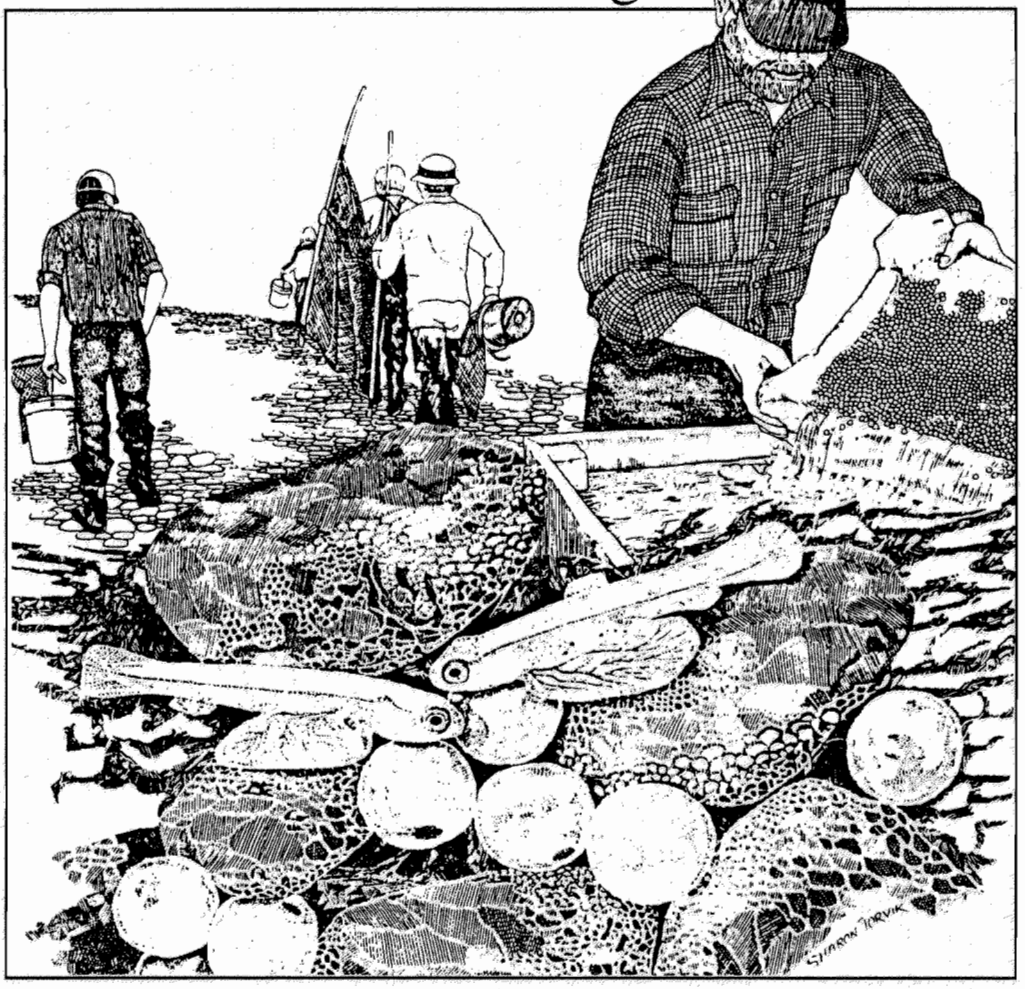
43rd Annual Northwest FISH CULTURE CONFERENCE

— Proceedings—



December 1—3, 1992

Wenatchee, Washington

PROCEEDINGS

OF THE

FORTY-THIRD ANNUAL

NORTHWEST FISH CULTURE CONFERENCE

DECEMBER 1-3, 1992

WENATCHEE, WASHINGTON

John Kerwin
Fisheries Management Division
Washington Department of Wildlife

Irv Brock
FRED
Alaska Department of Fish and Game

THE NORTHWEST FISH CULTURE CONFERENCE

The Northwest Fish Culture Conference is an annual informal meeting by and between fish culturists for the exchange of information and ideas about all aspects of fish culture. These conferences are hosted on a rotating basis by the various fisheries agencies and entities of the Northwest. At the conferences, progress reports of management practices and problems, new developments, and research studies are presented. Both within the meeting and outside the formal meeting setting, active discussion, constructive criticism, and personal contacts are not only encouraged but actively cultivated. All persons interested in or associated with fish husbandry are invited to attend and to actively participate. The subject matter is limited to topics that have direct application to fish culture.

This PROCEEDINGS contain abstracts and or talks presented at the conference. They are unedited, contain progress reports of uncompleted programs, and, as such, SHOULD NOT BE CONSIDERED A FORMAL, PEER-REVIEWED PUBLICATION.

Mention in these PROCEEDINGS does not indicate approval, recommendation, or endorsement of any proprietary product or material.

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Agenda Design:	Darrell Pruett

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THE U.S.FISH & WILDLIFE SERVICE BOZEMAN FISH TECHNOLOGY CENTER: A PROGRAM OVERVIEW

BY
CHARLIE E. SMITH
DIRECTOR

Within the Division of Fish hatcheries there is a small but extremely valuable activity called Fish Technology Centers. Their relative importance to the hatchery system, however, is significant in proportion to other activities within the system. The Centers provide leadership relative to new technologies in fish culture, nutrition, broodstock, water quality/effluents and many other areas of hatchery activities. The primary purpose for the Centers is to improve day to day hatchery operations, by improving efficiency, and fish quality to meet the fish production goals and objectives. Working with Threatened & Endangered species is also an important part of some of the Center's programs. Technology Centers were created in 1965 to evaluate fishery research information, and new technology for application in fish culture . There are currently 5 Centers in operation with an additional site proposed as a Center.

In 1966, the Bozeman National Fish Hatchery was designated a Fish Culture Development Center (name later changed to Fish Technology Center). A small staff was employed that began investigations related to salmonid fish culture. Investigations addressed primarily: water treatment systems, water reuse, hatchery effluent sedimentation facilities, carrying capacity and rearing indices, trout diets, trout broodstock, and other projects related to salmonid fish culture. A fish disease biologist also worked out of the station.

In 1986 the Beulah Fish Technology Center (Wyoming) was closed and it's function of diet testing and development, as well as it's staff was transferred to Bozeman.

The current Center program includes studies in fish culture, nutrition, broodstock management, Threatened & Endangered Species, fish health (primarily diagnostic histopathology), and fish management. In addition, technical assistance is provided to federal, state and private aquacultural programs in all of the above areas.

Most of the Center's staff members are involved as instructors in
in training programs conducted by the USFWS Training Academy, Leetown, WV.

The Center's unique water supply of a cold spring, warm spring and Bridger creek allow work at various water temperatures. In addition to working with salmonids, studies with walleye and various species of sturgeon are also an important part of the Center program.

Expansion of Lake-shore Rearing Facilities at Pyramid Lake, Nevada

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Abstract

The design and justification for constructing a Lahontan Cutthroat Trout (LCT) rearing facility at Pyramid Lake, Nevada is presented. The challenge of this project was to find a cost effective way to build a water delivery system for this project that would accommodate the extreme fluctuations in surface elevation experienced at Pyramid Lake. A submersible pump station was found to be an effective solution to this problem.

Background

The construction of an agricultural project in the Nevada Desert at the turn of the century destroyed a world class Lahontan Cutthroat Trout (LCT) fishery at Pyramid Lake, Nevada. A hatchery program was built to reestablish the LCT population. A factor limiting hatchery production is the scarce regional supply of freshwater. Recirculating freshwater facilities were constructed to make the best possible use of the limited freshwater resource. However, expansion of freshwater rearing facilities is constrained by the high capital cost of construction, the high operating cost of a recycle facility, and the lack of freshwater. Instead, the water of Pyramid Lake was targeted as source of water to expand fish rearing operations.

Pyramid Lake is a large (100,000 surface acres) desert Lake. Because it is a terminal desert lake it has some unique water chemistry. The Lake's salinity is 4.5ppt and it's quite alkaline, the pH is 9.4. Use of lakewater as a hatchery water source is limited to the rearing of juvenile LCT. The water chemistry will not support the LCT's early life stages. A lakewater rearing a rearing facility was needed to acclimate LCT prior to release, and increase the size of fish released. Acclimation of LCT to lake-water was necessary to reduce predation. The direct transfer of hatchery fish from freshwater to the Lake resulted in heavy predation by birds. Data indicated increasing the size of fish at release improved survival.

The factor limiting expansion of lakewater rearing facilities at Pyramid Lake was a cost effective pump station design that would accommodate the extreme fluctuations in surface level that occurs at Pyramid Lake. Since the Lake has no outlet, it is dependent on freshwater inflow to maintain its surface level. There is no regulating structure that controls the high or low point of water in the lake basin. During the

period of 1980 to 1986 the lake rose 30 feet, but during the years 1987 to 1992 the lake fell 20 feet. Standard designs for pump stations that can accommodate this type of level change were far beyond the budget of the program.

Project Description

The basic facility design that was selected for this project was:

1) An offshore submersible pump station.

2) A screened water intake structure located 1500 feet offshore in a depth of 45 feet of water.

3) A 24" diameter high density polyethylene pipeline (HDPE) which extended 1100' from the pump station to the intake structure.

4) A 20" diameter HDPE pipeline which extended 1000' onshore to supply water to the rearing facility.

5) A total of sixteen 36 foot diameter rearing tanks.

The rationale for selecting the pump station and pipeline design was dictated by cost and ease of construction. Circular tank selection was essentially made by the fish. Experience had shown that the LCT performed much better in circular than linear containers.

