch PVC pipe and upward to a packed column utilizing Koch rings for gas removal and aeration. Heated water then gravity fed downward to the incubator stacks and fiberglass rearing tanks. Heated water quantities into each incubator stack were regulated by ½ inch PVC ball valves and raw water quantities by one inch PVC ball valves. Water flows through each incubator stack were maintained at 4 GPM. A box was designed and constructed which was located on top of each stack of incubators. The box served three major functions: (a) As a mixing area for heated water and raw water to achieve the desired water temperature to the incubator stack. (b) A method for mounting a float switch for a low water flow alarm. (c) Filter for silt and other debris. Total dissolved gasses were monitored three times daily with a saturometer and dissolved oxygen by use of a Hach kit.

Rearing Tanks

Two 21 x 2.5 x 2 ft. fiberglass tanks were set up in series and stocked with swimups, Tank #1 at 55,000 fish, and Tank #2 at 50,000 fish. Heated water from the electric boiler system and raw water was introduced into a mixing/alarm box where the desired temperature was attained. Flows to the tanks was increased over the period of study as the fish poundage increased, ranging from 20 GPM in late January to a maximum of 55 GPM in late March (Table 1) and thereafter, achieving a terminal density of 5.1 pounds of fish/GPM (290 lbs/tank). Fingerlings were fed a standard diet of Oregon Moist Pellets, beginning with mash and graduating

through size 1/16 inch as fish size increased. Rearing tanks were cleaned twice daily to assure sanitation.

Results

Swimups from Group 1 were ponded into heated-water rearing Tank #1 at 1,388/lb on January 23, 1982. Swimups from Group 2 were ponded into Rearing Tank #2 on February 16 at 1,380/lb. Both groups were moved to outside circular ponds in mid-April at 190/lb (Group 1) and 330/lb (Group 2). At the same date, the majority of the production fish which had not been exposed to heated water were sac fry and/or eggs (Fig. 2).

Even after heat-advanced fish were moved to outside rearing ponds, they continued to display a significant growth advantage over control production groups. Through the end of October, 1982, both heat-advanced groups were 9.8 fish/lb and had a cumulative food conversion of 1.51, while historic conversion at this station at time of spring release has been 2.0. The control group was 35 fish/lb (Fig. 3), and had a cumulative food conversion of 1.43. Based on past performance, we expect a terminal food conversion of 2.0 on these production fish. The uniform large size and length frequency distribution (Fig. 4) justified fall release of the heat-advanced fish, a situation never before achieved at Marion Forks Hatchery.

The apparatus installed at Marion Forks cost approximately $17,000. Since relatively little heated water is required to incubate eggs, we feel we can use the existing apparatus and incubator system to maintain the entire hatchery production of 1.5 million eggs through the swimup stage. Early rearing capability is currently limited by volume of rearing troughs to about 100,000 fingerlings. We believe the existing system can be used to double this figure, so we have ordered two additional fiberglass tanks, costing $1,400 each.

Based on comparison of total power costs at the hatchery between 1982 and 1981, it appears that the program of heating water to advance early fish development that we followed in 1982 cost approximately $5,200. As we gain more experience with the system and incorporate more rearing troughs, this figure may increase. While the initial capital cost of the facilities themselves can be amortized over 10-20 years, power expenses will substantially increase operation costs at the hatchery. We are therefore planning extensive tagging studies to assure that the costs of advancing fish growth provides adequate adult returns to be economically justified. Based on these initial results and the current high economic values associated with spring chinook salmon, we are optimistic about the prospects of achieving a favorable cost benefit.

Conclusions

Our first experience with using heated water to advance fish growth at Marion Forks Hatchery resulted in the largest spring chinook smolt ever produced at Marion Forks Hatchery by the fall of the first year. The size of these smolts justified fall release. Continued excellent growth and food conversion was observed even after fingerlings were moved from the heated water to colder water in the outside ponds, illustrating the importance of early development on ultimate fish growth performance.

While these initial results cannot be considered entirely conclusive, we are extremely pleased with the progress observed. We are optimistic that future experience with this water-heating system may allow us to produce more uniform fish sizes at time of release by manipulating time of egg exposure to heated water. Since bimodality of length frequency is sometimes a problem at some other ODFW stations that rear spring chinook, we feel results of our tests at Marion Forks may have application beyond

Marion Forks. Presumably, we could manipulate fish growth to eliminate the need for grading in the fall.

We anticipate evaluating the effects of heat-advancing growth via marking and tagging studies. If adult returns from heat-advanced smolts are as good as we expect, we think we can develop the option of tailor-making a smolt of a given size at a given time for release to maximize adult returns, which is the ultimate goal of any anadromous fish hatchery.

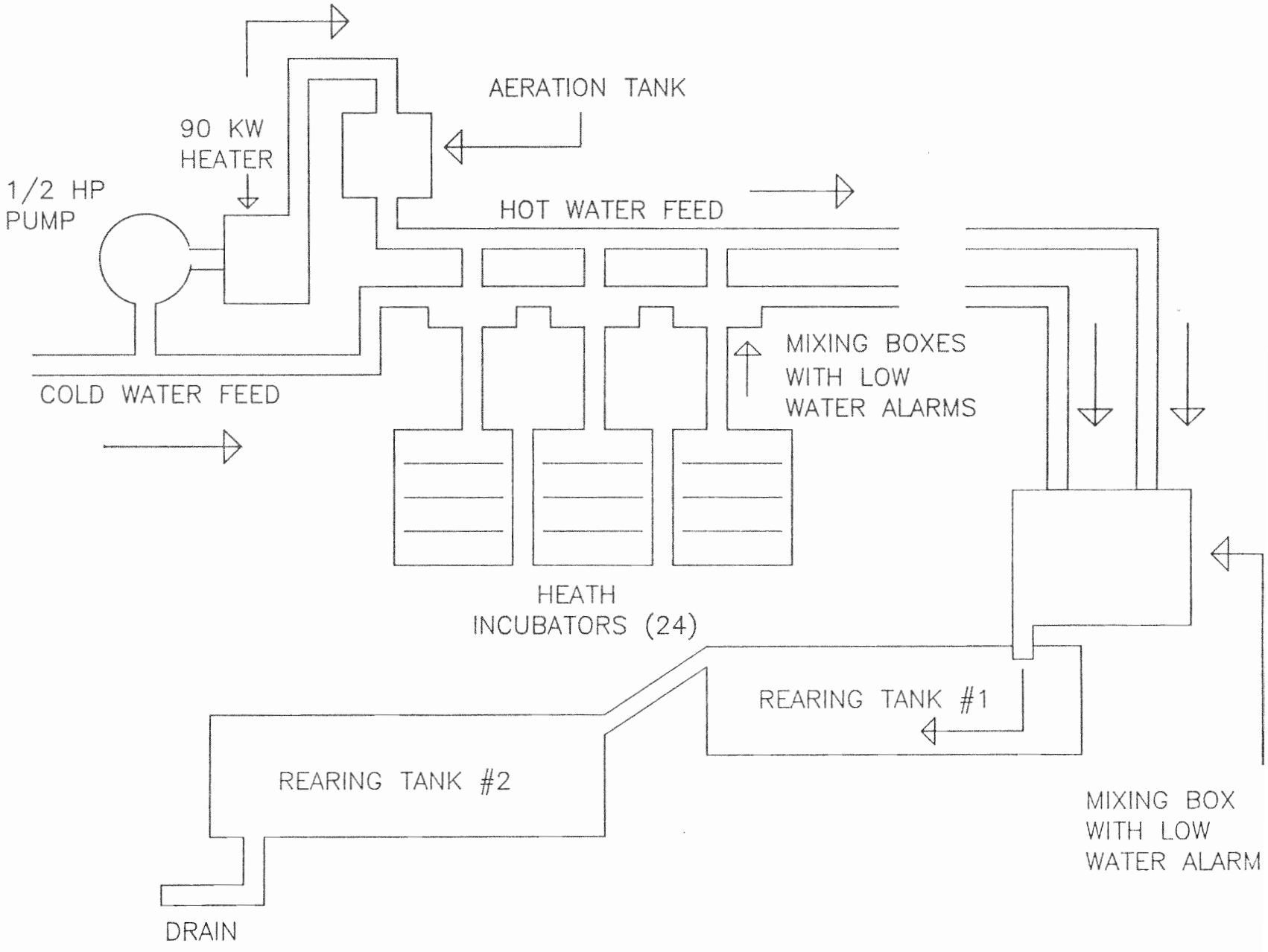


Fig. 1. Diagram of water heating system, Marion Forks Hatchery

Table 1. Results of rearing in heated troughs, Marion Forks Hatchery, 1981-brood spring chinook smolts.

Date 1982	Heated Water Inflow - GPM	Group 1		Group 2	
		Fish/Lb	Mort.	Fish/Lb	Mort.
1/23	20	(Ponded)1388			
2/1	20	1268	932		
2/3	20	1182	270		
2/8	30	1085	38		
2/12	30	962	26		
2/16	50	817	75	(Ponded)1380	
2/22	50	738	26	1300	1364
2/26	50	616	30	--	837
3/1	50	602	19	1122	311
3/5	50	556	38	1050	75
3/10	50	469	34	921	106
3/15	50	391	24	788	81
3/20	50	370	13	675	50
3/24	50	304	6	569	17
3/28	55	284	12	554	39
3/31	55	255	3	--	--
4/2	55	240	0	454	20
4/5	55	235	6	--	--
4/7	55	212	4	382	14
4/11	55	190	6	349	18
4/12	55	190	--	--	--
4/16	30	Ponded Outside 4/12		330	31
4/19	30			Ponded Outside 4/19	24

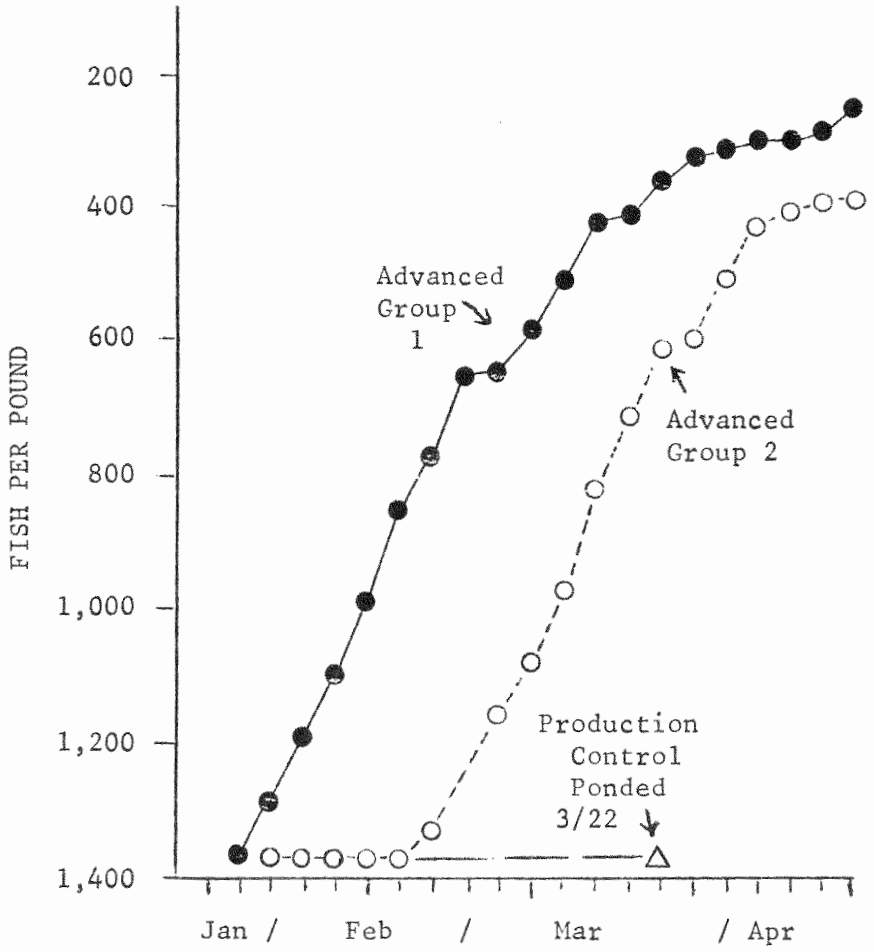


Fig. 2. Early growth performance, spring chinook salmon, Marion Forks Hatchery, January through mid-April, 1982.

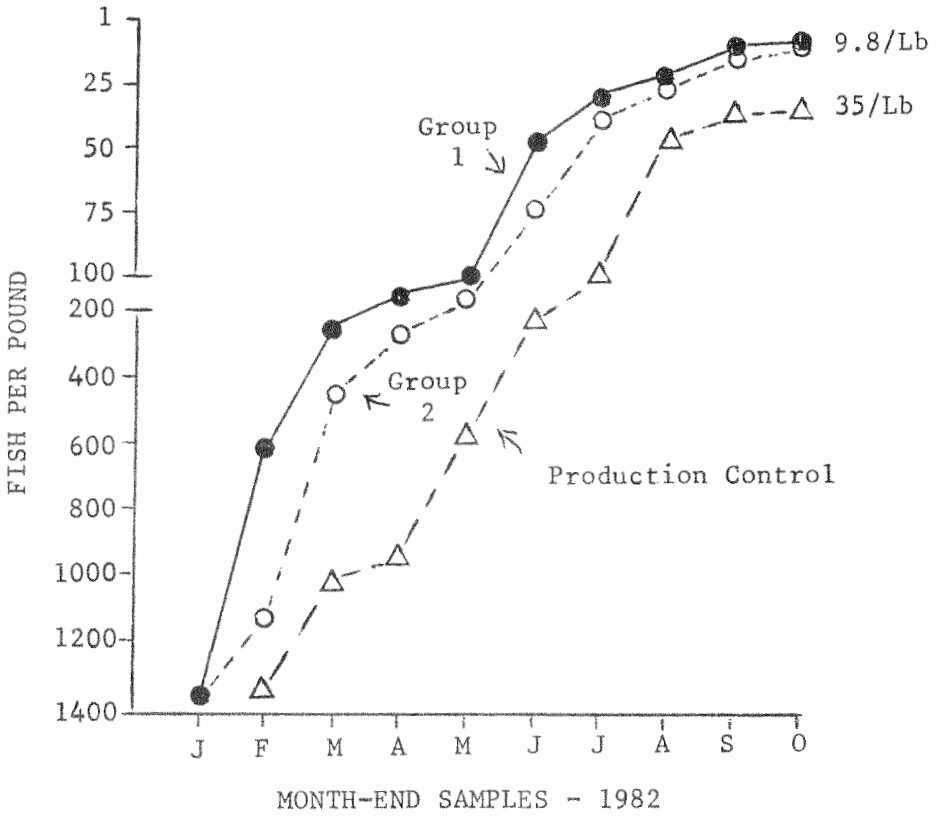


Fig. 3. Comparison of growth performance, 1981-brood spring chinook salmon at Marion Forks Hatchery.

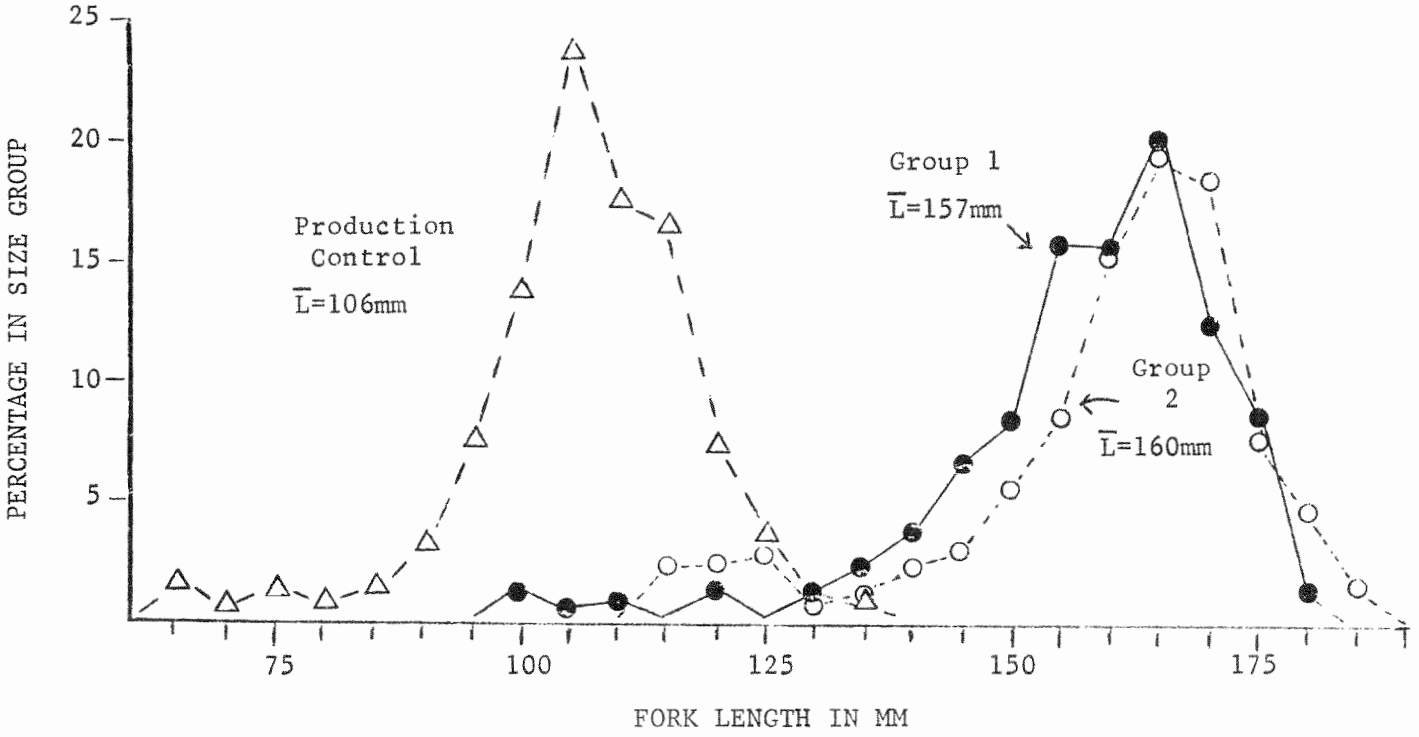


Fig. 4. Length frequency at release, Marion Forks spring chinook, 1982.

JAR INCUBATION OF SALMONID EGGS FROM GREEN TO SWIM-UP

Wayne H. Olson

U.S. Fish and Wildlife Service
Dworshak National Fish Hatchery
Ahsahka, Idaho

Jar incubation of salmonid eggs is not a new concept. It has been used successfully to some extent at a number of hatcheries.

Dworshak National Fish Hatchery began testing use of plexiglass hatching jars in 1977 on steelhead eggs. Eleven jars were constructed similar to a design used at several federal trout hatcheries in Regions 2 and 6 of the Fish and Wildlife Service. Success was apparent in eye-up of eggs; however, some losses developed at hatching time. Emerging sac fry changed hydraulics of the water flow causing dead spots through the jar from an uneven flow pattern.

Several design changes were tested at the hatchery in 1979 and 1980 to correct the problem of losses in sac fry. This was especially important to Dworshak's program as hatching jars were being considered for use on tanks in the new nursery building.

The original jar was constructed of 12-inch diameter acrylic pipe, 18-inches high. A perforated screen holds eggs off the bottom. Under the screen, four 3/4-inch PVC elbows direct water against the bottom with flow moving upward through the eggs to an overflow (figure 1).

The modified hatching jar, designed by Rolf Simonsen, consists of a 6-inch

diameter pipe (24-inches high), inserted into a 12-inch pipe of lesser height. The flow is forced down in the 12-inch pipe and up in the 6-inch pipe. Eggs are in the smaller jar. The hydraulics allows for an even flow pattern through hatching and swim-up (figure 2).

It is now possible with a change in design to successfully complete the entire hatching process at the nursery tank. Green eggs from steelhead and spring chinook are placed directly into the jars from the spawning room. These eggs develop and once hatched, swim into the tank. Separation of dead eggs can be done by pouring remaining fry through an egg basket while emptying the jar into the tank. No dead spots are noticed in the jar as seen in the earlier design. Fungus treatments are not needed in jar incubation but must be continued when incubating in trays.

Jar incubation has been further expanded at Dworshak to include one jar on each of the 128 nursery tanks and plumbed separately to the water supply. Jars are loaded with the number of eggs needed for fingerling production from each tank. A table has also been constructed for the incubator room to hold 40 jars for eye-up use only. All 168 jars were constructed at an average materials cost of $42, using station labor to complete.

Our experience with the hatching jar indicates that the number of eyed eggs to carry through to swim-up is; 20,000 for chinook, 25,000 for steelhead, and 40,000 for rainbow trout. The limiting factor for number of eggs held in a jar from green to eye-up appears to be container size; water flows adjusted accordingly. The hatchery uses 2-3 gallons per minute (gpm) on green eggs, 5 gpm when eyed, and 4 gpm at hatching time.

Dworshak's steelhead capacity, using jars, is 5.5 million green eggs. Stacked tray incubation can also be used to supplement the program and allow for additional egg capacity, when needed.

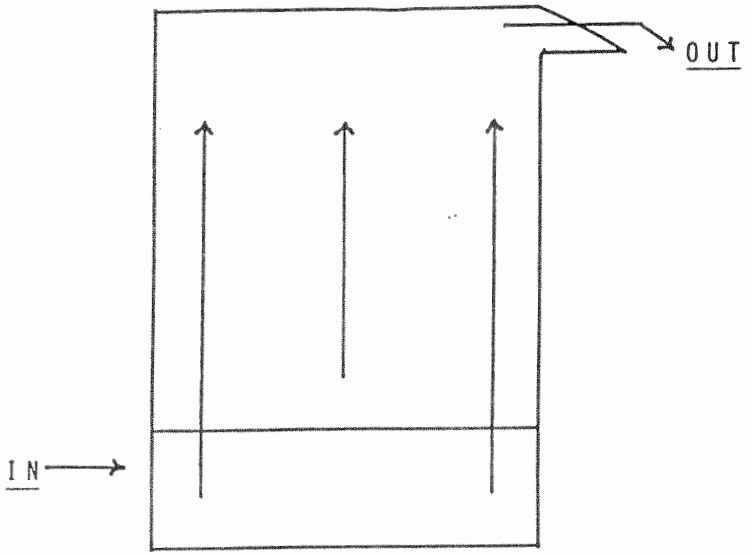


FIGURE 1. ORIGINAL HATCHING JAR
FLOW PATTERN UPWARD IN 12-INCH COLUMN

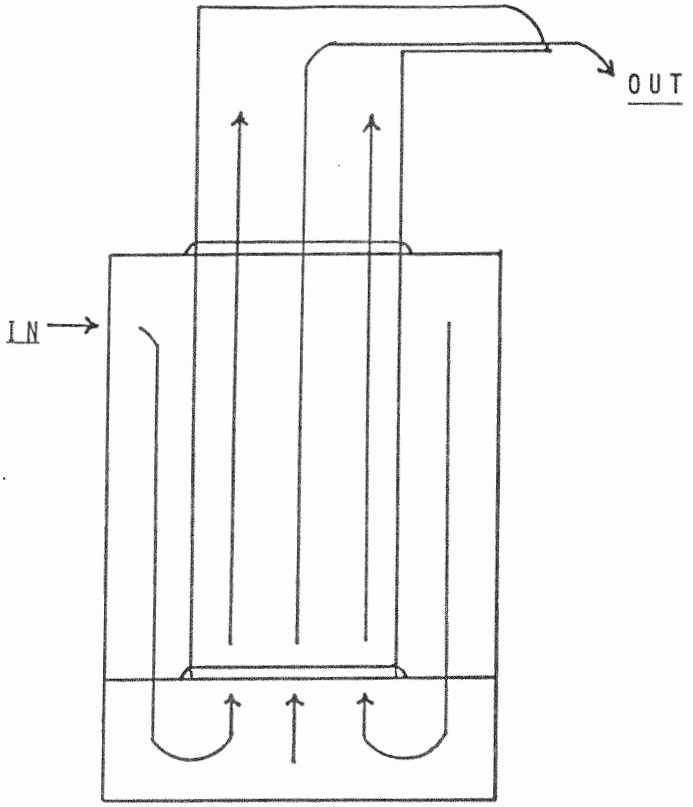


FIGURE 2. MODIFIED HATCHING JAR
DOWNWARD FLOW IN 12-INCH COLUMN
UPWARD FLOW IN 6-INCH COLUMN

Use of Controlled Photoperiod for
Advancing Maturity of Spring Chinook Salmon Brood Stock

Ronnie Wong, Assistant Manager
Little White Salmon-Willard National Fish Hatchery

PHOTOPERIOD CONTROL

The Little White Salmon-Willard NFH Complex is located approximately 60 miles east of Vancouver, Washington, on the Little White Salmon River. Our schedule is to plant 2.5 million silver salmon from Willard NFH. At Little White Salmon NFH our schedule is to plant 8.5 million fall chinook salmon and 750,000 spring chinook salmon each year.

We are trying to raise a larger spring chinook salmon smolt at release (schedule to plant at 15 fish/lb.) and initiated a photoperiod control study.

A temporary building was constructed over a raceway (8 ft. x 63 ft.) in 1970. This building contained 8 florescent light fixtures,(8 feet long at 40 watts per bulb) each fixture containing two bulbs. The florescent lights were eight feet above the surface of the water.

Starting with 12 hours of light per day, we reduced the light 2 hours per week until we attained 4 hours of light per day.

Spawning date before we initiated the light study was mid August. With the light study, spawning started about a month earlier in mid July.

With the light study (temporary building-florescent lights) we:

1. Reduced date of spawning by about one month.
2. Saw that egg size at spawning was smaller.
3. Used Oct. 1 date (7 months prior to normal April plant) for comparisons of size as planting dates varied. With the light study, fish were larger at the Oct. 1 date.

The temporary building was torn down in 1975. A metal (aluminum) building was built in 1979 and covered 60 feet of two brood ponds (10 feet x 240 feet). This new building has six sodium vapor lights, three over each pond, about 10 feet above the water.

Starting with 12 hours of light per day we reduced the light 30 minutes per week until spawning (approximately 5 even hours per day of light).

Spawning date before we initiated the light study (in new building) was still mid August. With the light study, spawning started about a month earlier, in mid July.

With the light study (new aluminum building-sodium vapor lights) we found:

1. Reduction in spawning date by about one month.
2. Egg size at spawning was smaller.
3. No difference in % eye up of eggs.

4. Fry at initial feeding started one month earlier.
5. Fry at initial feeding smaller in size.
6. With the Oct. 1 comparison date, fish are larger by about 10 fish per pound.
7. With 1981 brood year fish, fingerling smolted about one year prior to normal April release.

Light Control (Aluminum Building - Sodium Vapor Lights)

Brood Year	Date Spawn	Eggs/Lb	# Eggs/ Female	% Eye Up	1st Feeding Fish/Lb Date	Plant Fish/Lb Date	Fish/Lb Oct. 1
1980	7/22/80	2,275	3,876	81.5	1,705 11/12/80	17.1 2/20/82	18.4
1981	7/16/81	2,429	3,476	92.6	1,880 10/29/80		21.4
1982	7/20/82	2,064	4,413	88.0	1,554 11/8/82		

Before Light Control (Aluminum Building)

Brood Year	Date Spawn	Eggs/Lb	# Eggs/ Female	% Eye Up	1st Feeding Fish/Lb Date	Plant Fish/Lb Date	Fish/Lb Oct. 1
1976	8/11/76	1,835	4,602	88.6	1,390 12/28/76	18.9 4/20/78	30.4
1977	8/17/77	1,978	3,690	74.6	1,539 12/24/77	19.9 4/26/79	29.6
1978	8/15/78	1,728	4,853	91.1	1,282 12/15/78	21.5 4/16/80	38.3
1979	8/17/79	1,964	3,554	83.5	1,465 12/10/79	19.4 4/20/81	34.3

Light Control (Temporary Building - Florescent Lights)

Brood Year	Date Spawn	Eggs/Lb	# Eggs/ Female	% Eye Up	1st Feeding Fish/Lb Date	Plant Fish/Lb Date	Fish/Lb Oct. 1
1970	7/22/70				1,548 11/1/70	19.1 1/20/72	24.9
1971	7/29/71				1,671 12/4/71	12.6 4/19/73	24.4
1972	7/12/72				1,430 11/12/72	21.0 1/15/74 Combined w/fish not under lights.	22.4
1973	7/26/73				1,439 11/28/73	12.2 4/17/75	16.8
1974	7/24/74	2,176	4,418	62.3	1,526 11/20/74	19.3 4/20/76	32.9
1975	7/22/75	2,347	3,526	93.6	1,867 11/24/75	16.5 5/2/77	

Before Light Control (Temporary Building)

Brood Year	Date Spawn	Eggs/Lb	# Eggs/ Female	% Eye Up	1st Feeding Fish/Lb Date	Plant Fish/Lb Date	Fish/Lb Oct. 1
1968	8/21/68				1,679 12/18/68		
1969	8/19/69	1,915	5,445	94.7	1,300 1/6/70		44.2
1975	8/20/75	1,991	3,805	91.6			

USE OF EXISTING FACILITIES FOR THE IMPROVEMENT OF INCUBATION WATER

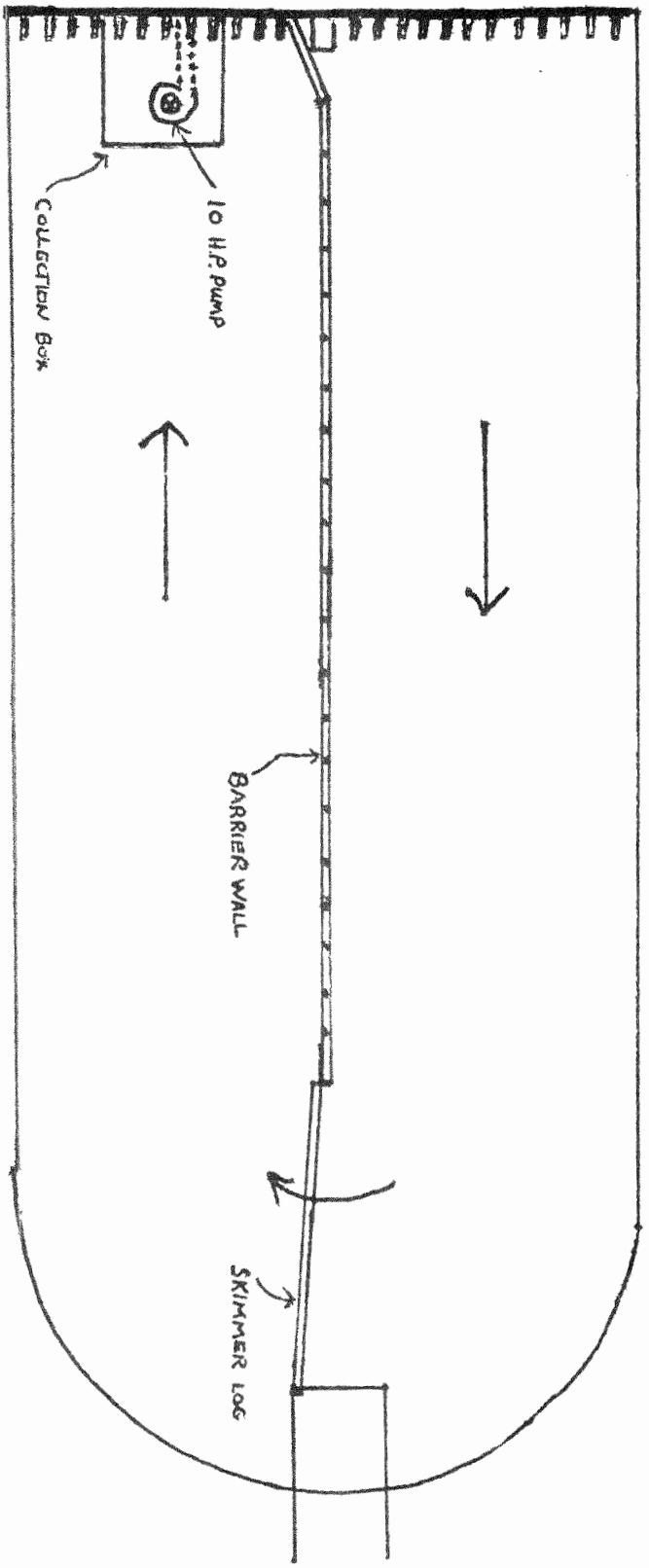
BY KENT DIMMITT
WASHINGTON DEPT. OF FISHERIES

Those of us who have been associated with salmon culture have been involved with "dirty water" during incubation and hatching. At the Green River Hatchery located on Soos Creek just northeast of Auburn, Washington this is an ongoing problem.

In years past, mechanical sandtraps in the pipeline and settling boxes for each set of shallow troughs were installed. They helped a little, but with continued land development above the hatchery the problem has not disappeared. This past summer the crew at the hatchery helped install a settling basin using an existing rearing pond. (Fig. 1)

Construction consisted of installing a barrier wall (or diversion wall) 90' long (22 sections) down the middle of a 120'x 50'x 4' asphalt rearing pond. The height of each section increased gradually from the inlet end to the outlet to compensate for the gradual slope of the pond bottom. The water depth is regulated by stop-logs to maintain a level of one foot below wall height. Water enters on the southeast side of the pond and flows around to a collection box (perforated screen) where a 10 horsepower pump will pump water to the hatchery building for incubation. A 4' wide skimmer log will be placed at the west end of the wall to deflect any floating debris to the overflow. The wall will be removed after incubation and the settling basin will be converted back to a rearing area.

This being the first year with the settling basin the combined used of the sandtraps and settling boxes will have a marked effect on the incubation water. Survival of eggs should increase and less stress put on resulting fry from constant cleaning of the shallow and deep troughs. Finally, less time will be spent by the crew removing the sand from the ponds.



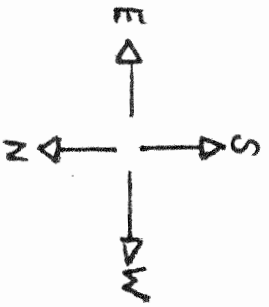


FIG. 1

AERATION AND DEGASSING OF HATCHERY WATER SUPPLIES

David E. Owsley, P.E.

U.S. Fish and Wildlife Service
Dworshak National Fish Hathcery
Ahsahka, Idaho

Dworshak Dam, on the North Fork of the Clearwater River near Orofino, Idaho, is the highest straight-axis, concrete gravity dam in the western world. It is the third highest dam in the United States and largest ever constructed by the Corps of Engineers. Construction of Dworshak Dam blocked the anadromous steelhead trout run on the North Fork. To perpetuate the run, Dworshak National Fish Hatchery was built in 1968. Located 1.6 miles below the dam at the confluence of the main stem and the North Fork of the Clearwater River, it is the largest steelhead hatchery in the world.

Oxygen and nitrogen gas have been serious concerns to achieving a successful production program because of various water requirements and location of the hatchery. Hatchery personnel have taken a lead role in the field of aeration and degassing to solve problems associated with pumping water from the North Fork.

In 1973, Einar Wold, hatchery biologist, conducted a study on surface agitators as a method of reducing nitrogen gas. The study showed that a minimum of four agitators (out of twelve existing) was required to reduce nitrogen levels from a range of 115 to 130 percent saturation to a

level of 103 percent. Wold's study was based on a maximum flow of 37,000 gallons per minute (gpm). The number of agitators were later reduced from twelve to eight. Under the current flow demand of 62,000 gpm, surface agitators do not reduce the nitrogen gas to below 105 percent. The Fish and Wildlife Service has requested that the Corps of Engineers modify this system and replace agitators with packed column aerator/degassers.

From 1974 through 1976, various modifications were tested in the reuse systems for better aeration. This included turning the inlet header at different angles, dead spots and low oxygen areas would be eliminated. It was found, however, that regardless of the direction the header was turned, dead spots and low oxygen areas exist in the Burrows ponds.

Aspirators were tested for efficiency with several variations in insert diameter, insert length, pipe diameter, pipe length and pressure. A major achievement occurred when personnel found a minimum of 20 pounds of pressure was required to work effectively. The original design stated a minimum of 10 pounds of pressure.

In 1977, the hatchery tested various methods of removing nitrogen gas and increasing oxygen in the water systems:

1. Splash Plates: Splash plates were added to the aspirators to eliminate a plunging effect and an increase in nitrogen gas. No appreciable benefit was gained.
2. Spray Nozzles: Spray nozzles were tested instead of aspirators. although they increased oxygen and decreased nitrogen, several operational features restricted their use; mainly, flow restriction and problems with freezing.

3. Perforated Screens: Perforated screens of various sizes and shapes were tested. No appreciable efficiency was shown. The screen tests led to the testing of a Swedish degasser. After several modifications, a model was successfully operated using heated incubator water. Efficiency of the Swedish degasser led to installation of a unit capable of degassing the entire incubator water supply. Its one major problem was noise from the blower supplying air to the screen area.

4. Pagoda-Shaped Structure: A pagoda-shaped structure (similar to one used at Wells Dam Hatchery, Washington) was designed and tested. It did not reduce nitrogen to below 105 percent as desired. The pagoda did reduce notrogen gas to below 103 percent by adding media to the baskets. The design was so successful that a working model was constructed and built into the System II reuse aeration basin. The pagoda led to the design and testing of the packed column aerator/degasser.

5. Packed Columns: The packed column was the most efficient aerator/degasser tested at Dworshak. Testing was limited by flow, and need for a smaller degasser. A 10-inch diameter column was found to be most efficient with a flow range between 100 to 150 gallons per minute.

In 1978, all aspirators were replaced with 10-inch diameter packed columns. Oxygen efficiency went from 85 percent to 95 percent in the reuse aeration basins. The Swedish degasser in the incubator room was replaced with five 10-inch diameter packed columns.

In 1979, the Bonneville Hydraulics Laboratory, Corps of Engineers, continued testing of packed column aerator/degassers. Laboratory

testing of larger diameter columns, at higher flows, showed similar results to data collected at Dworshak. Flow no longer became a restraint in aerating/degassing a hatchery water supply using larger columns.

In 1980, the Corps of Engineers constructed a new nursery building at Dworshak. All 128 nursery tanks have 6-inch diameter packed columns for degassing of raw water and aerating reuse water.

In 1981, aspirators, in conjunction with packed columns, were tested at Kooskia National Fish Hatchery. The combination of the aspirator/packed column increased oxygen from less than 10 percent to over 90 percent and reduced nitrogen from 140 percent to less than 103 percent.

In 1982, 30 new raceways were built for a spring chinook salmon production facility at Dworshak. All raceways have packed column aerator/degassers for single-pass rearing water. These columns are 24 inches in diameter and have been very effecient in removing nitrogen gas and aerating the water. In addition, all three reuse systems were modified to use the larger 36-inch diameter packed columns. Modification included make-up water which is aerated and degassed by 24-inch diameter packed columns.

In summary, all three reuse systems are protected from nitrogen gas and have excellent aeration when operated on reuse in contrast to no being fully protected from nitrogen gas when on single-pass water. The nursery building and incubation room are completely protected against nitrogen gas regardless of the mode of operation. Oxygen levels are maintained close to saturation

in these systems. The new raw-water, single-pass raceways have good nitrogen protection and excellent aeration.

Dworshak has virtually eliminated its nitrogen gas problems, through extensive testing and modification, to achieve excellent aeration for its production facilities. However, further improvements can be made by replacing surface agitators, at the river intake, with packed columns.

Flow Control and Alarms

by

John G. Hoskins

Oregon Department of Fish and Wildlife

Fall Creek Hatchery

The ODFW operates thirty three hatcheries and four rearing ponds within the state. In the last year hatcheries have lost around 328,000 eggs and fry due to interruptions of the flows for various reasons.

The purpose of this report is two-fold:

1. To point out the major areas felt to be problems by the hatchery managers.

2. To provide some information on equipment or changes that are available to help correct these situations.

The information was gathered through a telephone survey conducted with hatchery personnel. Not every hatchery was called, in some cases to save long distance telephone charges one manager was able to give me detailed information on a hatchery that he had just transfered from.

Table 1. shows the results of this survey.

PROBLEM AREA	YES	NO
Individual ponds protected	18	15
Intake protected	24	10
Troughs protected	18	1
Incubators protected	14	3
Unable to hear alarm	11	21
Vandal protection	7	22
No water problems	8	

Table 1.

As you can see the areas of concern range from no problems to no alarms. One rearing area has no protection at all and one hatchery has no alarms in the houses, which is not uncommon, but the personnel cannot hear the

siren in the houses either, so the manager requires the men to sleep with their bedroom windows open so that they can hear it.

One hatchery, Rock Creek, started with virtually no alarm capabilities and developed a system whereby every pond and trough headbox has an individual alarm. There is a siren that operates both off 110 volts and battery. Every house has a bell system. The crew designed and built this system by themselves for around $600.00 . Engineerings estimate for the job was $ 7000.00, proof again that the average crew , given adequate time can do almost anything.

Figure 1 shows the electrical diagram to build a basic system that will provide adequate protection in most situations. Any number of Phipps level monitors can be installed in the circuit as can any number of bells or sirens.

Table 2 gives a parts and price list for components. Conduit or wire prices depend on distances run. You might note that I have listed a KEY TRANICS AUTO BURGLAR ALARM . If you have a remote intake or area that needs an alarm but does not have a power line running back to your station this bears looking into. The transmitter operates on a 12 volt battery with the reciever mounted in the hatchery and an antennae is mounted on the roof. The transmitter sets of a coded signal that the reciever picks up and then activates a beeper that can be carried on the person or mounted in the houses or office. The unit sells for around $ 118.00. Another unit which will protect isolated areas as long as they are served electrically is called the POWER LINE CARRIER . This unit sends a signal along a power line back to any terminal with the matched impedence of the sending unit and sets off an alarm. I have not had a chance to check out the units to see if they are suitable for hatchery use or economics.

Another area of concern that proved to be troublesome is the unalarmed HEATH incubator. Of the 328,000 eggs and fry lost in our hatcheries last

year 303,000 were lost due to the valves on incubator stacks becomming plugged with debrie and shutting off the water. Even though only three hatcheries reported that their incubators were not properly protected many others indicated their protection from debrie in their incubator valves were their intake screens. I personally do not believe this to be adequate . At Fall Creek hatchery the incubation water intake screens plugged briefly during a storm, caved in and let debrie come into the incubator system . The low water alarm did not go off because the flow was only interrupted briefly. The debrie plugged the valve on one incubator stack and 120,000 coho fry were lost.

Figure 2 shows a screened head box designed for us by NEILSON NORTHWEST of Salem Oregon. This unit sold for $ 1100.00 unfortunately our budget was cut and with it all capitol outlay items. We do have a screened head-box, erected immediately after the loss, but it is a temporary one. So if you dont have an alarm on every stack or a screened headbox I would urge you to think about getting one or the other.

One major area of concern that deals with flow control that can and should be dealt with immediately is pond protection from vandalism. It is a sad situation when valve handles must be removed or chained, but the survey indicated that several hatcheries had incidences of vandals shutting of the water supply to ponds. I would recommend that you remove or secure all valve handles as soon as possible to prevent loss.

In conclussion I would say that we do have flow control and monitoring problems at various hatcheries within the state and it is going to take a dedicated effort on all our parts to correct the situation.

