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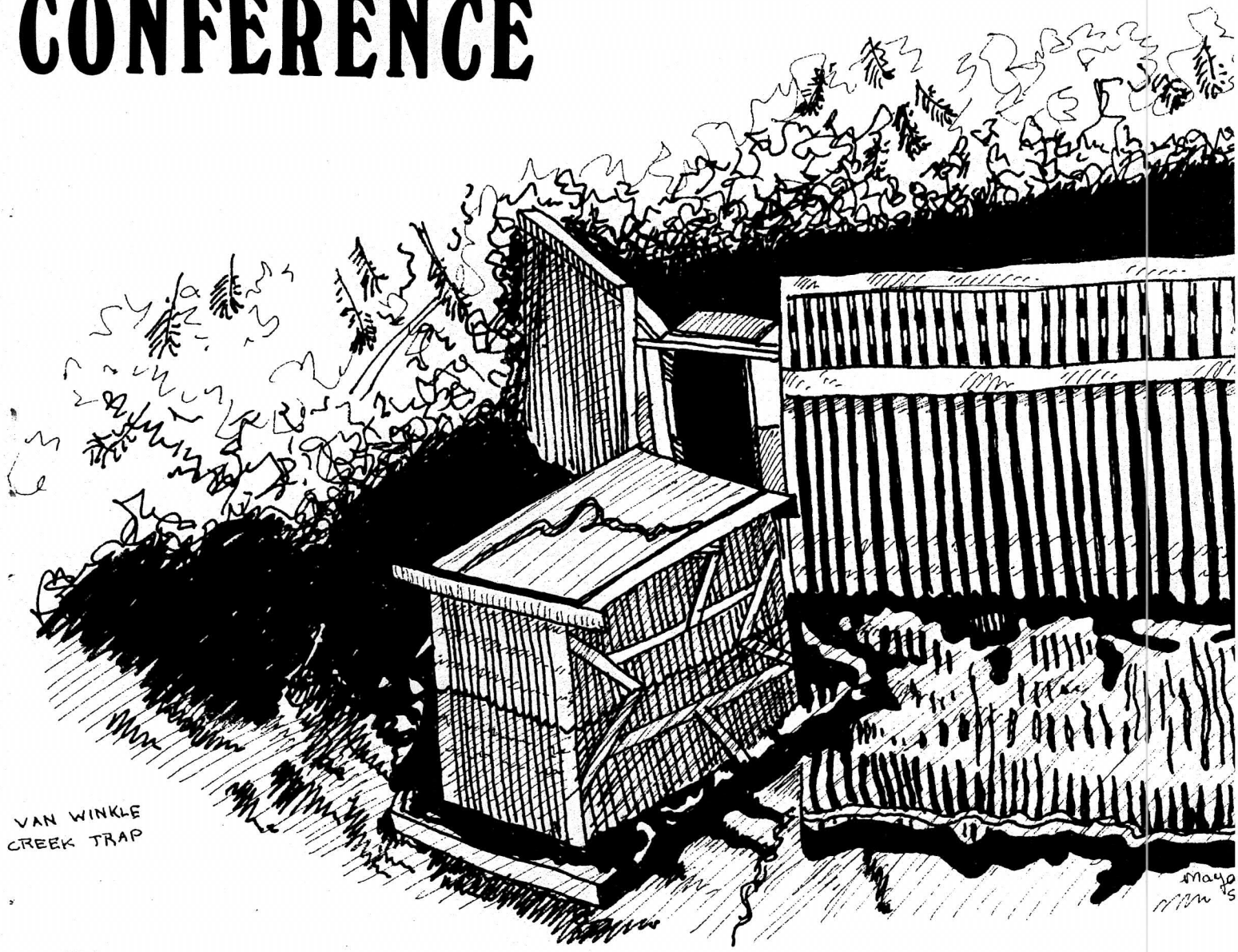
PROCEEDINGS OF THE
35TH ANNUAL NORTHWEST FISH CULTURE CONFERENCE



VAN WINKLE
CREEK TRAP

Kennewick, Wash.

Dec. 4, 5, 6

1984

PROCEEDINGS

of the

Thirty-fifth Annual

NORTHWEST FISH CULTURE WORKSHOP

December 4 - December 6, 1984

Chairman

James M. Gearheard
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600 North Capitol Way
Olympia, Washington 98504

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.

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DECEMBER 4, 1984

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It is genuinely my pleasure to excercise this opportunity to speak at the 35th annual Northwest Fish Culture Conference. Furthermore, I feel there is special significance that your conference is being held near the confluence of the Columbia and Snake rivers - two of the greatest conveyors and producers of fish in the United States.

Some of you may be wondering about my background and what qualifies me to be your keynote speaker. After graduating in 1968 from the University of Washington with a Bachelor of Science in Fisheries Management, I began a career with the Washington Department of Game - fulfilling a goal that I dreamed about continuously after reading Roderick Haig-Brown's Return to the River when I was in the 7th grade. My first assignment as a college graduate was the then-new Cowlitz Trout Hatchery as a Fish and Game Technical Aide where I received one year's experience three times. The Fish and Game Technical Aide positions in the Department of Game were intended to serve as trial service training for future field biologists and hopefully attract a few future hatchery managers. It was then Department practice to station all new employees, especially hopeful biologists in a hatchery to allow the employee to gain valuable experience and to allow the Department a chance to look at the employee's potential during their probationary period. I didn't realize it at the time, but I was one of the last to participate in a program of this type.

Needless to say, I was excited about going to work at one of Washington's largest game fish production facilities complete with six brand new spacious residences, three sources of water, a complex water telemetry system, an automatic fish sorter/loader (that never did work while I was there); a seemingly endless number of hatching/rearing troughs, 24 large cement raceways, and 4 quarter-mile long rearing ponds - all complete with automatic feeders (another fact that no one mentioned was that each one had to be filled on a regular basis, using non-automatic labor).

There was even a biologist to oversee the detection of fish diseases using a modern $2500.00 microscope.

The chief of the Fisheries Management Division at that time must have detected a hidden talent that had escaped my attention, for after 2½ years as a Fish and Game Technical Aide, I was unceremoniously demoted to the position of Hatchery Assistant. At this point, I gave up all hopes of ever becoming a fishery biologist and began envisioning thoughts of being doomed for the next 27½ years as a fish culturist.

Miracles do happen however, and the following 10 years were spent in eastern Washington as an Area, then Regional Fisheries Biologist. These 13 years spent working with fish culture and management formed the knowledge base that I constantly use today as an administrator in one of the Department's six administrative regions.

The majority of you are likely aware of the heritage associated with fish culture. If you are not, you should take the time to research the literature for two very important reasons. The first being to learn of others' mistakes so you can avoid making the same ones. The second reason is the pride of recognition and identity associated with a profession that possibly dates back as far as ancient China.

Some of the earliest recorded efforts at experimenting with artificial trout propagation are often attributed to the French during the 14th century. Further improvements were made by the Germans and again the French in 1763 and 1842, respectively. It is interesting to note that in the early stages of fish culture, private facilities made most of the advances - a trend not too much different than today, especially when considering economic efficiency.

The need for fish culture in the United States became evident early in the nation's history. The 1700's saw runs of fish such as striped bass, sturgeon and Atlantic salmon depleted through the mass removal of trees, clearing of land for agriculture, and even then, the construction of dams. Unrestricted use of fish traps and the nearly total lack of conservation laws placed further stress on wild stocks. The increased demand for fish in addition to declining resources created, in all likelihood, the beginning of fish culture in this country.

Doctors Theo. Garlick and H.A. Ackley were among the first to experiment with artificial production of brook trout in 1853. Seth Green, another pioneer American fish culturist, is normally credited with starting the first large scale trout breeding program with emphasis on the sale of eggs (about $8.00/thousand). He also taught classes of fish culture to others for $10.00/day and sold trout for table fare at $1.00/lb. when the daily wage

was $1.00/day! Much of the early activities in fish culture were performed by the wealthy, strictly as a hobby. The states generally preceded the federal government in fish cultural progress and organization, the latter not being formally organized until 1871. To demonstrate this, in 1870, 19 of 37 states were involved with fish culture of one type or another. As more and more individuals became active in fish culture, wide variances in the price of eggs became apparent with the overall impact of declining profits. In order to protect their interests, in 1871 a meeting of all fish culturists of the period was called to exchange information and hopefully stabilize prices. It soon became obvious there was need for a more formal organization. This realization created the catalyst that resulted in the formation of the American Fish Culturists Association, which held its first meeting in 1872.

The past 114 years has resulted in considerable changes regarding the practice and production of fish culture. From the early days of a few hatcheries producing a few thousand pounds of salmonids, the present non-private production in Washington State, depending on the manner used to compute, equals approximately 13 million lbs., with sports and commercial returns exceeding some 35 million lbs. and worth in excess of $123 million dollars per year.

Interesting enough, many of the problems facing culturists of the past also face the culturists of today. As an administrator, I and others like me see fish culture in a different light than possibly you do. Fish hatcheries, unfortunately, are expensive facilities to operate, whether they be operated by private, tribal, state, or federal managers. During times of economic slowdown, even the most efficient of operations can be subjected to the microtome edge of the budget axe. And unless conditions improve, you can expect further reductions in operating funds, personnel, equipment, and materials. Yet, you will be asked to produce the same or even more - I can guarantee you that only the fittest will survive. Many of you have already experienced the aforementioned - once or maybe a number of times and you might be saying to youself, "What else is new?" Nevertheless, this is reality. It's actually not much different than the events and circumstances that have historically occurred during the past 100 years - except the old luxury of trimming "fat" is now the painful cutting of essential muscle.

Fortunately, fish culturists are some of the most innovative, hard working, and frugal individuals in modern day society and there are a number of things, speaking from an administrative viewpoint, that you can do to meet the challenges of today and tomorrow. If you doubt it, just look at what's been done and the changes you've already affected. Powerful international fisheries treaties have been negotiated, complex and emotional allocations of fish between tribal and non-Indian entities have been established, dam construction and operations have been substantially modified, major project developments have been impacted,

water quality standards have been improved, high tech knowledge through expanded use of computers is becoming a fact, the hiring of trained pathologists specializing in the detection and treatment of complex diseases, constant improvement in the area of diets, the addition of previously unproductive waters, and more production per given volume of water are just a few of the advances worthy of mention.

As technically sound as you are becoming, there are other facets of modern day fish culture that you will have to realize and accept. While it is highly unlikely that administrators will immediately find less expensive means to replace costly labor, you must assume the worst and work even harder to make it more difficult for folks like myself to further reduce the ranks and production of your profession. You need administrators to survive and we need you to further refine management techniques. Don't allow yourselves to become so involved in specialization of certain aspects of fish culture that you can't see or comment intelligently on the needs of modern day people and wildlife management. Administrators don't hope that you'll get involved in today's management complexities, they expect you to get involved! If this upsets you or even scares you, it should!

Learn as much as you can, beyond the immediate needs of fish culture, about problems and potential solutions that affect wildlife as a whole, such as socio-political issues, mechanisms to increase funding, habitat loss, animal behavior, legislative processes and new areas of research. Don't become discouraged with the publics that visit your installations and seem bewildered with the mystique surrounded by fish culture and management. They need your help too and you need them to understand. Don't be afraid to ask for administrative assistance, but do it in a manner with supportive justification.

If you'll assume this type of an approach and attitude, I can assure you that administrators will be among your strongest allies and supporters.

With this, I commend you all for the achievements and advances made to date and encourage each of you to take full advantage of this opportunity in having a successful and meaningful 35th annual Northwest Fish Culture Conference.

DEMAND FEEDER USE ON A LARGE STEELHEAD REARING POND

by

Jack Tipping, Roy Rathvon, and Steve Moore

Washington Department of Game

Introduction

Based on the positive results of demand feeders found at Dworshak and elsewhere, similar Babington feeders were installed at the Cowlitz trout hatchery in a series of raceways and one rearing pond. Cowlitz has four five-acre rearing ponds from which the bulk of hatchery production is obtained. Pond dimensions are about 160 feet wide by 1450 feet long. Flow is about 8 cfs in each.

Severe feed conversion problems ranging up to 173:1 and averaging about 3:1 have been encountered on the ponds in previous years. Conversion problems arise because fry are planted in each pond at the beginning of the rearing term and cannot be enumerated until planted out. During the rearing term Ceratomyxa shasta, predators, and occasionally IHN virus take an unknown and unseen mortality. Consequently, the technique of blowing in a calculated amount of feed can be a source of error.

Demand feeders offer a potential solution to overfeeding by allowing the fish to feed themselves. Since little information on demand feeder use on large rearing ponds was available for salmonids, an experiment was conducted to examine their performance.

Methods

Winter steelhead fry were acclimated to demand feeders in raceways at about 100/lb and were then transferred to one five-acre pond at about 40/lb in July and August. Eight docks were built, each extending about 30 feet from shore and staggered around the lake. Distance between feeders was about 350 feet on the same shore and about 210 feet across the lake. One 125 pound feeder was placed on each dock.

A second pond was fed as in previous years with OMP and was used as a control. Each pond had 350,000 fry planted. Also, each pond had an

electric fence installed to ward off herons. This was modified in the demand feeder pond to keep ducks from utilizing the feeders.

At the end of the rearing period, fish were enumerated by weight and smolts were sampled for length, weight, and condition factors. A criteria of 18.0 cm was used for a smolt.

Results

Results indicated total survival of fish in the demand feeder pond was comparable to the control (Table 1). However, number of smolts produced per hundred fry planted was improved over the control as was the smolt to subsmolt ratio. So, even though total survival was similar, a greater percent of fish reached minimum smolt size in the demand feeder pond.

Table 1. Total survival and smolts per hundred fry planted.

Lake	Total Surv.(%)	Smolts/HFP	Smolt:Subsmolt
Control	66.3	54.7	4.8:1
Demand feeder	67.2	61.2	10.2:1

Mean length of smolts was about one cm longer in the demand feeder pond while condition factor was only slightly greater (Table 2). Most notable was the improved conversion factor; 1.84 versus 2.28. A greater difference in conversion may have been observed except the demand feeders were used somewhat as a barometer for feed on the control pond.

Table 2. Length, weight and conversion.

Lake	$\bar{X}$ L	$\bar{X}$ WT	K	Conver
Control	20.5cm	81.2g	.94	2.28:1
Demand feeder	21.4cm	94.1g	.96	1.84:1

Demand feeder use appeared to be somewhat tuned to water temperature and climatic conditions, although in the spring the fish did not wait for the temperatures to go up (Figure 1). Some seasonal changes in location of feeders utilized was observed.

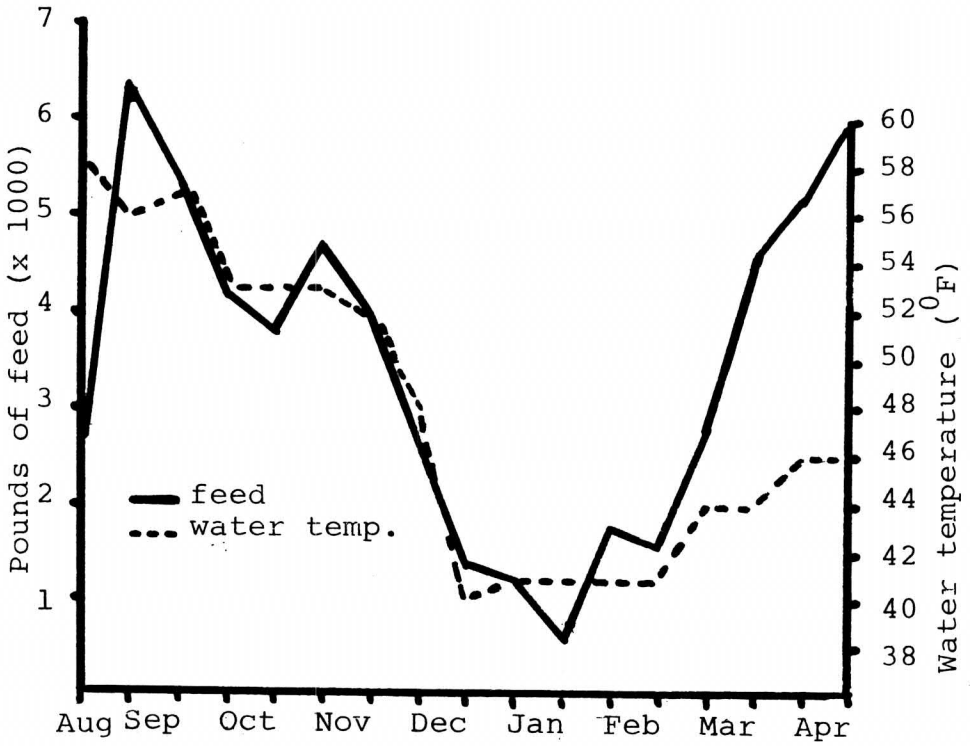

Figure 1. Pounds of feed and water temperature.

Cost analysis to gain 30,000 pounds of fish in a pond showed demand feeders could cut costs by about fifty percent (Table 3). The combination of improved conversion and reduced feed costs for dry feed versus OMP could lower feed costs by about $13,000 per pond. Additionally, man power and capitol costs requirements are reduced.

Table 3. Feed costs to grow 30,000 pounds of fish (10,000 in 40,000 out).

Control	30,000 lbs. x 2.28 conv x $.3900/lb. feed = $26,676
Demand feeder	30,000 lbs. x 1.84 conv x $.2425/lb. feed = $13,386

Discussion

The positive results we found in using demand feeders for a large steelhead rearing pond certainly falls in line with results of others for raceways. For the present rearing season we have installed demand feeders on the remaining three ponds. With the combination of improved conversion and reduced feed costs of dry versus OMP, we should be able to save about $50,000 - $60,000 per year while producing similar quality smolts.

LOW-FLOW ISOLATION SYSTEM FOR SALMONID EGG INCUBATION

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INTRODUCTION

The progressive increase in national and international salmonid aquaculture has resulted in increasing geographical transfers of stocks and species beyond watersheds. This has led to more stringent requirements of health certifications to reduce the risks of spreading fish diseases. Most of the major shipments of fish take place during the "eyed egg" stage. The fish are the least sensitive to handling and environmental changes at this stage of development, can be packed and shipped in high densities per unit volume, and require almost no water exchange. However, certification of parent stocks takes time, and the eggs must be incubated between fertilization and shipping at the "eyed" stage with minimal handling to prevent losses due to mechanical shock during the sensitive stages. Most salmonid egg incubation systems use one point source of water to incubate the eggs from many females. A few hatcheries are using modified production systems to incubate the eggs from individual female salmonids here in the northwest, but the flow rates are approximately 1.5 gpm (5.7 lpm) per female, and in most hatcheries, this would limit the number of females that could be used for such purposes.

Our CZES Division has been culturing Atlantic salmon (Salmo salar) from the eggs of pure Northeast Atlantic stocks, with the intent of shipping "eyed" eggs back to the Northeast states from the adult progeny raised here in sea-cages as a means of rapidly increasing supplies of their own genetic stocks. However, each spawned male and female raised here in sea-cages in the Puget Sound area would have be certified free of certain specific diseases. This would require an isolation system, but because there could be as many as 400 5-year old brood females of one stock alone, we were forced to develop a low-flow isolation system in order to conserve water.

We thoroughly examined the literature, and decided that the most economical and oxygen transport efficient system would use down-flow or down-welling water. Further, we decided that we had to test systems in which the eggs were always submerged in water, which we call "flow-through" systems, and systems in which the eggs were not submerged in water, but always kept moist. We call these "moist" systems.

The first tests began 12 March, 1984, with the objective to determine if moist incubation of steelhead eggs could produce eyed eggs with high survival under low-flow conditions.

MATERIALS

1. Standard 12"x12" perforated styrofoam egg shipping trays were used as "incubators".

2. Eggs were from Tokul Creek winter steelhead (supplied by the Washington State Department of Game-WDG).
3. Incubation water was dechlorinated, ambient temperature Seattle City water supplied by a vinyl garden "soaker" hose.
4. Two trays were tested; 1 egg layer deep, and 2 egg layers deep.
5. Several layers of industrial tissues were placed below and above the eggs to spread and hold water, and prevent agitation from the spray.

RESULTS

The water flow averaged 0.330 lpm at 50 psi. The water temperature was 7.8 C. in the top tray (used to distribute the water), and 7.8 C. in the lower (incubation) tray. Room temperature during the test was 16.5 C. The eggs eyed on 25 March after 104-110 incubation units (13 days @ 8.0 C.). Rainbow trout were also tested for a comparative species study(Figure 1).

Table 1. Results of the first test of Low-Flow/Down-Flow egg incubation systems. Corrections are incorporated in the data for "blank" eggs (% fertile), and survival to the "eyed" stage (% survival). Controls were incubated in a standard "Heath" incubator (control-%) to the eyed stage. One tray contained rainbow trout eggs (RBTRT); the second tray held a single layer of steelhead trout eggs (STHD1), and the third held two layers deep of steelhead trout eggs (STHD2).

	Rainbow Trout	Steelhead	
		(1 layer)	(2 layers)
Initial Fertilization rate	83.3%	87.3%	88.5%
Initial egg number	3337	1641	3392
Mortality to eyeing	1014	324	784
Final egg number	2323	1317	2608
Final egg survival	69.6%	80.3%	76.9%
Controls (heath incubator)	74.8%	82.3%	

Final egg survival (%) is real, and not corrected for "blank" eggs.

CONCLUSIONS

This system works well for eyeing eggs with minimal equipment or maintenance. Egg loss beyond the initial "blanks" was due primarily to shock caused by water droplets hitting the relatively unprotected eggs. There is a 2" drop from the top tray to the egg layers. Some "cushion" is needed that will still spread the water, but absorb shock.

FINAL (SECOND) EXPERIMENTAL TESTS

The second tests began on 14 May, 1984 with water-hardened cutthroat trout eggs from the WDG Chelan hatchery and transported to the NMFS/NWAFC in chilled water. Approximately 30,000 well mixed eggs were used for the laboratory tests. Between 1900 and 3000 eggs were used for each test chamber. In these tests, the individual chambers were supplied with water via a commercially available water "misting" system typically used in greenhouses and nurseries. These low-flow plastic piping systems are inexpensive and require no more tools for assembly than a pair of pliers, a screwddriver, and a pocket knife. The systems tested were as follows:

MOIST TUBS:

A 2 gallon (7.6 L) tapered polyethylene bucket served as the container.The eggs were sandwiched between layers of foam, and were 4 to 5 layers deep. The tub walls were lined with foam. Water drained directly out through a hole at the bottom. Incoming water sprayed or dripped onto the top layer of foam. Three tubs were tested with the following flow rates: 48 mls/min; 135 mls/min; and, 150 mls/min.

FLOW-THROUGH TUBS:

The same type of tub was used, but with an additional outer tub for each unit to serve as a reservoir. The inner tub had most of the bottom replaced with plastic screen. The outer tub was perforated with large holes about 3/4 of the way up. A screen covered the top, and a foam pad rested on the screen. Water flowed onto the pad, saturated it, and dripped into the tub. Water flowed down through the eggs, out the screened bottom of the inner tub, and up through the discharge of the outer tub. The dripping foam pad prevents currents from being set up that could disturb the eggs. The flow rates tested were:285 mls/min; 588 mls/min; and, 1200 mls/min.

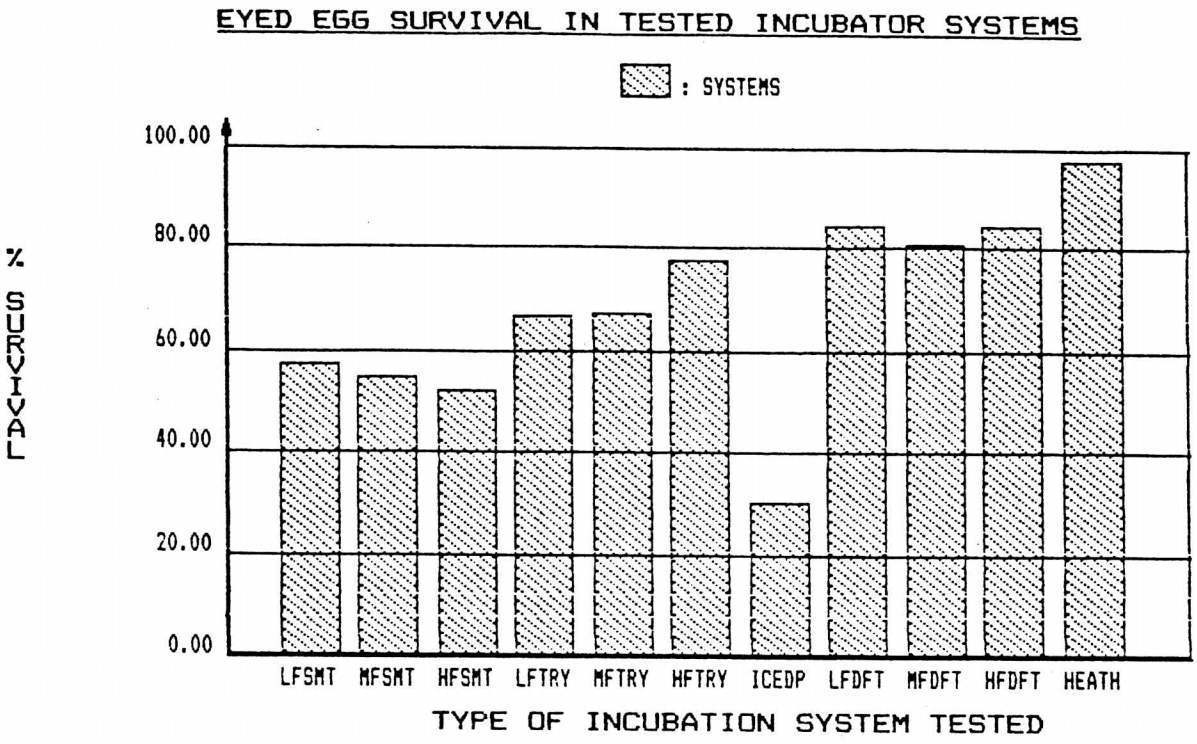
MOIST TRAYS:

Standard perforated styrofoam egg-shipping trays were set up in a styrofoam box. A layer of foam was placed on the bottom of each tray (saturated), the eggs were spread over the foam, and a second saturated foam sheet was placed over the eggs. The "mist" tubing was arranged in a loop around the top layer of foam, pierced with a dissecting needle, and the water was directed to the various corners of the trays as best as possible. The object was to keep the pads saturated. Ice was packed each morning in the empty spaces between the trays to keep the water temperatures down as much as possible. Generally, about 8/10 of the ice had to be replaced each morning. The flow rates were: 45 mls/min; 100 mls/min; and, 135 mls/min.

ICE DRIP-TRAY:

A standard perforated styrofoam egg-shipping tray was set up with two saturated sheet foam layers, with the eggs sandwiched in between. A 2" wall sheet foam box was built on top of a second perforated tray. The inside dimensions of the box were 60x23x23 cm., which is 31.7 liters of ice. Melting ice dripped through the perforated tray and saturated the foam layer below. This prevented the weight of any ice from directly contacting the eggs.

No treatments for fungus were provided at any time during the tests. Water temperatures varied from 1.5 to 14 C., depending on the system. As the eggs eyed out, they were shocked and counted.The results are shown in Table 2 and Figure 2.



LEGEND

LFSMT - LOW-FLOW, SEMI-MOIST TUB AT 0.048 LP/M
MFSMT - MEDIUM-FLOW, SEMI-MOIST TUB:0.135 LP/M
HFSMT - HIGHEST-FLOW SEMI-MOIST TUB:0.150 LP/M

LFTRY - LOW-FLOW, SEMI-MOIST TRAY: 0.045 LP/M
MFTRY - MEDIUM-FLOW, SEMI-MOIST TRAY: 0.100 LP/M
HFTRY - HIGHEST-FLOW, SEMI-MOIST TRAY: 0.135 LP/M

ICEDP - ICE-DRIP TRAY; EXTREMELY LOW FLOWS AND TEMP.

LFDFT -LOW-FLOW,DOWN-FLOW,FLOW-TROUGH TUB:0.285 LP/M
MFDFT -MED.-FLOW,DOWN-FLOW,FLOW-TROUGH TUB:0.588 LP/M
HFDFT -HIGH-FLOW,DOWN-FLOW,FLOW-TROUGH TUB:1.200 LP/M

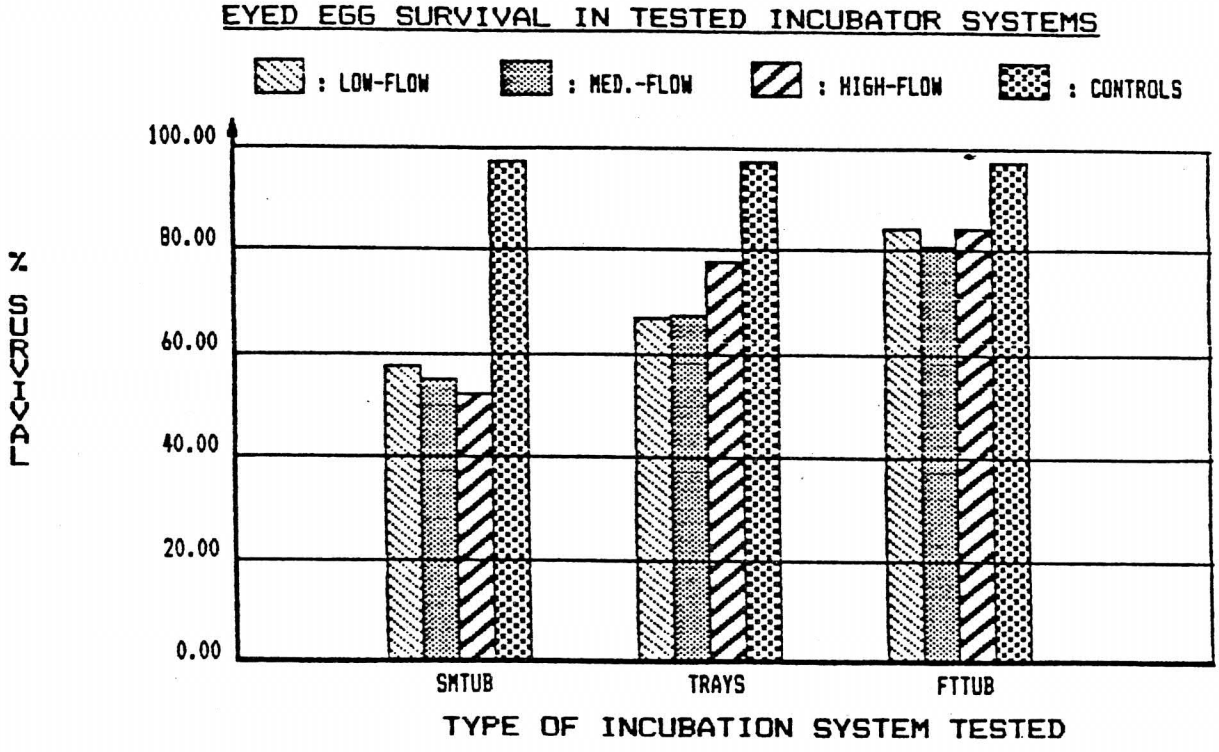
HEATH - CONTROL: LOW-TEMPERATURE FLOW THROUGH HEATH INCUBATOR

Figure 2. **LOW-FLOW EGG INCUBATION**
2ND TESTS: RESULTS OF VARIOUS DOWN-FLOW SYSTEMS TESTS USING CUTTHROAT TROUT EGGS

Table 2. SURVIVAL TO LATE-EYED STAGE FOR VARIOUS INCUBATION SYSTEMS

System	Flow-rate	Survival (%)
Low-flow, semi-moist tub	48 mls/min	57.1%
Medium-flow, semi-moist tub	135 mls/min	54.6%
Medium-flow, semi-moist tub	150 mls/min	52.1%
Low-flow, semi-moist tray	45 mls/min	66.8%
Medium flow, semi-moist tray	100 mls/min	67.0%
High flow, semi-moist tray	135 mls/min	77.5%
Ice-tray	drip	∿ 30%
Low-flow, down-flow, flow-through tub	285 mls/min	84.2%
Medium-flow, down-flow, flow-through tub	588 mls/min	80.9%
High-flow, down-flow, flow-through tub	1200 mls/min	84.2%
Control: Low-temperature flow through Heath incubator		97.3%

A better perspective of the results can be seen by examining the data grouped by types of systems (Figure 3).



LEGEND

SMTUB - SEMI-MOIST TUBS TRAYS - SEMI-MOIST TRAYS FTTUB - FLOW-TROUGH TUBS

NOTE:
THE CONTROLS ARE A SINGLE LOW-TEMPERATURE HEATH INCUBATOR TRAY - STANDARD FLOW.

Figure 3. LOW-FLOW EGG INCUBATION
2ND TESTS: RESULTS OF VARIOUS DOWN-FLOW SYSTEMS TESTS USING CUTTHROAT TROUT EGGS

There was a tendency for the eggs in the moist chambers to have much softer shells than those that were in flow-through tubs. On the basis of these tests, a production system was installed at the NMFS/NWAFC using flow-through nested tubs and a misting spray system to provide down-welling water for each unit. Materials costs for a production system that will incubate the eggs from 400 individual females in 7 insulated water tables with a total flow of 40 GPM(152 LPM) was less than $2500. Survival data for the Atlantic salmon should be ready by the time of this meeting. We are applying for a public patent for the down-welling system that is now being used for this production program.

PRODUCTION SPAWNING OF ATLANTIC SALMON IN A LOW-FLOW ISOLATION SYSTEM

5 year old adult Penobscot River Atlantic salmon from the 1979 brood year were brought from the sea water pens at Manchester to the NMFS fresh water hatchery in Seattle in late October. All of the females and about 1/2 of the males were from each lot were injected twice with LHRH with about 4 days between injections to stimulate final maturation. The fish were killed and bled. The females were stripped into sterile 1.5 liter poly-pails. Sperm was collected from individual males in sterile poly-cups. The eggs and sperm were identified by number, and brought into a room just off the isolation incubation area for fertilization. The numbered carcasses were tissue sampled for certification tests.

The fertilized eggs were then placed in the numbered production units. Each unit is comprised of two 2-gallon poly-buckets. The inner bucket has the bottom cut out and replaced with a "Vexar" screen cemented with non-toxic silicone sealer. The outer bucket has 4 large holes drilled through just above the lower rib. When nested, water flows through a 6 gallon/hour spray head (380 ml/min.) down through the inner bucket, rises up the inside of the outer bucket, and spills out through the holes. The bucket will hold 6 liters of water with this configuration. A small diameter hole is drilled through the ribs of both buckets when they are nested, a metal rod is bent to shape and inserted, and the spray head slips on the end of the rod with a simple molded socket. The spray heads cost about $.60/each, and the buckets $.98/each locally (in the Seattle area). The buckets are packed side by side into plywood water tables insulated with sheet styrofoam. The water table can be drained from the bottom or the side, and you can adjust the levels in the tables depending on the strength of the table construction and a level which might start the buckets "floating". A slight water level might have some temperature "buffering" effect.

The plumbing is a combination of PVC to the water tables followed by simple connections to the 1/2" poly lines. The main thing to remember on the commercial "misting" systems is that the 1/2" poly line is designed to provide 240 gallons/hour at 55 PSI. This is equivalent to 40 buckets with 6 GPH spray heads each. Our water tables hold 50 or 60 units per table, so we simply split the line with a "tee" right when we come through the box. We run along both side of the box from each side of the "tee", and have no problems servicing 60 units.

There is a gentle surface agitation of the water by the spray, but this can only be felt for about 1" below the surface. Each box has a simple plastic garden-hose shut-off valve on the outside. We currently have 210 units filled, some from females that produced about 1500 mls of eggs. We are also filling some of the spare units with eggs from returning Pacific salmon. The costs of the "misting" system itself was about $650.

The D.O. level has been about 9.5 PPM at 10 oC.

We have been treating for fungus daily with the "California flush " method with a repeating dispensor. It takes about 15-20 minutes for the buckets to clear.

MARKING TABLES

Karl M. Muller

Washington Department of Game
South Tacoma Hatchery

Last summer we were required to clip fins from most of the steelhead leaving South Tacoma hatchery. These fish ranged in size from 264 per pound to 100 per pound. During the month of June we had a crew of six and seven people hired to do most of the marking.

We had one small marking table and we borrowed a larger one from Puyallup hatchery. Both tables were really spawning tables as they were about 30 inches wide and were hung with netting. The netting caused the fish to dry out very rapidly in the June sun. Because the tables were so wide, each fish had to be thrown across the table into the pond. This caused much complaining of sore arms among the fish marking crew as they were averaging 5500 fish per person per day.

My wife was a member of the crew, therefore each evening I would hear how the tables could be improved. I put all of the input together and built two tables that function much better.

The fish are no longer thrown, but are just dropped into the gutter and washed into the pond. I used burlap to cover the tables because it holds the moisture much better and is less expensive to purchase. The fin clippers can be rinsed in the gutter to remove the cut fins that cling to them. With the gutter in the center of the table, people can work from both sides, consequently, only half the number of tables are needed.

With an attachment on the end of the gutter, aluminum pipe can carry the fish as far as one desires.

The cost of the lumber:	$ 15.00
Four inch sewer pipe:	4.20
Burlap:	7.16
The total cost of one table	$ 26.36

Some of the lumber was scrap, and the hose fittings were salvaged from scrap garden hoses.

BOOT DRIER

Karl M. Muller

Washington Department of Game
South Tacoma Hatchery

Each morning after arriving at South Tacoma hatchery, I would hear the same thing from someone in the crew, "My boots leak." After close examination of the boots, I found that the perspiration from the day before did not dry overnight. After some thought on this I built a boot drier.

Now all boots are dry each morning and the drier is an excellent place to store extra pairs of boots. The boots are no longer scattered all over the breakroom.

If a boot is really leaking, it is noticed usually in the first few minutes the dry boot is worn. No one in the crew was able to put a patch on a boot that would stay over twenty minutes. Therefore it required some training, but now everyone can patch their own boots. Everyone has dry feet most of the time and I have a much happier crew.

The drier has no heater, but uses room temperature. It can dry a completely soaked boot in four hours.

One addition that would improve the drier is a 12 hour time switch, to replace the reastat.

Lumber and PVC pipe used was from a previous construction project.