The pump station was fabricated from plate and structural steel that was welded to make a water tight box with dimensions of: 8 feet width, 16 foot length, by 6 foot height. The concept of the station was to create a suction chamber when the pumps ran which would draw the water from a cooler deeper depth offshore. The pumps discharge would move the water upshore to the rearing facility. The system was designed to deliver 3500 gallons of water per minute. The station was placed in a depth of 20 feet of water (figure 1). At the time of the pump station's placement underwater, water could decrease in depth by 10 feet or increase in depth by 30 feet without having to reposition the station. A dual pump system was installed to allow for 100% backup in the event of a pump failure.

The piping material selected for the project was high density polyethylene (HDPE) pipe because: it does not corrode, is strong, light, flexible, fairly inexpensive, and is easy to weld. Welding is accomplished by a heat fusion technique. A weld can be performed in about one half hour. The half mile of large diameter pipe used in this project was welded in a period of one week.

Tanks for this project were provided by two different suppliers. Aquacare provided a bolt together tank system which is manufactured by the A.O. Smith company. This system consists of a "tank kit" that is shipped on a pallet. The sheets of steel that the tank is built from are bent, punched, and epoxy coated at the factory to make a tank with the dimensions specified by the buyer. Assembly consists of applying a mastic to the joints of the steel panels and bolting the panels together. The base of the tank is made from concrete, which is pumped into the tank once the tank's walls are erected. A seal system made a water tight joint between the tank walls and concrete base.
A fiberglass tank system was supplied by Gemini Inc. The Gemini system consists of two tank halves with a 17' radius which are delivered by a wide load transport. The tanks halves are joined together by bolting the two sections together along a pre-drilled flange. Assembly of the tanks was performed on beams supported by sawhorses. Following assembly of the tank, a crane lifted the tank to remove the support beams, and the tank was placed into position.

Water level in the tanks was controlled by an external standpipe (figure 2). The standpipe control box consisted of 4' diameter pre-cast concrete manhole risers. A unique feature of this project was to apply the "second pass" gravity flow concept to this tank farm. Although a second use of water is a standard feature in raceway systems, it has not been applied to tank rearing systems. A five foot difference in grade was required to provide adequate head pressure and 10" diameter pipe was required for the tank drains to minimize head loss.

The design and construction of this project was performed by the staff of Pyramid Lake Fisheries. The designs and piping details were reviewed by an engineering firm to assure the concepts being applied were valid. The initial reason for keeping the project within the organization was to reduce cost. However, the benefits obtained by performing the project internally were: a feeling of accomplishment, the development of problem solving skills by the staff, an understanding of the project by the staff, and a sense of pride of ownership within the program.

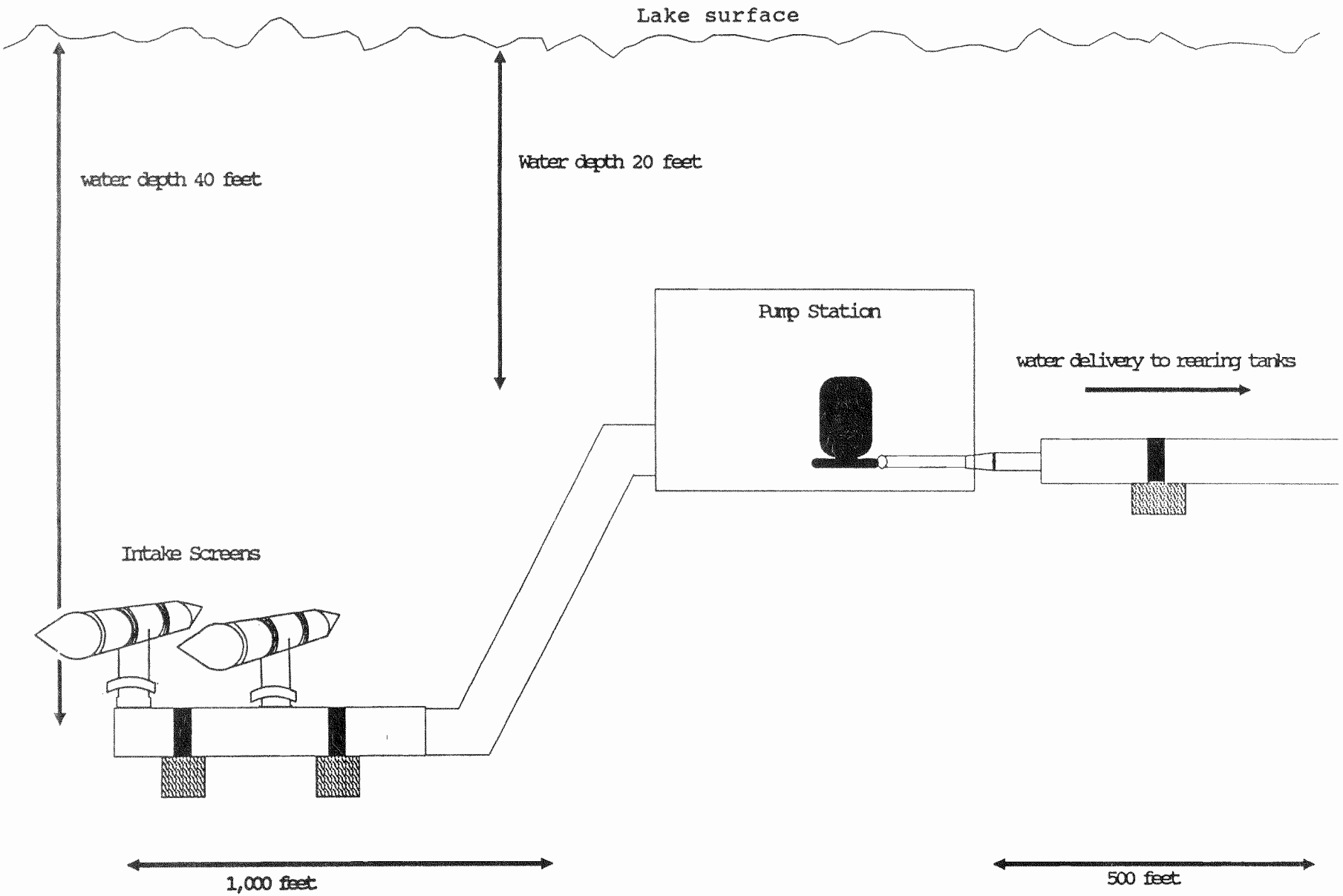


Figure 1. Conceptual plan of water intake and pump station design.

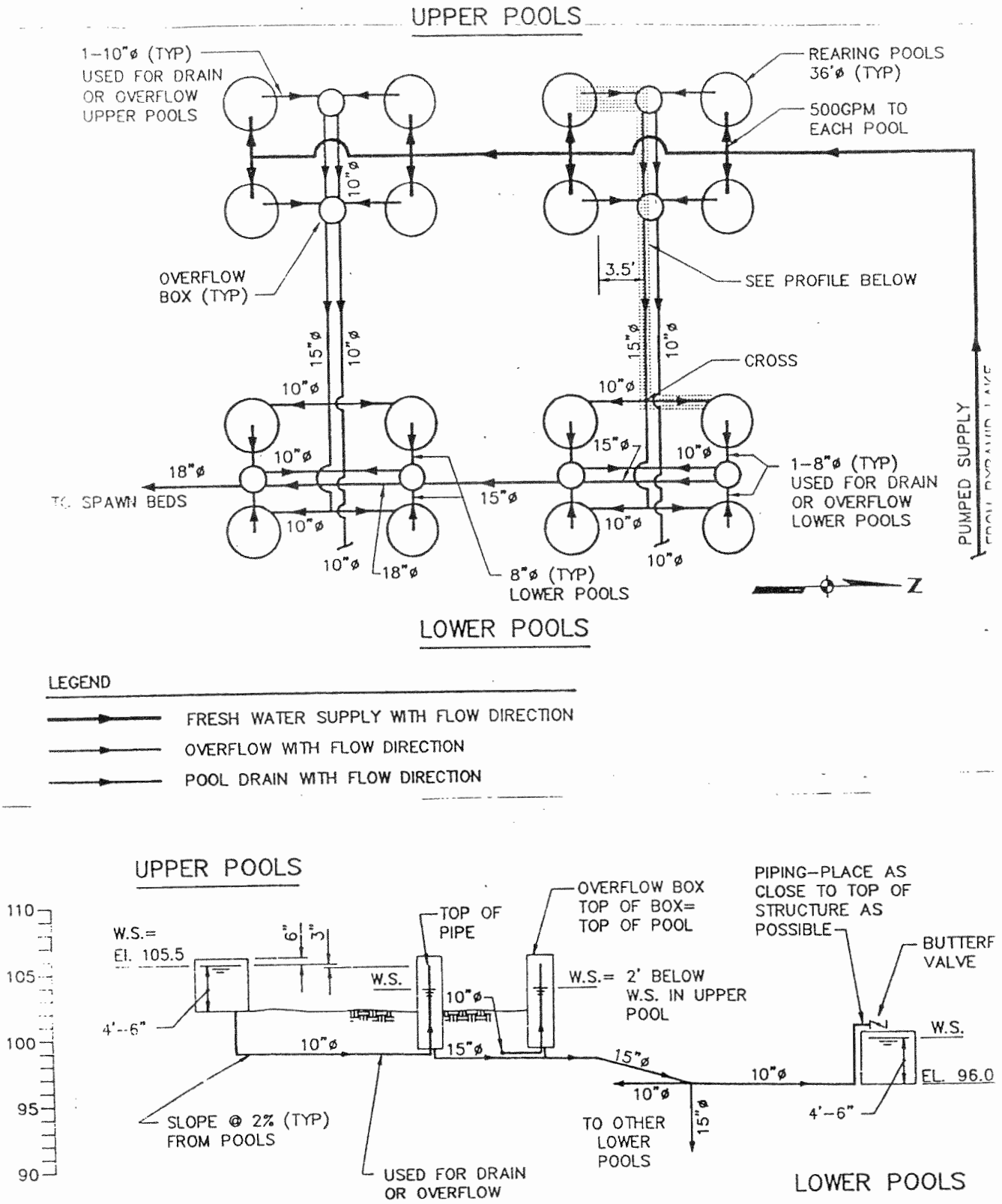


Figure 2. Schematic of onshore rearing facilities depicting water delivery system, tnak level control structure, and the elevation differnce required for water to gravity flow from the upper to the lower tank series.