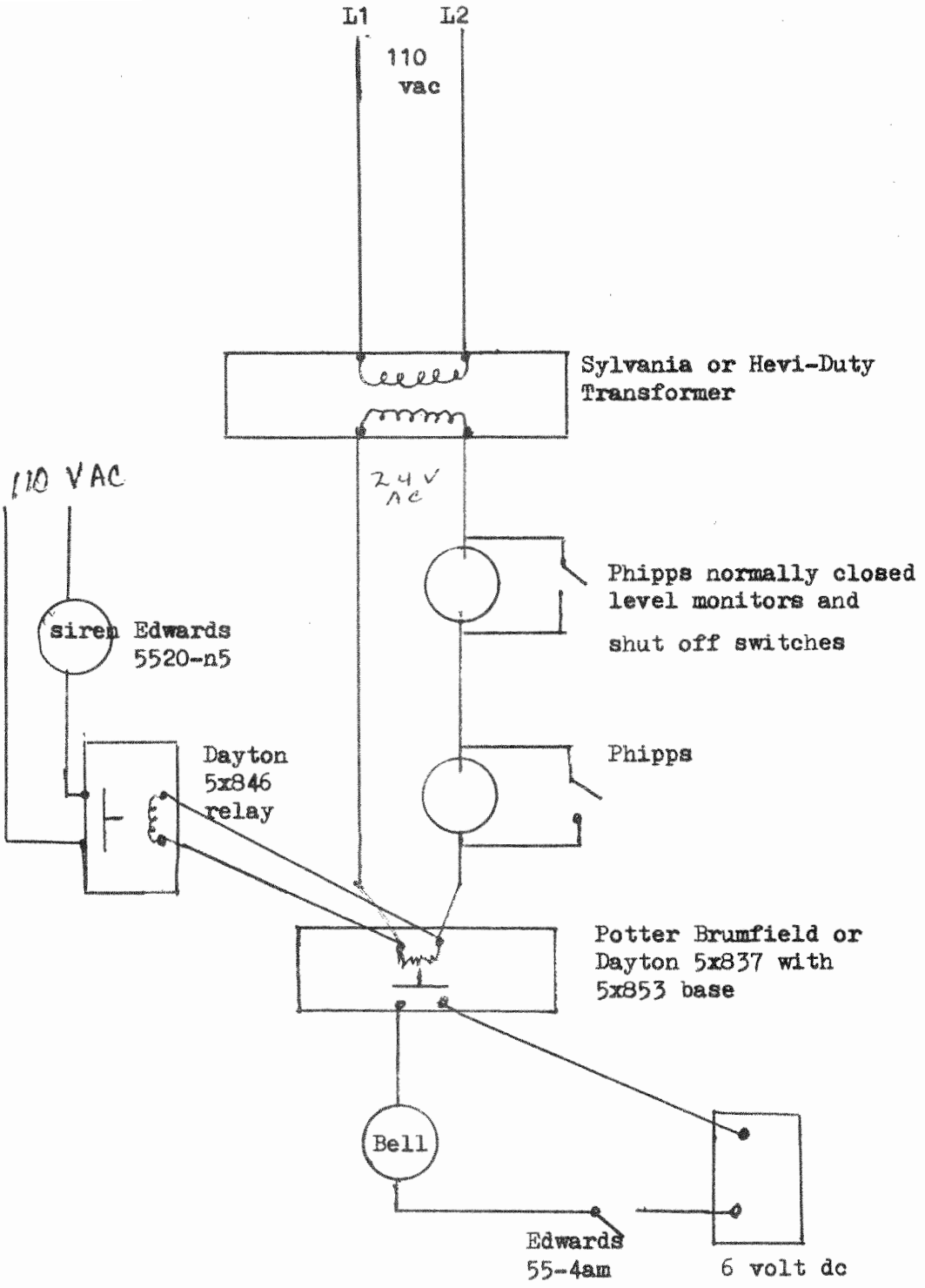

L1
L2
110
vac
Sylvania or Hevi-Duty
Transformer
110 VAC
24 V
AC
Phipps normally closed
level monitors and
shut off switches
siren Edwards
5520-n5
Dayton
5x846
relay
Phipps
Potter Brumfield or
Dayton 5x837 with
5x853 base
Bell
Edwards
55-4am
6 volt dc

Figure 1

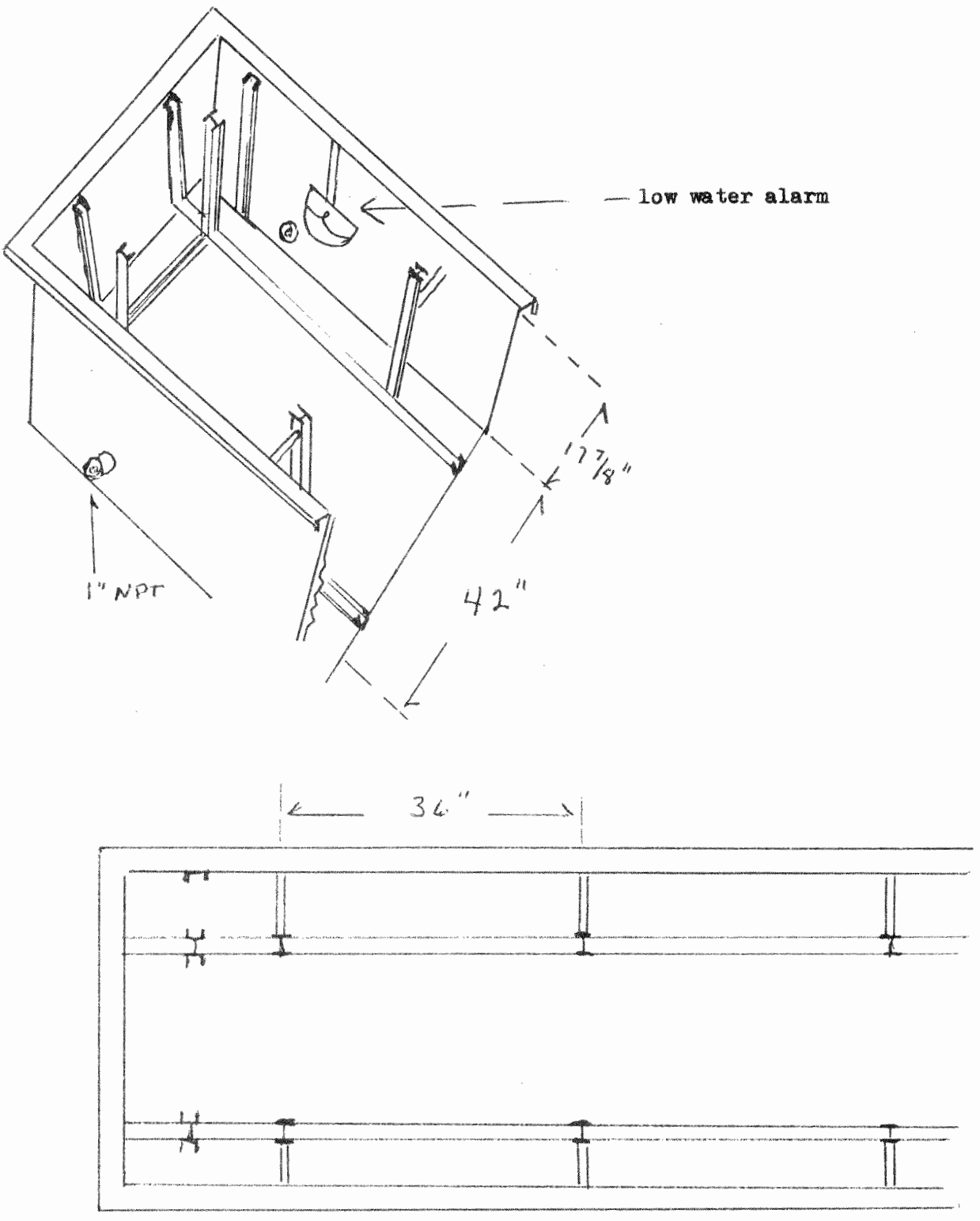


figure 2 material: 5056 aluminum 1/8" thick
length : dependent on number of incubators served
Screening tank for use with Heath incubators

Relay- Potter and Brumfield 5XR537 $ 7.10

Relay Base 5XR53 $ 5.25

Sylvania power transformer 240X120 to 12/24 volts cat.#106-1A0 $37.50

Hevi-Duty power transformer 120X240 to 12/24 volts P19FB100 $30.00

Alarm Bell 6 volt Edwards 55-4AM $13.00

Switches Toggle $1.40 ea

Switches, Level Monitor Phipps $19.95 ea

Relay Dayton 5X846 $22.65

Siren 110 volt Edwards 5520-N5 $166.50

Battery 6 volt DC $4.50

Key Tranics Auto Burglar Alarm $118.00 Beepers and Antennae extra

Power Line Carrier manafactured by the following firms.

English Elect 102 Midland Ave. Port Chester Ny. 10573

Landis and Gyr Moore System 1730 Technology Dr. San Jose, Cal. 95115

Table 2

Use of Physical Barriers to Address Bird Predation Problems at Salmon Hatcheries and Rearing Ponds Operated by the State of Washington Department of Fisheries

Robert Hager
Salmon Culture Division
Washington Department of Fisheries

Introduction

Bird Predation is, in various forms, a problem common to hatchery managers everywhere. Because of the migratory nature of most birds occurring at hatcheries, the U.S.F.W.S. has legal jurisdiction and is charged, thereby, with their protection. Put another way, permits are required from the U.S.F.W.S. to kill offending birds.

U.S.F.W.S. Wildlife Management Leaflet No. 475 (Control of Bird Damage at Aquaculture Facilities) provides life history and behavioral characteristics of fish-eating birds and a variety of control methods used in the control or reduction of bird-related fish losses at existing facilities. It also provides some insights which should be considered when new facilities are constructed or when those presently existing are modified, repaired, or expanded.

The Washington Experience

The State of Washington Department of Fisheries once held a large number of bird control permits but the number of active permits allowing

shotgun control of birds has been reduced to five. In the case of the remaining permits, the allowable kill is reduced each year as part of a cooperative program between the management agencies which provides protection in severe cases while alternate methods addressing the problems are explored and developed.

We have experimented with a number of techniques over the years, nearly all of which are discussed in the leaflet mentioned above. This effort has shown that some stations or certain ponds at hatcheries, have no bird problems of any consequence and some, of course, have severe problems. In our case, physical barriers appear to offer the best overall solution to most of the problems. A variety of approaches are presented here.

Pond Canopies

Typically, larger ponds ranging up to two acres or so are presently covered with a netting canopy. This canopy is supported by a lattice-work consisting of one or more main supporting steel cables, usually 3/16" or 1/4" diameter and lateral supports of braided polypropylene hanging twine (#42 size). The lateral lines cross the primary support cable(s) and are laced from side-to-side attaching through "S" hooks to a variety of anchoring systems, usually chain link fences or cables anchored to pond bank perimeters. Spacing is project specific, generally enough to support the type of netting used.

Main support lines bisect most ponds and are usually held up by poles set at each end of the array and, in some cases, by poles set where convenient and necessary to provide added support. Lines are kept taut by using a boat winch at one end. This feature is especially useful during periods of snow and ice since it allows for ready lowering of the canopy to prevent weight-caused damage.

Netting varies in size from 3/4" to 4" (square measure). Most managers presently prefer smaller mesh sizes since we have found that common and hooded mergansers, grebes, and goldeneyes, buffleheads will actually land on the netting and then wiggle through the mesh to get into the ponds.

Overhead Lines

This approach is usually one step back from the canopy discussed above in that netting is not installed. Effectiveness appears to be species specific - gulls, terns, and mergansers appear to be readily deterred from entering rearing ponds covered with monofilament or, again, braided polypropylene line.

Gulls and terns have historically been troublesome at our Priest Rapids facility. Longitudinal monofilament lines (80 lb. test) spaced at 3' intervals is effective except for the occasional smart bird that lands first and then walks to dinner down the pond banks.

Lines set in a transverse manner to the Elwha Rearing Channel are effective in eliminating a merganser problem. Here, lines are set at an interval approximating two feet. Goldeneyes and buffleheads enter the pond through these lines but are a nuisance that is presently tolerated.

Raceway Covers, Enclosures

Most recently, we have undertaken the covering of raceways with bird covers. Some hatchery managers have placed their bird covers immediately above the water level using pond walkway supports as anchoring points for supporting polypropylene lines. Personnel at Minter Creek and Nooksack have gone to the extreme of constructing complete enclosures for banks of raceways. Here, curtains are hung from an overhead cable which borders the pond battery and supported by 3-4" pipes set in concrete to a depth

of 3'. Access to the pond for feeding, etc., is through a shower curtain-like door at the lower end of the ponds. Orange poly lines are laced on 2-4' intervals across the top. The array is constructed to provide ample working room, 8' or so, above walkways.

Costs, Effectiveness

Cost of constructing pond covers is an area of interest, especially in these times when production programs are being reduced or eliminated as part of budget reductions. In essence, we have found that cost of covering ponds is not excessive. For example, it is presently estimated that the cost to cover a 1 acre pond with netting roughly approximates $3200.00. Supplies required and approximate costs are as follows:

40 rolls braided twine @ $20.00/roll	$ 800.00
1,000 "s" hooks @ $6.00/100	60.00
350 ft. stainless steel 1/4" cable @ $0.40/ft.	140.00
1 small hand crank boat winch @ $40.00	40.00
220 studded steel 1/2 posts @ $1.50 ea.	330.00
Assorted hardware (eyebolts, turnbuckles, bolts)	25.00
12 rolls bird netting @ $130/roll	1,560.00
4 man-days for installation	300.00
	$ 3,255.00

We have not made any specific attempts to quantify production gained or saved as a consequence of installation of covers. However, observations made at Minter Creek, relative to the management of a large earthen pond indicate that fish (dollar) savings can be significant! In this case, maximum loading, as measured by d.o. levels from February through May 5, was attained prior to canopy installation by stocking the pond with 1.8 to 2.0 million coho for rearing and release as yearlings. Since canopy installation, we

have had to reduce the stocking level to 1.5 million fish while retaining the same time and size at release criteria. This cursorily indicates an annual saving of at least 300,000 fish or so. Fish and other rearing space saved by this effort have been reprogrammed for other uses.

In summary, we feel that physical barriers can effectively be used to reduce bird predation problems, and we intend to continue what appears to be a low cost solution with significant production-related economic benefits. We are presently including anti-bird features into our on-coming capital projects and will continue to upgrade existing efforts with improvements as they develop.

Evaluation of Predator Control Attempts at the Cowlitz Trout Hatchery

by

Jack Tipping

Washington Game Department

With construction of the Cowlitz Trout hatchery, excellent habitat was created for fish eating birds. Four 5-acre rearing ponds used for steelhead and sea-run cutthroat production made easy pickings for Great Blue Herons, mergansers, kingfishers, crows, seagulls, osprey, and others. Prior to 1980, predator control consisted of hazing with shotguns. Still, we suspected significant losses due to birds.

In 1979-80 background data was obtained on production from the rearing ponds by subsampling fish at outmigration. The ponds lie side by side, have a common headbox, are about 165 feet wide, 1300 feet long, and have an inflow of about 10 cfs. Length, weight, condition, and number of smolts and culls per 50 pound samples were extrapolated for groups of fish loaded out, once and often twice daily. A criteria of 160mm was established as a minimum length for smolts based on condition factors and information by Buchanan (1977).

Cowlitz fish suffer heavy loss due to Ceratomyxa and many never reach 160mm (Tipping, 1982). In spring 1980, 58.0 percent of outmigrants survived, while 38.7 percent reached smolt length (Table 1).

Table 1. Smolt production from rearing ponds, 1979-80.

Pond	Fry Planted	Total Out	Total Surv. (%)	Smolts Out	Smolts (%)
1 SH	232,730	151,973	65.3	100,307	43.1
CT	156,990	149,611	95.3	72,686	46.3
Total	389,720	301,584	77.4	172,993	44.4
2,3,4	1,152,000	593,280	51.5	423,936	36.8

In 1980-81 as part of potential production improvements, a predator control net was placed on one pond. Predator netting consisted of a series of sixteen foot wide panels of plastic, five inch stretch mesh attached to ¼ inch polypropelene rope, tied to anchor stakes on shore. Mesh and rope floated on the water surface. Material costs amounted to $3,150.

Other parts of the experimental design included using LLMO (Liquid Life Micro-Organisms), a commercial waste treatment product, on another pond in hopes of improving water quality. Slaked lime was applied to the bottom of another. The last pond was used as a control. About 400,000 fry were planted into each pond except the predator control pond, and it received about 320,000 fry.

Results in spring, 1981 (Table 2), indicated production from the net covered pond was 76 percent better than the remaining three. If loading densities had been similar, it could be concluded about 44 percent of production had been lost to predators.

Table 2. Smolt production from rearing ponds, 1980-81.

Pond	Fry Planted	Total Out	Total Surv. (%)	Smolts Out	Smolts (%)
1 SH	276,287	151,682	54.9	98,358	35.6
CT	119,142	54,567	45.8	39,317	33.0
Total	395,429	206,249	52.2	137,675	34.8
2	423,759	241,543	57.0	136,027	32.1
3	440,184	198,083	45.0	147,462	33.5
4	324,209	236,673	73.0	191,608	59.1

In 1981-82, density remained similar for three ponds (Table 3) but increased in one. LLMO was again tried in one pond and the predator net remained on another.

Table 3. Experimental design, 1981-82.

Pond 1	Pond 2	Pond 3	Pond 4
Control	High density	LLMO	Predator net

Spring, 1982, did not reveal anticipated results (Table 4). The pond with the netting had nearly the worst production of any pond. Direct interpretation of results would indicate predators could be beneficial and LLMO caused severe fish mortality. However, the underlying parameter affecting production was probably health of fry placed in ponds. IHN virus was discovered at Cowlitz in 1981 and several groups of fry placed in ponds were suspect. The virus added an uncontrolled variable that invalidated the experiment.

Table 4. Smolt production from rearing ponds, 1981-82.

Pond	Fry Planted	Total Out	Total Surv. (%)	Smolts Out	Smolts (%)
1 SH	260,263	99,372	38.2	70,164	30.0
CT	97,692	76,893	78.7	60,648	62.1
Total	357,955	176,265	48.6	130,812	36.2
2	407,318	129,014	31.6	104,454	25.6
3	336,452	47,791	14.2	36,625	10.9
4	346,588	120,481	34.8	76,125	22.0

Because severe juvenile mortalities continue, population estimates via seining and mark and recapture are necessary to adjust feed ration. The predator net precludes seining and is now viewed in that regard as a hindrence. We will not emplace any more nets until our disease problems ease.

However, we have installed a Sears brand electric fence around one pond to keep wading birds out. The fence is mounted about one foot offshore and one foot above water surface level. Cost of materials was about $300. The fence has proven effective in warding off Herons, but does not help for non-wading birds.

Literature Cited.

Buchanan, D. 1977. Monitoring smolt outmigration of hatchery steelhead in the Willamete River system. In 28th NW Fish Cult. Conf. (informal proceedings).

Tipping, J. 1982. Cowlitz steelhead rearing pond production. Progress report. Wash. Game Dept.

SOME RECENT METHODS OF PREDATOR CONTROL AT OREGON FISH HATCHERIES

by

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Leaburg, Oregon 97401

The Oregon Department of Fish and Wildlife (O.D.F.W.) carries out a wide variety of fish and wildlife activities. Nongame as well as game species are involved. Sometimes the management activities from one project seem to be heading for a collision with another project. For example, biologists offer suggestions to farmers or loggers to leave bird nesting sites as undisturbed as possible. Biologists might be providing guidance on protection of a blue heron rookery, while only a few miles upriver a hatchery may be trying to rear fish to meet production goals. Naturally the herons want to feed on fish, and the hatchery is a very convenient spot. The hatchery, on the other hand, doesn't want the herons taking fish and "painting the walls".

In the past, the generally accepted method of dealing with hatchery predators was to eliminate them by whatever means did the job. Conflicts began to arise and became more pronounced when outside groups became involved. Due to inside as well as outside pressures, the Department has recently found it proper to more openly address the hatchery predation problem. One well-publicized situation, more than any other, brought the problem to center stage:

In 1981, the observed shooting of a blue heron at an Oregon hatchery ruffled the feathers of the Audubon Society. The Society wrote to the U.S. Fish and Wildlife Service and Oregon State Police. As a result, the

O.D.F.W. Director sent out a memo stating his concerns about dealing with predators at hatcheries. He reminded employees that blue herons and kingfishers are protected by federal law and that their removal without a permit is illegal regardless of the damage being done. He said that under no circumstances will legally protected birds be destroyed without a permit, which will very rarely be issued. Employees were informed that any violation of the rule would result in disciplinary action.

With this directive, changes were soon apparent at the hatcheries. All shotguns previously issued to hatcheries were recalled. Hatcheries were asked to be more creative in their methods of predator control. So new control methods began to be tried.

At Leaburg Hatchery we have suffered fish loss from herons, kingfishers and water ouzels. In July 1980, 9,856 cutthroat fingerling were inventoried into a 20 foot circular pond. Two months later when liberated, there was a recorded loss of 3.5 percent but a total shortage of 34.5 percent. During this period, we had many blue heron droppings around the ponds and observed frequent visits by water ouzels. Shotgun cracker-shells were used during the daytime to discourge the ouzels, but the birds would only be gone a short time before returning. A scarecrow made-up by an artistic employee worked fairly well for the herons, providing you moved it to a different location every night. But forgetting to move the scarecrow resulted in herons figuring out that the scarecrow was harmless. Upon seeing new droppings, the hatcherymen installed a Christmas light blinker inside the head of the scarecrow. This worked well, however the blinker would soon burn out and the heron got wise again. At about this time the order from our Director was issued. It was then that we decided to try an electric fence.

In June 1981, 21,847 cutthroat were inventoried into 3 of Leaburg Hatchery's 20 foot circular ponds. Shortly thereafter, in an attempt to deter well-established walking bird predation, an electric fence wire was strung around a circular pond at a height 3 inches above the wall. It was operated from late evening hours until 7:30 the following morning. Since the circular ponds are fenced to keep out the public, we never had any problem with people coming in contact with the wire. The electric fence controller used is a Red Snapper solid state model 88 with a standard 110 volt plugin and a claimed operational range of 20 miles. This unit delivers 50 shocks per minute of direct current for a duration of 1/4000 of a second.

When inventoried in October, 4 months after the June inventory, there was a recorded loss of 2.4 percent but a total shortage of 46 percent. From droppings, it was evident that the single strand electric wire 3 inches above pond wall height was only partially successful in deterring the herons. Since the strand was so low, the herons simply stepped over the wire to the center walkway and header pipes. Other herons would land in the roadway, walk up to the pond and hop or fly to the center walkway or header pipes. Modifications would be to use another wire 6 inches above the first and also hot-wire the walkway and header pipes. The single electric wire did decrease water ouzel usage, as these birds would land on the wall and get zapped as they did their teetering. Some remained but altered their method of approach, flying directly to the header pipe, which was not wired. Overall usage by water ouzels was decreased.

At Cole Rivers Hatchery the electric fence concept was employed on both raceways and circulars. Blue heron usage had been quite heavy, as indicated by fresh droppings. At one point 24 herons were observed flying to the hatchery in a 20 minute interval. The first crop of fish put into the cir-

cular ponds without any bird control measures showed an eventual 22 percent shortage. Two strands of electric fence wire were installed around the circulars, one 8 inches and one 16 inches above pond wall height. After close observation, changes were made to include wiring of the header pipes and the center walkway. Within 2 days of the modifications, there was no sign of new droppings around the circulars. The unaccountable loss dropped to 1½ percent.

Fall River Hatchery uses a single strand electric fence mounted on a piece of angle iron 6 inches inside the top of the pond wall. As a heron leaned over and down to catch a fish, his neck or upper chest came in contact with the wire. This system operated on a time clock from dark to dawn. Within 2 or 3 days the herons quit using the ponds. Siletz Hatchery has a single electric strand around the inside edge of its rearing pond. This system has also reduced blue heron predation.

Marion Forks installed a double strand system, one line 2 inches above pond wall height and the other at 6 inches. Ponds were surrounded on 3 sides, leaving an open side toward the hatchery building. This set-up reduced a rather severe river otter predation problem. During winter, heavy snows buried the fence and otters resumed their nightly raids. When the snow melted, the otters were willing to take a jolt or two in order to get a tasty meal, but less frequently. The problem was not solved but was reduced enough to warrant installation of the electric fence.

Fall River Hatchery recently experienced a very heavy predation problem from ospreys. Out of 150,000 legal rainbow, a shortage of 5.7 percent was found. Approximately 2000 legals were being taken per month. At one time 20 ospreys were observed fishing, flying or perched in trees at the hatchery. These birds were not eating all fish taken; many trout were

found with talon marks on the hatchery roadways and lawns. Two and a half miles of electric fence wire were strung across the 20 by 100 foot concrete ponds. This wire was fastened at 1 foot intervals to the header pipes at one end of the ponds and to wooden walkways at the other end, and distance from wire to the water was 1 foot. The first day after complete installation all but four persistant birds left the hatchery area. Some ospreys would end up in the ponds and couldn't fly out. They would work their way to the lower end and climb out over the screens, sit there, fluff, fly up into a tree for awhile, then try it again. Within a week all ospreys had quit visiting the hatchery. South Santiam uses a similar system.

Big Creek Hatchery uses a propane cannon which goes off every 20 minutes all night long. This method of harassment may take some time for hatchery personnel to adjust to, but is very effective in keeping blue herons from being unwanted guests.

Bonneville is limited to the scare pistol at this time. The cartridge fired causes a screeching sound and gives only temporary relief.

In 1982 at Leaburg Hatchery a 20 foot by 100 foot pond was provided with a center divider to keep cutthroat in the upper half of the pond. It was not on a roadway but sort of hidden from easy view. Water ouzels did not seem to find it. The only time that kingfishers used the pond was when a disease problem caused some fish to ride high in the water. The pond's water depth was 30 inches, and distance from top of the pond wall to the water surface was 30 inches. The water was too deep for the heron to wade in and too far from the top of the pond wall for him to reach the fish. In May, 222,370 cutthroat swim-ups were inventoried into the pond. By October, counts revealed essentially the same number of fish. This big pond with lots of space and a high wall provided good small cutthroat

escape from any source of predation. Consequently, past shortage problems did not occur this year.

In summary, the killing of most predators will no longer be tolerated at Oregon hatcheries. I've discussed only a few control methods being tried. Electric fence systems are proving effective in controlling several fish predators. These fences may need modification for best results. Sometimes, simple methods like changing ponding locations or pond water depths may solve a predation problem.

One positive way of looking at the situation is that predation is commonly more than offset by modern hatchery production techniques. Examples are new heated water systems, better diets and improved disease control.

We will probably never solve all predator problems. There is still plenty of room for creative thinking in deterring hatchery predators, be it by electric fencing, wire netting or scarecrows with flashing eyes.

LIST AND DECRIPTION

OF SLIDES TO BE USED

1) Picture of Red Snapper electric fence unit.

2) Picture showing view of all round circulars at Leaburg with electirc fence controller in center undercover.Fenced from visitors.

3) Picture showing close-up of controller, single strands on 2 ponds.

4) Picture showing close-up of electric wire on insulators.

5) Picture of electric fence charger used at Cole Rivers with weather cover.

6) Picture of fence charger hooked up to circular ponds. Walkway, header pipe and pond wired up double wire set-up.

7) Picture showing view of a number of circulars with electric wire set-up.

8) Closer picture of single pond, with double strand wire - charger along side pond.

9) Picture of South Santiam showing ponds with wires strung at spaced intervals.

10) South Santiam showing hook up of wires to the end of the pond.

11) South Santiam showing upper end of ponds and wire attachment and spacing.

CONTROL OF BIRD PREDATION AT DWORSHAK NATIONAL FISH HATCHERY

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Dworshak National Fish Hatchery, 500 river miles from the mouth of the Columbia River, had only a small resident population of sea gulls, a few kingfishers and water ouzels, and an occasional osprey frequenting the rearing ponds in the early years. Later, as the hatchery progressed to using the reuse systems, warmer water brought migrating ducks into the rearing ponds.

The initial action to rid the hatchery of the birds was to use noise. A propane-powered "boom" gun was employed--with limited success. Birds became accustomed to the noise over time, and the gun's effectiveness was soon lost. Resident neighbors of the hatchery never did adjust to the noise, and the "boom" gun was retired--by popular demand.

Another noise device, the "cracker-shell", experienced about the same success as the "boom" gun. The "cracker-shell" was a shotgun shell with a short-fused, firecracker type explosive. The "cracker-shell" could be fired some distance from the birds, and the explosive projectile would explode above them. The main problem was fuse length which, at times, caused the explosive to go off in the gun barrel; and at other times, caused the explosive to land in the pond and kill the very same fish that the person was trying to protect from bird predation.

Needless to say, the Fish and Wildlife Service banned the "cracker-shells" from hatchery use.

In 1977, cold river temperatures caused mallard and merganser ducks to occupy the warm water reuse systems. The ducks took advantage of the excellent food source resulting in some pond inventories to show excessive predation losses. To verify that fish-eating birds were present, several were sacrificed and examined by the hatchery biologist. This diagnosis confirmed that both mallard and merganser ducks were feeding on steelhead smolts.

In 1978, two methods of bird control were compared to determine which would be the best to reduce predation. The two methods were:

1. Overhead Wires:

   Overhead wires, spaced two feet apart and spanning an area of 450 feet by 75 feet, were installed above 25 ponds in reuse System II. The 6-inch steel supports extended 12 feet above the pond walls. Materials and labor used were:

6-inch black iron pipe, 680 feet	$4,000
1/16-inch stainless steel wire, 19,000 feet	720
Bird netting, 16,800 square feet	150
Miscellaneous hardware	1,250
Welding	2,500
Labor, 15 staff-days	800
Total Cost	$9,420

2. Intermittent Water Jet System:

The water jet system provided an intermittent jet of water over the pond surface. Two jets were installed on each pond with two ponds in operation at any one time. An irrigation control unit was used to turn the system "on" or "off". Time of operation and interval between operations was adjusted as needed. Material and labor used were:

Pump	$1,060
Electric parts	575
Irrigation control	750
Pipe and fittings	745
Miscellaneous materials	225
Labor at 20 staff-days	920
Total Cost	$4,275

Evaluation of the two systems showed that the bird wire was more effective and more practical in a production situation.

In 1979, construction of the bird wire protection was started in reuse Systems I and III. The total project included 115,000 square feet of netting. Work was completed over a 3-year period at a cost of $15,500 for materials and welding. Young Adult Conservation Corps (YACC) enrollees did the major share of installing the wires and netting. The bird problem has been nearly eliminated as a result of the covering.

In 1982, 30 new raceways were built through a contract by the Corps of Engineers. These 30 raceways have the same bird wire installation as the 84 Burrows ponds in reuse Systems I, II, and III. This latest installation completes protection of Dworshak's outside rearing facilities from bird predation.

GOOD GADGETS FROM THE GREAT WHITE NORTH

W.T. Foye and B.G. Shepherd

Department of Fisheries and Oceans
S.E.P. Enhancement Operations
1090 West Pender Street, Vancouver, British Columbia V6E 2P1

1. JAPANESE-STYLE CHUM KEEPER CHANNELS: WE'VE GOT THEM COVERED.

Phase I of British Columbia's Salmonid Enhancement Program will see the completion of ten major government-staffed facilities capable of producing 1.7 million adult chum using Japanese-style methods. A trademark of the Japanese system is the keeper channel, which is used to incubate chum from the pre-hatch stage through to emergence. In order to eliminate light and snow, keeper channels traditionally have been housed in buildings where the snow load is significant, or covered with boards and plastic sheeting where it is not. Five of our Phase I SEP facilities require the latter treatment, and some thought was expended in finding a better way to cover them. Boards are expensive to buy, awkward to handle, bulky to store, and have a short lifetime. In addition, standard boards can warp and allow light into the channel; plastic sheeting or tongue-and-groove boards help to reduce light entry, but make mid-channel inspections of alevins difficult. Several types of lightweight covers were considered and rejected because of their cost and their inability to stand up to winds, and the weight of snow or hatchery personnel.

We are now using aluminum cladding of 81 cm width (71 cm coverage) and 1 mm thickness, held in place with 5 cm aluminum stock (3 mm thickness). For strength sufficient to support passage of personnel, we recommend that the squared, rather than rounded type of corrugation be used; the stucco-embossed finish is also preferable in that it provides safer footing. Cost of the cladding is about \$18 CAN/m^2.

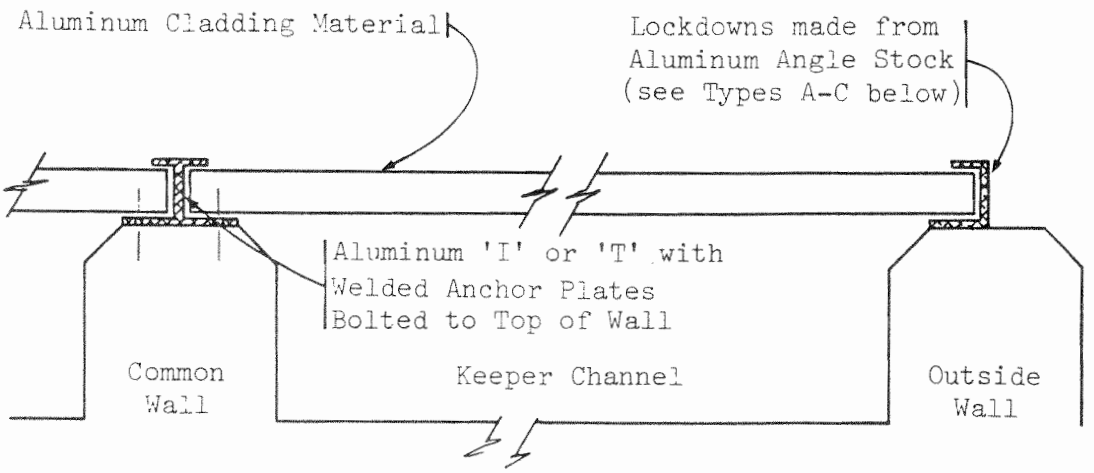
As these panels are prone to lofting by wind, three types of lockdown systems have been developed (see sketch). The first system ('Type A') was simple to construct, but it was not obvious when the system was unlocked, and neoprene has a limited lifetime. The newer systems ('Type B and C') are the more expensive to construct, but locking is more obvious and maintenance should be less.

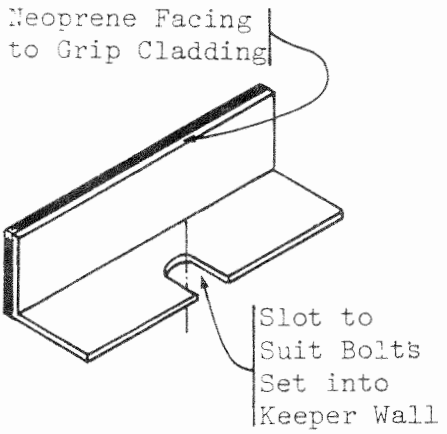
2. PNEUMATIC DIVIDER SCREENS FOR REARING TROUGHS (OR, WHAT'S DADDY DONE WITH MY BICYCLE?).

Ponding and rearing of chinook and coho up to 2g is most often done in British Columbia with 'Capilano-style' starter troughs, which are semi-circular in cross-section. The small size of fry introduced into these troughs has meant that particular care has had to be taken in fitting screens to avoid fry escape. In some cases, trough variations have forced staff to custom-fit screens to each trough; movable screens within troughs have presented even greater difficulties.

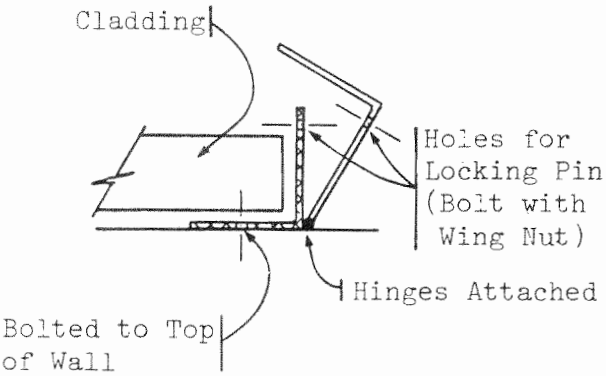
A new type of guideless screen has been developed which will automatically seal variable gaps as well as lock strongly into the trough. The innovation revolves about the use of a standard bicycle inner tube. The deflated tube is slipped into a channel frame enclosing the fry screen, the screen is placed where desired, and the tube is inflated. Once inflated the tube expands to meet the trough walls in all directions, and it takes considerable pressure to dislodge the screen. Production versions are projected to cost $128 CAN/screen for ten screens in plastic (which may become brittle in cold weather); the aluminum version will cost slightly less at $105 CAN/screen. In comparison, our standard screens presently cost $95 CAN/each.

SKETCH OF KEEPER CHANNEL COVER SYSTEM





TYPE A



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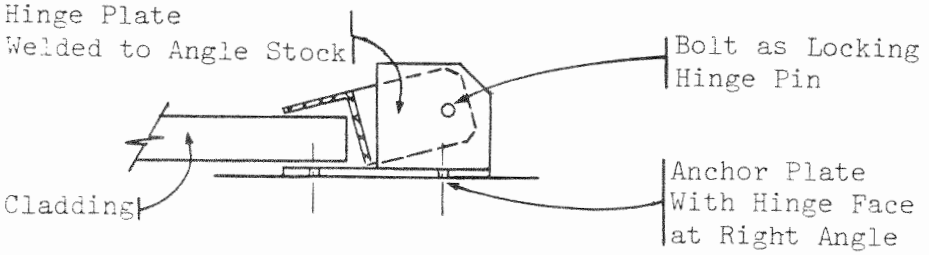

TYPE C

TELEPHONE ALARM SYSTEM AT KOOSKIA NATIONAL FISH HATCHERY

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Kooskia National Fish Hatchery
Kooskia, Idaho

The water flow and electrical power supply at the Kooskia National Fish Hatchery is monitored by an alarm system that alerts emloyees to actual and potential problems. This system has been in use for three years without a failure.

When a problem occurs, a signal from an alarm point sets off a time delay, which starts an audio and visual alarm at the station. The time delay is set for three minutes, at which time an employee can intercept the signal. If no one responds, the signal goes to a control panel and dialer which calls the telephone number of each employee and alerts them, by a taped message, that a problem has occurred.

The dialer and control panel (Model NW-322AC) can be obtained from Adcor Electronics, 349 Peachtree Hills Avenue, N.E., Atlanta, Georgia 30305, telephone 800-241-2470. Current price $330. The Cutler-Hammer time delay relay can be obtained from local suppliers, and models are available to monitor flow, electrical power, temperature, intrusion and pressure.

Continuing Education in Aquaculture

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Continuing education, in its broadest sense, implies the acquisition of knowledge after formal training and during one's professional career. It should begin with a desire to keep abreast of the advances in one's professional field and then progress through independent reading to attending professional meetings, seminars, workshops and symposia - and taking academic leave.

The initial desire to learn more, in my opinion, is what makes a professional truly professional. Professionalism is a state of mind - a dedication, if you will - to applying one's acquired skills in the best fashion he or she knows how. Professionalism is not limited to just those who have slaved long and hard through undergraduate and graduate curricula to become proficient in one of the classical professions such as medicine, law or dentistry. Anyone, no matter what they do, can perform their daily activities in such a way to be a professional - be they delivering the mail, picking up the weekly garbage or scrubbing ponds and feeding fish. By their dedication to their tasks they bring a certain something into their efforts that causes others to say, "That guy is a real pro. He takes pride in his job."

In the fishery profession we have men and women performing a variety of tasks at a variety of levels of proficiency. But, like other walks of life, we have our share of professionals and non-professionals. Not that this is undesirable, but it is rather discouraging to have an apparent non-professional directing the activities of both and aspiring professionals.

So, what is the basis for this situation? Unfortunately - or fortunately, depending upon your point of view - the academic background of each of us is the cause of the majority of personal professional problems. We who are older and well entrenched in our jobs (we think) have become somewhat academically stagnant. Most of us feel pretty smug about our academic training we received decades ago. Very few of us have spent some of our free-time and energies in attending and participating in the continuing education opportunities offered by various agencies and universities. Even college professors fall into this category. For example, I just completed my first college course since I graduated in 1963. It was quite an eye-opener for me. This academic stagnation has

prevented us from seeing the increased professional capabilities of recent graduates over those of ten years or so ago. Believe me, these new professionals have been exposed to a lot more "book learning" than we ever received. I guess we are to blame for that because it has been the results of our professional efforts that have led to educators providing more information.

I think the "retired-but-still-hired" professional could be sparked into becoming a contributing professional, through one or more of the following:

1. By offering regularly scheduled continuing education opportunities to middle-management personnel.

2. By middle-management personnel adopting a philosophy that using the talents of new professionals can make them more productive.

3. By utilizing the talents of senior personnel in both long term and short term training sessions - both at the agency level and at the institutional level.

4. By recognition of creative team efforts - not just a single person.

5. By university educators instilling a sense of realistic idealism and professional ethics in future professionals.

As I see it, the benefits of continuing education are:

1. All personnel feel part of the team. An important consideration if the hatchery system is going to keep promising young fish culturists. A young man (or woman) who feels their self-esteem and professional growth needs are not being met will either continue in their present position at a sub-optimal output level or seek employment elsewhere. The commercial food fish industry has a very high employee turnover rate - partly because of what I have alluded to.

2. New information is disseminated to the people who can benefit most from it. It shortens the lag time (often a year) from writing a research report and getting published. Also, fish culturists do not subscribe to the journals in which most of the research results are published.

3. Current problems are discussed in depth with potential researchers (short-course staff). I am a firm advocate of applied research and I get my ideas from the people who raise fish. Many problems faced daily in the pond do not "see the light of day" until they become crises. This is very expensive in terms of raising a pound of fish.

4. An opportunity is provided for the researcher to discuss what he (or she) is doing to improve fish culture methods. Many - perhaps the majority - of researchers have very little contact with the guys in the ponds other than at meetings such as the Northwest Fish Culture Conference of the American Fisheries Society meeting.

In summary, production practices need to be innovative in this day of increasing costs; i.e., labor, feed, eggs, and so forth. Good fish husbandry will also reduce the number of fish dying from a myriad of maladies, thereby decreasing the production costs. In my opinion, continuing education - short courses, seminars, symposia, academic leaves - is the best method (as well as the least expensive) to economize production costs.

DEMAND FEEDERS REPLACE HAND FEEDING AT DWORSHAK NATIONAL FISH HATCHERY

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Dworshak National Fish Hatchery has experienced excellent success in use of demand feeders in their production program. Beginning in 1980, when five Burrows ponds were equipped with "self" or "demand" feeders and evaluated against hand-fed ponds, the hatchery has continued to expand the program to 114 production units with two feeders each.

In 1981, feeders were installed on 25 System I Burrows ponds on single-pass water, rearing second-year steelhead on a 2 year program. This was the result of a 1980-81 rearing study in which self-feeding conversions were found nearly half that of hand-fed fish reared in 38°-42°F. water temperatures. Feeders were also installed on one-half of reuse Systems II and III (29 Burrows ponds), leaving for comparison 30 ponds in the two Systems for hand feeding. All three systems (84 Burrows ponds) are designed to carry an annual production of 400,000 pounds of steelhead smolts.

Six adult holding ponds, earlier modified to carry rainbow production, were also placed on demand feeders in 1981. These same ponds were further modified into twelve 8-foot x 80-foot raceways in 1982, and feeders installed.

In 1982, station personnel completed mounting 36 bracket assemblies for the feeder support arms on the remaining 18 Burrows ponds in System III. This gave the hatchery 72 ponds on self-feeding a dry diet and 12 ponds from the three Systems (15 percent of Dworshak's steelhead program) on hand feeding a moist diet. The hatchery will continue this practice of using two diets as a precautionary measure in identifying any nutritional problem.

Expansion of Dworshak's program with the Lower Snake River Compensation Plan, in 1982, saw feeders being mounted on 30 new 8-foot x 80-foot raceways for spring chinook salmon production. The feeders provide a 100 percent self-feeding program to second year chinook production.

All production (steelhead, spring chinook and rainbow trout) is hand fed until fish reach nearly 75 per pound. A 3/32-inch pellet diet is added to the feeders while supplementing with hand feeding. The breakover to self feeders is completed within 2-3 weeks if moist diet is fed but almost immediately if continuing on the dry diet. Fish remain on the feeders using primarily a 1/8-inch pellet until released.

Dworshak's program includes an annual fish production of 530,000 pounds. Of this total, 430,000 pounds are gained by self feeding. At a conversion of 1.65, the hatchery forecasts use of 700,000 pounds of food through demand feeders.

A 16 to 22 percent lower food conversion was shown in 1981-82 using demand feeders on a 50/50 basis with hand feeding of steelhead production in SystemsII and III. This comparison was on a production gain of 261,000

pounds from November 1981 until release of the smolts in May 1982. Applying the lower conversion figure to the forecasted use of 700,000 pounds through the feeders, a saving of 130,000 to 200,000 pounds of fish food can be realized by using demand feeders in lieu of hand feeding.

Further attention is being given to bulk feed deliveries and to methods of transferring feed to the demand feeders. Presently, the hatchery employs two high school students to work three hours each afternoon (Monday through Friday) to fill the feed containers. A system is followed to assure all 228 feeders (each holding 100 pounds of feed) do not require daily filling.

Use of demand feeders has given Dworshak a more labor efficient and cost-efficient production program. Soon, the hatchery will initiate testing of demand-type feeders on nursery tanks in hopes of expanding this program to include smaller fish.

Questions and Answers

Q. Do you have a maintenance problem with the throat down at the bottom of the demand feeders? In our climate the condensation that comes up into the throat from off the pond and the splashing during feeding causes dust and feed to build up. There is quite a bit of maintenance required as you have to take a wire or something and use it to work the dust out. Maybe in the dry climate where you are located, you don't have this kind of problem.

A. We're not having a problem. Make sure the end of the wire rod is about one inch into the water. If set lower, it will bring the feeder closer to the surface and could cause water to be splashed on the feed plate. We

see very little dusting as our outside feeding program uses only a pelleted diet.

Q. I was just curious if those demand feeders actually affect the density relationship in the ponds by fish clumping up towards the feeders.

A. Fish are well dispersed throughout the circular ponds and in raceways. We'll see fish move up to the feeder, actively feed, and then move away and spread out. Feed is always available on a 24-hour basis.

Q. How many feeders per pond?

A. We had four feeders on a Burroughs pond, two on each side of the center wall, and then went to two feeders. We could see no difference in food conversions. Our 8-foot by 80-foot raceways also have two feeders per unit.

Q. Do you ever mix dry and moist pellets in the demand feeders?

A. No. We only use dry feed in the demand feeders. You would probably experience problems with a moist diet hanging up in the feeders. During a breakover period, between feed sizes and type, and when fish reach three inches, dry feed is made available in the demand feeders while continuing to supplement by hand feeding a moist and dry diet. We have been feeding OMP up to this point. After fish take to the demand feeders, the moist feed is discontinued.

Q. We have a problem at some of our hatcheries with wide variations in fish sizes and it appears that demand feed situation is worked one way or another. You might, by having feed available all the time, make your range of fish sizes more uniform. On the other hand, you may have a situation where more dominant fish get most of the feed. Do you have a feeling for that, particularly with chinook, whether you get a more uniform fish size using demand feeders?

A. Right now we're looking at hand feeding versus demand feeders on chinook. These fish are normally in the hatchery for about 20 months until release and we do find large and smalls when hand fed. Based upon work with steelhead, we found a greater size spread in fish on demand feeders when compared to hand feeding. These fish are normally in the program 10-12 months. It doesn't appear that demand feeders are tightening up the length/frequency range.

Q. Have you looked at the difference in dissolved oxygens between hand feeding versus the demand feeders at your station?

A. We are taking oxygen readings on a three times a week basis at the hatchery. Ponds being hand fed show an oxygen drop in the afternoons. Demand feeders appear to even out the oxygen levels.

Automatic, Multiple Channel Monitoring of Critical Parameters in Hatchery Water Quality

Brian G. D'Aoust, Ph.D. - Common Sensing, Inc.

Specific reliable sensors have always been the critical link in monitoring any system. Temperature oxygen and supersaturation are three important parameters affecting water quality in hatcheries, however, only recently have these become available in on instrument. This is because oxygen sensors have not been unrelibale sufficiently reliable and total gas sensors have only recently becomw available for continuous monitoring in remote locations. Past research combined with new sensors, solid state data logging, and automatic dialing technology, now allows cost-effective monitoring of these quantities and can avoid catastrophic and costly system failure. This not only provides the desired information with increased reliability, but also provides complete insights as to how one parameter is affected by changes in the other. As a result, it should be possible to optimize each unique water system according to the engineering flexibility available, and this leads to more intelligent selection of allowable levels to fit the particular system. The critical ingredient of such "fine tuning" of a system remains an ability to continuously monitor the relevant parameters such as temperature, oxygen, total gas pressure, inert gas pressure and flow reliably and inexpensively. Results of typical uses, including the Columbia and Snake Rivers systems, and decompression and supersaturation experiments with salmonids, demonstrate the utility of this approach.

Improved Hatchery Inventory Techniques

Andy Appleby
and
Rich Schneider
Washington Department of Fisheries

The critical nature of hatchery inventory information to both hatchery and fishery management makes it imperative that contemporary approaches to quantifying fish hatchery populations be explored. The Washington Department of Fisheries (WDF) recently evaluated the error associated with standard inventory methods and investigated the use of electronic counting hardware for quantification of large numbers of salmonids in hatchery environments.

Inventorying hatchery pond populations can be a difficult task for hatchery managers. Undetected mortality and uncontrollable predation can change accurate ponding figures into inaccurate "guesstimates". The degree of error may not be large in smaller, standard size ponds but can be quite difficult to estimate in today's large asphalt and gravel ponds.

Most traditional methods of pond inventory involve the determination of total fish population weight multiplied by the average size of individual fish. The usual methods employed by WDF hatcheries are weighing an entire pond using a screen bucket and milk scale or by pumping the fish into a planting truck and measuring the amount of water displaced. Fish size is determined by hand counting a number of samples of fish after they have been weighed either by using a screen bucket and milk scale, or more preferably, by pouring the fish sample into a pre-weighed bucket of water on a balanced beam scale.