Pipe Strap at 25¢ each:	$ 2.00
PVC pipe caps at 69¢ each:	5.52
Squirrel cage fan:	32.00
Reastat:	13.65
Total cost of Boot Drier:	$ 53.17

THE USE OF STROBE LIGHTS AT GNAT CREEK HATCHERY TO CONTROL BLUE HERONS

Dell M. Warren

Oregon Department of Fish and Wildlife

After reading an article in American Fisheries by Dan Barrett we decided to try the "Barret Blinkers" mentioned therein. A Rota Beam RB-120 AC was purchased from Sanderson Safety Supply, with mounting kit extra.

For added shock effect, a strobe light called Fire Bolt Light from the Mallory Company of Longview, Washington was added to the system. Various colors of lenses are used with the strobe light to vary the effect.

Knowing herons become accustomed to nearly anything, even carbide cannons, we had the electrician install a repeat cycle timer, adjustable from 1.8 seconds to 180 seconds to allow us to change both how long the time between cycles and the length of time the lights stay on.

We believe that the lights scare off the herons before they have time to leave their calling card. No droppings have been seen for a long time.

Bonneville Hatchery is using strobe lights with a different approach. They use them to blind the birds rather than scare them away. An airport strobe called Strobe Light SADF - 14 was purchased from Troutdale Airport. They use three lights placed in a triangle to saturate the area from all angles with blinding light.

The Use of the Weinberg Signal Pistol as a Scare Method for Predator Bird Control at Cowlitz Salmon Hatchery

Michael Baxter
Washington Department of Fisheries

Because of movable cranes and divers cleaning ponds, overhead bird netting or pond surface netting are not practical at the Cowlitz Salmon hatchery. Due to high public use of the facility, and Federal regulation, the shotgun/cracker shell method is not used.

Crows, various types of gulls and herons have well-established feeding habits. Crows are somewhat beneficial as they eat feed that sometimes lands on walkways. Also, it has been observed that in a given season, certain gulls reside on the ponds.

The signal gun uses .22 caliber blanks to launch noise rockets. Three different types of rockets have been made available to the Cowlitz Salmon hatchery: whistles, rockets and bombs. The gun is very compact and easy to handle. It can be carried in a coat pocket while still doing work. This makes it more convenient than a shotgun for harassing birds at opportune times.

The red whistle makes a soft, whistling sound and has lots of smoke with a 5-second duration and a firing range of approximately 75 to 100 feet. The green rocket makes a loud shrieking sound with smoke, a 2-second duration, and a firing range of approximately 100 to 150 feet. The bombs, which are no longer available, are like cracker shells, and have a firing range of approximately 100 yards. These bombs explode with a loud boom. The red whistles scare herons and crows, but seem to have little effect on gulls. The green rockets work well to harass all types of birds. A rocket/bomb combination is also very effective. The signal gun seems to work best when used after long, irregular intervals.

Though the signal gun does not completely control predators, it has eliminated much predation at Cowlitz without harming predators.

DISPLACEMENT FISH COUNTING AT THE SKYKOMISH STEELHEAD REARING PONDS

Loren Dingwall

Skykomish Rearing Ponds
Washington Department of Game

In August of 1973, the first load of fish was received at the newest Washington State Game Department steelhead rearing ponds. The Skykomish Steelhead Rearing Ponds are located in the foothills of the Cascade Mountains, about 5 miles east of Goldbar, Washington.

There are two 2.2 acre dirt ponds. Each pond is 1,250 feet long and 90 to 110 feet wide. The pond depth is 4 feet at the head end and 11 feet at the outlet. The ponds were designed to each produce from 50,000 to 75,000 pounds of fish.

Surface water from Austin and Hogerty creeks is used. Each pond receives 3 to 7 CFS of water. Temperatures range from January's 38 degrees to 60 degrees in August, with an occasional dip to 32+ degrees during cold spells.

The theme behind the construction plan was for the rearing ponds to be operated by one person most of the time.

One of the unique features is a device that counts fish by displacement. The device has four parts. The cement displacement tank is 11 feet 4 inches long, 18 inches wide and 5 feet deep. The displacement tank was constructed with a 4 inch sloping bottom that was supposed to slide the fish out. Aluminum tubes were added to increase the slope to 10 inches. An 8 inch slide valve is used to release the fish into the outlet stream.

A 4 inch pipe is connected to the bottom of the displacement tank. It is used to measure the amount of displacement. A float with attached rod comes up through the top of the measuring tube. A sliding scale is attached to the measuring rod.

The dewatering table is constructed of aluminum tubes that allow the water to fall through and slide the "dried" fish into the displacement tank.

The holding raceways are constructed with a sloping cement dam at the end that maintains a water depth of 16 inches. The upstream slope allows the fish to be safely pushed over the edge with a crowder.

Before operating the device, the fish must be sampled for size per pound. The displacement tank is partially filled with water. The measuring rod is marked with a sliding scale at the top of the measuring tube. The rack at the end of the holding raceway is removed and the fish are crowded over onto the dewatering table. The fish slide over the tubes and into the displacement tank. The person that is crowding the fish is able to watch the measuring rod and can easily estimate when enough fish have been moved over the edge. The holding rack is put back in place. The operator then gets out of the raceway and reads and records the amount of displacement. The end valve is opened and the fish are on their way to the river and migration.

The entire operation takes less than 4 minutes from the time that the displacement water tank water is shut off to the time the fish are released. 300 to 500 pounds of fish are handled each time the devices is used. No apparent stress or physical damage has been observed in any fish moved with this system. The hardest work for the operator is climbing out of the raceway to measure, record, and release the fish.

After three years of carefully weighing every load of fish that went through the displacement tank, I found that every 1/16th of an inch of displacement equals 5.27 pounds of fish. The fish I release are 7 to 11 inches long and are 4 to 9 per pound.

By multiplying the 1/16's times 5.27 you find the pounds of fish weighed. The pounds are then multiplied times the size per pound for the number of fish counted.

The system is easy on the fish and the operator. It is quick and accurate. It is also easily operated by one person.

PRODUCTION OF TRIPLOID CHINOOK SALMON *Oncorhynchus tshawytscha* USING FLOW-THROUGH HEAT SHOCK AND SUBSEQUENT, GRADUAL COOLING

J. M. Hill
A. Hickerson
D. L. Sheldon
K. A. Warren
Clatsop Economic Development Committee
Fisheries Project
Astoria, Oregon

ABSTRACT

Four groups of fertilized chinook salmon eggs were heat shocked for 10 minutes at 28.5°C using a vertical egg and fry incubation cabinet. Two groups were immediately transferred to cold water, and two were gradually cooled after the 10-minute heat period. Increased triploid levels and decreased mortality were observed in the groups of gradual cooling. Flow cytometry tests of 40 fish from the two groups of immediate transfer to cold water resulted in 57.5% triploidy, and of 32 tested from the two groups of gradual cooling, 100% were triploid. A substantial reduction in egg mortality was observed in the groups of slow cooling.

The results demonstrate that this technique may make it possible to study the value of triploids in salmon culture.

INTRODUCTION

This report describes a technique that may make it possible to study the value of triploids through production-scale releases. There has been considerable interest recently in the possible application of induced triploidy in salmon culture and management. Heat shock has been applied to many fish species for inducing triploidy and subsequent sterility (Thorgaard et al. 1981; Utter et al. 1983). Triploid trout appear to be sterile, (Allen and Stanley 1978; Thorgaard and Gall 1979) and sterile salmon have the potential for improved growth, longevity, and flesh quality in recreational and commercial fisheries. This study was begun to determine if standard flow-through, stack incubators (Heath-Tecna) could be used to successfully induce triploidy in chinook salmon through heat shock; to determine if mortality would be reduced, and to test the feasibility of mass heat shock.

METHODS AND MATERIALS

Gametes from chinook salmon (*O. tshawytscha*) were collected from spawning adults in Plympton Creek near Westport, Oregon on October 7, 1983. Eggs and sperm were kept separate and transported on ice up to two hours before fertilization. The eggs and sperm were mixed, and five groups consisting of 3,500 eggs each were placed in Heath incubator trays. Groups 1 and 3 were fertilized in 9°C water (source-water temperature) and groups 2 and 4 in 11°C water (Table 1). Ten minutes after fertilization, these groups were subjected to heat shock (Fig. 1).

The four groups were placed in a Heath stack that contained 28.5°C circulating water at 3 gpm flow. Immediately after the 10-minute heat treatment period, groups 1 and 2 were removed and placed back in the 9°C water. Groups 3 and 4 remained and were administered a gradual cooling by slowly reducing the 28.5°C

water flow and adding cold water (9°C), being careful not to agitate the eggs. Cooling time was 15 minutes.

On October 11, 1983 this process was duplicated with the source water at 8.5°C instead of 9°C (Table 1).

Mortality from both treatment dates was monitored through January 1983. The October 7 treatment was sacrificed prior to ploidy determination, and the October 11 treatment fish were reared through June, at which time blood samples were taken by severing the caudal fin of 20 fish from groups 1-3 and 12 from group 4. Ploidy was determined by analysis of red-blood-cell DNA content with flow cytometry (Thorgaard et al. 1982).

RESULTS

The mortality of the treatment groups is shown in Fig. 2. Heat-shock treatments with subsequent, slow cooling resulted in a decrease in mortality. Mortality after ponding was minimal and not recorded.

Ploidy was determined on the October 11 treatment groups only (Fig. 3). No triploid individuals were identified in the control group. Group 1 indicated 35% triploids; group 2, 80%; and groups 3 and 4 each resulted in 100% triploids.

DISCUSSION

The successful induction of triploidy, reduced mortality, and ability to mass heat-shock should make it possible to study the value of triploid salmonids through production-scale releases. The utilization of standard flow-through incubation with the ability to gradually cool after heat shock, suggests an approach for production-scale study.

The mortality of the heat-shocked groups appears to be quite high relative to the control groups. We attribute some of this mortality to handling during the process. The eggs may be extremely sensitive to disturbance at these high temperatures. In the groups of slow cooling the mortality was reduced, and these groups weren't handled until after total cool down to source-water temperature. This technique can be varied to minimize egg handling even further and will be implemented in further studies.

The high rate of triploid induction appears to be correlated to the gradual cooling, which in effect, also allows for a slightly longer time in the higher-temperature water.

The variable of major concern in shocking large numbers of eggs at once is water-temperature reduction when the cool eggs are placed in the warm water. Low-flow circulating water systems that are capable of providing constant-temperature water without being affected by the cool eggs, aid in ensuring a constant treatment temperature.

TABLE 1. Heat treatment process of October 7 and October 11 treatment groups

	Group #	10 min fertilization °C	10 min heat °C	Source water °C
10/07/83	Control	9	9	9
	1	9	28.5	9
	2	11	28.5	9
	3	9	28.5	Cool slowly *
	4	11	28.5	Cool slowly *
10/11/83	Control	8.5	8.5	8.5
	1	8.5	28.5	8.5
	2	11	28.5	8.5
	3	8.5	28.5	Cool slowly *
	4	11	28.5	Cool slowly *

* Approximate 15 minute cool down to source-water temperature

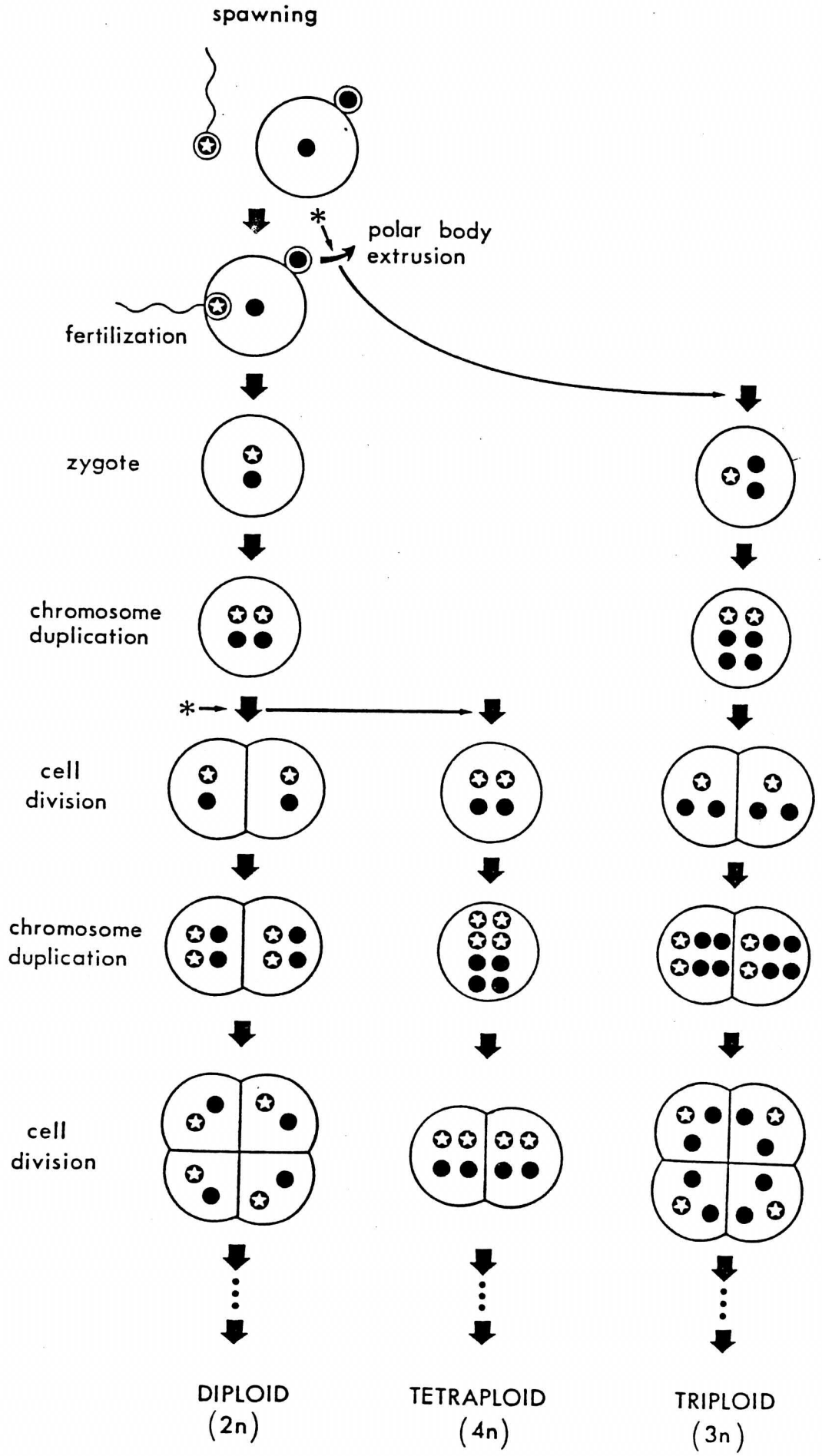


Fig. 1. Chromosomal manipulation in salmonids by heat shock
* denotes heat shock

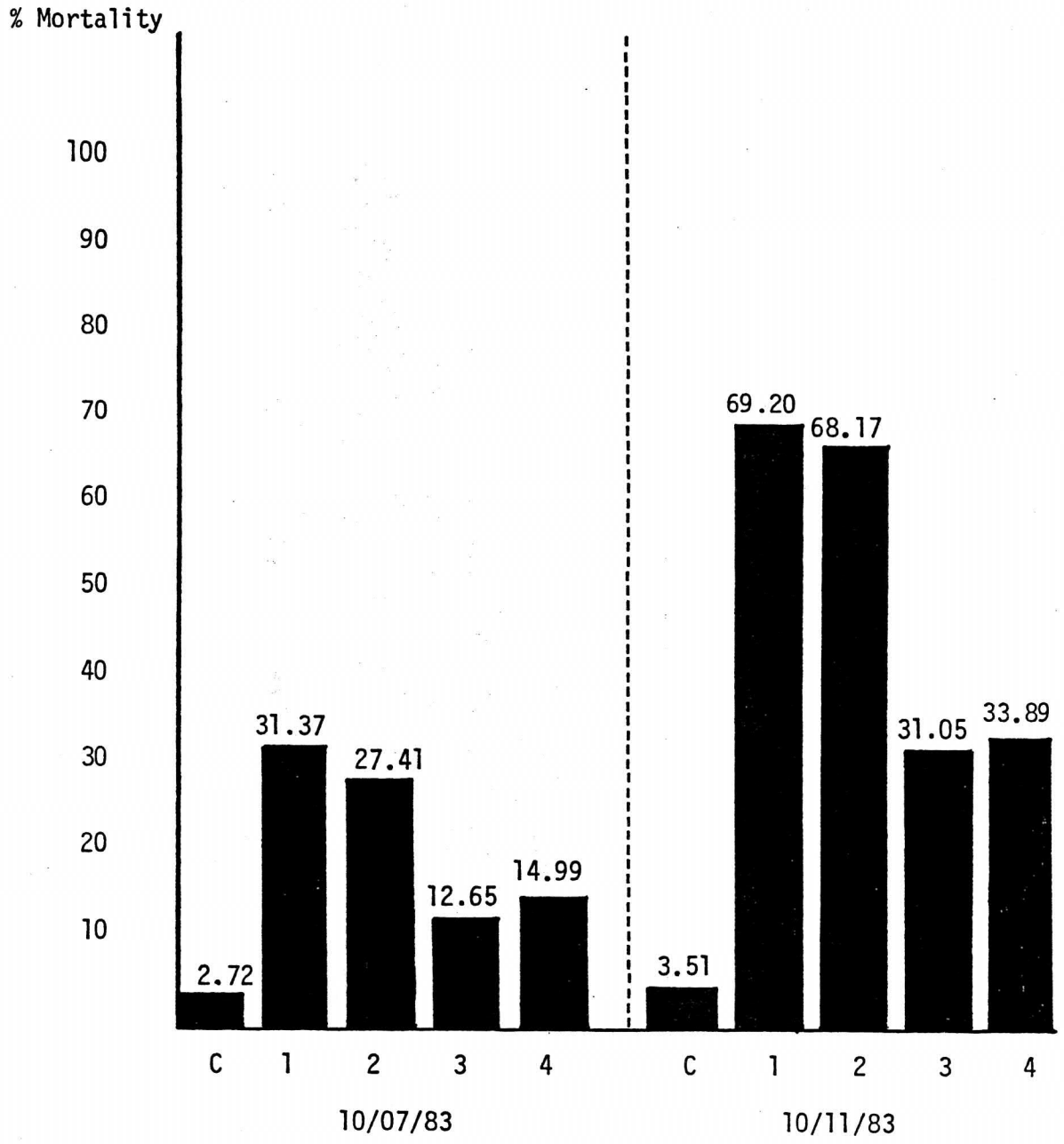


Fig. 2. Mortality of the October 7 and 11 heat treatment groups.

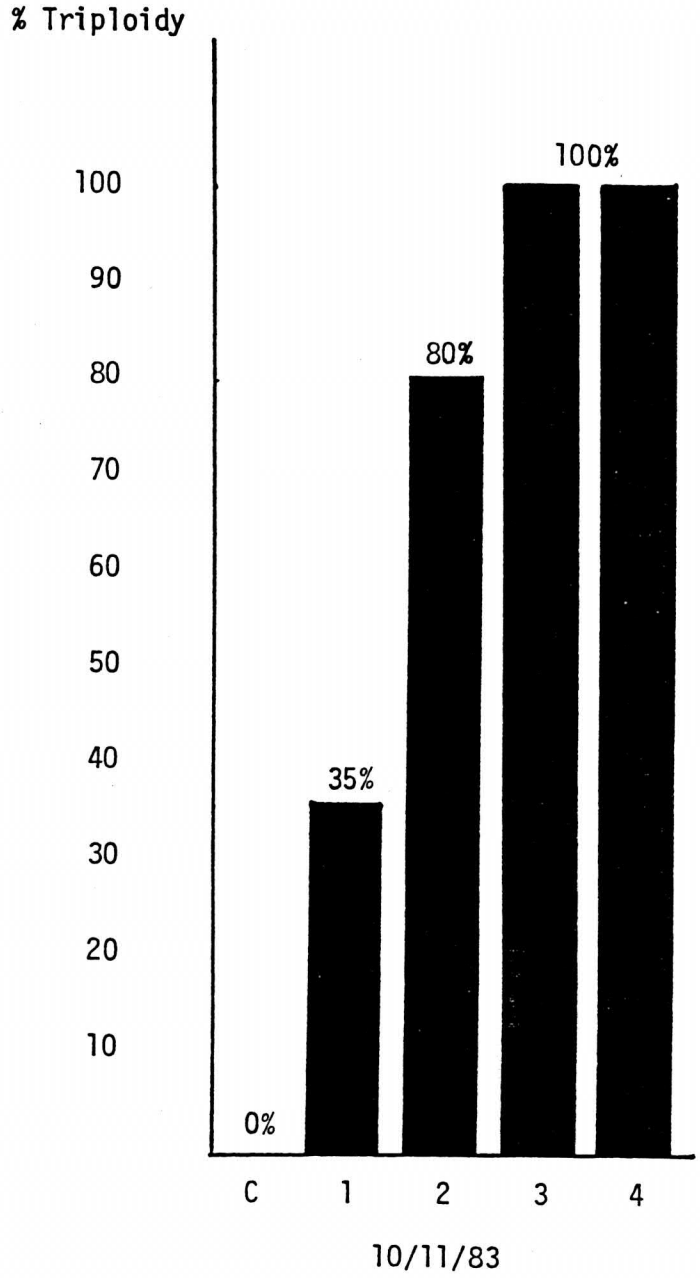


Fig. 3. % Triploidy of the October 11 treatment

ACKNOWLEDGEMENTS

We thank Orlay W. Johnson for transporting the blood samples and processing through the flow cytometer, Dr. Peter Rabinovitch and the University of Washington for expertise and flow cytometry use, Duncan K. Law for technical assistance, and Toni Dean for typing the manuscript.

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Twin Lakes Cutthroat Program: 70 Years of Sucess

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Twin Lakes are located in Chelan county in north central Washington on a tributary of the Wenatchee river. Although its unclear when these alpine lakes were first planted with cutthroat; by 1915 Washingtin Department of Fisheries and Game had established an egg taking and eyeing station and took 1.4 million eggs.

The Twin Lakes cutthroat probably orginated from Lake Chelan since a hatchery which collected cutthroat eggs was located on the Stehekin river a tributary of Lake Chelan. These fish are probably represntative of the Columbia Basin cutthroat. Behnke (1979) describes the fish as a westslope cutthroat (Salmo clarki lewsi).

Fish are trapped on two streams and the main channel between the two lakes in May and June following ice out. Eggs are spawned on site and in the early days were incubated to the eyed stage at Twin Lakes and then transported out by horse. Today, the eggs are fertilized and transported to the Chelan hatchery for incubation and distribution to other hatcheries.

Cutthroat are 3 to 6 years old at spawning with females producing 500 eggs per fish. Annual production is 1.0 million eggs. The majority of the eggs are reared to the fry stage at Washington Department of Game hatcheries and planted throughout the Cascade mountains in the high lakes. Late each summer 20,000 fry are planted back into Twin Lakes to provide for future broodstock.

Because of the sucess of the Twin Lakes cutthroat egg taking operation; millions of fish have been caught by satisfied anglers throughout the high country in Washington state.

Reference:

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Dropout Disease and Diet in Spring Chinook Salmon

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Eagle Creek National Fish Hatchery

Introduction

Dropout disease causes a 15-20% mortality loss in Spring Chinook Salmon (Oncorhynchus tshawytscha) at Eagle Creek National Fish Hatchery, Oregon. Wood (1968) first investigated this disease and observed that the fish stop feeding at about 400 fish/pound, become pinheaded, experience clubbing of the gills, and finally succumb.

Subsequent work at Eagle Creek NFH assumed that dropout disease was not genetically predetermined. These studies have eliminated most possible causes including: changes in flow velocity, changes in water temperature, the time of feed size changes, the length of the feed size transition period, and handling stress. Further work with different diets (BioDiet, OMP, Abernathy Dry, Silver Cup Salmon Feed, and Liver) produced results that pointed toward the possibility that dropout was a result of either a basic feed rejection or a nutritional problem.

The current study has been undertaken to determine the role of diet in dropout mortality. The objectives have been to recreate the dropout syndrome, to define and characterize the disease more clearly, to relate the incidence of the disease to diets with varying physical characteristics (OMP, BioDiet, Abernathy Dry), to determine if the disease can be controlled or reversed through dietary regimentation, and, finally, to demonstrate a cause of the problem.

Materials and Methods

Approximately 230,000 Willamette strain SCS eggs were incubated and hatched in Heath trays at temperatures ranging from 0-12° C. All of the eggs were obtained from Clackamas Hatchery, Oregon, except for those in Tank 1 which were Willamette strain SCS from Eagle Creek NFH. Initially, 23,000 SCS were reared in each of ten fiberglass tanks at an average water temperature of 8.9° C. Heated creek water was continuously recycled through a clinoptilolite biofilter system (Horsch and Holway, 1983) with 10-15% make-up water added daily.

The experimental procedure is shown in Figure 1. Initial feed levels were based on demand feeding in the BioDiet tanks. Quantities of feed fed to the OMP and Abernathy Dry tanks were equalized with the BioDiet tanks by using a moisture correction factor (Table 1).

Table 1. Percentage dry matter per diet and corresponding correction factors for feed level determinations.

Diet	Description	% Dry Matter	Correction Factor
1	BioDiet	79	1.00
2	OMP	71	1.11
3	Abernathy Dry	93	0.85

Later, when fish were on feed, ration levels were recalculated with hatchery constants (Holway, 1976), rather than by demand. Each size transition occurred over a seven day period where the larger food size was gradually introduced. Particle size determination was based on fish size (Table 2).

Table 2. Relationship between fish size and feed size.

Diet	Particle Size	Fish Size (#/lb)
Abernathy Dry and OMP	Starter Mash	1300-900
	1/32 Pellet	900-500
	3/64 Pellet	500-250
BioDiet	Starter #2	1300-900
	Starter #3	900-500
	Grower 1.0 mm	500-450
	Grower 1.3 mm	450-250
	Grower 1.5 mm	250-

All tanks remained on their initial diets until a number of dropout related symptoms were observed. These symptoms included: decreased growth, changes in feeding behavior, low gastro-intestinal tract content, poor gill condition, weakness, pinheading, and increased mortalities.

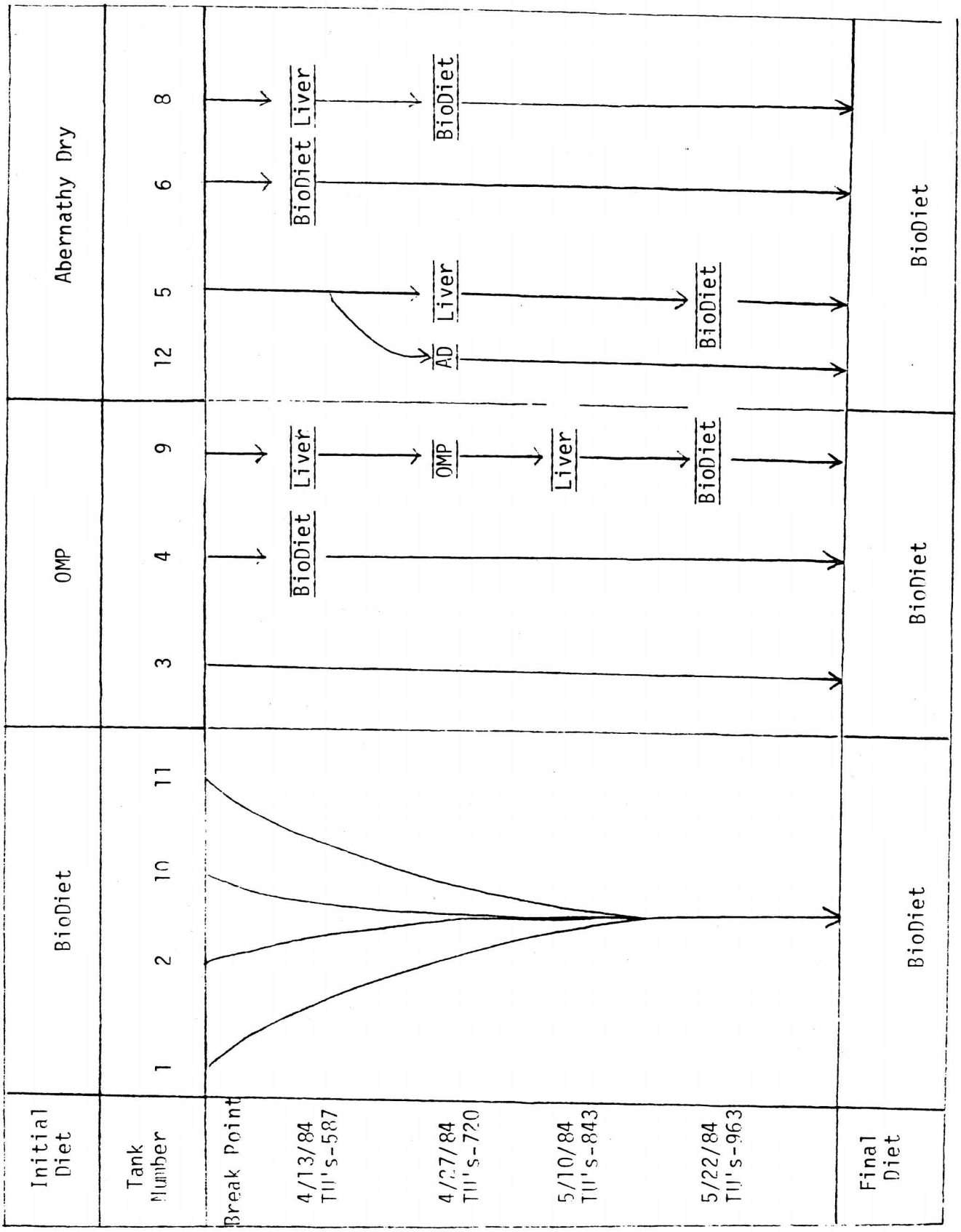

Figure 1. Experimental design including: initial diet per tank, dates of diet alterations (break point) and TU's. Note 1010 fish were isolated out of tank 5 (4/22/84) and maintained on Abernathy Dry.

Fish were crowded and quarter sampled bi-weekly in order to determine growth rates, condition factors, G.I. tract contents, and gill conditions. Routine production records were also maintained (Piper. 1982).

Results

Emaciated pinheaded fish began to appear in all tanks around mid-March at 250 TU's (celcius degree days). These fish appeared to be weak or lethargic and often had opaque white pectoral fins.

Aside from extreme emaciation, dropout symptoms may also include: gill clubbing, empty gastro-intestinal tracts, weakness, and poor growth. Also, all of the pinheaded-dropout fish fall in a length range between 37.0 mm and 49.0 mm, regardless of the diet fed.

Poor gill condition and low gut content are considered to be symptomatic of dropout disease, but only about 50% of the pinheaded-dropout fish exhibited both of these symptoms. In addition, only 14% of the BioDiet dropouts, 27% of the OMP dropouts, and 29% of the Abernathy Dry droupout fish exhibit both empty guts and clubbed gills as described by Wood (1968).

Using the percentage of dropout fish which exhibit the classic dropout symptoms (both clubbed gills and empty guts), it was possible to estimate the percent of the total population that was affected by droupout. Thus, based on the results of the examinations of randomly selected fish, dropout mortality could be expected to reach 5% in the BioDiet fish, 23% in the OMP fish, and 53% in the Abernathy Dry fish if the experiment were allowed to continue uninterrupted.

Mortalities began in mid-April, at 560 TU's, and continued through May when the experiment was concluded due to production constraints (see Figures 2-5). Loss was lower in the moist diets (and in those tanks recovered with liver or BioDiet) than in the dry diet or in the unrecovered replicates. By the end of May, actual dropout mortalities had reached 0.71% in the BioDiet (tank 2), 6.33% in OMP (tank 3), and 14.72% in Abernathy Dry (tank 12) as shown in Table 3.

Table 3. Dropout mortalities in diet treatments (April & May 1984).

Diet (tank)	% Mortality (dropout)	Recovery Diet
BioDiet		
1 (EC)	1.18	(-)
2	0.71	(-)
10	0.60	(-)
11	0.89	(-)
OMP		
3	6.33	(-)
4	2.39	BioDiet
9	0.31	Liver/OMP/Liver
Abernathy Dry		
5	1.86	(-) Liver
6	4.35	BioDiet
8	0.43	Liver
12	14.72	(-)

(-): No recovery diet was fed to the replicate.

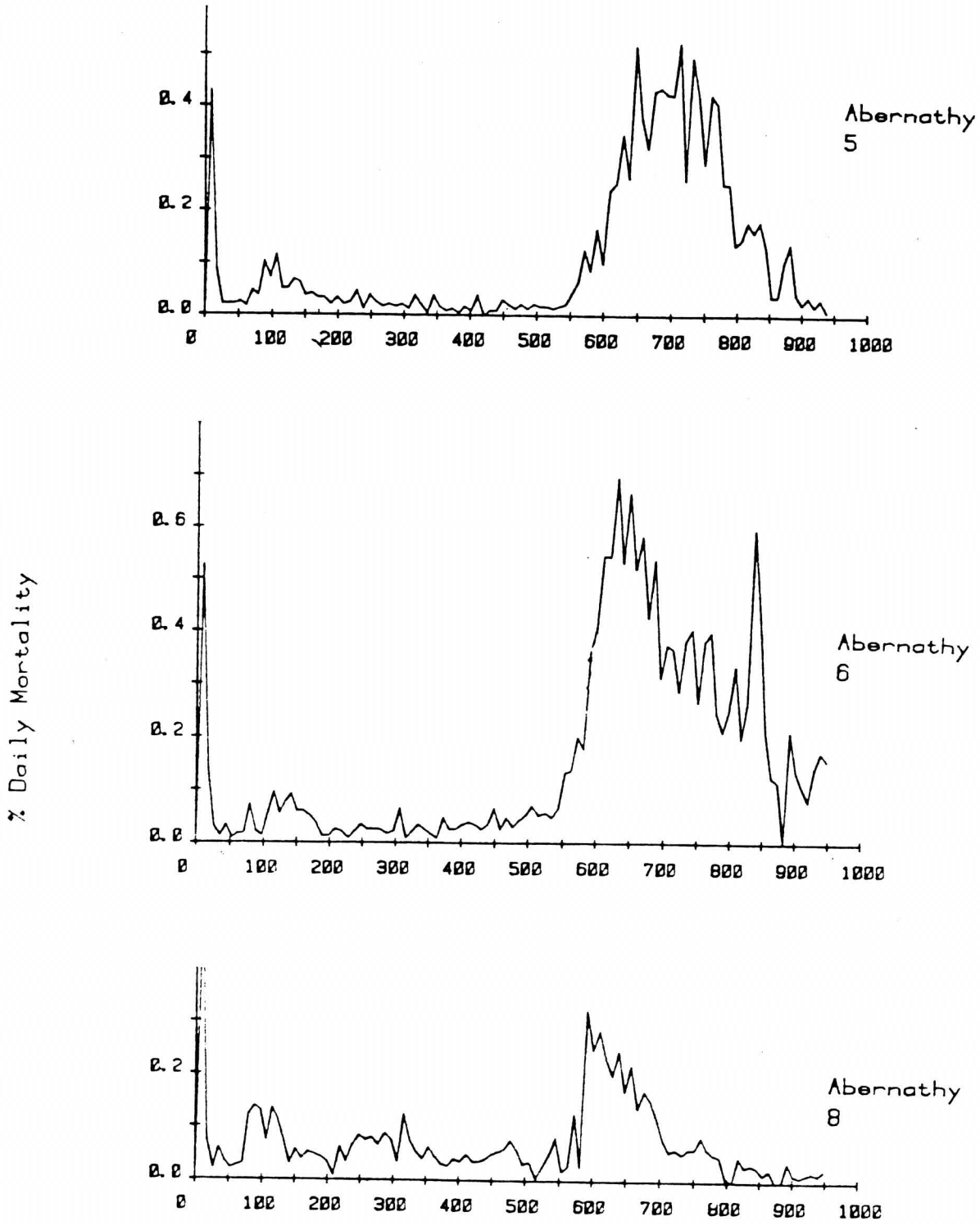

Figure 2. % daily mortality vs TU's for Abernathy tanks 5,6, and 8. Dropout mortalities began at about 560 TU's, 1st feed size change on March 13 at 300 TU's, 2nd change on March 27 at 450 TU's. Tank 5 switched to liver on April 27 at 700 TU's. Tank 6 switched to BioDiet and tank 8 to liver on April 13 at 600 TU's. Tank 8 switched to BioDiet on April 27 at 700 TU's.

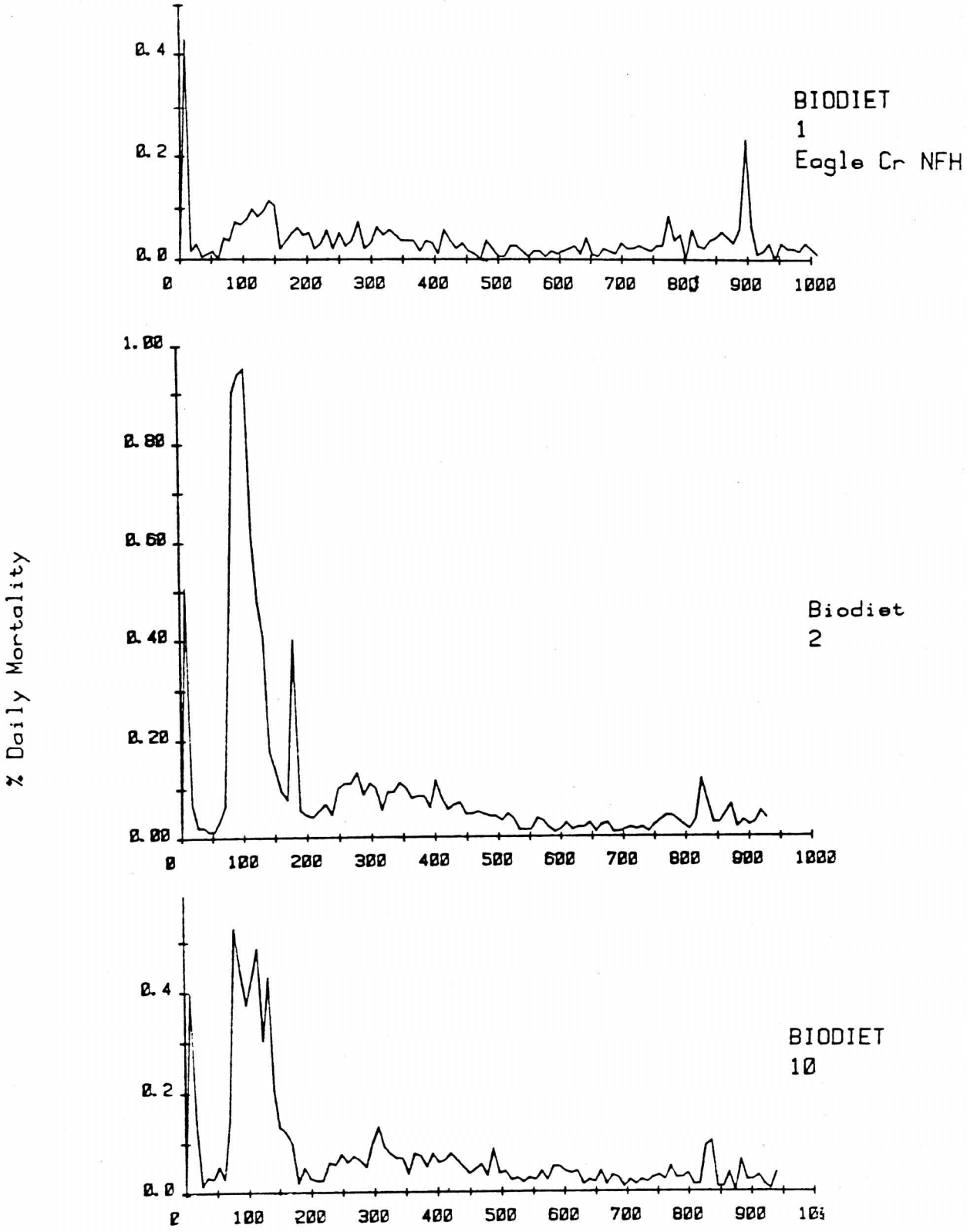

Figure 3. % daily mortality vs TU's for BioDiet tanks 1,2, and 10. High initial mortalities due to fungal infection. 1st feed size change March 7 at 300 TU's, 2nd change March 27 at 450 TU's, 3rd change April 7, 4th on May 9.