Private Non Profit Salmon Enhancement in Alaska

William J. Halloran
Southern Southeast Regional Aquaculture Association

Introduction

The private non profit salmon enhancement concept in Alaska is a unique attempt by fishery user groups and state agencies to resolve the historic concerns of production, harvest and management of Alaska's important commercial salmon industry. The economic value of commercial fishing has historically been and continues today to be vital to the economic health of Alaska. Only petroleum production leads in economic importance. This discussion will view the development of the private non profit salmon enhancement efforts in Alaska and describe their unique organization and production accomplishments.

Historic Development

Alaska remains even today a vast, diverse, and resource rich state, in which commercial harvest of salmon is important. The diversity of the people, climate and geography make broad generalizations about Alaska difficult, but the presence of the roller coaster of harvestable salmon on a sustained basis is one that can be safely made. When the harvest of salmon in Alaska is viewed since the turn of the century some trends can be seen (figure 1). Early fisheries exploited sockeye salmon and by the 1930s pink salmon were the most abundantly caught fish. Various explanations to explain the harvest patterns have been offered, but presently cyclic climatic variation (that effect both the fresh water and marine phases of salmon biology) and management of the fisheries are generally accepted as reasons for the most dramatic trends shown. This trend line does not reflect the extreme variations that occur within regions of Alaska that have profound effects on local economics. The management of the fisheries in Alaska prior to statehood in 1959 was performed by various federal agencies, and the severely depressed salmon harvest during the 1950s provided great political focus for control of Alaska's resources by state government. This control of the management of Alaskan natural resources included the abolition of fish traps, leaving the other traditional capture methods of salmon (seining, trolling, and gillnetting) as legal commercial gear.

The fisheries management of salmon, since statehood, has been performed by the Commercial Fish Division and salmon enhancement was given to the Fisheries Rehabilitation and Enhancement Development Division (FRED) of the Alaska Department of Fish and Game. Commercial Fisheries Division instituted management changes to emphasize wild stock protection and rebuilding programs and the FRED Division concentrated on hatchery enhancement. Private enterprise, interested in ocean ranching appealed to the Alaska legislature as another alternative to public sector hatchery enhancement. This alternative was generally not accepted by the commercial salmon fishing industry, which feared the loss of control, to multinational corporations, of the salmon resource of Alaska.

In 1974 the Alaska Legislature enacted legislation for creation of private non profit corporations to operate salmon hatcheries for ocean ranching. The salmon enhancement requirements of the traditional fishing regions within the state were different depending on the level of wild stock depletion and perceived conflicts between gear groups. The initial enabling legislation identified the creation of the enhancement efforts to provide salmon for the common property fisheries of Alaska. The cost of construction and operations was to be borne by the sale of a portion of the returning fish to special harvest areas in excess of broodstock needs. Regional aquaculture associations were created by the legislature in 1976, to create regional entities that reflected the geographic, political, and economic diversity of the state. Originally, Prince William Sound, Cook Inlet, Northern and Southern Southeastern Alaska were identified. The make-up of the membership of the regional aquaculture associations was to be all the commercial limited entry permit holders of the area. The Board of Directors for each regional association was by statute and regulation to include commercial limited entry permit holders representing the gear groups of that region, as well as other representative user groups from the region. Additionally, the 1976 regulations created the option for the regional aquaculture associations to levy a voluntary assessment tax on limited entry permit holders.

This same law also established the formation of regional planning teams (RPT) to develop regional salmon plans. Each RPT consist of 6 voting members, with 3 ADF&G personnel appointed by the ADF&G Commissioner and 3 appointed by the board of directors of the appropriate regional aquaculture association. The duties and responsibilities of the RPT's have been mandated in a formal charter from the commissioner. The responsibilities of the RPT's in developing regional comprehensive salmon plans, including provisions for public involvement in the planning process, are described in regulations. The commissioner may also request the involvement of representatives of other federal and state agencies. The teams develop 20 year comprehensive plans, 5-year action (strategic) plans, and perform annual plan update and maintenance.

The last significant legislation concerning the private non profit organizations, both regional and non regional, was the establishment of the Fisheries Enhancement Loan Fund in 1977. This revolving fund administered by the Alaska Department of Commerce and Economic Development allowed low interest loans (not to exceed 9.5%) with a six to ten year (interest and principle) deferable period prior to the first repayment installment. This schedule allows the organizations to develop the cost recovery potential of returning adult salmon to the Special Harvest Areas given the two to six year life cycle of pacific salmon. As full production capability was recognized as being unlikely in one life cycle the deferment period was established for up to ten years. In reality, the Department of Commerce has charged the highest interest rate allowable by statute and the shortest deferment period.

Regional Aquaculture Associations since 1980 have adopted a mandatory tax by the vote of the members on the permit holders of either 2 or 3 percent of their salmon landing's value per year. The loans of the regional associations are secured by the potential cost recovery of returning salmon to the Special Harvest Areas and by the future enhancement tax potential of limited entry membership should a loan default occur. The non regional corporation's loans are secured by cost recovery potential only (figures 2, 3, and 4).

PNP Production

Much of the salmon enhancement by the various PNPs (presently 8 regional aquaculture associations and 12 Non-Regional Corporations) has to date been primarily directed toward efforts to create and maintain hatchery production. This effort was made to provide harvestable salmon to the fishing community, and develop cost recovery to pay for the operations of each PNP. (The goal of most PNPs is 70% harvestable salmon to the common property fishery and 30% for cost recovery and broodstock).

The diversity of the fishing fleets in different areas reflect the philosophy and ultimately the production goals and aquaculture techniques used. Each PNP has tailored their production goals, some opting for large production facilities whose production constitute in both the Special Harvest Areas and the common property fishery the majority the total commercial catch in the region. Other PNPs have production plans to only argument the existing wild stocks. Some have emphasized coho and chinook to satisfy the large troll fleet membership, or to establish a fishing area that one or more species are targeted principally by one particular gear group. In some cases enhancement production is geared toward the mitigation of depressed wild stock harvest during a period of rebuilding of that run.

I use the word enhancement rather than just hatchery production, as each year increasingly more of the total adult fish harvested comes from non-traditional hatchery production (lake fertilization, sockeye fry plants, spawning channels). In fifteen years the enhancement production by the PNPs has risen from zero to nearly 1.1 billion smolts (figure 5). This represents about 76% of the present permitted capacity. Pink salmon make up the majority of adults harvested overall, but regionally, significant harvest by the commercial fleets of chum, coho, chinook and now increasingly sockeye make up the 40 million PNP produced adults harvested in 1991 (figure 6).

The production by the PNPs would not have been possible without the Alaska Department of Fish and Game, National Marine Fisheries Service, the United State Forest Service, and the University of Alaska. All have played significant roles, along with the fishing community, in salmon enhancement. A most important recent event has been the State of Alaska's resolve to step away from state funded salmon production by having the Regional Aquaculture Associations operate the former State of Alaska salmon facilities. This privatization has been brought about by declining state oil revenues and the philosophy of user pays; i.e., the commercial fleets derive the majority of the benefit of the production, they should pay for it. The mechanisms are now in place and large production facilities have been turned over to the Associations, including hatcheries at Hidden Falls, Cannery Creek, Gulkana, Main Bay, Tutka, and Trail Lakes. These facilities not only are large, but in most cases at a production level that cost recovery, (i.e., operating money), can be immediately derived. The statutory ability to perform cost recovery and/or assess a salmon tax by the PNPs allows sustained salmon production to benefit all the common property fisheries; commercial, sport and subsistence without continued State of Alaska funds required.

The contribution by public agencies to the success of the PNPs cannot be over emphasized, and a special note should be made to the technical services provided by the Alaska Department of Fish and Game. The genetics and pathology policies are models by which other similar state and federal efforts are measured. The limnology and pathology labs have been key in the development of the success in sockeye culture. The coded wire tag program has aided the management of the fisheries to maintain the wild stock abundance while allowing maximum harvest of enhanced stocks, as well as to answer research and production questions.

Conclusion

The efforts by all parties to this Alaskan experiment; the fishermen, the state and federal agencies, and the PNPs have been stellar and steadfast; i.e. to sustain wildstock viability and to produce additional salmon to the common property for economic benefit to all Alaskans.

A cooperative mechanism between all the parties has been established and now the ability to pay for that effort by the user groups of the resource has been created. Whether the unique Alaskan model can be used successfully elsewhere is problematic, but at least for now I believe the Alaskan experience can be judged a success.