Determination of average fish size is a critical source of potential error. Some water always remains in screen buckets and must be compensated for by subtracting an arbitrarily determined amount of weight. Care and consistency are necessary to minimize this error.

Although other methods of determining mean weight, such as anesthetizing fish and taking individual weights of representative samples may provide more accurate numbers, the techniques that are used on a day-to-day basis are those techniques that provide good estimates in a minimal amount of time and with minimal effort and fish handling stress.

WDF undertook two studies to attempt to determine the amount of error that results from the forementioned standard methods of pond inventory. The personnel from two hatcheries inventoried ponds of fish by screen bucket weight and by truck displacement. Fish in one pond were first counted by hand, then weighed by screen bucket and milk scale then pumped into a 1000 gallon tanker. Weight samples were determined using a tared bucket of water on a balanced beam scale.

The results of the study showed that the screen bucket method consistently underestimated the population size (2.4-9.3%). Discrepancies in numbers are likely due to either an exaggerated fish per pound estimate (caused by residual water adhering to fish in the screen bucket) or because of an underestimation of total pounds of fish in the pond (caused by using too large a correction factor for water in the screen bucket).

The displacement method consistently overestimated the population size (5-11%), most likely due to the small but inevitable amount of water that accompanies large surges of fish into the tank.

These results are probably not surprising to most fish culturists who are familiar with pond inventory problems but they point to a need for the development of inventory techniques that give accurate results with a minimum of time and effort expended. Recent availability of electronic fish counting hardware appears to have the potential to fulfill this need.

Electronic fish counters have been used successfully in other states to measure downstream migration of wild fish and to quantify volitional outmigration of fish from hatcheries. The intent of our investigation was to develop a portable fish counting apparatus that would accurately and rapidly count production-size populations of hatchery salmonids.

The electronic counter chosen for our design is a commercially available model that operates on the balanced bridge principle. It consists of a counting head 3.5 X 5.5 X 11 inches with 16 one-inch diameter counting tunnels. The electronics package is also compact (4-1/2 X 6 X 12 inches) and is operated by a standard 12 volt battery. The fish tally is shown on a lighted, 8 digit display. The counting head can be used to count fish up to 60 to the pound which makes it particularly suited for counting release-size fall chinook. A counting head with two inch diameter tunnels also is available for counting yearling coho salmon. The electronics have the capacity to count 1,000 fish per second at 99% accuracy. The compact design of the counter makes it adaptable to a variety of hatchery outlet structures for counting fish during release.

To make the counter portable for use statewide, WDF's Auburn Shop designed a 4 X 8 X 2 ft. aluminum box into which two counters could be mounted. The box was placed on a trailer with the counters at the rear so that it can be backed to a pond or stream into which the fish can spill as they are counted. The box also contains a removable center wall so that separate

groups of fish can be passed through each counting head.

Initial counting trials were conducted at Minter Creek Salmon Hatchery. Yearling coho salmon were hand counted into a concrete pond. Water was supplied to the counting trailer via a small pump and the fish were transferred from the pond to the trailer using dip nets.

Three trials were done. The results showed an average 5% overestimate by the counter (Table 1). While a 5% average was not as good as hoped, if the error proved constant, future population estimates could be corrected with good results.

Following the initial trials the trailer was plumbed to allow the hookup of a 4 inch Morton fish pump. This facilitated movement of fish and water to the trailer, but the pulsing water from the pump created a large standing wave inside the box which could have adversely affected the counters. Subsequent counting trials produced numbers ranging from -4.5% to + 5.3% of the hand counted number (Table 1).

The standing wave was eliminated by pumping the water and fish across a dryer grate before spilling into the trailer. The resultant smooth flow of water to the trailer eliminated the wide variation in counts but did not correct the aforementioned 5% overestimation.

Close inspection of the counter in operation led to the realization that occasionally, as fish passed out of a tunnel, an air bubble would propogate itself back up the tunnel, causing an extra count to be registered. A splash guard was attached to keep the rear of the tunnels flooded but the turbulence created by the splash guard allowed some fish to reenter the tunnels from the rear, again tallying extra counts.

This is the status of the project at the present time. The counting errors appear to be an artifact of our particular configuration and not inherent

in the counters themselves. We feel confident that by removing the splash guard and extending the counting tunnels, neither fish nor air bubbles will be able to move far enough up the tunnels to register additional counts. Work on this modification is presently underway and testing of the new design will continue this winter.

TABLE 1 RESULTS OF FISH COUNTING TRIALS

Initial Counting Test

Trial	Hand Count	Counter Tally	% Difference
1	1987	2078	+ 4.6
2	1987	2086	+ 5.0
3	1987	2094	+ 5.4

Second Counting Test

Trial	Hand Count	Counter Tally	% Difference
1	5707	5450	- 4.5
2	5707	5895	+ 4.2
3	5707	6009	+ 5.3

FISH HANDLING AT

DWORSHAK NATIONAL FISH HATCHERY

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TECHNIQUES

Moving fish from one rearing unit to another is a requirement at most hatcheries. Time requirements for such an operation depend on design and overall size of the facility. A large, highly-diversified program, such as Dworshak's, requires moving fish on nearly a year-around basis. When moving fish, it must be conducted in a time-efficient manner with the least possible stress to the fish.

On-station movement of fish at Dworshak can be broken into three categories: (1) nursery tank to rearing pond; (2) rearing pond to rearing pond; (3) and rearing pond to river.

Nursery-Tanks-to-Rearing-Ponds

Two basic techniques are used to move fish from the nursery building to the outside rearing units:

1. Use of a forklift and a 100-gallon distribution tank. With this technique, fingerling fish are netted from the nursery unit and placed

directly into the distribution tank. When the tank is loaded, it is taken to the receiving pond and dumped. This method is somewhat time consuming, as each round trip requires 3 to 5 minutes. Stress is minimal, however, if loads are kept between 75 and 100 pounds.

2. Pumping fish from the nursery building directly to outside rearing units. Being a newly-designed technique, it has "bugs" which need to be worked out. It presently requires a great deal of set-up time as there are several hundred feet of irrigation pipe involved; the longest distance being 800 feet.

Basically, the technique involves transferring fish from the tanks via a distribution box and 2-inch aluminum pipe, to a central receiving tank. From there, fish are pumped to the pond through a 4-inch pipe. Set-up time is substantial; however, the time required to get fish from the nursery building to the outside pond is less than with the forklift and tank. Again, stress to the fish is minimal.

Rearing-Pond-to-Rearing-Pond

Generally speaking, once fish have been moved to ponds from the nursery building, any further moving is minimal. For the most part, splitting of ponds is a matter of thinning to an adjacent pond.

Occasionally, a pond of fish may have to be relocated. For these larger moves, we use the forklift and distribution tank or pump the fish. Pond-to-pond

pumping involves placing the pump intake line in the pond and crowding fish to it.

Rearing-Pond-to-River

At spring release time, Dworshak may have more than 400,000 pounds of steelhead trout and chinook salmon smolts to release to the river over a 4-week period. The original design of the reuse systems (steelhead) required pumping all fish to the North Fork Clearwater River. This procedure changed once it had been established that fish released to the main stem Clearwater River would return to the ladder on the North Fork side.

Systems I and II, each with 25 Burrows ponds, were designed in such a manner that fish could be released directly from the pond to a waste channel and subsequently to the main stem of the Clearwater River. This requires opening a gate in the end of the pond and crowding the fish out. A pond can be released in approximately 15 minutes. An added benefit is that fish are not handled to cause unnecessary stress.

System III, with 34 Burrows ponds, was designed without the waste channel (only a reuse return channel) and, therefore, did not have the same release capability. To eliminate pumping, we modified the design by constructing a redwood trough above the reuse channel. This redwood trough serves as a waste channel and allows for release of System III fish directly to the main Clearwater River.

Design of the new chinook salmon raceways is such that by removing the tail screens and dam boards, chinook smolts are gravity released into the North Fork. Evaluation of the design will be made for the first time in Spring 1983.

Liberation of Excess Steelhead Adults

In years when returning adults exceed program needs, fish are transported to upstream locations. This is complicated because fish must be handled unanesthetized. Once anesthetized in MS-222, fish must be held for 21 days prior to releasing where a consumptive fishery exists. Limited pond space precludes holding these fish.

Transportation of excess adults involves use of a large basket net. By means of a hydraulically-controlled crane, the net is lowered to the holding pond where personnel can load the adults. Once loaded, the net is raised and placed over the distribution truck and emptied. Loading and distribution can be a very time-consuming task depending on the number of adult fish. In Spring 1978, a total of 29 trips (4,900 miles) was made from the hatchery to distribute 89,000 pounds of unspawned adult steelhead to upriver tributaries on the Clearwater River.

MECHANIZED MOVEMENT OF ADULT BROODSTOCK FROM HOLDING POND TO SPAWNING ROOM

Regardless how adults enter the hatchery, they are held until spawning in one of three outside holding ponds. Movement of fish from the holding ponds to the

spawning table is almost completely mechanized.

A large, battery-operated crowder is used to move fish from the holding pond to the attraction water channel. Once the fish have been crowded out of the pond, the gate is closed to prevent re-entry. Fish are then crowded upstream by way of one of two channel crowders.

At the end of the attraction channel is a basket into which 15-20 fish at a time are allowed to enter. When the desired number of fish have entered the basket, a gate is closed and the basket raised. Raising the basket dumps fish into one of two anesthetic tanks, depending on the position of a diverter. When the fish are fully anesthetized, the basket, which sets in the anesthetizing solution, is elevated--dumping the fish onto the sorting table. Green males and females are returned to the holding pond by way of a 12-inch pipe.

A pneumatic knife is used to sever the dorsal aorta and spinal cord of ripe females before they are passed down to the spawning table. Ripe males are moved to the spawning table by way of an aluminum chute.

FISH TRANSPORTATION

The majority of Dworshak's off-site releases consist of distribution of resident species to Dworshak Reservoir. Distribution of rainbow trout fingerling and catchables is conducted in cooperation with the U. S. Army Corps of Engineers.

It involves trucking fish from the hatchery to a boat launch where the trucks are loaded onto a barge. Once on the barge, plants to a number of sites are made possible. Because there are only four sites accessible by road on the 60-mile reservoir, the barge is extremely valuable for dispersal of the fish. A number of plants of catchable size trout are made at each of the boat ramps to supply a put-and-take fishery.

Loading the trucks with trout is completed with one of three methods, depending on location and size of the fish. Fish smaller than 6 per pound can be pumped from the ponds to the truck. For larger catchables (larger than 6/lb.) we use either the small mesh basket net and the crane or a Sartorius elevator. Use of the Sartorius involves netting fish into the elevator which carries the fish up and into the truck.

Helicopter plantings have been made of fingerling kokanee salmon. This involves loading the fish into a hopper suspended by cable from the helicopter, and flying them up the reservoir and releasing at selected sites.

Truck transportation of anadromous smolts appears to be increasing at Dworshak. Up until 1981, trucking of steelhead smolts from Dworshak was restricted to test groups transported to various downstream locations. Beginning in the Spring of 1981, the policy changed to allow releases upriver in anticipation of extending adult returns beyond the hatchery. For the past two years, plants have been made to the South Fork Clearwater River (500,000 each year). Fish are pumped from the ponds into Corps of Engineers' trucks for transportation.

Trucking of adult spring chinook from Kooskia NFH to holding facilities at Dworshak is done in addition to the resident program and the transportation of smolts. Fish are loaded manually from the Kooskia trap, trucked to Dworshak and dumped directly into a pond. The one hour transfer does not adversely affect the fish. The cooler water temperature provides better holding conditions for survival of the broodstock.

Adult steelhead are occasionally trapped at Dworshak Dam and trucked to the hatchery. This is done in low run years or when requested by Idaho Department of Fish and Game for early indication of run size. Maintenance of the trap is the responsibility of Corps of Engineers personnel. Activation is simply a matter of calling the project engineer at the Dam. Hatchery personnel are responsible for monitoring the trap and collecting fish when needed. Operation of the trap is relatively easy. A hopper is raised from the trap, positioned on the truck, and fish are released from the hopper into the truck. It is a water-to-water transfer and causes no stress to the fish.

EVALUATION OF CLINOPTILOLITE AS A MEDIA IN AN UPFLOW ION EXCHANGE AND BIOLOGICAL FILTRATION SYSTEM

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Introduction:

A major problem encountered at fish hatcheries which utilize streams as a water source is fluctuation in water temperature. During summer months water temperatures are higher than desirable and in winter are lower than desirable. At Eagle Creek National Fish Hatchery, Estacada, Oregon, this continual fluctuation in water temperature has presented numerous difficulties associated with the intensive culture of Spring Chinook Salmon (Oncorynchus tshawytscha). High water temperatures of 73°F (22.8°C) have caused losses of up to 70% among returning adults. Low temperatures have caused freeze over of rearing raceways at the time when young fingerlings are begining to feed, producing poor growth and condition of the fish. Surmounting these obstacles requires chilling of the water in summer and heating it in the winter to maintain a stable temperature range of 50 to 55°F (10-12.8°C), optimal for culture of chinook salmon. To minimize the cost of heating or chilling the water during these periods, a recirculation system has been employed. However, ammonia nitrogen (NH_4^+) produced by the digestion of food and the decompostion of excrement must be constantly removed to prevent toxicity to the fish (Burrows, 1964).

Two filtration systems for NH_4^+ removal were considered at Eagle Creek; a biological filter utilizing bacterial reduction of ammonia waste and an Ion exchange filter using the zeolite, clinoptilolite, to remove NH_4^+. Two years of testing a small biological filter designed to remove NH_4^+ by upflowing water through polystyrene beads demonstrated that a sufficiently

high flow rate could not be maintained due to compaction of the beads (Bracey and Kenworthy, unpublished data, 1980). Disease and poor growth were perpetual problems. The desired reduction of nitrite (NO_2) to nitrate (NO_3) was not accomplished resulting in high losses to NO_2 toxicity. Consequently, a clinoptilolite filtration system was investigated as a means to remove NH_4+ from the recirculating water. Based on the works of Bruin, Nightingale, and Mumaw (1980) and Smith, Piper and Tischer (1981) an 18 gal/min test system was evaluated.

The purpose of this test was threefold: (1) to test the efficiency of an upflow system as opposed to the downflow systems operating at Bozeman Fish Cultural Development Center, Bozeman, Montana, and at the Seattle Aquarium, Seattle, Washington; (2) test the use of only two bed volumn of brine solution, continually recycled and airstripped for regeneration of the clinoptilolite bed; (3) test the use of clinoptilolite as a biological filter media.

Materials and Methods:

A standard Baker hydro-sand filter, originally designed for downflow with a divertor lens to introduce water, and twelve, 12-inch laterals containing 150, mm slits to collect the water, was used for the filtration durning this test. (The process was reversed for the upflow application, while leaving the piping unchanged). The laterals were covered with 6 ft^3 (312 lbs) of clinoptilolite (8 x 20 mesh Anaconda 1010A). The clinoptilolite was supplied by Anaconda Minerals Company. Smith et al (1981) reported that this mesh size clinoptilolite was capable of removing 0.5g

of NH_4^+ per pound. The 6 ft^3 (312 lbs) of clinoptilolite contained in the sand filter therefore had a potential capacity to remove 156g of NH_4^+. Willoughby, Larsen and Bowen (1972) reported that 15g of NH_4^+ is produced per pound of fish food. Thus, the fish in the system could be fed a total of 10.4 lbs of food before the clonoptilolite was saturated.

According to Smith, Piper and Dwyer (1975) much of the total suspended solid load can be efficiently removed by passing effluent water through a series of clarifying raceways. Routine pollution abatement monitoring at Eagle Creek NFH has shown that about 90% of the settleable solids produced during fish rearing can be eliminated from raceway water by settling for less than one hour. A settling basin was therefore incorporated into the system to reduce solid loads and to minimize plugging problems. The settling basin with a 40 minute retention time was put on line between the fish tank and the filter (Figure 1). This plus the 20 minute retention time in the fish tank itself gave a total of one hour of settling. The solids were removed daily by vacuuming with a suction pump.

The system was initially started in February 1982 with a lot of 3500 (2.87 lbs) of coho salmon (Oncorynchus kisutch) fingerlings. The rearing tank was a 96 ft^3 retangular fiberglass tank having a flow rate of 18 gal/min of recycled water plus 10% (1.8 gal/min) fresh spring make-up water (Figure 1). The fish load was decreased to 1850 (8 lbs) fingerlings when the load factor (lbs/gal/lenght-inches) reached 0.35 (51 days). After an additional 28 days of operation the flow rate was reduced to 5 gal/min recycled water plus 0.5 gal/min make-up water to increase the load

factor to 1.0. This test was terminated after 96 days total operation.

Water quality parameters (NH_4^+, NO_2, NO_3, PH, Dissolved Oxygen) were monitored daily at the intake and outlet from the filter bed. NH_4^+ determinations were made using the phenolhypochlorite method (Solorzano, 1969). NO_2 determinations were made following Standard Methods proceedure (APHA, 1976). NO_3 determinations were made using the Hach method (Hach Company).

Regeneration of the clinoptilolite bed was considered necessary when the NH_4^+ absorption by the filter dropped to 25% of the amount introduced into the system (via food). Regeneration of the filter bed was accomplished by recycling two bed volumn of 2% brine solution for approximately 24 hours at 10 gal/min flow through two airstripping towers (Figure 2). The brine solution with a PH of 12 (Koon and Kauffman, 1975) was made by adding 13.5 lbs of sodium chloride and two lbs of sodium hydroxide to 80 gallons of water contained in two collecting sumps at the base of the stripping towers. During regeneration, effluent from the fish rearing tank by-passed the filter and was pumped directly back to the fish (figure 3). Roccal was used at concentrations of 2 mg/liter and 10 mg/liter during the regeneration cycle of the first test period (February through May 1982) in attempts to remove nitrifying bacteria from the filter bed.

During the first hour of the regeneration cycle, NH_4^+ level of the regenerate was measured every 15 minutes after which it was measured every hour until regeneration was completed. Samples were taken at two points; (1) out of the clinoptilolite filter bed and (2) out of the sump at the base of the stripping tower. NH_4^+ removal by airstripping was calculated

from the differential readings between the filter and the stripping tower.

A second test to evaluate the clinoptilolite as a biological filter media was initiated in June 1982 using 7400 (3.35 lbs) steelhead trout (Salmo gairdneri) fingerlings. Flow rate was set at 5 gal/min recycled water plus 0.5 gal/min spring make-up water. Fish load was reduced to 3000 (8.34 lbs) fingerlings when the load factor reached 1.5 (41 days). This test was terminated after 89 days total operation (September 1982).

Results and Discussion:

Two problems arose in conjunction with operating the Baker filter in an upflow mode; (1) the 150, mm openings plugged quickly and the clinoptilolite bed clogged with particulate matter and the slime bacterium, Sphaerotulus, causing channeling through the filter bed; (2) water turbulance caused the mechanical disintegration of the clinoptilolite grains and produced cloudy water. To alleviate these problems, the system was modified by (1) replacing the laterals with twelve, 12-inch PVC pipes, each containing 2, ¼ inch holes, allowing particulate matter to pass through without plugging; (2) blowing air through the laterals to scour the clinoptilolite bed and allow particulate matter to move through the bed; (3) covering of the laterals with 3/8 to 1/4 inch pea stone to stop the break down of the clinoptilolite grains and help diffuse the water through a larger area of the filter bed. These modifications allowed the Baker filter to be used effectively in an upflow mode over six months of continual operation.

Growth of the coho salmon fingerlings during the first test period is contained in Table 1. During this time NH_4^+ level in the effluent water from the fish rearing tank averaged 0.07 mg/liter (range, 0.0 to 0.39 mg/liter), well within the limit of 1.2 mg/liter NH_4^+ given by Bullock (1972) and Smith and Piper (1975) as toxic for salmonids. Dissolved exygen in the effluent water ranged from 9.3 to 11.8 mg/liter and was at no time a growth limiting factor. Mortality was low, averaging 0.4% (range, 0.0 to 1.1%).

The clinoptilolite bed was first regenerated after 48 days of operation. Thereafter, the filter bed was regenerated every 7 to 15 days. This was a somewhat longer time between filter regenerations than for the system at Bozeman Fish Cultural Development Center (Smith et al, 1981) which was regenerated every 5 to 8 days. This was most likely accounted for by the different size and loading of fish being used at Bozeman (9 to 11 inch trout) and the point at which their filter was considered saturated (50% NH_4^+ removal by clinoptilolite). The system at the Seattle Aquarium, which operated with similar fish size and loadings (0.7 to 1.35 load factor), also required more frequent regeneration of every 3 to 8 days (Bruin et al, 1980). They did not report at what NH_4^+ removal level regeneration was considered necessary; when the NH_4^+ from digested food equaled the NH_4^+ holding capacity of the clinoptilolite, the bed was then regenerated.

Although the frequency of regeneration required for the continued operation of the clinoptilolite filter was less than at Seattle and Bozeman, the results were the same; NH_4^+ was removed from the effluent allowing successful re-use of the water in an upflow mode through the filter bed.

Regeneration of the clinoptilolite filter by the single-pass method (Koon and Kauffman, 1975), as done at Seattle and Bozeman, was not possible at Eagle Creek due to storage limitations for the large quantity of brine regenerate (20-30 bed volumn) needed. However, regeneration was accomplished using only two bed volumn of brine continually recycled and airstripped of NH_4^+ over a 24 hour period. The effects of the 24 hour brine recirculation and airstripping on NH_4^+ elution from the clinoptilolite filter are contained in Table 2. NH_4^+ concentration in the brine regenerate peaked at approximately 9.0 mg/liter, ten-fold less than that reported at Bozeman and Seattle. The average differential in NH_4^+ level between the filter and the stripping tower was 0.7 mg/liter.

The overall efficiency of regeneration by this method was approximately 93%. Bacterial nitrification would account for a portion, if not all, of the NH_4^+ not removed by the brine regeneration (C. Smith, personal communication). A typical nitrification curve observed during this test is contained in Figure 4.

From June to September 1982 the clinoptilolite filtration system was operated utilizing bacterial reduction of NH_4^+ waste. The system was not preactivated with nitrifying bacteria. Bacteria were allowed to establish themselves on the clinoptilolite and were not disturbed with either the brine regeneration or Roccal treatments. Nitrification began within 2 days of initiating this test. A typical curve showing the reduction of NH_4^+ to NO_2 by the bacterium, Nitrosomonas, is contained in Figure 5. Growth of the steelhead fingerlings during this second test period is contained in Table 3.

As was observed during the first test period, the reduction of NH_4^+ to NO_2 by Nitrosomonas ensued rapidily after initiating the test. The reduction of NO_2 to NO_3 by the bacterium, Nitrobacter, began 8 days after NO_2 was first detected in the system. NO_2 rose to a peak of 0.24 mg/liter, after which it averaged 0.06 mg/liter. NO_3 rose to a peak of 0.9 mg/liter. A typical nitrification curve showing the reduction of NO_2 to NO_3 is contained in Figure 6.

The efficiency of the clinoptilolite used as a biological filter media, measured in terms of percent NH_4^+ removal, was 80%. NH_4^+ levels in the effluent water averaged 0.19 mg/liter (range, 0.0 to 0.38 mg/liter) while NH_4^+ levels in the influent water averaged 0.04 mg/liter (range, 0.0 to 0.09 mg/liter). At no time did either the NH_4^+ or NO_2 levels cause toxicity to the fish. Dissolved oxygen averaged 8.9 mg/liter (range, 7.5 to 10 mg/liter) in the effluent water.

Total hardness (Ca^{++} and Mg^{++}) level of the recycled water ranged from 15 to 20 mg/liter during this test. According to Lai and Klontz (1980), Ca^{++} and Mg^{++} are very necessary in the nitrification process, with increasing efficiency as the total hardness level increases. Regardless of the low hardness of the water, the clinoptilolite operated efficiently as a biological filter media. Although not tested, the efficiency of the clinoptilolite as a biological filter media, as opposed to other media, is attributed to its ability to hold the NH_4^+. The bacteria are able to establish themselves on the clinoptilolite and also use it as their food source rather than filtering the NH_4^+ out of the water. The clinoptilolite also has a lesser affinity for Ca^{++} and Mg^{++} (Smith et al 1981) and it would then become the source of these ions for utilization by the bacteria.

At the conclusion of this test, the clinoptilolite filter was flushed with ammonia-free water. After one week of flushing, there was no detectable Nitrogen (NH_4^+, NO_2, NO_3) on the filter bed. In systems where brine regeneration is difficult or impossible, use of bacterial regeneration of the filter bed could be a practical alternative.

Summary:

The clinoptilolite filter operated efficiently for removal of NH_4^+ in an up-flow mode with only a few minor changes: (1) laterals containing the 150, mm slits were replaced with laterals containing two, ¼ inch holes; (2) scouring the clinoptilolite bed with air daily to keep bed from fouling with organic material; (3) covering the laterals with pea stone to prevent mechanical disintegration of the clinoptilolite grains.

Regeneration of the saturated clinoptilolite filter bed was accomplished using only 2 bed volume of brine solution by continuous recycling and airstripping over a 24 hour period. Efficiency of regeneration by this method was 93%.

The clinoptilolite filter bed also functioned efficiently as a biological filter. The ability of the clinoptilolite to function as a substrate as well as food source for nitrifying bacteria made it a superior filter media for application at Eagle Creek NFH. Bacterial regeneration of the filter was accomplished within one week after the filter was taken off line, making this an alternative to brine regeneration of the clinoptilolite.

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USING SEASONAL CHANGES IN CONDITION FACTOR (K) FOR MORE ACCURATE MONITORING OF GROWTH IN STEELHEAD TROUT

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Monitoring growth rate is an important tool in the management of a production program. Both weight gains and length increases are used in a number of ways to maintain accurate records.

Because there are seasonal changes in the condition factor (K) of most fishes, a true gain, in terms of linear growth, can only be obtained by adjusting the K factor accordingly. Anadromous species, in particular, show changes in condition factor as they enter smoltification. An overall "slimming" of body shape is observed in smolting salmonids and is a normal part of the physiological metamorphosis in preparation for the seaward migration.

Linear growth based on sample counts (No. fish/lb.) can be obtained by referring to tables in U.S. Fish and Wildlife Service Manuals of Fish Culture which display a total length corresponding to a number of fish per pound. A series of these manuals is available, based on a spectrum of individual condition factors. If a fishes' condition factor remained constant throughout the hatchery rearing cycle, it would be be a matter of simply selecting the manual with a length-weight relationship most closely corresponding to the species being reared. Length could then be obtained by referring to the column corresponding to measured number of fish per pound. An error in regard to monthly linear gains results from the use of the Manuals because K does not remain constant.

Computerized analysis of production data in conducted, for Region 1 Fish and Wildlife Service (FWS), by the Abernathy Salmon Cultural Development Center in Longview, Washington. Unless otherwise instructed, total length and all computation using total length are based on a constant K factor. As a means of more accurately monitoring linear growth in steelhead trout, Dworshak National Fish Hatchery regularly calculates the K factor and submits changes with their monthly production data to Abernathy. The procedure used consists of obtaining fish weight through a normal sample count while, at the same time, obtaining a length-frequency distribution to calculate the mean total length. With these data, calculation is made as follows:

$$K = \frac{W}{L3} \times 10^5$$

Where: W = mean weight of an individual fish (g)

$$\left(W = \frac{454g/lb.}{No.\ fish/lb.}\right)$$

$$L^3 = (\text{mean total length}^{mm})^3$$

EXAMPLE: $\frac{454g/lb.}{25\ fish/lb.} = 18.6g/fish = W$

*assume 123 mm is mean total length

$$K = \frac{18.16}{(123)3} = .00000975 \times 10^5 = 0.975$$

This procedure has been used at Dworshak for three years to accurately monitor linear growth rates on a monthly basis as a parameter of performance.

Seasonal changes in K for steelhead trout reared at Dworshak NFH are shown in the following table:

June 1	K = 0.94
July 1	K = 0.96
August 1	K = 0.98
September 1	K = 1.00
October 1	K = 1.02
November 1	K = 1.03
December 1	K = 1.03
January 1	K = 1.02
February 1	K = 1.00
March 1	K = 0.98
April 1	K = 0.94
May 1	K = 0.94

The procedure becomes especially important at smoltification when condition factor changes rapidly. In general, growth rate itself decreases as the physiological changes burn up energy that would ordinarily be converted to growth. This, coupled with the "slimming" due to catabolism, results in a drastic reduction in weight gain. In hatcheries with low water temperatures, it is not uncommon at smolt time (when using the FWS Fish Culture Manuals) for the growth rate to appear to zero out or in some extreme cases, display negative growth.

This procedure is a method which has proven useful in maintaining accurate growth records at Dworshak and can be used by anyone.

SEASONAL CHANGES IN K FOR STEELHEAD TROUT
AT DWORSHAK NFH

JUNE	K = 0.94
JULY	K = 0.96
AUGUST	K = 0.98
SEPTEMBER	K = 1.00
OCTOBER	K = 1.02
NOVEMBER	K = 1.03
DECEMBER	K = 1.03
JANUARY	K = 1.02
FEBRUARY	K = 1.00
MARCH	K = 0.98
APRIL	K = 0.94
MAY	K = 0.94

CALCULATION FOR K

$$K = \frac{W}{L^3} \times 10^5$$

WHERE: W = MEAN WEIGHT OF AN INDIVIDUAL FISH (g)

$$\left(W = \frac{454\ g/LB.}{NO.\ FISH/LB.} \right)$$

L^3 = (MEAN TOTAL LENGTH IN MM)^3

(L IS DETERMINED FROM THE LENGTH-FREQUENCY DISTRIBUTION)

EXAMPLE:

$$\frac{454\ g/LB.}{25\ FISH/LB.} = 18.16\ g/FISH = W$$

*ASSUME 123 MM IS THE MEAN TOTAL LENGTH

$$K = \frac{18.16}{(123)^3} = .00000975 \times 10^5 = 0.975$$

Date (Days)	Start	3/8 (19)	3/17 (28)	3/31 (42)	4/9 (51)	4/21 (63)	5/5 (77)	5/19 (91)	5/24 (96)
Number at Start	3500	3482	3457	3443	1848 1/	1844	1842	1842	1822
Mortality		18	25	14		4	2	0	20
Weight (Lbs)	2.87	4.15	7.98	12.55	7.97	11.53	16.90	22.47	24.62
Food Fed (Lbs)		2.25	3.5	5.1		3.66	4.84	6.38	2.09
Conversion		1.76	0.91	1.09		1.03	0.90	1.15	0.97
Load Factor (Lbs/Gal/ lenght-inches)		0.15	0.23	0.31	0.19	0.24	0.31	1.25	1.31
Flow (Gal/Min)		19.8	19.8	19.8	19.8	19.8	19.8 2/	5.5	5.5
Temperature °C		10	10	9.4	10	9.7	10.5	10.8	10.5

1/ Fish load reduced from 3440 to 1848 fingerlings.

2/ Total flow in system was dropped to 5 gal/min plus 0.5 gal/min make-up on 5/6/82 to increase the load factor to 1.0.

Table 1. Growth of coho salmon fingerlings during first test period (96 days)

Table 2. Effect of 24 hour brine recirculation and airstripping on Ammonia elution from the clinoptilolite filter bed.

Period	Days	NH_4^+ Introduced to system 1/	NH_4^+ Eluted and airstripped	NH_4^+ Lost through overflow 2/		Percent NH_4^+ removal
1	48	58.87	42.32	10.42		89.6
2	15	59.85	48.87	9.40		97.4
3	13	65.25	50.20	4.85		84.4
4	7	36.45	33.34	2.41		98.1
5	9	65.32	61.20	3.83		99.5
	Totals	285.74	235.93	30.91	Average	93.4

1/ 15 grams of NH_4^+ per pound of food fed (Willoughby, Larsen and Bowen, 1972).

2/ Lost in waste water through tank overflow.

Date (Days)	Start	6/15 (13)	7/14 (29)	8/13 (30)	8/31 (18)
Number Fish	7373	7277	3000 1/	2991	2983
Mortality		96*	86*	9	8
Weight (Lbs)	3.35	6.18	8.34	17.25	27.29
Food Fed (Lbs)		4.34	14.1	13.30	10.75
Conversion		1.53	1.13	1.49	1.07
Load Factor		0.74	0.76	1.23	1.67
Flow		5.5	5.5	5.5	5.5
Temperature °C		14.5	16.7	20.0	15.6

1/ Fish load decreased from 7191 to 3000 fingerlings.

* Higher loss due to unknown cause not related to this study. High loss was also experienced in production lots of steelhead at the hatchery.

Table 3. Growth of steelhead trout fingerlings during second test period (June through September 1982)

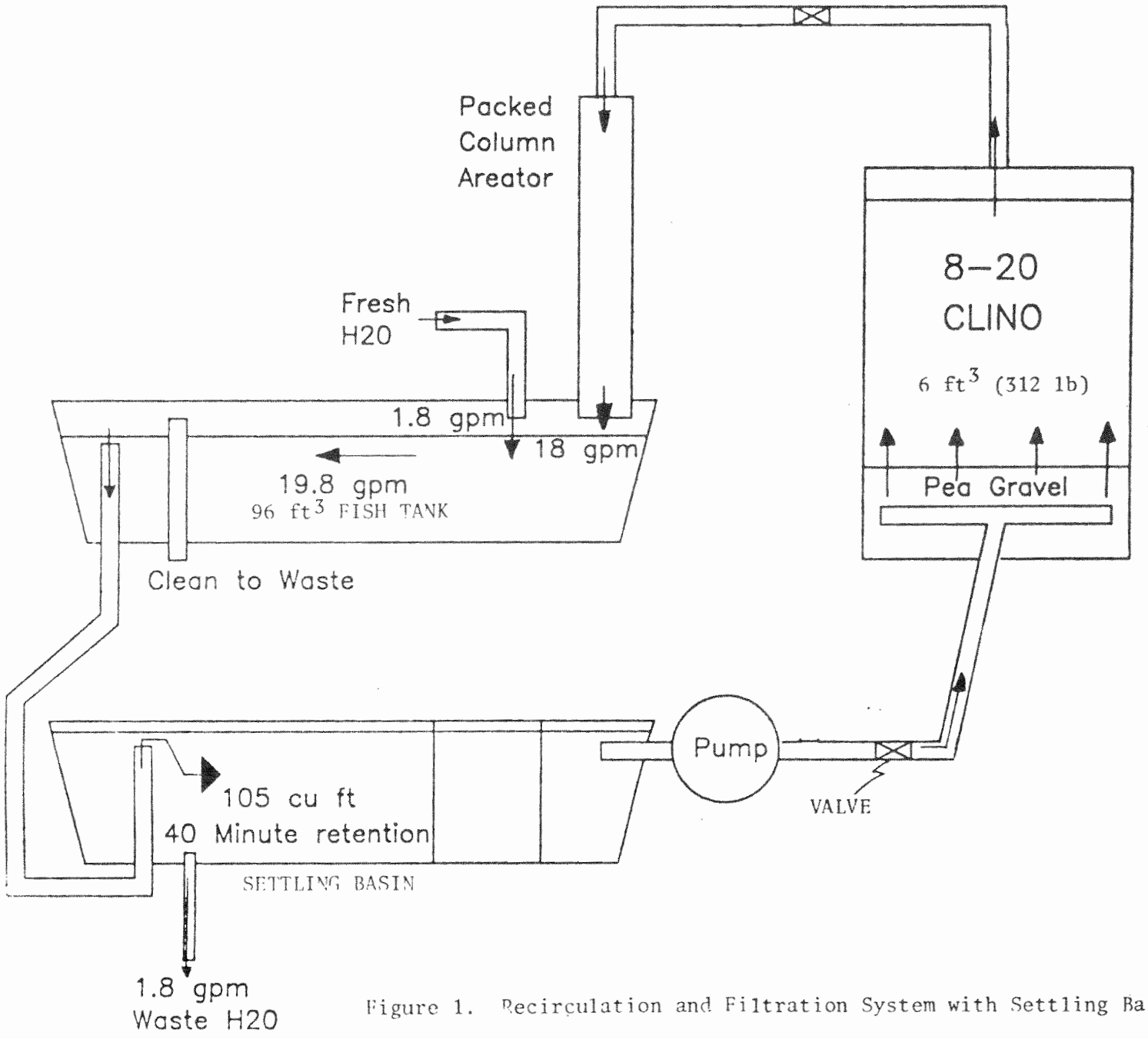

Figure 1. Recirculation and Filtration System with Settling Basin.

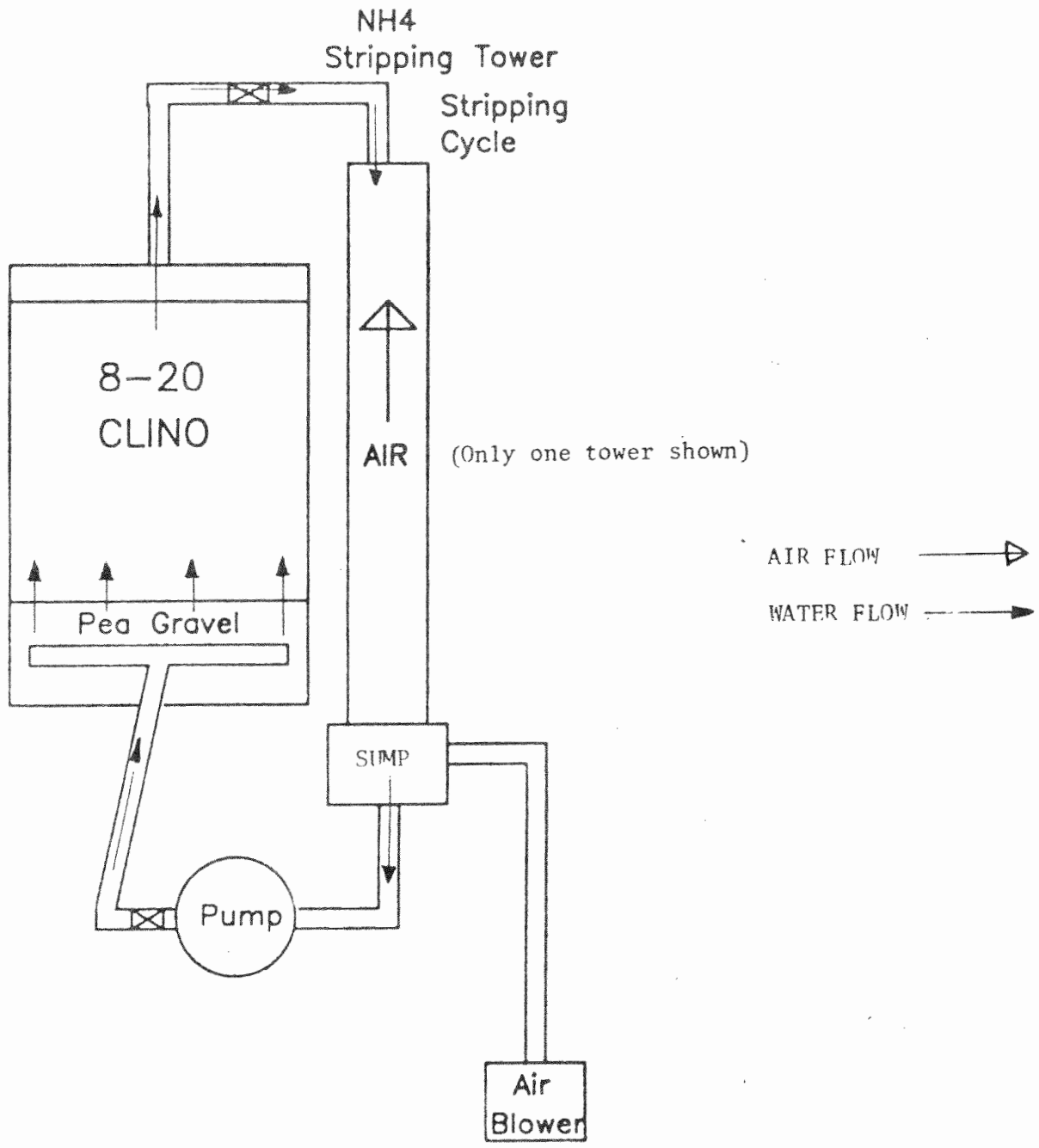

Figure 2. Regeneration Recycle and Airstripping System

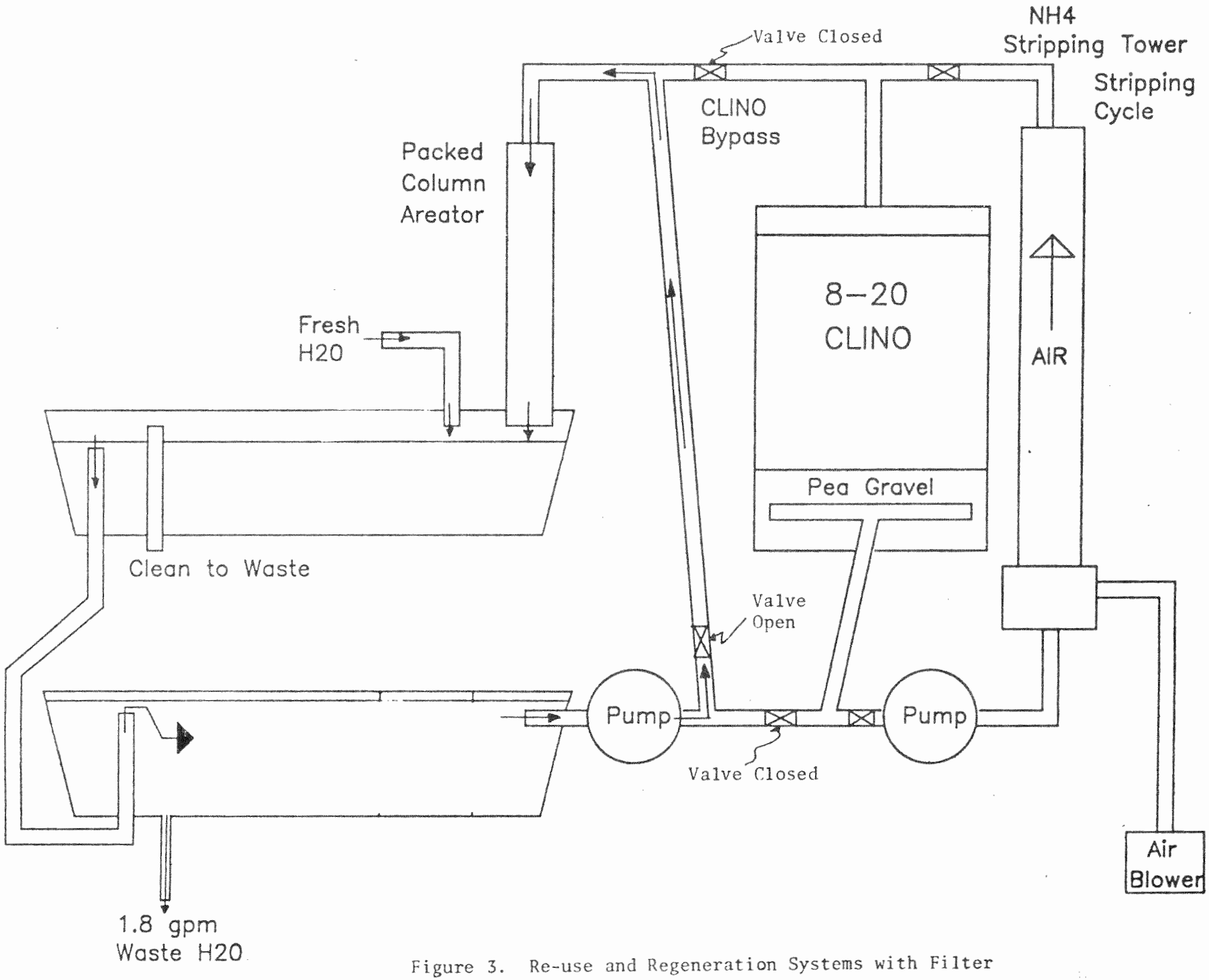

Figure 3. Re-use and Regeneration Systems with Filter By-pass.

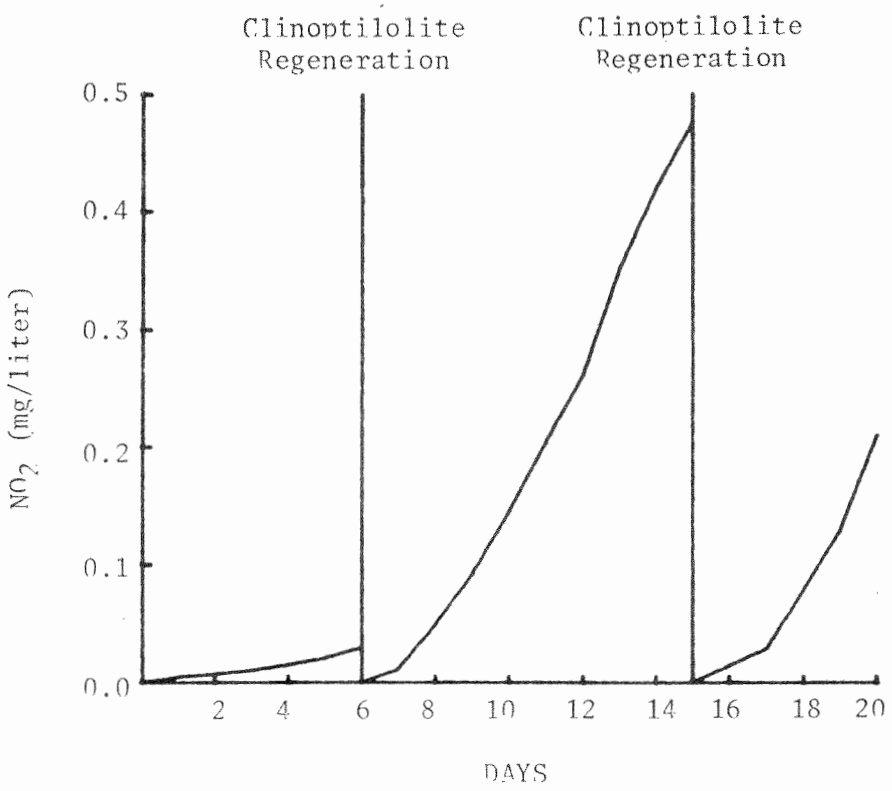

Figure 4. Typical Nitrite production on Clinoptilolite filter bed (February through May, 1982).