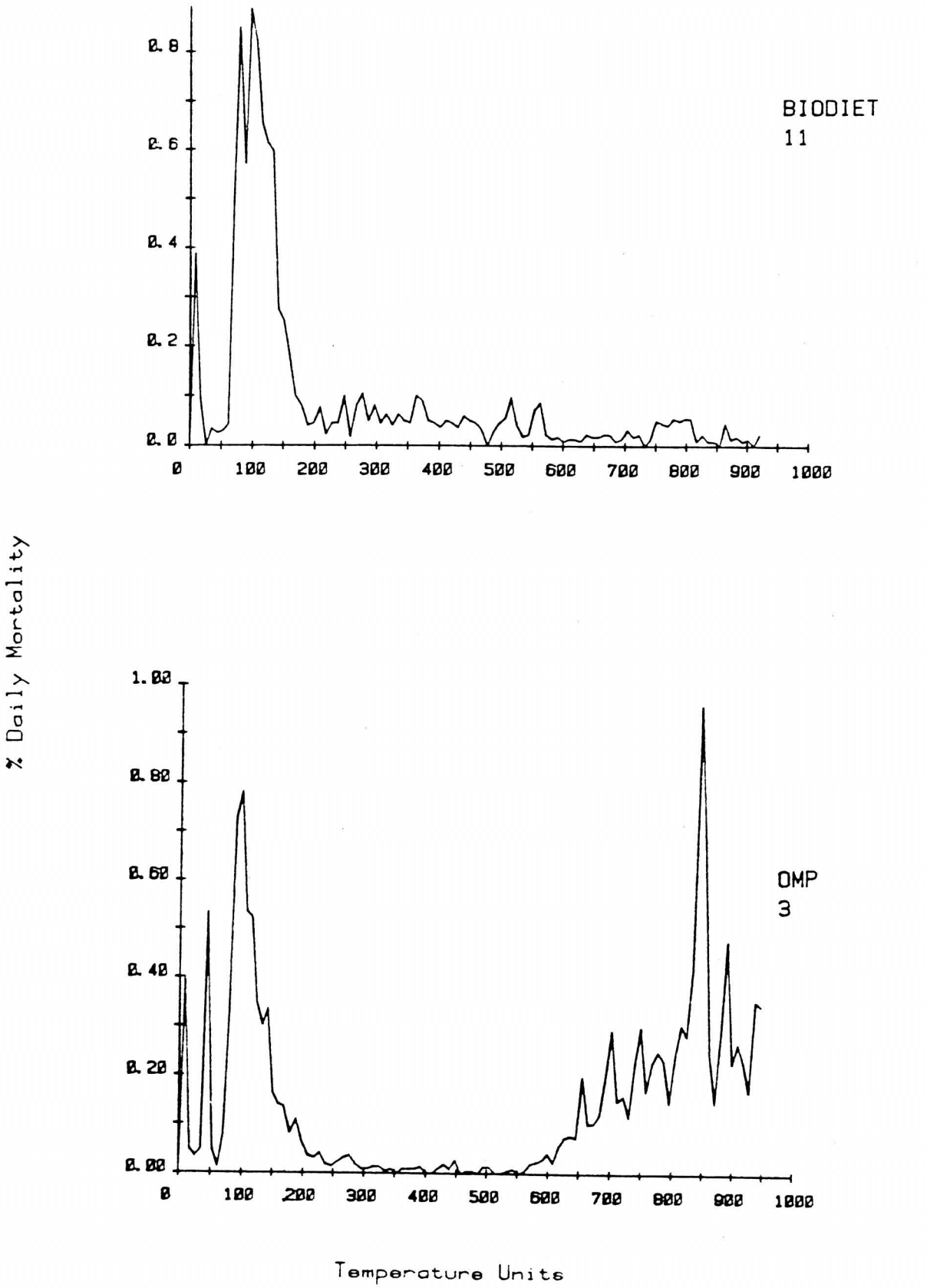

Figure 4. % daily mortality vs TU's for BioDiet tank 11 and OMP tank 3. Tank 11 feed size changes correspond with other BioDiet tanks. Tank 3 dropout mortalities began at about 600 TU's. 1st feed size change March 13 at 300 TU's, 2nd change March 27 at 450 TU's. High initial loss due to fungal infection.

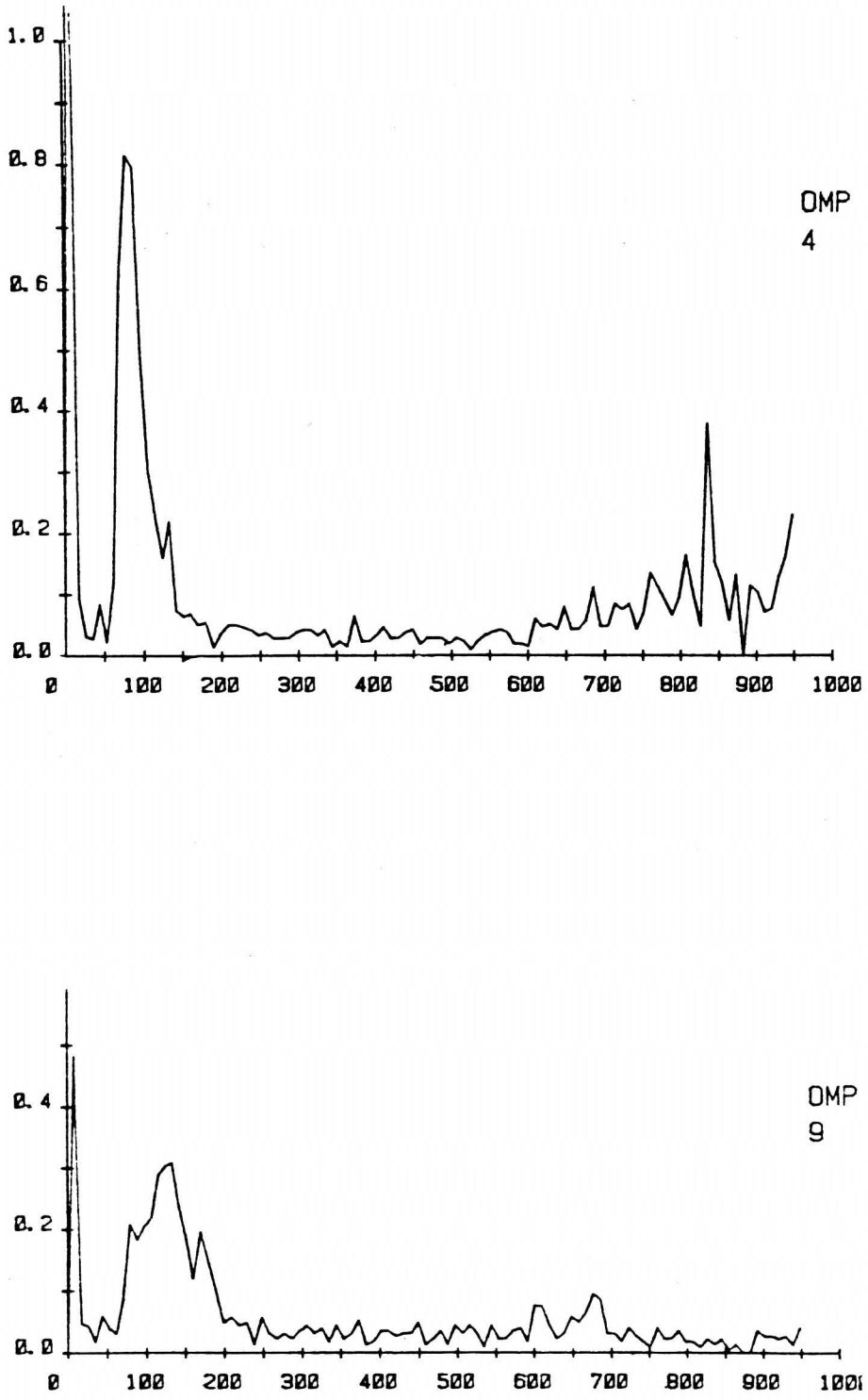

Figure 5. % daily mortality vs TU's for OMP tank 4 and 9. Feed size changes on March 13, March 27. Tank 4 switched to BioDiet April 13 (600 TU's). Tank 9 switched to liver April 13, switched back to OMP April 27 (700 TU's), switched back to liver May 10 (850 TU's), switched to BioDiet May 22 (950 TU's). High initial losses due to fungal infection.

Growth data indicates that the moist diets produced larger fish than the dry diet, with BioDiet producing the best results (Table 4).

Table 4. Number of fish/pound/tank based on bi-weekly quarter sample results: Date and TU's accumulated/sample day shown.

Diet	(Tank)	Date	# fish/pound 2/14	3/27	4/10	4/25	5/9	5/21
		TU's	36	432	560	692	833	963
BioDiet	1		1263	435	307	233	198	151
	2		1178	451	351	262	228	164
	10		*1178	426	313	238	203	141
	11		*1178	431	304	238	193	138
OMP	3		*1178	507	401	372	321	244
	4		*1178	487	416	316	262	202
	9		*1178	507	412	267	295	231
Abernathy Dry	5		*1178	501	459	456	387	277
	6		*1178	531	517	375	329	215
	8		*1178	513	508	373	339	279
	12		N/A	N/A	N/A	N/A	492	306

*Size was estimated for these tanks based on tank 2.

Conclusion

Dropout disease occurs with varying incidences among all of the diets (BioDiet, OMP, Abernathy Dry). Because the size range of pinheads has an upper limit, it may be safe to assume that the cause of the problem occurs before the fish reach 50 mm in length. Thus, the increased mortalities and other symptoms are only delayed manifestations of the syndrome. The symptoms, then, may vary. It is therefore, difficult to correlate poor gill condition with empty guts, for example, in pinheads. Generally, fish condition does deteriorate with time to the extent that typical dropout fish will exhibit many of the symptoms: pinheading, weakness, gill clubbing, empty guts, length less than 50 mm, and increased mortalities.

The incidence of dropout disease seems to be directly related to the type of diet fed. The moist diets experienced lower losses to dropout than the dry diet. Lower incidences, then, are associated with diets that produce better growth. Thus the level of dropout in the BioDiet tanks was found to be lower than in the OMP tanks.

Yet, BioDiet did not prevent dropout disease from occurring, it only controlled the extent of the problem. However, liver was effective at preventing the losses as well as relieving the effects of the other dropout symptoms.

Further experimentation is required before any definitive cause can be established. Yet, it seems clear that the problem begins very early and that it is related to the diet fed. It is unclear whether the fish have certain nutritional requirements that are not being met or whether, in fact, the fish are rejecting some feeds in preference of others.

This year at Eagle Creek National Fish Hatchery emphasis will be placed on nutritional modifications of the OMP diet.

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Update on the Study of IHNV Carrier State in Sockeye Salmon

--Kathleen Hopper, Kevin Amos and
Lori LeVander
State of Washington
Department of Fisheries

Most hatchery and fish health personnel are aware of the increase in the numbers of adult salmon and trout that are surveyed for viruses in the Northwest. We check the stocks at spawning time because it is one of the two times we can isolate the viruses in question. The other is when the juveniles are dying from a clinical outbreak of the diseases caused by infectious hematopoetic necrosis virus, or IHNV, and infectious pancreatic necrosis virus, IPNV.

If we isolate a viral agent from an adult anadromous salmonid, how do we differentiate between horizontal and vertical transmission? After all, the fish has returned to the same water that supplied the virus in the first place. Was he reinfected upon return to freshwater or was he a lifelong carrier?

We study these questions with an expansion of a project we did last year.

The Cedar River empties into Lake Washington, the eastern boundary of Seattle. Lake Washington, through a series of lakes and canals, empties into Puget Sound via the U.S. Government Locks, where a fish ladder is in operation. The Cedar River has a large natural sockeye run, which we sampled as the fish entered the locks from saltwater.

On August 1st, we lowered the water in the ladder, netted the sockeye and anesthetized them with MS-222. At this time we injected them with erythromycin and terramycin (in a single dose) for the control of bacterial diseases. We separated them by sex as best we could, identifying the males by an adipose clip. We transferred 40 fish in an aerated 100 gallon tank across town to 20 containers at the U.S. Fish and Wildlife Laboratory.

The tanks are converted fish totes with approximately 150 gallons volume and 1 to 1½ gallons per minute flow. The water is pathogen-free dechlorinated and chilled city water, with temperatures from 50° to 60°F. We placed one male and one female in each container and treated them biweekly with a .5% salt solution to control fungus.

Thirteen (13) females survived to maturity. We spawn them from initial ripeness as many as four times to obtain ovarian fluid for viral assay. When spawned out, they are killed and kidney and spleen samples are taken. At this time, we have nine (9) females left. Sixteen (16) males survived. At maturity, they are killed and tissue samples removed. Five (5) of them are still alive.

All samples are processed individually according to the American Fisheries Society Blue book specifications at our lab in Olympia.

Results nd Discussion

We presume the fish we obtained were destined for the Cedar River. Spawning sockeye sampled there this year by Dr. Dan Mulcahy's Lab had as high at 98% incidence of IHNV. Both this year and last we found no virus in any fish from our study.

Statistically, we can make no valid conclusions from the data we gathered. But 0% carrier rate from these test fish suggests that horizontal transmission of IHNV at the spawning grounds is very important.

"Pathologic Changes Associated with Dropout Disease in Rainbow Trout, Spring Chinook Salmon, and Westslope Cutthroat Trout."

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Dropout disease (DO) is a term referring to an non-infectious disease of as yet unknown etiology that occurs in trout and salmon fry.

Dropout in rainbow trout and cutthroat trout is characterized by a gradual, but sustained increase in mortality of first feeding fry. Mortality normally remains high and peaks at about 33-35 mm or about 1000/lb., after 30-50 days. Mortality rate in rainbow trout may reach 25-30%, while in cutthroat it may be as high as 70-80%. The disease in cutthroat trout is sometimes referred to as "2-inch break". Trout dying from dropout disease are usually healthy appearing fish. Some, however, show edematous changes and have fluid in their visceral cavity; others became dark in color.

Dropout in spring chinook salmon usually occurs when fry are about to 45-50 mm or about 500-600/lb. The disease is characterized by the occurrence of pinheaded fish that are weakened and gather near the tail screens of tanks. They generally suffer from clubbed gills and have empty gastrointestinal tracts. Mortality rate may range from 15-30 percent or higher.

Pathological changes that occur in rainbow trout and cutthroat trout include degenerative changes in liver, kidneys, and musculature. Livers are most adversely affected and show severe necrosis and swelling of liver cells. Regenerative foci of liver cells are often diffusely scattered throughout sections of liver tissue. Kidneys often show swelling of renal tubule epithelium and sometimes necrosis of tubules. Edema is occasionally found. Necrosis of skeletal muscle fibers is also common in rainbow and cutthroat trout with DO disease.

The most consistent pathological changes seen in salmon with DO disease are found in gills. Extreme hyperplasia (proliferation) of gill lamellar epithelium results in fusion of a few to all the lamellae on gill filaments and often fusion of several filaments on gill arches. Such changes are typical of nutritional gill disease caused by panthogenic acid deficiency. Degenerative changes are sometimes seen in livers of salmon with DO.

Similar changes are found in summer chinook salmon dying from what is referred to as "Spring thing" and which may be the same as DO.

Dropout disease of trout and salmon appears to be nutrition related since the feeding of certain diets and or beef liver prevents the occurrence of the disease.

A Significant New Systemic Disease of Net-pen Reared Chinook Salmon, Onchorynchus tschawytscha, Brood Stock

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A severe infectious systemic disease occurred in 3-year-old Snake River fall Chinook salmon (Onchorynchus tschawytscha) brood stock held in saltwater net pens. Cumulative mortalities exceeded 90 percent (4,500 fish) over eight months. The agent, apparently a simple marine fungus, replicates intracellularly in macrophages, endothelial and possibly other cells. Organisms appear in the circulatory system both within macrophages and extracellularly. Accumulation and replication of the organisms occurs extensively in the filtering organs, i.e., spleen kidney, and liver, and results in massive enlargement and compression necrosis of these organs but is accompanied by relatively little inflammatory response.

The causative organsism are spherical, 3.0 to 7.0 μm in diameter, and have a cell wall which contains cellulose. The organisms are positive in the periodic acid-Schiff reaction, birefringent and yield a brown reaction with iodine staining. They divide by daughter cell division.

The organism was isolated in vitro by organ explant cultivation and subsequent transfer to CHSE/214 cells. Mortalities and characteristic lesions were reproduced in juvenile salmon by inoculation with the isolate. Organisms were reisolated from moribund fish 25 days after inoculation. Antigenic identity was demonstrated between the isolate and the organism in the net-pen reared fish using a rabbit antiserum. Application of fluorescein conjugated antiserum to infected tissues also suggested an additional life stage of the organism may be present in infected tissues.

In vitro studies indicate that tetracycline, amphotericin-B and Mycostatin prevent replication of the organism and thus offer potential utility in chemotherapy.

Infectious diseases of salmonids in saltwater have received little study although the marine phase accounts for the greatest part of the life cycle. The significance of this disease and other marine diseases of salmonids will be discussed.

Bacterial Kidney Disease Control in Brook Trout

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Introduction

Two Washington Department of Game hatcheries, Ford and Spokane have had bacterial kidney disease (BKD) losses in brook trout. At Ford, the brook broodstock hatchery BKD losses have occurred postspawning in the broodstock. At Spokane, BKD mortalities have been seen in fingerling and yearling brook trout.

Test were initiated in 1980 using methods developed by Dr. G.W. Klontz and K. Amos to control BKD mortalities. This paper describes results of BKD control tests in brook trout.

Methods

1980 - In 1980 a group of 500 2 yr old female brook trout were injected erythromycin (Gallimycin Poultry Formula Improved, Abbott Laboratories, Chicago, IL) at 5 mg/lb at 70 and 30 days prespawning. Injections were administered with Cornwall multi-dose syringe subcutaneously, anterior to the dorsal fin.

At spawning, all eggs from the injected females were water hardened in 2.0 mg/L erythromycin except for 6 randomly selected females. The same procedure was used with the uninjected females. Four experimental groups resulted: 1. 1. injected - water hardened, 2. injected - not water hardened, 3. not injected - water hardened, and 4. not injected - not water hardened. The four groups were reared seperately.

1981 - In 1981 all females brook broodstock were injected with erythromycin at 70 and 30 days prespawning. At spawning, all eggs were water hardened in 2.0 mg/L erythromycin for 2 hr. A summary of procedures are contained in Table 1.

Table 1. BKD Control Procedures

I. Prespawning Erythromycin Injection in Female Broodstock
A. Two injections @ 70 and 30 days prespawning
B. Dose - 5 mg/lb (Gallimycin PFC)*
II. Water Hardening Eggs in Erythromycin Solution
A. Unwashed eggs water hardened for 2 hr
B. Dose - 2 mg/L (Gallimycin PFC)*
* Gallimycin PFC, Ceva Laboratories, Inc. Overland Park, KS

1982-83 - The same methods used in 1982 were again employed in 1982 and 1983. All females and eggs were treated with erythromycin.

Results

1980 - No BKD mortalities were observed in any of the four test groups after one year of rearing. The experimental groups were reared at Ford hatchery. However, BKD losses were observed at Spokane hatchery in brook trout received from Ford that were water hardened in erythromycin.

1981-83 - No BKD mortalities were observed in any of the brood years that have been treated with erythromycin. A summary of BKD control production test are shown in Table 2.

Table 2. Summary of BKD Control Test in Brook Trout

Year Class	Treatment	Results
1979	None	BKD Mortality
1980	Eggs Treated	BKD Mortality
1981	Female Injected & Eggs Treated	No BKD Mortality
1982	Female Injected & Eggs Treated	No BKD Mortality
1983	Female Injected & Eggs Treated	No BKD Mortality

Discussion

Erythromycin was effective in controlling BKD mortality in brook trout. The procedure as describe above using a combination of treating female brook broodstock and eggs was the effective technique. However, just treating eggs with erythromycin was ineffective in controlling BKD mortality in brook fingerlings and yearlings.

35th Annual Northwest Fish Cultural Workshop
December 4-6, 1984, Kennewick, WA

Title: Research on Dropout Disease (Studies of dietary causes of early mortality in hatchery reared spring chinook salmon)

By: H. George Ketola*, Research Physiologist, Tunison Laboratory of Fish Nutrition, USFWS, 28 Gracie Road, Cortland, NY 13045

Introduction

In many cold, soft-water hatcheries, a 15-30% incidence of early feeding mortality (termed dropout), occurs in spring chinook salmon fed Oregon Moist Pellet (OMP). Closed-formula Biodiet was suggested as a possible means of preventing dropout mortality. A request for assistance to help solve this mortality problem was sought through the Tunison Laboratory of Fish Nutrition. A two-year study was planned and this summary covers progress for the first year of the study. Studies were conducted at Eagle Creek and Carson National Fish Hatcheries (NFH), and at the National Fisheries Center in Seattle, and at the Tunison Laboratory of Fish Nutrition in Hagerman. Objectives of the first year studies were to: (1) determine if diet was involved in dropout mortalities in Oregon and Washington, (2) define and characterize the onset and progression of these mortalities, (3) characterize any diets shown to cause or prevent mortality, and (4) attempt to produce mortality syndrome in the laboratory which would enable further and more specific studies on the causes and prevention of the mortality. Besides these objectives, the possibility of halting dropout mortality by feeding fish liver or Biodiet after onset was conceived and examined by Jim Holway at Eagle Creek NFH. The possibility of preventing dropout by early feeding with Biodiet for different periods of time prior to mortality was conceived and examined by Don Zirjacks at Carson NFH. At the Seattle NFC, a controlled study was conducted with salmon that were reared in chilled (41 to 50°F) soft water and fed the same diets tested at Eagle Creek NFH.

This report will concentrate on results of tests at Carson NFH and at the Seattle laboratory, because Jan Rowan and Jim Holway have reported on the results for Eagle Creek NFH. Comparative aspects of key results will be briefly discussed.

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*With the collaboration of: Dr. John G. Nickum, USFWS Cooperative Unit, Iowa State University; Dr. Robert Smith, Tunison Laboratory of Fish Nutrition, Hagerman, ID; Dr. Donald W. Johnson, Iowa State University; Dr. G. Wedemeyer, Seattle National Fisheries Research Center; Don Zirjacks and John Davis, Carson National Fish Hatchery, Carson, WA.

Methods:

The Seattle study was done in collaboration with Dr. Gary Wedemeyer who provided daily oversight for the study while Michele Dimmitt handled most of the daily care of the fish during most of the study. In the study, three diets were assigned at random and fed to duplicate tanks each stocked with 500 spring chinook salmon alevins (Clackamas lot) obtained from Eagle Creek NFH. Diets included the Abernathy salmon starter (S8-2(83)) and grower (A18-2(83)) feed, Oregon Moist Mash and Pellet (OMP:OM-3 and OP-4) and Biodiet starter and grower feed. All diets were fed at equal levels of dry matter based on the levels of Biodiet fed according to hatchery constants depending on water temperature as used in the study at Eagle Creek NFH by Jim Holway. The transition from one particle size to another was accomplished by mixing different-sized particles for 2 weeks: During the first week, particles were mixed in a 70/30 ratio of smaller/larger particles; during the second week a ratio of 30/70 was used; after that only the larger particle was fed. Fish were fed by automatic clock feeders six days/week throughout the study except for the first 4 weeks when they were fed 7 days/week. The water supplied to all tanks was chilled Lake Washington water containing 7.5 ppm $CaCO_3$. Water was chilled to a few degrees higher than water at McCall Hatchery (ID) and increased accordingly. The initial temperature was 41°F (5°C) and gradually rose to about 50°F (10°C). (The chiller we used could not fully chill the water to exactly duplicate the McCall temperature profile.) Feeding began February 21, and the study was terminated on July 17, 1984 -- about 1050 centigrade degree days (TU) post first feeding.

The study at Carson NFH was a practical, large-scale hatchery test comparing the feeding of five lots of approximately 105,000 spring chinook salmon alevins each. One lot of fish was fed OMP throughout, another lot Biodiet throughout, and three other lots were fed Biodiet to fish up to a size of 800/lb, 375/lb or 100/lb. All fish were fed in a similar fashion and on an equal dry matter basis. Transitions to larger particle sizes were accomplished by mixing larger particles with smaller ones in equal amounts up to 4 to 7 days at which time the transition was completed. First feeding began on January 18, and the study ended on July 15, 1984 -- about 1200 TU post first feeding.

Results at Seattle:

The results of the Seattle study showed that salmon fed Biodiet grew about 22% faster ($P < .05$) than those fed OMP, while those fed OMP grew about 42% faster ($P < .05$) than those fed the Abernathy diet. Mortality up to 550 TU (May 24) ranged from 4 to 9% and did not significantly differ between diets. In contrast, mortality between 550 and 1000 TU (July 13) was significantly greater in salmon fed

Abernathy (18%) and OMP (16%) diets than in those fed Biodiet (2%).

Mortality began at about 550 TU in fish fed Abernathy and OMP diets. Overall, the fish were, on the average, just slightly over 1 gram in body weight (454/lb) at that time. Measurements of total body lengths and condition factors on moribund and normal fish showed that moribund fish were less than 50 mm long and had low (53 to 57, K x 10^{-7}) metric condition factors (pin heads) in contrast to normal fish which were longer (63 to 69 mm) and had higher condition factors (73 to 80, K x 10^{-7}).

The mortality peaked at about 700 to 900 TU and was over by about 1000 TU. At the end of this mortality the average body weights of the fish in the general population were between 2 and 3 grams (or about 227 to 150/lb). Histological examinations by Charlie Smith revealed clubbed-gill pathology similar to nutritional gill disease. Some fish fed Biodiet and OMP had Costia infestations and hypertrophy of chloride cells -- the significance of which is not understood.

The onset of this mortality appeared to be similar to the dropout disease described by Wood (1979) who indicated that "fish start to feed in a satisfactory manner but after reaching a size of approximately 400 fish/lb, a portion of them will stop feeding, eventually become pinheads, and finally die." Wood indicates they also show clubbed gills and do not respond to pantothenic acid.

Results at Carson:

Results at Carson NFH showed that continuous feeding of OMP (OM-3 and OP-4) caused "dropout" mortality occurring between 550 and 950 TU, whereas Biodiet prevented it. This mortality began in early April and ended in early June. Early feeding with Biodiet followed by changing to OMP reduced dropout mortality when the change was made at fish weights of 800 and 375 fish/lb (or at about 200 and 425 TU post first feeding). The reduction in mortality was greater when the change occurred at 375/lb. This regime prevented most dropout mortality. Feeding Biodiet up to 100 fish/lb completely avoided all dropout mortality. The pathology associated with dropout mortality at Carson was determined by Charlie Smith to be similar to nutritional gill-disease as seen at Seattle and Eagle Creek NFH.

Measurements of total body lengths and metric condition factors on moribund and normal fish at about 850 TU (May 21) showed that moribund fish were less than 50 mm long and had low (53 to 58, K x 10^{-7}) condition factors (pin heads) in contrast to the normal fish which were longer (68 to 75 mm) and had higher condition factors (89 to 91, K x 10^{-7}). One exception is that the moribund fish fed Biodiet up to 375/lb

had intermediate condition factors though they had an average length of 44 mm. These results are very similar to those in the Seattle experiment and those at Eagle Creek NFH as demonstrated by Holway and Rowan at this workshop.

Conclusions

Mortality observed in spring chinook salmon reared in cold, soft water in Washington was proven to be diet related. Feeding OMP (Oregon Moist Pellet, OM-3 and OP-4) and Abernathy diets (S8-2 and A18-2(83)) induced mortality and closed-formula Biodiet starter and grower diets prevented all or nearly all mortality. Early feeding of Biodiet to salmon up to about 400 centigrade degree days (TU) post swim-up (or when fish were about 375/lb) and converting to OMP (OP-4) markedly reduced drop-out mortality.

The progression of the condition was as follows: Fish started feeding at an average length of 32 mm, grew for a while, stopped eating, became emaciated or "pinheaded" when 40 to 50 mm long, developed a clubbed-gill pathology similar to that of nutritional gill disease and mortality started at about 550 TU and ended at approximately 1000 TU, and most fish died before they were 50 mm long.

This mortality has been called dropout and it may be the same condition described (under the same name) by James Wood in his 1979 manual "Diseases of Pacific Salmon, Their Prevention and Treatment."

ENVIRONMENTAL GILL DISEASE: A REVIEW

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Environmental gill disease (EGD) is a subchronic to chronic noninfectious respiratory disease of juvenile fish being raised under intensively managed conditions. Its causal factors (etiology) are very complex. The major contributory cause has been considered to be accumulations of free ammonia at levels above 0.015 mg/l. Also implicated in the process have been suspended solids from uneaten feed and feces. Recently it has been demonstrated by Eib that another major factor is population density which acts as a stressor, which in turn affects ammonia-N release, among other things physiological.

Under usual conditions where the process is uncomplicated by infectious agents, EGD has a very high morbidity (many fish are sick) and a relatively low mortality. Its main clinical sign is inappetance. This is thought to be largely due to the fish's inability to satisfy its oxygen demand. The gill tissues at this point are usually grossly affected. The initial hypertrophic response has been replaced by hyperplasia resulting in what is termed "swollen gills". The fish subsequently begin to become quite dark and visibly depressed. The fins are often frayed-looking due to the loss of the membranes between the fin rays. By now it should be very obvious to the hatcheryman that all is not well. So, what is to be done?

It has been usual - far too usual, I might add - to diagnose this condition as bacterial gill disease and treat the population with whatever medicament is at hand. Formalin, permanganate, "Four Power", Cutrine, Hyamine and what all else have been used with variable results. These chemicals are not getting at the cause of the situation - only the effects. Granted, the effects need to be considered - but not at the expense of ignoring the underlying causal factors - the most usual of which is a system overload.

Our research these past years on EGD have demonstrated that the following regimen is currently quite effective in reducing the effects of EGD:

1. If the fish are of a size to permit withholding their feed for three days, this should be done initially. If total nonfeeding is a risk, then reduce the feeding rate to 20-25% of the daily level for 3-4 days.

   This practice reduces the oxygen demand followed by the reduction of solids and ammonia production.

2. The excess solids accumulation should be removed. This decreases the BOD and the potential for gill irritation.

3. If there is an overload of fish in the pond, this should be corrected.

4. Add sufficient salt to the pond to get a 1-1.5% solution. A satisfactory practice is to dump a 50 lb bag into the head-end of the pond and let it slowly dissipate.

Although we currently have no conclusive data to prove our opinions, we think the benefit here is to knock-down what external parasites and myxos there might be and to provide an "extra-shot" of sodium for the fish. Sodium is known to be taken up across the gills in exchange for ammonia which is released to the water, thus reducing the stress response from this. The chloride is also known to help the fish cope with the stress response. This next point may be a little far out for some, but there is some evidence that increasing the Vit. C intake is also beneficial.

Now that the episode has been treated satisfactorily, the next topic to be dealt with is how to prevent further episodes. At this point in time, the only suggestion we can make is the maintain pond loads below the "no-effect" limits with respect to population density and life support. Remember, as Fred Fish once stated, "cleanliness is not next to godliness - it supersedes it!!"

PACIFIC NORTHWEST FISH HEALTH PROTECTION COMMITTEE UPDATE

Kevin Amos

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(Presented by Einar Wold)

The history of the first year of existence of the PNFHPC was reviewed. Its recognition by other fisheries groups and progress made toward the development of a comprehensive fish health protection program was noted. The fact was pointed out that in taking on these responsibilities, the PNFHPC must demonstrate professional competence and press on with the Model Program because input from the committee is increasingly being sought in a variety of issues.

Good progress has been made by all subcommittees. The Project Priorities Subcommittee completed an important survey in November and is ready to seek information from PNFHPC cooperators on projects and studies that should be done to prevent or control fish diseases. The Technical Procedures people have been working hard on their sections of the Model Program in concert with revisions of the AFS/FSH lab procedures "Bluebook". The Database Subcommittee has provided a case history report form and solicits prompt reports from member organizations. The Fish Culture Procedures and Facilities Subcommittee has completed a detailed outline for Section X of the Model Program and has prepared two resolutions to be considered at the next PNFHPC meeting.

Also of importance are some new things for the committee to consider. A procedure, following the concensus approach, must be established within the committee for reviewing and approving subcommittee drafts and recommendations prior to submission to the full committee. The PNFHPC charter has no provisions for an Executive Committee to do this between meetings. The PNFHPC also needs to establish a surname review process for obtaining cooperating party approval of letters from the PNFHPC to outside parties seeking PNFHPC comments or guidance.

IDAHO DEPARTMENT OF FISH AND GAME

SPRING DEVELOPMENT PROGRAM

AT

EXISTING STATE HATCHERIES

PRESENTED AT THE

NORTHWEST FISH CULTURE WORKSHOP
KENNEWICK, WASHINGTON

BY

PHILIP G. JEPPSON, P.E.
FISH AND WILDLIFE ENGINEER
IDAHO DEPARTMENT OF FISH AND GAME

DECEMBER 1984

Philip G. Jeppson, P.E.
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SPRING DEVELOPMENT PROGRAM AT EXISTING STATE HATCHERIES

I. INTRODUCTION

In the fall of 1981, the Idaho Department of Fish and Game started planning efforts to remodel an existing state trout hatchery at American Falls. Existing facilities included a three and one-half acre spring pond with 20 cfs and deteriorated pipelines and raceways. The spring pond contained a large number of diseased fish which transmitted diseases to the rearing vessels. Algae, moss, acquatic weeds, and insects were also transmitted to the hatchery facilities resulting in labor intensive maintenance requirements. Algae was particularly a problem because it plugged the screens in the Heath incubators.

Water quality was also poor due to 126 percent dissolved nitrogen + argon and 4.5 ppm dissolved oxygen at the spring vents. Consequently, as part of the overall design, it was decided to enclose the springs underground and aerate/degas the water before the rearing facilities.

New raceways were designed as a two-pass system with a 24-inch drop between passes and were located low enough in elevation to allow packed-column aeration at the head ends of the raceways. Using low head loss pipelines, the water surface in the filled-in spring pond is maintained at a lower elevation than the old pond water surface.

When the construction was complete in the fall of 1983, tests on the water quality were very encouraging. Dissolved oxygen content was up to 92 percent and dissolved nitrogen + argon was down to 102.9 percent..

It was then decided to use the same design criteria and construction procedures for the spring pond reconstructions at the Ashton and Mackay Fish Hatcheries.

II. GOALS

The primary goal of the spring pond development or reconstruction is to enclose totally underground all springs without increasing the head on the springs.

Also, where possible, provide gravity aeration of all supply water using packed-column aerators.

Specific objectives are to obtain:

- o dissolved oxygen levels to 95 percent saturation
- o dissolved nitrogen + carbon dioxide + argon to a maximum of 103 percent saturation

Providing gravity aeration for all spring water to obtain the aforementioned quality is usually not possible without reconstructing existing rearing facilities and pipelines as there is usually not an extra four feet of head available.

III. PACKED COLUMN DESIGN

(1) Structure

Figure 1 shows a typical packed-column design in use at both American Falls and Mackay Hatcheries. Two-inch media was selected for all columns 18-inch diameter through 48-inch diameter based on the recommendation contained in The Performance and Design of Packed Column Aeration Systems for Aquaculture, Hackney, 1981, University of California, Davis, California. This reference states a minimum ratio of 8:1 for packed column diameter versus media diameter for best results.

Corrugated metal pipe was used to reduce the "wall effect" and aluminum was chosen over plain or galvanized steel due to corrosion and toxicity concerns. We have used the standpipe water entry to the packed column because it provides good distrubution without increasing the head requirements. Only at very low hydraulic loading rates have we seen the water run down the sides of the standpipe, i.e., it normally is immediately broken up by the media and is distributed over the entire cross-section of the culvert within two thicknesses of the media (even with 48-inch diameter columns).

This design allows the culvert pipe to be removed and the media replaced without undoing any bolts or welds. The aluminum culvert rests on a neoprene gasket glued to the rolled steel angle. The media itself is used to center the culvert around the standpipe and no structural support is necessary. Plywood or metal sunshades are used to keep algae from growing at the top of the media. A gap around the shade is needed for air flow. This gap should be two inches wide, but not wide enough to allow the sun to hit the media. At minus 20° F., we have not had any ice build-ups in the media.

Fans or blowers do not appear to be necessary and have not been used due to maintenance considerations and unreliable power at the hatcheries. There may not be enough open area around the fan for adequate air transfer when the power is off.

(2) Media Depth

At the hydraulic loading rates we have been using, the same results have been obtained at media depths from 3'-3" to 4"-0". For gravity-air or

non-blower/fan types of columns, the media should not be over five feet deep. Four feet was originally considered the minimum media depth and the 3'-3" depth was used in this instance so as not to back the water up and raise the head on the springs.