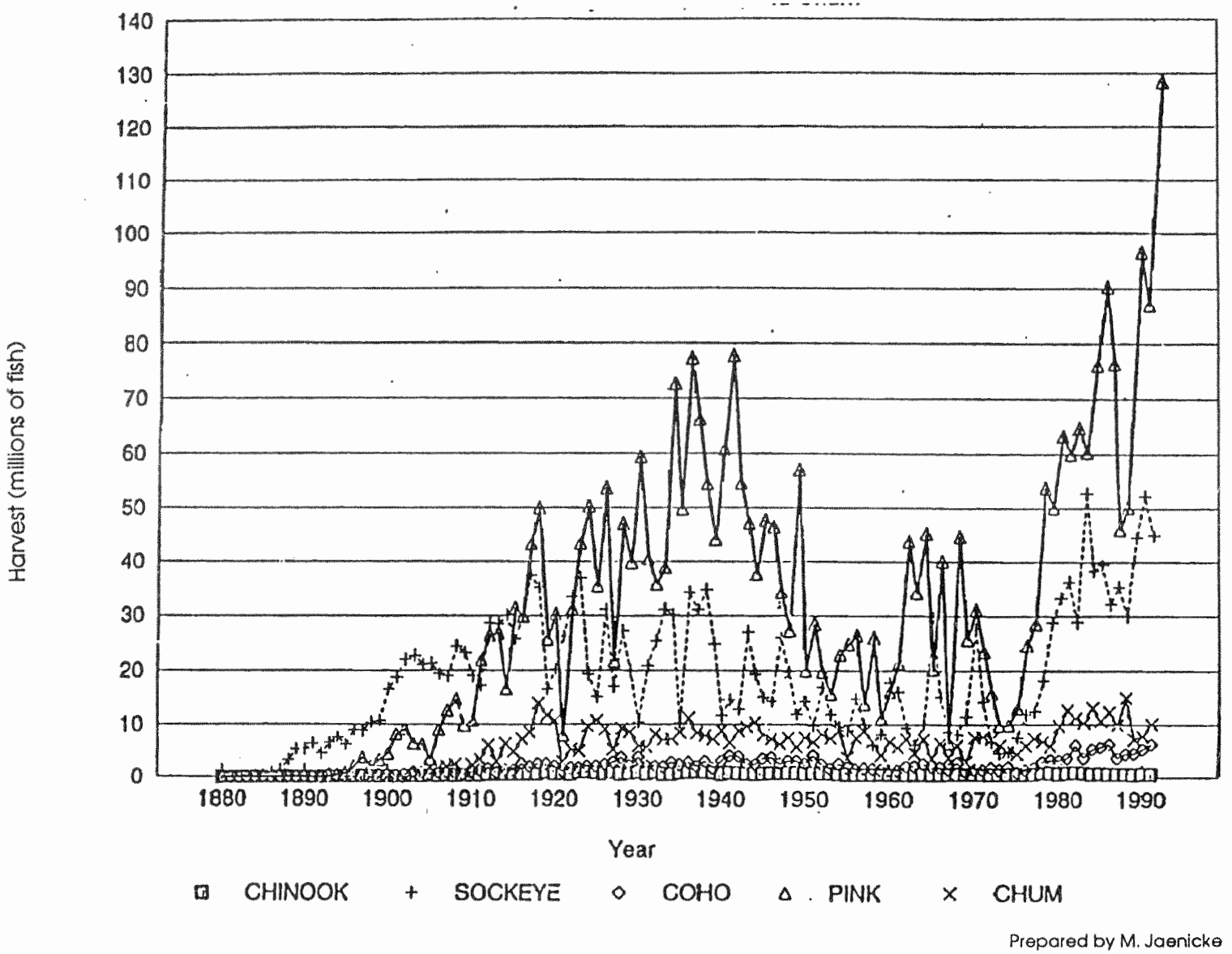
Sources:

FRED 1991 Annual Report to the Alaska State Legislature, Alaska Department of Fish and Game, January 1992.

Selected Alaska Statutes and Regulations for Private Nonprofit Salmon Hatcheries, Alaska Department of Fish and Game, 1986 Edition.