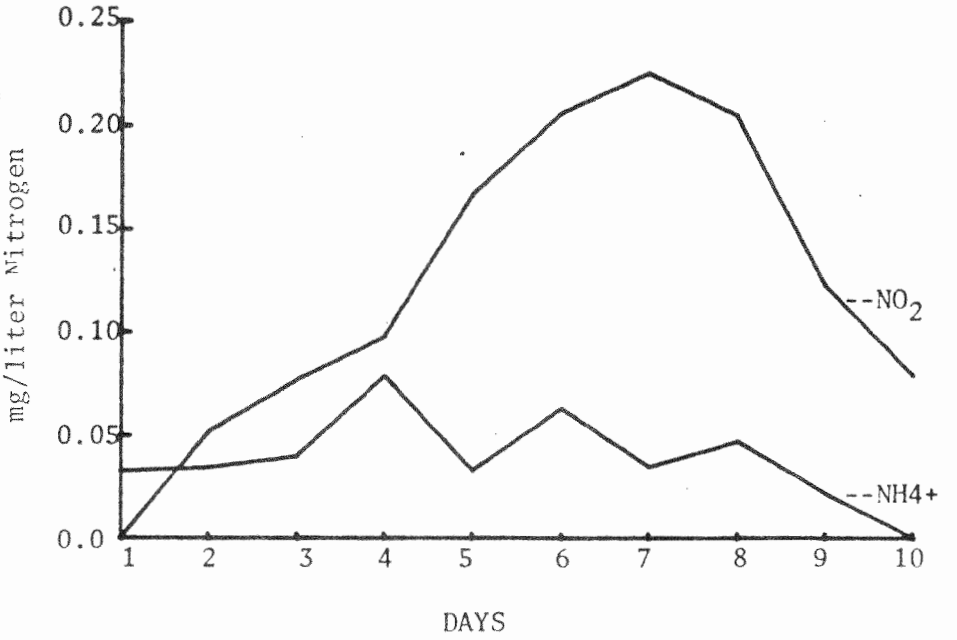

Figure 5. Reduction of NH_4+ to NO_2 in Recirculation Water (June to September, 1982).

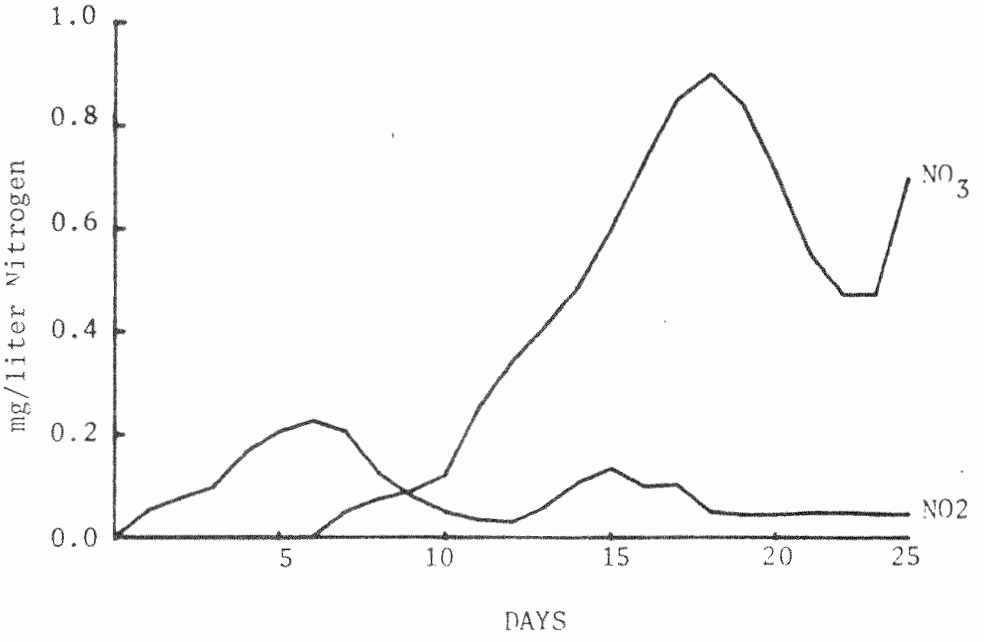

Figure 6. Reduction of NO_2 to NO_3 in Recirculation Water (June to September, 1982).

UV IRRADIATION IN FISH REARING SYSTEMS:

CRITERIA AND CONDITIONS FOR USE

John W. Nightingale and Wayne J. Daley

In aquaculture applications, ultraviolet (UV) water purifiers are devices designed to kill waterborne microorganisms. They have been, and presently are being used in many United States hatcheries and other aquaculture facilities primarily to prevent outbreaks of fish diseases by killing the bacteria, viruses, or other microorganisms which cause them. Ultraviolet purification systems have been widely used in the United States since the early 1960's when the first large unit was installed in the Dworshak National Fish Hatchery. Between then and today, the numbers of units, commercial brands, as well as the types of design have multiplied so that in 1982 there are at least four major manufacturers and three major design types for sale on the commercial market.

Through the late 1970's, use of UV units tended to be on the "blackbox" principle. That is, manufacturers specified that a particular unit was rated at 50 or 100 gallons per minute. The unit was installed in a water stream matching those specifications, and it was assumed that the unit was killing microorganisms. As the number of manufacturers and the types have increased, it has become difficult for engineers and hatchery personnel to differentiate between the kinds of units and to specify the results they wanted.

One reason is that ultraviolet irradiation of water does not produce readily detectable physical or chemical changes. There is nothing which can be measured using standard water chemistry techniques to determine the dosage delivered. All manufacturers have, and some still do, attempt a variety of indirect methods to estimate the dosage delivered by their equipment. Most of these emperical methods are based upon a 99% kill rate of a coliform organism, usually E. coli, at a particular flow rate. However, because various units have different configurations, hydrodynamic flow patterns, types of germicidal lamps, and the water quality which must pass through the UV units is variable, calculated dosages are subject to considerable error. A survey of various commercially available UV water purfication units suggests that there is no discernable relationship between their configuration and their dosage rating or capacities (Elner, 1981).

Two major factors have caused an increase in research and development of UV units and their application. First, in many situations the UV units have not been working. That is, they have not eliminated the desired microorganism. Secondly, manufacturers, in their quest for an advantage over their rivals, have done significant amounts of work. There are four areas where new information and increased understanding will assist fish culturists (Flatow, 1981). They are:

water quality
the organism
design of the unit: specifications
useage

Water Quality - There are two major factors which determine the dosage required to kill particular microorganisms. First is the water quality of the process water and secondly, the organism itself.

During most of the history of the use of ultraviolet light irradiation in fish culture, users have known that to kill organisms the ultraviolet photons must first reach them. The factors of increased turbidity or total suspended solids were long thought to diminish the effectiveness through attenuation of the photons. Some hatcheries sought to reduce turbidity through installation of filters or settling ponds. New data, however, shows that turbidity within the normal fish rearing ranges of 0 - 12 Ntu and suspended solids in the range of 5 - 50 mg/l have very little influence on the effective dosage and therefore kill rates. Both of these measurements involve the transmissibility of visible light and have little effect on dosage. What is important, is the transmission of light in the UV wave length (254 Nm, 2537 A)--transmission of the UV photons which will actually kill the organism (Figure 1) (Jepson, 1972). Thus, when measurements of water clarity are made, they should be made with a spectrophotometer, not a turbidimeter, and the analysis of transmissibility should be done at 254 Nm.

Aside from excessive turbidity, the prime factor in reducing effectiveness (or causing increased required dosages) is the presence of oxidizable organic molecules, cells, or organisms in the water to be treated. These molecules or organisms effectively soak up UV photons as they are oxidized. This causes situations where visibly clear water passing through UV units may still contain many live organisms after treatment, because organics in the water cause reduced UV transmittance while organisms in visually cloudy water may be completely killed. The filtering of sediments, settling of turbidity, or the killing of larger microorganisms through electric grids may not improve the effectiveness of the UV unit in killing bacteria at all. The specification of flows provided by most manufacturers for various units does not take into account various levels of organics or other factors which cause reduced UV transmittance.

The Organism - With all other factors being equal, different amounts of energy are required to kill different organisms. Table 1 provides a summary of dosages required to kill an assortment of microorganisms. Note that the dosages are in terms of energy, not a retention or contact time for water in the unit, or in gallons per minute flow. The initial specification of manufactured units as 50 gpm or 100 gpm were designated around the use of bacteria E. Coli as a standard organism. At 6600 mw sec/cm^2, the dosage to kill E. Coli is considerably less than that required for other organisms of concern to fish culturists. Therefore, in choosing an ultraviolet unit, the fish culturist must look to the kinds of organisms which are to be destroyed and their relative dosage requirements.

Design and Specification - There are three types of units now for sale: (1) the quartz sleeve type where the UV lamp is in air in a sleeve surrounded by the water to be irradiated; (2) the thin-film type where the UV lamps are suspended in air above a surface over which flows a thin layer or film of water; (3) the teflon tube type where the UV lamps are in air with the water contained in nearly clear teflon tubes. No manufacturer

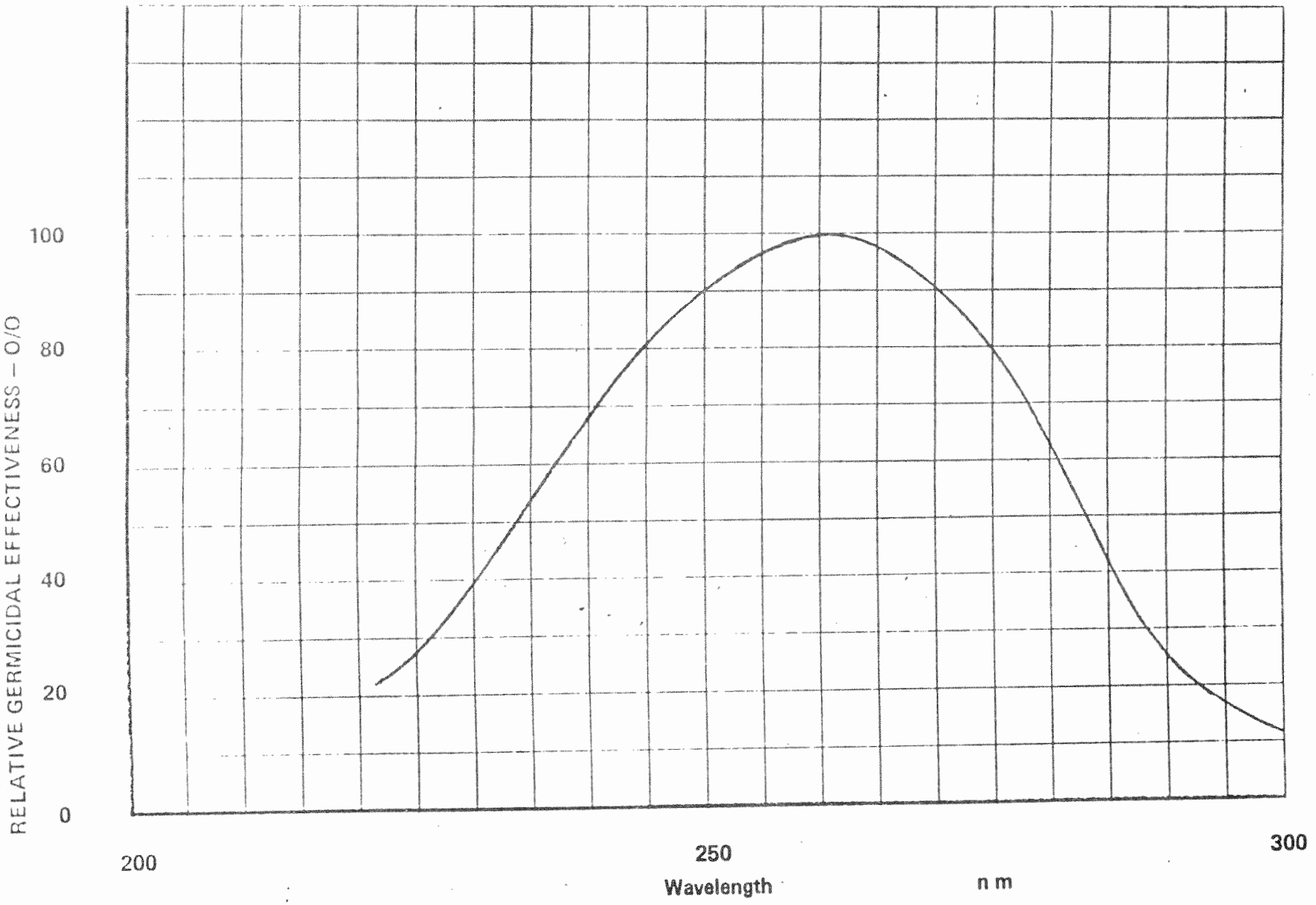

Fig. 1 Relative bactericidal efficiency of UV radiation according to wavelength

makes more than one type and the competition between builders often comes down to effectiveness of the unit and its price. Some builders claim higher effectiveness, thus they say a smaller and cheaper unit will provide the same results.

Finding a unit to deliver the desired dosage is complicated by the amount of organics in the water, discussed earlier. Add to that the differences in configuration between the units of various manufacturers and it becomes obvious that calculating the required number of lamps and water retention times for each particular case would be difficult. It is now generally accepted that it is not possible to accurately calculate required dosages in each situation (Ellner, 1981). Therefore, biological techniques for accurately determining the dosages delivered by UV water purifiers have been developed. These techniques are based upon the widely accepted principles of bioassays--response of a specified test organism to graded quantities of the parameter to be measured. In this case, the flow through the particular unit is the variable. Ideally, the bioassay would be conducted with the water to be run through the unit in its normal operating process situation. If that is not possible, the actual process water needs to be analyzed for organic content. Some adjustments can be made to bioassay results made with other water.

Results from some new and still proprietary work have shown that in recirculating systems, UV dosage is cumulative. That is, an organism need not receive the energy needed to kill it in one pass, but may receive it over 2, 3 or even 4 passes. Whether receiving the required dosage during several exposures causes an increase in the actual dosage needed to kill, is not yet known. This means that when writing specifications for a UV unit to be used in a recirculating unit, use of a bioassay is even more important in order to avoid over or under sizing the unit ordered.

UV units are usually fitted with one of two standard ultraviolet lamp types. The G30T8 and the G64T5 are two commonly used. The latter lamp type costs approximately three times the former and provides over twice the UV light output at the desired 2537A range. Selection of the higher output lamp is imperative if the unit is to reach a dosage level of approximately 40,000 micro watt seconds/cm^2, which seems to be the generally accepted level in cases without unusual organisms. All UV lamps age with time and their output decreases. They lose approximately 10% of their output in the first 100 hours and will lose up to 30% of their output in 6 months of continuous use. Some commercial manufacturers recommend changing the lamps yearly. However, in some cases, it may be necessary to change UV lamps half yearly. An intensity meter measuring the critical wave length for each lamp in the system will provide a positive evaluation tool for determining when lamps have dropped to 70% output. When examining specifications for a UV unit, one must be certain that dosages provided for the unit by the manufacturer are measured with the lamps at the end of their life (at the 30% reduced output rather than when they are brand new and operating at their highest level). If this is not done, the unit may meet specifications when the lamps are new and then fail to meet these requirements after a brief period of operation. If specifications for a unit are written such that bioassay results are required by the buyer, they should be written so that the bioassay is done at the end of lamp life. This can be simulated with a new unit for testing purposes by reducing the electrical input to the lamps as measured by

intensity meters--one for each lamp. A second alternative is to add UV absorbing substance to the water to the point where 30% of the lamp's output is absorbed. This can be measured through use of a spectrophotometer. However, removal of 30% of the lamps for such bioassay testing will negate the results and make them inaccurate because it has the action of changing irradiation exposure patterns.

Cleaning - All UV units will need maintenance and cleaning. Settling of sediments or growth of algae and other organisms on the glass or teflon through which the water passes will greatly reduce UV transmissibility. Some manufacturers claim that because of the constant UV irradiation, no organisms will grow. A brief survey of users shows, however, that fouling and growth of biological organisms occurs in all units. Routine cleaning is required to maintain maximum levels of UV transmissibility. Cleaning is very difficult in some units because the units must be shut down and partially disassembled. At least one maker offers a built-in ultrasonic cleaning device. Before choosing a unit, the aquaculturist should determine the ease with which the unit can be maintained and cleaned.

Summary - It is obvious from the above discussion that in choosing a UV unit to sterilize process water in aquaculture situations, the engineer or biologist must consider a great deal more than the manufacturer's recommended flow. He must first determine whether the water to be treated has a significant impaired transmissibility at the desired wave length. As discussed above, this must be done with a spectrophotometer and not determined strictly from the basis of turbidity or suspended solids. A biologist should look to the organism or organisms whose destruction is desired and choose the organism with the highest dosage requirement. That done, a specification can be written which requires the manufacturer to provide a certified bioassay by an independent testing laboratory. The certification will state that the unit operating at 70% of its new lamp output will kill 95%, 99% or 100% of the desired organisms. This will usually be done in terms of dosage by certification that the unit will, at 70% output, provide a dosage of 40,000 mw sec/CM ^{2} with the particular water available, as demonstrated via the organism of concern or a test organism with similar dosage requirements. Under no circumstances should an aquaculturist accept an empirically calculated dosage. Once the dosage curve is known, the flow rate for each particular unit is automatically determined. Because of the various water characteristics and the different organisms whose destruction may be desired, the flow rate may be considerably different than that specified by the manufacturer. A biologist can then be assured that a system has been assembled which will kill the desired organisms given the particular local conditions. He can also, through continued used of bioassay techniques, have a method available to verify that the desired kill is occurring in the future.

TABLE I

Ultraviolet Light (253.7 nm) Dosages

(mws/cm ^{2}) Necessary to Inhibit Colony Formation

	Percent Inhibition	
	90	100
BACTERIA		
Bacillus Anthracis	4,520	8,700
Bacillus Megatherium sp (veg)	1,130	2,500
Bacillus Megatherium (spores)	2,730	5,200
Bacillus Paratyphosus	3,200	6,100
Bacillus Subtilis (mixed)	7,100	11,000
Bacillus Subtilis (spores)	12,000	22,000
Clostridium Tetani	12,000	22,000
Corynebacterium Diphtheriae	3,400	6,500
Dysentery Bacilli	2,220	4,200
Eberthella Typhosa	2,100	4,100
Escherichia Coli	3,000	6,600
Micrococcus Candidus	6,000	12,300
Micrococcus Piltonensis	8,100	15,000
Micrococcus Sphaeroides	10,000	15,400
Mycobacterium Tuberculosis	5,400	10,000
Neisseria Catarrhalis	4,400	8,500
Phytomonas Tumefaciens	4,400	8,500
Proteus Vulgaris	2,600	6,600
Pseudomonas Aerugenosa	5,500	10,500
Pseudomonas Fluorescens	3,500	6,600
Salmonella	5,400	10,000
Salmonella Enteritidis	4,000	7,600
Salmonella Typhimurium (ave)	8,000	15,200
Sarcina Lutea	19,700	26,400
Serratia Marcescens	2,400	6,160
Shigilla Paradysenteriae	1,700	3,400
Spirillum Rubsum	4,400	6,160
Staphylococcus Albus	3,300	5,700
Staphylococcus Aureus	4,950	6,600
Streptococcus Hemolyticus	2,160	5,500
Streptococcus Lactis	6,150	8,800
Streptococcus Viridans	2,000	3,800
YEASTS		
Saccharomyces Ellipsoideus	7,300	13,200
Saccharomyces Sp.	9,700	17,600
Saccharomyces Cerevisiae	7,300	13,200
Brewers' Yeast	3,600	6,600
Bakers' Yeast	4,800	8,800
Common Yeast Cake	7,300	13,200
MOLD SPORES		
Penicillium Roqueforti	14,500	26,400
Penicillium Expansum	12,000	22,000

Table 1 (continued)

	Percent Inhibition	
	90	100
Penicillium Digitatum	48,000	88,000
Aspergillus Glaucus	48,000	88,000
Aspergillus Flavus	54,000	99,000
Aspergillus Niger	180,000	330,000
Rhisopus Nigricans	120,000	220,000
Mucor Racemosus A	19,400	35,200
Mucor Racemosus B	19,400	35,200
Oospora Lactis	6,000	11,000
VIRUS		
Bacteriophage (E. Coli)	3,600	6,600
Tobacco Mosaic	240,000	440,000
Influenza	3,600	6,600
OTHER		
Paramecium (protozoa)	110,000	200,000
Nematode Eggs	51,000	92,000
Chlorella Vulgaris (Algae)	12,000	22,000
Fungi (typical)	24,000	45,000

(from Jhawar, 1981)

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TRAPPING, REARING AND CODED-WIRE TAGGING ANTHARKO RIVER CHINOOK, 1976-1978

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Department of Fisheries and Oceans

The Atnarko River, a tributary of the Bella Coola River on the central coast, supports one of the largest wild chinook stocks left in British Columbia. Adult scale patterns indicate that Atnarko chinook migrate seaward as fry, "90-day" juveniles or yearling smolts. Trap records indicate that although "90-day" and yearling smolts account for less than 10% of the total outmigration, approximately 20% of the scales from returning adults show either a "90-day" check or freshwater annulus, indicating that these fish have a higher rate of survival than those migrating as fry.

In order to study the exploitation and distribution of the Atnarko stock, migrant fry were trapped, reared, and coded-wire tagged in the years 1976-1978. This program was the first attempt to culture and mark north central British Columbia chinook. In 1978, the rearing performance of chinook fry from the Atnarko pilot hatchery was compared to that of wild fry. Hatchery fry grew more rapidly, with fewer mortalities.

The above studies resulted in the production of a number of groups of coded-wire tagged "wild" and "hatchery" chinook, whose mean weight at release was similar, but whose time of release differed. Tag recovery data indicates that the highest juvenile-to-adult survival was provided by "wild" fish, released on June 29, 1976.

It is not possible at this time to assess the effect of time of release on distribution and subsequent exploitation.

Methods

Fry Trapping

The primary fry trapping site was located adjacent to the Atnarko pilot hatchery (Fig. 1). Each spring an Inclined Plane Trap (IPT) with a 1.2m x 1.2m opening was fished at this location (Fig. 2). A smaller IPT was intermittently fished 3km upstream from the main trap to supplement the total number of fry available for rearing.

The traps were normally fished from dusk until dawn. However, when flows were excessive, or debris abundant, they could not be fished continuously. Each morning the catch was sorted and chinook fry transported to the Atnarko pilot hatchery in aerated plastic buckets. When water conditions in the Atnarko River prevented the use of IPT's, pole seines and minnow traps were used to capture chinook fry from side channels and sloughs.

Rearing

All fry were reared in 2.85m wide, 1.2m deep oval fiberglass tubs supplied with 110 l/min of pumped river water (Fig. 3). Oregon Moist Pellets were hand-fed in accordance with Stauffer's formula for maximum ration. Tagging commenced when the average fry weight approximated 3 gms (140-150/lb).

Fingerlings to be tagged were anaesthetized (1 g MS222 per 20 l of water at 10^{o} C), adipose clipped and tagged immediately (Fig. 4). Samples were regularly dissected to check tag placement and retention.

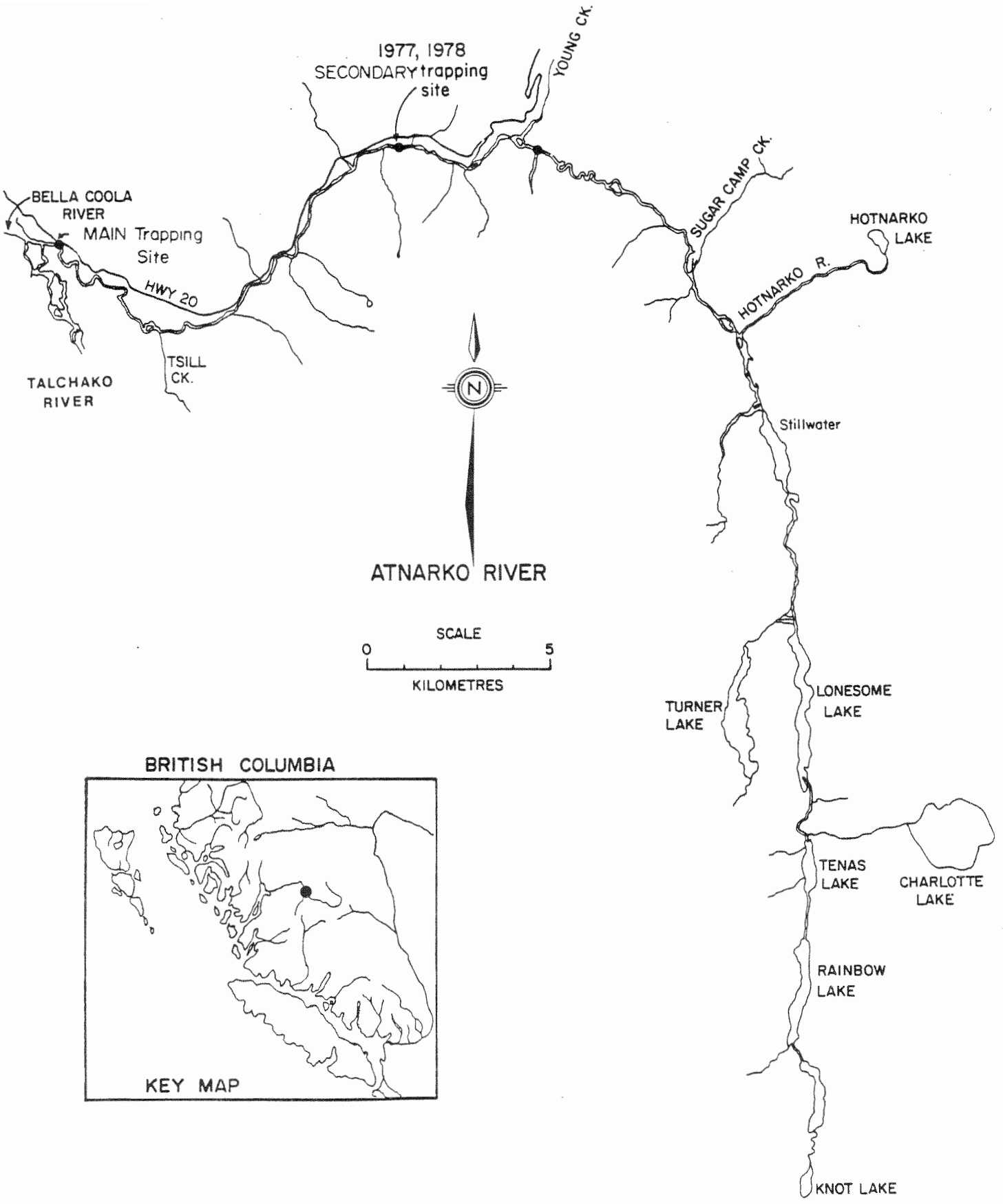

Figure 1 - Atnarko River showing inclined plane trap locations.

Tagged fish were transferred to net pens in the river and released at dusk.

Results

The results of the 1976-1978 rearing and marking programs are presented in Table I. Table II summarizes coded-wire tag recovery data to September, 1982.

Discussion

Some of the release groups were small, which makes comparisons of survival rates difficult. Compounding this problem is the subjective nature of the spawning estimates. Total escapement is estimated visually and the marked to unmarked ratio observed during hatchery donor stock capture is extrapolated to provide an estimate of total marked escapement.

Bilton et al. (1980) conclude that for coho 'optimum conditions of time and size of release are probably those providing entry of juveniles into near shore and coastal ecosystems at a time and size when maximum advantage can be taken of the available food supply'. This principle most likely can be applied to coastal chinook.

Chinook juveniles released from the Atnarko facility were all 3.0-3.25 gms, therefore size at release was not a factor in the experiment. Fry quality may have varied from year to year. However, given this, the highest reared fry-to-adult survival rates appear to have been provided by the group tagged with code 02-01-10. That is "wild" juveniles released on June 29, 1976.

Table 1. Atnarko chinook rearing success and coded-wire tag releases 1976-1978.

Date	Release Group	Number Released	% Mortality to Release	Release Date
1976	02-01-10	6,810	12.9%	June 29
1977	02-20-16	49,207	3.5%	June 20
1977	02-20-17	2,921	3.5%	June 20
1977	02-20-18	2,850	3.5%	June 20
1978(H)	02-20-20	9,376	2.6%	June 12
1978(H)	02-20-21	5,490	2.6%	June 14
1978(W)	02-20-22	57,654	3.5%	July 3-6

Table II. Estimated total recoveries and spawning ground returns, coded-wire tagged Atnarko River chinook.

Group	Code	Estimated Recoveries	Estimated Spawning Ground Return	Total Recoveries and Return	% Survival Release Adult
1976	02-01-10	63	174	237	3.77%
1977	02-20-16	71	178	249	.50%
1977	02-20-17	3	0	3	.10%
1977	02-20-18	10	56	66	2.32%
1978(H)	02-20-20	52	47	99	1.06%
1978(H)	02-20-21	33	121	154	2.81%
1978(W)	02-20-22	132	359	491	.85%

The date on which optimum conditions for release occur probably varies from year to year, in response to environmental factors such as snow-melt, run-off, and marine plankton blooms. Possibly in 1976 the release of the reared juveniles coincided more closely with the optimum release conditions than any of the subsequent releases.

There is some evidence to suggest that time of release is more critical than size at release, in determining survival to the adult. Both groups of 1978 "hatchery" fry grew to marking size more quickly than "wild" fry, thus were marked and released three weeks sooner than the "wild" fry. Both groups of "hatchery" juveniles have enjoyed a higher rate of survival, to date. Perhaps the "hatchery" fish remained in the Atnarko for a short time, and migrated seaward under optimum conditions. On the other hand, if the "hatchery" juveniles had been held until the "wild" juveniles were released, their release size would have been greater, which may have also given them a higher survival rate than "wild" juveniles.

The effect of time of release on distribution has not been fully determined. However, some interesting trends appear. Time of release appears to have an effect on the northward feeding range, and the proportion of the fish which spend an extra year in the ocean. Perhaps the fry whose seaward migration is interrupted for rearing, overwinter in fresh water more frequently, and migrate seaward as yearling smolts. Scale sample analysis of returning marked adults should provide further insight.

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RECENT OCCURRENCES OF INFECTIOUS HEMATOPOIETIC NECROSIS VIRUS IN FISH AT COLUMBIA RIVER BASIN HATCHERIES[1]

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ABSTRACT

Since 1980 a significant increase in isolations of infectious hematopoietic necrosis virus (IHNV) from hatchery salmonids in the Columbia River basin has been documented. Production losses to the virus increased more than twentyfold from 1980 to 1981 and this trend has continued into 1982. Extreme modifications to conventional hatchery practices have been adopted at certain locations where viral infected stocks must be used as an egg source. Because the virus is now widespread in the basin, personnel at locations with no previous history of IHNV will need to be especially alert to prevent its introduction.

From 1980 (Table 1) to 1981 (Tables 2 and 3) an alarming increase in the incidence of infectious hematopoietic necrosis

[1]Oregon Agricultural Experiment Station Technical Paper No. 6620

virus (IHNV) in fish at Columbia River basin (CRb) hatcheries has been observed. The data concerning IHNV in the basin thus far in 1982 (Tables 4 and 5) indicates that the virus continues to be more widely disseminated than previously recognized. This increase is apparent in terms of the number of locations at which the virus was detected in adult (carrier) fish (Tables 2 and 4) and as epizootics amoung juveniles (Tables 3 and 5) at several locations. Noteworthy, is that from 1980 to 1982, twelve locations reported the occurrence of IHNV for the first time. Estimated losses to the virus increased more than twentyfold from 1980 to 1981 and this trend has continued into 1982 (Table 6). The widespread occurrence of the virus in the CRb now poses a serious threat to susceptible species reared throughout the system and fish at all hatcheries within the basin are vunerable to this disease.

The magnitude of losses to IHNV (Table 6) are now such that production quotas may not be met at some facilities. This is the case, primarily at certain rainbow and steelhead trout hatcheries because mortality in this species has been devastating. Managers of such hatcheries should be alert for the rapid onset of any unusually high mortality, associated with signs of IHN disease (Pilcher and Fryer, 1980), in alevins and young fish. Reports of IHNV isolation from yearlings and smolts are becoming more frequent and this is typically associated with an insidious, chronic type of loss. This form of the disease was probably not the result of a

recent infection with IHNV and most likely these fish were infected when they were very young. Generally, in cases where IHNV was recovered from larger fish, other infectious agents or severe stress factors were involved. It is difficult, therefore, to determine if the virus was a direct cause of the chronic loss.

Speculation concerning the mechanism that lead to the rapid spread of IHNV in the CRb was the subject of a recent report (Groberg, in press). A precise determination of the event(s) that caused this situation would require intensive laboratory and epidemiological investigations. For purposes of discussion it is most important to realize that a serious disease problem now confronts fish culturists throughout the CRb.

As indicated (Tables 1-5), IHNV isolation was most often made from asymptomatic, adult carriers or from juveniles with IHN disease. Between these life stages the virus apparently resides in the tissues of carrier fish in a latent or eclipse phase. Present methods for virus recovery do not allow detection during the eclipse phase in carrier fish. When virus is detected in adult fish at spawning a management decision must be made concerning the disposition of eggs derived from the infected brood. Because there is circumstantial evidence for vertical transmission of virus from one or both parents to the egg (Carlisle, Schat and Elston, 1979; Pilcher and Fryer, 1980), destruction of potentially infected eggs is recommended by many pathologists.

However, other factors are often involved in these decisions; infectious disease is not always the prime consideration. Similar decisions are required when the disease occurs in young fish. Again, destruction of infected lots is a biologically sound practice because it appears that a portion of survivors become lifelong carriers and release infectious virus only as they approach sexual maturity (Amend, 1975). Therefore, transmission of virus from carrier fish can be prevented only by the elimination of carrier fish and eggs derived from them. While this approach seems drastic and difficult to accept, avoidance represents the only known method of control for IHN.

The prevalence of IHNV in the CRb has profoundly affected fish culture practices at certain hatcheries where infected stocks must be used. In essence, all procedures for control of IHN are avoidance measures designed to prevent transmission of virus to eggs or fish. It must be emphasized, however, that many of these methods are unproven in terms of controlling IHN. Some examples of modifications to conventional spawning and egg incubation methods are: (1) fertilization of eggs from an individual female with sperm from a single male, (2) iodophor disinfection of individual egg lots during or after water hardening and (3) incubation of each egg lot using a separate, pathogen-free water source. (4) Viral examinations are conducted on every fish spawned and (5) only progeny from mating pairs in which virus cannot be detected are reared. Segregation of fish into small rearing

lots during early rearing when they are highly susceptible to IHN affords an additional measure of precaution. The concept here is, that if indeed the disease occurs in some groups, it will not occur in all lots and those can be used for production. Infected lots are destroyed to eliminate potential carriers which may survive. Obviously, a large excess of eggs must be taken to accommodate the anticipated loss. This technique has been successfully applied at Round Butte Hatchery in central Oregon.

Several other avoidance considerations are required if epizootics are to be prevented. Infectious hematopoietic necrosis is a contagious disease and therefore, carrier fish in a hatchery water supply will transmit the virus to hatchery fish. Obviously, then, carrier fish must be eliminated from the water source or the water must be sterilized to prevent contamination of hatchery fish. Transfers of eggs or fish into a facility should be made only if the parent stock has a documented history of viral inspections (3-5 years) and a high probability that the stock is not infected. The watershed from which transferred fish come should be evaluated as part of this disease history. Any egg transfers from facilities in the CRb to areas where it does not occur must now be regarded as a high risk practice for the introduction of IHNV. When transfers are made, they should involve only eggs. This is because the certainty of production lots of fish not having possible exposure to viral contaminated water is low at most

rearing sites. Hatchery managers should insist upon prior sanitation of any fish transport equipment and trucks, tagging equipment and vans, grading devices and other paraphernalia brought into their facility. Sanitary practices within the hatchery should also be strictly followed to limit the spread of disease if outbreaks occur amoung fish in only certain tanks or ponds.

Indications are that IHN will continue to pose a severe threat to hatcheries in the CRb. Personnel at hatcheries with no previous history of IHN will have to be particularly alert to prevent introduction of the virus into their facilities. Spawning stocks and water supplies must be kept free of infected or carrier fish and sanitation of equipment coming into a hatchery should be insisted upon. Fish culture by conventional methods is probably impractical at stations where infected stocks must now be used. Extreme measures at the level of hatchery practices may be the only means now available to successfully rear fish at such locations.

ACKNOWLEDGMENTS

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The following abbreviations are used in Tables 1-5.

A. Abbreviations for management agencies responsible for facilities listed.

IDFG	Idaho Department of Fish and Game
ODFW	Oregon Department of Fish and Wildlife
USFWS	United States Fish and Wildlife Service
WDF	Washington Department of Fisheries
WDG	Washington Department of Game

B. Abbrevations for species of fish.

ChF	fall chinook salmon	Rb	rainbow trout
ChS	spring chinook salmon	StS	summer steelhead trout
Ct	cutthroat trout	StW	winter steelhead trout
K	kokanee salmon		

C. Abbreviations for age of fish.

Juv	juvenile
Yl	yearling
Ad	adult

Table 1. Isolations of infectious hematopoietic necrosis virus from salmonid fish at Columbia River basin hatcheries during 1980.

Hatchery	Major river drainage	Species	Age	First known occurrence IHNV this location
Round Butte (ODFW)	Deschutes	StS	Ad	8-73
Warm Springs (USFWS)	Deschutes	StS	Ad	4-79
Round Butte (ODFW)	Deschutes	StS	Juv	8-73
Pahsimeroi (IDFG)	Salmon	StS	Ad	5-80
Speelyai (WDF)	Lewis	ChS	Ad	4-73
Dworshak (USFWS)	Clearwater	ChS	Ad	9-80

Table 2. Isolations of infectious hematopoietic necrosis virus from adult salmonid fish at Columbia River basin hatcheries during 1981.

Hatchery	Major river drainage	Species	First known occurrence IHNV this location
Round Butte (ODFW)	Deschutes	StS	8-73
Cowlitz (WDG)	Cowlitz	StW StS Ct	2-81
Warm Springs (USFWS)	Deschutes	StS	4-79
Little White Salmon (USFWS)	Columbia	ChS	8-81
Round Butte (ODFW)	Deschutes	ChS	8-73
Minto Pond (ODFW)[a]	North Santiam	ChS	9-81
Speelyai (WDF)	Lewis	ChF K	4-73
Cowlitz (WDG)	Cowlitz	Ct StS StW	2-81
Beaver Creek (WDG)	Columbia	Ct	12-81

[a] Adult trapping and spawning site.

Table 3. Isolations of infectious hematopoietic necrosis virus from yearling and juvenile salmonid fish at Columbia River basin hatcheries during 1981.

Hatchery	Major river drainage	Species	Age	First known occurrence IHNV this location
Entiat (USFWS)	Columbia	ChS	Yl	6-74
Eagle (IDFG)	Snake	Rb	Juv	4-81
		K	Juv	
Gnat Creek (ODFW)	Columbia	StW	Juv	4-81
		StS	Juv	
American Falls (IDFG)	Snake	Rb	Juv	1-80
Skamania (WDG)	Washougal	StS	Juv	5-81
Mossyrock (WDG)	Cowlitz	StW	Juv	5-81
		Rb	Juv	
		Ct	Juv	
Cowlitz (WDG)	Cowlitz	Rb	Yl	2-81
		Ct	Juv	
Niagra Springs (IDFG)	Snake	StS	Juv	7-78
Dworshak (USFWS)	Clearwater	Rb	Yl	9-80
Hagerman (IDFG)[a]	Snake	Rb	Juv	11-81

[a] IHNV diagnosed coincident with a proliferative kidney disease epizootic.

Table 4. Isolations of infectious hematopoietic necrosis virus from adult salmonid fish at Columbia River basin hatcheries during 1982.

Hatchery	Major river drainage	Species	First known occurrence IHNV this location
Pahsimeroi (IDFG)	Salmon	StS	5-80
Dworshak (USFWS)	Clearwater	StS ChS	9-80
Cowlitz (WDG)	Cowlitz	Ct StS StW	2-81
Beaver Creek (WDG)	Columbia	StS StW	12-81
Skamania (WDG)	Washougal	StS	5-81
Kalama Trap (WDG)[a]	Kalama	StS	3-82
Rapid River (IDFG)	Salmon	ChS	?-79
Leavenworth (USFWS)	Wenatchee	ChS	?-51[b]
Speelyai (WDF)	Lewis	ChS	4-73

[a] Adult trapping site.

[b] Loss attributed to an unknown filterable agent in later years identified as IHNV (Watson et al., 1954).

Table 5. Isolations of infectious hematopoietic necrosis virus from juvenile salmonid fish at Columbia River basin hatcheries during 1982.

Hatchery	Major river drainage	Species	First known occurrence IHNV this location
Niagra Springs (IDFG)	Snake	StS	7-78
Dworshak (USFWS)	Clearwater	ChS StS	9-80
Round Butte (ODFW)	Deschutes	StS	8-73
Cowlitz (WDG)	Cowlitz	Ct StW StS	2-81
Beaver Creek (WDG)	Columbia	Ct StW StS	12-81
Skamania (WDG)	Washougal	StS	5-81

Table 6. Estimated losses of trout and salmon eggs and juvenile fish to infectious hematopoietic necrosis virus at Columbia River basin hatcheries[a] since 1980.

Year	Eggs destroyed[b] (X 1,000)	Juvenile mortality[c] (X 1,000)	Cummulative loss (X 1,000)
1980	149	150	299
1981	4,805	2,938	7,743
1982	1,125	5,446	6,571

[a] Does not include data for private trout hatcheries in Idaho.

[b] Eggs destroyed because IHNV recovered from brood fish.

[c] Mortality to IHN including fish destroyed because they were in infected lots.

Q. Has there been any word on people going into the field and verifying IHN in wild populations? Most of your work was with the hatcheries.

A. We have a wild population of kokanee in Oregon which is above our Round Butte facility which we think is a source of contamination for that hatchery. That's why we don't even try to eliminate the virus at that location because we have the wild kokanee stock which is probably 100% infected. In the Chilko River in Canada there is actually documentation of an epizootic in juvenile sockeye salmon where they migrated from the river below Chilko Lake. Egg to fry survival was significantly below normal, 5% or so; this loss was attributed to IHN in that case. That is one documentation of an epizootic in the wild, and there are a few wild stocks that are known to have the virus.

Q. If and when you do that in the Columbia Basin, you go into the system and see it in there, what is that going to do to your philosophy on management if for example you go into the Grande Ronde and find it in the natural populations? What is that going to do to your philosophy of not putting fish into that system if it's already got it? I guess my concern is like yours, with this great outbreak of it or seeing it more and more, management's got to do something with some fish, some place, or we are going to be faced with destroying every fish in the Columbia?

From the pathologist's point of view where does the break point come? When do we say we cannot release any of these fish? You infer Idaho lives with it, so that everything they release is IHN positive. It's got

to come through the entire system. Where is the breaking point on this thing?

A. Where it goes is to monitoring of stocks on an annual basis. For example, at Wallowa Hatchery on the Grand Ronde, we've done that for the last 4 or 5 years. We have not seen the virus there but potentially we are going to see it there because of the close proximity to the Idaho stock. The way we've got that set up is in the hatchery design, which is going to be renovated this year, is to anticipate seeing the virus. We sample every fish spawned there, and if we get virus we can go back and identify those egg lots and they will be destroyed. We're also prepared for outbreaks in the juveniles. It's been set up so the fish are reared in small rearing lots so that if one lot breaks they can be destroyed without wiping out the whole production or a half or a third. This leads to the other part, dealing with known IHN stocks. The break point comes, I guess, at our hatcheries we don't presume the virus is established there until we see loss in the juveniles even though we might find it in the adults. Typically we will destroy eggs where we do find virus in the adults.

If we have lost the juveniles almost invariably we will destroy those lots and hopefully then there will be production lots left to meet production goals. Now this year at Round Butte we were unable to do that. The virus hit at the largest size ever there. It was the last lot that was left after we destroyed 2 others and they broke with virus. So this year we are going to have to release fish from a known outbreak if they survive

tagging. They're going to be finclipped and handled and there could be a substantial loss in them.

Q. I saw a comment which showed the number of eggs being destroyed last year versus this year 5.0 versus 1.3 million. Is that the situation of those that are not involved in any outbreak? You were just saying we can't destroy everything and we have to live with it in certain cases. The reason I asked, I understand Leavenworth shipped their eggs to Idaho and nothing was destroyed. They simply went to Idaho where they live with it. Is this reflection of people beginning to really live with IHN, saying we can't destroy every egg or whole lot of fish that have it?

A. I think that is a reflection of that, yes. And I don't know what my own personal recommendation as a virologist for the State of Oregon will be the next time we get an isolation like Minto. I had a lot of difficulty with the 2.3 million eggs destroyed as a result of one isolation. I think all of us who have been around this for a few years are in a real state of quandary about it. I hate that phrase "live with it". I despise it because if living with it is a 40-fold increase in loss in 2 years, I don't want to live with that. Because if that trend continues, let's say we go to 10 million and to 20 million, who's going to be raising steelhead. You won't be living with it, they'll all be dead!

Q. I don't say it's inevitable to live with it but who's going to make the decision, what's going on here with the pathologists or the agencies or what? What you're saying is don't spread this stuff all around. Now

we've got agencies that are saying, hey give it to us we'll take it. Who's going to make the ultimate decision, who's going to put their foot down and say that's enough, stop this? You know, who's going to make that decision? I guess Oregon basically kills or destroys their eggs but other agencies don't, and who has the final say or who do you wish to have the final say on that?

A. No one has the final say on that. There have been some discussions there have been meetings and proposals made to have a regional committee made up of all the agencies in the Columbia Basin including private people from the Hagermann Valley in Idaho that could address these kinds of things. I don't think it will ever get to the point that committee with representatives of Oregon, Washington, Idaho and the Federal Government and private people would have enough power to tell an agency to destroy an infected group of fish. I just don't think it will ever go that far. But certainly recommendations coming from that committee would have hopefully pretty strong consideration by the agency which is receiving those recommendations. I don't know what the answer to that is, at some point in time we're not going to keep destroying eggs in Oregon if other states keep propagating carrier fish. We simply can't do that. I think we're going to probably continue to destroy infected groups of fish because we don't want that high carrier rate. But there are some questions about vertical transmission and egg destruction. I think as long as everyone isn't going to it might not be a viable alternative much longer. But we will do it until we absolutely don't have any alternative.

Green Eggs and H.A.M. (Hatchery Anti-pathogen Management)

Kevin H. Amos
Pathologist
Washington Department of Fisheries

Perhaps as curious, and at times confusing as a Dr. Seuss story is the manner in which certain infectious diseases are transmitted from fish to fish in our hatcheries. Much speculation, circumstantial evidence and some documentation indicate that infectious hematopoetic necrosis virus (IHNV) and bacterial kidney disease (BKD) are pathogens transmitted vertically and horizontally. The argument begins however, when researchers try to lobby for one manner over the other. It is important for the fish culturist to know how these diseases spread so that they may implement a control or prevention program. Today, I would like to review some of these methods used to control IHNV and BKD and discuss the techniques used by the Washington Department of Fisheries.