(3) Hydraulic Loading Rates

We also used the "Hackney" paper for sizing the column diameter or determining the hydraulic loading rate. Oxygen transfer curves showed that for the two-inch media, essentially the same results are obtained between 50 and 150 gpm/ft^2. This was verified in later tests. For economy's sake, we used 100 to 125 gpm/ft^2 for sizing the column diameters.

IV. AMERICAN FALLS HATCHERY PROJECT

A three and one-half acre spring pond was filled in and 20 cfs captured underground. Due to the large flow (2-3 cfs) in most springs, manholes were used to obtain the large open area needed. A total of 20,000 cubic yards of fill material was placed. Pervious construction fabric was used to allow truck access over the muck/mud in the pond bottom.

Forty-eight-inch diameter packed columns were used with 12-inch diameter risers, 3'-6" of media, and two cfs flow per each. The hydraulic loading rate was 77 gpm/ft^2 with resulting water quality of 92 percent dissolved oxygen and 102 percent dissolved nitrogen and argon. A detailed discussion of this project is included in a paper by L. R. Taylor, Spring Pond Improvements for Hatchery Water Supplies, 1984, CH_2M Hill, Boise, Idaho.

V. ASHTON HATCHERY PROJECT

The Ashton Hatchery had been experiencing the same problems as the American Falls Hatchery with its water supply until the Fish and Game construction crew filled in the spring pond in the fall of 1983. 40,000 cubic yards of fill material were used in the one and one-half acre pond. Only six cfs flows out of this pond and approximately five cfs comes from one spring area. Therefore only one manhole was installed and numerous collector lines with slotted ADS pipe and slotted PVC well screens at the small springs.

No packed columns were installed as part of this project although it would have been desirable. The water quality at the raceways is 8.2 ppm dissolved Oxygen (87 percent saturation) and 108 percent saturation of dissolved nitrogen + argon. The pond was constructed by a long, high earthen dike and raising the dike and water surface was not considered feasible due to the cost, the probability of high percolation losses, and potential for catastrophic failure. There was also no chance to lower the raceways as water already backs into the lower pass. The pipelines to the hatchery building and raceways are also low head pipelines, so there was no place to obtain the extra head needed for aeration/degassing.

VI. MACKAY HATCHERY PROJECT

Funds were budgeted for filling in the springs and spring ponds ahead of two diversions for the summer of 1984. Because approximately 10 cfs out of the total 20 cfs comes out too low to provide any aeration before it goes into an existing conrete pipeline and existing raceways, no aeration was planned.

However, the earthquake of 1983 changed all that. (The epicenter was 10+ miles away.) New springs appeared adjacent to old springs throughout the spring area. The new springs were of even worse water quality than the old, 3.0 ppm D.O., 118 percent D.N. + Ar., and 5 ppm CO_2. Fall chinook and kokanee fingerlings had greater than 50 percent losses.

After considerable planning and budget-shifting, it was decided to aerate as much as we could without adding extra head onto the springs.

Invesigations show that the highest springs could supply up to one cfs that could be aerated before it went into the existing hatchery building supply line. A small concrete dam, a 10-inch diameter PVC supply line and a 24-inch diameter packed column were installed to serve the hatchery building.

A second concrete dam was installed to collect spring water below the first dam, but still high enough to provide aeration for the eight fingerling raceways. A 20-inch diameter steel pipeline carries up to 4.3 cfs to eight 18-inch diameter packed columns.

A third spring area initially flowed at 16 cfs and was planned to be the main flow to the large raceways after aeration. This spring area was comprised almost entirely of old water (before the earthquake). A 30-inch diameter steel pipeline and six 48-inch diameter packed columns were installed for this water. This part of the project was the last to be constructed and in the meantime, the flow dropped to approximately 5 cfs, resulting in a hydraulic loading rate of 31 gpm/ft^2. An additional 8 to 10 cfs is available as un-aerated make-up water to the large raceways.

There were several more tremors that occurred during construction that resulted in cracks in the fresh concrete, but we feel fortunate that no more damage than this occurred. This was a game of chance that we played, but we had to either do it or close the hatchery down.

Table 1 shows the results of the water quality tests at the three different aeration facilities and varying hydraulic loading rates. Note that the same percentage of dissolved oxygen was obtained at 31 to 152 gpm/ft^2 hydraulic loading rates.

The media heights were derived from the available heads with no increase in water depth over the springs and essentially no head loss in the transmission lines. Pneumatic pipeline plugs were used in construction to keep sand and gravel out of the pipelines as the design velocities were too small to flush the pipeline clean.

Figure 2 shows the typical spring collection design. Note that Ø.1 ft/sec. velocity was used through the openings in the PVC well screen placed over the spring vents. Maximum velocity of Ø/5 ft/sec. was used in the ADS collection pipes going to the concrete dams. Extra open area was also added by forming aluminum grating in the concrete head walls. Window wells were installed on each side of the rear concrete wall with dropboard slots to act as spillways for unneeded water.

VII. SUMMARY

In summary, filling in spring ponds did not reduce the flow and effectively eliminated the diseased fish, algae and acquatic vegetation from the water supplies.

Packed-column aerators are relatively inexpensive, effective aeration devices that require no maintenance if used with clean water. There is a wide range of hydraulic flow rates that will produce essentially the same optimum water quality.

MACKAY HATCHERY	PACKED COLUMNS	FIG. 1

CMP ϕ	RISER ϕ
18"	6"
24"	10"
48"	12"

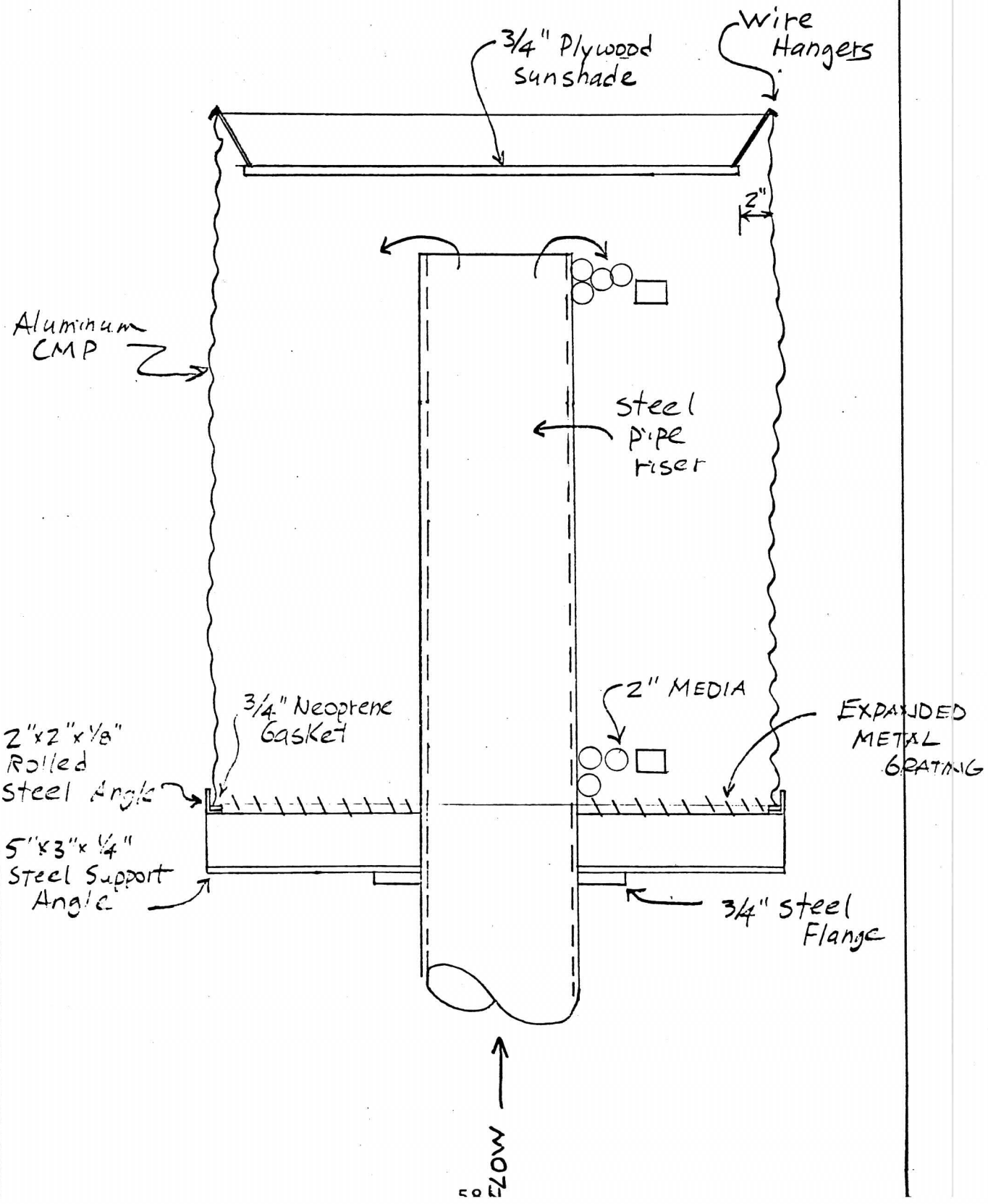


TABLE 1

MACKAY HATCHERY

MEDIA = 2" KOCH RINGS

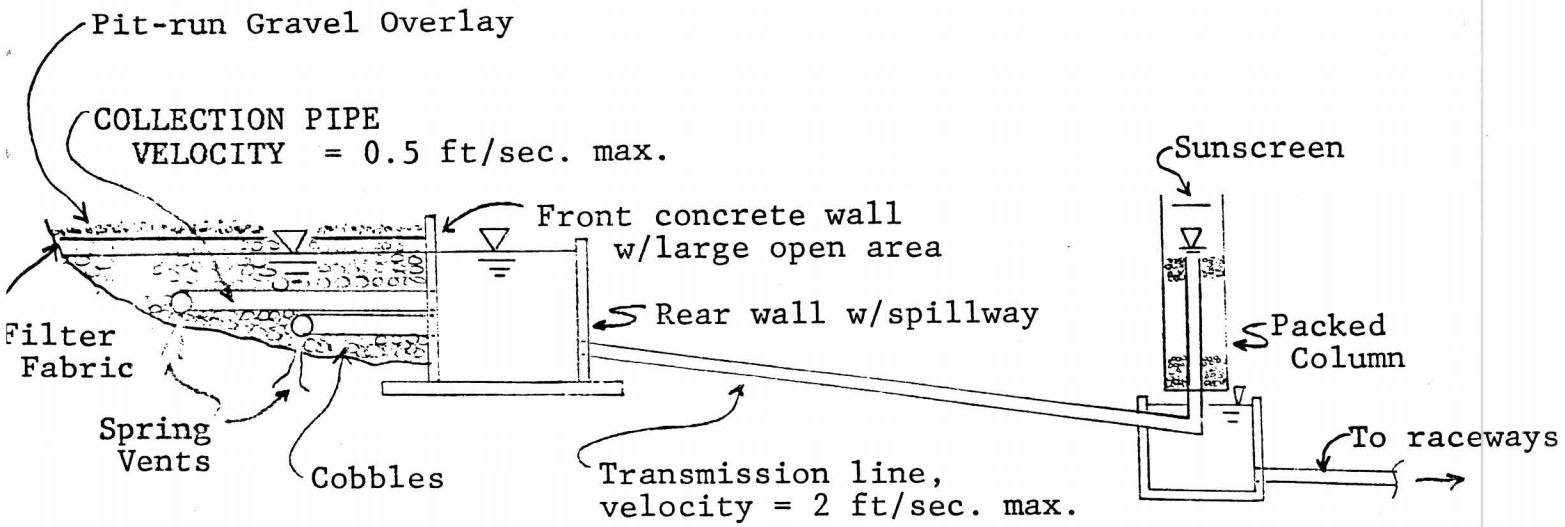
LOCATION	PACKED COLUMN DIAMETER	DESIGN LOADING RATE	MEDIA HEIGHT	TEMP.	FLOW	ACTUAL LOADING RATE	D.O.	% SAT D.O.	% SAT N2, CO2 & Ar.
HATCHERY BUILDING	1 each: 24" Ø w/10" Ø riser	120 gpm/ sq. ft.	3'-6"	52° F.	PRIOR 320 gpm	N/A 123 gpm/ sq. ft.	4.0 ppm 8.1 ppm	45% 92%	118% 101.1%
					30 gpm	12 gpm/ sq. ft.	7.4 ppm	84%	-
FINGER-LING RACEWAYS	8 each: 18" Ø w/6" Ø risers	125 gpm/ sq. ft.	3'-3"	52° F.	PRIOR 240 gpm/ ea.	N/A 152 gpm/ sq. ft.	4.2 ppm 8.2 ppm	48% 93%	116.6% 102.3%
					110 gpm/ ea.	70 gpm/ sq. ft.	8.2 ppm	93%	102.3%
LARGE RACEWAYS	6 each: 48" Ø w/12" Ø risers	100 gpm/ sq. ft.	4'-0"	55° F.	PRIOR 370 gpm/ ea.	N/A 31 gpm/ sq. ft.	3.4 ppm 7.9 ppm	40% 94%	118.3% -

TESTING EQUIPMENT:

YSI D.O. Meter

WEISS SATUROMETER

MACKAY HATCHERY - TYPICAL SPRING COLLECTION DESIGN



MATERIALS

- SPRING COLLECTION:
  - (A) SLOTTED ADS (ADVANCED DRAINAGE SYSTEM) PIPE 12", 18" & 24" DIAM. DESIGN VELOCITY = 0.5 FT/SEC. MAX.
  - (B) SLOTTED 12" DIAM. PVC WELL SCREEN, AND COBBLES DESIGN VELOCITY = 0.1 FT/SEC THROUGH OPENINGS IN PVC PIPE
  - (C) PIT-RUN GRAVEL OVERLAY W/FILTER FABRIC OVER COBBLES
- TRANSMISSION LINES:
  - (A) 10" DIAM. CLASS 160 PVC PIPE
  - (B) 20" DIAM. AND 30" DIAM. STEEL PIPE WITH EXTERIOR COAL-TAR COATED AND WRAPPED
- PACKED COLUMNS:
  - ALUMINUM CULVERT PIPE, STEEL RISER PIPE (PRIME COATED) AND 2" KOCH RINGS

AMMONIA REMOVAL

Gene Forest

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ATEC, a zeolite technology company, provides aquacultural services in: water utilization; water oxygenation; zeolite water treatment; zeolite selection; engineering consulting; systems design and development planning.

Our report to you today covers ammonia removal using a continuous moving zeolite filter bed. To explain to you the benefits and value of such a system, I am going to summarize Utah's Division of Wildlife and ATEC's Joint Investigative Program conducted at Glenwood hatchery. The Glenwood facility is one of Utah's 10 hatcheries contributing to the state's trout fishery program. This briefing examines a 6 year study into remedial and enhanced planning measures for that hatchery.

New facilities were constructed in 1976 to increase fish production and improve annual cost of operations. Because of inadequate testing and the adaptation of systems across fish culture methods, the new facilities failed to perform as expected. Consequently, the facility was partially closed in 1979 and studies began to determine the reasons and any remedy.

Many changes were made to the new bio-filters to propel their efficiency to that of specification. Extensive research and experimentation was conducted to find alternative methods of operation and equipment required to achieve the original production goals. These alternate systems included ozone generation for oxidizing nitrites, process systems management and fixed bed zeolite physical-chemical filtration. No adequate solution was found. Other similar hatcheries reportedly encountered like conditions. A fresh look at the problem was made in 1983 when ATEC offered its services and joined with Utah's Wildlife Division efforts. First, a test program was established to provide for valid information and to substantiate the collected data for both biological and engineering review. Second, the Glenwood facility was prepared through temporary system alteration.

The diagram on the screen shows a simplified arrangement of the systems component parts. Make-up is admitted into the system from the hatchery's springwater supply. The existing aeration tower provides oxygenation and mixing between make-up and recycled waters. The mixed water supplies are then gravity fed into two parallel rearing units of equal volumes. Water flows were likewise adjusted. One of the rearing units was converted from the Burrows design into a flow-through race. Existing bio-filters were simply altered to provide for the settlement of non-filterable solids. Settler effluents were then collected and mixed in a pumping sump when the water was conveyed to the Atec ZW Unit for the removal of ammonia and other toxins. Lastly, water to be retained in the system was collected in the clearwell for the reaeration equipment.

A schematic flow diagram of the ammonia removal system is shown on the screen. The raceway effluent is pumped as feed to the ZW Unit. It enters the ion-exchange vessel and contacts zeolite solids flowing in a direction opposite the water. As the water proceeds through the downward moving-bed of zeolite, the ammonia is removed and the purified product water leaves the top of the ZW Unit where it is discharged to the clearwell. The zeolite proceeding through the ion-exchange vessel captures the ammonium and is eventually removed in a continuous stream from the bottom of the vessel. The zeolite is then conveyed to the regenerator sections where the ammonia is removed, and the freshly regenerated zeolite is then continuously returned to the top of the ion-exchange vessel.

The regenerator also enjoys benefits of the moving-bed process, such as high efficiency and adjustment to the demands of the rearing program. The system employs a novel energy efficient technique, using no chemical additives and producing no chemical wastes. The ammonia is converted to ecologically harmless nitrogen gas and water vapor, which are vented into the atmosphere.

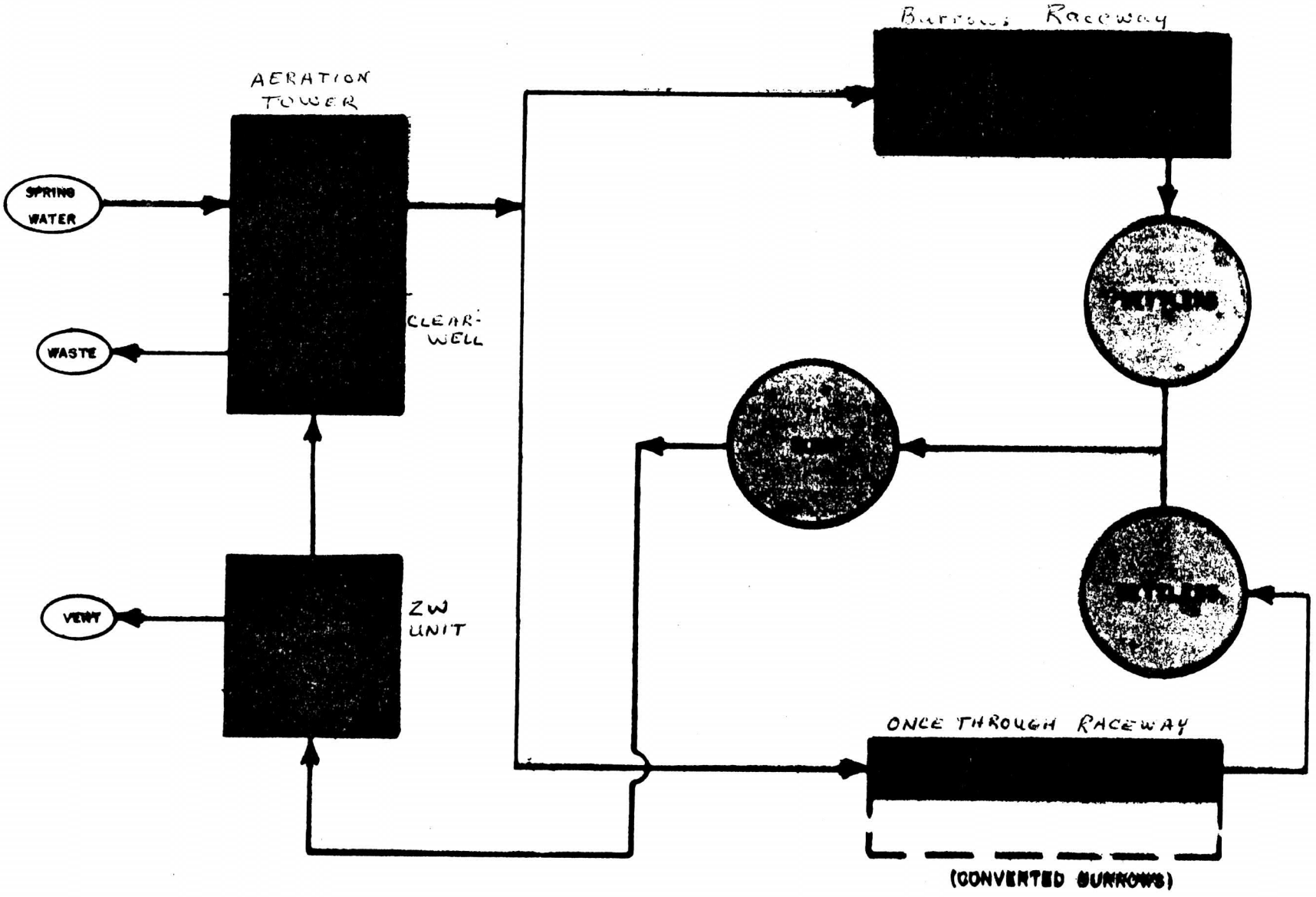
The Glenwood test program was carried out from February through July of this year. The system was balanced with equal flow and density indices in the two rearing units where the total average weight of the rainbow trout used in the study was maintained at approximately 6,000 pounds by sampling and splitting on a weekly basis. System analyses were conducted jointly at three laboratories operated by ATEC, Glenwood Hatchery, and Logan, Utah Experiment Station personnel.

Over 30,000 water, zeolite, and trout samples were analyzed. Biological concepts and criteria, including metabolic byproduct control and ammonia removal means and methods, were examined during the 5 month on-site joint-study. Fish production data was collected to tie-down cost and benefit analysis, as well as health and quality monitoring.

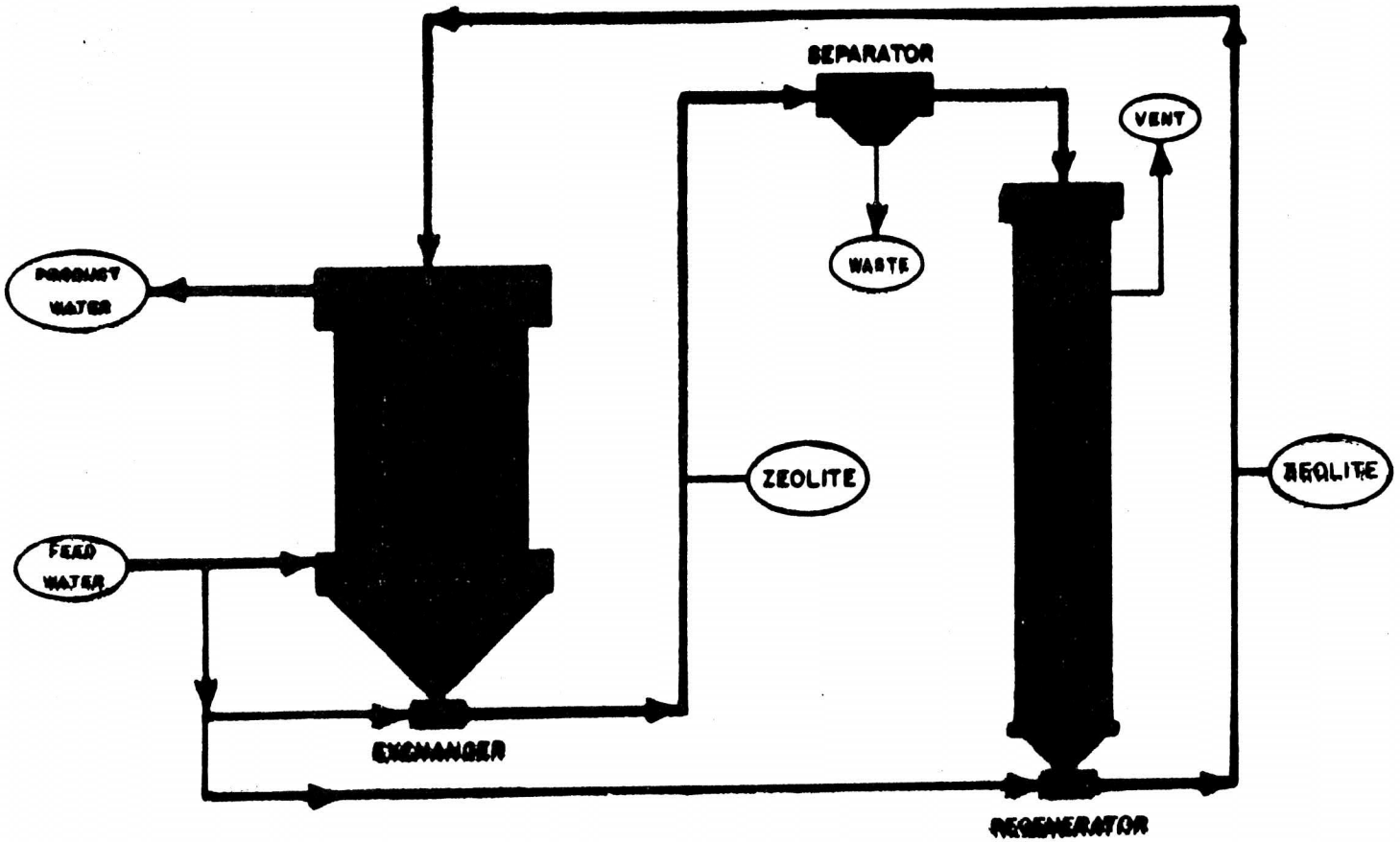
The graph on the screen shows growth characteristics for the rainbows in both rearing units over the same space in time. As shown by the lower curve, the rainbows reared in the Burrows pond developed poorly and many died, while the rainbows reared in the flow-through raceway flourished. The health assessment conducted at the program's end was very favorable where the rainbows' condition factor was 4,050 at 8 inches in length with a fat index of 2.5.

After the conclusion of on-site testing, conceptual biological and engineering workshops evolved to evaluate the results and data of the research conducted. Based on the beneficial results observed, parameters were established for the inclusion of the demonstrated technology into development planning for modification of the hatchery. Enriched-air injection was also included in the development planning as beneficial and feasible.

GLENWOOD DEMONSTRATION



ATEC ZW UNIT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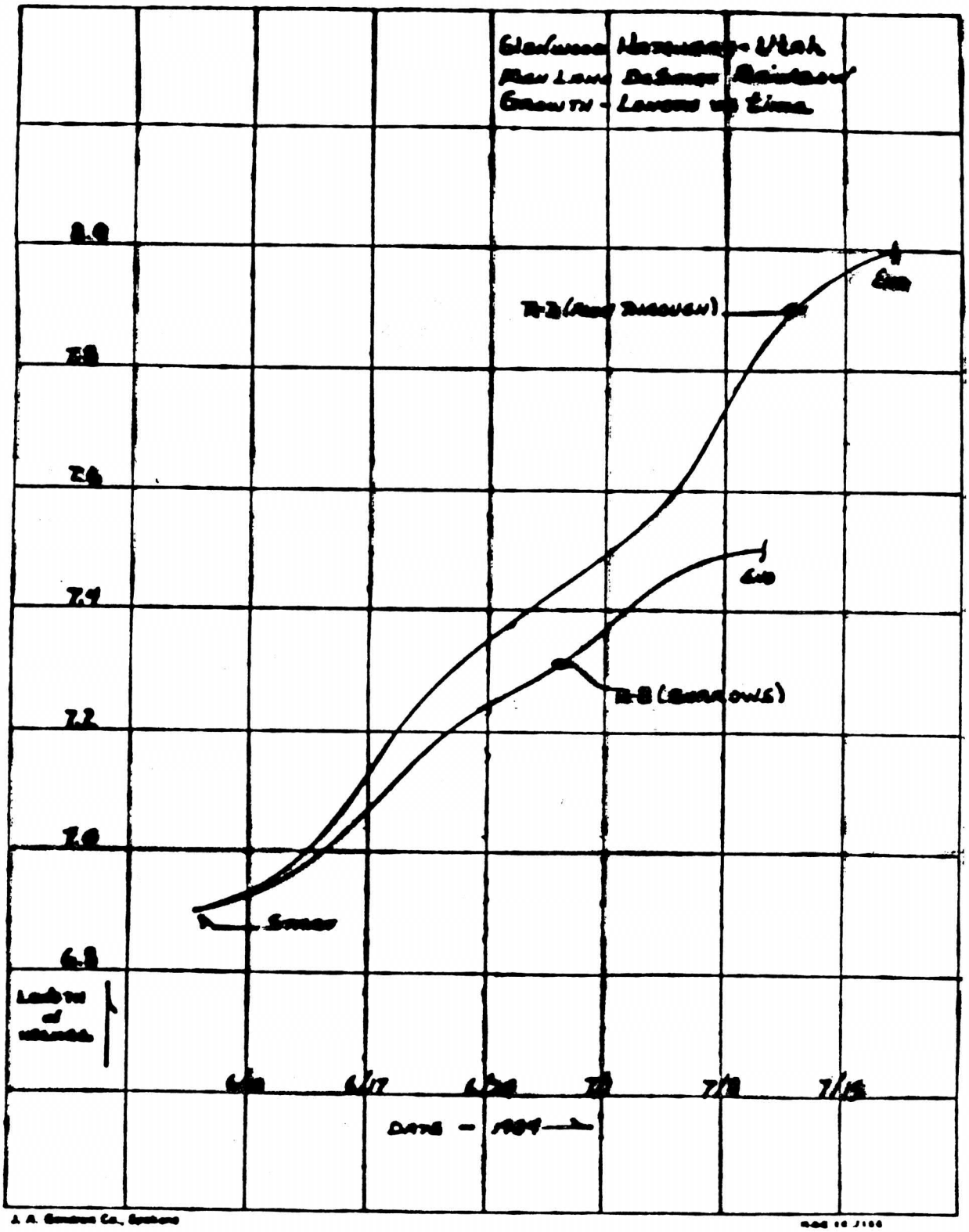
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A VENTURII APPLICATION OF A SUBMERSIBLE PUMP FOR GAS STABILIZATION IN HATCHERY WATER SUPPLIES USING A PACKED COLUMN

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ABSTRACT

Using a 2 horsepower pump mounted on a flanged 6 inch pipe in combination with a packed column; oxygen generation and nitrogen gas supersaturation were monitored. Under optimum submergence, and lift (head) conditions, flows of 1,100 gallons per minute and oxygen generation of 1.5 - 2.5 pounds per hour were accomplished at 17 degrees C.

In a typical hatchery use, well or spring water can be stabilized at greater than 90 percent 02 saturation and less than 105 percent N2 saturation with 8.1 amps of current draw when pumping at 1,100 gallons per minute.

Introduction

In 1983 the Bioengineering Section of the American Fisheries Society held a work shop on gas supersaturation. In August of this year a follow up session was held at the annual AFS conference. There are several areas around the country where gas supersaturation in hatchery water supplies continue to be a serious problem. In designing new facilities where the water supply has a high level of supersaturated N2 an efficient system for gas stabilization requires careful evaluation. Not only must the system be built at a reasonable cost, it should be cost efficient to operate.

At the request of the Flygt Pump Company* I designed a test configuration of a new submersible pump which operates on a venturii principle for pumping. The objective of the test was to evaluate the pumping capabilities of the unit and to evaluate the potential for oxygen generation and nitrogen stripping.

Methods and Materials

The pump used for this test was a Flygt model 4350, portable submersible mixer mounted as shown in Figure 1. This pump has a motor rating of 1.6 horsepower and is designed to operate on 3 phase, 460 volt power supply. A transformer was used to step the 220 volt power supply in the lab to 460 volts. The packed column system was a 4 foot diameter fiberglass pipe, 3

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* Trade names are used for reference only.

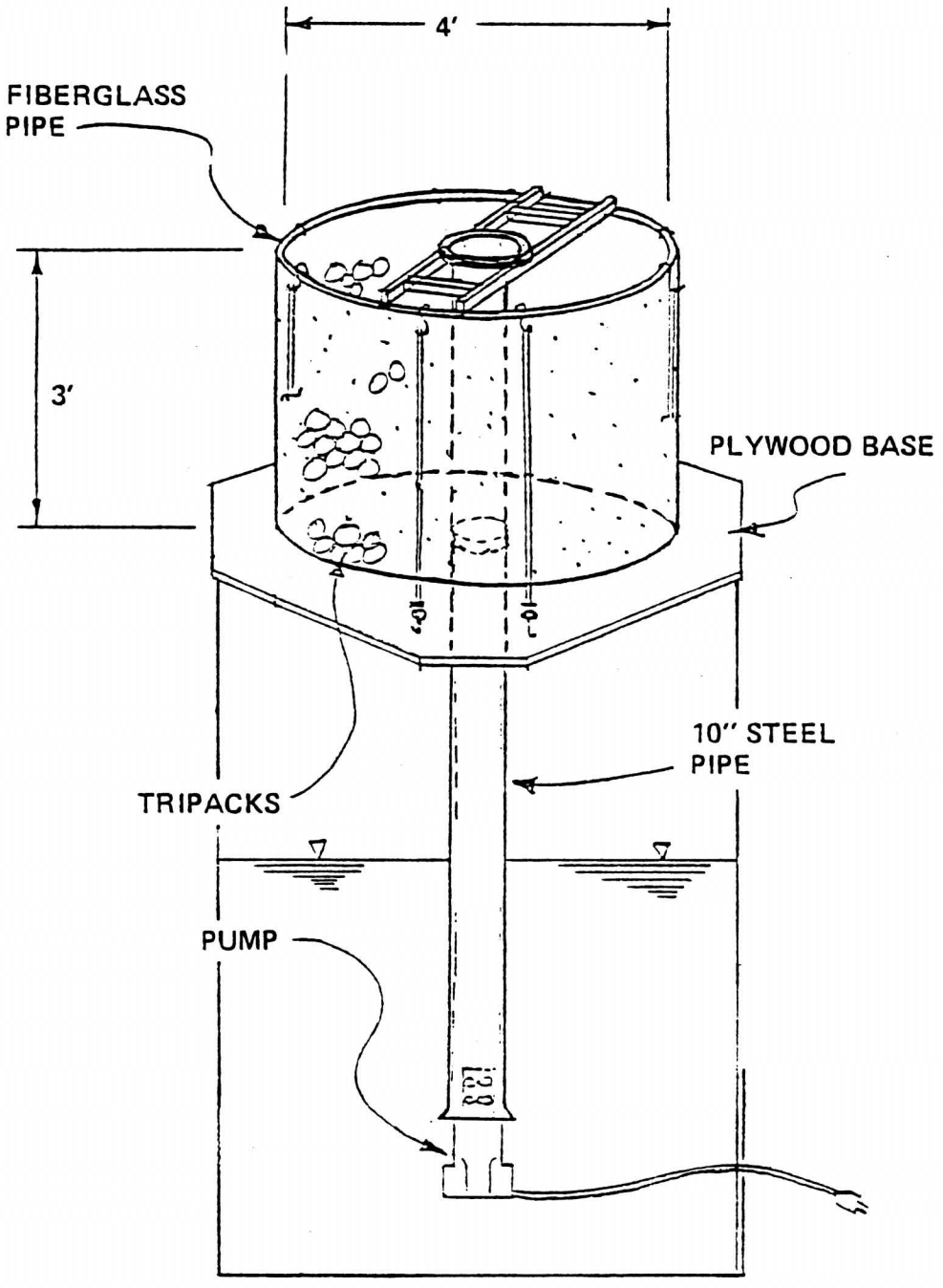

FIGURE 1
TEST CONFIGURATION

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feet in height and filled with 3 inch diameter Tri Packs.* Oxygen levels were monitored with a YSI D.O. probe. The oxygen levels in the tank were chemically reduced by adding sodium metabisulphite to the water and then buffering the solution with sodium bicarbonate.

The test cell was a 40 foot by 2 foot by 4 foot deep tank. An aluminum trough was placed under the discharge of the packed column to capture a portion of the effluent and measure dissolved oxygen.

Water Flow Rates

The water flow rates were determined by two methods. The first method measured the height of the splash at the lift pipe discharge and with the hydraulic formula for flow as a function of pipe size and height of the splash above the pipe, the flow was determined. This calculation was done for 4 different head (total lift) configurations.

A second method for calculation of flow was the use of an equation which was dependent on measuring current flow and dynamic head (total lift).

Oxygen Transfer

To establish the rate of oxygen transfer it was necessary to alter the dissolved oxygen level in the test cell chemically. To accomplish this a calculated amount of sodium metabisulphite, Na2S205, was mixed into the tank. The reaction involved is as follows:

$$2NaOH + O2 + Na2S205 \rightarrow 2Na2S04 + H20$$

Formula Weights: $O2 = 32$
$Na2S205 = 190$

Therefore 1mg 02 requires $\frac{190}{32}$ or 5.94mg Na2S205

or 1g 02 requires 5.94g NA2S205

At saturation of the oxygen in the water of the tank the following equation is developed:

$$\left(\frac{1g}{1000mg}\right)(2'x4'x40')(28.3\ /\text{cubic feet})(9.2\ mg/\ ) = 83.3\ g\ 02$$

$$(83.3g02)(5.94g\ Na2S205/g02) = 495\ g \text{ sodium metabisulphite to reach } 0.0mg/ \text{ of } 02$$

Sodium bicarbonate, NaHC03, was added to act as a buffering compound with the pH maintained at a level of 6.5 to 7.0. After the initial trial of reducing the D.O. levels, only approximate amounts of sodium metabisulphite were used and the D.O. levels were monitored until the desired oxygen concentration level was reached in the tank. When a desired oxygen level was reached, the tank was allowed to sit for twenty-four hours. The D.O. level and pH were checked and then the pumping test was started.

When the test was started the D.O. level in the tank and the discharge was measured at twenty minute intervals until the tank reached 100 percent saturation of D.O. The system was then allowed to run for a minimum of two hours to determine if supersaturation was occurring.

Gas Supersaturation

At the same time that oxygen levels were being monitored a tensionometer was on line to measure the gas saturation levels in the test tank and in the discharge. These measurements and calculations were accomplished using the technique described by Colt; The Physics of Gas Saturation, 1983. The gas saturation levels of N2 + Ar in addition to total gas pressures were established for the source before chemical treatment and during the test.

Results

The calculating of flow as a function of splash height is based on the equation:

$$Q_{GPM} = 5.68\ (K)\ (D^2)\ (H\ 1/2)$$

Where: K is a rate constant = 0.92
D is the diameter of the pipe in inches = 9.75
H is the height of the splash above the lip of pipe

The test cell was filled with water to the maximum height and the pump was started. When the flow had stabilized the height of the splash was measured. The water level in the tank was lowered 6 inches and the splash height was measured again. This was repeated at 4 water depths. At each of the test points the current draw of the pump was measured. The results of these test points are presented in Table 1.