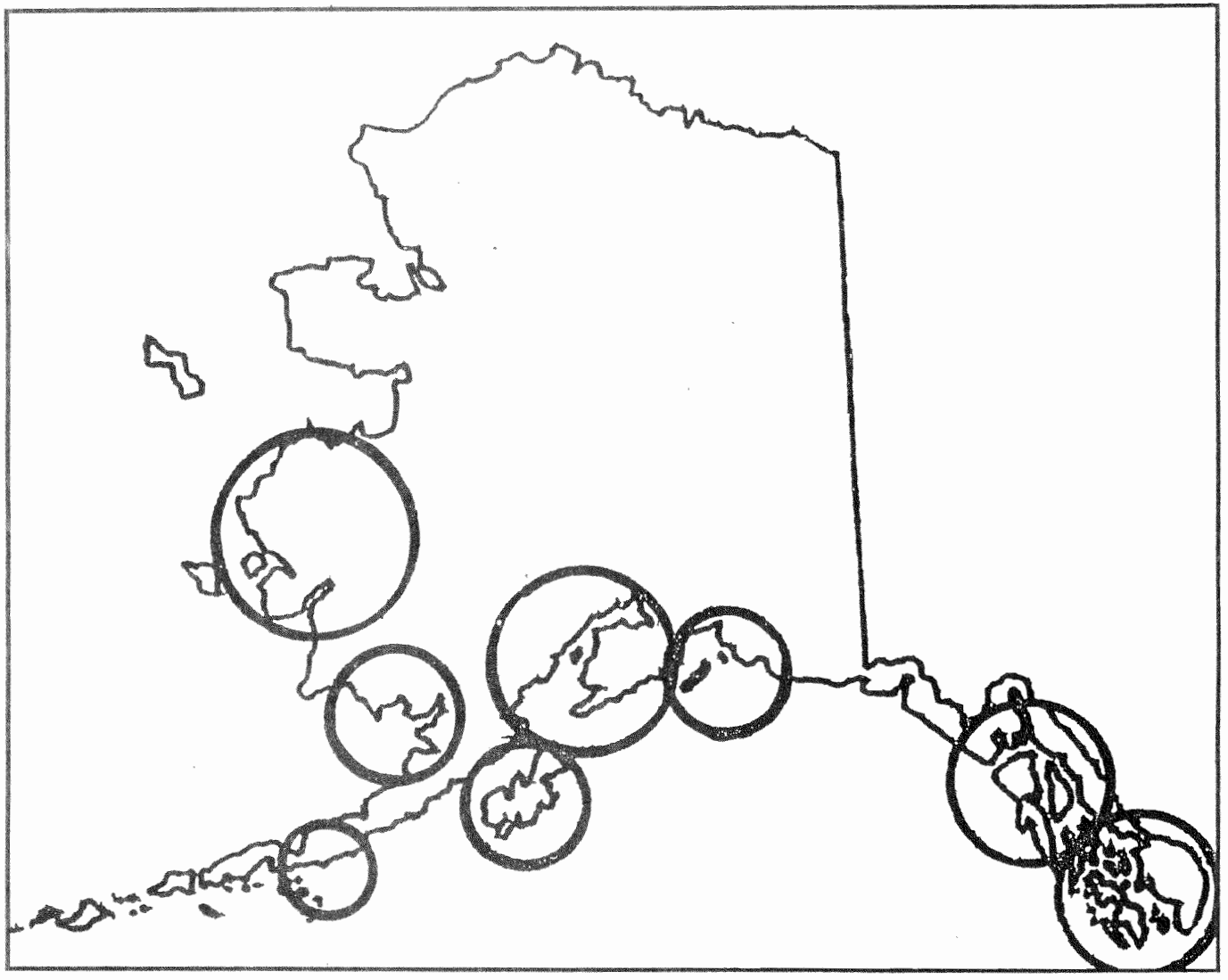
Commercial Salmon Harvest in Alaska

Chinook, Sockeye, Coho, Pink and Chum



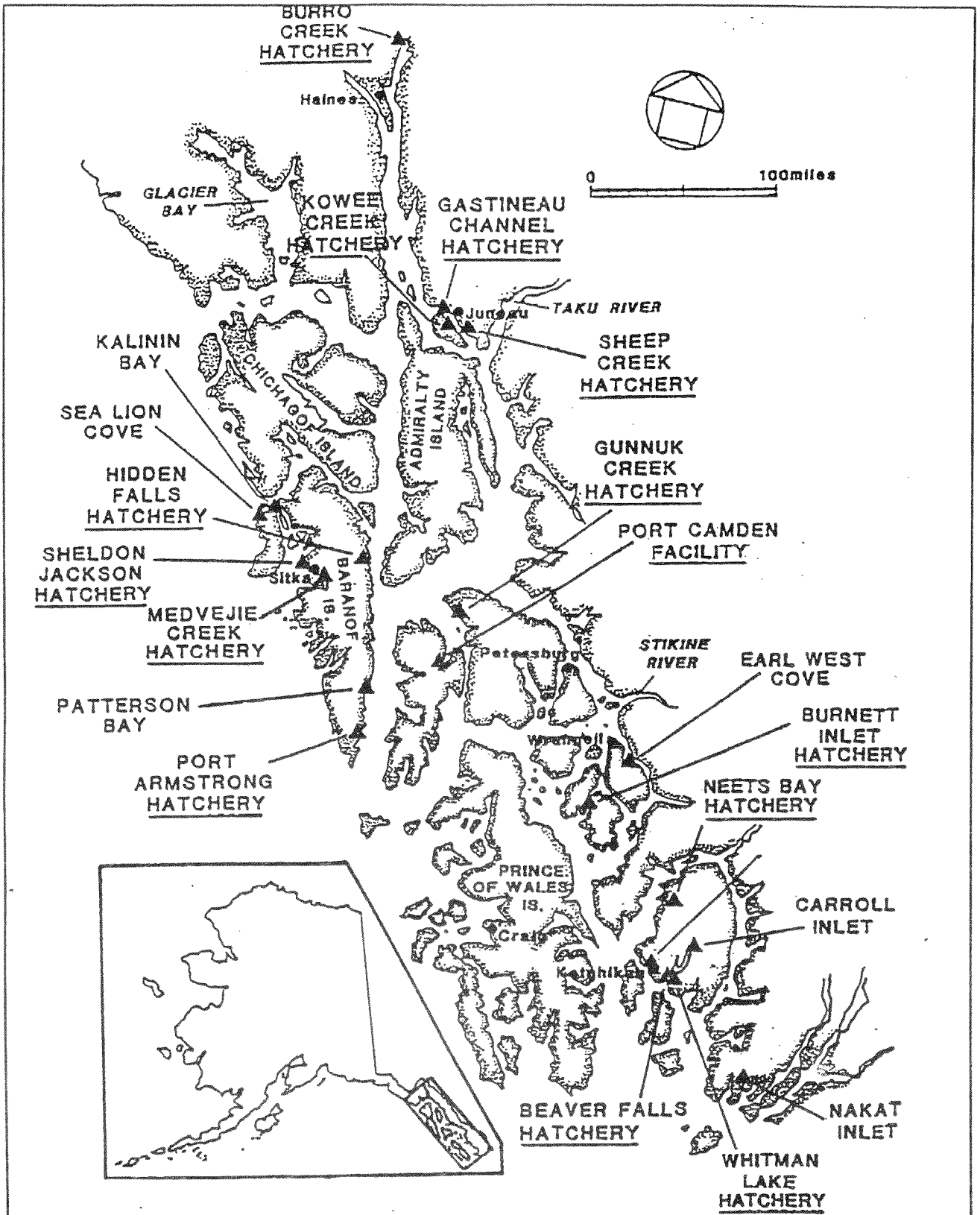
Prepared by M. Jaenicke

Figure 1



Alaska Private Non Profit
Regional Aquaculture Associations

Figure 2



Regional & Non Regional Projects in Southeastern Alaska

Figure 3

PRIVATE NON PROFIT SALMON ENHANCEMENT FUNDING		
	Regional Aquaculture Associations	Non-Regional Aquaculture Corporations
Capital Loans	$30,932,299	$17,858,939
Operational Loans	$7,021,307	$15,164,482
Enhancement Tax	***$46,204,622***	***$0***
Cost Recovery	$59,521,548	$11,347,728
Total Revenue	**$143,679,776**	**$44,371,148**

Figure 4

ALASKA'S PNP SMOLT RELEASES

ALL SPECIES

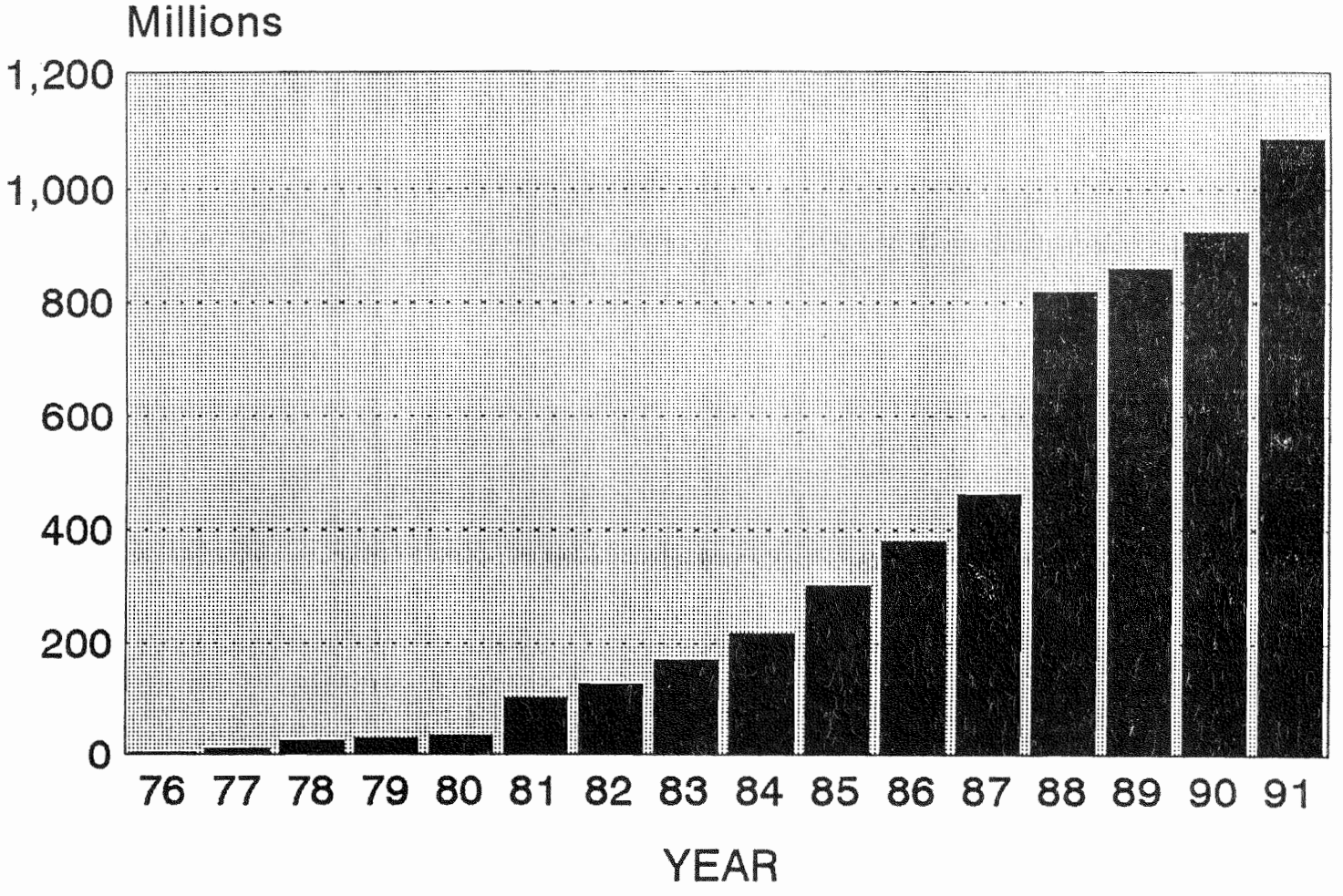


FIGURE 5

ALASKA'S PNP ADULT RETURNS

ALL SPECIES

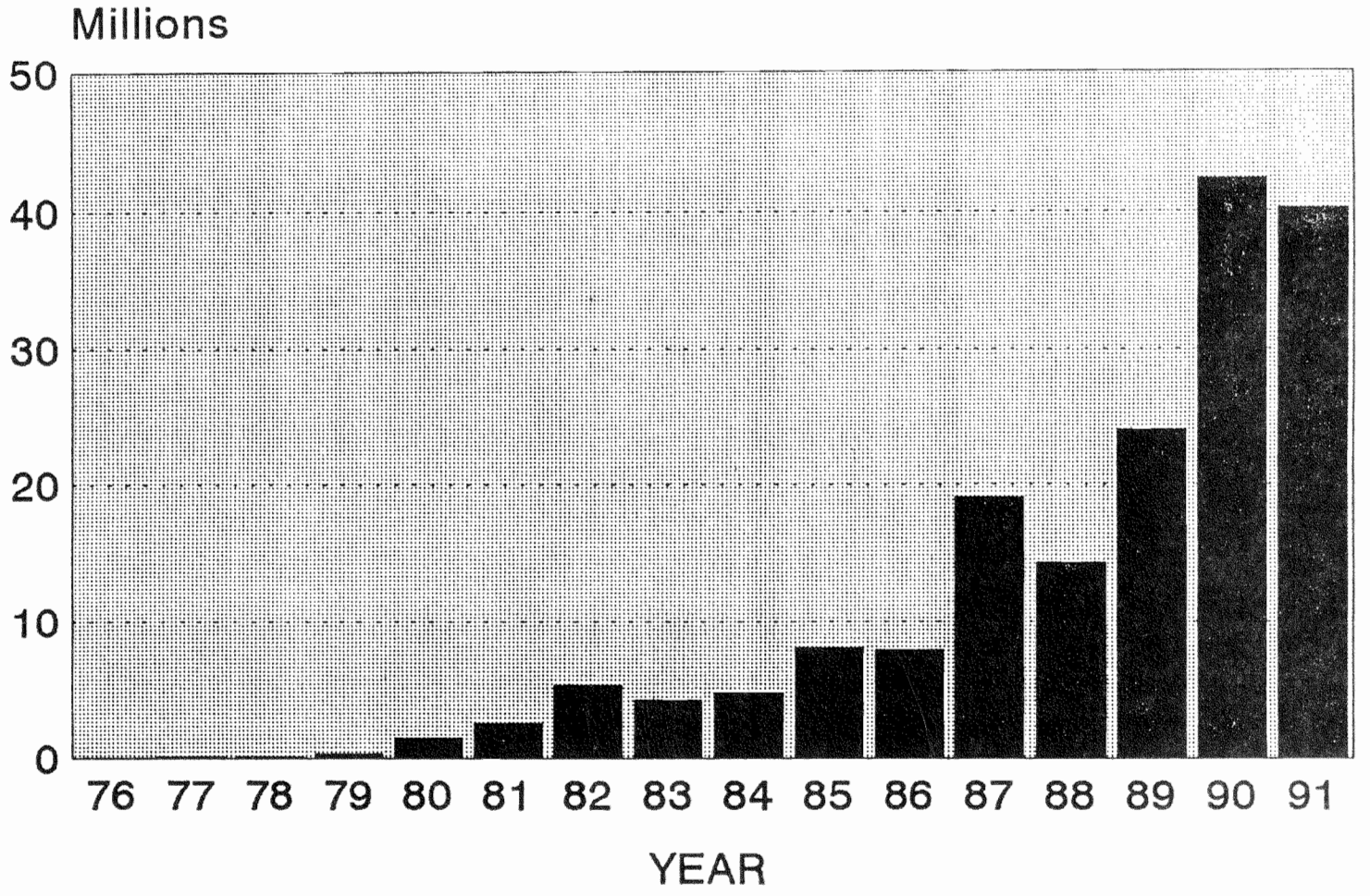


FIGURE 6

AN OVERVIEW OF THE PUBLIC HATCHERY SYSTEM IN ALASKA

Mike Fallon
Alaska Department of Fish and Game

The Alaska Public Hatchery system was formed in 1973. This new division was created within the Alaska's Department of Fish and Game. The division was named F.R.E.D. which stands for Fisheries Rehabilitation Enhancement and Development. Initially, FRED division consisted of only 3 hatcheries, but by 1986 had rapidly grown to 21. Several of the facilities incorporated new designs and technologies for improved incubation and rearing. However, due to reduced oil revenues, subsequent budget cuts and privatization, FRED division currently comprises only 13 hatcheries. The hatcheries are depicted in Figure 1. A description of each hatchery follows - beginning in the far north and ending in Southeast Alaska near Ketchikan.