First of all, I will differentiate between vertical and horizontal transmission. Vertical transmission is the method of pathogen transfer in which a parent fish infects the offspring either in utero or at the time of spawning. Eggs, ovarian fluid and milt have been shown to carry both IHNV and BKD. At the time of fertilization, either (or both) pathogen(s) could be attached to the egg surface or enter through the micropyle with the result of establishing the carrier state of disease in the offspring.

Horizontal transmission is the method of pathogen transfer in which a reservoir of disease infects another fish either directly or by a vector. The reservoir for the pathogen may be a carrier fish (as is often the case) or any other animal and the vector includes the water, fish feces and/or hatchery equipment. IHNV and BKD are known to spread in this manner, yet it

is open to speculation which method of infection, horizontal or vertical, is the primary cause of epizootics. We must not forget that besides the presence of a pathogen other extrinsic and intrinsic factors such as stress are necessary for a clinical outbreak.

Before we discuss the control and prevention of IHNV and BKD, I will examine the treatment regimes we have available to us. This will be a very short discussion as there are not many effective and legal alternatives. Antibiotic therapy has demonstrated to be effective on a short-term basis, with BKD reoccurring when treatment stops. Erythromycin seems to be one of the most effective drugs; however, it is not approved! Chemical therapy for clinical IHNV fish is not available. The reduction of stress such as reducing loading levels can be quite successful in slowing an epizootic. One can also rely on an old favorite of releasing the sick fish - you know, "out-of-sight, out-of-mind", however, some of these carrier fish will probably come back to haunt you.

We now see that with the limited tools available to combat epizootics, our best bet is to try to prevent IHNV and BKD from occurring. The first step is to have a hatchery health management plan. This plan should consist of several elements to include: 1) provisions for optimum rearing conditions when possible to reduce stress, 2) good hatchery sanitation, 3) proper disposal of mortality, 4) annual inspection of brood stock to determine carrier status, 5) limited movement of fish between hatcheries and particularly fish free of viral diseases, and 6) contingencies to treat eggs from known or suspect carrier adults. The hatchery personnel should take an active role with their pathologist in setting up the program so that they will be carried out effectively.

At Department of Fisheries hatcheries where IHNV has appeared in the past, or has a high probability of occurring, we use a "throw out" program similar to that used by other agencies. The process includes thorough sampling in small groups of adult brood stock (as small as one fish per sample) for viral diseases. All eggs are water-hardened in relatively pathogen-free water and then disinfected for ten minutes in a 100 ppm iodine solution (Wescodyne) before being put into an incubation container. All spawning equipment and buckets are disinfected between groups of fish to prevent cross-contamination. The labelled samples are assayed for virus and if a sample is positive the corresponding pool of eggs is discarded. This technique has been successful for us to date, yet I have no way of knowing whether or not an epizootic would have occurred had I not discarded the positive pools. One must also be aware that this method has limited sensitivity and that it is possible for an IHNV positive sample to go undetected.

Another experimental method to prevent vertical transmission of virus is the use of viricidal chemicals during water-hardening. Several researchers have tried a variety of agents with iodophors frequently being mentioned. In vitro and laboratory in vivo experiments appear successful with Wescodyne; however, failure to isolate IHNV after a water-hardening treatment does not mean that the virus is not present. Often viral particles will bind to tissue in such a manner that it does not replicate in our assay system and is therefore undetectable. I have not run hatchery - scale tests on known positives but I have conducted tests on virus-negative eggs to determine if the iodophor is detrimental to the egg. The data, which I will show later, indicates that iodine-related toxicity does occur.

Bacterial kidney disease is still a nuisance at many of our hatcheries

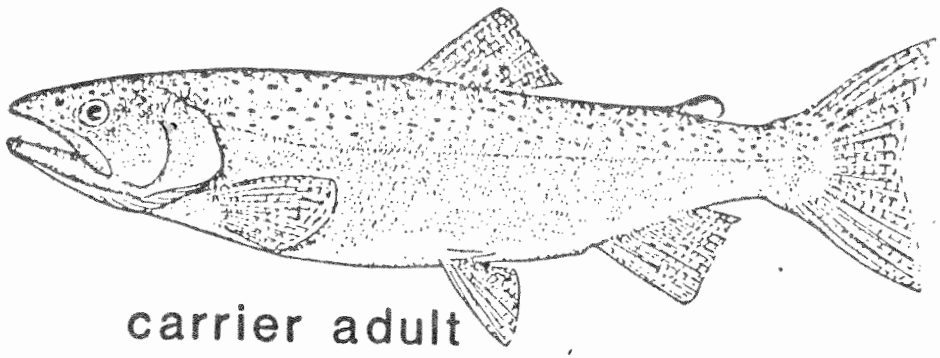
but our prevention program has decreased losses, especially in spring chinook salmon. Our program is one that I am sure you are all familiar with, especially if you have attended this conference the past couple of years. It includes the injection of adult brood stock with an Erythromycin solution prior to spawning (four weeks minimum), discarding eggs from severely infected females, and water-hardening the eggs in a four (4) ppm Erythromycin solution (PFI). The original work we completed at the University of Idaho indicated that a two (2) ppm solution provided therapeutic levels. The manner in which we add the drug to green eggs directly to the incubation tray may not allow even dispersal of the agent to all the eggs, therefore we think four ppm will be more effective and guarantee all eggs will uptake at least two ppm of Erythromycin. Some allegations have been made in the past that even two ppm was detrimental to eggs. Our hatcheries have never had a problem with toxicity but I thought I would test higher levels to determine at what level toxicity occurs. I administered levels of 300, 100, 30 and 10 ppm Erythromycin (as PFI) on green, unwater-hardened spring chinook eggs. At 300 and 100 ppm a slight but significant increase in mortality over the controls was observed.

These control programs are not a guarantee that IHNV or BKD will not occur at your hatchery. They will, however, decrease the likelihood and in some cases, the severity of epizootics. I think the key is to anticipate these problems and have a sound health maangement plan in effect.

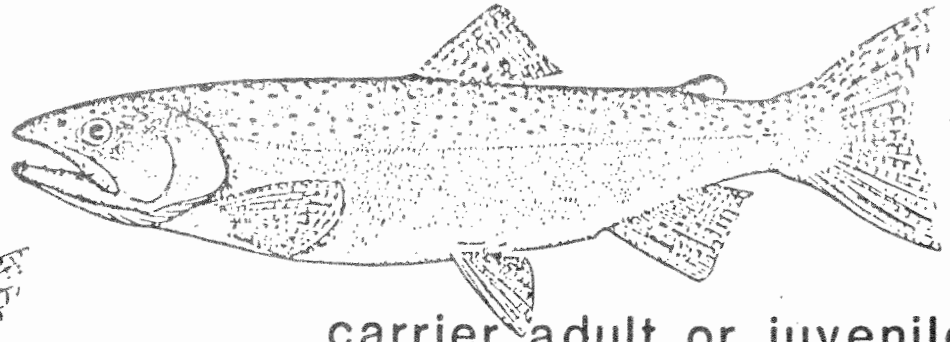
EFFECTS OF WATER-HARDENING SALMON EGGS IN SELECTED THERAPEUTIC AGENTS

TREATMENT	LOSS TO EYEING	ANOMALIES IN FRY
Control	3.3%	0.14%
Gallimycin 50 (as ppm Ery)		
300 ppm	6.7%	0.36%
100 ppm	6.9%	0.15%
30 ppm	4.7%	0.00%
10 ppm	4.4%	0.14%
Wescodyne (as ppm iodine)		
32 ppm	8.7%	0.45%
16 ppm	9.5%	0.25%

TRANSMISSION of PATHOGENS



carrier adult



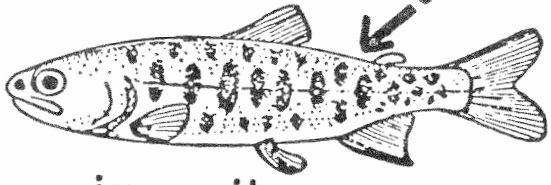
carrier adult or juvenile

H_2O

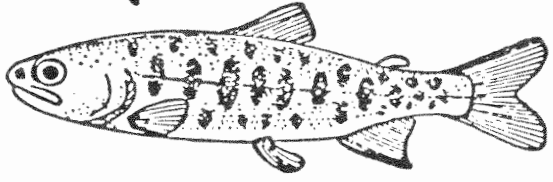
feces

cannibalism

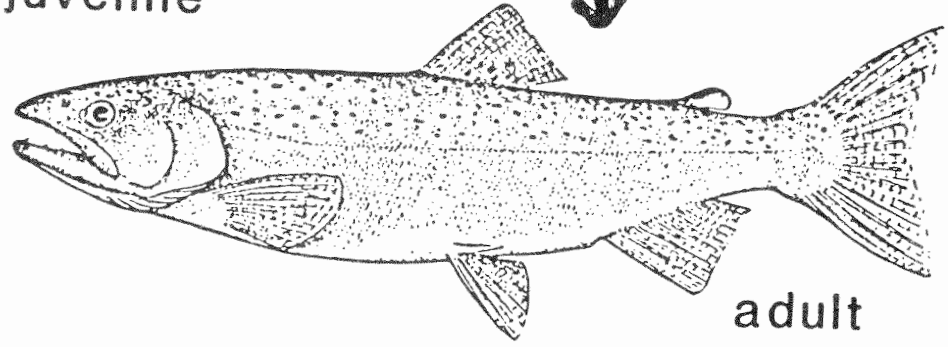
infected egg



juvenile



carrier juvenile



adult

VERTICAL

HORIZONTAL

EPITHELIOCYSTIS FOUND IN SALMONIDS IN THE PACIFIC NORTHWEST

Joseph C. Lientz
Fish Disease Biologist-Dworshak Fish Health Clinic

Plehn in 1920 described mucophilosis observed in the gill tissue of carp. Hoffman in 1969 found a similar organism in the gill tissue of bluegill. Until 1980, it had not been reported in Salmonids.

During the 1980 rearing season at Dworshak, the organism was found in spring chinook fry. Since that date, it has been observed in all species reared at Dworshak and Kooskia NFH's. While SCS appear to be the most susceptible, it is also found on RBT and steelhead.

Now that we are aware of the organism, it has been found in the states of California, Idaho and Nevada. It has appeared in cutthroat and FCS as well.

Description

The causative agent is Richettsia or Chlamydia-like. Its size ranges from 6 - 80 µm depending on what stage of development it is found. The shape is round to ellipsoid. Normally it is found in gill tissue and in the mucuous but has been isolated from the intestinal tract. Brownian movement is noted inside the cysts.

The cysts appear to be cyclic during the rearing season and often void of internal structure--yet they retain their shape. An internal nucleus can often be seen. As the organism increases in size, the nucleus many be compressed to one side. When the cysts reach a size of 70 - 80 µm, the cyst is usually filled with the inclusion body. At this stage the organism is on or near the surface of the gill epitheliuum. It is also observed in all stages in the mucous.

Observations in Salmonids

Epitheliocystis has been found on young first feeding fry and on yearlings. It usually causes mortality in the weaker fish, healthier fish may harbor the organism and serve as carriers, but it does not appear to effect the fish. Costia is usually found when the organism is observed.

Concerns

Epitheliocystis infections in fish may be pathogenic and cause severe mortality, particulary to juvenile fish. It occurs as a benign infection in the gills which induces only limited time response. As a proliferative condition, it causes extreme gill swelling. The severe gill swelling can result in a complete respiratory shutdown, with secondary fungal and bacterial infections and bacterial infections and necrotic tissue leading to death.

The precentage of mortality in the fry is difficult to calculate as it is usually masked by other fish health problems.

Treatment

Normal treatments are of little effect in controlling the disease. The weakened fish usually die from the treatment, not the disease. Terramyacin in the feed at a three percent level appears to have the most control to date.

Concern

If the Epithetiocysts organism is harbored in your water supply, then at any time your fish are weak or poor performers there is the potential for heavy infestations and additional losses.

I would be interested in any new findings and the distribution of this organism.

IHN VIRUS DISEASE OUTBREAK IN CHUM SALMON, HISTOPATHOLOGY

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Histopathology was utilized to confirm infectious hematopoietic necrosis (IHN) virus disease in chum (Oncorhynchus keta) alevins from Kitoi Bay Hatchery. Kitoi Bay Hatchery is located on Afognak Island near the island of Kodiak. Juvenile sockeye salmon were planted into the hatchery water supply during 1973. Fish held concurrently from this lot underwent an IHN virus disease epizootic in that hatchery. The remaining portion of that lot was transported to Hokkaido, Japan where an epizootic in those fish resulted, and the disease subsequently occurred in other salmonids including chum salmon. Chum salmon 1981 eggs (465,069) were collected from the Sturgeon River on Kodiak Island and incubated at Kitoi Bay Hatchery. After picking, 427,399 eyed eggs remained. A water manifold failure resulted in death of close to 99% of these fry and eggs. Some fish survived in one incubator. A portion of these were removed and placed in a plywood incubator. From these, 970 emerged fry died due to IHN virus, and the survivors were destroyed. An estimated 1850 total chum fry emerged with 49% having died due to IHN virus. Chum alevins affected showed cephalic depression--different from the cephalic bump present in sockeye (Oncorhynchus nerka) alevins infected with IHN virus, erythemia of the eyes, ventral surface and at the base of the fins and lordosis (dorsal-ventral deformation) and scoliosis (lateral deformation) of the vertebral column. The presence of IHN virus disease involvement in the

mortality was diagnosed using standard cell culture virus assay with the EPC cell line, the plaque assay system with the same cell line and serum neutralized with IHN antiserum. Detailed histopathology of this original finding on the North American continent of IHN virus disease in chum salmon was conducted. Hematoxylin and eosin is the only stain yet used for this examination. The primary organ which shows histologic alterations caused by the disease is the kidney. Kidney sections show massive necrosis of hematopoietic (red blood cell producing) tissue, karyorrhexis (rupturing of cell nuclei into formless debris), edema (the presence of excessively large amounts of fluids in intracellular spaces) in voids of parenchyma (the essential elements of an organ) and general necrosis and fragmentation of the nucleus of renal tubule cells into two distinct portions. The fragmentation is a condition associated with this virus disease in several different organs or tissues. It is most closely analogous to karyoschisis (the breaking or fragmentation of the nucleus). The divided nuclear material may be two nucleoi or the remaining chromatin. The kidney necrosis was noted to be in several apparent stages. Pyknosis (a condition of thickening of a cell by shrinkage and concentration of nuclear material) of the parenchyma cells and abundance of serous fluid with renal tubules unaltered and some normal kidney architecture present seems the least advanced. Renal tubule cell degeneration would be proposed as the intermediate stage with a terminal necrosis phase being without tubules remaining. Only subtle changes are noted in the liver of IHN virus disease-infected chum alevins. Karyoschisis of hepatocytes and minor intracellular vacuolization were the liver conditions seen. Areas adjacent to the liver were hemorrhagic and edematous. Pancreatic tissue of moribund Sturgeon River chum salmon displays the aberrant condition of acinar cell

pyknosis. The intestine of chum alevins taken as moribund samples during an epizootic also had tissue alterations which included the rounding of cells, karyoschisis, edema, hemorrhage and pyknosis. The coelomic cavity in general is filled with cellular exudate containing primarily erythrocytes which are the result of hemorrhage and edema. Since IHN virus disease is known to be caused by a rhabdovirus, the brain of Sturgeon River infected chums was examined with no definite conclusions drawn, although some cell damage may be present.

Questions and Answers

Q. Could you quickly summarize known species in Alaska that have IHN whether they are hatchery fish or wild stocks. There may be some cases with sockeye we don't know for sure, we know with chum. Could you quickly give us some perspective of how great a problem IHN is in Alaska?

A. There seem to be about two questions there. Let me go to the first one first. We have the disease in the new case with chum salmon and normally with sockeye salmon. In sockeye it's related to a previous question, natural epizootics have occurred in 1980 in smolts, sockeye smolts, in one lake and in fingerlings of another lake. The same lake, which as far as we know is the first time that a sockeye smolt epizootic in the wild has been known, had mortalities in the next two years also. We have carrier state IHN virus in three stocks of chinook salmon and there has been one reported finding of IHN virus in a pink salmon stock of southeast Alaska that was not by our agency and we've

not been able to confirm it. Is it a big problem? The numbers are big enough in terms of our losses when we have them that it would make Warren Groberg's look very minor. It tends to be a higher order of magnitude when we have it. With the exception of the chum mortalities we have not had IHN virus disease in two years.

Q. I have a final question. Looking back at Columbia River hatchery records, I see where eggs have been shipped to Alaska on quite a few occasions. Do you run any back checks to see if some of your problems with IHN come from the Columbia because of these transfers in the Past?

A. Actually the records that I am looking at show that millions of eggs went the other direction from Kodiak area hatcheries to the Columbia River.

TOTAL DISINFECTION OF PRODUCTION FACILITIES

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A good hatchery management plan includes safeguard of the production facility from disease and parasites. It is extremely important when the facility rears more than one species of fish.

At Dworshak National Fish Hatchery, steelhead trout, spring and fall chinook salmon, rainbow trout and kokanee salmon are all incubated; and some are reared in the same rearing vessels. Each of these species has its own disease history and care must be taken not to cross-contaminate between species.

There are six separate fish-rearing facilities at Dworshak; three of which are large reuse systems.

-- System I consists of 25 Burrows ponds, six clarifiers and five "fluidized bed" biological filters. Total flow in this system is 15,000 gallons per minute (gpm) with a 10 percent make-up water rate. Total volume of water in System I exceeds 1.5 million gallons.

-- System II consists of 25 Burrows ponds and four biological filters. Total flow is 15,000 gpm with a 10 percent make-up flow rate. Total volume of water in this System exceeds 1 million gallons.

-- System III consists of 34 Burrows ponds and six biological filters. Total flow is 20,400 gpm with a 10 percent make-up flow rate. Total volume of water in this System is in excess of 1.5 million gallons.

The three large reuse Systems all have a potential for disease carry-over from year to year. Each System on reuse is disinfected after a production cycle.

There are 30 new raw-water, single-pass raceways. These are standard 8-foot x 80-foot raceways with a total flow of 15,000 gpm.

The incubation room operates strictly from sterilized make-up water. This flow is single-pass, and maximum demand is 750 gpm.

The nursery building consists of 128 nursery tanks (3-foot by 16-foot), two clarifiers and two biological filters. Total flow in this system is 6,000 gpm with a 10 percent make-up flow rate. The main concern from a disease standpoint is the nursery building. Here, four different species of fish are reared in the same vessels.

Chlorine had been used in the past in a granular form known as HTH (Calcium hypochlorite). While there were several problems in using HTH, the main drawback was mixing of the granular material and getting it into solution. To overcome this problem, the station started using liquid chlorine in 1977. Although the cost of liquid chlorine is higher than the granular form, the benefits make up the difference. Liquid chlorine is easy to apply, and all of the chlorine goes into solution.

A routine disinfection at Dworshak consists of adding enough liquid chlorine to attain 50 parts per million (ppm) of available chlorine. This rate used to be 250 ppm, but was changed when this level was found too high for routine disinfection; 200 ppm is recommended when a disease outbreak is diagnosed. Chlorine is added to a System and allowed to circulate within the system for a 24-hour period. All fish production equipment is sterilized along with the System. Care must be taken that no chlorine leaks out of the system. By proper water level control and continuous monitoring, a reuse System can be disinfected quite easily.

It is extremely important that personnel doing the disinfecting be safety conscious and know the material they are handling. Safety gear includes a rain suit, rubber gloves and a face mask or goggles. A mask is preferred as chlorine will burn the skin. Care should be taken to avoid breathing the chlorine fumes. If the area is not well ventilated, a respirator should be used. Enough sodium thiosulfate should be on hand to completely neutralize all the chlorine added. Chlorine containers are labeled as to the hazards of the product, what safety precautions to use, and directions for medical attention. Before applying chlorine, consult local, state and federal regulatory agencies for the proper procedures that relate to a given watershed.

Some disinfecting at Dworshak is done after daylight hours because of the rapid breakdown of chlorine by sunlight. Chlorine is added at the latter part of a work day and carried through the night. In the past, this has been done routinely

at Kooskia National Fish Hatchery; a part of the Dworshak complex. Only experienced personnel should disinfect at night, and the design of the system must be thoroughly known beforehand. One small leak can be a disaster to downstream recipients and the environment!

Disinfection may very well become routine in the hatchery environment.

LIVING WITH THE IHN VIRUS AT THE COWLITZ HATCHERY

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The Cowlitz Trout Hatchery was completed in 1968. It is located seven downstream from the Mayfield Dam on the Cowlitz River. The facility is owned by the City of Tacoma and is operated by the Wanshington Dept. of Game. Total construction cost was $ 3,700,000. The hatchery was constructed with a projected downstream migrant release of 650,00 steelhead, 200,000 sea-run cutthroat and 38,000 pounds of legal rainbow trout.

The facility consists of a 104 trough hatchery, 6 fry raceways, 24 fingerling raceways, 4 five acre rearing lakes and the necessary trapping and brood holding facilities. The water supply consists of 50 c.f.s. of pumped river water supplemented with 3 to 5 c.f.s. of well water. The annual egg capacity is 3,500,000.

In late April of 1981, nearly a year after the eruption of Mount St. Helens there was an increase in mortality at the hatchery. The water temperature was not high enough for the usual summer outbreak of Ceratomyxa Shasta. The Dept. of Game pathologist examined the fish and sent samples to Mr. Kevin Amos at the Dept. of Fisheries laboratory in Olympia, Washington. Mr. Amos identified the problem as infectious hematopoietic necrosis virus (IHNV). This was confirmed by Dan Mulcahy, research Virologist, National Fisheries Research Center in Seattle.

A complete house cleaning was in order at the Cowlitz Hatchery. All suspected infected fish were destroyed, stop logs pulled and burned. Raceways were pressure pumped down to bare concrete, including the head box and tailrace and treated with 200p.p.m. chlorine solution. All boots brooms, nets, pails, brushes and implements used in the daily routine were sterilized with 150 p.p.m. Argentyne solution. Every effort has been made to avoid recontamination.

Working in conjunction with Dan Mulchay, new egg taking techniques were implemented here at the hatchery. Credit should be given to the Mgr. Harold Fischer Benzon for his efforts in this transition. Females were spawned individually. Ovarium fluid samples were taken and transferred to the National Fisheries Disease Lab in Seattle for culturing. The hatchery was set up with PVC pipe manifolds so that each females eggs could be held separately until the

culture was completed in ten days. As soon as the results were known all positive eggs were destroyed.

Egg taking on a one at a time basis was at first thought to be quite time consuming but after several spawnings the crew developed a good working procedure and little time was lost. This did however increase record keeping.

The 1981-82 eggs hatched with very little mortality. Fry were growing nicely. On April 14, 1982 we had a power outrage that resulted in the loss of 5 c.f.s. of well water. The hatchery and fry raceways are operated on well water. We were forced th operate using river water for these five days. Eight days later, after grading a raceway and splitting the fry into two raceways mortalities increased. Both raceways were found to have the virus IHN.

The fish were apparently stressed by the grading process. To eliminate this factor we did not grade for the next two months but divided the fish as they became heavy with poundage. In August grading was resumed we used a Morton grader borrowed from the Skamania hatchery. This seemed to create less stress. A fish pump was employed to move fish from raceway to raceway instead of netting with a pot.

The fish that were infected with IHNV were isolated in the last series of raceways. They were held for the remainder of the summer. Mortality was picked daily. They were treated periodically to control fungus infections. The IHNV mortality stabilized but the majority of this group were lost as a result of Ceratomyxa Shasta.

In conclusion, after living with IHNV for two brood years, it appears the best tools that we have are:

1. Complete disinfection and sterilization of all rearing facilities tanks, pumps, boots, brushes, nets, pails, etc.
2. Spawn each female separately, taking ovarium fuild samples and holding the eggs until the lab tests are returned. Destroying the positive eggs.
3. Operate on well water as long as possible.
4. Keep fish loads spread out as much as space and available water allows.
5. Avoid stressing and limit handling to a bare minimum.
6. Continue seeking new information and apply it here.

The Use of Substrate in the Reduction of Coagulated Yolk Disease in Chinook Salmon (*Oncorhynchus tshawytscha*)

Howard Fuss
Washington Department of Fisheries

Introduction

White spot or coagulated yolk disease has been a chronic problem in salmonid culture for many years. It affects nearly every cultured specie of salmonid but appears to be restricted to various areas or hatcheries.

There have been many postulated causes of the disease. In 1961, Robert Rucker reported to the Northwest Fish Culture Conference on the proceedings of the coagulated yolk disease conference. Aside from defining coagulated yolk disease, the conference discussed possible causes or contributing factors. These included: Heredity, Bacteria or viral, Temperature, Malachite Green, Water Chemistry, Loadings and Physical Injury. To date, 20 years later, the cause or causes of coagulated yolk disease are not known.

The Washington Department of Fisheries has had chronic problems with coagulated yolk disease affecting primarily chinook salmon at certain Columbia River hatcheries. The hatcheries primarily affected are Klickitat Hatchery, Elokomin Hatchery and Grays River Hatchery. Of the three hatcheries, Grays River has the most serious problem with the disease.

In recent years, WDF has incorporated artificial plastic substrates during incubation as a means of reducing the impact of the disease. The following report describes the results of experiments conducted at the three forementioned hatcheries located on the Columbia River.

Methodology

In 1980, substrate was used at Klickitat, Elokomin and Grays River hatcheries. Three types of substrate were used in deep troughs at Klickitat - bio-rings, vexar and flat screen. At Grays River, bio-rings Intalox saddles and flat screen were used and at Elokomin only vexar was used. Eggs and alevins were incubated in deep troughs at all three hatcheries. The fry were ponded as per normal procedures and mortality was monitored throughout the rearing period. Unfortunately, the data collected was mostly subjective in nature. To gain some greater insight into the effectiveness of substrate, a more comprehensive study was initiated the following year at both Elokomin and Grays River hatcheries. In this experiment, half of the production at each hatchery was incubated with substrate and half without substrate. At both hatcheries, alevins in both treatments were visually examined for incidence of the disease prior to ponding. Fry from the substrate groups were ponded separately from fry in the control groups so that rearing mortality could be monitored effectively. In addition, the fry from each treatment were marked prior to release with separate Ad-CWT codes for purposes of monitoring marine survival rates.

Results

As previously mentioned, the 1980 results were largely subjective. Hatchery managers at all three stations felt that the substrate fry were higher quality and suffered lower mortality. The 1981 experiment was more definitive. At Grays River, mortality was very high in both groups (Fig. 1). The overall mortality rate in the control group was 17 percent up to the time (May 5, 1982) when both groups were combined in the release ponds. The mortality rate of the substrate groups during the same period was 10

percent. Two peaks of mortality occurred (Fig. 2), the first in late January was characterized by large numbers of fry with obvious signs of coagulated yolk sacs. The second peak occurred in mid-April and was characterized by fish of all sizes with frayed caudal (flag tails) and pectoral fins. A higher percentage of both groups died during the second peak than the first peak, however, the control group fish died at a much higher rate than the substrate group fish. Prior to ponding, a random sample of 25 alevins from both groups were examined and it was determined that roughly 50 percent of the control group and 10 percent of the substrate group were afflicted.

The data from Elokomin was not as conclusive as the data from Grays River. The mortality rate of the substrate group was slightly higher than the mortality rate of the control group (1.2% and 0.8%, respectively) prior to combining. The lower overall mortality rate at Elokomin and the slightly higher mortality rate of the substrate groups at Elokomin may be due to: 1) Elokomin Hatchery has been experiencing a decline over the last three years in the severity of coagulated yolk disease. This was, in part, due to a reduction of the incubation flows in the deep troughs. 2) The fry in the vexar may have suffered injury due to the method of ponding, which was somewhat different than at Grays River. The mortality at Elokomin was also not accurately determined during several periods because of muddy water. This may have resulted in inaccurate mortality figures for both treatments.

Conclusions

1. The use of bio-rings at Grays River Hatchery was effective in reducing the mortality of chinook salmon caused by coagulated yolk disease.
2. The coagulated yolk problem at Grays River is much more severe than at

Elokomin Hatchery.

3. The use of substrate at Elokomin Hatchery did not appear to reduce the incidence of coagulated yolk disease.

Figure 1. Mortality due to coagulated yolk.

	Grays	Elokomin
Control	17%	0.8%
Experimental	10%	1.2%

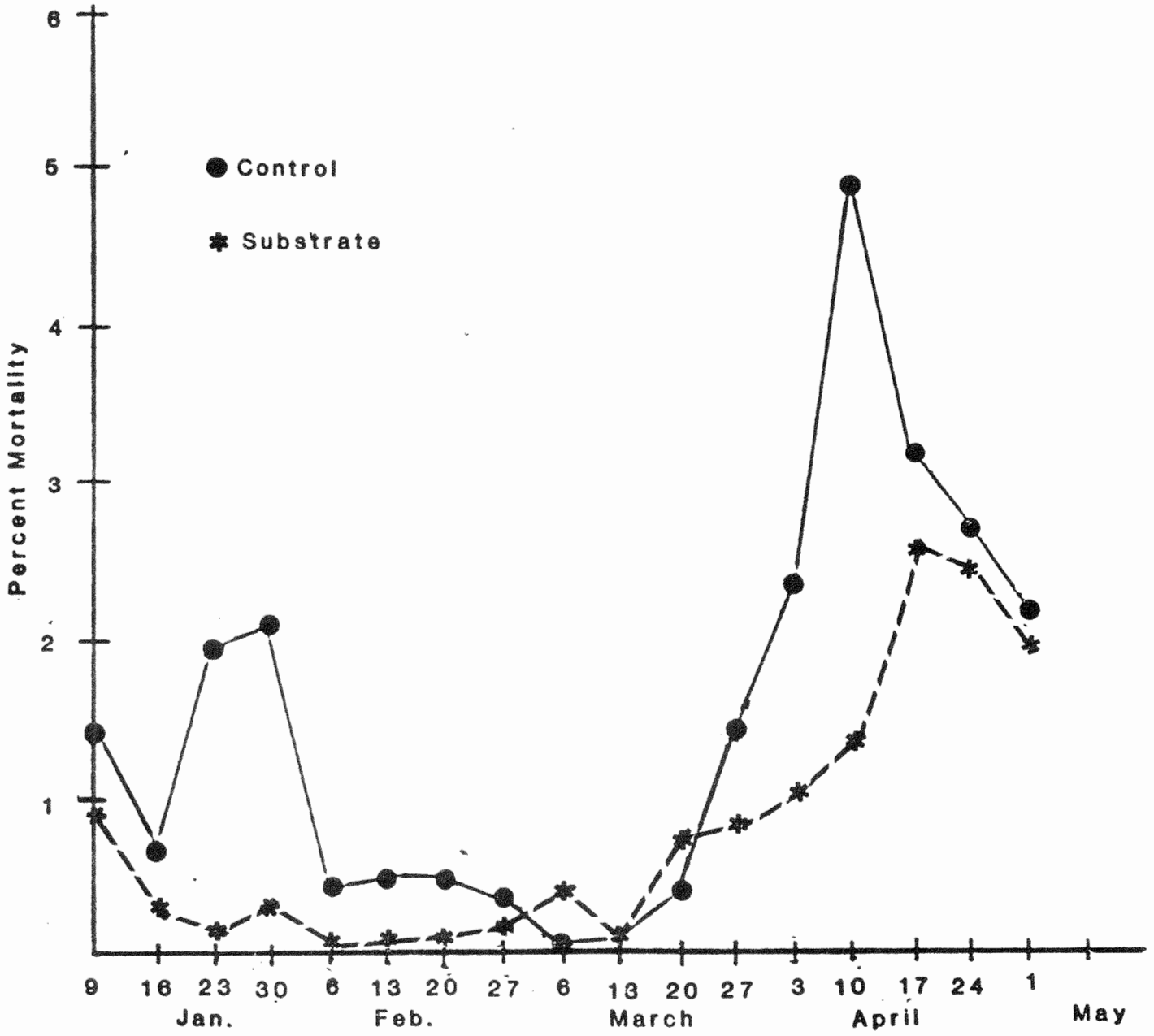

Fig. 2. Mortality rates of the control and substrate groups at Grays river hatchery prior to being combined in common ponds.

Procedures for Routine Monitoring of Fish Health and Water Quality At Dworshak National Fish Hatchery

Joseph C. Lientz, Fish Disease Biologist - Dworshak Fish Health Clinic

Fish health and quality depends on the quality of water used in fish rearing facilities. Intensified fish cultural operations can only be successful if the basic water quality parameters and fish health are monitored routinely.

Water Quality Monitoring

Specific fish cultural problems can result from water quality changes--many of which go undetected.

Although tests performed routinely are simple in nature, analysis of the parameters and fish management methods as related to fish health changes can be complex.

Specific water quality parameters may have to be sampled at various times during the year. Collection and analysis techniques are complex and deserve special consideration. EPA samples must be monitored and accurate records kept in order to comply with permits.

Each fish rearing facility will need to:

1. Determine parameters to be monitored and frequency of monitoring.
2. Analyze data for normal ranges and alert fish culturists to any potential effects on fish health.
3. Maintain a history of fish health problems as related to water quality changes. Establish a specific monitoring program if a particular parameter is suspected of causing a fish health problem.
4. Assign one or more individuals to monitor water quality. A training program will be initiated and close communication should exist between the biologist and the station concerning water quality changes.
5. Establish and maintain a format of records for EPA monitoring. Submit EPA reports.

At Dworshak, we have found the above monitoring program to be not only beneficial but a necessity in producing healthy fish and avoiding fish health problems.

The typical Dworshak monitoring program consists of basic water parameters (dissolved oxygen, pH, temperature, flow, ammonia and nitrite), three times a week, which takes approximately one to two hours. Nitrogen gas sampling is done once a week or whenever systems changes are made that might indicate a potential change in gas levels. EPA sampling is conducted two times a month on seven effluents for settleable and suspended solids. Other parameters are run quarterly on the four major water systems consisting of Zn, Mg, Na, K, Pb, Fe, and Cu. The domestic water supplies are sampled quarterly by the Department of Health and Welfare for fecal coliforms.

Coordination between the station manager, fish culturists, fish disease biologist and fisheries engineer must be maintained. Development centers, research stations and private laboratories may be called on to help determine problems and to help find solutions.

Establishment of a coordinated water quality monitoring program will improve understanding of the relationship between production and water quality in producing quality fish. The potential for increasing production or improving fish quality can be supported by water quality monitoring. An increase in mortalities can be averted if water quality changes are noted in advance. Specific water quality problems may be removed if they are found.

Fish Health Monitoring

Diseases of cultured fish cause fish health problems as long as fish are held in confinement. Quality fish can only be produced and problems reduced through fish health examinations and monitoring.

Four objectives need to be approached:

1. Conduct fish health examinations and monitor changes. Specific exams relating to gill changes, metabolism and disease organisms present should be conducted.

2. Note those areas in the hatchery rearing program where fish health changes may affect fish quality through fish health examinations and input from the hatchery staff.

3. Develop a history of disease and fish health problems during the rearing cycle so future management plans can avoid the problem. Specific disease organisms should be isolated and noted as to size, flow, temperature and feeding relationships.

4. Support of management goals by monitoring test groups and changes in management plans.

The importance of fish health changes in advance of a mortality increase cannot be emphasized enough. Production of quality fish can be achieved by reducing fish health problems and predicting changes needed in the management plan.

Each station, water source, species to be produced and design is an individual problem. Successful operation depends on having the basic information at hand, concentrating on solving specific problems and recruiting the needed expertise to solve the problems.

Our goal is a quality product.

Q. In terms of the KD we heard you talk about IHN and prevention of spreading and transferring it around. Is KD the same or do we routinely send KD around from hatchery to hatchery. It seems to me that that with KD we do and it doesn't seem like we're as concerned about it as we are about the IHN. Is there a reason for that? Maybe you can kill KD and not worry about transferring it or what's the deal?

A. I think we worry about KD but possibly we've been mesmerized into living with it because it's been around so long. One reason is that you can treat it with antibiotics with some success. Secondly your losses normally will not be nearly as catastrophic. It's true that during an IHN outbreak you may have 2-3% mortality groups. There is also potential of 90-100% mortality. You can use other management schemes to reduce your losses from KD. It's not a good idea to move it around if possible, especially to a place where it is not enzootic but it appears to be in most stocks.

Q. Have you or the other pathologists from the States done the kind of analysis like is being done with IHN and has it been published?

A. It may have been done but I couldn't speak to that. I would say that you have to assume that BKD is in most all of our stocks whereas we don't make that assumption with IHN and I don't think you should ever make that assumption. The reference was made earlier that I noticed to Idaho fish coming down with IHN. That is not necessarily true, you can't make that assumption. There may be some in the stocks' history

but you never can assume that they are carrying it and you should treat it that way.

Q. One question I was wondering if anybody is using heat treatment for the IHN?

A. For IHN? At one time at Dworshak when Einar was there as the hatchery biologist they used to chlorinate the system as well as heat the system and bring it up above 90° at least three times and this seemed to be of benefit. It's also expensive to do this on a large production level. Can anyone else field that question? Is Warren Groberg still here?

Warren Groberg: Just a couple of comments. Original heating of water work took place in California and there is a pretty good deal of evidence that that strain of IHN is different than Oregon's and Alaska's and Washington's and in fact there is an experiment that indicates that mortality and lost IHN increases as temperature just like typical bacterial pathogens. So far that would only be applicable to the California strain so far as reduced mortality in heated water.

EVALUATION OF ERYTHROMYCIN FOR CONTROL OF BACTERIAL KIDNEY DISEASE IN SPRING CHINOOK SALMON AT COLE RIVERS HATCHERY

by

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INTRODUCTION

Cole Rivers Hatchery located on the Rogue River at km 252 (river mile 156) was constructed by the U.S. Army Corps of Engineers to mitigate for fishery losses resulting from the three dam complex known as the Rogue Basin Project. The hatchery which began operations in 1972, produces about 800,000 yearling spring chinook smolts annually. Since 1977, following the closure of Lost Creek Dam (located immediately upstream of the hatchery), bacterial kidney disease (BKD) has caused moderate to high losses in juvenile spring chinook reared at the hatchery. Development of a treatment strategy to control BKD began in 1980 using the drug erythromycin.

METHODS

In 1980 (1979 brood), two test groups of spring chinook juveniles were given two 21 day treatments (beginning June 18 and September 2) of OMP feed containing erythromycin phosphate (Gallimycin-50) administered at 0.10 g (active)/kg body weight. These groups were coded wire tagged and released in October 1980 along with two control groups (released at corresponding sizes) which were part of on-going experiments to evaluate the effects of size and time of release, and Vibrio anguillarium vaccine on survival of juveniles to adulthood.

Beginning in 1980, all spring chinook eggs were water hardened for a minimum of 60 minutes in a 2 mg/l solution of erythromycin PO_4 ("Gallimycin PFI - Poultry Formula Improved"). In addition, 1980 brood juveniles received two 21 day prophylactic treatments of erythromycin treated feed, similar to the 1979 brood, with the exception that the feedings were initiated about 3 months earlier (March 16 and May 21) than the previous year. One treated and one control group (non-medicated feed) were coded wire tagged and released in October 1981.

In 1981, we adopted a new experimental design to evaluate the practice of injecting adult spring chinook with erythromycin in addition to testing prophylactic treatments of medicated feed. A group of 497 adults (357 females and 140 males) was given subcutaneous injections (along the anterior insertion of the dorsal fin) of erythromycin phosphate ("Erythro-200") at an average dose of 11 mg (active)/kg body weight on June 30 and July 1, 1981. A second control group of 190 fish was handled similarly to the injected fish, but received no injection. Each group was placed in separate holding ponds. Pre-spawning mortalities were examined for visible kidney lesions, and kidney smear samples were collected for later analysis. We also examined fish that survived to spawn for the presence of kidney lesions and collected kidney smear samples for BKD analysis. Eggs obtained from both groups were water hardened in an erythromycin solution, as previously described, and incubated and held separately. Experimental release groups were later established to test the four combinations of treatments utilizing adult injections and prophylactic feedings of erythromycin medicated feed. These groups were coded wire tagged and released in October 1982.

Three methods were used to diagnose kidney disease in adult salmon: 1) visual examination for kidney lesions; 2) laboratory analysis of kidney smears using the gram stain technique; and 3) laboratory analysis of kidney smears using the fluorescent antibody technique. The least sensitive method

of diagnosis is visual examination for kidney lesions, while the most sensitive method is the fluorescent antibody technique. Kidney smears collected from adult chinook were first analyzed using the gram stain method. Samples from fish that tested negative for BKD by the gram stain method were then analyzed using the fluorescent antibody technique. Fish testing positive for BKD using gram strains were not further tested. Dr. Jim Sanders (Oregon Department of Fish and Wildlife pathologist) and Mr. Jim Long (Oregon State University, Dept. of Microbiology) diagnosed all kidney smear samples.

RESULTS AND DISCUSSION

Completed returns to Cole Rivers Hatchery for age 1+ jacks in 1981, and incomplete return data for age 2+ jacks in 1982 of 1979 brood test groups shows comparatively high return rates to the hatchery of the two groups that received prophylactic treatments of erythromycin medicated feed (Table 1). At age 1+ the large release group treated with erythromycin returned at about six times the rate of the large control group, while the small release group treated with erythromycin returned at about 1.5 times the rate of the corresponding control group. Incomplete 1982 returns also show better survival for both erythromycin medicated groups, although differences are less than those observed for 1981 returns. The magnitude of survival differences observed was particularly surprising because both medicated and non-medicated groups appeared to be in similar states of health at release as measured by mortality rate for the 45 day period prior to release. Prerelease mortality, which ranged from 0.62% to 1.16% for this period, was about 13-23% higher for control groups than corresponding medicated groups, but not high enough to suggest the large survival differences observed. Prerelease pathological examination also indicated little or no differences between groups. Adults from these groups will continue returning through 1984.

Incomplete returns of 1980 brood groups also showed a better return of age 1+ jacks to the hatchery for the medicated group (Table 2), although the magnitude of the difference is lower than observed for 1979 brood groups returning at age 1+. Although prerelease mortality during the 45 day period before release was nearly 3 times greater for the control group, the rate (1.3%) did not indicate a severe problem. However, a test conducted by Mr. Craig Banner, (Oregon State University, Dept. of Microbiology) that involved the transfer of fish from the control group to salt water tanks located at the O.S.U. Marine Science Center, indicated a potentially serious BKD problem within that group. Of 171 fish tested, 51 (29.8%) fish that died during the 100 day exposure period were diagnosed positive for BKD using the fluorescent antibody technique. Only 1 of 100 fish examined prior to seawater exposure tested positive for BKD.

Data collected in 1981 from adult spring chinook indicate some positive benefits attributable to erythromycin injections. There were fewer prespawning mortalities in the erythromycin injected group as compared to the control group. Differences in mortalities between injected an noninjected females were highly significant ($P \leq 0.01$) (Table 3). Although lower mortality was also observed for injected males as compared to control males, the difference was not significant ($P > 0.05$).

Diagnostic data also suggested positive benefits attributable to erythromycin injections. Significantly higher ($P \leq 0.05$) proportions of prespawning mortalities from the control groups exhibited kidney lesions (Table 4). Highly significant ($P \leq 0.01$) differences were also found between prespawning mortalities from control and erythromycin injected groups using the gram stain method of diagnosis. Additional testing using the fluorescent antibody technique revealed a high incidence of BKD in both groups, although no significant

differences were found in prespawning mortalities. These data suggest that although a high proportion of both control and injected groups were infected, the level of infection was reduced by erythromycin injection. Diagnostic data for spring chinook that survived to spawn also supports the previous conclusions (Table 5). No differences between groups were found using the kidney lesion and gram stain methods of diagnosis; however, a significantly higher proportion ($P \leq 0.05$) of samples from the control group tested BKD positive using the gram stain plus fluorescent antibody method of diagnosis.

In summary, preliminary data collected from these studies suggest the following:

1) Low level infections of BKD in spring chinook juveniles during hatchery residence may seriously impact survival to adulthood.
2) Prophylactic treatments of erythromycin medicated feed may result in substantially improved survival to adulthood, even when BKD levels appear inconsequential.
3) Erythromycin injections of adult spring chinook can significantly reduce BKD related prespawning mortality and reduce the level of infection in surviving adults, confirming the findings of several other studies in this area.

Table 1. Observed tag recoveries from October release groups of 1979 brood adult spring chinook returning to Cole Rivers Hatchery in 1981 and 1982.

Group	Number marked at release	Fish/ kg	Tags recovered (%) 1981	1982[a]
Large, Control	33,132	18.5	7 (0.021)	14 (0.042)
Large, Vibrio Vac.	32,105	16.8	3 (0.009)	3 (0.009)
Large, Erythro.	32,041	18.5	39 (0.122)	26 (0.081)
Small Control	31,710	19.2	7 (0.022)	7 (0.022)
Small Vibrio Vac.	31,878	20.9	7 (0.022)	6 (0.019)
Small Erythro.	32,169	22.9	11 (0.034)	11 (0.034)

[a]Incomplete data.

Table 2. Observed tag recoveries from 1980 brood erythromycin test groups returning to Cole Rivers Hatchery in 1982.[a]

Group	Number marked at release	Fish/ kg	Tags recovered (%)
Control	31,102	11.7	10 (0.032)
Medicated Feed	31,966	12.3	28 (0.088)

[a]Incomplete data

Table 3. Percentages of adult spring chinook pre-spawning mortality from control and erythromycin injected groups, 1981.

	Control (n)	Injected (n)	X^2
Females	27.1 (140)	14.6 (357)	10.47[a]
Males	22.0 (50)	16.4 (140)	0.74
Total	25.8 (190)	15.1 (497)	10.34[a]

[a]Indicates significant difference for $P \leq 0.01$.

Table 4. Percentages of control and erythromycin injected prespawning mortalities diagnosed positive for BKD using kidney lesions, gram stain, and gram stain plus fluorescent antibody methods of detection, 1981.

	Control (n)	Injected (n)	X^2
Kidney lesions	61.4 (44)	38.5 (78)	5.14[a]
Gram stain	79.6 (49)	44.6 (74)	13.98[b]
Gram stain plus fluorescent antibody	91.8 (49)	86.5 (74)	0.76

[a]Indicates significant difference for $P \leq 0.05$.
[b]Indicates significant difference for $P \leq 0.01$.

Table 5. Percentages of spawned spring chinook from control and erythromycin injected group diagnosed positive for BKD using kidney lesions, gram stain, and gram stain plus fluorescent antibody methods of detection. 1981.

	Control	Injected (n)	X^2
Kidney lesions	6.5 (108)	3.8 (104)	0.38
Gram stain	39.7 (63)	29.8 (57)	1.32
Gram stain plus fluorescent antibody	100.0 (63)	91.2 (57)	5.23[a]

[a]Indicates significant difference for $P \leq 0.05$.

Questions and Answers

Q. I have a question in relation to the issue of BKD. We've talked about IHN this morning. We live with BKD if you know you've got it and release the fish. Do you have wild stocks of spring chinook left in the system and if so, are you concerned about the potential impact of what you're doing on these stocks?