Table 1

Total Lift (Head)	Water Depth	Height of Crown (splash)	Amps (single wire)
4.83'	2.5'	3-5/8"	9.0 (3.0)
4.33'	3.0'	4-5/8"	8.55 (2.85)
3.83'	3.5'	5-1/4" plus	8.10 (2.7)
3.33'	4.0'	5-1/2" minus	7.5 (2.5)

Using the general formula relating horsepower (hp) to flow (gpm) and total head, a second calculation of flow was made.

$$Q_{GPM} = \frac{(HP)\ (Efficiency)\ (3960)}{Head}$$

where:

$$HP = \frac{(volts)\ (amps)}{746}$$

$$Efficiency = 0.45$$

The results of these two calculations are presented on Figure 2. The two results show very close agreement given the opportunity for error in trying to measure the height of the splash above the pipe. Figure 3 demonstrates the significant increase in power when the total lift is increased.

The results of the oxygen transfer measurements are as follows:

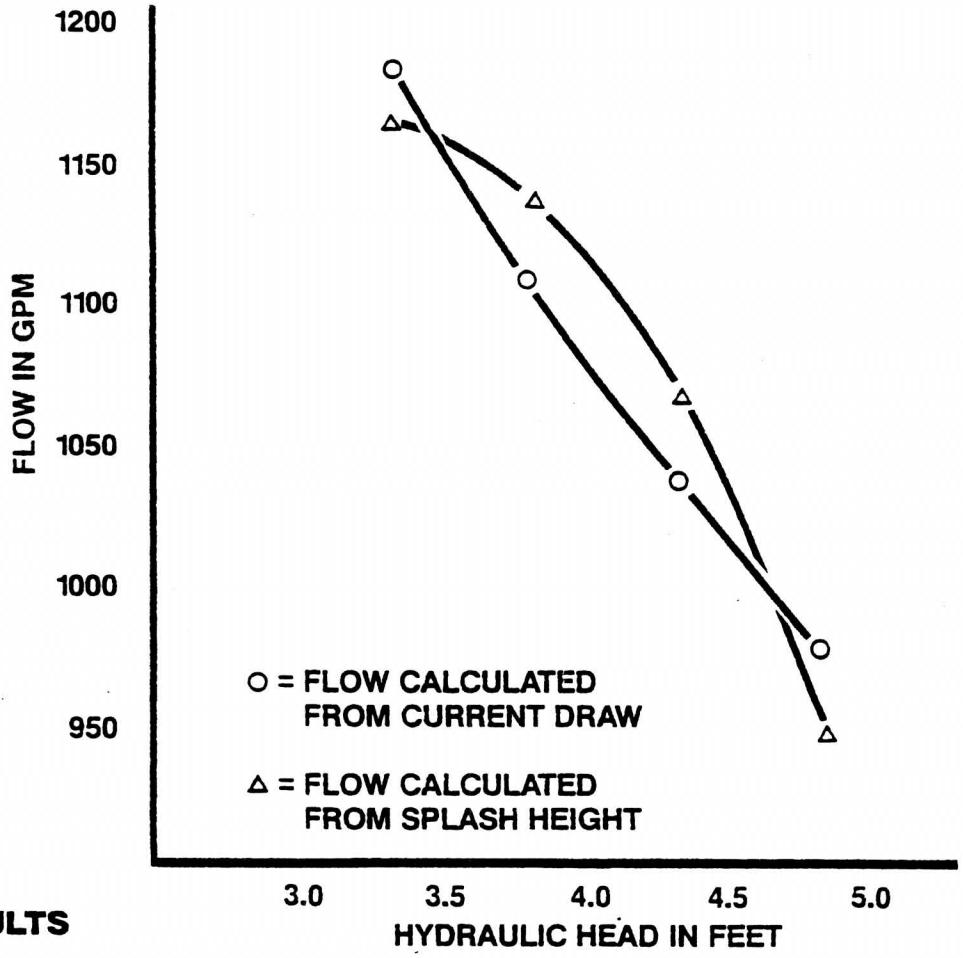
When the tank D.O. level was at 5.0 ppm the discharge D.O. was 9.6 ppm for a differential D.O. of 4.6 ppm. When pumping at a rate of 1,170 gpm this is equal to 2.3 LB of oxygen per hour in a reuse mode where the effluent has a dissolved oxygen level of 5.0 ppm.

If the D.O. differential is 2.9 ppm the resultant oxygen generation is 1.5 LB of oxygen/hour. This is enough oxygen to support 1,100 LB of trout at 10 fish/LB. in 50 degrees F. water (11,000 fish).

Conclusions

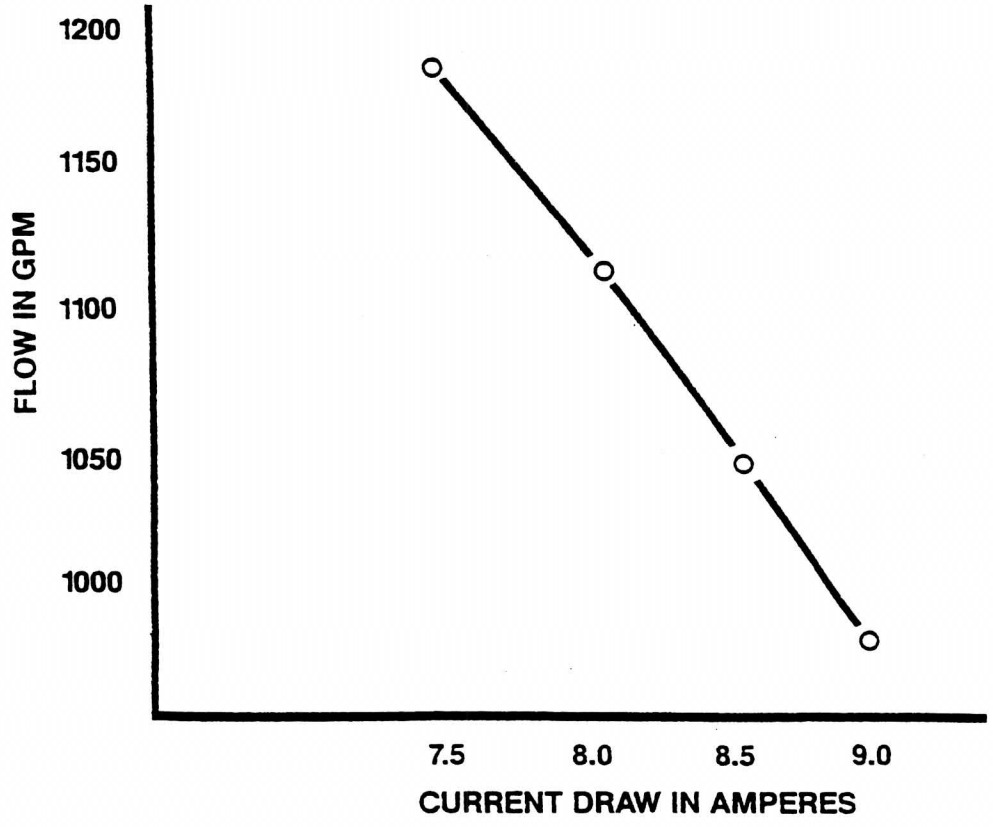
The use of packed columns for gas stabilization in a fish hatchery application is well documented. Hackney (1982) presents an excellent guide for design of a packed column. Additional data is presented by Hartman (1983) on the use of screen decks in lieu of packing medium. The screen deck system with the pump used in this test is shown in a potential application in Figure 4. If site geometry allows raceways to be elevated in relation to 1st pass and 2nd pass, the unit in Figure 4 could be modified to provide aeration between raceways rather than reuse within a given unit.

In the case of a spring system, the application as tested is ideal for gas stabilization in a sump or spring house prior to distribution to the raceways. The only change in configuration is a catch trough which directs the treated water away from the pump and allows untreated water to reach the pump. This type of configuration was tested at the Manchester Fish Hatchery in Iowa. In the application at Manchester nitrogen levels were reduced from 118 percent to 110 percent and oxygen was increased from 8.5 ppm to 9.5 ppm. The higher level of nitrogen after treatment may have been due to the large diameter medium. However, the effectiveness of the system is clearly shown by the change in the level of D.O. Further testing of the nitrogen stripping capability will be done using smaller media.



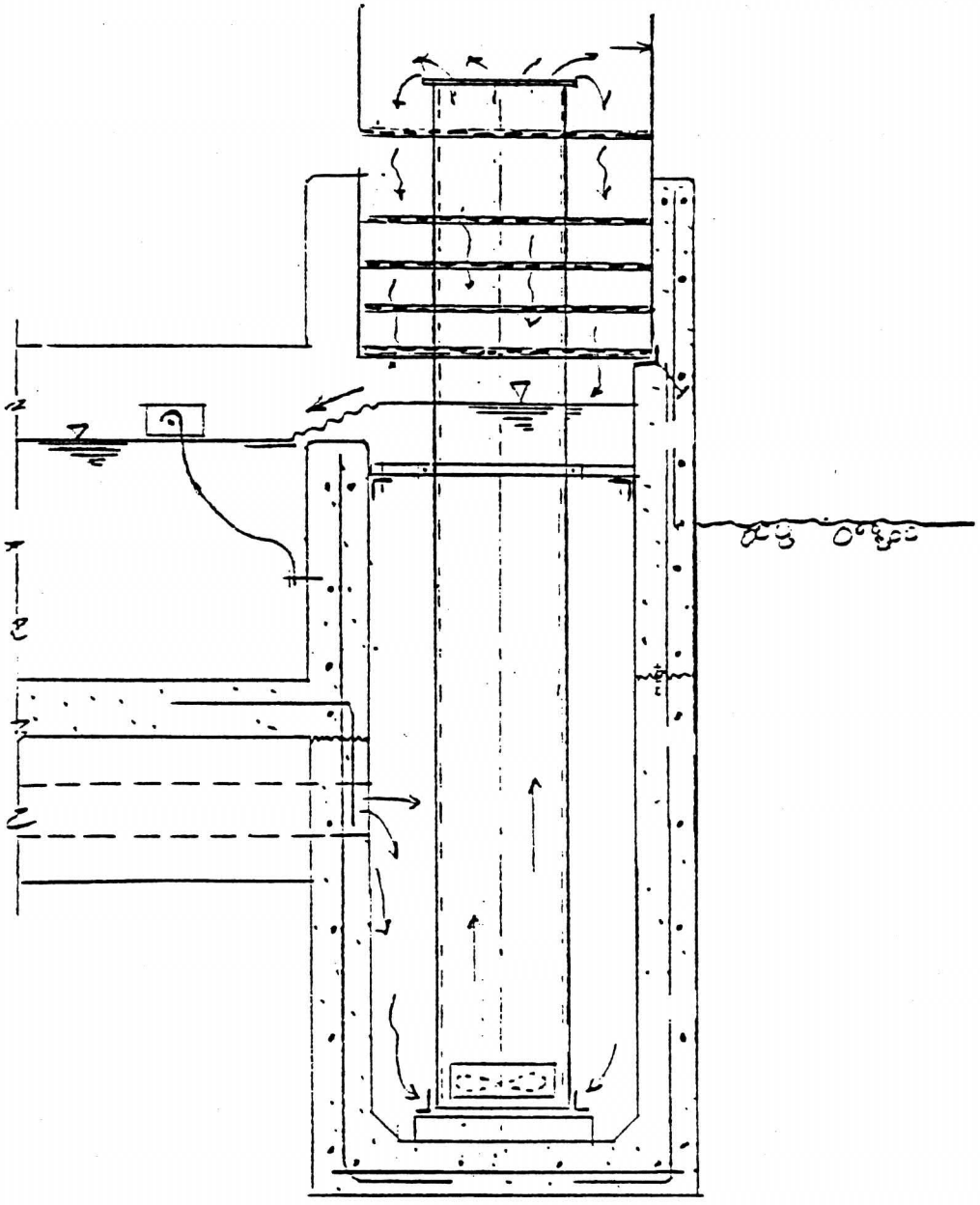
WATER FLOW VS. HEAD TEST RESULTS

FIGURE 2



WATER FLOW VS. AMPERES TEST RESULTS

FIGURE 3



POTENTIAL RACEWAY REUSE DESIGN

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FIGURE 4

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ENGINEERING ASPECTS OF THE OZONE PILOT SYSTEM AT COWLITZ TROUT HATCHERY

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Department of Public Utilities, Light Division

ABSTRACT

Ozone is a powerful germicide and oxidant that has unique engineering requirements. Research indicates that water ozonization, when it is properly designed, appears to be potentially advantageous to aqua-culture application. This report focuses on the engineering aspects of the ozone pilot system at Cowlitz Trout Hatchery: the design, equipment selection, materials, monitors, safety and reliability of the ozone system.

IHN Virus and Ceratomyxa Shasta Protozoan have been responsible for the high fish mortality in hatcheries in Alaska, the Pacific Northwest, and California in the last five years. According to Roy Rathvon and Jack Tipping, Cowlitz Trout Hatchery probably lost 80 percent in 1980 and 40 percent of the fish product in the last three years.

In the last two years, the Washington Department of Game and Tacoma City Light made a joint effort to solve this fish disease problem at the Cowlitz Trout Hatchery. As an engineer of this team, I studied, and discussed the problem with many users of chlorination/dechlorination, ultra-violet, as well as ozone water treatment systems. I found that: (1) chlorination-dechlorination systems would be able to destroy the subject virus and protozoan at 1.5 ppm in 100 minutes or 3.8 ppm in 60 minutes. However, fish are very sensitive to chlorine and it might require manpower around the clock to monitor the system. (2) Ultra-violet systems would be effective if clear water was always available at the hatcheries. (3) An ozone system would be able to destroy the IHN virus and C. Shasta at the low ozone dosage of from .5 ppm to 3 ppm, depending on water turbidity. For the water condition at Cowlitz, we decided that an ozone water treatment system would be feasible to control the disease and the most cost effective. Our first step was to set up a pilot ozone system so that we could verify the ozone dosage required to kill the disease.

This paper will focus on the designing and setting up of this pilot system. It is our first progress report on the system. We will probably have more information to report when we conclude our test; hopefully at the next fish culture workshop.

OBJECTIVES OF THE PILOT SYSTEM

The objectives of the pilot system at the Cowlitz Trout Hatchery are to detaermine:

(1) The lowest ozone dosage required to destroy IHN virus and C. Shasta Protozoan during clear and turbid water conditions. This will provide necessary data to properly size the ozone equipment for the production system that treats a water flow of approximately 25,000 GPM or 36 MGD.

(2) The short- and long-term effect of ozone on the fish.

(3) The reliability of ozonator, monitors, and other equipment.

(4) Test methods that would permit measurement of the low ozone residuals in the water.

(5) The suitable materials for piping, valves, seals, etc.

THE PILOT SYSTEM

The pilot system at Cowlitz consists of: (1) A turbine pump that has a capacity to provide a water flow of 100 GPM--50 GPM for the control, the other 50 GPM for the treated water, (2) a contact tank, (3) a retention tank, (4) an aeration tank, and (5) eight fish troughs that are 9" high X 12" wide x 15' long--four of the troughs receive raw river water for control, the other four receive treated river water for the test fish, (6) an ozone monitor, a spectro-photometer and a turbidity meter.

For the treated water side, river water is pumped to the contact tank, in which high concentrated ozone air is mixed into the water through four diffusers. Thereafter, the ozonated water, by gravity, flows to the retention tank, then to the aeration tank for de-ozonation before it goes to the fish troughs.

THE OZONE GENERATOR

The ozonator used in this pilot system is an OREC model SP 38-4R. It has four water-cooled corona cells and a 2-lb/day capacity at 2% ozone concentration. The ozone output can be varied from 1/2 lb/day to 2 lb/day by controlling the power inut to the corona cells. The ozonator is fed by two oil-less air compressors. Under normal operating conditions both compressors operate on an eight-minute cycle. However, one compressor can handle the load if the other unit is out of service.

The air (feed gas) applied to the ozonator is treated extensively to remove particulate matter and moisture. The treatment includes passage of the air through a prefilter before it is compressed up to about 65 psig. Thereafter, it is cooled through a water-cooled cooler and then dried by a silica gel air dryer to lower the air temperature dew point to -60°F. The outlet pressure is reduced to approximately 15 psi and passed through a fine filter to prevent carry-over particulate to the corona cells. This perfectly clean and dry air is now ready to be applied to the corona cells or dielectric tubes, in which the high intensity corona discharge, produced by a high voltage electric field, will convert a portion of the oxygen in the air to ozone.

The ozone concentration and efficiency of an ozonator is affected by moisture, particulate content in the feed gas, as well as the power applied to corona cells.

A control system that includes indicator lights and a sound alarm with silence switch is used to monitor the ozone generator and air compressors. It will shut down both ozone generator and air compressors automatically under any of the following conditions:

- Any panel or door of the ozone generator is open.
- Insufficient air flow to the ozone generator.
- Excessive moisture in the feed air.
- Cooling water flow below minimum required flow.
- Excessive temperature of the ozonated air leaving the ozone generator.

THE CONTACT TANK

This is a stainless steel tank 24 ft. high and 2 ft. in diameter with a baffle in the middle. The operating water depth is about 22 feet and the residence time is about five minutes at a flow of 50 GPM. Ozonated air is diffused into water through four (two on each side of the baffle) air stones, each are 2-1/2" O.D. by 8" in length by 3/8" thick, and are of the 80 micron pore size. The baffle makes the ozonated air counterflow with the water on one side and concurrent flow on the other side. I found that efficiency of this mixing method is approximately 90% to 95%.

Another type of diffusion system that uses air jets in water pipe to mix ozonated air into water was also available. However, the efficiency of this mixing device is only about 65%.

THE RETENTION TANK

The retention tank is a fiberglass tank, 3 ft. in diameter by 12 ft. in length. There are five baffles inside the tank to provide the maximum retention time of 15 minutes at 50 GPM. Extra pipe and valves were installed so that the retention time can be varied from 0 to 15 minutes. This will be used to determine the effectiveness of the ozone system at the minimum ozone dosage and retention time.

THE AERATION TANK

The aeration tank is also a fiberglass tank. It is an open-top, vertical tank approximately 3 ft. in diameter by 8 ft. high. When the system was first put in operation, three plastic grids were used to break up the water to increase air-water contact and release ozone gas from the ozonated water. This was not satisfactory. The tank efficiency was then improved by adding packing materials in the tank and is being still further improved by the addition of a forced-air blower.

There are several different designs that appear to be available for de-ozonation. At Sea-World in San Diego, the contact tank is 2' in diameter and 10' high and is installed in the middle of a 12' x 12' x 12' concrete reservoir that is filled to about an 8' depth with packing materials. The ozonated water overflows out of the contact tank and trickles down through the packing materials. Other examples of aeration towers are located in Tacoma. They were designed by CH_2M Hill and built for EPA to remove trichloroethane, a contaminant in the well water system in the Tacoma area. These towers are approximately 12' in diameter by 20' high. Fans are used in these towers to increase air-water contact. Each has a capacity to treat a water flow of approximately 5000 GPM.

PIPING MATERIALS

PVC-Type I was used in the water side of the system. Valve bodies are also PVC, but the valve disc or seats are stainless steel or Buna-N material.

For the ozonated air side, teflon tubing and compression-type teflon tubing fittings are used. Valves are 316 S.S.

MONITORING EQUIPMENT

An ozone monitor, OREC Model DM 110, is used to monitor the ozone concentration from the ozonator and also the off gas from the contact tank. A Bausch-Lomb Spectronic 70 spectro-photometer is used to measure the ozone residual in the water. With this data we can determine the ozone produced by the ozonator, the ozone demand of the water, as well as the efficiency of the diffusers.

A turbidity meter from Hach Company is also used to monitor the turbidity of the water.

SAFETY OF THE OZONE SYSTEM

Ozone is very toxic and extremely corrosive when it comes in contact with many construction materials, especially natural rubber.

A person is when exposed to ozone can detect the ozone by its smell even at the low concentration of .01 to .05 ppm. Ozone gas smells like watermelon. The current OSHA standard for ozone is .1 ppm in the air over an eight-hour workshift. At low concentrations, less than 1 ppm, ozone produces local irritation of the eyes and mucus membranes. Concentrations of 2 to 3.7 ppm caused the sensation of irritation to human eyes within six minutes. However, damage from low-level exposure is typically reversible in healthy individuals.

PROBLEMS

The system has been in operation since August 1984. The ozonator appears to be simple and easy to operate. It is fairly reliable, eventhough we have to shut it down from time to time to replace parts and/or to make adjustments. So far we have had the following problems with this system:

(1) Excessive vibration of the compressor - it may be the machine is not secured to the floor properly.

(2) Excessive noise from the compressor (being checked on).

(3) The ozonator needs some fine-tuning because two of the corona cells seem to produce more ozone than the other two cells.

(4) Determining the low ozone residual. It appears that our ozone standard is not really accurate when the concentration is less than .01 part per million.

CONCLUSION

In summary, I think that even though more tests are needed to verify the effectiveness of ozone in controlling the IHN virus and C. Shasta protozoan, the ozone water treatment system is technically feasible for a production system. I hope that our work on this pilot system will contribute some useful information that would be applicable for a fish enhancement program for you.

Thank you,

Are there any questions?

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A TEST OF POTENTIAL POND AND RACEWAY APPLICATIONS OF THE RAMCO MAT-3* AERATOR AT VARIOUS DEPTHS, AIRFLOW RATES AND STATIC TUBE LENGTHS.

Wayne J. Daley

ABSTRACT

A test was conducted to determine the pumping rates for the Ramco Mat-3, 8 inch and 12 inch aerators at 6 feet, 8 feet and 12 feet of water depth. In addition, flow rates were checked with an extension to the static tube above the counter rotating blades. The flow rates varied from a low of 150 GPM when operating in 6 feet of water with an air flow rate of 8 CFM to a high of 680 GPM when operating in 12 feet of water with an air flow rate of 27 CFM.

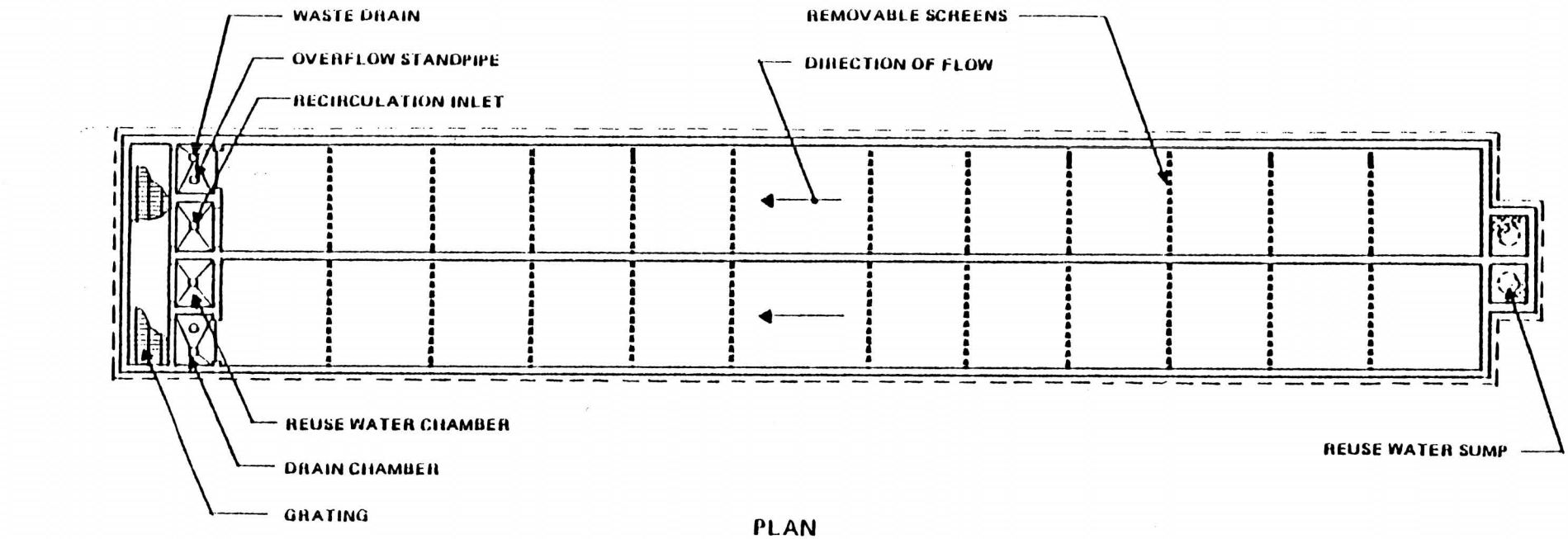
INTRODUCTION

In order to verify that the pumping requirements for the air lift pumps, designed for raceway reuse at Milford Hatchery, Milford Reservoir, Kansas, would be satisfied a test was conducted. The requirements for the pumps as they are in operation in the raceways calls for 400 GPM of reuse flow with a maximum of 32 CFM of air. Previous installations using helix coil air lifts have been less than exceptable. The raceway configuration for reuse is shown in figure 1. The intent of this system is to provide oxygen generation during critical loading periods as well as providing for a reduced volume of water when treating for disease. In the treatment for disease new water is stopped, or reduced, and the raceway water line is lowered to the top of the air lift unit leaving the pump completely submerged.

METHODS AND MATERIALS

The air lift equipment for this test included an eight (8) inch and a twelve (12) inch diameter Mat-3 airlift equipped with a flow meter. Low pressure high volume air was supplied by a 3/4 horse power and 1-1/2 horse power motor and blower. These units were connected in series and the 3/4 HP unit was only used when more than 20 CFM of low pressure air was needed. Figure 2 shows the installation of the 12 inch unit without an extension.

The test cell was a swimming pool with a sloping bottom which changed from 3 feet of depth to 12 feet of depth. The unit was placed perpendicular to the side of the pool to allow the air lift to be placed in a vertical position.



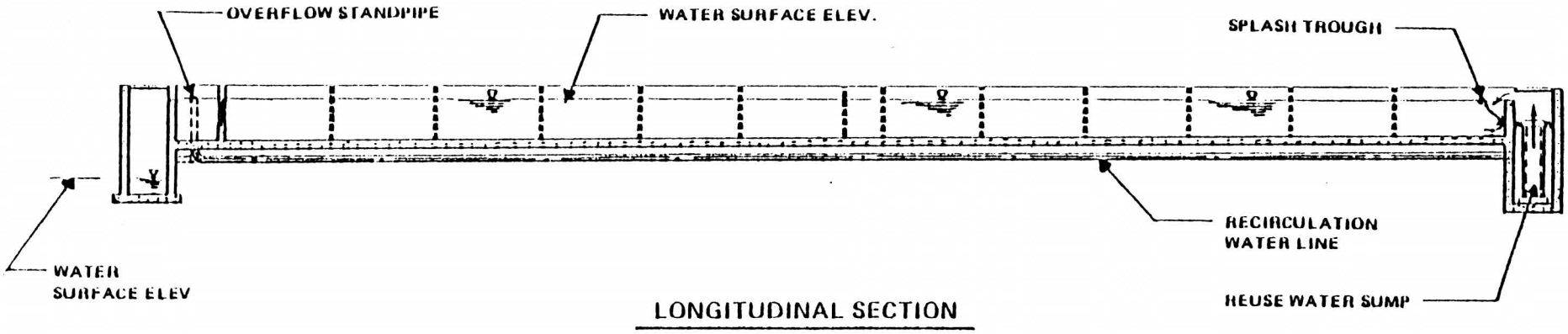


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FIGURE 1
RACEWAYS
TYPICAL PLANS & SECTIONS

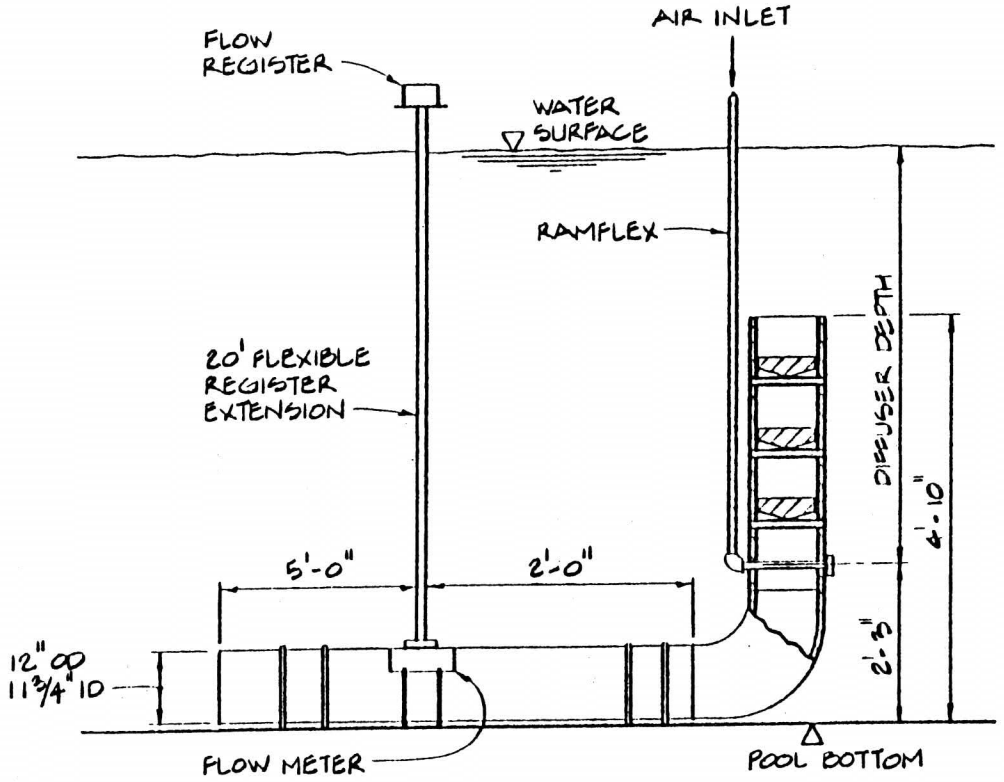

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FIGURE 2
MAT-3 AERATOR

The water flow meter was calibrated to measure 10 GPM increments from 0 to 800 GPM and the airflow meter was calibrated to measure 4 CFM increments from 0 to 56 CFM of low pressure air. For every test point the air pressure was also recorded using a low pressure gauge calibrated from 0 to 25 pounds air pressure.

For each water depth and air lift configuration the following procedure was used; the large air pump was started and the valve to the air line was opened until the air flow was stabilized at 4 CFM of air.

The unit was allowed to run for 2 to 3 minutes and then the air pressure and water flow rate were recorded. This process was repeated for each increment of 4 CFM of air up to 32 CFM or until an air pressure of 4.8 psi (air pump limit) was reached.

An additional test configuration was run at the 8 foot and 12 foot water depth. This consisted of an extension of 24 inches to the static tube length (Figure 3).

RESULTS

Figure 4 is a graph of water flow rate versus airflow rate for three depth configurations and one depth with an extension to the diffuser. The rate of change for all the configurations is uniform and approaches an asymtote at the high air flow rates. There is a significant shift in the pumping rate when the 24 inch extension is added, with the rate of water flow increasing from 530 gallons per minute to 680 gallons per minute at 27 CFM of air flow. This was the highest flow rate tested.

For the test configuration intended to match the installation in the raceways at the Milford Hatchery, the desired water flow rate of 400 gallons per minute is reached at an air flow rate of 14 cubic feet per minute. This is a 56 percent reduction in the amount of air specified to provide the required reuse flows in the raceways and will provide a substantial cost savings in energy consumption.

A plot of air pressure versus water flow rate for several configurations is presented on Figure 5.

The results shown on this curve clearly point out the sharp reduction in air pressure required for the configuration if the diffuser is at 4.9 feet of water depth. When a curve is drawn along a constant air flow line of 12 cubic feet per minute the air pressure changes from 1.75 psi at 4.9 feet of water depth to 4.0 psi at 10.9 feet of water depth. This is equivalent to a 1/4 horsepower change in energy consumption. This does not mean that the same transfer of oxygen will occur as there is less contact time with the water and less water pressure acting on the air thus reducing the driving force to increase the saturation level of oxygen in the water.

The 8 inch diameter test results are shown in Figure 6. The maximum water flow rate obtained with the 8 inch unit was 260 GPM at a diffuser depth of 8.3 feet. Figure 6 shows the same trend as Figure 5 in relation to efficiency of pumping with a reduced diffuser depth. However the 8 inch static tube becomes air saturated rather quickly and a water flow rate in