Sikusuilaq Springs Hatchery:

This remote facility on the Noatak River is located 4 hours by jet boat from Kotzebue, the nearest town. This northern most hatchery in the hemisphere was built in 1981 as a pilot program for 2 million chum salmon. Successful returns resulted in expansion of the hatchery in 1987 to its current capacity of 10 million eggs. A spring produces 1500gpm of 39 degrees water year round. The hatchery contributes primarily to commercial and subsistence user groups. Future plans are for increasing to 60 million eggs.

7,365,000 CHUM SALMON @ .4 grams.

Clear Hatchery:

Built in 1980, this facility is located on the road system approximately 75 miles southwest of Fairbanks. This facility experiences severe cold with a winter average of -10 degrees and a record of -70F degrees!. The hatchery is one of three that utilizes warm water produced from local power plants. The facility uses 1500 gpm of warm water at 13 degrees and 4000 gpm of well water. The four 6'x 60' indoor concrete raceways are in a one pass system . Oxygen contactors are also utilized. The hatchery stocks over 100 lakes each year.

477,000	ARCTIC CHAR.	@	29.5 g.
1,300,000	GRAYLING	@	3.7 g.
52,900	LAKE TROUT	@	4.2 g.

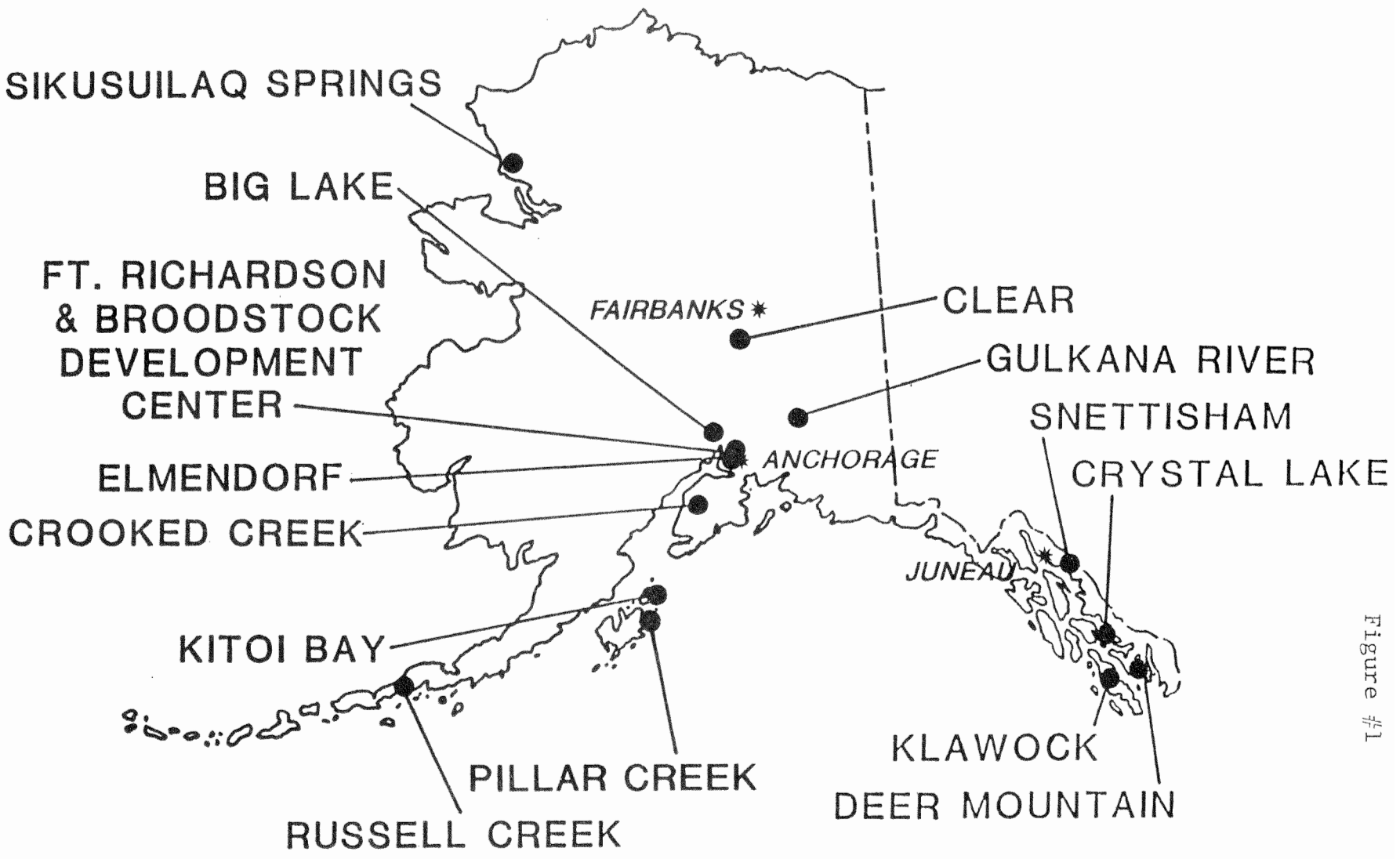


Figure #1

FISH HATCHERIES
OPERATED BY ADF&G F.R.E.D. DIVISION

Gulkana Hatchery:

This facility was constructed in 1973 as a "stream side" incubation program. It is located about 60 miles north of Glennallen. Seventy 4x8 plywood boxes are used to incubate about 35 million sockeye. Each box has its own water source which minimizes disease. This results in a 75% survival to release as unfed fry. Natural gravel is used as substrate.

22,514,000	SOCKEYE	@	.4 g.

Big Lake Hatchery:

Built in 1976 to rehabilitate the local sockeye program, it is located on the road system about 1 hour by car from Anchorage. This facility operates with 2000 gpm of well water. Eight 8'x 80' aluminum outdoor raceways are used for rearing. Oxygen contactors are also employed. This hatchery has developed a very successful methodology for egg disinfection using iodophores to minimize the incidence of IHN. Survivals of 95% to eyed have been achieved.

10,292,000	SOCKEYE	@	.2 g.
224,000	COHO	@	25.2 g.

Fort Richardson Hatchery:

Originally built in 1957 in cooperation with the U.S. Army, this hatchery located 20 minutes from downtown Anchorage also benefits from its location utilizing power plant effluent. Furthermore, a heat exchanger is used to extract heat from the power plant effluent to warm the 2000 gpm of available well water. The 24 8 x 80 outdoor raceways are arranged in a four pass system. In addition 24 3 x 30 indoor raceways are used for early ponding and rearing. Heath trays are used for incubating 8 million rainbow eggs at capacity. This facility is the showcase of our public hatcheries in the state, featuring a computer monitored alarm system, oxygen contactors, and a computer controlled variable pump for maintaining temperature control.

1,872,642	RAINBOW TROUT	@	2.0 g.
187,000	" "		100.0 g.
433,000	COHO	@	22.0 g.
532,000	CHINOOK	@	12.1 g.
52,000	"	@	110.0 g.

Broodstock Development Center:

This facility is located adjacent to the Fort Richardson Hatchery supplying the rainbow trout egg take production goals. Eggs are taken from 2-4 year old fish. The center is also involved in various research and genetic projects which include rainbow and chinook triploids, chinook and coho crosses, oxygen contactor comparisons, and the use of "pit tags". Air spawning is used for the rainbow egg takes which occur in April.

10,000 2 - 3 year old RAINBOW Broodstock
4-6 Million egg take

Elmendorf Hatchery:

Like Fort Richardson , this hatchery is located within the Anchorage area and also uses available power plant effluent. The facility depends on Ship Creek water for its chinook and coho production. The twenty 10 x 60 concrete raceways are arranged in a two pass system. Limited well water is used primarily for incubation.

1,160,000	CHINOOK	@	18 g.
532,000	COHO	@	23 g.

Crooked Creek Hatchery:

Built in 1973, this hatchery is located also on the road system about 100 miles southwest of Anchorage. It originally was designated for the enhancement of sockeye. The facility operates with 5'x 50' and eight 6'x 60' concrete raceways. Currently, it has expanded to accommodate other species. This hatchery is our first in FRED division to evaluate "moist air" incubation.

12,650,000	SOCKEYE	@	.2 g.
273,500	CHINOOK	@	26 g.
69,000	STEELHEAD	@	70 g.
72,000	COHO	@	24 g.

Pillar Creek Hatchery:

This facility is our newest addition, built in 1990 under an agreement between FRED division and a private non-profit organization. It was designated as a 20 million-egg sockeye facility located on the road system about 7 miles from the city of Kodiak. The hatchery uses eight aluminum 3'x 50' outdoor raceways for short term rearing.

3,314,000 SOCKEYE @ .2 g

Kitoi Hatchery:

This hatchery, only accessible by boat or plane, is located on Afognak Island northwest of Kodiak. The facility is one of the original hatcheries of FRED Division. Built in 1965 for pink salmon, the hatchery has contributed much to incubation technology and short term rearing that has greatly enhanced the local pink salmon fishery. Kitoi is the only FRED hatchery that uses UV light for fungus and disease control in incubation.

124,148,000 Pink Salmon fed fry @ .4 g

Russell Creek Hatchery:

Built in 1982, this hatchery operated successfully for several years but has recently been closed due to previously mentioned budget cuts. Historically, the hatchery reared chum and pink salmon. The remote facility was located near the town of Cold Bay which is found on the mainland of the peninsula that forms the Aleutian Islands.