A. Yes, the Rogue supports probably the largest wild run of spring chinook left in Oregon and the hatchery is located at the upper end of the area of production for spring chinook. One reason we're concerned about controlling BKD at the hatchery is to reduce the impact that the hatchery may have as a "disease reservoir" on wild production downstream.

Q. You mentioned feeding erythromycin. Which form of erythromycin do you feed?

A. Gallomycin 50. We mix it in the feed at a 9% level and feed the medicated feed first thing in the morning. The fish seem to take it pretty good. The remaining ration of untreated feed is fed later in the day.

Q. And your dosage rate was what again?

A. 0.1 g (active ingredient/kg of body weight).

Eagle Creek National Fish Hatchery Density Study Progress Report

Jamieson E. Holway

Review and Introduction:

In 1979 Dr. Keith Sandercock of Canada reported here at the Northwest Fish Culture Conference on a density study with cohos at their Capilano facility. In short he showed that if they cut the load in half they increased the percent survival. In 1977 it was 100% and in 1979 it was 50%.

His presentation set off a number of responces and reactions:

1) It was the first time we have had hard evidence that crowding in itself at the hatchery does effect survival.
2) It started some real communications between many interested parties.
3) It has paved the way for greater understanding of the problem and the definition of loading.
4) It has promoted a new series of research into the problem.

The first thing was to agree on a common language to be sure we were saying the same things. Keith was talking in terms of numbers per surface area. Other workers think in terms of numbers per volumn, some in terms of pounds per volumn, some in terms of pounds per flow, and others in terms of density factors. To complicate it more, some used the metric system while others used the english system. On top of it all everyone has different size ponds, fish size, flows and lastly loading was confussed between biological life support and space requirements.

I belive that in the past three years most of us have resolved these delemas. We now seperate density factor (space) from load factor (biological life support). We have come around to using a common language for space requirements as defined by Bob Piper. Density factor = $\frac{\text{weight/volumn}}{\text{lenght}}$. This puts all holding ponds regardless of size, shape and depth into a common denominator. It also puts any size fish into a relationship with the space available at any point in time.

Through Piper's methods it becomes possible for others to varify the Canadian results under different sets of conditions as they exist at any location. For example Eagle Creek has 8x80 raceways, single pass water, 30" depth with a fish size of 15.0/lb (5.9"). To the Canadians using Burrow's ponds 36" deep with fish 22/lb (5.0"). Space and flow limitations durring the production cycle at Eagle Creek requires that we must split three times a year thus brings us to higher loadings four times prior to release. The Canadian test shows only one split when the fish are ponded from the hatchery rearing tanks in June of the first production year. With the density factor concept we can limit the crowding to the same relative maximums at any point in time.

It is not enough to just varify the Canadians findings but to see what actual differences can be expected under Eagle Creek's unique production situations for use in planning our future program.

Analysis of the Canada loading data indicates that they were infact measuring the effect of space requirements rather than effects of metabolic requirements. Abernathy Fish Culture Development Center is under taking tests at Willard NFH on cohos and Carson NFH on Spring

Chinnok that takes into account both space and metabolic loadings. Eagle Creek's study while varing density levels has set up maximum metabolic loadings well below what should not interfere with the study results.

Eagle Creek's Basic Test:

The proceeding of the Northwest Fish Culture Conference in 1980 and in 1981 outlines in detail the tests used at Eagle Creek. Basically, however the test is set up as follows:

A. Three densities, two raceway replicates, each given a coded wire tag.
   1) Density Factor .15 = Canadian Low
   2) Density Factor .30 = Canadian High and Eagle Creek Normal
   3) Density Factor .45 = Eagle Creek's normal prior to 1977.

B. Loads are set to reach maximum densities four times durring the production year, in April, June and August and released on June 1st the following year. Splits occured when maximum densities were reached.

C. Metabolic loading (load factor = $\frac{wt/flow}{lenght}$) to be maintained below critical levels for NH_4 not to exceed .3 ppm or oxygen to go below 7 ppm.

D. Study to run a partial year starting January 1, 1980 with a release of May 1, 1980 and three full production cycles 1980, 1981 and 1982.

E. Evaluation is based on coded wire tag (CWT) recoveries primarly to the hatchery.

Evaluation Program:

U.S. Fish and Wildlife Service, Eagle Creek National Fish Hatchery,

Jamieson E. Holway:

1) Evaluation of production data
2) CWT returns to
    a) Jones Beach
    b) Jacks to the hatchery
    c) Ocean and River adults
    d) Adults to the hatchery

U.S. Fish and Wildlife Service, Oregon State University,

Dr. Carl Schreck:

1) Stress and Health
    a) Plasma cortisal
    b) Interrenal cell activity
2) Performace capacity
    a) Vibrio resistance
    b) Regulate sodium
    c) Pay back on oxygen debt following exertion
    d) Growth in sea water
3) State of Smoltification
    a) Plasma thyroxine
    b) Cortisol level
    c) Cortisol metabolic clearance rate
    d) Juvenile hemoglobin patterns
    e) Gill NA^+/K^+ ATPase activity

4) Behavioral avoidance tests

a) Presence of unfavorable ordorants

(Dr. Schreck is reporting his findings elsewhere in these proceedings)

National Marine Fisheries Service, Jones Beach,

Earl Dawley:

1) Lenght frequency

National Marine Fisheries Service, Willard,

Dr. Wally Zogg:

1) Gill NA^+/K^+ ATPase

U.S. Fish and Wildlife Service, Little White Salmon Complex,

Steve Leek and Eric Pelton:

1) KD carrying rate of Eagle Creek's smolts using fluorescent antibody technique.

University of Washington,

Steve Mathews:

1) Lenght, weight and sex relationship.

RESULTS EAGLE CREEK 1980 - 1981 DENSITY STUDY COMPATED TO CANIDIAN TESTS

Eagle Creek	.15		.30		.45	
1980	Number	Percent	Number	Percent	Number	Percent
Jack	41	.049	31	.036		
		← 36%				
Adult	67	.080	57	.068		
		← 18%				
1981						
Jack	90	.207	137	.164	161	.127
		← 26%			← 29%	
Adult (Ocean catch)	249	.572	367	.438	622	.491
		← 31%			→ 12%	
		← 16%				
Canadian						
BY 1975	1323/1000		718/1000			
		← 84%				
BY 1977	605/100		403/1000			
		← 50%				

RECOVERY FOR DOWNSTREAM MIGRATION AT JONES BEACH

	.15		.30		.45	
	Number	Percent	Number	Percent	Number	Percent
1981	62	.142	136	.162	179	.141
1982	76	.194	135	.159	220	.163

Results:

Statistacally no significance

Conclusion:

Loading densities at the hatchery cause no difference in survival durring down stream migration to Jones Beach.

PRODUCTION DATA FOR

1982 RELEASE

		.15		.30		.45	
Raceway Number		47	48	43	42	40	41
Conversion		1.70		1.57		1.62	
Mortality	5/7/81	1.59		.83		1.41	
	6/11/81	.35	.33	.14	.13	.36	.41
	8/26/81	2.83	2.16	.90	.68	.74	.74
	5/5/82	12.56	4.20	1.08	1.09	1.14	1.44
C Factor		.0003631	.0003527	.0003488	.0003462	.0003414	.0003459
Lenght		6.0211	5.8755	5.8313	5.6581	5.613	5.6101
#/lb	5/5/82	13.1	14.1	14.4	15.8	16.6	16.2
DF	5/5/82	.146	.15	.31	.29	.42	.43
LF	5/5/82	.42	.43	.89	.84	1.23	1.25
O_2 Low/High		7.2/11.9	7.2/11.9	7.0/11.9	7.2/11.9	6.8/11.8	7.0/11.8
" Gain		4.69	4.54	4.50	4.32	4.23	4.27
"/30 day		.33	.32	.31	.30	.29	.30
TU/" Gain		24	25	25	26	27	27
NA^+/K^+ ATPase		17.4		12.4		15.6	

Lenght of Study from 03-01-1981 to 05-05-82 a total of 431 days

Average H_2O temperature was 46.3° F or 7.94° C

NH_4 was practicly 0 for the entire study.

1982 Production data is essentially the same as for 1981 except that

- Conversion is averaged 1.5 in 1981 release
- High mortality in low density groups occured just prior to release and was attributed to cold water disease.

Effects of Rearing Density on Performance Indices of Eagle Creek Coho Salmon

by

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Corvallis, Oregon 97331

For the last several years coho salmon (Oncorhynchus kisutch) at Eagle Creek National Fish Hatchery, near Estacada, Oregon, were reared at different densities to help define optimum pond loading levels. In an effort to 1) develop criteria to define smolt quality relative to performance characteristics affected by pond loading density and 2) determine the applicability of these characteristics in establishing hatchery loading densities, we corroborated with the Eagle Creek evaluation. Our objectives were to establish the relative fitness of coho salmon reared under various densities and to determine potential heuristic benefits of findings at Eagle Creek relative to establishing optimum loading densities at other hatcheries.

The basic premise upon which our tests were founded rests on the fact that hatchery practices can affect the parr-smolt transformation process and the performance of anadromous salmonids subsequent to release (Schreck 1981, 1982). It is well established that pond loading levels can affect production (Piper 1970, 1972; Westers 1970; Brauhn et al. 1976) and performance (Sandercock and Stone 1982) of hatchery stocks. We know from our earlier work that tests of individual performance abilities are sensitive indicators of the health and

general quality of the fish. At the Carson National Fish Hatchery, for example, fish reared at high densities could not osmoregulate as well when introduced into sea water as those raised at lower densities (C. Schreck and J. Banks, unpublished data). Elevated rearing densities may thus impose a stress or less than salubrious situation for the fish. In support of this contention, Fagerlund et al. (1981) showed that clinical signs of stress (hypertrophied interrenal cells) were present in coho salmon living in crowded raceways.

We thus ran a suite of tests measuring the performance capacities of the fish reared at Eagle Creek under the various densities to establish their potential for performing once released. Because timing of release is critical to performance of the salmon, we also ascertained the "state of smoltification" of the fish at release by clinical means. It is possible that fish of different sizes at a particular density respond differently (Fagerlund et al. 1981). We thus evaluated our data to see not only if density affected means for a particular population of fish but also if crowding affected variability amongst individuals. Since one of our aims is to help design relatively quick and simple (compared to release trials) tests to establish optimum loading levels, our data will be verified with return data from the CWT-marked fish raised under the various densities at Eagle Creek when it becomes available.

The following tests were conducted at the time when the Eagle Creek fish were released: 1) clinical status of health and stress by assaying plasma cortisol (the primary hormone of stress) and measuring interrenal cell activity; 2) performance capacity of the fish by determining their ability to resist vibriosis, regulate sodium when stocked into sea water, pay-back on oxygen debt following exertion, and grow in sea water;

3) state of smoltification at release by evaluating plasma thyroxine and cortisol levels, cortisol metabolic clearance rate, juvenile hemoglobin patterns, and gill Na^+/K^+ ATPase activity; and 4) presence of unfavorable odorants produced by fish by conducting behavioral avoidance tests.

To standardize and replicate experiments at Eagle Creek, we established populations at the appropriate densities at our Smith Farm hatchery in Corvallis and at the Marine Science Center, Newport. This allowed us also to conduct cortisol metabolic clearance rate tests, Vibrio challenges, and evaluate growth potential in sea water, none of which could be conducted at the National Fish Hatchery. We realize that densities established at Eagle Creek cannot be duplicated in a strict sense at any other facility because each location is unique, but we standardized things as much as possible.

Loading densities evaluated at Eagle Creek and the Marine Science Center and at Smith Farm appeared to affect smoltification of the coho, with lower densities resulting in "more smolted" fish at the time of release. This is evident from the higher plasma thyroxine titers and gill Na/K-ATPase activities evident in the fish reared at lower densities (Fig. 1). Similarly, even though plasma cortisol or interrenal cell nuclear dimensions did not vary due to density treatment, fish reared at high densities had appreciably faster metabolic clearance rates of the cortisol as determined by the radio-labelling experiments (Fig. 2). We have other evidence indicating that clearance of cortisol and its metabolites in coho salmon varies over the smolting cycle much like gill ATPase (R. Patino and C. B. Schreck, unpublished data).

The fact that rearing density affected rates or degrees of smoltification is also evident from the seawater challenge tests where we found an inverse relationship between sodium regulatory ability and density

(Fig. 3). Following 24-hr exposure to sea water, smolts should be able to bring their plasma sodium loads down to about 170 Meq/L (Clarke and Blackburn 1977). This was accomplished by only those salmon reared at lower densities.

Rearing density also affected other performance capacities of the fish. Fish reared at low densities were much more able to resist challenge with the marine pathogen Vibrio than those raised at higher densities (Fig. 4). This suggests that raceway crowding levels can have a significant effect on the ability of the fish to resist pathogens.

We did not find that rearing density measurably affected the variability within a treatment group, but this should not be interpreted to mean that subtle differences within a group did not exist. Our results should be considered in the light of results from release tests of the fish which will be available in a few years and from preliminary conclusions presented by J. E. Holway elsewhere in these proceedings.

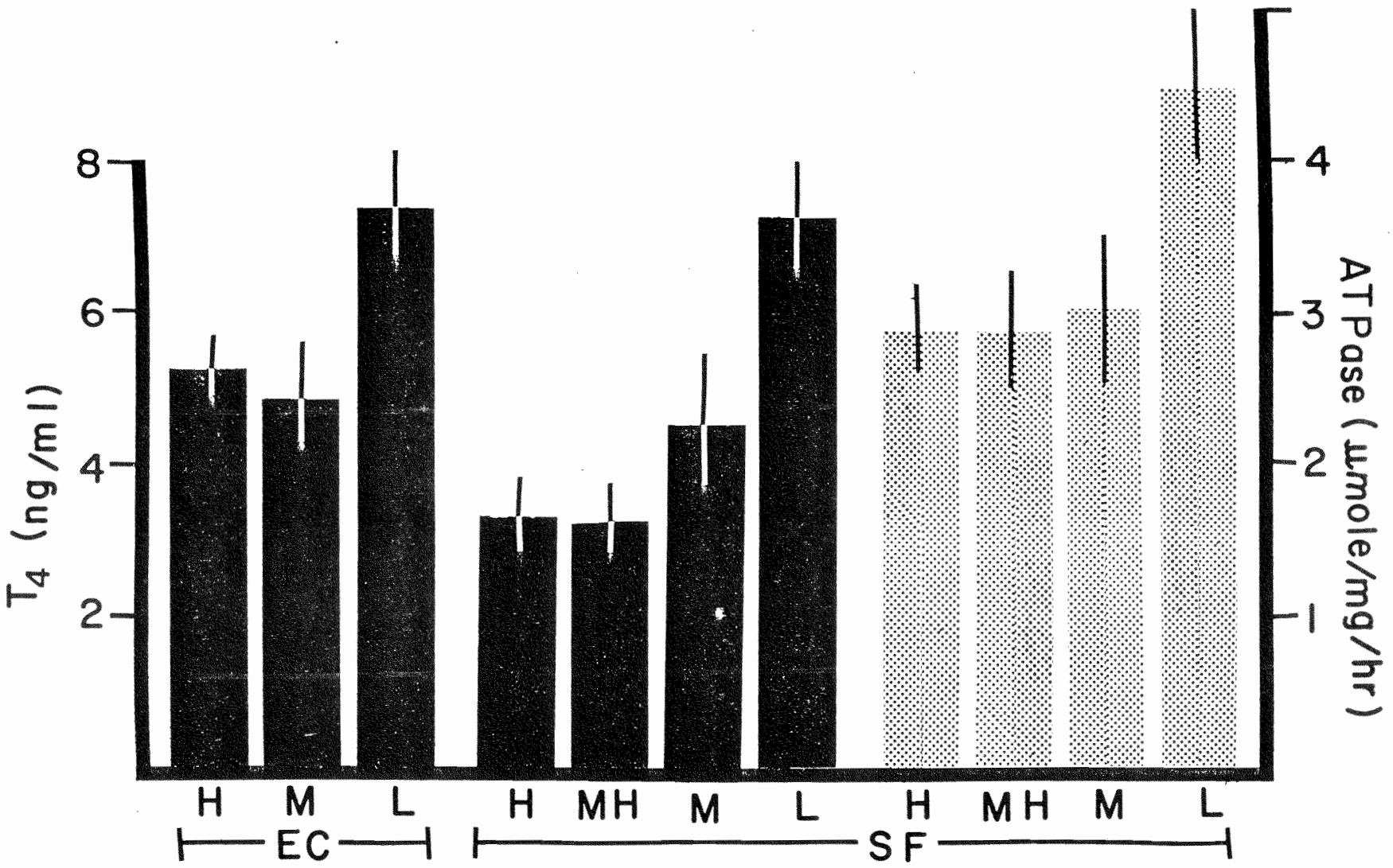

Figure 1. Mean (± se) plasma thyroxine level (replicates pooled, black bars) and gill Na/K-ATPase activity (stippled bars) in Eagle Creek coho salmon raised at Eagle Creek (EC) at high (H), medium (M), and low (L) densities (0.45, 0.30, and 0.15 total wt in lbs/vol. in ft^3 , mean fork length in inches, respectively) and at Smith Farm (SF) at high (H), medium high (MH), medium (M), and low (L) densities (0.55, 0.43, 0.29, and 0.11, respectively) at the time of release.

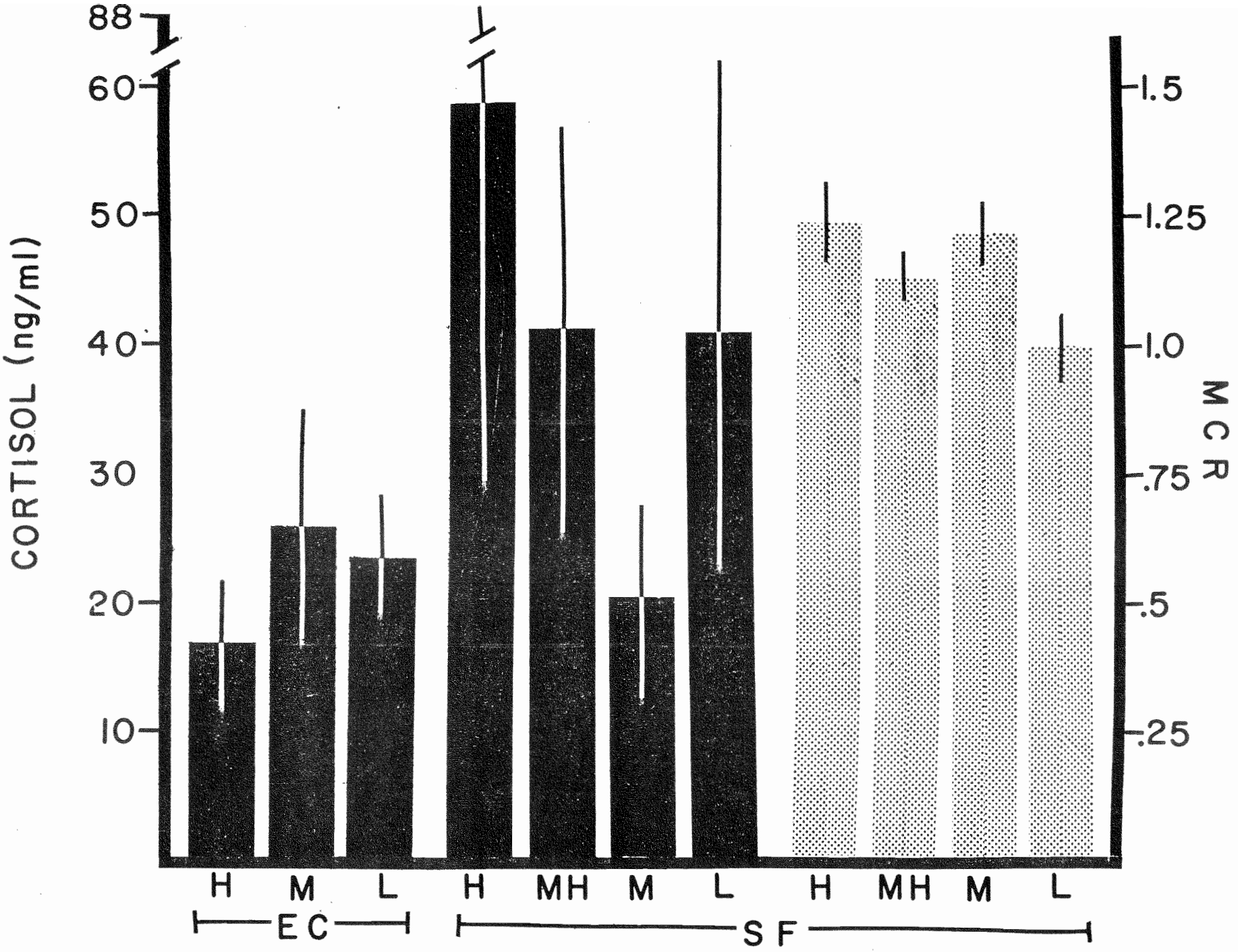

Figure 2. Mean (± se) plasma cortisol levels (replicates pooled, black bars) and cortisol and its metabolites relative metabolic clearance rate (stippled bars) at time of the time of release. See Fig. 1 for key.

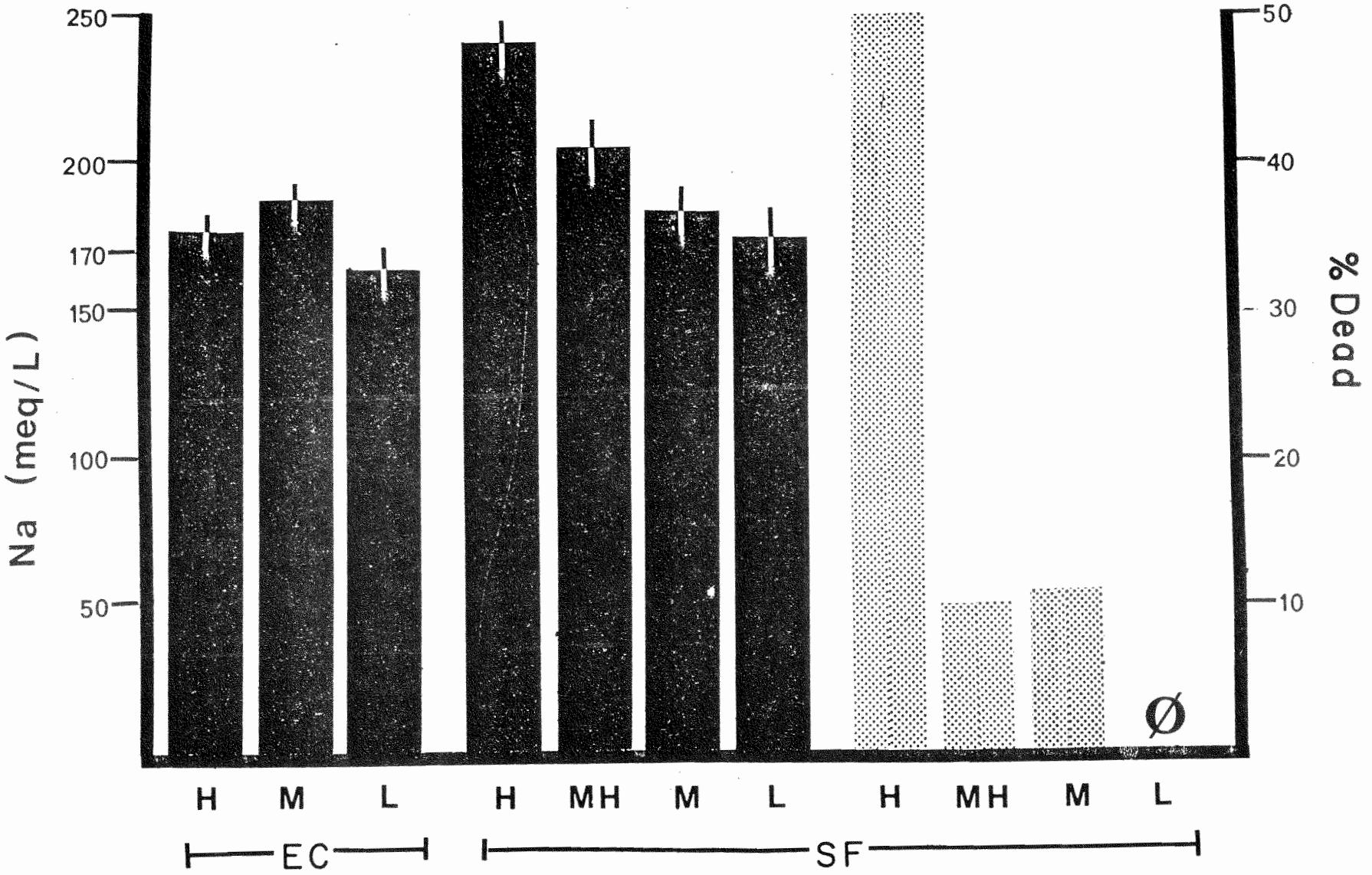

Figure 3. Mean (± se) plasma sodium level (replicates pooled, black bars) and % dead (stippled bars) coho salmon following 24-hr seawater challenge at the time of release. See Fig. 1 for key.

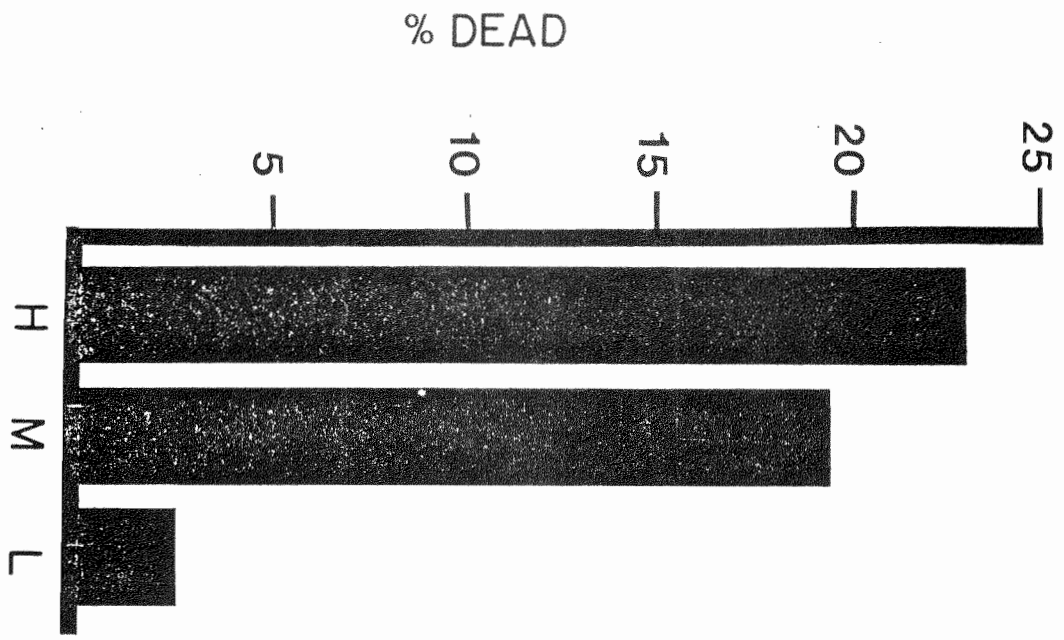

Figure 4. Mortality (% dead) of coho salmon raised at high (H), medium (M), and low (L) densities (0.45, 0.30, 0.15) exposed to Vibrio anguillarum in sea water.

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Questions and Answers

Q. I guess the big question that comes out from realizing that there is somewhere in the neighborhood of a 90% mortality out in the ocean and is unaccounted for, and realizing that the goal should be to "get the most out of the hatchery facility." Your studies obviously showed that the low density fish were better fish. Do you think it's better to put out better fish or get the most out of the hatchery?

A. I think that gets back to the comment that Jim's making. That maybe in economic terms as far as contributing to the fisheries you're better off raising more fish, liberating more fish because there are more fish coming back even though the percentage of returns is lower. But that's not really a decision for us to make. That's up to the managers.

Q. What is your feeling about the jack to adult ratios produced by fish reared under different densities?

A. One other interesting thing, even though the numbers that Jim showed you are like trying to predict the election returns at maybe 2 o'clock in the afternoon, is that not only do lower densities appear to cause a greater return of adults, but they also cause a greater frequency of jacks to adults. We get more total fish back, more adults back, and proportionally a greater proportion of jacks to adults back.

THE EFFECT OF WATER REUSE ON STEELHEAD TROUT FINGERLINGS

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Steelhead trout fingerlings were reared in water reused through a series of seven troughs for a period of 225 days. Troughs were set up in duplicate with each containing 2.75 cu. ft. of water. Flow through the series was adjusted to 2.64 g.p.m. and water temperature was maintained at 50 ± 2 F. Fish loading was based on a Flow Index of 0.74 per trough, giving a cummulative Flow Index of 5.18 at the seventh water use (Piper,1975).

Growth, mortality, food conversion and water quality data are presented in Table 1. Average dissolved oxygen concentration decreased from 7.2 ppm after the first water use to 3.1 ppm after the seventh use. Average ammonia concentration increased from 0.1 ppm after the first water use to 1.1 ppm after the seventh use. Water pH varied from 7.8 to 7.3 through the series.

Growth rate began to decline at the third water use when dissolved oxygen averaged 5.0 ppm and ammonia averaged 0.5 ppm. Mortality increased significantly after the third water use. The fish in the last four water uses were very susceptable to bacterial gill disease and treatment with hyamine 3500 was often necessary. Gills from fish in the 6th and 7th water uses showed severe fusion of gill lamellae.

Deterioration of water quality due to serial reuse has detrimental effects on steelhead trout. Findings similar to those seen in rainbow

trout (Larmoyeux and Piper, 1973) and brown trout (Morrison and Piper, 1982) were demonstrated in this study. When dissolved oxygen fell below 5.0 ppm and ammonia increased above 0.5 ppm growth rate decreased while food conversion and mortality increased. These two values (5.0 ppm D.O. and 0.5 ppm ammonia (NH_3-N) may not cause problems when occurring singly but they can provide a guideline for projecting water requirements.

Table 1. Cumulative growth and water quality data for steelhead trout fingerlings reared in water reused through a series of troughs for 225 days.

	A	B	C	D	E	F	G
Cumulative flow index	.74	1.48	2.22	2.96	3.70	4.44	5.18
Total length increase (in.)	2.6	2.6	2.4	2.3	2.1	1.7	1.8
Food Conversion	3.0	3.0	3.3	3.8	4.5	12.2 1/	6.1 1/
Avg. oxygen (ppm)	7.2	5.9	5.0	4.1	3.6	3.3	3.1
Avg. ammonia (ppm)	.1	.3	.5	.7	.8	.9	1.1
Avg. % mortality per weigh period	.1	.3	.2	1.0	1.6	4.9	3.2

1/ High mortality

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EFFECT OF REARING DENSITY ON SOME PHYSIOLOGICAL PARAMETERS OF COHO SALMON

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and

R. D. Ewing

Oregon Department of Fish and Wildlife

INTRODUCTION

Early investigations into population rearing density and the determination of the stocking rate of a rearing unit were directed at maximizing the carrying capacity of a hatchery. That may be economical if the goal is to produce maximum fish pounds or numbers from a facility. In salmon culture, such maximization may be false economy if the result is reduced potential of juvenile fish to survive to adulthood. Thus some existing definitions of carrying capacity may no longer apply.

METHODS

In 1981, we tested a series of densities for a laboratory situation where 3-ft circular fiberglass tanks having a useable rearing volume of 360 L (12.7 ft^3) were supplied with 12 C (54 F) well water at a flow rate of 4.0 lpm (1.1 gpm). Each tank had a theoretical water exchange rate of 0.7 per hour. For these conditions, we arbitrarily assigned a portion (85%) of the recommended density of Westers (1970) the

relative density (RD) value of 1.0. The absolute density, expressed as fish mass per unit of rearing volume, changed as fish grew since the recommended values were proportional to a function of fish size. We also tested relative densities of 0.33, 0.67 and 2.0, which were about 30, 60 and 170% of the recommended levels, respectively. That range of treatments encompassed maximum loading (fish mass per unit water inflow) rates of yearling coho at most Oregon Department of Fish and Wildlife hatcheries (Table 1).

Coho salmon used in the experiment were 1979-brood hybrids of Big Creek, Or. and Soleduck, Wa. stocks. At start of the experiment in early February, fish averaged 26.5 g in weight. Coho were fed Oregon Moist Pellet once daily at 60% of the Oregon feeding chart.

We initiated sampling one month after acclimation to test environments. Bi-monthly, 40 coho from each treatment were randomly sampled for length, weight, gill (Na+K)- and Ca-ATPase, plasma thyroxine (T_4) and triiodothyronine (T_3). After sampling, group weights were obtained on all fish remaining in each tank. We calculated mean fish weight for a population by including sampled and non-sampled fish. Population densities to be stocked for the subsequent test period were determined from the recommended value at RD=1.0.

RESULTS

Generally, there was suppression of growth as coho population density increased. Mean fish weight at end of the experiment ranged from 48g at RD=0.33 to 41g at RD=2.0.

Interpretation of density effects on growth is confounded by the removal of fish for sampling and replacement of fish from a stock population to maintain densities, and will not be dealt with in this paper.

We observed a consistent ordering of the magnitude of gill (Na+K)-ATPase specific activity with increased density at any given time (Fig 1). (Na+K)-ATPase specific activity in coho at the lowest density peaked in March; it dropped by early April, but gradually increased until termination of the experiment. Specific activity in coho at RD=0.67 peaked in March, dropped slightly, and rose to a second (higher) peak in mid-May. At RD=1.0, (Na+K)-ATPase specific activity rose until mid-April, then increased only slightly in mid-May. Specific activity in coho at RD=2.0 initially declined; it then rose to maximum level (lowest of all treatments) in mid-April. That level was maintained throughout the remainder of the experiment.

Increased population density tended to delay the timing of peak Ca-ATPase activity (Fig. 2). Coho at RD=0.33 displayed peak Ca-ATPase activity in mid-March. At RD=0.67, specific activity tended to peak mid-April. Coho at RD=1.0 displayed a pattern of Ca-ATPase activity similar to that of coho at RD=0.67, although the peak occurred two weeks later. At RD=2.0, specific activity remained relatively low until it peaked in early May.

Coho at RD=0.33 consistently displayed highest plasma T_4 concentrations, which peaked early in May (Fig. 3). Coho at RD=2.0 consistently displayed lowest plasma T_4

concentrations that never clearly peaked, although that may have occurred after final sampling. Concentrations of thyroxine from coho at RD=0.67 and 1.0 were intermediate to those shown, and tended to be closer in magnitude to concentrations from coho at RD=2.0.

DISCUSSION

These data suggest that varying population density at one water exchange rate can affect the physiology of juvenile coho. Increased density tended to supress the magnitude of (Na+K)-ATPase specific activity, delay the timing of peak Ca-ATPase activity and suppress plasma thyroxine concentration. Several points are suggested.

First, all the parameters observed are thought to be important in the parr-smolt transformation process. Particular actions that occur in yearling coho are unclear, but regardless of the explicit role each plays, the cyclic activity of the enzymes and hormone mentioned are probably necessary. We might expect that full and free expression of those cycles results in fish best adapted to seawater. By rearing coho at high densities, we may impair processes necessary for survival.

Second, there has been considerable attempt to use (Na+K)-ATPase activity and plasma thyroxine concentration to indicate the best time to release hatchery salmonids. It appears that we can affect the magnitude and timing of these "indicators" simply by manipulating rearing density. These results increase the inadequacy of these parameters as

indicators of optimal release times with current knowledge. Furthermore, use of these parameters to compare populations, i.e. hatchery to hatchery, must consider the influence of rearing density.

Third, it appears that a recommended level of rearing density for coho salmon is too high, at least for the conditions tested. This conclusion needs verification through hatchery experiments that evaluate survival to adulthood.

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Westers, H. 1970. Carrying capacity of Salmonid Hatcheries. Progressive Fish Culturist. 32:43-46.

TABLE 1. COHO SALMON POPULATION LOADINGS EXPRESSED AS KG FISH PER LPM WATER INFLOW THROUGH TIME. VALUES IN PARENTHESES ARE EQUIVALENTS IN LBS PER GPM.

	RELATIVE DENSITY			
DATE	0.3	0.7	1.0	2.0
FEB 7	0.5 (3.8)	0.9 (7.5)	1.4 (11.8)	2.8 (23.0)
MAR 5	0.5 (4.5)	1.0 (8.2)	1.6 (12.9)	2.8 (22.9)
MAR 19	0.6 (4.8)	1.1 (8.8)	1.6 (13.4)	2.9 (23.7)
APR 2	0.5 (4.5)	1.1 (8.8)	1.6 (13.0)	3.0 (24.6)
APR 16	0.6 (4.7)	1.1 (9.3)	1.7 (13.9)	3.1 (25.9)
APR 30	0.6 (4.8)	1.2 (9.6)	1.7 (14.3)	3.2 (26.9)
MAY 14	0.6 (4.9)	1.2 (9.7)	1.7 (14.4)	3.3 (27.7)
JUN 2	0.6 (5.1)	1.2 (10.3)	1.8 (15.2)	3.5 (29.2)

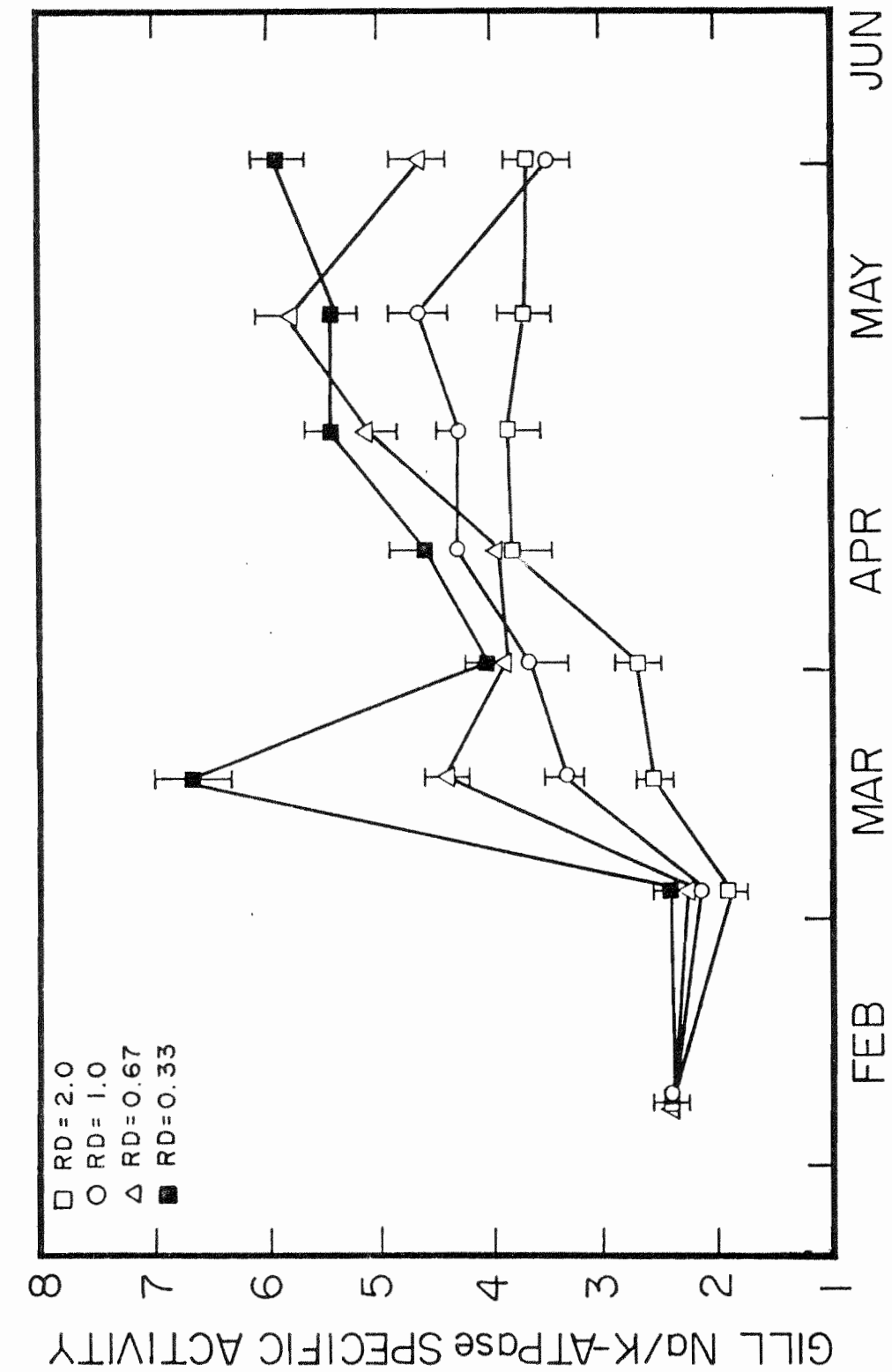


Fig. 1. Gill Na/K-ATPase specific activity in coho salmon reared at various relative densities.

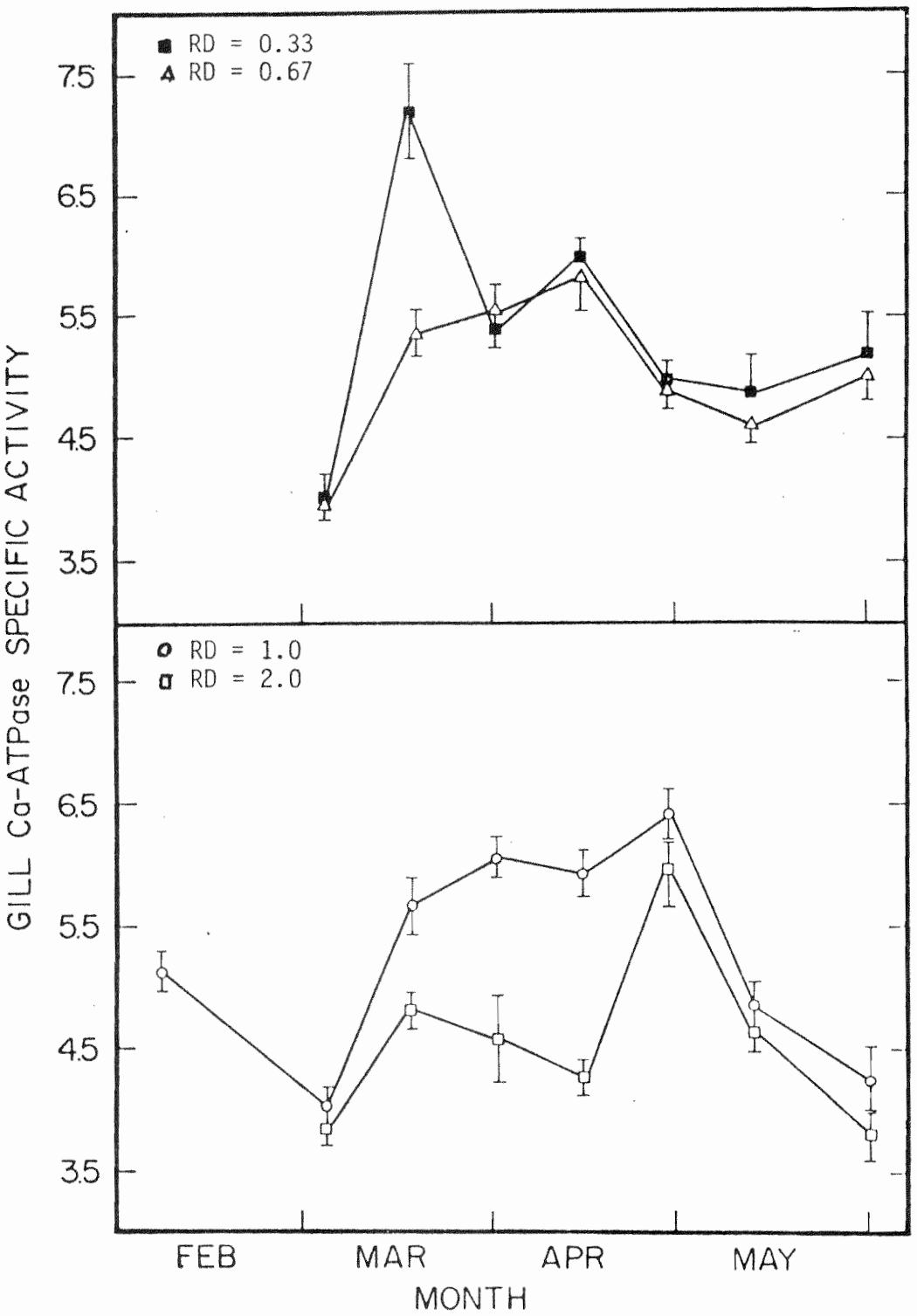


Fig. 2. Gill Ca-ATPase specific activity in coho salmon reared at various relative densities.

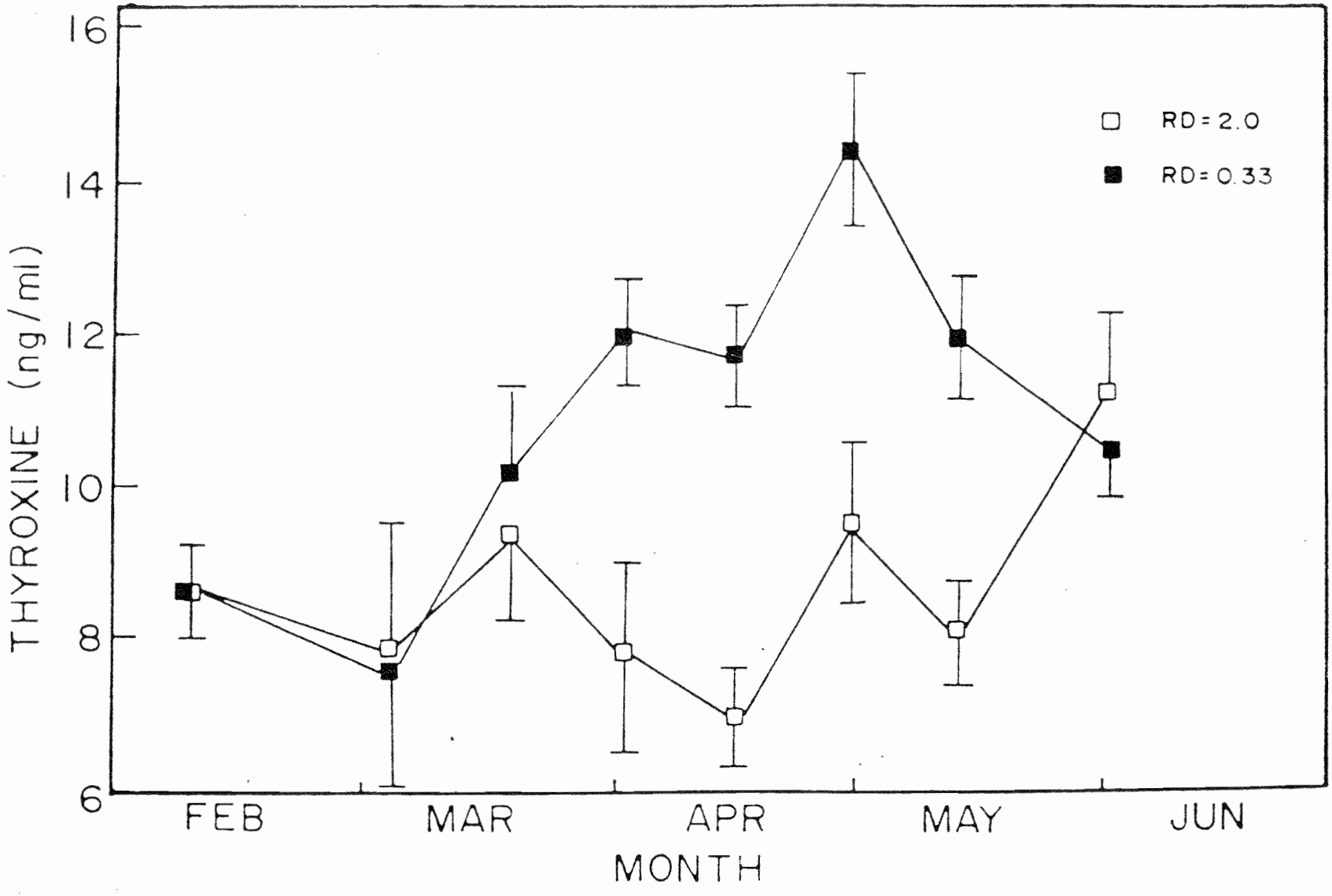


Fig. 3. Plasma thyroxine concentrations in coho salmon in highest and lowest relative densities.