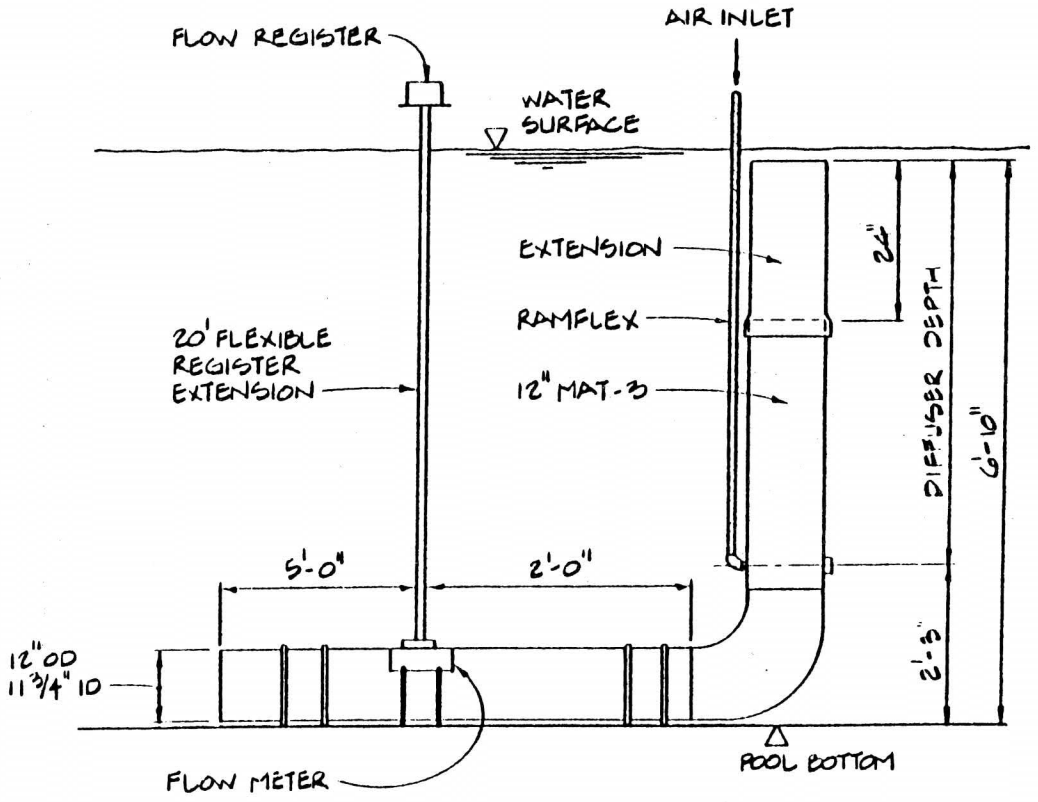

FIGURE 3
MAT-3 AERATOR
WITH EXTENSION

KCM

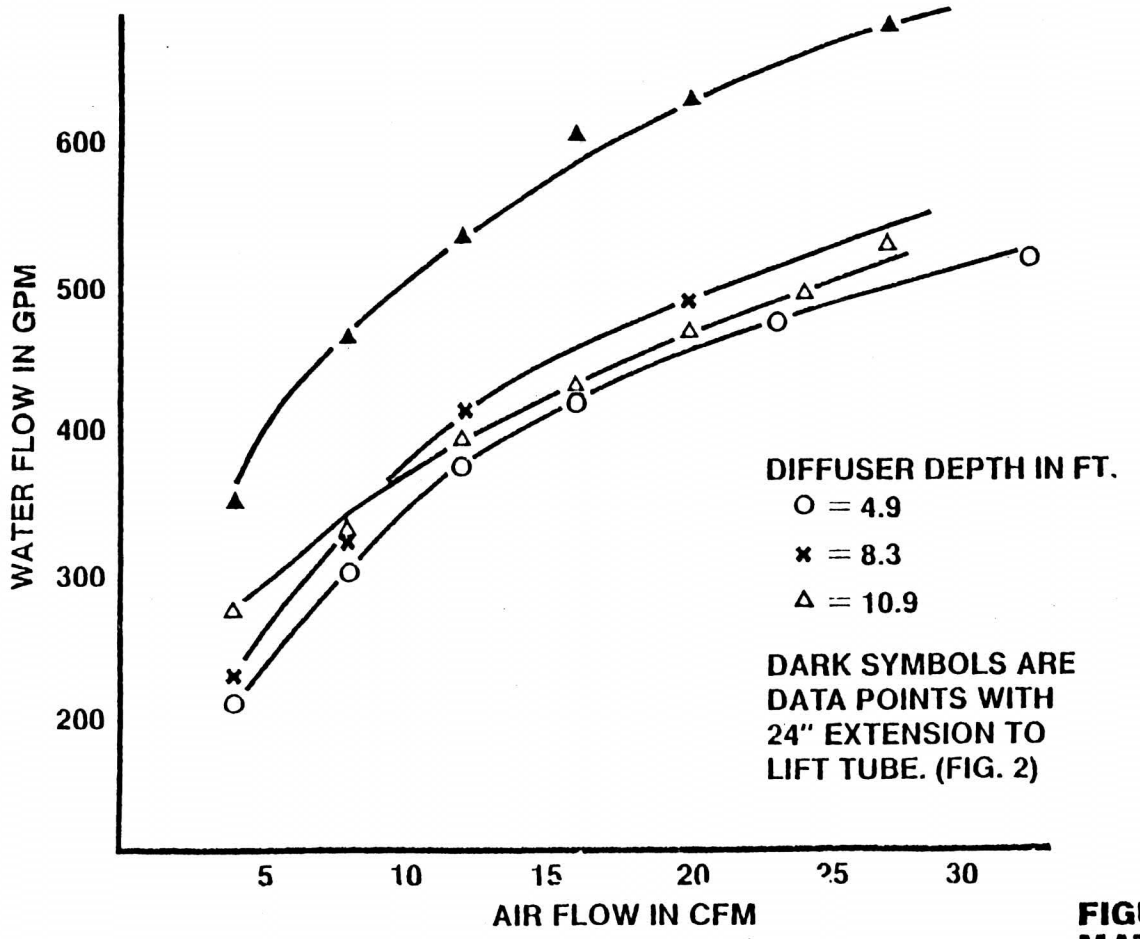

FIGURE 4
MAT-3
AIR LIFT PUMP

KCM

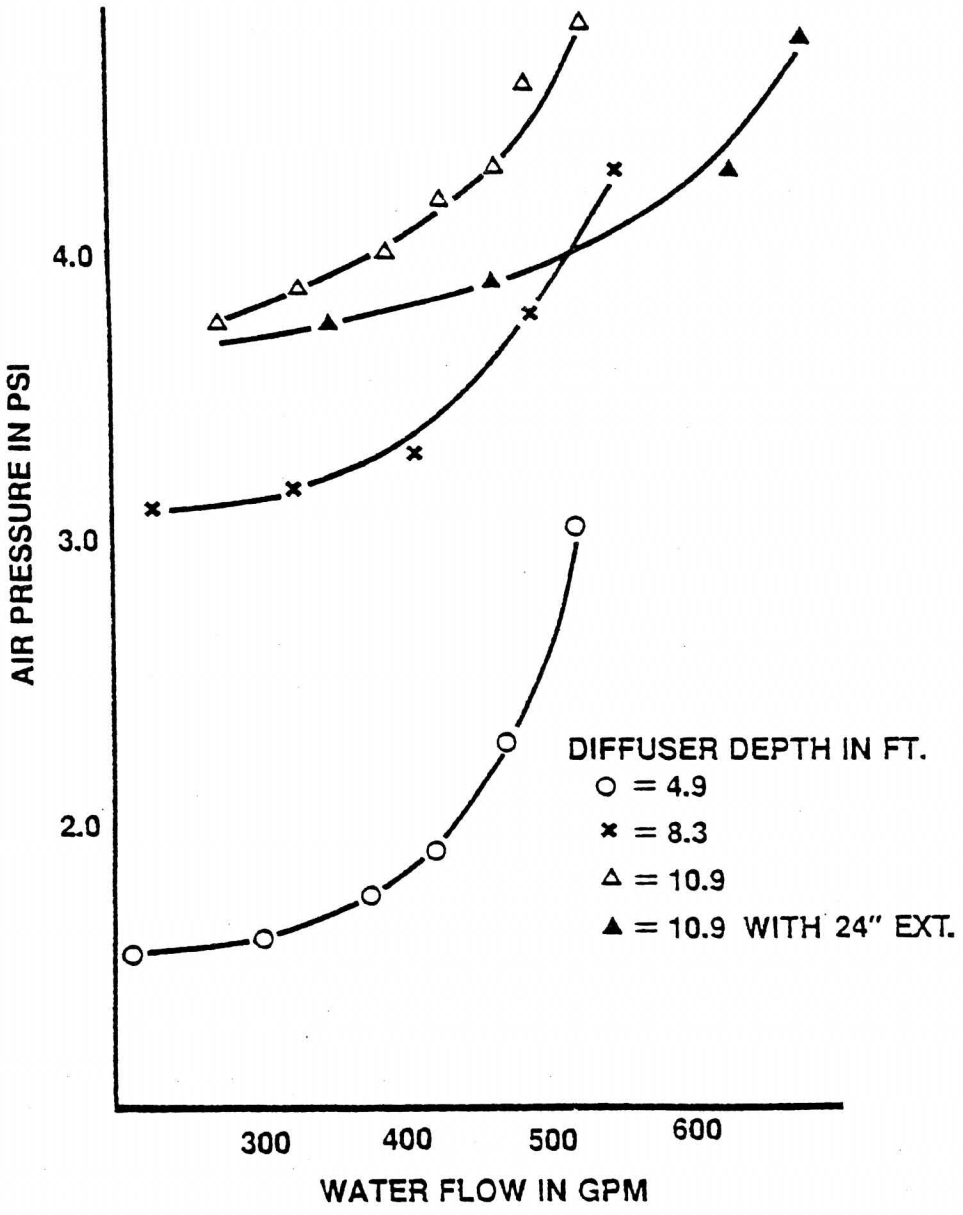

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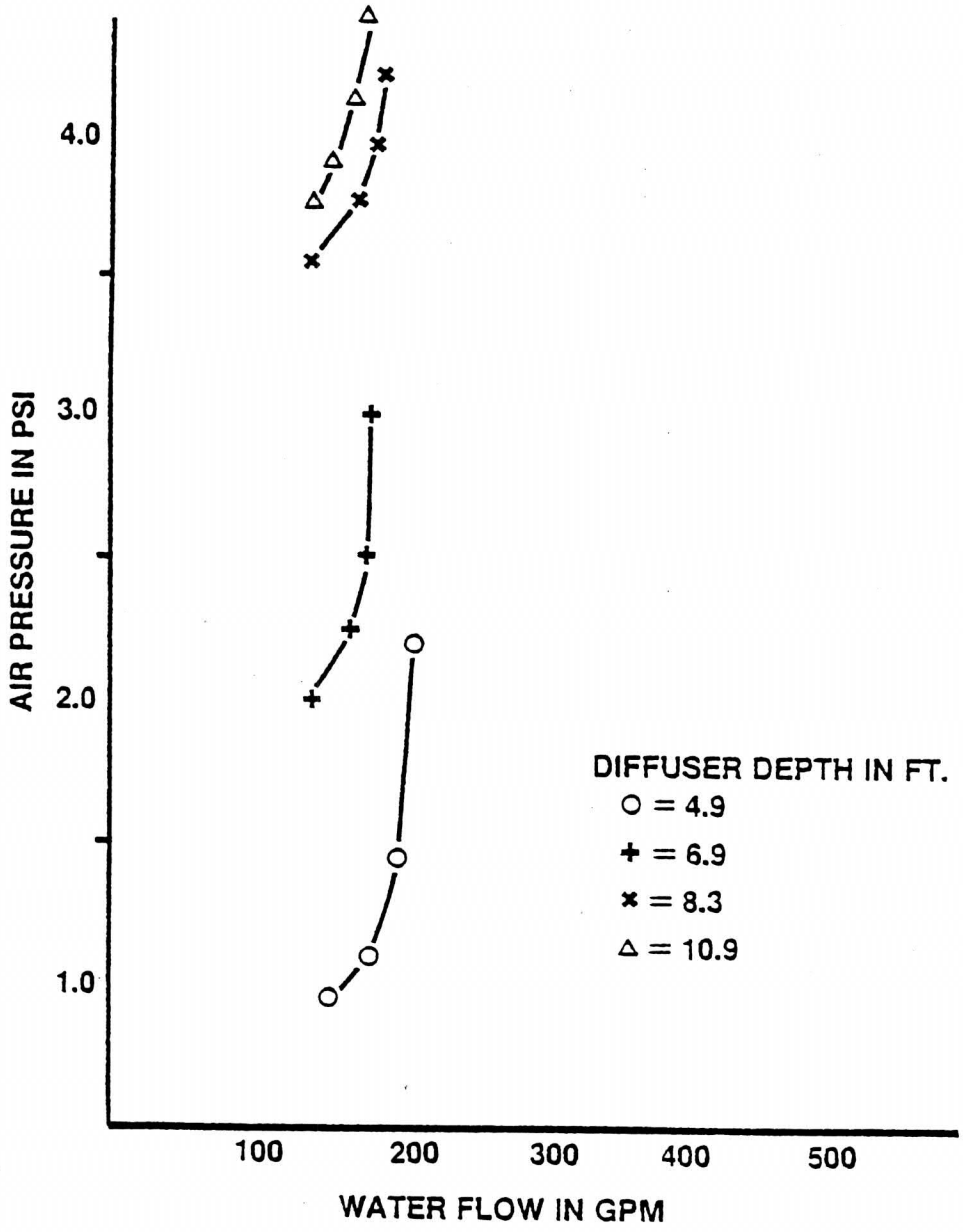
FIGURE 5
MAT-3
AIRLIFT PUMP



KCM

FIGURE 6
8" MAT-3
AERATOR

excess of 180-210 GPM cannot be accomplished without an extension to the static lift tube or a change in the diffuser orfice configuration (the 260 GPM case above).

CONCLUSION

The test site for this evaluation of the Mat-3 was only intended to provide flow rates, as oxygen generation evaluation was not practical. However, a previous test of the Mat-3 for oxygen generation (DALEY, 1983) together with this test provide the necessary data for a final evaluation. In addition there are several observations that relate to potential use in pond culture.

In the previous test of oxygen generation rates, the 12 inch Mat-3 provided 0.25 pounds of O2/hour at a water flow rate of 160 GPM. At 400 GPM the oxygen generation will be in excess of 0.63 pounds per hour in the raceway configuration at Milford. This does not account for oxygen transfer at the water to surface interface.

In the case of the application of this unit to pond aeration and destratification there are several items to consider.

An article by Boyd (1982), on a test of an aeration device in a 1 acre pond, commented an the importance of mixing the entire pond rather than aeration at discrete points. In the test of that unit a 1 acre pond is completely mixed in approximately 45 minutes with a 2 hp motor.

Busch et.al. (1978) evaluated the use of small paddle wheel aerators in a pond for mixing and aeration purposes. The results of that test, where 6 1/4 hp motors resulted in complete mixing of a 1.4 acre pond in 5 hours (6-1/4 hp units = 1-1/2 total hp).

Using a single 12 inch Mat-3 unit equipped with a 90 degree elbow at the water surface, a 1 acre pond would be mixed in 1 hour with an equivalent energy use of 1/2 hp. This is based on the test result with the diffuser in 4.9 feet of water operating at 400 gallons per minute and 12 CFM of air flow at 1.75 psi.

Parker (1981) released a technical note describing a series of pond aeration tests using airlift units. In this note it is emphasized that "under most conditions found in shallow ponds and tanks very little of the oxygen contained in a bubble of atmospheric air will diffuse into the water." This statement is supported by several independent researchers; Colt, Speece and Buss.

The combined effects of direct aeration and the water surface - air interface transfer of oxygen needs to be evaluated in a controlled environment to develop the most efficient system sizing for use of the Mat-3 in pond culture. Based on the preliminary results of this test it appears that the Mat-3 is more efficient than surface aerators or paddle wheel aerators when used in shallow fish ponds.

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OPERATION FISH RUN: 1984 TRANSPORT SUMMARY

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ABSTRACT

Operation Fish Run is a program operated by U.S. Army Corps of Engineers to increase the survival of migrating salmon and steelhead smolts by transporting them downriver in barges and trucks. Idaho's role in Operation Fish Run is that of biological oversight of fish collected at Lower Granite Dam. Smolt collection and transportation at Lower Granite began on March 30 and continued through July 26, 1984. A total of 2,052,006 smolts were collected including 1,114,741 steelhead, 925,857 chinook, 11,152 sockeye and 256 coho. Twenty-eight truckloads and 40 bargeloads of fish were transported from Lower Granite this year carrying a total of 2,046,020 smolts.

INTRODUCTION

In 1970 the National Marine Fisheries Service began experimenting with the downstream transport of salmon and steelhead smolts as a means of increasing the survival of Snake and Columbia River chinook and steelhead stocks. Initial research was conducted at Little Goose Dam with experiments beginning at Lower Granite Dam in 1975 and continuing through 1979. In 1980 under the direction of the U.S. Army Corps of Engineers, Operation Fish Run became fully operational, with fish being collected and transported from Lower Granite, Little Goose and McNary dams to release points below Bonneville Dam. In recent years this program has provided for the transport of up to 65% of the total outmigration of chinook and steelhead smolts in the Snake River system.

SYSTEM OPERATION

The collection system at Lower Granite is designed to bypass the smolts around the dam to a collection facility where they are loaded on trucks and barges for mass transport downriver. As the migrating salmon and steelhead smolts approach the Lower Granite forebay they are attracted toward the turbine intakes by the strong flow of water. A series of 18 submerged travelling screens deflect the smolts away from the turbines and into the gatewell slots. The fish exist the gatewell through any one of 72 orifices entering the bypass gallery. From here the fish enter a 42 inch pipeline which carries them a distance of 1300 feet to the collection facility where electronic counters record the number of fish collected. A series of pipes and flumes then carry the fish either directly to an awaiting barge or

to one of 10 holding raceways where they can be held until a truck or barge becomes available. Once the smolts are loaded, the trip from Lower Granite to the release site takes approximately 8 hours by truck and 36 hours by barge.

IDAHO'S ROLE

Idaho took an active role in Operation Fish Run in 1981 with the formation of the Fish Transport Oversight Team (FTOT). This team is comprised of state, federal and tribal agencies whose duty it is to develop transport guidelines and coordinate the activities of the transport program. As part of FTOT, Idaho each year stations a biologist at Lower Granite Dam during the peak migration period (April 1 to July 1) to provide biological oversight to the transport program and assure that the fish are handled with a minimum amount of stress. The primary responsibilities of the state biologist are to supervise the sampling and handling of all fish and to evaluate the general condition of the fish at various points in the collection system. This requires that the state representative conduct daily descaling checks on sample fish and periodic spot checks of fish throughout the system. He must also monitor all handling and loading operations, paying particular attention for signs of unusual behavior or distress. To prevent unnecessary stress, FTOT guidelines dictate that raceway loading densities do not exceed 0.5 lbs./gal. and that truck and barge loading densities do not exceed 0.5 lbs./gal. and 5 lbs./GPM inflow respectively.

1984 COLLECTION AND TRANSPORT

Collection and transport operations at Lower Granite began on March 30 and continued through July 26, 1894. Spring runoff in the Snake River system was well above average in 1984 providing excellent conditions for the downstream movement of migrating juveniles. The major peaks of smolt migration occurred on May 2 when 74,712 chinook smolts were collected, and May 17 when 80,195 steelhead were counted through the collection facility. A secondary peak occurred on June 16 when 7,317 chinook smolts were collected.

A total of 2,056,006 smolts were collected at Lower Granite this season including 1,114,741 (54.3%) steelhead, 925,857 (45.1%) chinook, 11,152 (0.5%) sockeye and 256 (0.1%) coho. Trucks transported a total of 177,543 smolts representing 14.7% of the chinook and 3.5% of the steelhead for the entire season. Barge transport accounted for 1,868,477 smolts or 91.3% of the total transport from Lower Granite in 1984.

BEAR LAKE CUTTHROAT (*Salmo clarki utah*) CULTURE and REARING

by
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November 1984

BEAR LAKE CUTTHROAT (Salmo clarki utah)

CULTURE and REARING

Thomas S. Frew
Idaho Department of Fish and Game

ABSTRACT

The Bear Lake cutthroat (Salmo clarki utah) is a strain of cutthroat important to the fishermen of southeastern Idaho and northern Utah. This strain was originally found only in Bear Lake, a boundary water divided by the Idaho-Utah state line.

The fish have historically used St. Charles creek and Swan creek for spawning in the spring. Idaho has a trapping facility on St. Charles creek and Utah has a permanent trap and holding pens on Swan creek. The purpose of these facilities is to capture, mark, and spawn adult cutthroat. The eggs are then transported to Mantua hatchery, southwest of the lake for rearing.

Some of the eggs are reared at the Fisheries Experimental Station at Logan, Utah. These offspring undergo intensive disease diagnosis testing, and then are transported to J. Perry Egan hatchery near Bicknell, Utah. Here they are held until maturity, spawned and the resultant eggs are used for Idaho's Blackfoot Reservoir project and to supplement the natural spawn taken at Swan creek.

The rearing techniques used at both Grace and Mantua are somewhat different than commonly used in trout culture. Also there are several techniques that we are trying to implement to keep costs down and produce a high quality product. These techniques include covering the rearing units, adjusting the photoperiod, adjusting feed levels and diet composition, and adjusting rearing densities.

INTRODUCTION

Bear Lake is a large remnant of Lake Bonneville, approximately 20 miles (32 kilometers) long and 8 miles (13 kilometers) wide. This 210 foot (64 meters) deep lake is equally divided by the Idaho-Utah state line in southeast Idaho. It was isolated until the early 1900's when the Bear River was diverted into the lake for irrigation water storage and power production. There are three main tributaries to the lake; St. Charles creek, Swan creek and Big Spring creek.

At least four endemic fish species occupy Bear Lake; the Bonneville cisco (Prosopium gemmiferum), Bear Lake whitefish (Prosopium abysicola), Bonneville whitefish (Prosopium spilonotus), and Bear Lake sculpin (Cottius extensus). These four fishes provide forage for the Bear Lake cutthroat (Salmo clarki utah), which is the indigenous salmonid found in the lake (Nielson, 1983).

Apparently populations of the Bear Lake cutthroat were large enough to attract indian tribes and to provide a commercial fishery around the turn of the century (McConnell, 1957). A declining fishery into the 1960's prompted consideration as a threatened population (Miles, 1983). A cooperative agreement between Idaho and Utah, funded by Dingell-Johnson money, was established to try and save and enhance the declining population of Bear Lake cutthroat. This project was initiated in 1973 to increase and enhance the remaining population through population analysis, controlled

culture of offspring, evaluation of stocking at certain times of the year at different sizes, and evaluation of the sport fishery and harvest.

METHODS

Bear Lake cutthroat adults are trapped on Swan creek and St. Charles creek. Utah has installed a permanent trap and holding area on Swan creek, and Idaho installs a temporary trap on St. Charles creek. Idaho transports the fish trapped at St. Charles to the Swan creek holding pens. Big Spring creek is not used due to dewatering for irrigation and the presence of a commercial hatchery at the head waters. At Swan creek the adults are spawned, tagged with a Floy tag, measured and released back into the lake.

The eggs taken at the Swan creek trap are water hardened and transported to the Mantua hatchery, 65 miles (105 kilometers) southwest of the lake, to be reared and stocked back into the lake about a year later. In addition, some adults are spawned, one male to one female, and these eggs and the sacrificed adults are taken to the Fisheries Experimental Laboratory in Logan, Utah. These eggs are intensively tested for diseases and reared for about a year, then shipped to the J. Perry Egan hatchery at Bicknell, Utah to be used as brood stock. The sacrificed adults are tested for disease carrier incidence and if any problems are found, the offspring are destroyed before transport to Egan hatchery. These brood stock are used as a back up in case of a poor natural run in the tributaries or if some other problem occurs, such as run-off damage to the traps. Surplus offspring from these brood fish are eyed, then shipped to Grace hatchery at Grace, Idaho. These fish are reared for planting in the Blackfoot Reservoir in the Snake river drainage.

Grace hatchery receives eyed eggs from Egan hatchery in June. The eggs are tempered to 52°F. (11.5°C.), disinfected with Argentyne at 150 ppm for 30 minutes, then they are enumerated and placed in upwelling incubators of our own design. Once they hatch, they swim up and out of the incubators into the hatchery vats where feeding commences. They are fed a commercial dry salmon diet.

The fish are kept as long as possible in the hatchery vats before moving them outside. We have found the somewhat darkened environment is preferred by the fish. They grow much better, are not as wild, and in general are easier to raise in this environment. Once the density requires thinning beyond the capacity of the hatch house, we move the fish outside to raceways that are 100 feet x 4 feet wide x 2.25 feet deep (30.5 meters x 1.2 meters x .6 meters). We have found these cutthroat perform better in narrow, deep raceways, rather than shallow, wide raceways. We are usually able to hold the entire population in these rearing units until they are stocked out the following spring. If we cannot hold the fish in the narrow raceways, we can only move them to our 14 foot (4.2 meter) wide production raceways.

Once the fish are moved to these raceways, 14 feet wide x 100 feet long x 1.5 feet deep (4.2 meter x 30.5 meter x .5 meter), some problems arise. The most important one is the fish quit growing. There are several theories behind this phenomenon. Part of the water that supplies these raceways is second use. The ammonia and solids present stresses these fish and Bacterial Gill disease (Myxobacteria) becomes a chronic problem. These raceways are shallower so there is less time for the feed to travel from the surface to the bottom. Once the feed reaches the bottom, the fish will not pick it up. These are open water fish that rarely feed off of the bottom. This wasted feed contributes to the ammonia and solids loading in the water, which further stresses the fish. Careful, slow feeding

is needed to minimize this problem. Finally, the large volume of these raceways leads to a low loading density, which we have found to be undesirable when raising this particular strain of cutthroat. We have found a minimum density index of 0.4 to give the best performance in these fish, at least up to one year of age. This is also noted by the Mantua hatchery personnel (Miles, 1983).

The hatcheries involved with Bear Lake cutthroat culture are trying to raise these fish from two different approaches. Mantua hatchery is trying to obtain maximum growth in their system. This hatchery is designed for production of Bear Lake cutthroat only. They produce an average of 80,300 pounds (36,500 kilograms) per year of 7 to 9 inch (18 to 23 cm.) fish (Nielson, 1983). Grace hatchery produces only 15,000 pounds (6,800 kilograms) at a much smaller 5 inches (12.7 cm.). Both hatcheries have 52°F. (11.5°C.) water supplies and both grow fish approximately one year. Grace is limited to fewer pounds because of rearing space. This hatchery also produces five other species of fish.

The Bear Lake cutthroat at Grace have historically developed Bacterial Gill disease and some Cold Water disease (Cytophaga psycrophilia) in the early spring. We feel this is partly caused by poor nutrition brought on by trying to slow down the fishes growth during this time of the year. We are presently testing two commercially available diets. We have set up two raceways with 56,418 fish and 76,654 fish each. These are fed diet "A". A duplicate set of raceways are stocked the same and fed diet "B". All feed projections are run on a McNinney feed projection program that has been modified for use on a TRS-80 Color Computer. This simple test is to be run until the time of stocking in June. Each set of raceways will be handled identically. Mantua hatchery is also doing the same diet comparison testing.

Mantua hatchery is doing some photoperiod testing in covered production raceways. These fish are particularly sensitive to light, and maybe light manipulation will help to hold down stress caused by direct sunlight. At both Mantua and Grace hatcheries, rearing Bear Lake cutthroat at high density indexes has been shown to produce a healthier, stronger product than rearing at low densities. The density index in the hatchery vats at Grace reach 1.25 while the recommended density index for trout is 0.5 (Piper, 1982). In our production raceways the density index reaches 1.0 with no side effects to these extremely crowded conditions. This has also been noted by Mantua hatchery (Miles, 1983).

Two weeks before scheduled planting, Grace hatchery sets up constant flow containers to deliver the chemical Morpholine to the raceway inflow. A concentration of 5×10^{-5} mg/L is dripped for two weeks immediately before planting to imprint the fish. We set up and dripped the same concentration into the Little Blackfoot river, a tributary to Blackfoot Reservoir, at the time of stocking. The drip was continued for two weeks after the stocking. We will drip the chemical again, when the fish reach maturity, into the river. Hopefully, this procedure will help the fish home in on this river to spawn (Hasler and Scholz, 1983).

The past two years, 1983 and 1984, 715,329 cutthroat at approximately 20 fish per pound (44 per kilogram) were planted in the Little Blackfoot river. 133,424 of the 290,179 Bear Lake cutthroat planted in 1983 were adipose clipped for year-class identification. This project is an attempt to establish a spawning run of Bear Lake cutthroat to further back up the brood stock program at J. Perry Egan and the wild runs in Bear Lake.

DISCUSSION

The Bear Lake Enhancement Program is a multifold effort involving research biologists and hatcheries. The biologists are striving to maintain and increase an indigenous population of fish that has great importance to the fishermen that utilize the Bear Lake, as well as the scientific communities desire to maintain a pure population of a truly unique fish in its natural habitat. The hatcheries are involved with producing relatively large numbers of appropriate size fish to replace and enhance the wild populations at specific times of the year. The hatchery men have to deal with a fish that has very narrow habitat and tolerance limits.

The Bear Lake cutthroat requires a quiet, clean, deep environment to perform well in a hatchery situation. If these perameters are not met, any number of problems can, and do, arise. Bacterial Gill disease, cold water disease, and general poor fish quality are some of the results of not meeting this fishes needs. These problems can escalate in the wild environment to result in poor survival and eventual ruin of the very fishery we are trying to enhance.

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DOLLY VARDEN CULTURE IN BRITISH COLUMBIA

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Declining populations of Dolly Varden char (Bull Trout) have been a source of concern for fisheries managers in British Columbia. The declines have been caused by overharvesting, poaching and dam construction blocking access to spawning areas.

One of the conceived methods of restoring these populations was envisioned in the hatchery production of juveniles, even though knowledge of cultural techniques for this species was extremely limited. The information that was found was not encouraging, such as this note from Bernie Kepshire (Alaska) to Hugh Sparrow (B.C.), "These critters do not seem to like life... They sure like the bottom as you said; maybe we should rename them 'cottid char' or 'sucker char'." And indeed they do perform differently in many aspects from other salmonids.

This talk will give you some information about what we have done and will conclude with what we feel are some acceptable methods of culturing Dollies; reminding you that each hatchery, and indeed, different stocks of this species, may require slightly different techniques to achieve some measure of success.

Our initial attempts in 1977-78, 1978-79 and 1980-81 were relatively limited with only indicate testing being done. Very little conclusive information was gained, though many avenues were explored.

In 1981-82, the emphasis was placed on getting qualitative results. Experiments were carried out on the effect of water temperature during incubation as well as the testing of several diets.

In 1982-83, we tested adult males to try to determine causes for the loss of ripeness during holding, the use of substrates during incubation and their effects on growth for three months after initial feeding, as well as the testing of four diets.

In 1983-84, we felt relatively confident in much of our work and did only some further testing on substrates and their effects on growth.

It should be noted here that, to a great degree, the philosophy behind the testing was not necessarily to find the ultimate method of raising these fish, but to find the best methods, within reason, to suit our existing hatchery structure; i.e. trying to fit the fish to the facility.

From our experimentation and experience, we have found the following to be worthwhile methods of achieving success with Dolly Varden at the Kootenay Trout Hatchery:

1. Adult Capture

This has been done successfully by angling, dip-netting and electroshocking. The fish should be treated fairly gently, avoiding undue stress. These techniques are normal compared to other trout and char species.

2. Adult Holding

The fish should be held in conditions resembling natural spawning areas until just prior to ripening. In our operation, the fish were captured 2 to 3 weeks prior to initial spawning, and were held in a portion of a spawning channel. As we noted evidence of redd building taking place, the fish were then confined to a corner pool which had a concrete floor; this discouraged further redd building activities.

Males present a problem in that, for some unknown reason, once captured and held, lose their desire or ability to produce sperm. This often causes problems toward the end of the egg collections.

3. Egg Collections

We have used normal expression spawning techniques with good results. All adults are anesthetized prior to spawning, using 2-Phenoxyethanol. The eggs have been water hardened in an erythromycin phosphate solution as a precautionary measure against BKD. The eggs are transported back to the hatchery within 24 hours of fertilization. A 100 ppm Wescodyne treatment is given upon arrival at the hatchery.

4. Incubation

Water temperature appears to be a major factor in incubation success. Our best results have been wth our ground water supply, normally 7° - 8° C, which is chilled to about 4° C. This temperature is maintained throughout incubation. Some minor fluctuations, due mainly to mechanical failures, have not seemed to cause serious problems. The next best incubation water supply would be a source simulating creek-like temperatures, i.e. declining in the fall, low overwinter and increasing in late winter. We have had reasonable success with creek temperatures as low as 0° C for short periods.

The use of substrates in later incubation, i.e. placed shortly before hatching, does produce a larger fry to the initial feeding stage. We have not been able to conclude, however, that over an extended period of time, three months, that the substrate produced fry maintain the size difference or are a better fry ready for ponding in our outside raceways.

5. Rearing

Nearly buttoned up alevins are placed in our indoor rearing troughs (4.9m x .44m x .16m water depth), with water flows of about 40L/min. Temperatures during the trough rearing stage is 7° - 8° C. We raise up to 35,000 fry per trough. This type of trough appears to be suitable for this species. We have heard some negative comments about circular containers.

Fry are started out on Silver Cup salmon starter, to which is added approximately 10% by weight, raw, pureed beef liver. This liver is mixed into the Silver Cup food and then it is rescreened so that it can be fed through our automatic feeders. This diet is given for 4 to 6 weeks, then we switch to OMP. Although we are happy with this diet schedule, we feel confident in saying that they are not the only diets that will work. For those planning diet testing on this species, one criteria must be noted, that being that as these fish are not generally surface feeders, a food that will sink is a necessity. Palatability seems to be a major concern; it is not that some diets are missing ingredients for growth, but that the fish appear to prefer certain flavors and textures.

At about three months after initial feeding, the fish reach about .5g and are then transferred to our outside rearing ponds, (14.5m x 3.6m x .83 water depth). Water temperatures can vary from 7° - 11° C at this time. We continue to feed OMP, supplementing with unaltered Silver Cup salmon diets. Our major problems, especially since we have overcome those encountered initially in incubation and early fry rearing, tend to come at this time. These take the form of myxobacterial outbreaks, which have caused losses of up to 20% of our fish in a week. The main cause has been a Flexibacter, similar to cold water disease, but gill disease has been involved as well. We have treated with oxytetracycline in the food and externally with Hyamine 3500 and have been able to eventually control the problems. These fish appear to be fairly susceptible to diseases and respond stubbornly to treatments. We try to avoid water temperatures in excess of 12° C for this species as the disease problems appear to become more acute.

The fish are reared for three to four months in these ponds prior to release in the fall as 3g to 4g fish. Overall, growth apepars to be slower with this species compared to other wild species that we culture.

6. Transportation and Liberation

We have encountered problems on several occasions because of the nature of Dolly Varden to orient to the bottom. Since they generally utilize such a small portion of the water column, loading densities must be reduced significantly. Also, in the way our tank truck oxygen systems are set up, the fish can get underneath the oxygen lines. Even though the space is only 1-2 cm, it is enough room for them to lay on top of one another and cause suffocation. Ideas for new tanks would prevent this happening have been contemplated, but not yet built.

All of our stocking has been into streams, which flow into large lake systems. The fish are scatter planted over as wide an area as possible. Dolly Varden apparently do not move very far from where they are released until it is time for them to migrate to the lake system, which is usually at least one year after stocking.

At this time we are out of Dolly Varden production at the Kootenay Trout Hatchery as it is being handled by a private contractor at another facility. Our Section is continuing to keep its hand in Dolly culture as one of our hatcheries has a rearing project underway.

I would like to leave you some targets for production which you can shoot for if you decide to get into rearing Dollies. Those figures noted as 'attained' have been, with the percentage figure indicating the survival

of the entire year class of eggs or fish, (about 350,000), and not just successful experimental lots.

1. Green egg to 'swim-up' fry - 93% survival (attained)
2. 'Swim-up' fry to 0.5g* - 95% survival (attained)
3. 0.5g to release (3-4g) - 95% survival (not yet attained)

Although the possibilities for success with Dolly Varden looked bleak a few years ago, it has been demonstrated to be a culturable species provided we can accommodate its requirements.

*This is the stage at which we transfer the fish from the indoor troughs to the outdoor raceways.

LOADING MULTIPLE-PASS RACEWAYS

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With supplies of adequate quality water in which to raise our valuable commercial and sport fish becoming limited, fish raising facilities are being designed to re-use water. This necessary fish culture practice has dictated a new area of research; namely, defining the carrying capacities of serial water reuse ponds.

Conceptually, what is a reuse water system? First, it is a series of raceways or ponds arranged so that water flows through each pond in the series. As the water flows from the inlet of the series to the lower end of the last pond, there are several water quality changes occurring. Across each pond there is a dissolved oxygen drop due to the oxygen requirement of the fish and the Biological Oxygen Demand of the system. As the water leaves the first pond and drops either into the next pond or into a head-box there is some degree of oxygen recharge. The amount of resaturation is a function of the initial saturation and the height of the fall. Thus, the water entering the next use is more saturated with DO than when it left the preceding pond. This process is repeated throughout the entire series. The next step to make this an effective tool in fish culture is to put the concept of oxygen recharge to use. This is best accomplished by dealing next with the standard metabolic rate (SMR) of the fish.

First, we must establish some basic ground rules with respect to the outfall limits of dissolved oxygen. In the first use, the outfall DO should not fall below 70% of saturation. Next, the recharge is calculated using the appropriate table. This value then becomes the inflow DO of the next pond. The outflow DO of each of the next ponds in series - all of them, in turn - should not fall below 90 mm Hg pO2 (the partial pressure of oxygen in solution at the temperature and elevation). This value approximates 58-60% of saturation. The actual value in mg/l DO can be obtained from a table.

The next step is to calculate the DO available - that is, the allowable decrease in DO from the head-end to the tail-end of each pond - per hour. This value is calculated by multiplying the mg/l DO by the liters per hour inflow. 1.0 cfs equals 28.32 lps, which when multiplied by 3600 yields lph.

Now, comes the fun part! Namely, putting fish into the system. First, the size of fish at take-out must be established. That is when will the pond population be split or planted or what. By calculating the weight of an average sized fish at this point in time, the SMR of that fish can be determined. The SMR is

expressed in mg DO per hour. By dividing this number into the available DO per pond the number of that sized fish permitted in the pond is known. By taking that number and back-calculating (accounting for mortality and growth rate) the number of fish of the beginning size is known. This number is divided by the number per pound of the beginning size fish to produce how many pounds of fish to be stocked into the pond. Now all that remains to be done is feed them. The "no-effect" limits of DO will not be exceeded until the day set to remove the fish.

Nonetheless, there is a caveat. The fish should be watched very closely during the grow-out period. The following should be done at each inventory time: (1) Examine the gills for EGD; (2) compare the expected weight or length gain with the observed weight or length gain. If there are differences, something in the system is not right. Also, the DO should be monitored at the inflow and outfall of each pond to compare these values with the "red line" values established. Finally, the ammonia-N should be measured in the morning before the first feeding and at mid-afternoon. The free ammonia levels should not exceed 0.03 mg/l for more than just an hour or so. If the DO's and ammonia levels exceed the "no-effect" limits, the best thing to do is to reduce the feeding rates.

In summary, the foregoing still remains to be conclusively fine-tuned for application. We are in the process of writing a computer program to reduce the difficulty in making the required calculations. We are also in the process of setting up a rather involved experiment to increase the precision of the technique. All we do know for certain is that this approach is valid.

APPLICABILITY OF MICROCOMPUTER PRODUCTION PROGRAMS IN CONSERVATION HATCHERIES - A PROGRESS REPORT

by
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Production of salmonid game fish under intensively managed conditions is a complex task. Klontz (1982) has identified fifty-six factors that can affect the productivity of raising salmonids. These factors are interacting, dependent and independent, biotic and abiotic, and when operating together constitute a functional aquaculture system. All these factors fall into the five major components of raising salmonids, namely, fish, water, container, nutrition, and management. Such is their interrelationship that changing one factor of one component, especially if it is directly related to production, can bring about a series of changes through the entire system. The net effect of this cause and effect relationship is a change in the growth rate of the fish. The system remains in this state until another change is introduced (Klontz 1982).

Management must try and control the various factors and their interactions in an aquaculture system to assure optimum production. To attain optimum production, the production goals must be defined (i.e. product definition). The product definition consists of setting criteria (species of fish, quality of fish, date the fish are to be released to the wild, size of fish to be produced, and the number of fish required (Klontz 1982)) which define the goal(s) of the system. Once the product definition is established, input variables and subsequent interactions of the aquacultural system such as growth rates, percent of body weight to be fed, space and water requirements can be defined. This process of defining the system and management objectives is called "production forecasting".

To adequately employ production forecasting, detailed records of fish production must be kept. Records of feed consumption, water flow, biomass in ponds, mortalities (including assessments of cause), water temperature, numbers of fish on hand, and maintenance and operations costs are necessary, not only for production forecasting, but for cost effective operation of an aquaculture system.

In addition to record-keeping, good inventory techniques are necessary for proper hatchery management. Whether the inventory data are gathered for direct management of fish, or for administrative purposes, they are necessary for production forecasting techniques (Piper et al. 1982) The two most common methods of growth assessment consist of estimating the number of fish per weight unit and/or the average length of fish in the population (Klontz 1982). This estimation of a population parameter is in all likelihood the most common error in any aquacultural facility. Generally, less than 1% of the population is sampled and the inventory data are expanded to represent the entire pond or hatchery. For production forecasting, sampling techniques should have no more than a +/- 5% error and be conducted every 14 to 28 days. This small error amount is necessary since the entire production program is based upon the inventory sample (Klontz et al. 1979).

Fish culture personnel have done remarkably well in the past in meeting production goals within financial limits, but this is becoming increasingly difficult to realize. Hatchery facilities often have been operating at, or exceeding the aquacultural system limits to remain within the operating budget. This has often resulted in poor quality fish, high fish rearing costs, and/or reduced numbers of fish planted. Therefore, in order to meet fish production demands and cost limitations, it is imperative that state and federal conservation hatcheries, make the best possible use of their operating dollars and hatchery facilities.

The costs of producing game fish have been divided into three categories: feed costs, labor costs, and fixed costs. Of these, feed costs constitute approximately 60% of the total cost in a conservation hatchery. Analysis of most commercial trout and salmon feeds indicated that a 1.3 - 1.5:1 food conversion was possible (Klontz et al. 1983). However, in practice, WDG hatcheries are reporting a mean statewide food conversion of 1.4:1 (pers. comm. Jim Gearheard). Reduction of this food conversion to the potential feed conversion would result in a 18-24% decrease in feed costs. Realizing this decrease in production costs could enable WDG and other conservation hatcheries to produce more fish, better quality fish, or both.

In summary, production forecasting integrates data from segments of the system (i.e., fish, water, container, feed and management) to determine how to best meet the product definition. The product definition can then be met because pond, water, and feed requirements are predictable and controllable. In addition, production forecasting will allow the culturist to improve and/or reduce the variance in condition factors (length - weight relationship) and improve documentation of all aspects of rearing and release of fish. Improved documentation will also aid fishery resource managers in making management decisions.

There has been much concern and discussion lately on quality fishing and quality fish. But, what constitutes a definition of a quality fish. Fishery managers may define a quality fish as one that has good survival and return, good length - weight ratio, healthy, etc.. Sportsmen will define a quality fish as having a large length - weight ratio, fighting characteristics, color, and taste. However to produce quality fish, whether for the manager or sportsman, starts in the hatchery.

There has also been considerable argument over the quality of hatchery produced fish. Often the fishery manager seems unsatisfied with the hatchery product, whereas the aquaculturist is happy with the product produced. Again a dissonance over what is a quality fish.

Currently the literature suggests that a quality fish has a good length - weight relationship, and the ability to survive. CHOP does not attempt to define a quality fish, but attempts to achieve some of the common attributes that define a quality fish, and that is - produce a fish with the "proper length - weight relationship", a fish that looks "good", and a fish that can survive.