4,900,000	CHUM	@ 1.1 g.
3,500,000	PINK	@ .3 g.

Crystal Lake Hatchery:

The remaining four hatcheries, including Crystal Lake, are located in the Southeast region of the state. Crystal Lake hatchery can be reached by boat from Juneau in just a few hours. It was built in 1972 with 10 "Burrows" ponds which were eventually converted to 20 raceways. The facility uses 10 cfs of available lake water to rear chinook,coho, and steelhead. Its contribution is primarily to the commercial troll and net fishery.

837,000	CHINOOK	@ 15.8 g.
412,000	COHO	@ .5 g.
78,000	COHO	@ 14.0 g.
2,180	STEELHEAD	@ 66.5 g.

Snettisham Hatchery:

Located 30 air miles from Juneau, the hatchery is operated in conjunction with the hydroelectric plant. This facility utilizes 100 cfs of available lake water to rear primarily chinook and sockeye. Recently, the hatchery has been planning an increase in production of sockeye as a result of the U.S./Canadian Pacific Salmon Treaty. The 24 concrete raceways are arranged in a one pass system. The hatchery program has also been investigating the process of "thermal marking".

6,960,000	SOCKEYE	@ .2 g
2,357,000	CHUM	@ .6 g
398,000	CHINOOK	@ 22.0 g
220,000	COHO	@ .6 g

Deer Mountain Hatchery:

Built in 1954, this is our oldest hatchery and is located in Ketchikan's city park. Originally designed for enhancement of chinook, it has expanded for other species as well. The facility uses 4,000 gpm of lake water. Rearing is performed in 20 6'x 6' and 8 16'x 16' Swedish ponds. Due to its location this hatchery is our most visited with over 150,000! tourists each year - the majority of which are from the frequent tour boats. Special projects include rainbow trout and chinook triploids, dietary fluoride supplementation to reduce BKD, and a small population of natural run summer coho.

154,000	CHINOOK	@ 21 g.
66,200	COHO	@ 17 g.
5,480	RAINBOW TROUT	@ 4.5 g.
5,020	STEELHEAD	@ 45 g.

Klawock Hatchery:

This remote facility, constructed in 1978, is located on Prince of Wales Island, 4 hours by boat from Ketchikan. It operates using 3-5000 gpm of lake water, 24 16'x 16' Swedish ponds, and 4 48'x 12'x 4' concrete raceways for rearing. The program also includes a very successful steelhead fishing derby for local kids.

1,310,000	COHO	@ 25 g.
197,000	SOCKEYE	@ 25 g.
25,700	STEELHEAD	@ 45 g.

Figure 2. Other salmonids released in 1991 from Alaska State facilities.

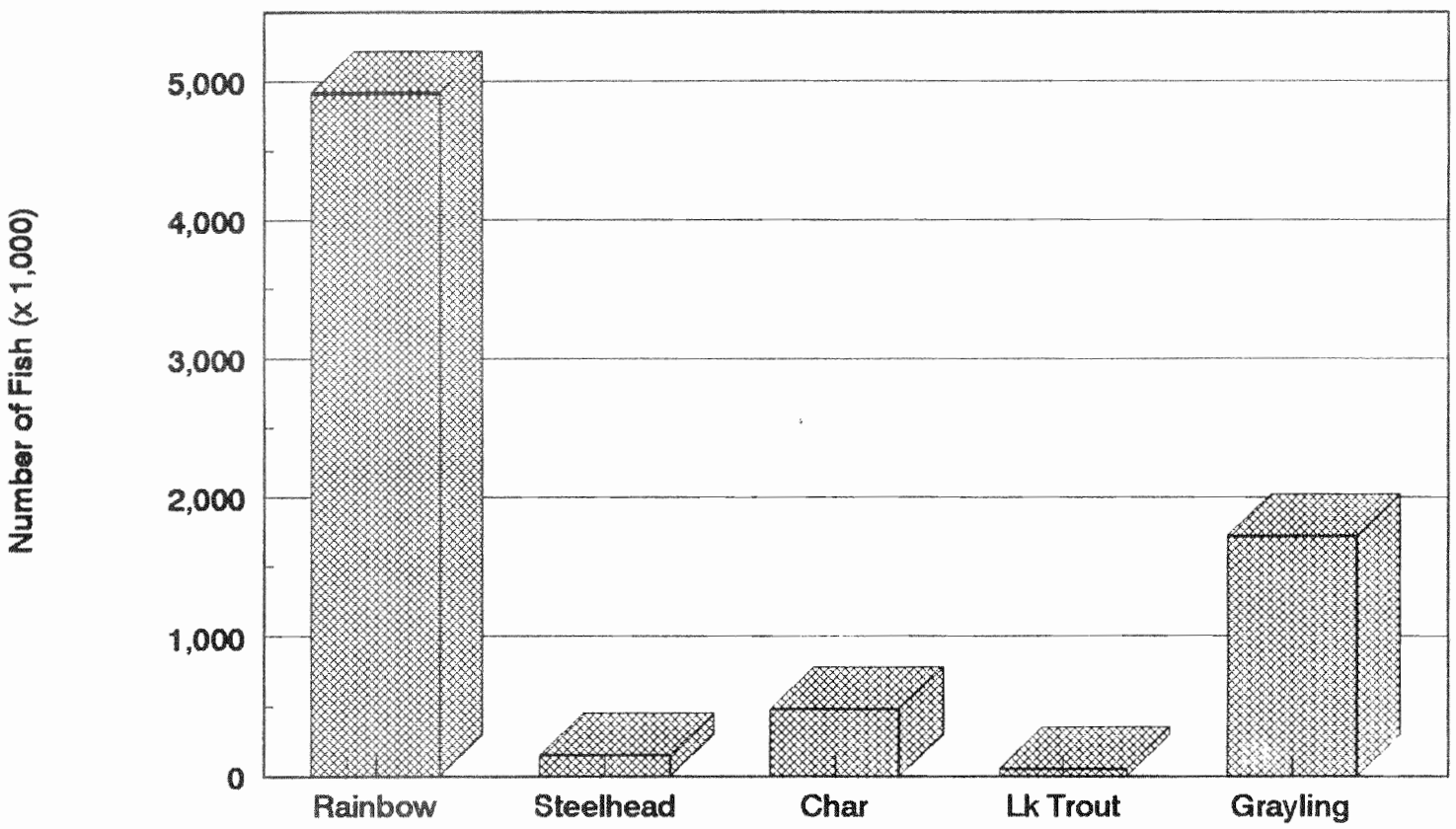
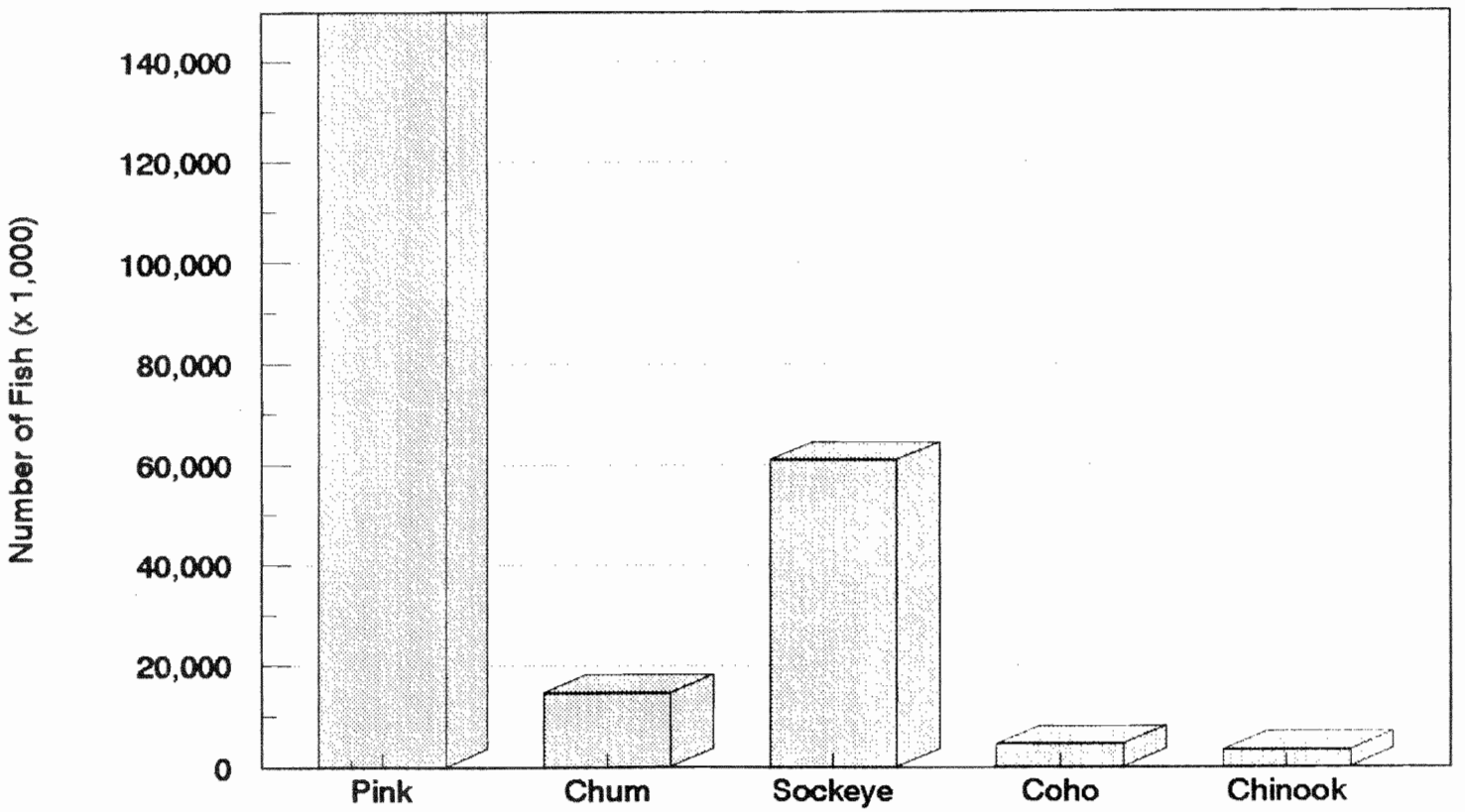


Figure 3. Total salmon releases in 1991 from Alaska State facilities.