1978 Brood Green River Coho Pond Loading/Size at Release Study

Andrew Appleby
Washington Department of Fisheries

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 loadings.

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

To this end, eight raceways (10 by 80') were set aside at Green River Hatchery. Four ponds were programmed for 25 f/lb. at release and four for 15 f/lb. Within each size group, four loadings were tested. Based on pond flow, the loadings are expressed in lbs/gpm/inch of body length. They range from 1.10--1.71 and were duplicated in each size group. (table 1).

The ponds were randomly populated on May 24, 25, 1979. The original intent was to use fish from a common egg take. This proved impossible at ponding time. Fish from a different egg take were supplied proportionally to all 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 ponds' 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.

Results

Survivals were calculated on the Washington catch and escapement only. They have been expanded for sampling rates and pond populations. (table 2).

The survival for fish less than 20/lb. went from a low of 6.5% for the heaviest loading (1.71lbs/gpm/inch) to a high of 9.0% for the medium high loading (1.53lbs/gpm/inch). The two lower loadings, 1.15lbs/gpm/inch, 1.32lbs/gpm/inch, had almost identical survivals of 8.4% and 8.2% respectivly.

The fish greater than 20/lb. did have a slightly higher average survival (8.9%), than fish less than 20/lb. (8.0%).

Once again the heaviest loadings (1.6lbs/gpm/inch) did have the lowest survival at 7.9%. The medium high loading (1.49lbs/gpm/inch) had the highest survival rate for the group (9.6%).

The survivals for the two lower loadings were 8.9% in the lowest loading (1.10lbs/gpm/inch) and 9.2% in the medium low loading (1.47lbs/gpm/inch).

No significant differences were found in these survivals, based on size of release or loading rates, using a Two Factor Analysis of Variance without replication. There is certainly not the direct linear correlation that can be found in the Capilano data (fig.1).

Conclusion

We conclude that depression of survival due to loading rates did not occur within the ranges of loading applied in this study. It should be noted that some of these same loading rates duplicated those used in the Capilano studies. Those studies showed a strong correlation between increased loading and decreased survival.

The Capilano studies, however, made use of Burrows type rearing ponds while raceways were used in the Green River study.

One might speculate that the pond design played a role in the conflicting results of this study when compared to the Capilano results. It is possible that raceways are a more "forgiving" rearing design. This should lead us to avoid a set standard for loading rates to be applied across all pond configurations. Instead we should develop loading rates specific to each rearing situation or at least specific to a class of rearing situations.

TAB. 1

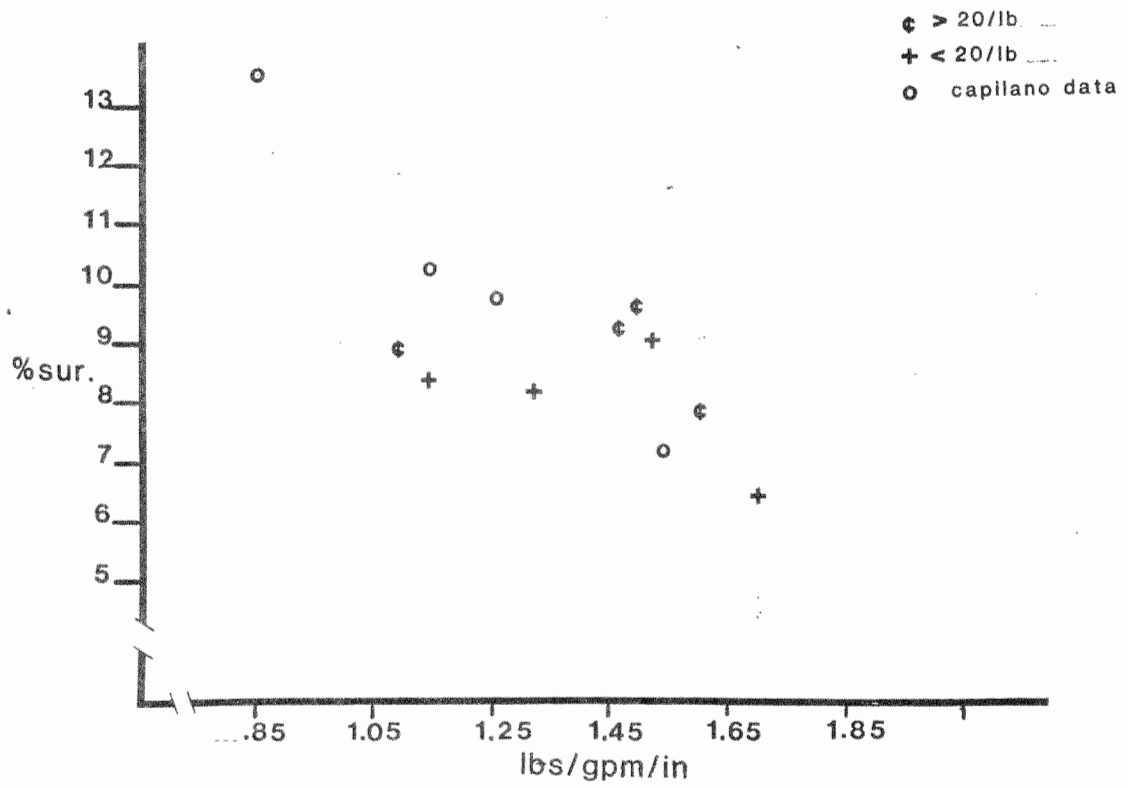
GREEN RIVER COHO 78 BROOD

POP.	58,800	69,800	81,600	90,700
SIZE	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
	5	6	7	8
	4	3	2	1
POP.	79,300	92,800	107,500	119,400
SIZE	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

TAB.2 GREEN RIVER COHO 1978 BROOD
WASHINGTON CATCH and ESCAPEMENT

POND	SIZE	POP.	%SURV.	CONT.	CONT./lb rel	
1	25	119,400	6.5	7,843	1.6	HD
2	25	107,400	9.0	9,793	2.3	
3	25	92,850	8.2	7,664	2.0	
4	24	79,300	8.4	6,720	2.0	LD
5	17	58,840	8.9	5,287	1.5	LD
6	15	69,800	9.6	6,726	1.4	
7	18	81,600	9.2	7,543	1.6	
8	19	90,700	7.9	7,219	1.5	HD

FIG.1 1978 Green River Coho Sur.



SMOLTING 0-AGE PROGENY FROM SPRING CHINOOK ADULTS UNDER PHOTOPERIOD REGULATION AT LITTLE WHITE NATIONAL FISH HATCHERY

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National Marine Fisheries Service
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Spring chinook salmon generally return to Pacific Northwest hatcheries in the spring of the year. Adults are held in raceways or ponds until maturation in the fall. Often high prespawning mortality occurs from disease, increasing water temperature, and other physical and environmental factors.

Progeny from these traditionally held adults are reared in ponds or raceways for 13 to 15 months. Smolts are released in the spring as yearlings. However, some wild spring chinook salmon in the Rogue River system (Oregon) migrate as 0-age fish in the fall of the year and as adults have made significant contributions to recreational and commercial fisheries (Buckman and Ewing, manuscript submitted for publication).

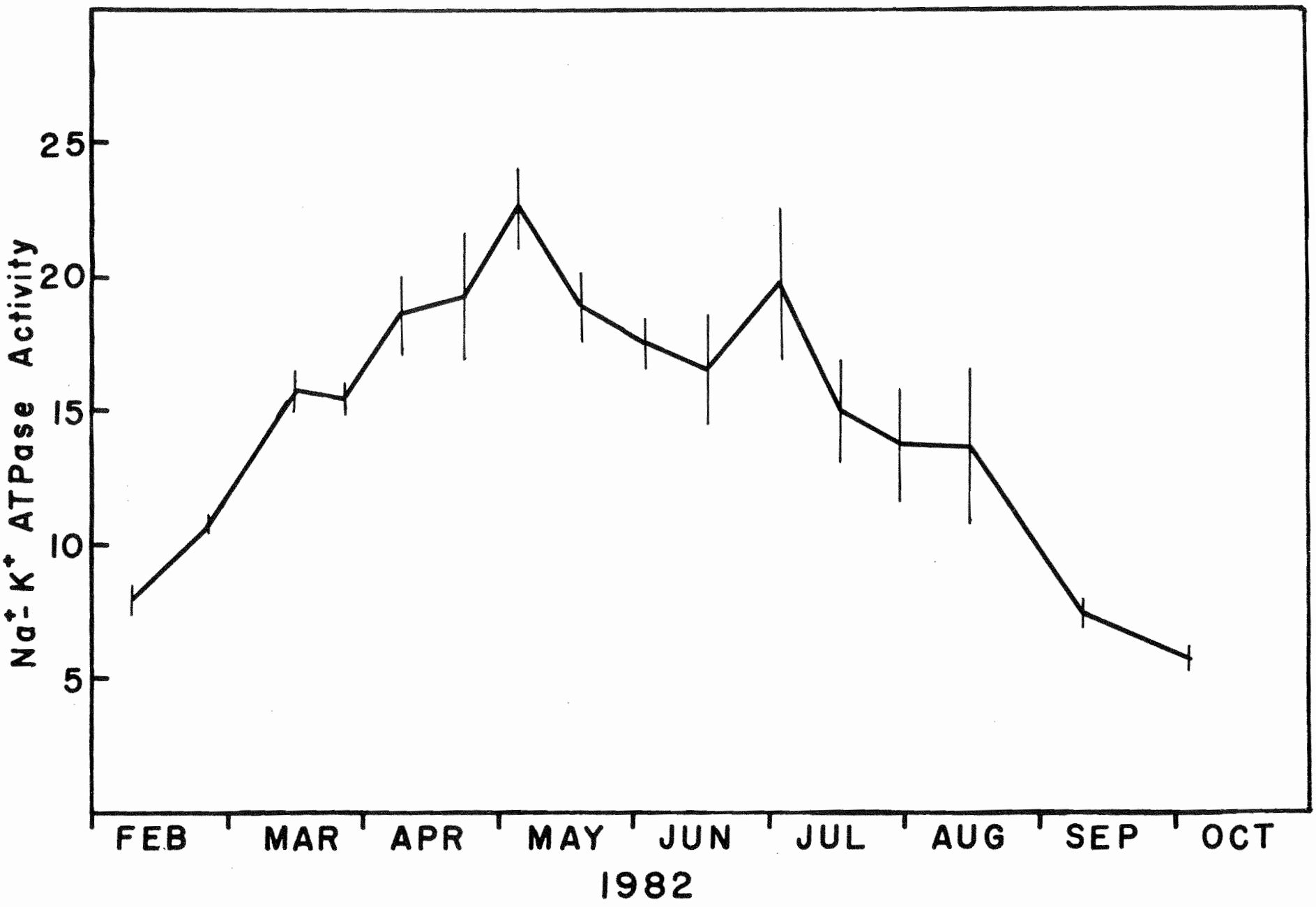
The management at Little White Salmon NFH on the Columbia River has substantially reduced prespawning mortality by subjecting returning spring chinook salmon to decreasing photoperiods to accelerate maturation. The adults are held in ponds under cover of a building and are initially given 12 hrs of light beginning about 1 June. Light exposure is then reduced by one-half-hour increments each week until spawning begins about mid-July, 5 to 6 weeks earlier than normal. Because of early hatching and additional rearing time, the progeny from these adults are larger than normal in the spring of their first year and, as a result, exhibit signs of smoltification. This year (1982) gill Na^+-K^+ ATPase activity in these fish began to rise early in the spring and remained elevated throughout the summer (Fig. 1).

Other indications of smolting such as increased swimming activity and body silvering were also evident. Progeny of normally held adults in the Columbia River system do not generally exhibit these characteristics until age 1+.

The above observations suggest that: 1) parr-smolt transformation did occur in 0-age spring chinook; 2) these fish would migrate seaward rapidly; and 3) transition to a marine environment would be successful. This early development of smoltification might permit spring chinook salmon to be released from the hatchery as 0-age fish rather than yearlings. Such releases could produce a number of benefits: 1) fish would require much less rearing time in the hatchery, thereby reducing production costs; 2) disease incidence should be reduced; 3) additional rearing space would be available; and 4) adults may be larger because of additional ocean rearing time.

Further studies to determine the potential of photoperiod controlled adult spawning and 0-age releases of spring chinook salmon are strongly urged.

FIGURE 1. Gill Na^+-K^+ ATPase activity (μmoles $P_i \cdot$ mg $prot^{-1} \cdot hr^{-1}$) of 0-age spring chinook salmon at Little White Salmon NFH - 1982. Each point represents the mean activity of 10 fish $\pm$ standard error.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Na+- K+ ATPase Activity
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Ammonia and Nitrite Toxicity, Dynamics, and Attenuation in Crustacean and Fish Culture

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A copy of the paper presented by David Armstrong was not supplied to the Chairman. Any interest and/or questions regarding the paper should be directed to the author.

Einar Wold

STRIPED BASS CULTURE IN OREGON

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Striped bass have been cultured in the United States since the late 1800's (Worth 1882). The first striped bass hatchery was built in 1906 on the Roanoke River at Weldon, North Carolina. This hatchery is still in production and is being operated by the North Carolina Wildlife Resource Department.

Early efforts to culture striped bass were hampered by the inability of workers to obtain ripe females. Striped bass males are mature for an extended period of time, but eggs from female stripers are only viable for about 1 hour after ovulation. The eggs are released into the body cavity at ovulation with a subsequent loss of blood supply to the eggs. Egg viability actually begins to decrease 30 minutes after ovulation and is essentially zero within 1 hour.

A major advancement in striped bass culture was made in the early 1960's with the development of techniques to induce ovulation by injection of hormones (Stevens 1967). Another major advancement was made in 1974 when procedures were developed to induce stripers to spawn in circular tanks (Bishop 1975).

Currently, full-scale hatchery operations exist in 13 states and smaller scale operations exist in several other states. Combined production capacity is approximately 15 million fingerlings and several hundred million fry per year.

Only California and Nevada have been involved with the culture of striped bass on the West Coast. A good example of the tremendous potential that exists with striped bass culture is the Lake Mead experiment in Nevada. Juvenile and yearling striped bass were introduced into Lake Mead beginning in 1969 by the Nevada Department of Wildlife and the Arizona Department of Game and Fish. By 1974 a sport fishery had developed and 1,700 stripers were harvested. The sport

catch increased to 8,000 stripers in 1976 and to 48,000 by 1978. In 1979, approximately 576,000 stripers were harvested in Lake Mead by the sport fishery (pers. comm., Butch Padilla, Nevada Department of Wildlife). The catch has fluctuated between 180,000 and 377,000 since 1979.

Striped bass were first cultured in Oregon in the spring of 1981 at a site on the South Coos River, a tributary of Coos Bay on the southern Oregon coast. The Oregon Department of Fish and Wildlife (ODFW) initiated a cooperative research effort with Aquatic Systems Incorporated (ASI) of San Diego, California. The purpose of the project was to learn more about the early life stages of Oregon stripers and to investigate methods that could be used to culture striped bass. A temporary spawning and rearing facility was erected at the South Coos River site.

Aquatic Systems Incorporated has been investigating the feasibility of rearing striped bass to marketable size utilizing warm seawater from coastal power generating facilities. ASI provided research equipment, manpower, feed, and technical assistance for this program in exchange for a share of the fry produced at the pilot hatchery.

Results of the project in 1981 were encouraging. Approximately 3.1 million fertilized eggs and 1.4 million larval striped bass were produced at the project site on South Coos River. A small experimental lot of 3,240 juvenile stripers was marked and released in the upper tidal portion of the South Coos River. Both pelvic (ventral) fins were removed from the juveniles prior to release. Standard fin marking techniques were utilized. MS-222 was used to anesthetize the fish prior to marking. Loss due to fin removal was about 5% in a test group of 2,301 juveniles with mortality dropping to zero by the third day following marking (Table 1). Success of the small release was evaluated during standard bi-monthly sampling with beach seines in the South Coos and Millicoma rivers. Sixty-three marked juvenile stripers were recovered during the month following release, and

Table 1. Mortality during and after marking, 1981.

Date	Total marked 8-13	Mortality 8-13	8-14	8-15	8-16	Remaining fish
Tank 4	771	38	19	1	0	713
Tank 3	793	15	11	0	0	767
Tank 2	737	29	10	1	0	697
Totals	2,301	82	40	2	0	2,177

the marked juveniles nearly doubled in size during this period (Table 2). Ten of these fish were recovered during sampling in the spring and summer of 1982. These 1981 brood yearlings had reached a size of 21-22 cm FL by September 1982.

Table 2. Growth and recovery of marked striped bass, 1981.

Date	8/13-17	8/18	9/2	9/15-16
Sample size	247[a]	35	23	5
Average fork length (mm)	45.1	54.9	71.8	93.2
Range	28-71	42-72	60-80	83-111
Release total—3,240				

[a] *Sample taken just prior to release in the upper South Coos River.*

A second cooperative project was initiated during the spring of 1982 at the South Coos River site. Emphasis was placed on producing hybrid striped bass (striped bass ♀ x white bass ♂) for release into Ana Reservoir in southeastern Oregon and the Tenmile Lakes system just north of Coos Bay. Aquatic Systems Incorporated again provided valuable technical and financial assistance with the project. White bass males were obtained from Lake Nacimiento, California, with the assistance of the California Department of Fish and Game and ASI. Live white bass were transported to the South Coos River site by ASI. Approximately 2.7 million fertilized striper and "hybrid" eggs were produced in 1982. Totals of 805,000 larval striped bass and 75,000 larval "hybrid" stripers were produced.

The "hybrids" were the first to be cultured on the West Coast. During October 1982, approximately 1,200 "hybrid" striped bass fingerlings were released into Ana Reservoir and approximately 3,000 "hybrids" were released into North Tenmile Lake with the hope of eventually providing a unique new sport fishery for Oregon.

The feasibility of culturing striped bass and "hybrid" striped bass in Oregon was clearly demonstrated during the projects of 1981 and 1982. Striped bass culture shows considerable promise for enhancing striped bass stocks on the West Coast. In addition, new inland fisheries could be developed in many freshwater systems by utilizing currently available technology for culturing striped bass and "hybrid" striped bass.

The Oregon Department of Fish and Wildlife has not made any decision yet regarding the possibilities for enhancement of estuarine populations of striped bass. Management plans are being prepared for all fisheries in each major river system like the Coos. This planning process will include a period for public review and comment and, ultimately, adoption of the plans by the Fish and Wildlife Commission.

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STRIPED BASS CULTURE IN OREGON

Q. Where and when were the striped bass introduced on the West Coast?

A. Striped bass were introduced in the late 1800's, I don't remember the person's name, but he brought them out by train which must have been quite an experience. But anyway, there were two different stockings. They were both into San Francisco Bay and I believe there were only a total of 435 yearlings. That was somewhere around 1885-1890, and within about 10 years there was a tremendous explosion of stripers in the Sacramento system and quite a fishery developed down there. Of course there still is a very large sports fishery in California; the commercial fishery was terminated in 1935, but it has been estimated that the sports fishery in the Sacramento system is worth about $25 million a year right now. They do have big problems down there also. Their population has declined fairly substantially. As far as I know, there were no other introductions. I could be wrong on that. But as far as I know, there were no other introductions and the fish that we have in Oregon are basically confined to the Coos and Umpqua although there are a few in the Coquille and the Siuslaw. As far as I know, those fish resulted from California fish that at one time or another migrated up into Oregon waters. The first documented striper in the Coos system was in 1914 and quite interesting to me is to note that the first documented striper in the Umpqua did not occur until 1935, so it took those fish a long time just to get from the Coos to the Umpqua a distance of about 25 miles. I'm not sure that they are done extending their range, but there may not be any other habitats that provide the right spawning conditions. There is certainly lots of habitat that would provide good conditions for juveniles up through adults.

Q. What is the northern extent of the range of striped bass on the West Coast, and what conflicts exist between stripers and salmon?

A I thought somebody might ask that question. First of all, how far north do they go? There have been a few stripers found in the Columbia River. As far as we know, there is no reproduction taking place there, just a very few have been documented. Reproducing populations—there may be some reproduction in the Siuslaw; there are striped bass in that system. That's about as far north as I know of any possible reproducing population. Second part of your question, I think you said competition from salmon people or from salmon. Okay, let me address the Coos Bay situation; every system is different and you have to look at each system individually. Even the Umpqua and the Coos are quite different. Part of my area of responsibility is the Coos system, so that is what I'll address. In the Coos system, I think there is a fairly minimal amount of competition, predation, whatever you want to call it between salmonids and striped bass. There has been a fair amount of work done with stomach analyses, Morgan and Gerlach about 1948 through 1950, which was a joint Fish Commission and Game Commission study, looked at over a thousand stomachs. They looked at fish three different summers and most every other time of the year. They never found any salmonids in the gut analysis in the summer periods. The only time they found salmonids was in the spring period which is when the striped bass are up in the spawning area and salmonids are generally passing through that area migrating out. Even at that time, salmonids were only 6.7% of the analyzed food found in their stomachs. When they're up in that area, they're generally there for spawning purposes, and more than 50% of the stomachs are empty at that time because especially when they get right near to spawning activity they don't feed at all. Anyway, that particular study only shows any interaction at all in the spring period up in the river and then the salmonids made up only 6.7% of their stomach contents. We've looked at about 300 striped bass stomachs from the Coos throughout the system and spread throughout time basically covering all the seasons. I've only found 7 salmonids out of those 300 stomachs. They were

all in the summertime down in the mid-Bay area. I suspect they were aquaculture fish because of the size. We haven't done that many samples from the spring up in the river, but I suspect you would still find some at that time of the year, but I don't think it is that significant. Now there is something that goes the other way, we found that coho smolts migrating out of the system in May and June get a tremendous boost by feeding on shad and striped bass eggs. They are just absolutely full of shad and striped bass eggs as they're migrating through that area so there's a little bit of benefit there both ways. That's all I can answer for really is the Coos system. Each system is different. The Coos system happens to be what I would consider a fairly ideal system for enhancing stripers without having too major an impact upon the salmonids because it is a large estuary but with a fairly small river system feeding the estuary.

Q. Do you know if there are any striped bass in Puget Sound or if there have been any efforts to establish them there?

A. Not that I know of. You have to realize striped bass are basically a warm-water fish. There has been some work done back east with temperature sensing tagging of striped bass and there has been a hypothesis that temperature has a pretty big influence on where striped bass will go in an environment. It appears that there is very little outmigration of any of the striped bass ages into the ocean as far as we know in Oregon. There have been tagging studies in the Coos and Umpqua systems and there has been very little recovery of tagged striped bass other than in the same system. If you look at the Coos system, the temperature theory explains that pretty well. In the Coos system, the water temperature decreases as you go from the headwaters or the head of tide downstream towards the ocean. In the summertime when the fish are really active and feeding and when you would expect stripers to go out to the ocean, water temperature gets progressively cooler until you reach the Charleston area where

generally it's 10^{0} C or ambient ocean water temperature. All the information we have on adult striped bass is that the ocean is far below the temperature they prefer. They prefer the 18^{0} to 20^{0} C temperature range which is where we find them in the Coos, up in the mid-Bay area around Highway 101 where the temperature is 15^{0} to 20^{0} C. I don't think there is much likelihood that they would be established in the Puget Sound area even if you tried. But the freshwater lakes are a different story. There are all kinds of potential habitats in freshwater lakes. That is where most of the successful introductions were made in the southeastern United States.

Bonneville Power Administration
Tom Clune - BPA
Presentation Outline for Northwest Salmon Culture Conference

Introduction:

1. BPA's Division of Fish and Wildlife
   a. Formed in 1982, Biological Studies and System Intergration Branches.
   b. Objectives - implementation of Council's Fish and Wildlife Program.
   c. Duties- Proposal evaluation and project oversite.

2. Northwest Power Act - BPA's Authority to Fund
   a. Protect, mitigate and enhance
   b. Develop/Operation hydro facilites on Columbia River and Tributaries
   c. Consistent with Fish and Wildlife Program
   d. Purposes of Act - sound business practices, efficient, economical, reliable power, etc.
   e. In addition to, not in lieu of . . .

3. Consultation - Council, Fish and Wildlife agencies, Tribes

4. Coordination - Council, Corps of Engineers, Bureau of Reclamation, FERC

Past/Present Projects:

78-1 NMFS methods and techniques that will assure transported fish will return, as adults, to desired locations. Imprinting/Homing study to be completed in 1984.

79-2 NMFS 8-year study to determine distribution, contribution and value of fall chinook salmon raised at Columbia River rearing facilities to the Pacific Coast salmon fisheries. Information will reveal: effectiveness of mitigation hatcheries, and aid fisheries agencies in planning and management. Tagging completed in FY 1982, data recovery through 1983.

81S-2 NMFS Migrational characteristics of juvenile chinook and coho salmon and steelhead as they enter the Columbia River estuary near Jones Beach. Objectives are to define migrational/behavioral characteristics via timing and abundance of both wild and hatchery smolts passing Jones Beach; estimate juvenile survival of hatchery reared fish to the estuary; provide recapture rate comparison between years for hatchery fish; and correlate differences in survival of smolts to river and dam passage conditions between 1977 and 1982.

82-2 NMFS determining if steelhead reared and imprinted at Dworshak NFH, trucked and barged for release below Bonneville Dam will return to Dworshak as adults in greater numbers that fish released at the hatchery. Based on data as of May 1981, transported group returned 1 1/2 times better than controls.

82-5 University of Idaho - examine the effects of stressor intensity and duration on the commonly monitored physiological stress indices and on physiological and behavioral performance and survival. Relative degrees of stress as indicated by physiological indices in spring chinook associated with the steps in collection - transportation at Lower Granite; clinical responses in steelhead at Lower Granite, Little Goose, and McNary; and clinical indices of fall chinook at Lower Granite. Stress response on Kooskia Hatchery smolts compared to the stress response of migrating smolts (Lower Granite) and Rapid River hatchery smolts.

82-7 NMFS - Snake River fall chinook egg bank development. Objectives include:

1. Pen rearing Snake River fall chinook brood stocks in Puget Sound-Manchester;
2. Pilot production of 8.5 million eggs by 1984; and
3. Determine nutritional requirements of captive fall chinook in seawater.

82-11 USFWS Evaluation of different rates of outmigration of smolts, determined by effects of water temperature, importance of food consumed during outmigration as a function of the total energy budget, and determination of energetic reserves.

82-13 Cooperative Federal/State fishery agencies U.S. and Canada CWT recovery to measure contribution of individual stocks of salmon and steelhead.

82-18 Confederated Tribes of the Umatilla Indian Reservation - construction of an acclimation ponds on the Umatilla River System for steelhead enhancement.

Future Areas of Emphasis

BPA's involvement in, and funding of future projects will be directly related to the implementation of the Council's Fish and Wildlife Program. Areas of emphasis regarding fish culture are as follows:

Release Sites for Hatchery Reared Fish

Release sites and release levels of hatchery fish to be compatible with natural stocks. Emphasis will focus on upriver stocks.

Improved Production at Existing Facilities

1. Improved production at existing facilities over the construction of new facilities.
2. Assessment of currently used stocks for:
   a. species, strain or stock;
   b. run timing;
   c. disease tolerance;
   d. stock size and ability to reproduce;
   e. migration characteristics;
   f. survival/contribution of stocks; and
   g. age, size and composition.

3. Disease control - methods to improve fish disease diagnosis and control at hatchery facilities.

Construction of major hatchery facilities - only after emphasis on maximum utilization of existing facilities and control of ocean harvest.

Construction of low-capital salmon production facilities

Columbia Basin - low cost, require less water, etc.

Integration of artificial and natural production

1. supplementing natural stocks with hatchery fish.
2. plan the use of hatchery stocks for "known stock" fisheries.

LOWER SNAKE RIVER COMPENSATION PLAN - FISH HATCHERIES AND RELATED FACILITIES

Evan Parrish, Idaho Department of Fish and Game

The purpose of this presentation was to familiarize fish culturists from the Northwest with the locations, problems and capacities of all fish facilities being constructed and/or planned for construction under the lower Snake River Fish and Wildlife Compensation Plan. This plan was established to compensate the States of Washington, Oregon and Idaho for anadromous fish lost as a result of the construction of Ice Harbor, Lower Monumental, Little Goose and Lower Granite dams on the Snake River by the U.S. Army Corps of Engineers.

Several sites in Idaho were shown, including Crystal Springs, Hagerman National, Sawtooth and the East Fork Salmon River satellite hatcheries, sites proposed on Brushy Forks, White Sands Creek, Fish Creek, Kooskia National Hatchery and the North Fork Clearwater site in the Clearwater drainage. McCall Hatchery and its South Fork Salmon satellite were depicted.

The Lyons Ferry site was shown as the major portion of Washington's production capability, and also the function of the Tucannon site that will be modified to hold adults for LSRCP projects.

The Oregon effort will be at Lookingglass hatchery and the Wallowa Hatchery, with trapping sites at Big Canyon Creek, Sheep Creek and the Imnaha River. Irrigon was not shown, but production goals were included.

Salmon Trout Enhancement Program

Dave Loomis

Oregon Department of Fish and Wildlife
Newport, Oregon

The Salmon Trout Enhancement Program (STEP) was established in 1981 by the Oregon Department of Fish and Wildlife. A primary objective of STEP is to obtain public involvement in various phases of enhancement for Oregon's salmon and trout populations. Four STEP Biologists were assigned to the program to provide technical assistance in planning projects and also coordinate STEP activities with the Department's overall management goals.

Ten different areas that the public can get involved in enhancement activities are discussed. Again, the program is based on public volunteers completing projects that can potentially increase fish populations on various streams. Emphasis is placed on streams that are not presently producing fish at their highest possible level.

BARRIER REMOVAL - Logjams, falls, and culverts may cause problems for upstream migrating spawners. Volunteer labor and use of equipment can balance the cost/benefit ratio based on the available spawning habitat above the barrier.

IMPROVING RIFFLE/POOL RATIO - Excellent fish habitat includes a good balance of rearing and spawning areas. Many streams need more diversity to improve the carrying capacity. Proper placement of structures in the stream is one method of improving the overall stream habitat. Logsills, gabions, or boulders will collect spawning gravel, scour out pools for rearing, and even provide cover for hiding.

ENHANCING STREAMSIDE VEGETATION - Stable streambank condition is very important to the fish habitat. Adequate streamside vegetation provides well shaded, cool streams with excellent hiding cover. Also, it controls bank erosion which

minimizes heavy siltation problems for the fish. Good streamside vegetation also provides habitat for insects which are an important source for all fish population. Reseeding, sloping, and fencing of disturbed areas are examples of possible STEP projects.

CAWT - Catch-a-Wildlife-Thief is a cooperative effort to assist the State Police in enforcement of laws to protect our fisheries resources. A toll-free number (1-800-452-7888) has been set up for the public to report any problems they might observe.

STREAM SURVEYS - An important part of an enhancement plan is to determine the "limiting factors" for the particular stream. Fish habitat is continually changing, so updated information for many streams is needed for use by district fish biologists and to provide information for outlining enhancement projects. These projects may include spawning fish surveys, juvenile sampling, or physical and biological surveys.

EGG INCUBATION - Surplus eggs are sometimes available for streamside incubation projects to hatch eggs for fry releases at appropriate stream sites. Stock transfer guidelines that consider genetic integrity, disease control, and species interaction will be followed for all hatchbox projects. Participants obtain salmon and trout eggs for home-built hatchbox systems and raise these fish until release as unfed fry into under-seeded streams. These projects are very popular and are especially successful when completed in conjunction with habitat improvement or protection activities.

ADOPT-A-STREAM - A group or individual may decide to do many, if not all types of enhancement projects on a particular stream. Many different activities can be planned on a long term basis to increase all fish populations for the stream.

EDUCATION AND INFORMATION - Cooperative projects with schools can provide students with a better knowledge of human impacts on fish resources. Curriculum materials, along with field activities will ensure future generations the knowledge to make the best decisions for this important resource.

STEELHEAD SCALE COLLECTION - Successful anglers are asked to collect a few scales from each steelhead they catch. The information obtained from "reading" these scales is very important to the management of this species.

PUBLIC AWARENESS - The goal to open a two-way communication between the general public and the Department is achieved simply by participating in STEP activities. There is a definite need to improve the awareness about our salmon and trout management. STEP brings together people that have a mutual interest in enhancement of our fisheries resources.

The STEP program has been very successful in its first year and it is expected that the number of activities will increase. An increasing number of people are becoming interested in learing what they can do to help Oregon's salmon and trout populations. STEP will be an important part of the overall enhancement goal of our Department for many years.

Questions and Answers

Q. I have been involved in this kind of program. How many projects are you associated with?

A. In my area I probably have about 100. We've only been going about a year and a half.

Q. You think you could handle more?

A. No, not in such a large area.

Q. How many volunteers would be involved statewide in this program?

A. I would say 3 or 4 thousand.

Q. One last question. I'm sure there are some district biologists in the audience so you might not be able to answer too clearly, but how are things going with the district fish biologists? In relation with this program?

A. I can only speak in my area. The district fish biologists have been very responsive to the program and worked very closely with it.

Fork Length Changes of Juvenile Salmonid Populations Following Migration Through the Columbia River

by

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December, 1982

INTRODUCTION

The National Marine Fisheries Service has been sampling salmonid smolts as they enter the Columbia River estuary at Jones Beach (River Kilometer 75) since 1977 using beach and purse seines (Dawley et al., 1982). During that period 2.3 percent to 5.0 percent of all fish migrating down the river were marked. Examination of fork lengths of individuals captured from those marked fish groups has provided the opportunity to observe size related survival differences during freshwater migration.

Increased body size at release for hatchery reared salmonids has been equated with greater survival to adulthood for most species; also minimum size thresholds for survival have been hypothesized.

RESULTS and DISCUSSION

Estuarine catch data indicates a positive relationship between survival during migration to the estuary and increased body size at the time of release for chinook, and coho salmon and steelhead. The smaller individuals from certain release populations are missing from the migrant groups captured at Jones Beach. Examples of length frequency

distributions for fall and spring chinook salmon, coho salmon, and steelhead, compared before and after migration are presented in Figure 1. Group A for each species shows an upward size shift after migration with proportionately fewer of the smaller fish in the catch; Group B for each species shows little or no size shift. Not all groups of fish were measured prior to release, consequently we are unable to determine the extent of this upward size shift for the overall migratory population.

Size Graded Groups

Spring chinook salmon groups graded for size and marked for size/survival research at various hatcheries in the Willamette and Deschutes River systems (Fessler, 1978; and Smith and Zakel, 1979, 1980 and 1981) showed higher catch percentages at Jones Beach in relation to increased weight in 7 of 10 experiments (Table 1).

Table 1.-- Jones Beach catches for spring chinook salmon smolts related to size at time of release from hatcheries.

Release site/source	Release date (day/mo/yr)	Juvenile catches at Jones Beach (no.)	(%)	Average size at release (no./lb)	(g)
Leaburg, OR/ McKenzie Hat.	15 Mar 80	18	0.153	3	151
" "	"	13	0.112	4	113
" "	"	13	0.079	11	41
" "	16 Mar 81	11	0.078	4	113
" "	"	4	0.029	6	76
" "	"	11	0.075	9	50
Minto, OR/ Marion Fks. Hat.	16-24 Mar 81	10	0.053	14	30
" " "	"	10	0.041	14	30
" " "	"	7	0.025	20	20
Dexter Pd./Oakridge Hat. (Oakridge stock)	20 Mar 79	32	0.173	12	38
	"	40	0.178	14	32
Dexter Pd./Oakridge Hat. (Dexter Stock)	20 Mar 79	36	0.299	6	76
	"	50	0.282	8	57
Dexter Pd./Oakridge Hat. (Oakridge stock)	10 Mar 80	15	0.145	4	113
	"	25	0.202	8	58
Dexter Pd./Oakridge Hat. (Dexter stock)	10 Mar 80	20	0.148	9	50
	"	18	0.134	16	28
Dexter Pd./Oakridge Hat. (Oakridge stock)	16 Mar 81	12	0.096	4	113
	"	9	0.063	7	65
Dexter Pd./Oakridge Hat. (Dexter stock)	16 Mar 81	14	0.104	7	65
	"	17	0.133	9	50
Round Butte Hat.	31 May 78	32	0.183	24	19
" " "	"	33	0.122	28	16
" " "	"	34	0.121	32	14

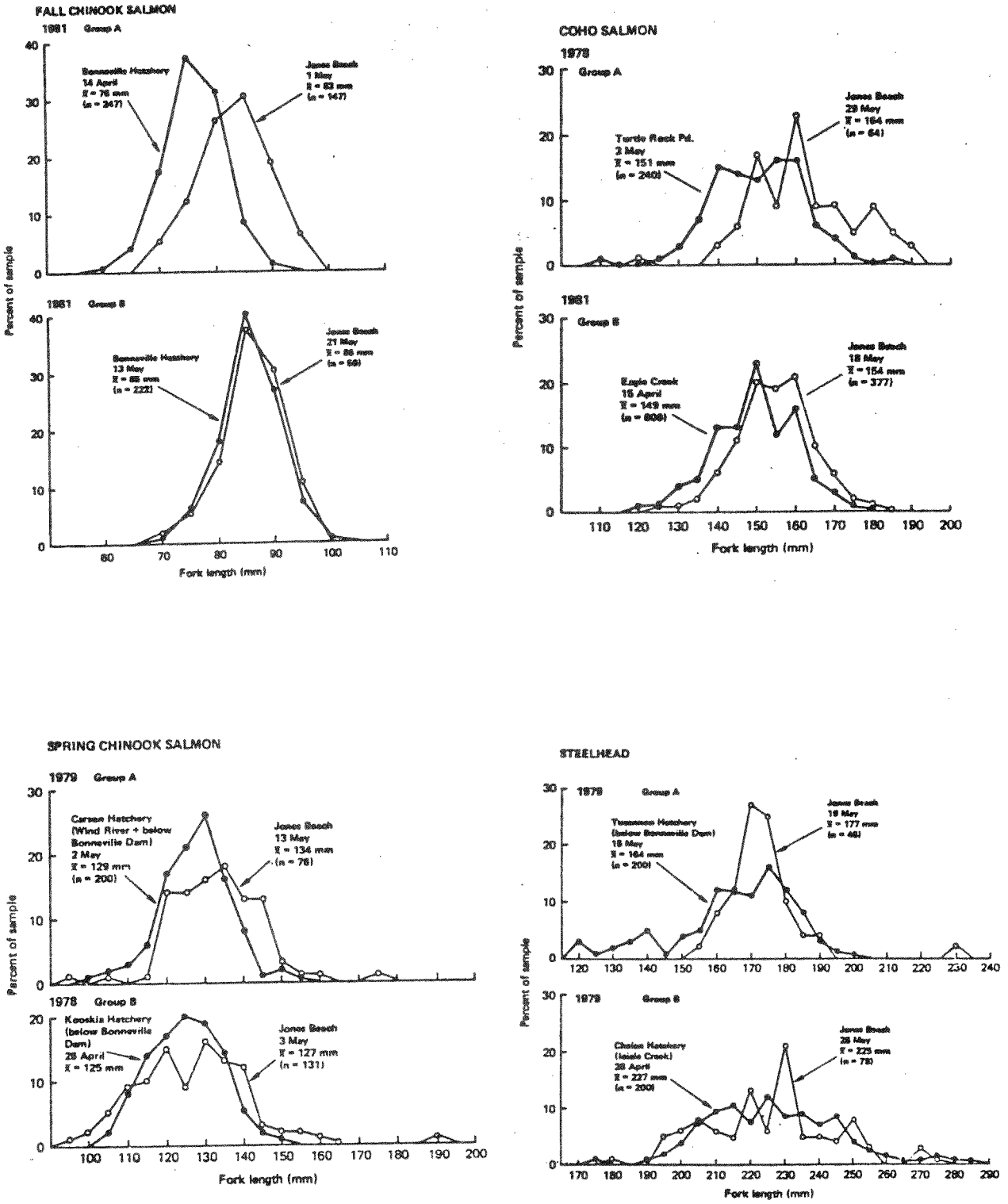

Figure 1.—Fork lengths of fall chinook, spring chinook, and coho salmon and steelhead before and after migration. Groups A showing size shift and Groups B no size shift.

Density Treatment Groups

Coho salmon groups from the U.S. Fish and Wildlife Hatchery at Eagle Creek reared at high, medium and low densities (0.45, 0.30, and 0.15 lb/ft.^{3} (water)/in. (mean length) were examined for fork length frequency shift and differences of catch percentages following migration to the estuary. Recoveries at Jones Beach from groups released in 1981 were compared to compiled length frequencies at release of all three density groups (Figure 2).[1/] The month duration between measurement at the hatchery and median recovery at Jones Beach was sufficient to produce the upward size shift of the groups. Catch percentages 0.19, 0.22, and 0.19 respectively for each of the density groups are not statistically different; from past observations at Jones Beach differences of this range would be expected for any set of three replicate groups (Dawley, et al. 1982).

Fork length frequencies for 1982 rearing density groups captured at Jones Beach were compared to length frequencies at the hatchery for the same groups before release,[1/] (Figure 2), and upward size shifts were not observed for any of the groups. Catch percentages were not statistically different between groups (0.17, 0.17, and 0.18 percent respectively). We concluded that affects from rearing density treatments on Eagle Creek coho salmon were minimal during migration to the estuary. Similar results were observed for rearing density treatment groups of coho salmon from the Sandy Hatchery and spring chinook salmon from the Cowlitz Salmon Hatchery.

1/ Hatchery release data from Jamieson Holway, U.S. Fish and Wildlife Service, Eagle Creek Hatchery, Rt. 1, Box 610, Estacada, Oregon 97023.

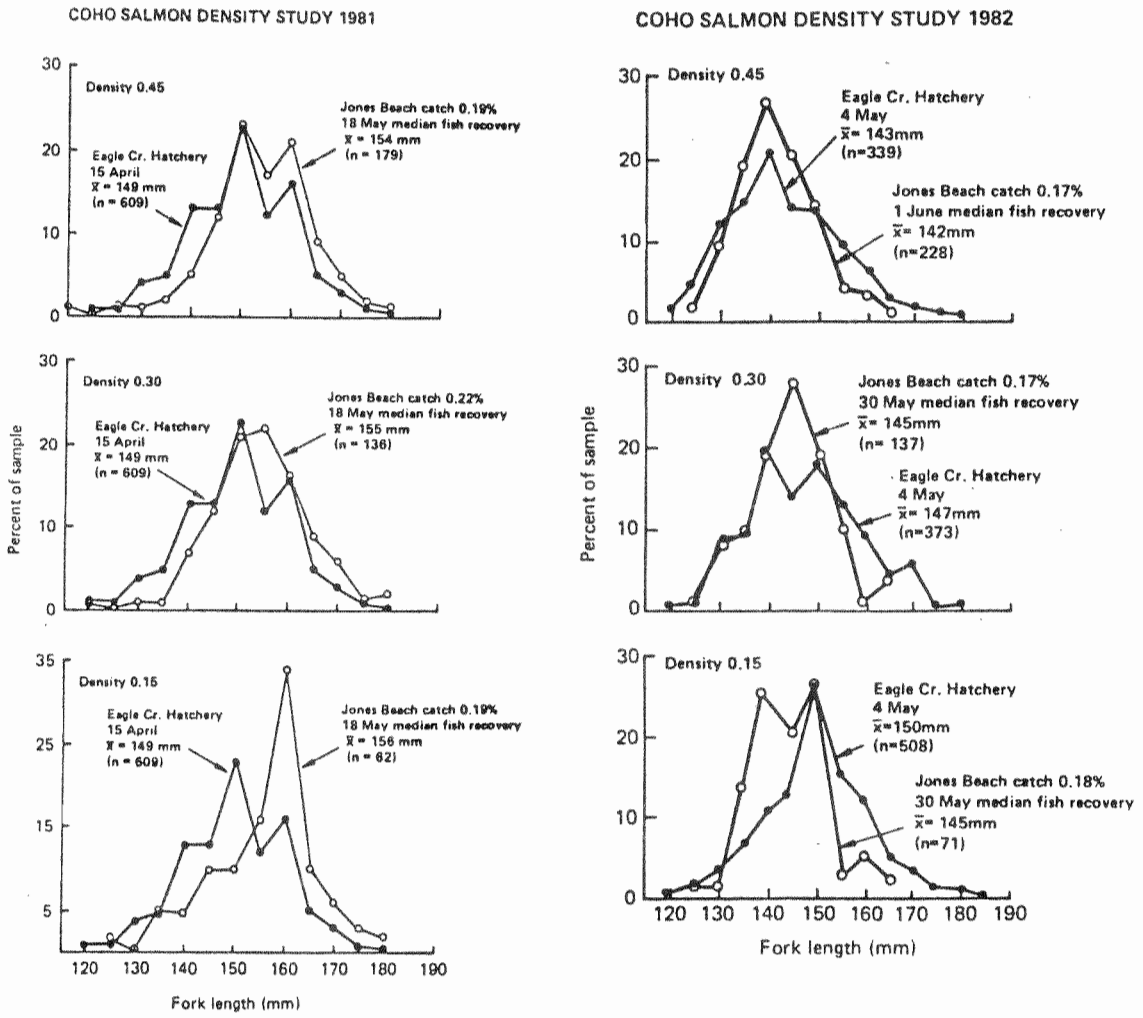

Figure 2.—Fork lengths of coho salmon before and after migration for groups reared at 0.15, 0.30, and 0.45 lb./ft.^{3} (water)/in.(mean length) in a density study at Eagle Creek National Fish Hatchery.