PROJECT EXPLANATION

Last year Washington Department of Game embarked on a new direction in fish culture techniques. Through considerable sales talking by myself on all the wonders of the computer, WDG administration decided to go ahead and install microcomputers and

programs in a few hatcheries. The objectives of the Computerized Hatchery Optimization Project were as follows:

1. Meet management objectives by producing fish that meet the product definition.
2. Reduce feed costs (relative to normal practices) by improving the food conversion rate and by increasing the accuracy of predicting and purchasing necessary food (i.e. reduce or eliminate excess food purchases and/or spoilage).
3. Improve the documentation of all aspects of rearing fish to release (i.e. eggs, fry fingerling, and legal sized catchables), including costs, through standardized formats.
4. Improve the utility, accuracy and detail of hatchery reports and speed the flow of information to management biologists, administration, funding agencies and the public.
5. Reduce the amount of time spent on data transformations, and preparation of hatchery reports.
6. Evaluate current methods of enumerating, and rearing fish.

Project timetable.

Year 0. 6/83 - 6/84 Acquisition and familiarization of computer equipment. Debugging software through field testing. Preliminary evaluation of models used in projecting growth. Each hatchery participating in project has one study pond and one control pond. Education and training of hatchery managers in software use and aquaculture techniques used in the project. Start electronic transfer of data. Collect baseline growth data.

Year 1. 6/84 - 6/85 Expand project ponds to 1/2 of hatchery production. Continue collecting growth data. Make changes or modifications (if necessary) in software. Continue educating and training of hatchery staff in use of computers and software, and in new aquacultural techniques. Evaluate over-all effectiveness of programs and techniques -- is it meeting CHOP objectives. Plan for full scale production.

Year 2. 6/85 - 6/86 Expand project to full scale hatchery production. Evaluate and if necessary modify or make changes in software. Continue education and training of hatchery staff in computerization and new aquacultural techniques. Evaluate hatchery production, does it meet CHOP objectives. Evaluate product produced, does it meet fishery management goals, sportsmens expectations. Make recommendations for statewide use.

Locations of project hatcheries.

Care was taken to select hatcheries in which the manager was willing to learn to use a computer, modify present practices to new techniques, and that the hatchery was a major production

hatchery. Project hatcheries are located at: Puyallup, Aberdeen, Shelton, and Chelan. Ancillary hatcheries are: Beaver Creek, Skamania, and Lyons Ferry.

Species.

An emphasis was placed on anadromous species, since it is hoped that the programs will increase returns of adult fish. However, non-anadromous stocks are also included in the study.

Hardware.

Each hatchery is equipped with an IBM PC with 256K, 2 double sided double density disk drives, a monochrome video monitor, 1200 baud modem, and graphics printer. This hardware configuration should satisfy most software and data processing needs.

Software.

CHOP incorporates three types of software into the project. Two of the software items are designed to interact with each other and act as a "help" to the third. One software package was developed at the University of Idaho, the second in-house, and the third set of software in both commercial and public domain.

COMPACT programs.

Several mathematical models for predicting the growth in trout and salmon have been developed at the University of Idaho. These models were subsequently incorporated into several computer programs. Klontz, McArthur and Klontz (1983) combine production forecasting and optimization techniques together with the data collection, storage, retrieval and calculations into a set of computer programs for the fish culturist. These programs encompass the entire aquacultural system. The programs are currently written in FORTRAN 77 and Microsoft BASIC. In keeping with technology, the programs are available for the IBM PC and Apple microcomputers.

AQUA. A hatchery simulation. This program is an excellent training and learning program. It is currently being used at UI in the Aquaculture class.

PRELIM. This can be seen as the "road map" program. You enter into the program the product definition and the output displays the growth schedule - from start to release.

GROW. Similar to KF-PRED. It is a period predictor of growth. You the user can specify the growth characteristics and the computer then projects ahead. It also supplies the manager with a feeding schedule to achieve the planned growth.

PROFILE. This program produces a complete physical and chemical description of the hatchery - from water chemistry to hydraulics of each individual pond.

DAYACT. This program is designed to act as a daily record book for the hatchery manager. It is an electronic "mort sheet" and "comment pad".

EVAL. This program summarizes observed production data, and compares it to predicted values. An "observed over expected" ratio is produced. This program lets the manager know how well he did.

K-Factor Programs

The K-Factor programs were created for CHOP. They operate out of the concept of the length - weight relationship, but they are not limited to that idea. Actually the programs should be called the "hatchery reporter" since they do much more than just calculate the condition factor. The programs were developed for the end user or hatchery manager in mind. That is, the programs require simple and understandable data input, and output clear concise information that is either necessary or very helpful for managing fish.

There are presently four programs with a fifth in the planning or construction phase. They are:

KF-ENTER. This is the heart of the programs. As it's name suggests it is the data entry program. It will accept hatchery or non-hatchery data, therefore allowing management biologists to use it. Hatchery users must enter a sample of fish lengths, or weights, or both, data about the pond (gpm, volume, how many fish, amount of feed fed, brand, and any comments), and temperature data. All of this data is stored on diskette and may be sent to my computer or the PRIME.

KF-DPRT. This program retrieves length - weight data and displays it in a manner that indicates characteristics about the pond population. Mean, median, range and standard deviation are given and graphically displayed. The hatchery manager can use this data as a "grading index".

KF-RPOND. This could be the next most valuable program to the hatchery manager. It displays summary data about the pond, i.e. density, water temperature, growth data both weight gained and length gained. It also serves as a historical record of "what went on" during that period in time.

KF-PRED. This program takes data from the pond data files, summarizes them and then allows the user to make predictions about the forth coming growth period. It is designed for "what if" planning.

KF-HLTH. When completed this program will assist the hatchery manager in disease treatment calculations and some simple disease diagnostics.

Commercial/Public domain software.

Each hatchery has the following commericial software: MS-DOS 2.0, and Lotus 1-2-3. Word processing software, communications software, database software and various other utilities are from the Public Domain software sector. Fisheries application software was either developed in house (K-Factor programs) or from the University of Idaho (COMPACT programs).

Public domain software fills a large portion of the software for each CHOP hatchery for several reasons:

1. It is free, all is asked is a small donation. If purchased, at market value it would cost over $695.
2. It is quality user developed software. It meets all demands and expectations of CHOP users including myself.
3. It can be freely copied and distributed.

PRELIMINARY RESULTS.

Observed vs. Expected.

The data gathered to date (5 months) displays some

surprising results. First of all, when comparing observed fish length to expected fish length from all hatcheries, there was only a 3% difference! This means that the programs were 97% accurate in predicting fish length. Chelan hatchery experienced an amazing 99% accuracy in predicting fish length.

(see Figures on following pages)

In comparing growth to PRELIM projections, CHOP hatcheries have been in most situations ahead of PRELIM, and have had to slow the growth of fish down in order to meet the product definition. Because of this, CHOP hatcheries have been experiencing some amazing feed savings compared to amounts fed in the past at the same time. What's more amazing is that the study fish are achieving the same amount of growth with 1/3 to 1/2 less feed. This can be interpreted several different ways. First, CHOP hatcheries are obtaining the potential conversion of the feed. Second, the growth is closely watched and the fish are fed to meet a targeted fish length, thus eliminating overfeeding. Thirdly, is that CHOP requires that a daily ration be fed instead of "just filling the feeders with feed" this too controls over feeding and requires that the culturist become aware of how much feed is being fed.

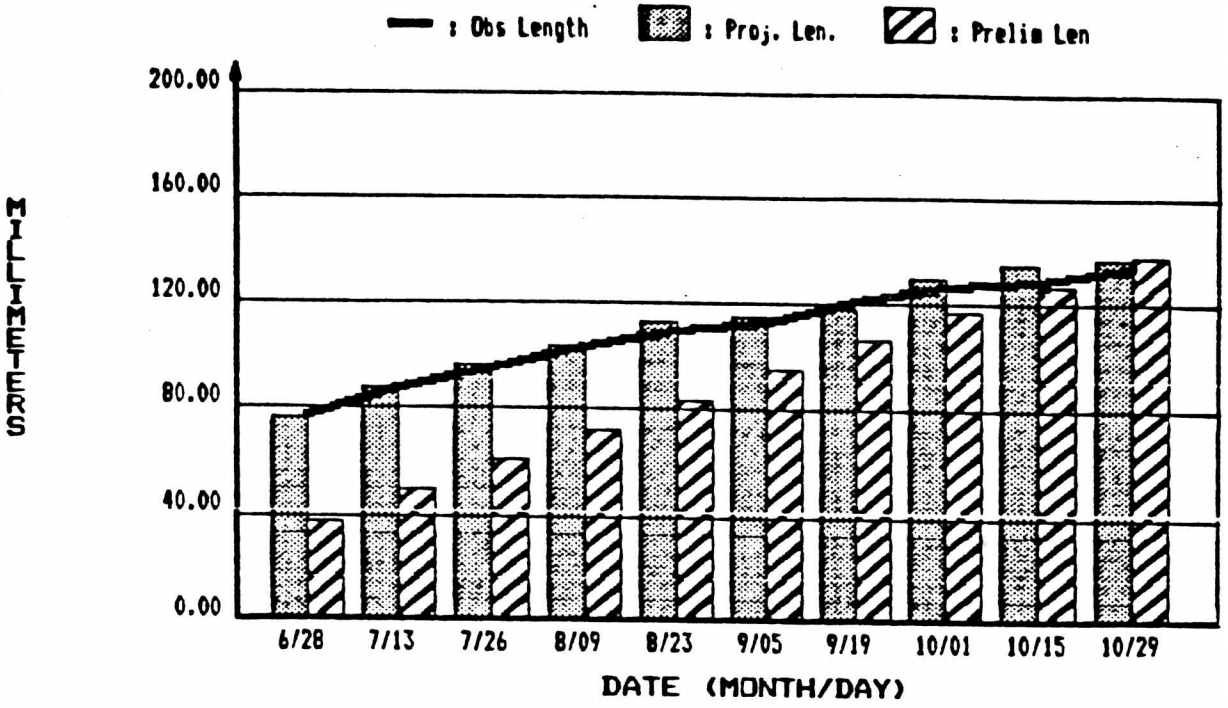
As a result of the above growth prediction accuracy, CHOP hatcheries were able to save feed, labor and maintenance dollars. Generally, about 25 - 35 percent less feed was fed to study ponds than control ponds. If these figures are expanded to encompass a whole hatchery, thousands of dollars could be save each month. Study results of fish growth and feed savings have been so remarkable that at Aberdeen hatchery the manager has "prematurely expanded" the project to include all ponds (except the controls). From June, 1984 to November, 1984, over 6,500 pounds of feed were saved! The manager reports that fish "look better than ever", and the fish grew in weight (individual fish weight) the same as the control fish.

Comparing the observed daily growth rate (delta L) to expected delta L, CHOP is not too far off. The data show a 25% difference between observed and expected delta L. However, the data does show the effects of disease and/or fish handling on the daily delta L. Generally, the delta L was met or exceeded during non-stress periods, but was greatly decreased when the fish were handled or during a disease episode.

Technical operations

Even though the data produced some interesting results, the project was not without it's difficulties and set-backs. The greatest difficulty was training hatchery managers on how to use their new management tool. Computers seem to have an awe inspiring, and mystical aire about them. When someone learns how to use a computer, they fear each key-press or action of the computer with the fear that something will be erased, or thousands of dollars are ruined. Others view the individual as "smarter than the rest" 'cause they know how to use a computer. Starting out on a computer is exiting and can be very humiliating. The user makes mistakes, the computer issues error message after error message, and then the user is still not sure what they've done. Now imagine installing a computer in a hatchery. I have found that hatcheries are run like family businesses, trade secrets, techniques passed on from one

ABERDEEN WINTER STEELHEAD - BOGACHIEL STOCK



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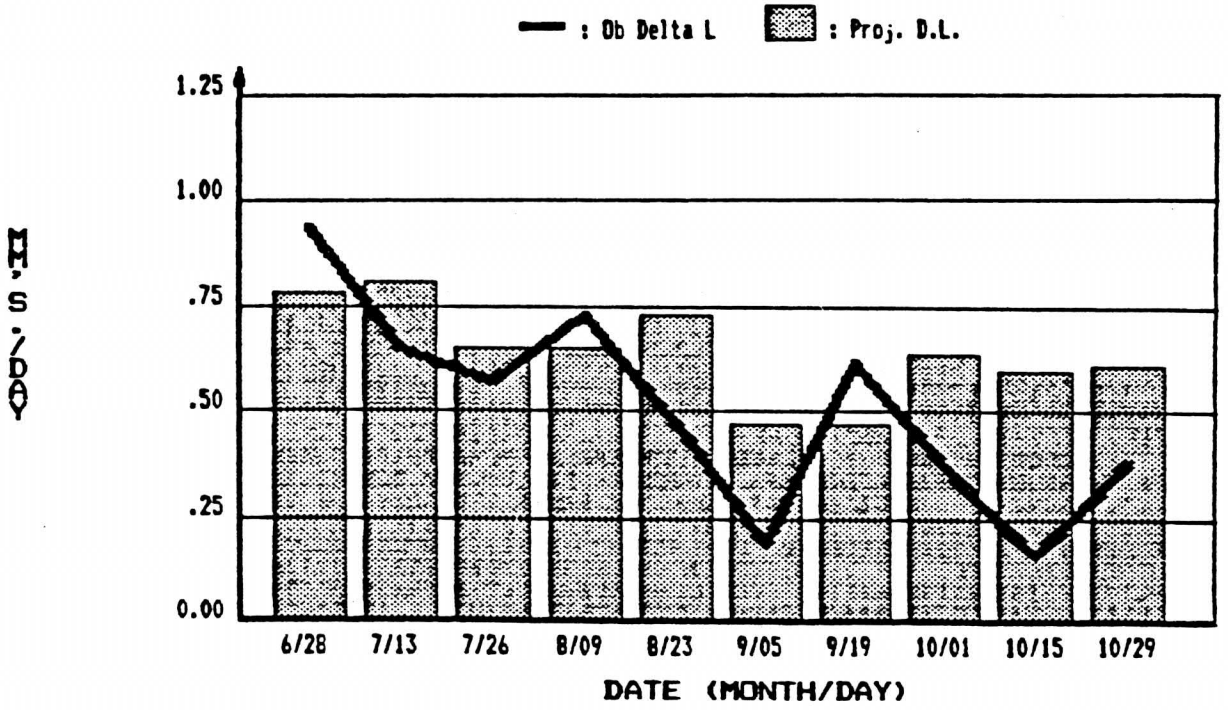
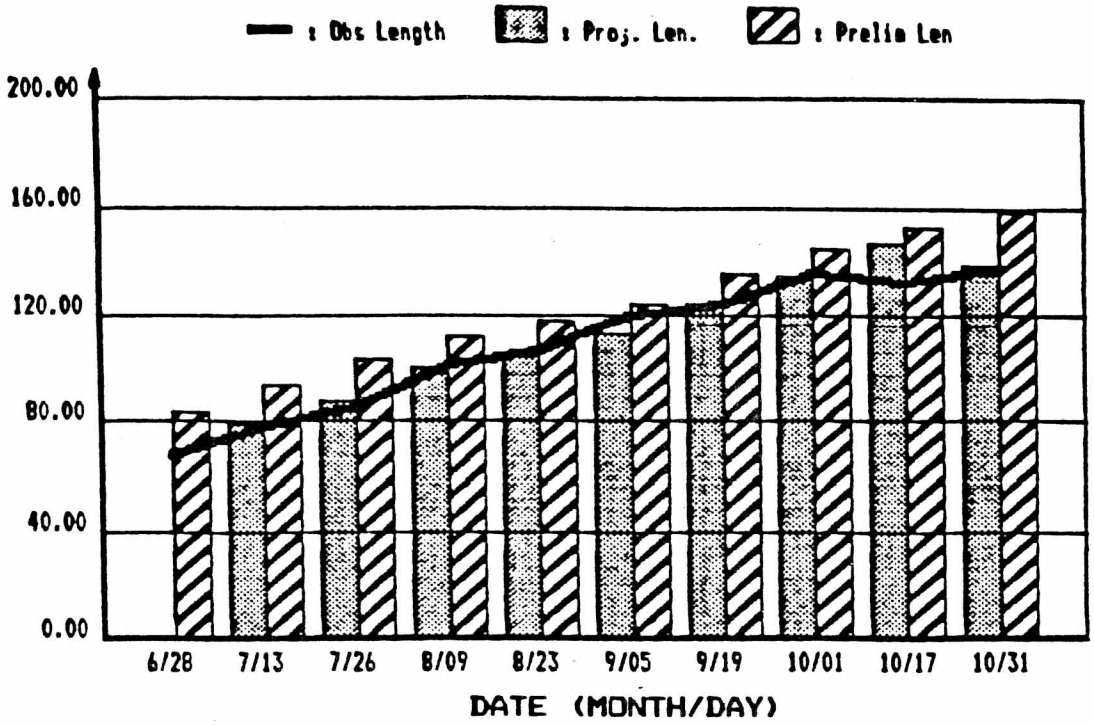
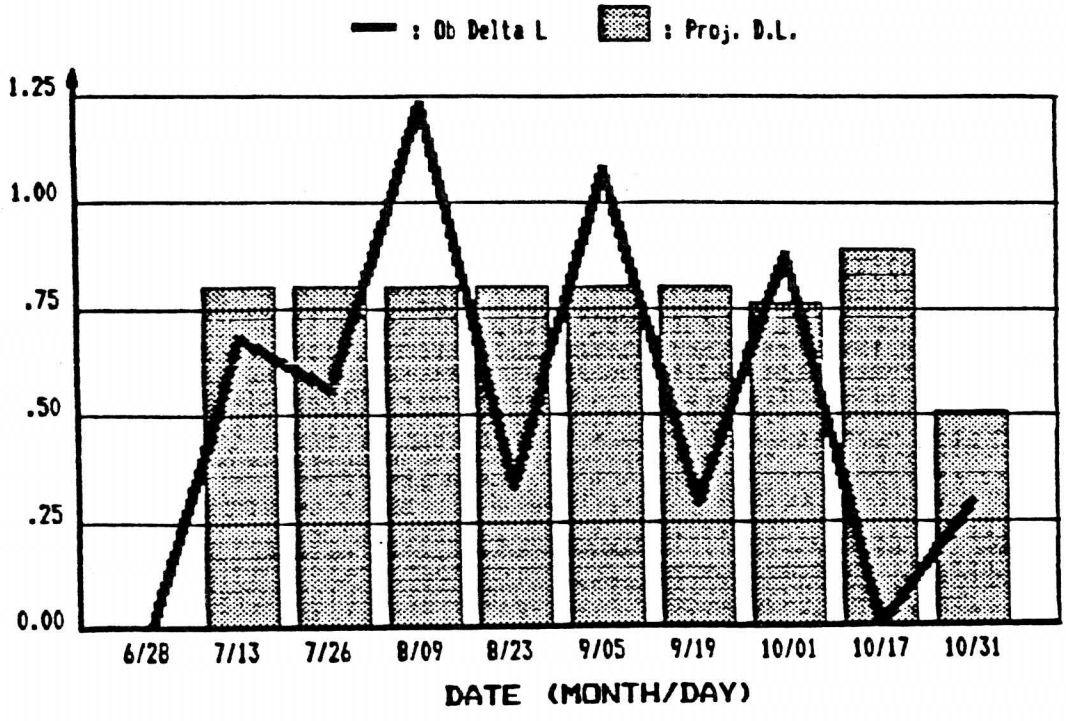


BEAVER CR WINTER STEELHEAD - ELOCHOMIN STOCK



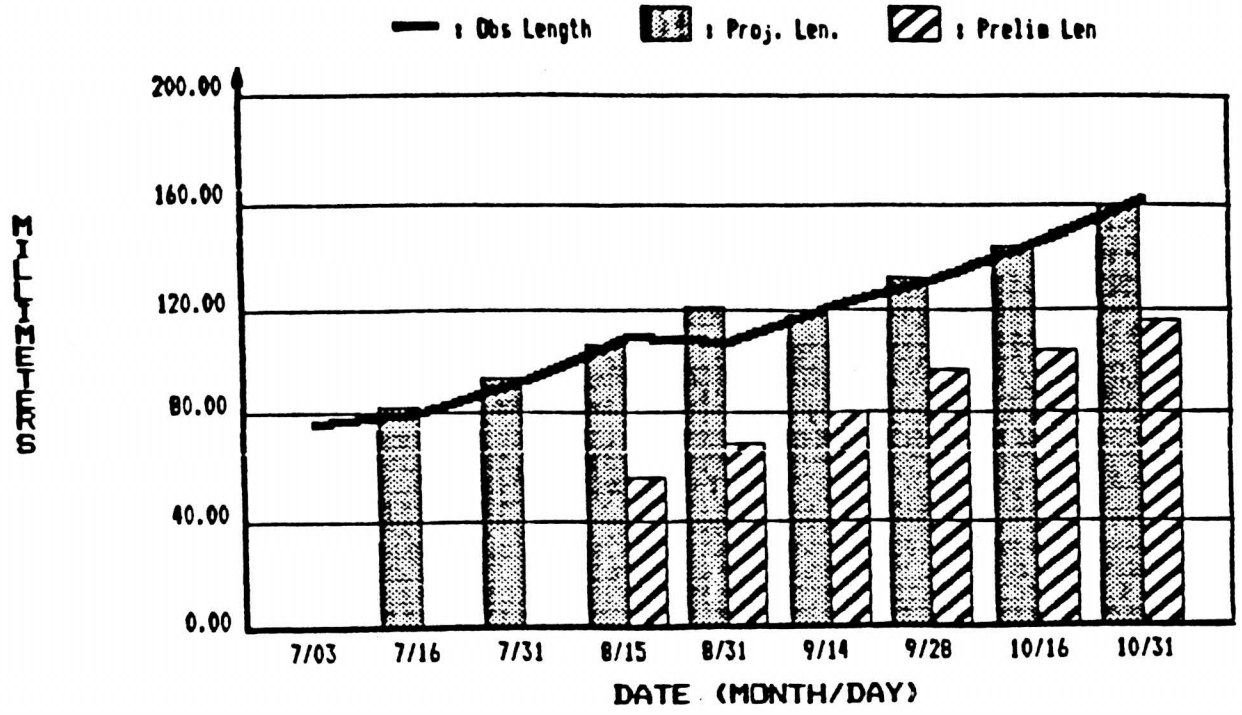
MILLIMETERS

BEAVER CR WINTER STEELHEAD - ELOCHOMIN STOCK

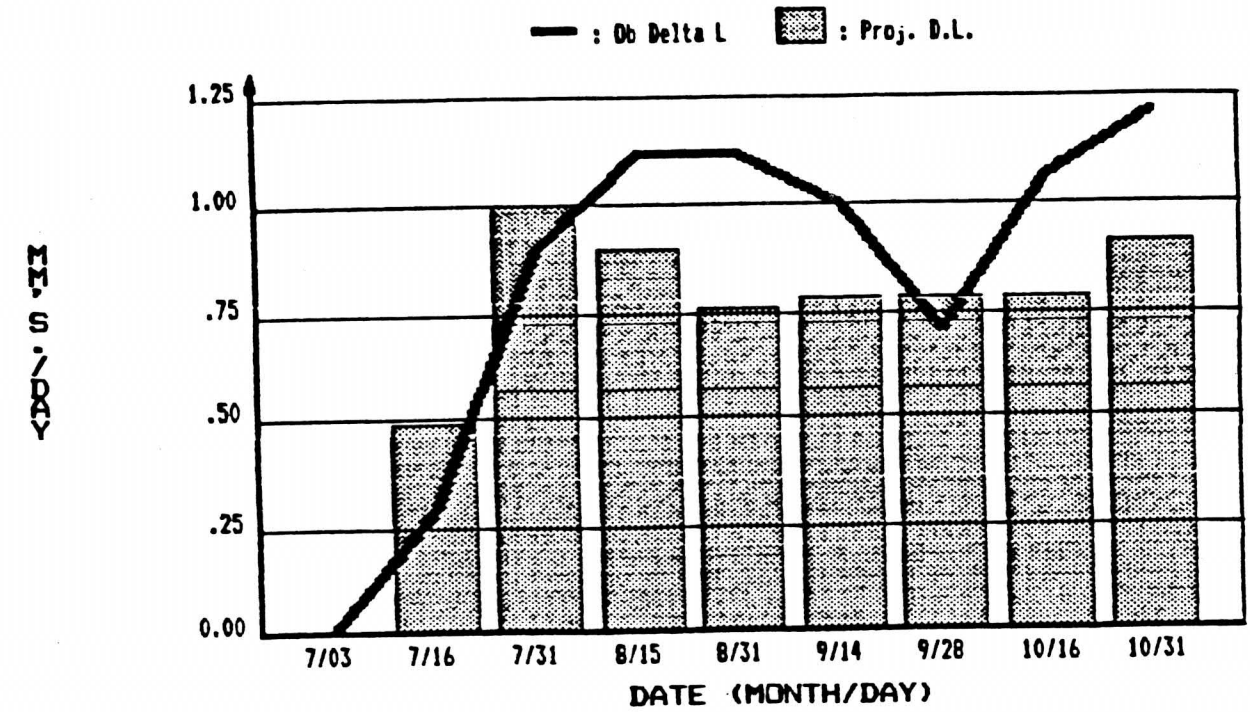


MM'S/DAY

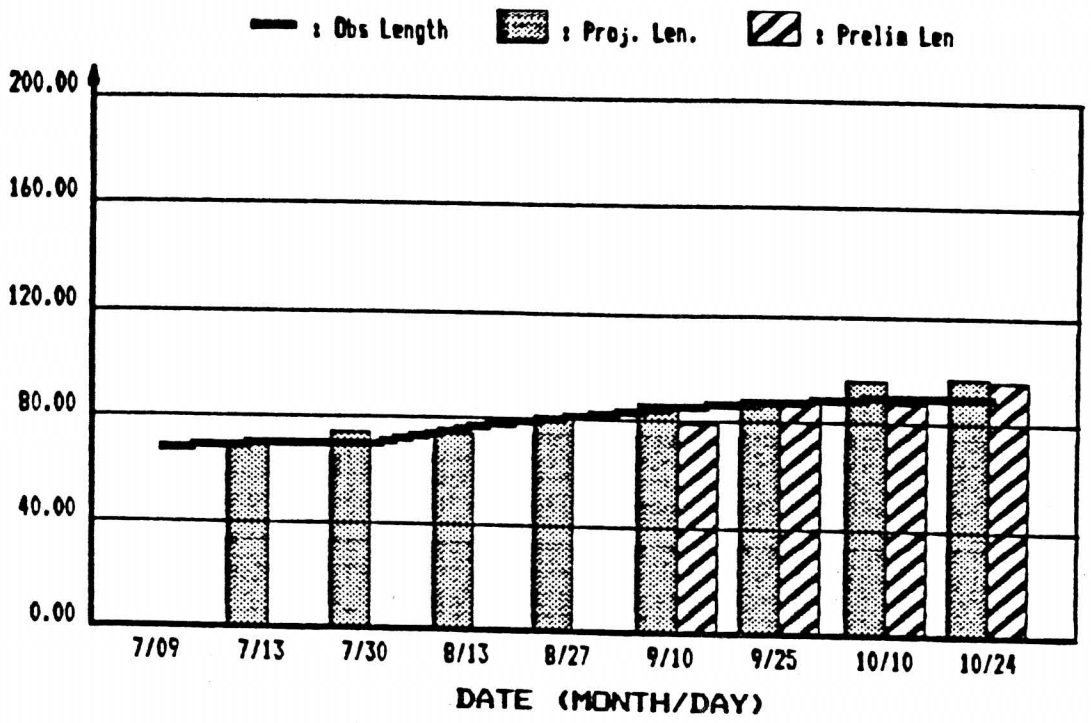
CHELAN SUMMER STEELHEAD - WELLS STOCK



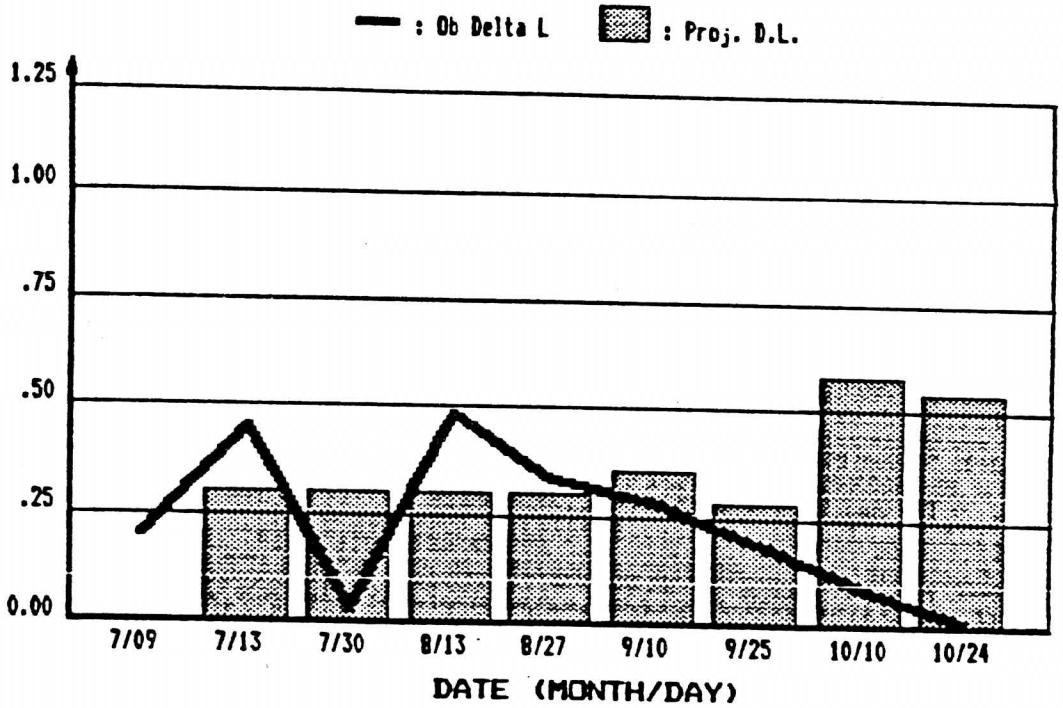
CHELAN SUMMER STEELHEAD - WELLS STOCK



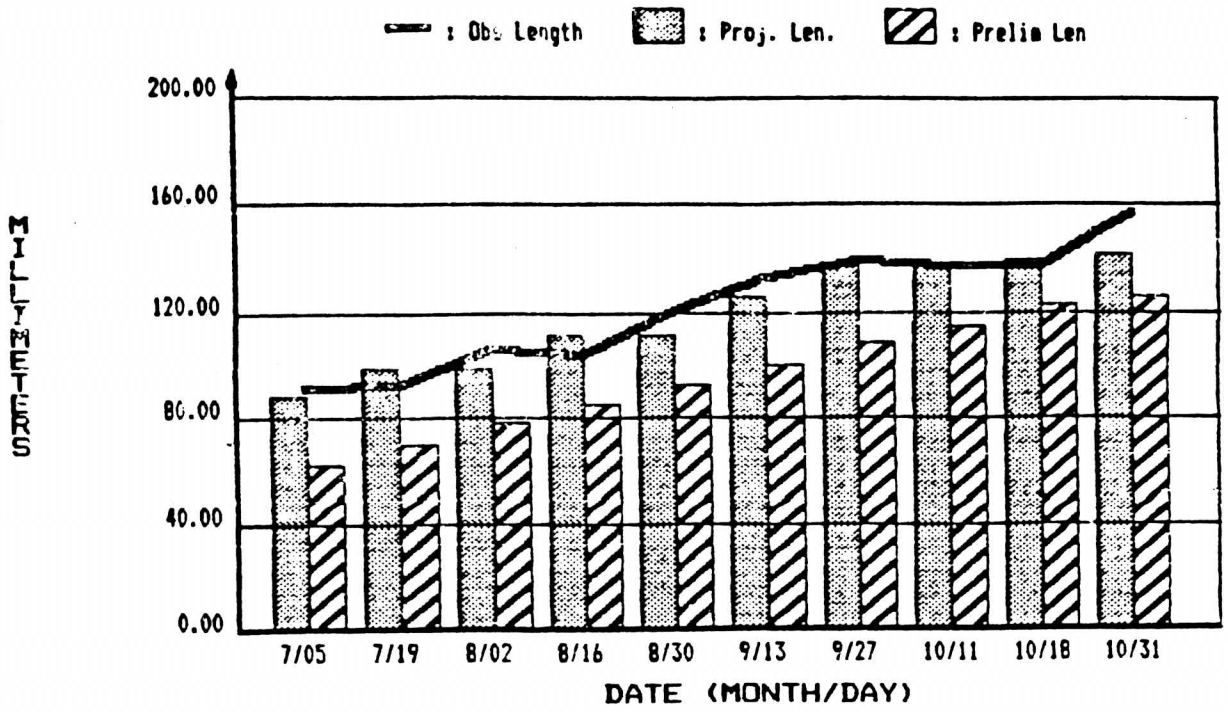
PUYALLUP WINTER STEELHEAD - CHAMBERS CR STOCK



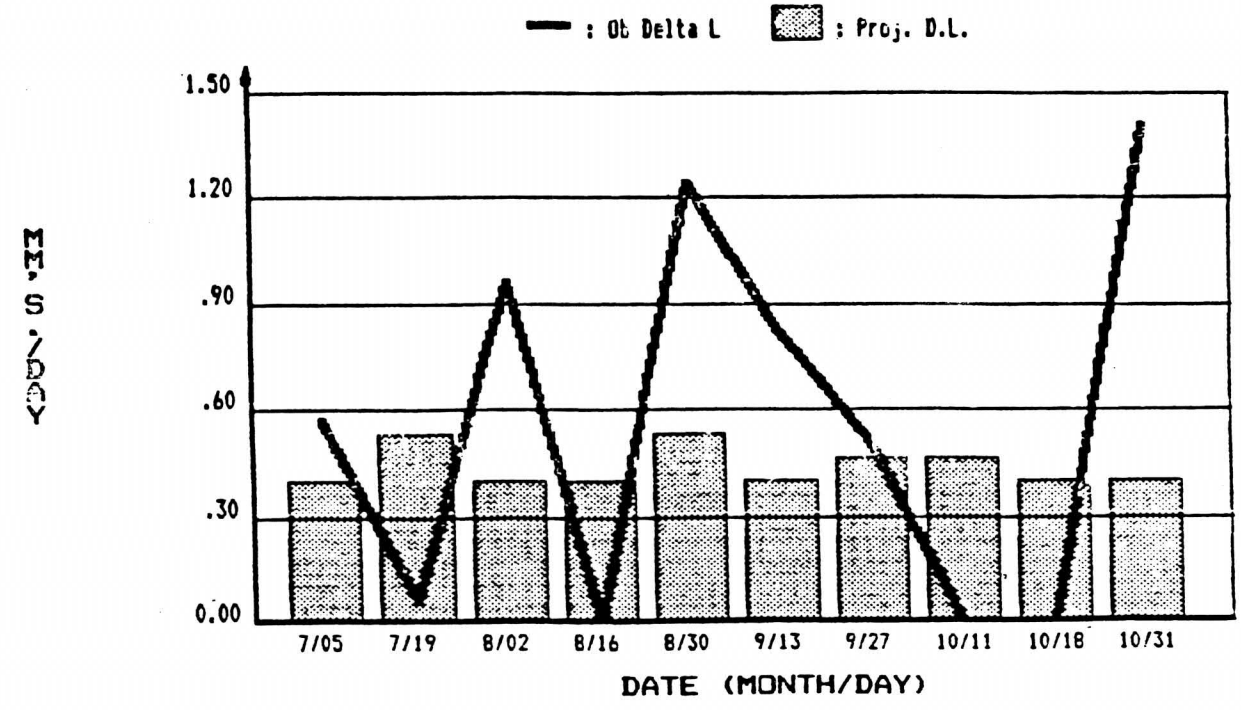
PUYALLUP WINTER STEELHEAD - CHAMBERS CR STOCK



SHELTON RAINBOW - GOLDENDALE STOCK



SHELTON RAINBOW - GOLDENDALE STOCK



generation to the next. New ideas, techniques, individuals are often greeted with hesitation and skepticism. Well, the computer was no exception. I found out that the computer could not become an aquacultural tool quickly, but rather with time. The computer and the programs would have to sell and prove themselves. This also is true for the new aquacultural concepts that were introduced along with the computer.

Growth programming, and the use of the concept of "delta L" are not totally new concepts, but practiced in a manner that was handed down from past superiors. A manager knew not to grow his fish too fast or they would be too large and he would have wasted feed, and not too slow or the product would be small. But it was (and still is) not a perfect practice. The computer has taken most of the guess work and estimation and is transcribing it to a hard copy form. The concepts of growth programming are still being taught, but in a step-wise logical progression. Again, as the computer and software must sell themselves, so must new concepts.

Another area the project has been set back in, is in time. I am quoted in saying that the user must spend at least 30 minutes every day with the computer until they feel they are proficient. The 30 minutes a day, are hard to come by with planting season, spawning, egg picking, grading, feed deliveries, vacations, hunting seasons, and a variety of other reasons. A shortage of learning time will always slow development of the project. However the crucial initial learning period of this project has been crossed.

Finally, the last area of project setbacks, is "bugs" within the programs themselves. They cannot be corrected immediately, even though the author does their best to make sure there are no "bugs" they inevitably occur. Only does extensive field testing will eliminate "bugs". "Bugs" were not a major problem (not yet anyway) in delaying CHOP.

Where is the project going?

It is not hard to see, but saving feed does save dollars. A high initial expenditure occurs with the purchase of the hardware software, but is rapidly repaid if allowed to continue. However, cost savings are contingent on the programs continuing to do what they are doing now. Raising quality fish with less feed through programmed growth. Personally, I feel that it is too early to tell if the above presented data can be considered as the norm. At least another year or two is necessary.

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NORTHERN ALBERTA TROUT AND WALLEYE HATCHERY AT COLD LAKE

by

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ABSTRACT

A dual species hatchery was designed for a remote area of Northern Alberta. The facility will produce 2 million rainbow trout (Salmo gairdneri) and 80 million sac-fry walleye (Stizostedion vitreum) with 750,000 walleyes reared in onsite ponds. This paper describes facility siting and water temperature problems, bio-engineering criteria, and production systems during incubation, early rearing, and grow-out.

INTRODUCTION

The Alberta Fish and Wildlife Department undertook the development of a dual-species hatchery to meet fisheries management goals for Northern Alberta. The hatchery has been designed to produce 2,000,000 fingerling rainbow trout and 80,000,000 sac-fry walleye pike.

Figure 1 shows the hatchery production goals. Rainbow trout will be reared to a size of 100 mm (38 per pound). Eggs will be supplied from other brood stock facilities in Alberta. Trout fry will be overwintered in raceways and outplanted in the spring and early summer. Walleye will be outplanted at the sac-fry stage in early spring. Approximately 750,000 walleye will be pond reared throughout the summer and released in early fall at about 100 mm size.

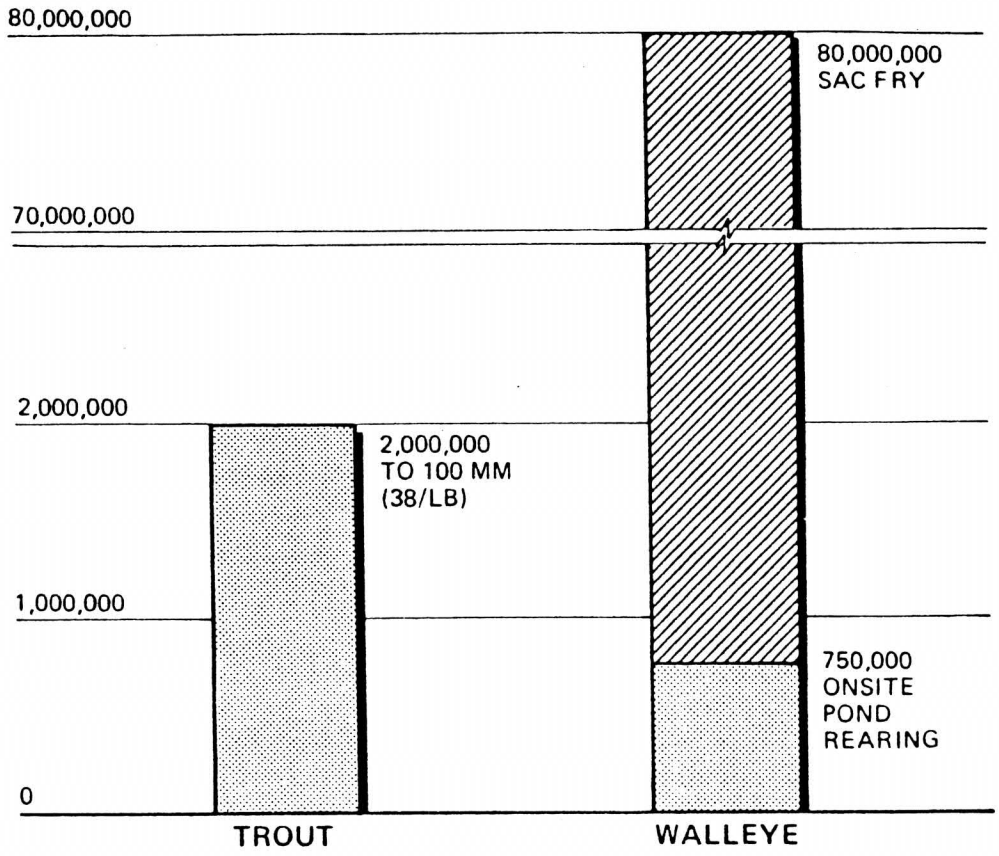

Figure 1. PRODUCTION GOALS.

FACILITY SITING

The facility site selection effort was confined to a triangular area of Northern Alberta as shown in Figure 2. Because of extreme climatic conditions (winter and summer), site selection proceeded along two lines of investigation: (1) identification of suitable surface water adjacent to a groundwater source which could be used to enhance water quality and temperature year-round, and (2) identification of suitable surface water adjacent to sources of waste heat (i.e., powerplants, gas pump stations, industry) which could provide acceptable winter water temperatures via heat exchange.

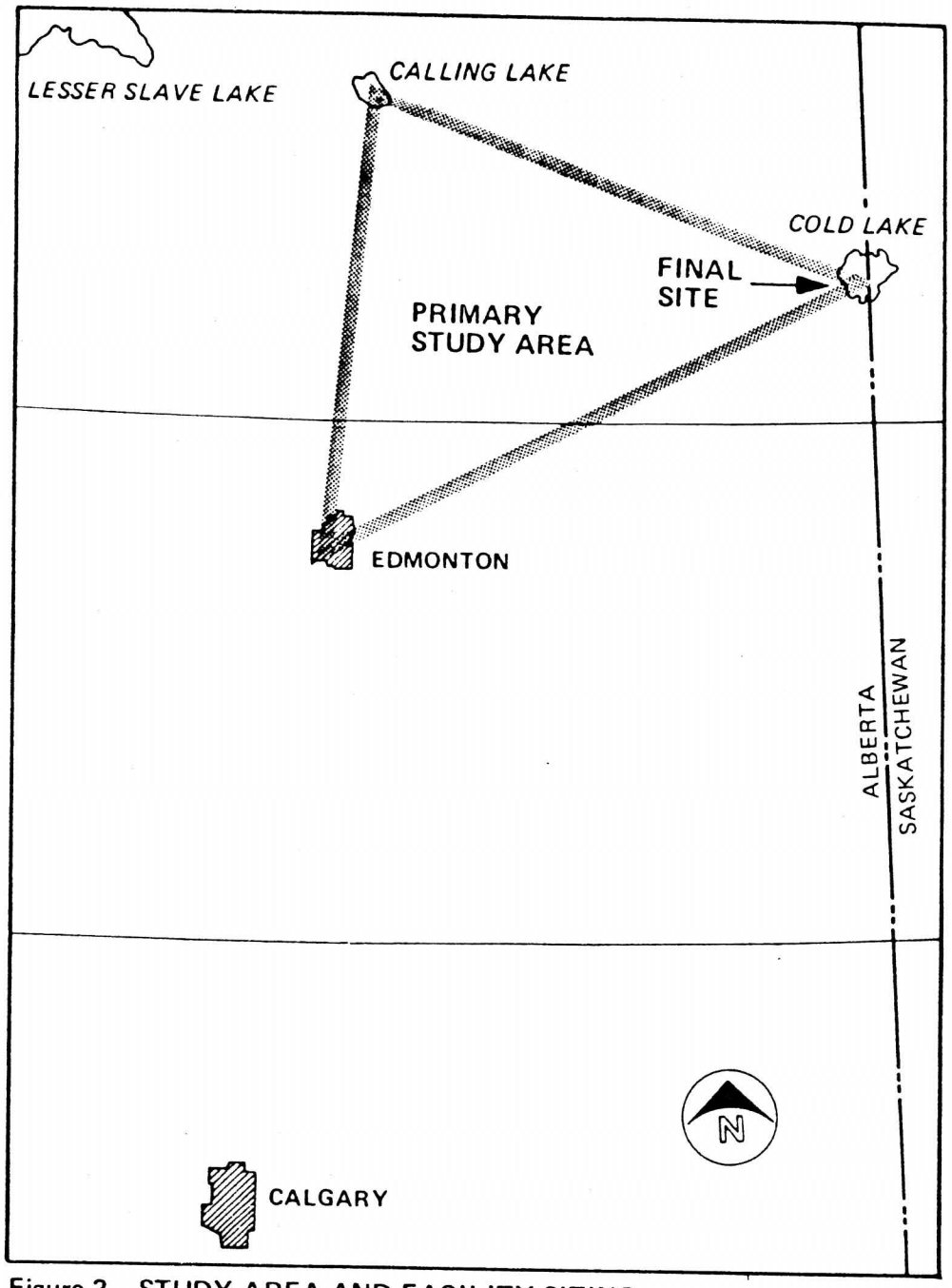

Figure 2. STUDY AREA AND FACILITY SITING.

Early in the investigation it became apparent that groundwater sources in the study area were not available because of limited quantity or extreme depth and that waste heat sources adjacent to a good surface water source were not available in the primary study area. Since it was deemed essential to site the facility within the study area, selection criteria were narrowed to select the

most suitable site within the study area based on surface water quality and temperature and on factors such as stocking patterns, site availability, availability of roads and utilities, etc. The Cold Lake site had the highest overall ranking, primarily due to the excellent water quality and relatively great depth and volume of Cold Lake.

Once the site was chosen, design concepts were evolved which took into account the relatively harsh climate while minimizing cost of energy for water and space heating.

DESIGN CONCEPTS

Figure 3 is a schematic representation of the system employed at the Cold Lake site to achieve suitable water temperatures. Lake water taken from two depths (shallow and at 20 m) will allow mixing to achieve the optimal temperatures in both summer and winter. Natural gas from a system supplied by natural gas wells in the area will provide the heating energy. Incubation and early rearing water is reused in outside raceways to minimize heating requirements. Temperature control for each species' life stage is also achieved by manipulating lake water mixing plus heat exchange.

Additional winter temperature control will be achieved with covered raceways as shown in Figure 4. Metal roofs will cover raceways to protect against snow, and a windbreak enclosing the raceways will reduce heat loss in the winter. Both the roof and windbreak are inexpensive enhancements to temperature control.

PRODUCTION FACILITY SUMMARY

The facilities flow sheet in Figure 5 summarizes the major components for incubation, early rearing, and grow-out of rainbow trout and walleye. Table 1 summarizes the design criteria for each component.

Two surface intake pumps and two deep intake pumps, each with a capacity range of up to 125 lps, will supply the facility. Water from the lake will be pumped to a mixing box/head box. Prior to entering packed column aerators (for oxygen and nitrogen control), water will pass through the heat exchanger to achieve the desired temperature for the incubation or rearing component.

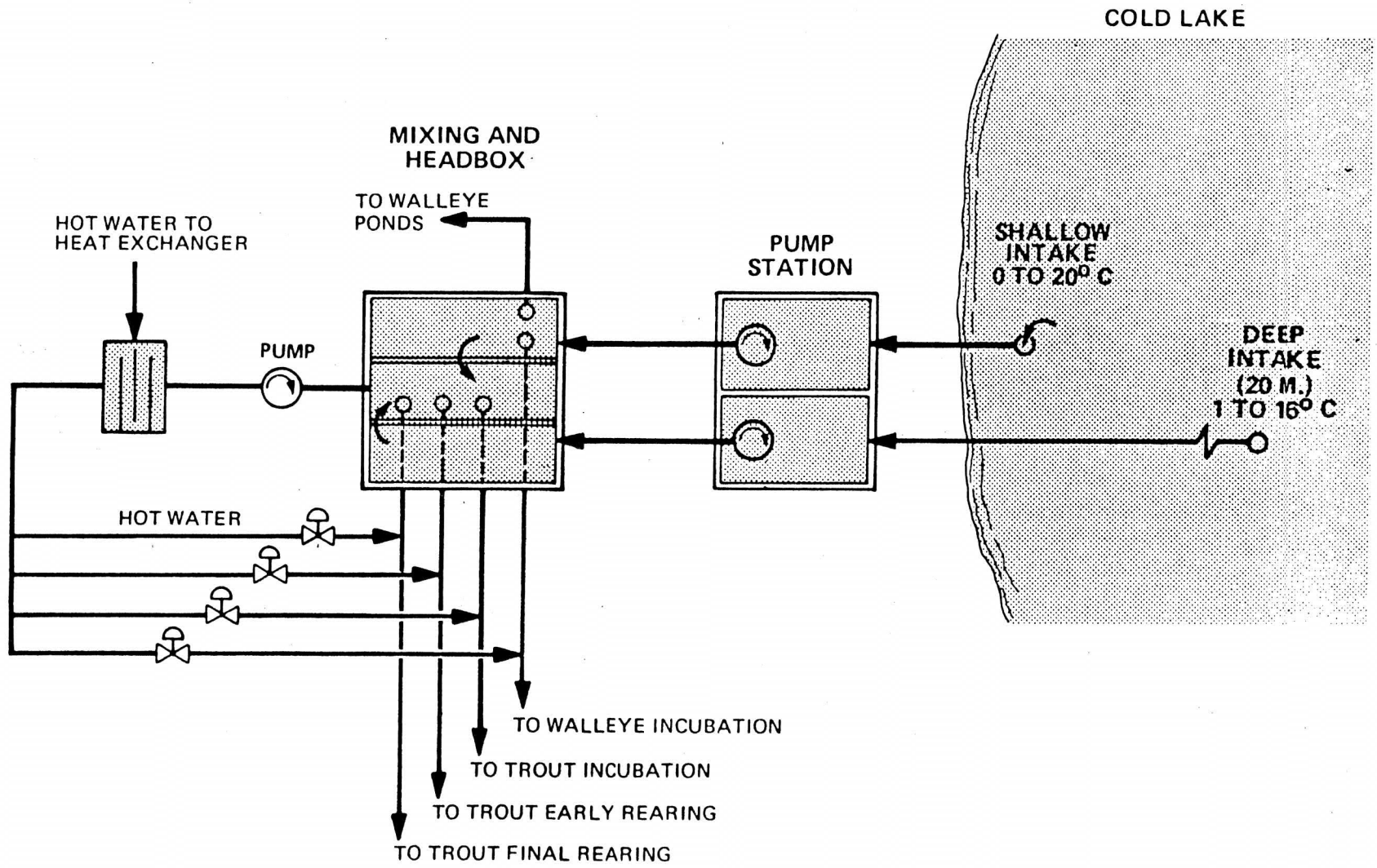

Figure 3. COLD WATER PROBLEM/SOLUTION.

NORTHERN ALBERTA TROUT AND
WALLEYE HATCHERY AT COLD LAKE

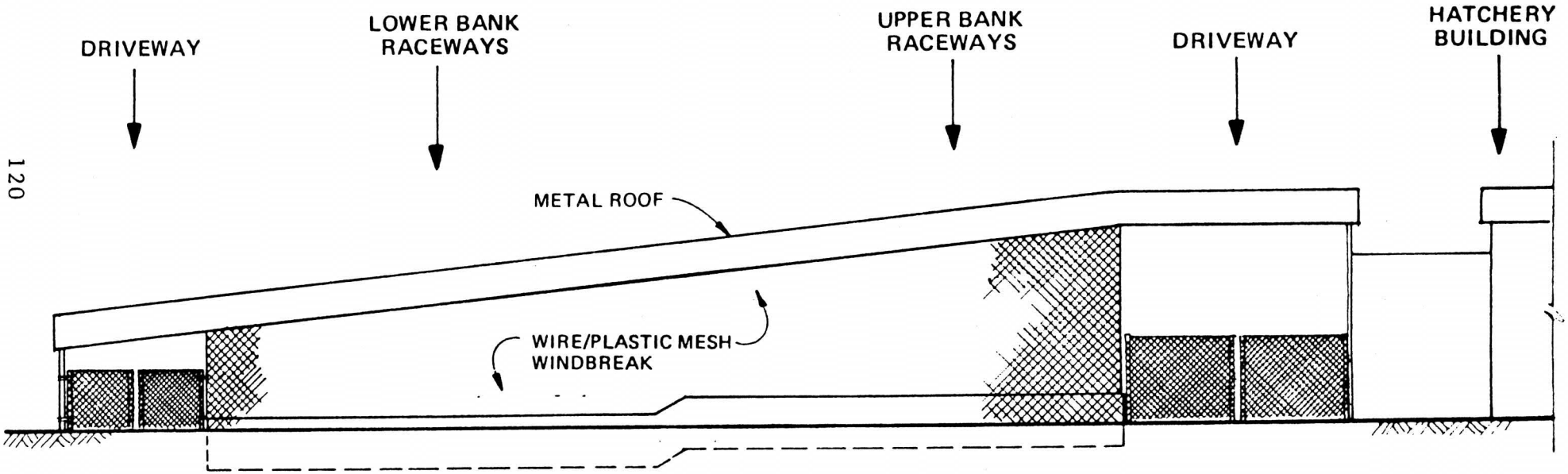

Figure 4. INDOOR/OUTDOOR RACEWAYS.

NORTHERN ALBERTA TROUT AND WALLEYE HATCHERY AT COLD LAKE

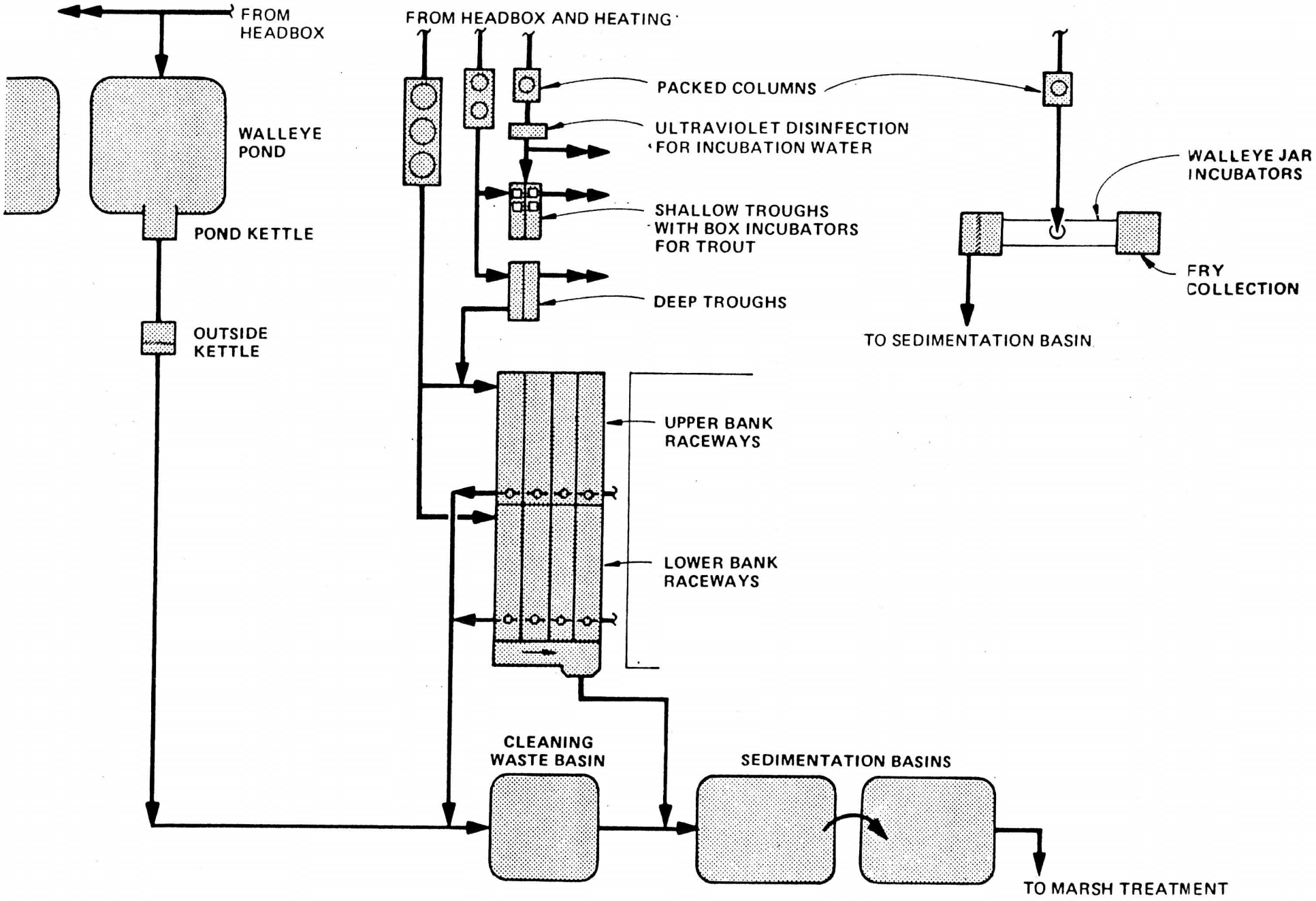

Figure 5. FLOW SHEET.

NORTHERN ALBERTA TROUT AND WALLEYE HATCHERY AT COLD LAKE

Table 1
DESIGN BASIS

System	No. Units	Egg/Fish Capacity Per Unit No.	Egg/Fish Capacity Per Unit kG	Egg/Fish Capacity Combined No.	Egg/Fish Capacity Combined kG	Process Water Supply/Drain Capacity Per Unit Normal LPS	Process Water Supply/Drain Capacity Per Unit Max. LPS	Process Water Supply/Drain Capacity Combined (Header) Normal LPS	Process Water Supply/Drain Capacity Combined (Header) Max. LPS	Remarks
Deep Intake, Pumps & Pipeline	2 Pumps	-	-	-	-	107	125	215	250	
Surface Intake, Pumps & Pipeline	2 Pumps	-	-	-	-	107	125	215	250	
Potable & Washdown Water	2 Pumps	-	-	-	-	Varies	3.12	Varies	6.25	
Fire Supply	1 Pump	-	-	-	-	31.5	31.5	31.5	31.5	
Walleye Incubation	2 Pumps	-	-	-	-	15.0	24.0	15.0	24.0	Based on 100% standby pump capacity
	4 Stands	28,750,000	-	115,000,000	-	3.75	6.0	25.0[d]	24.0	Use is 1/2 that shown when operated
	16 Fry Tanks	5,000,000	-	80,000,000	-	0.94	1.5	15.0	24.0	as 2 past system
Walleye Ponds	10 Ponds	75,000	-	750,000	-	6.25	12.5	125	125	Water surface area 0.456 ___/pond
Trout Incubation	48 Troughs	52,000	-	2,496,000	-	.17	.34	8.16	16.0	Four hatching boxes/trough
Early Rearing										
Shallow Troughs	24	c	4.7	c	113	0.32	2.34	-	-	
Deep Troughs	88	c	15.0	c	1,320	1.03	4.7	-	-	
Combined Troughs	112	-	-	2,250,000	1,430	-	-	100	146	
Fry Raceways approx. 1.10mm wide	16	68,750	104	1,100,000	1,670	7.7	12.4	-	-	2 bays of 8-16
Final Rearing Raceways						7.7	210.4	-	-	Same as fry raceways above
1,100 wide - upper bank	16	13,875	-	333,000	3,964	15.4	20.8	-	-	4 bays of 4 x 16
2,200 mm wide - upper bank	16	27,792	-	667,000	7,941	15.4	20.8	-	-	6 bays of 4 x 24
2,200 mm wide - lower bank	24	41,667	-	1,000,000	11,905	-	-	370	500	
combined capacity	56	-	-	2,000,000	23,810					
Cleaning Waste Ponds	2 ponds	-	-	-	-	65	65	130	130	
Sedimentation Pond (1 pond)	3 Inlets	-	-	-	-	406	500	430	500	

[a] Stands contain 18 jars/side/level x 2 sides x 2 levels = 72 jars/stand x 4 stands = 288 jars. Use 500,000 eggs/jar x 230 jars = 115,000,000 eggs. Remaining jars are hospital jars.

[b] Troughs contain 4 boxes each

[c] Operator preference

[d] Based on .061 lps/jar x 230 jars

BOPM1/018

Incubation

Walleye eggs will be incubated in jars at a loading rate of 500,000 per jar for a total capacity of 115,000,000 eggs and 230 jars. The component will consist of four double-tiered stands with 72 jars per stand (18 per level). Extra jars will be utilized as hospital jars to control fungus and disease. Water flow will be 0.063 lps per jar, individually controlled. The walleye incubation can be operated as a two-pass system with water from the upper tier circulating to the lower tier.

Rainbow trout incubation will be performed with box incubators set in shallow troughs. Egg loading rate will be 52,000 per trough for a total capacity of 2,496,000 eggs in 48 troughs, each with 4 boxes with a water supply of 0.34 lps to each trough.

Early Rearing

Walleye sac-fry will be held in fry tanks for a short period prior to outplanting. A total of 16 fry tanks (4 per stack) will each hold 5 million sac-fry. Individual fry tank inflow lines will allow for 0.94 lps. Outflow will be achieved with standpipes in the bottom drains.

Rainbow trout fry will be transferred from shallow troughs to deeper troughs after hatching. The deeper troughs (total of 88) will be used to rear trout fry to the all-feeding stage at which time they will be released to eight pairs of fry raceways, each 1,100 mm wide with a flow of 2.08 lps. Fry raceways will also be used for part of the final rearing component.

Final Rearing

Walleye fry (750,000) will be summer-reared in 10 grow-out ponds. Each pond will have a surface area of 0.456 hectares and will be approximately 1 meter deep. Stocking density will be 75,000 fry per pond and each pond will be supplied directly from the headbox with 6.25 to 12.5 lps.

At the end of the grow-out period, ponds will be drained to a sump or kettle (in the pond or outside of it) where walleye fingerlings will be harvested for outplanting.

Rainbow trout will be final reared in a double pass raceway system (0.6 m drops between raceways). The upper bank of raceways will consist of eight pairs, 1,100-mm wide and eight pairs 2,200-mm wide. The lower bank will consist of twelve pairs 2,200-mm wide. Water flow to the raceways will be 370-500 lps. Raceways will be loaded at 1 lb/ft^3 with two turnovers per hour.

Dropboards and screens at the bottom of the raceways will be pulled in the spring to crowd the fingerlings into collection basins in the tailrace. They will then be pumped, or transferred by gravity pipeline, to a loading station for haul trucks.

CURRENT STATUS

The Northern Alberta trout and walleye hatchery will be fully operational in 1986. Phase I of the construction program (the water supply system) was completed this year along with implementation of walleye pond construction.

BO049/003

FISH CULTURE IN CHILE AND THE SOUTHERN HEMISPHERE

Richard E. Noble

Salmon/Trout Advisory Service

A series of slides of the first successful introduction of Pacific salmon into the country of Chile was presented at the 35th Annual N.W. Fish Culture Conference held in Kennewick, Washington. The slides provided a visual account of the logistical, biological and cultural conditions that faced Domsea Farms (then a subsidiary of Union Carbide) in 1976. The area in Chile selected for the introduction of coho and chinook was the island of Chilow, south of Point Demontt. The location by latitude was between 42 and 43, being comparable to southern Oregon in the Northern Hemisphere.

The lack of any confirmed returns from introduction over the previous 100 years gave cause for concern and thus the company was not willing to invest large sums of money into hatchery facilities until there was evidence that Pacific salmon would migrate and return to the point of release. The successful introduction of chinook salmon into New Zealand did indicate that it was possible, thus a program was initiated. The selection of stocks was limited to those that were in excess to the needs of Pacific Coast states. Coho eggs from the Washington Skagit hatchery and eventually Skykomish and Bonneville were obtained. The only chinook eggs initially available were "springs" from the Cowlitz hatchery in Washington.

To bypass some critical summer water temperatures for hatching eggs at the initially selected streams, the eggs from the Skagit hatchery were delayed in their incubation by chilling. An improvised chiller, using coils of tubing immersed in a tank with ice supplied from an ice making machine was used and provided sufficient delay to have stream temperatures in Chile under 14 degrees C. The first coho eggs were shipped as eyed eggs by commercial carrier into Santiago, Chile, then by charter plane to Castro, Chile, near the selected release area. Eyed eggs were then transported to the selected streams by a 1-ton truck. The initial program was to complete the incubation within meter square trays submersed in pools of several selected streams near a freshwater lake that was to serve as the rearing area by using net pens within the lake. Over 48 hours was required to get the eyed eggs from Gorst, Washington to the incubation trays in the selected streams. The trays that survived the floods had survival rates to the "buttoned up" fry stage in excess of 75%. Some fry were released within the stream, but most were transferred to the lake net pens and reared to 25 grams. During the lake rearing period a more detailed survey of the area was undertaken and the stream for building a small "mother" station was finally selected. The selected stream was at the town of Curaco de Velez, located on a small island north and east of Castro. The release of smolts reared in the net pens was made during the Christmas season of 1977. Subsequent to the expected return and prior to next season's egg import, three large rearing ponds (approximately 30 x 100 meters and ranging in depth from 1 to 2 meters) were hand dug at the selected site. Two of the ponds were to be used as rearing ponds and one as the adult holding pond. Jack coho returns were the first indication that the project would be viable. Prior to the second release the rearing ponds were completed and incubation of the imported chinook eggs took place within the pond that was to be used as the adult holding pond. The hatched chinook

were reared and released over an extended period of time. The size of fingerlings released ranged from 35 grams to 75 grams with those reaching the large size being released after approximately one year's feeding. The initial plan was to take scale samples from the juveniles released and evaluate the success of return by adult scale pattern. Time and manpower simply did not allow follow-through. Adult chinook and coho did return to the release site. The migration of both juveniles and adults responded to the local season and not that of the Northern Hemisphere from which they came.

The strength of the returns favored the chinook with a rate that was near one percent. Adult chinook from a single egg take returned over a four year period and several months within a single year. Some chinook adults reached 25 kilo's. The coho stock from the Bonneville station appeared to return at a higher rate than from the more northern station, perhaps an indication of being from a more similar latitude.

There is no doubt that the environment in the Southern Hemisphere is favorable toward developing populations of Pacific salmon. The species most likely to succeed would be the chinook salmon, similar to the history of New Zealand Pacific salmon introductions. The first imports into New Zealand of chinook was from the period of 1875 to 1880, but with no apparent success. Subsequently the New Zealand government imported 1.8 chinook million eggs from the Baird station of Sacramento during the period of 1901 and 1907. This introduction resulted in populations of chinook numbering several hundred thousand, mostly in rivers of the east side of the South Island. Hydro development has reduced the numbers to a few thousand adults. In both New Zealand and Chile, the effective and proper use of hatcheries will be essential to the success and expansion of Pacific salmon in the Southern Hemisphere.

FISH FARMING IN EUROPE

GEORGE W. KLONTZ
PROFESSOR, FISHERY RESOURCES
UNIVERSITY OF IDAHO
MOSCOW, IDAHO 83843

During the past 5 years I have been privileged to make 1-2 trips annually to Europe. My main function was to attend professional meetings - but those can be somewhat exhausting if that is all one did. My benefactors - the agencies paying our way - set aside sufficient time to make some repeated in-depth visits to commercial fish farms in several countries. What I would to do is to share with you some of these experiences.

Food fish farming in Europe is big business. From the trout production standpoint, Denmark leads the world's production with nearly 50 thousand metric tons annually. There are 200 or so farms in production. The annual production is virtually 100% exported as fresh dressed, frozen dressed or chilled in the round. The usual size is 1-1.5 pound fish. The major constraint to production is water quality - especially dissolved oxygen. The Danish farms have become virtually free of VHS and whirling disease through the implementation of strict sanitization regulations. The major communicable disease of consequence is Enteric Redmouth Disease. This past month I presented two lengthy seminars on the subject.

Next in productivity is France with an annual production of 44-45 thousand metric tons. In the north of France, near Aras, the main problem is water quality and quantity. The fish really appear in not the best of shape, in many cases. In the south of France, near Lourdes, water quality is high since it originates in the Pyrenees to the south along the border between France and Spain..

Third in productivity is Italy with some 40 thousand metric tons annual production. The majority of the production farms are located just to the north of the Adriatic Sea west of Verona. Here the water is good and plentiful. It originates to the southern Alps to the north. Nonetheless, the Italians re-use their water unmercifully. One farm I visited had raceways systems which were nearly 1 kilometer long and the fish looked well for it. I think the most impressive observation I made about the Italian trout farms was that there were no dead or dying fish on the majority of farms I visited. I have been told that this was for my benefit - which I doubt because our itinerary was not that well known. However, if it were true, I am deeply flattered and further impressed because of the monumental task these farmers accomplished in preparation for our visit. The average size farm produces 1-1.5 million pounds per year and utilizes 3-4 man-years of effort. I know of no farms or hatcheries in the U.S. which

have that level of productivity. In Italy the majority of the fish are consumed domestically with the market size being 14-18 ounces per fish.

Fourth in productivity is perhaps West Germany - especially in Bavaria. Here I saw the usual methods of production but in addition I saw a unique method of processing and distributing. The processor buys the fish from the producers, depurates them on his premises, then processes them into the various products ranging from fresh-dressed to frozen to smoked to specialty products like trout stew in a bag. Very innovative.

Coming up in annual production of trout are England, Scotland, Norway and Finland. I do not have a "guesstimate" of the annual production other than to say that it's getting humongous. Norway is exporting to America more than 20 metric tons per week. These fish are of superb quality and are in high demand in the marketplace.

In summary, what I have seen throughout the trout farming community in the European countries impressed me very much. These farms are family-owned and the farmers are not fish culturists per se. They are very competent businessmen. They hire fish culturists from the technical colleges. One striking observation was their spirit of togetherness. To be sure, there is competition but not of the type seen in our country. I received a letter the other day from one of our leading fish feed manufacturers who had just returned from his first trip to Europe. He stated that the U.S. farmers had better get off their duff if they expect to control the U.S. market of trout and salmon. I think that's true.

IMPROVED HATCHERY PRODUCTION WITH WATER QUALITY MANAGEMENT:

Sediment in Downstream Quiet Zone Raceways.

International Aquaculture Research Center - Rangens

Richard Noble presented the abstract of the study involving screening off the lower 25 percent of three 100 foot raceways so as to provide a place for fish waste to settle and be pumped. This was compared to the control side with screens at the end of each raceway. The test demonstrated that as many or more pounds of rainbow trout could be reared in the shortened section of raceways as the full length raceways. The settling area allowed sufficient removal of waste products to more than meet EPA guidelines. The complete article has been written up in the October issue of "Salmonid" (1984).

EVALUATION OF CONDITIONING STEELHEAD TROUT IN COLD WATER AFTER REARING AT 15° C

T.C. BJORNN

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College of Forestry, Wildlife and Range Sciences
University of Idaho
Moscow, ID 83843

ABSTRACT

Steelhead trout transferred to a pond with cold water (4-10°C) 8 to 12 weeks before release after being reared in 15°C water, returned at higher rates than fish held in 15°C water until release. Of six marked groups released in 1979 and 1980, all three groups of fish conditioned in cold water returned at higher rates than the three groups of unconditioned fish. A group of conditioned fish that averaged 227 mm in length when released, returned at twice the rate of other groups. Size and health of fish were important factors in return rates. Fish held in 15°C water until release migrated seaward slightly later than conditioned fish.

Steelhead trout released in the Lemhi River during January-March survived poorly because of thermal shock despite eight hours of acclmation during transport. Steelhead released in the upper end of the Lemhi River were captured at Lower Granite Dam at only one-tenth the rate of fish released 69 km further downstream near the mouth of the river. Steelhead released in the upper river may have had difficulty negotiating the 40 or more irrigation diversions when migrating down the Lemhi River.

Editor's Note: This paper is available from the University of Idaho, Cooperative Fishery Research Unit as Technical Report 84-3.

DOOR PRIZES

Northwest Fish Culture Workshop

December 4, 5, 6, 1984

NO.	ITEM	DONOR	WINNER
115	Gift Box - Yukon Jack	Silver Cup	Roy Rathvon - WDG
104	St. Michelle Wines	Silver Cup	Fred Norman - WDG
180	Trout Fishing Outfit (spinning rod, reel, line tackle box)	Moore-Clark	Jerry Fisher - ODFW
33	Preston Cellars Wine	Argent Laboratories	A.J. Demarest - ODFW
184	Preston Cellars Wine	Argent Laboratories	Jerry Giles - Clear Springs Trout Co.
187	Jim Beam Collector Bottle	Silver Cup	Max Wooley - Clear Springs Trout Co.
323	Bolla Wines	Silver Cup	Carl Copper - ODFW
194	Aplets-Cotlets	Liberty Orchards	Gary Hager
2	Aplets-Cotlets	Liberty Orchards	Randy Aho
29	Box of Apples	Rangen	Lyle Curtis
56	Steelhead Trip - Wenatchee River	Ric Stilwater	Paul Hammerick - Warm Spr.
103	Graphite Rod & Spinning Reel	Sunset Sports	Dick Noble - Salmon/Trout Advisory Service
	Special Award - Muscatel	Silver Cup	Canadian Bed Race Team

ANNUAL NORTHWEST FISH CULTURE CONFERENCES

HISTORICAL RECORD

Year	Location	Host Agency	Chairman
1950	Portland, Oregon	U.S. Fish & Wildlife Service	Perry, T.
1951	Wenatchee, Washington	U.S. Fish & Wildlife Service	Burrows, R.
1952	Seattle, Washington	Washington Dept. of Fisheries	Ellis, B.
1953	Portland, Oregon	Oregon Fish Commission	Cleaver, F.
1954	Seattle, Washington	U.S. Fish & Wildlife Service	Rucker, R.
1955	Portland, Oregon	Oregon Game Commission	Rayner, J.
1956	Seattle, Washington	Washington Dept. of Game	Millenbach, C.
1957	Portland, Oregon	U.S. Fish & Wildlife Service	Johnson, Harlan
1958	Seattle, Washington	Washington Dept. of Fisheries	Ellis, R.
1959	Portland, Oregon	Oregon Fish Commission	Jeffries, E.
1960	Olympia, Washington	Washington Dept. of Game	Johansen, J.
1961	Portland, Oregon	Oregon Game Commission	Jensen, C.
1962	Longview, Washington	U.S. Fish & Wildlife Service	Burrows, R.
1963	Olympia, Washington	Washington Dept. of Fisheries	Ellis, B.
1964	Corvallis, Oregon	Oregon State University	Fryer, J.
1965	Portland, Oregon	U.S. Fish & Wildlife Service	Halver, J.
1966	Portland, Oregon	Oregon Fish Commission	Hublou, W.
1967	Seattle, Washington	University of Washington	Donaldson, L.
1968	Boise, Idaho	Idaho Fish & Game Department	Cuplin, P.
1969	Olympia, Washington	Washington Dept. of Game	Johansen, J.
1970	Portland, Oregon	Oregon Game Commission	Jensen, C.
1971	Portland, Oregon	U.S. Fish & Wildlife Service	Smith, M.
1972	Seattle-Tacoma, WA	Washington Dept. of Fisheries	Noble, R.
1973	Wemme, Oregon	Oregon Fish Commission	Jeffries, E.
1974	Seattle, Washington	University of Washington	Salo-Brannon
1975	Newport, Oregon (Otter Crest)	Oregon State University	Donaldson, J.
1976	Twin Falls, Idaho	University of Idaho	Klontz, B.
1977	Olympia, Washington	Washington Dept. of Game	Morrow, J.
1978	Vancouver, Washington	U.S. Fish & Wildlife Service	Leith, D.
1979	Portland, Oregon	Oregon Dept. of Fish & Wildlife	Jeffries, E.
1980	Courtenay, British Columbia	Fisheries and Oceans	Sandercock, K.
1981	Tumwater, Washington	Washington Dept. of Fisheries	Ashcraft, W.
1982	Portland, Oregon	National Marine Fisheries Service	Wold, E.
1983	Moscow, Idaho	Idaho Fish & Game and University of Idaho	Parrish, E. & Klontz, G.
1984	Kennewick, Washington	Washington Dept. of Game	Gearheard, J.
1985		U.S. Fish & Wildlife Service	Forner, E.