Fork Length Thresholds

A minimum fork length threshold for survival is hypothesized for steelhead smolts by Buchanan (1981), who reported a release threshold minimum of 180 mm for steelhead of Willamette River origin. However, our observations indicate that this threshold size may not be the same for steelhead of Snake River origin. Individuals as small as 110 mm migrated successfully from the Snake River to Jones Beach. For example there seemed to be no size selective mortality for a group of Dworshak steelhead ranging from 110 mm to 240 mm (Figure 3).

Similar threshold data are being compiled by Percy Washington for coho salmon.[2/]

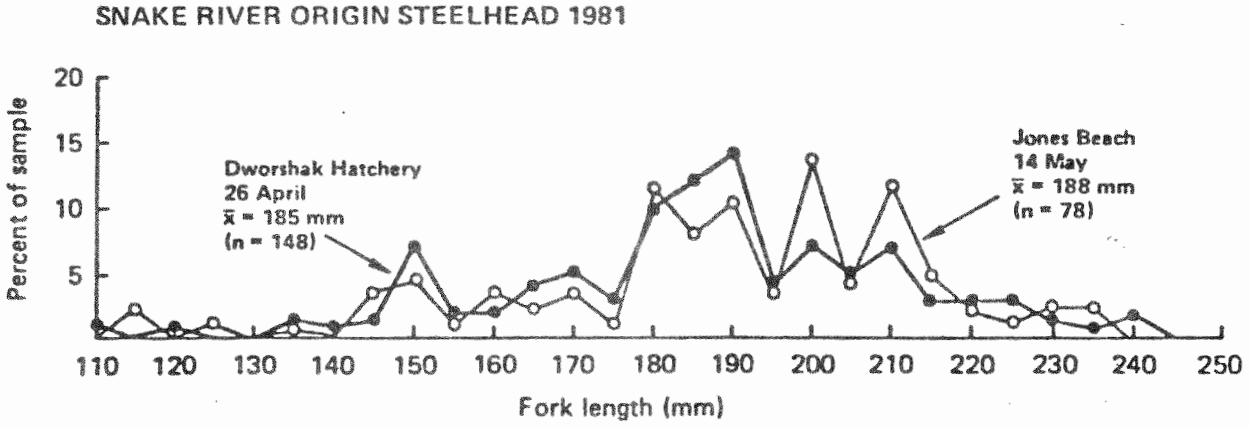

Figure 3.--Fork lengths of Snake River steelhead before and after migration showing little change in length frequencies for the portion of the population less than 180 mm.

2/ Percy Washington, Phd thesis in preparation, University of Washington College of Fisheries, Seattle, Washington.

CONCLUSIONS

Gear selectivity appears unrelated to observations of size shift within the population after freshwater migration. Beach seine efficiency for subyearling chinook salmon is inversely correlated with size, which tends to make the observed loss of smaller fish conservative (Dawley, et al. 1981). Changes of purse seine efficiency within the size range of yearling fish appears to be minimal based on the following: (1) in several instances length distribution of purse seine catches correlate well with length distributions prior to hatchery release (Figure 1, Groups B) - - if the shift in length distribution was associated with gear selectivity it should be apparent in all groups observed; and (2) substantial numbers of subyearling fish, some as small as 60 mm, were captured in the purse seine.

Size of smolts appears to be an important factor in survival during freshwater migration for some stocks of fish but unimportant for others. Reasons for smaller smolts dropping out of some populations but not others have yet to be determined but may be an important facet of imcreased adult returns.

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Stomach Fullness of Individual Stocks of Salmonid Smolts Entering the Columbia River Estuary during 1979, 1980, and 1981

by

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December 1982

INTRODUCTION

The objective of the study was to determine the amount of food in the stomachs of juvenile salmonids as they enter the Columbia River estuary and to identify those stocks that were not feeding. Snyder (1981) suggested that nonfeeding behavior might decrease survival; consequently the observations reported here could be important to understand fluctuations in adult return percentages and relationships between juvenile survival estimates and adult returns. This study was part of an ongoing effort to define the migrational characteristics and survival of chinook and coho salmon and steelhead in the Columbia River estuary (Dawley et al. 1982). Stomachs from tagged fish captured at the National Marine Fisheries Service (NMFS), Jones Beach, Oregon sampling station during the spring and summer outmigrations of 1979, 1980, and 1981 were used in these analyses. Between stock comparisons of feeding behavior for migrating smolts are a unique aspect of this research and was of particular importance when evaluating the effects on feeding produced by the extremely turbid water following the eruption of Mount St. Helens on 18 May 1980.

METHODS

Sampling was conducted at Columbia River kilometer (RKm) 75, using purse and beach seines (Dawley et al., 1982). Fish were collected from March through September each year. During the peak recapture period (May and June) fishing effort consisted of five purse seine and ten beach seine sets each day beginning at sunrise. At other times, effort varied with the number of migrants being captured. Beach seine sets were made at 45 minute intervals and purse seine sets at 90 minute intervals. The fishing period was about 7 hours each day. Fish captured were transported to processing facilities on shore. Fish were separated by species and fork lengths of marked fish were recorded to the nearest millimeter (mm). Fish containing coded wire tags (CWT) were sacrificed and the tags removed for identification. Stomachs of CWT fish were extracted, cleaned of external fatty deposits, and visually evaluated as to fullness.

In 1979 stomachs were judged to be full, partially full, or empty; however, beginning in 1980, the integers 1-7 were used to quantify the observations as empty; trace; one quarter; half; three quarters; full; and distended full, respectively (Terry, 1976). Stomachs appearing empty were opened; if traces of food items were observed the value 2 was assigned, if empty the value 1. For purpose of discussion, stomachs judged empty or trace were combined and termed nonfeeding when captured. Each fullness value was recorded along with corresponding tag information and the period between set time and time of stomach observation.

Holding time for captured fish used for stomach fullness observations was about 90 minutes. Elliot (1972) has shown that the rate of gastric evacuation in brown trout, Salmo trutta L., increases exponentially with increased water temperature. He reports 78% of digestible organic matter

remained after 2 hours at 16°C but only 56% remained after 2 hours at 16°C. Water temperature at Jones Beach from March through June increased from 8 to 16 degrees, water temperatures later in the summer increased to 21°C. Observations made after June may have been affected by water temperature and are therefore not presented except for the groups of coho salmon captured in July which were rapidly processed.

The data for 1980 and 1981 were computer processed to obtain fullness curves (the percentage of the population falling into each of the integer fullness values) for each tag group of fish. Fullness observations from replicate or similar tag groups were combined for presentation. The percentage of nonfeeding subyearling chinook salmon captured during May and June 1980, is compared to the percentages observed during the same date range in 1979 (pre-eruption) and 1981 (post-eruption).

RESULTS

In general, migrating fish are feeding when entering the estuary. Steelhead in both 1980 and 1981 had the lowest average fullness values (2.8 and 3.1) and coho salmon the highest (4.1 and 3.9); (Figure 1). However, stomach fullness comparisons between species may not be valid, especially between dissimilar sized fish.

Ninety-five percent confidence intervals of mean stomach fullness values by three day interval for each specie (all tag groups combined) are presented for 1980 and 1981 (Figure 1).

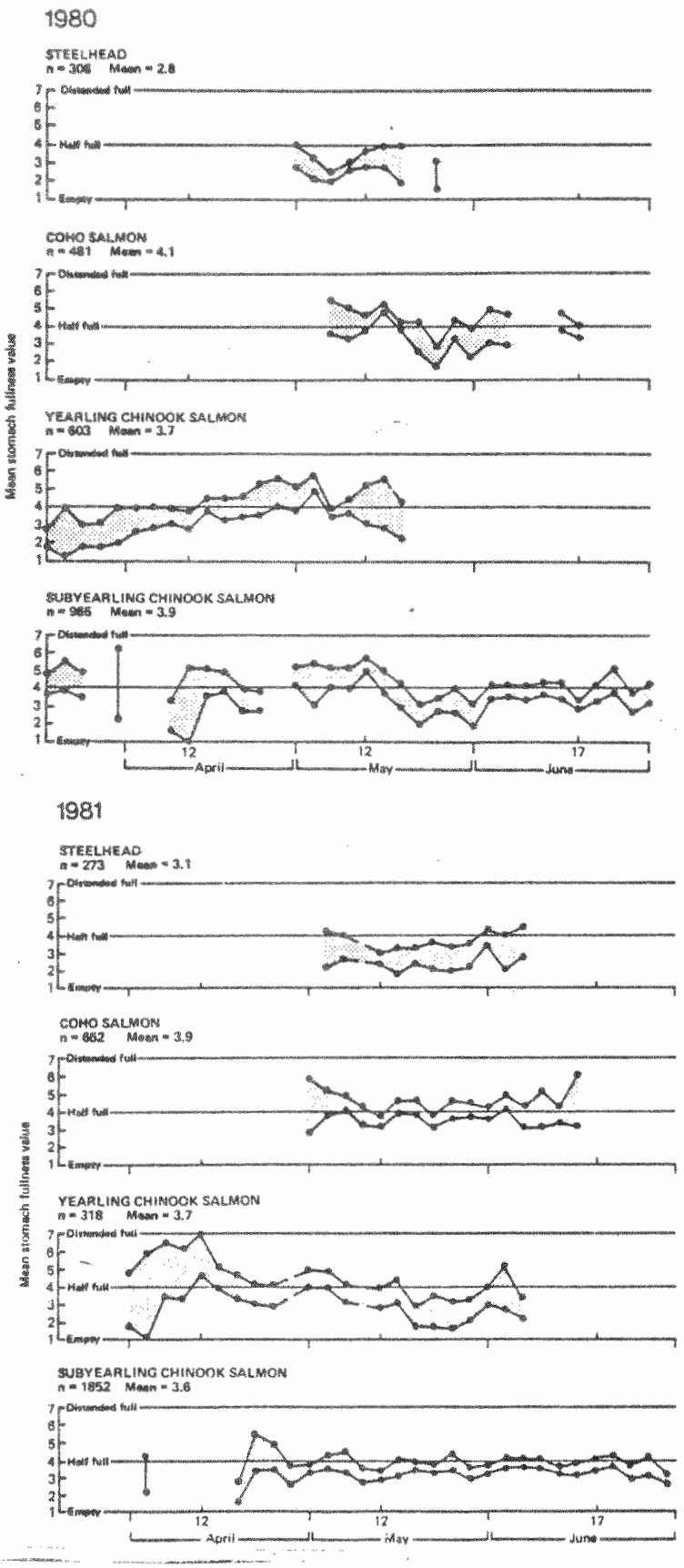

Figure 1. Ninety five percent confidence intervals for the mean stomach fullness values (3 day moving average) observed in juvenile steelhead, coho, and chinook salmon at Jones Beach, 1980 and 1981.

Subyearling Chinook Salmon

Catches in the March to mid-May period of 1980 (pre-eruption) were primarily fish released from Spring Creek Hatchery (March, April, and May release groups). Each of these groups had moderately low numbers of non-feeding fish (11, 15, and 0 percent respectively, Figure 2). Another group of fish during this time period, was released from Abernathy Hatchery, located only 16 Km upriver from Jones Beach; samples of these showed an exceptionally high percentage of nonfeeding fish in both 1980 (51%) and 1981 (44%, Figure 2). Apparently fish released from Abernathy Hatchery have insufficient time to begin feeding on natural food prior to capture at Jones Beach.

The Mount St. Helens eruption, 18 May 1980, produced a tremendous deluge of debris that arrived in the river at Jones Beach after fishing hours on 19 May 1980. The immediate increase in nonfeeding fish that was observed coincident with the highly turbid river water (3,000 Jackson Turbidity Units; 500 times more turbid than normal)[1/] was made clear only after eliminating the explainable empty and trace full stomachs of Abernathy fish, the majority of which were captured just prior to the eruption (median date 16 May). Specific groups of fish, passing just after the eruption, which were not feeding at normal levels were: (1) Spring Creek Hatchery fish released downstream of Bonneville Dam (30% nonfeeding) compared to a similar group in 1981 release upriver at Rock Creek (14%); (2) Bonneville production fish (21% versus 10% 1981);

1/ Measurements adjacent to or 8 Km downstream from the mouth of the Cowlitz River (RKm 109); collected by NMFS, Habitat Investigations Task, Robert McConnell, P. O. Box 155, Hammond, Oregon 97121.

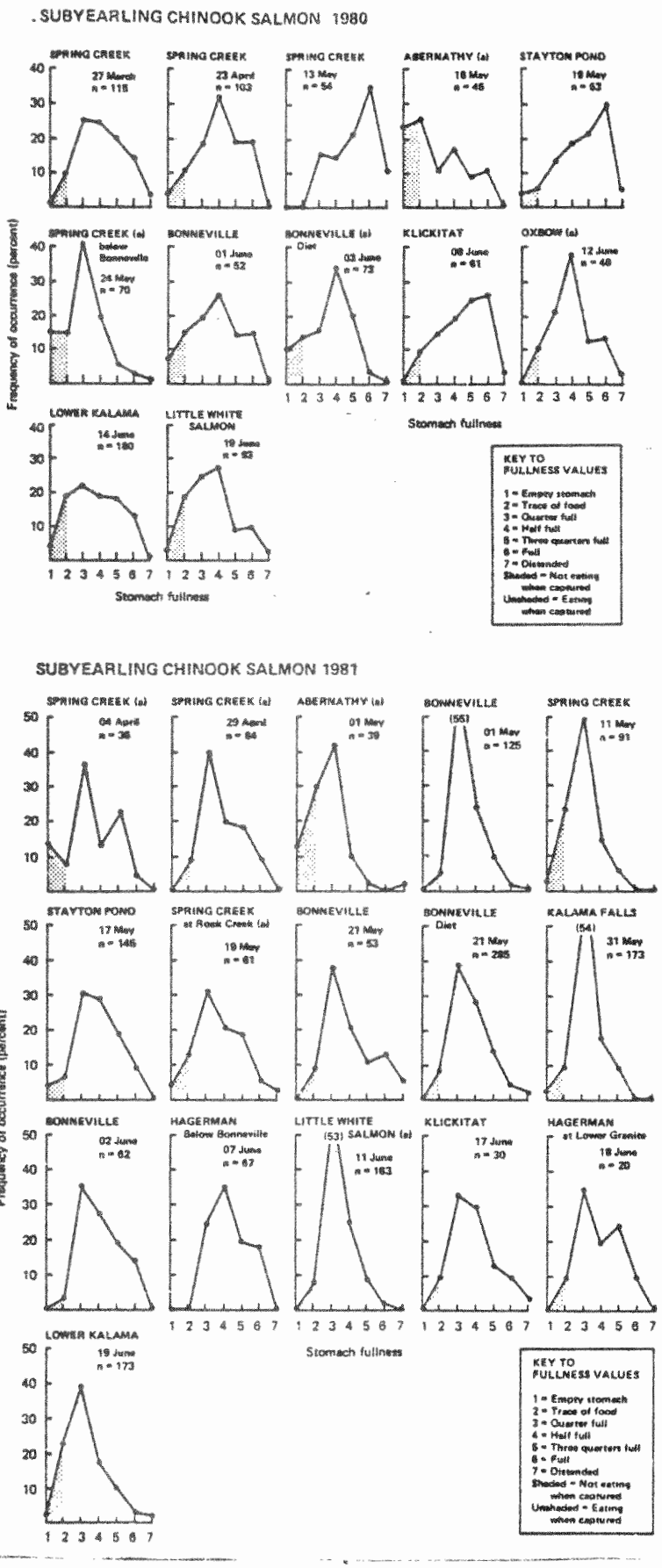

Figure 2. Stomach fullness observations of various hatchery groups of subyearling chinook salmon at Jones Beach, 1980 and 1981. Date of median fish passage is given, N equals number observed, and (a) refers to releases represented by more than one tag number.

and (3) Bonneville diet study fish (24% versus 10% 1981, Figure 2). This sudden increase in nonfeeding fish following the eruption in 1980 was not observed in 1979, nor was it repeated in 1981 (Figure 3). The gradual increase in percent empty or trace full stomachs observed in 1981 from 9 May to 14 May (Figure 3), is primarily associated with fish released from Spring Creek Hatchery (27% nonfeeding). A similar group released in 1980 passing before the eruption had no empty or trace full stomachs (Figure 2).

One tag group was captured in sufficient quantities before and after the eruption in 1980 to allow within group comparison of stomach fullness. The fish were reared at Stayton Ponds and were released into various Willamette River tributaries from 28 April to 21 June (median recovery date at Jones Beach was 19 May, 11% nonfeeding, Figure 2); 3% of the fish examined prior to the eruption were nonfeeding (n=34) compared to 21% after (n=19).

Apparent return to normal feeding occurred by early June (Figure 1). Catches during June and early July were primarily fish from Klickitat, Oxbow, Lower Kalama, and Little White Salmon Hatcheries. The nonfeeding percentage for each of these groups in 1980 was: 10, 11, 23, and 22% respectively compared to 9, no release, 24, and 8% in 1981 (Figure 2).

Yearling Chinook Salmon

From mid-March to mid-April 1980, yearling chinook salmon captured had very high nonfeeding levels (Figure 1). These fish originated from hatcheries at: Bonneville, Oakridge, McKenzie, and two groups from South Santiam with 37, 24, 40, 45, and 33% empty and trace full stomachs respectively (Figure 4). In this time period in 1981, although sample

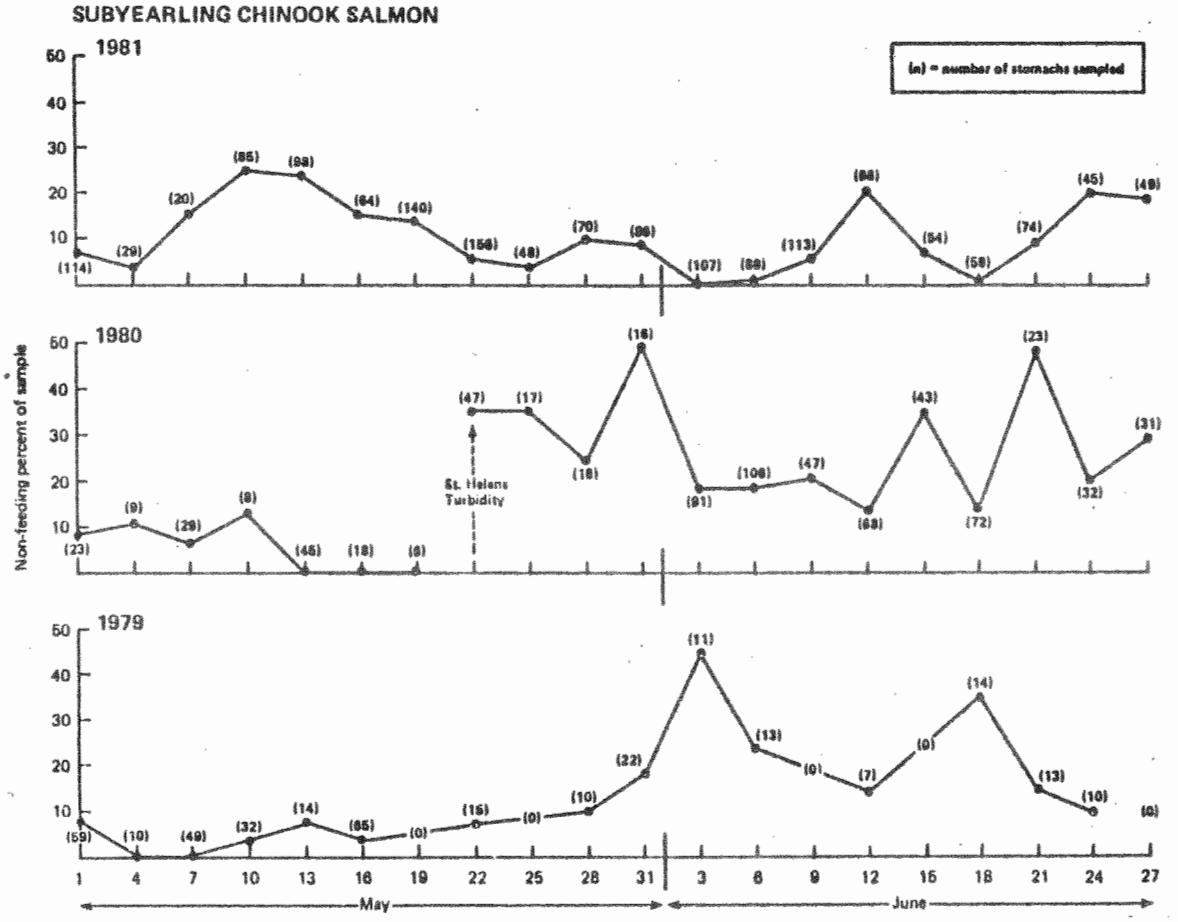

Figure 3. Percent empty or trace full stomach (non-feeding) observed in subyearling chinook salmon at Jones Beach during May and June 1979, 1980, and 1981. Number of stomachs observed during each 3 day interval is shown above each plot. Abernathy Hatchery fish omitted.

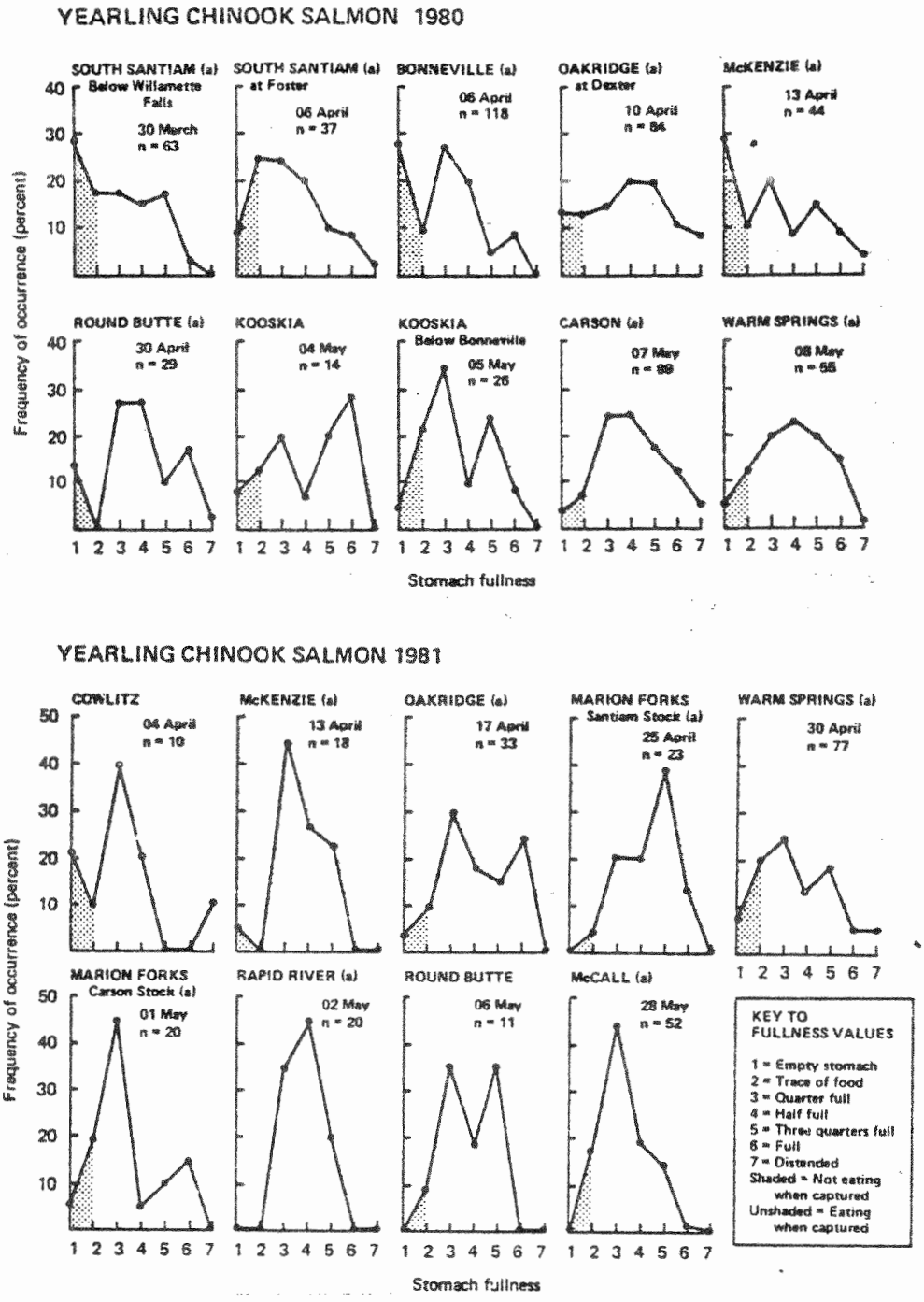

Figure 4. Stomach fullness observations of various hatchery groups of yearling chinook salmon at Jones Beach, 1980 and 1981. Date of median fish passage is given, N equals number observed, and (a) refers to releases represented by more than one tag number.

numbers were low, only Cowlitz Hatchery fish had such high nonfeeding values (31%); fish from McKenzie and Oakridge had low nonfeeding values (6% and 14% respectively, Figure 4).

In late April to mid-May 1980, high nonfeeding levels were not as prominent; groups from Round Butte, Carson, and Warm Springs Hatcheries showed fullness curves with 12, 11, and 18% empty and trace full stomachs respectively, although sample numbers were low. A group from Kooskia Hatchery was the exception with 27% nonfeeding. In late April to mid-May 1981, a similar feeding pattern was observed with groups from Marion Forks (South Santiam stock), Rapid River and Round Butte Hatcheries showing 3, 0, and 10% empty and trace full stomachs respectively, while groups from Marion Forks (Carson stock), and Warm Springs displayed somewhat higher nonfeeding percentages (26 and 28% respectively, Figure 4).

In late May and early June 1980, very few yearling chinook salmon were captured after the Mount St. Helens eruption due to a normal attrition of the migratory population during that date period (Dawley et al. 1982). In 1981, one group from McCall Hatchery was captured during this period with 18% nonfeeding (Figure 4).

Coho Salmon

Coho salmon generally had the fullest stomachs of the four salmonid species observed. It was unusual to observe greater than 10% nonfeeding coho salmon within any population in 1980 or 1981 (Figure 5). Significant catches of coho salmon began in early May with groups from Cascade, Toutle, Washougal, and Sandy Hatcheries represented in both years and an additional group from Eagle Creek Hatchery in 1981. The percent of nonfeeding fish in these groups ranged from 0 to 10% (Figure 5).

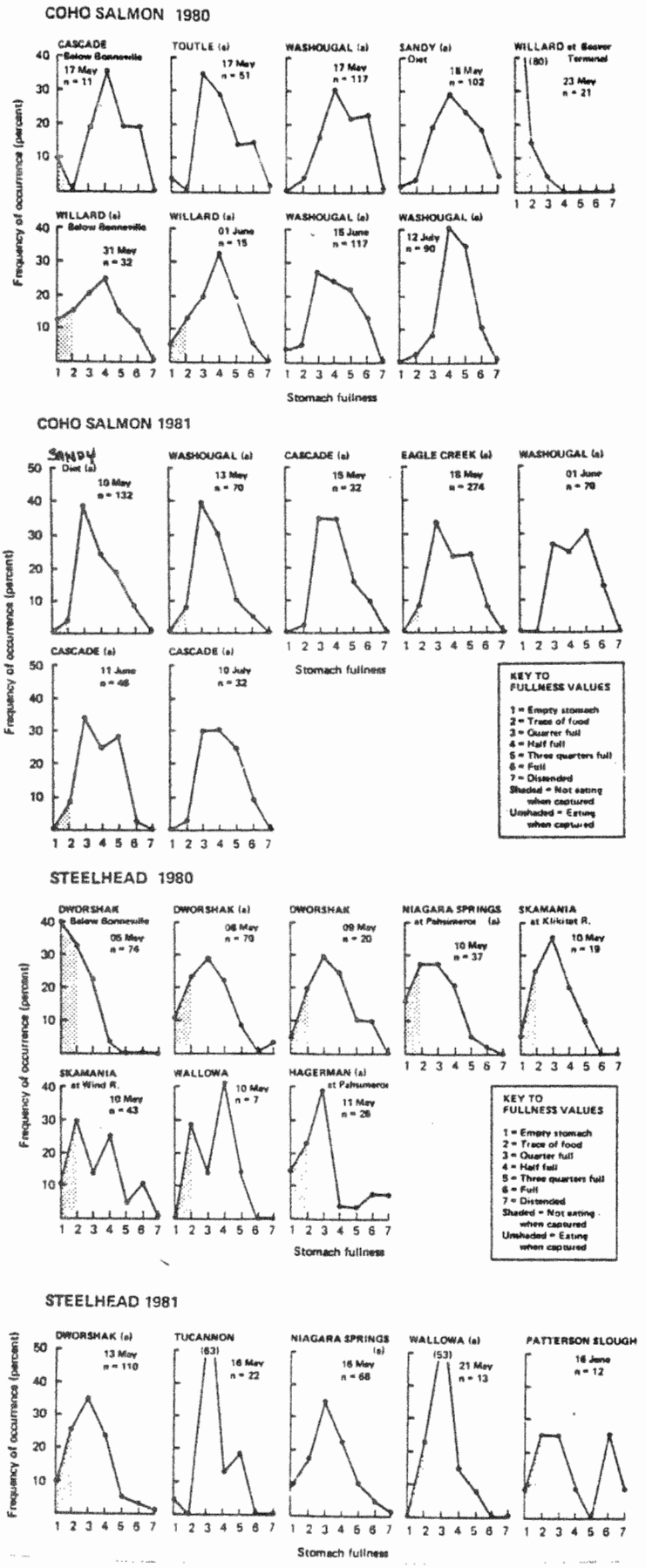

Figure 5. Stomach fullness observations of various hatchery groups of coho salmon and steelhead at Jones Beach, 1980 and 1981. Date of median fish passage is given, N equals number observed, and (a) refers to releases represented by more than one tag number.

Three groups of coho salmon did elicit low feeding levels following the eruption in 1980. These fish were reared at Willard Hatchery and released at the hatchery, downstream of Bonneville Dam (RKm 230), and at Beaver Terminal (9 Km upstream of Jones Beach); having 17, 21, and 95% nonfeeding percentages respectively (Figure 5). There were no similar releases from Willard Hatchery in 1981 with which to compare.

By mid-June 1980, fullness curves for coho salmon returned to apparent normal levels of nonfeeding; 5% for Washougal Hatchery fish. July releases in 1980 and 1981 from Washougal and Cascade Hatcheries had about 5% nonfeeding (Figure 5).

Steelhead

Steelhead had the lowest average fullness values of the four species (Figure 1). It was normal to observe 30% nonfeeding fish within a steelhead population. Significant catches of steelhead began in early May when fish groups from releases at Dworshak, Niagra Springs, Skamania, Willowa, Hagerman, Tucannon Hatcheries, and Patterson Slough were captured, all having similar fullness curves (about 30% nonfeeding, Figure 5). There was one group of steelhead from Dworshak Hatchery barged to a release site downstream of Bonneville Dam in 1980 that had extremely high numbers of nonfeeding fish (73%). A control group of fish which migrated from Dworshak Hatchery had a more normal amount of nonfeeding fish (34%). We suspect that the short time period between release of the transported group and capture at Jones Beach (88% captured within 3 days after release) was insufficient for fish to develop aggressive feeding behavior.

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CONCLUSIONS

1. Smolts entering the Columbia River estuary were generally feeding. Observations of most non-feeding fish groups in 1980 and 1981 appear to be related to either a) short time period between release and recovery at Jones Beach and/or b) high turbidities resulting from the eruption of Mount St. Helens. We have no explanation for the apparent low feeding levels of yearling chinook salmon captured in March and early April 1980.

2. Conclusions about feeding behavior of juvenile salmonids in the Columbia River estuary could be very missleading without knowledge of the specific stocks being examined.

Stress Induced Alterations in Chinook Salmon (Oncorhynchus tshawytscha) Gills

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Under the high population densities used in intensive fish culture, diseases of gills, often characterized by the presence of myxobacteria, are common (Wedemeyer, 1970). However, Snieszko (1962) noted that by reducing densities, fish with lesions characteristic of myxobacterial gill infections often recovered without additional treatment. Environmental stressors will decrease the resistance of fishes to infectious diseases, and the recovery of fishes with myxobacterial gill infections implies that environmental stressors, and not the presence of bacteria, are the precipitating factor in outbreaks of gill disease. This theory is in agreement with Wood (1968), who correlated occurrence of gill disease with high fish density and low water turnover rates in rearing containers.

The objectives of this study were to isolate the stress produced by high rearing density from the stress resulting from poor water quality, typically accompanying high rearing densities, and to determine the ability of stress from high rearing density alone to induce detrimental changes in gills which could lead to myxobacterial infections.

Age zero chinook salmon (Oncorhynchus tshawytscha) were raised for eight weeks at 0.15, 0.30, 0.60 and 1.00 lbs/inch/cu.ft. Densities were adjusted every two weeks, after inventorying the population of each tank, by means of a moveable screen. The volume of each rectangular tank was 95 liters and inflow was set at

12 liters/minute. Two tanks were loaded at each of the four densities. Water quality was maintained at the following levels:

Dissolved Oxygen	8.7 ppm
Temperature	15°C
pH	7.8
NH_3-N	.005 ppm
NO_2-N	.001 ppm
NO_3-N	4.7 ppm
Hardness (as $CaCO_3$)	108 ppm

During the experiment fish were fed according to Haskell (1955):

$$\% \text{ body weight fed daily} = \frac{\text{conversion} \times \Delta L \text{ daily} \times 3 \times 100}{\text{total length}}$$

Despite maintaining water quality at levels sufficient to avoid stress (Wedemeyer and Wood, 1974), increasing densities produced decreased length and weight gains (figs. 1 and 2). In addition, histological examination of gill tissue revealed seperation of the secondary lamellar epithelium from underlying capillaries and pillar cells in fish sampled from tanks loaded at 0.60 and 1.00 lbs/inch/cu.ft. The extent of this seperation was more severe among fish raised at the higher density, and among fish of below average size. No change in the histological appearance of gills from fish raised at 0.15 and 0.30 lbs/inch/cu.ft. was observed during the experiment.

In conclusion, stress from high rearing density alone appears capable of inducing changes in gill structure. The ability of these changes to predispose gills to myxobacterial infection remains to be determined, as does their relationship to reduced growth.

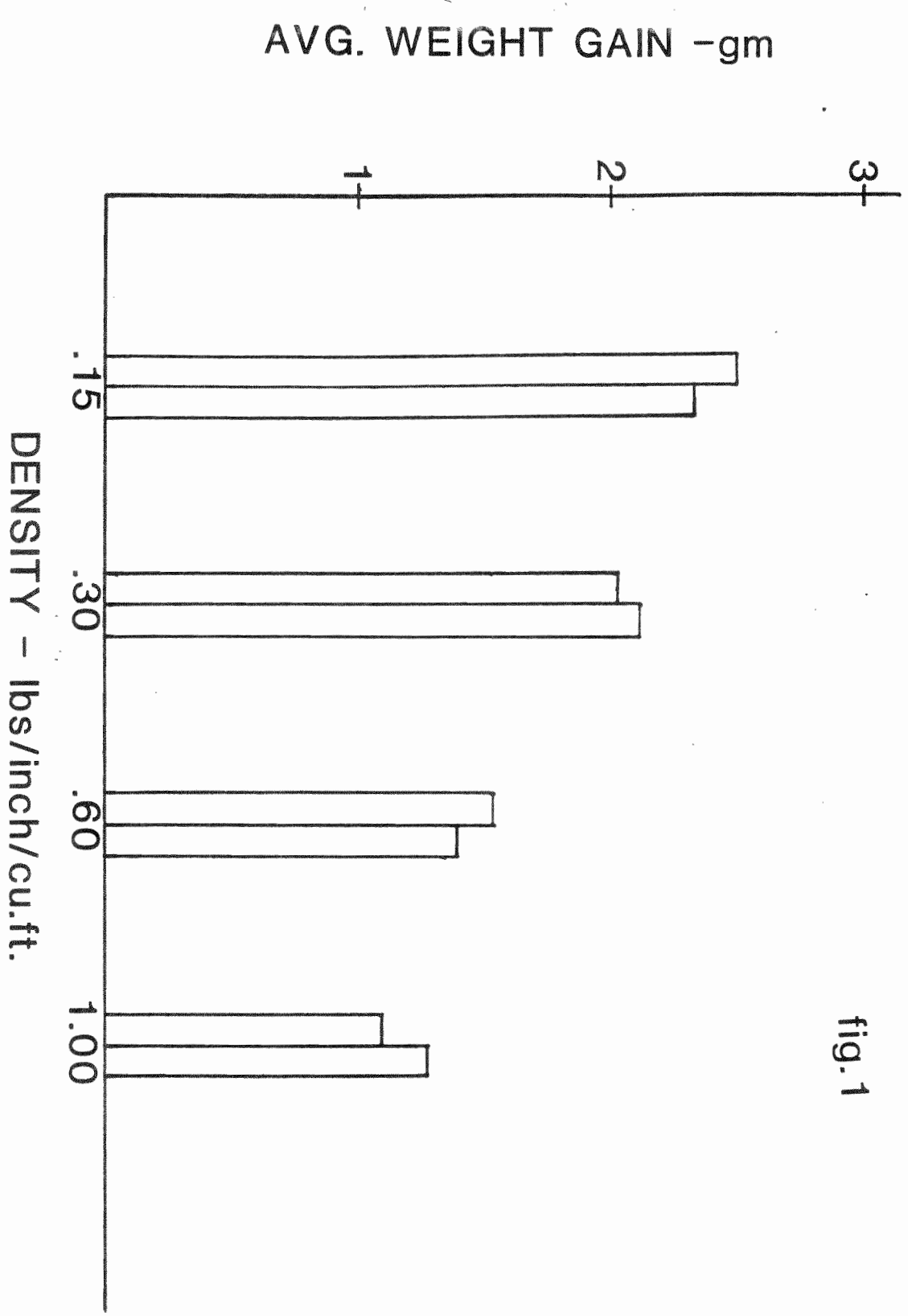

fig. 1

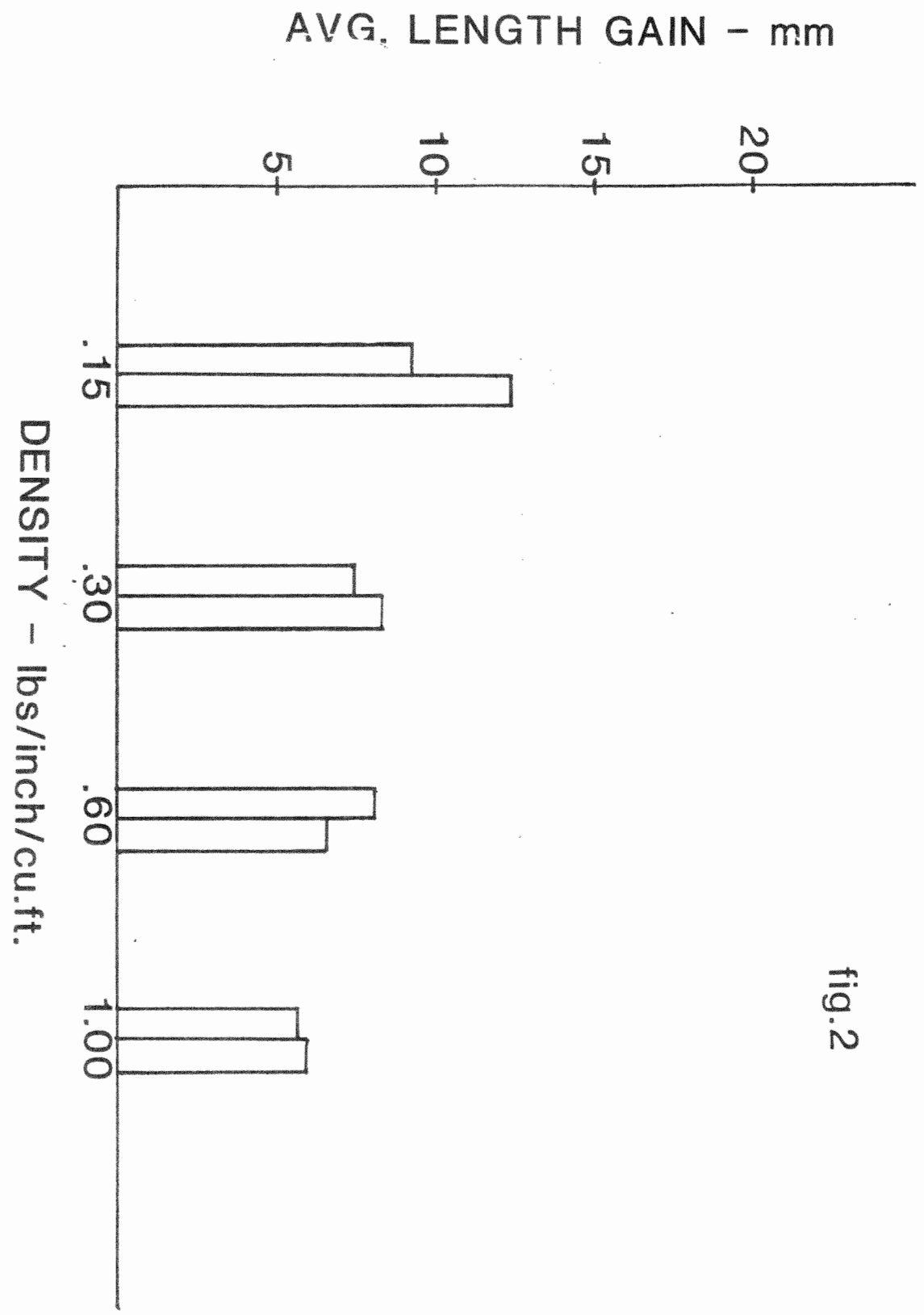

fig.2

Future work on this project will be directed towards evaluating the susceptibility to myxobacterial infection of fish stressed by high rearing densities, and towards elucidating the physiological mechanism responsible for the observed epithelial-capillary seperation in gills. Currently, this experiment is being repeated while taking samples for the determination of gill and blood ammonia levels, serum Na^+, K^+, and cortisol concentrations, and gill Na^+-K^+-ATPase activity. A depression in gill Na^+-K^+-ATPase activity has been noted in confined juvenile chinook salmon (Strange et al. 1978) and we suspect that cortisol, released in response to stress from high rearing density, may be impairing branchial ammonia excretion through its action on this enzyme.

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AMMONIA INDUCED ALTERATIONS IN GILL TISSUE AND GROWTH OF JUVENILE RAINBOW TROUT (Salmo gairdneri)

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Ammonia, a metabollic by-product resulting from protein anabolism and catabolism, is the main excretory product of fish (Burrows, 1964; Forster and Goldstein, 1969). It is escreted primarily across the gills in exchange for a sodium ion (Na). Ammonia dissociates into an unionized (NH_3) and an ionized (NH_4) form in the aquatic environment. Wuhrmann and Woker (1948) and Downing and Merkins (1955) demonstrated the unionized form to be toxic to fish. Numerous investigations have since been conducted to determine acceptable limits (no effect concentrations) of unionized ammonia, with wide ranging results. Possible reasons for these discrepencies are: (1) differences in water chemistry (ion content) of the test water, (2) failure to hold all other parameters below no effect levels, and (3) inconsistency in exposure (constant vs. fluctuating). Therefore, this study was designed with the following objectives:

1) Documentation of the individual effect of unionized ammonia on growth and gill condidion of juvenile rainbow trout.

2) Comparison of effects between constant vs. fluctuating exposure of unionized ammonia on juvenile rainbow trout.

EXPERIMENTAL DESIGN

Two reuse systems (A & B) were designed to isolate ammonia as the sole variable. Each consisted of four glass aquaria (18in.x18in.x24in.) draining into a common settling trough and biofilter. Makeup to the system was measured at 3gpm. Intravenous drip bottles (1 liter) were used to drip Ammonium chloride solutions into the tanks at a rate to obtain the desired unionized ammonia levels:

Tank #	Unionized Ammonia	Total Ammonia
1	0.00	0.00
2	0.01	0.93
3	0.03	2.80
4	0.05	4.67

System A was designed for a constant exposure (24 hours) and System B a fluctuating exposure (8 hours). Water chemistries were conducted daily using APHA Standard Methods for analysis.

Eyed rainbow trout eggs were obtained from Trout Lodge, Wahsington and hatched in an upwelling incubator on a separate water system. At a size of 29mm (5000fish/kg) the fish were inventoried into the test tanks to obtain a density of .1 lb./ft^3/in.. The fish were programmed to grow 1 inch/month and fed according to Haskells formula. Inventories were conducted at 2 week intervals at which time densities were adjusted so as not to exceed .2lb./ft^3/in.. Ten fish were sampled every four days, & fixed in 10% neutral buffered formalin and Bouins solution. The gills were excised, sectioned, and stained. After 12 weeks

the ammonia concentration in all tanks was allowed to return to Oppm by removing the drip bottles. The experiment was run 4 more weeks to monitor recovery of the fish.

RESULTS

Histopathological changes were noted after 2 weeks exposure to constant levels of .03 and .05ppm NH_3 in system A. Typical lesions noted at this time were: interlammelae hyperplasia at the distal end of the filament, hypertrophy, andearly signs of the epithelium separating from the pillar cell system. These changes proved to be progressive with filament causing focal occlusions in some cases, and the epithelium layer had been noticeably pulled away from the pillar cell system with a lightly eosinophillic staining substance in the space. During the 4 week recovery period the epithelium layer returned to normal but the hyperplasia was still prevalent. In the fluctuating exposure changes were noted only at the .05ppm concentration. Typical lesions after 2 weeks exposure were hypertrophy and separation of the epithelium from the pillar cell system. Hyperplasia was noted only after 6 weeks exposure but never became as severe as in the constant exposures. After the 4 week recovery the gill tissue returned to normal.

After 12 weeks of exposure, the average length and weight gain proved statistically insignificant for all concentrations within and between exposures. Daily mortality rates were below .02%/day and were considered insignificant. Grossly the fish were in good condition.

SUMMARY

1) Constant exposure to specific levels of unionized ammonia caused a more intense noninflammatory reaction in gill tissue than did fluctuating exposure.

2) Histopathological effect levels in our systems were:
   Constant Exposure - .03 and .05ppm NH_3
   Fluctuating Exposure - .05ppm NH_3

3) Histopathological changes in the gill tissue, although significant, did not compromise the fish enough to effect growth rates.

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