Alaska Department of Fish and Game
F.R.E.D. Division

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EASTBANK HATCHERY COMPLEX
SUPPLEMENTATION - HATCHERY CONCEPT FOR THE FUTURE

Glenn Liner
Eastbank Hatchery Complex
Washington State Department of Fisheries
E. Wenatchee, Washington

Eastbank Hatchery Complex, also known as Rock Island Fish Hatchery Complex, was completed in October of 1989 and was spawned from a Fisheries Settlement Agreement between Chelan County Public Utility District, Power and Light, fisheries agencies and Indian tribes.

The complex fulfills the requirements for hatchery-based compensation under the agreement which is mitigates for Rock Island Dam. Capital cost of construction was approximately $11 million. The central hatchery facility is shared by Washington State Fisheries and Wildlife Departments.

In addition to the hatchery program, the settlement provides for study and installation of systems to exclude juvenile salmonids from the projects turbines and transport them past the dam, an interim spill program, and fish ladder modifications.

Eastbank Hatchery Complex consists of a central hatchery (Eastbank),located at the east side of Rocky Reach Dam, and five satellite facilities. The complex is designed to rear 3,000,000 juvenile chinook, sockeye salmon and steelhead. Eastbank Hatchery has 8 standard raceways, 10′ by 100′, 5 super raceways, 20′ by 185′, 2 steelhead rearing ponds, 36 FAL vertical half-stack incubators, 6 Isoflow / early rearing troughs 3 holding ponds for about 1400 adult fish, and a pollution abatement pond. A hatchery office building with lab, freezer building and shop complete the facility.

Water is supplied from four wells for a total of 50 cfs. Temperature varies from 47-57 degrees depending on the time of year and how much is pumped from the aquifer. Water is pumped to a degassing tower, and then gravity carries the water out to the ponds and the hatchery building.

Mechanical chiller units on site provide 150 gpm of 38 degree water for salmon egg incubation. This capability allows for programming our stocks to match the timing of hatch and emergence in the hatchery to that of nature. The normal procedure is to put eggs down in trays with 43 degree water until blastopore closure and then put them on 38 degree chilled water until ponding.

By using chilled water, water temerature can be manipulated as well as temperature units of eggs from different take dates. They can be adjusted, so that all fish of a given stock are ponded at the same time. Also, by extending ponding dates, the feed ration can

be adjusted to allow a good growth curve rather then holding fish on a maintenance ration.

The Eastbank complex is designed to supplement native runs of salmon and steelhead. Supplementation can be described as the release of locally adapted juvenile fish into the natural environment to increase, maintain, or establish naturally spawning fish populations. It is a tool that may be used to restore natural production of fish populations that have been depleted, or to establish a stock in a barren habitat. It can be used in conjunction with other management strategies to achieve a desired objective.

In the Columbia basin, above mainstream dams, many different strategies may need to be implemented to achieve success. Supplementation in the Basin ,for the most part, will involve stocking fish into habitats that contain depressed, but existing natural fish populations.

Maintaining the natural biological characteristics of the population and the genetic integrity of each stock, is the key to successful supplementation. In the hatchery environment, egg to smolt survival is greatly improved over that in nature, by reducing losses due to predation and disease. Eastbank has a pathogen- free well water source that is near the optimum temperature range for small fish. Rearing densities in relation to flow and volume are low to reduce stress and disease, improving the survival of the hatchery reared fish after release. The maximum loading densities are 6 lbs/gpm and.75 lbs./cu.ft.

Brood stock collection takes place at selected sites to assure that all adults collected to supplement a specific river will be from t hat river, rather than mixed with adults from other rivers. Segregation of the adults and juveniles by stock is then maintained throughout the rearing cycle. As a consequence, juveniles released from a satellite pond on one of the selected rivers are of the same genetic stock as their wild counterparts.

The rearing facilities are also specialized to better match the characteristics of fish reared in the hatchery to naturally produced fish in the natal streams.

Adult traps for the Wenatchee River summer chinook stock are located at Dryden and Tumwater Dams . A new bladder barrier dam was constructed this summer at Dryden to increase trapping efficiency. Sockeye are also trapped at Tumwater for the Lake Wenatchee net pen program. The Chiwawa satellite traps its adults from a weir on the Chiwawa River.

Adults captured for the Wenatchee Summer Chinook and the Lake Wenatchee Sockeye are small percentages of the total run, and the Chiwawa Spring Chinook is not supposed to exceed 30% of the run. Broodstock are collected throught the duration of the run to get a representative sample.

Eastbank has two 2500 gallon insulated tank trucks for hauling adults back to Eastbank from trapping sites and juveniles from Eastbank to release ponds. They are equipped with liquid oxygen, fresh flow aerators and a recirculation pump for life support while hauling. The Similkameen satellite pond is a 3 hr. drive from Eastbank so the three support systems are vital in keeping stress to a minimum during transport.

Chiwawa Ponds are designed to hold 675,000 spring chinook yearlings in two ponds. Adults are captured on site using a floating weir. They are transported to Eastbank where they are held and spawned. Eggs are incubated at Eastbank and the juveniles are reared there until mid-September when they are about 20 fpp. They are hauled to Chiwawa where they will be released in April-May at 10 fpp. There are two river intakes for the ponds, one on the Chiwawa, and one on the Wenatchee River. During very cold weather, the Wenatchee River is warmer and that intake is used instead of the one on the Chiwawa where frazil ice formation is often a serious problem.

The Lake Wenatchee Sockeye net program will hold about 200,000 sockeye juveniles as well as the adult brood stock. Adults are collected at Tumwater Dam on the Wenatchee, and are taken to the net pens to ripen for spawning. The eggs are taken to Eastbank and incubated in Isoflow units until virology results are known. When fry are buttoned up in early April they are taken to the net pens. Juveniles are released at 25 fpp in the fall to allow them to mix with the wild sockeye and migrate out with them the following spring.

Similkameen Pond in Oroville holds 600,000 summer chinook. Adults for this program are captured and spawned at Wells Dam and brought back to Eastbank for incubation and initial rearing. Juveniles are hauled to the pond in late October at about 25 fpp. They are held over the winter where they will be acclimated to Similkameen river water and the seasonal temperature changes experienced by fish in the wild. They are released on site in the spring at 10 fpp.

The Twisp pond on the Methow River near Winthrop, gets 400,000 summer chinook from Wells. These fish go through the same scenario as the Similkameen fish. Adults are captured and spawned at Wells, incubation and initial rearing is done at Eastbank. They are transported to the Twisp acclimation pond in February,at 15 fpp. They are released in the spring at 10 fpp.

The final rearing and acclimation pond the Wenatchee River summer chinook is located at Dryden on the Wenatchee River. It is programed for 864,000 summer chinook. The adult fish are trapped at Dryden and hauled to Eastbank for ripening and spawning. After incubation and rearing on station, they are hauled back to Dryden in February, for acclimation. They are released in April-May at 10 fpp.

By spending several months at these acclimation ponds, the fish will have time to recover from the stress of transport in the tank trucks and give them time to adjust and imprint to the water. The release procedures at all of the ponds are adapted to allow fish to decide when they are ready to migrate, rather than just emptying the pond and forcing

them to leave. As they smolt, they can leave and join the natural migration cycle.

The steelhead, which the Wildlife Department raises at Eastbank, are trucked for release in small groups at several locations in the Wenatchee River system.

The concept of supplementation has been attempted at other locations , sometimes with mixed results. Although the concept is not new, much remains to be learned about the best methods for supplementing wild populations of salmonids. The Eastbank Complex is among the first of a new generation of supplementation hatcheries built in the Columbia and Snake River basins. With all the features of genetic integrity, specialized rearing conditions, and volitional releases, this program has great potential for success.

The Rock Island Fisheries Settlement Agreement provides for extensive evaluation of the hatchery program. First returns for sockeye, chinook jacks and steelhead are expected in 1992, with chinook adults returning in 1995.

Major Noninfectious Diseases and Their Prevention

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In this day and age of efforts to increase our capabilities to detect bacterial and viral pathogens in populations of hatchery fish, I think we have set aside efforts to understand one or more of the most significant aspects of fish health management. Specifically, I am referring to taking concern, or at least note, of the repeated occurrences of noninfectious diseases in our piscine charges. I am also referring to taking efforts to increase our understanding of the quantitative dynamics of an intensively managed fish culture system, which contain the primary causal factors of noninfectious diseases.

While I was mulling over what I have just said, I pondered about possible reasons for the lack of concern about these nonbacterial and nonviral diseases. The best one I could come up with is that, for the most part, they are not very dramatic in terms of sick and dead fish on the tail screens.

When I presented my thoughts on this topic to the assemblage at the Western Fish Disease Conference, one could have concluded that I was being quite heretical by saying that more than 90% of the infectious disease episodes in hatchery fish have an identifiable noninfectious cause, if we were but to look for it. Further, I stated that the majority of bacterial, viral, and parasitic diseases were really not much more than clinical signs that the fish could no longer cope with the environmental situation.

So, my purpose here is to present information on the causal factors, clinical signs, treatment regimens, and preventive regimens for some of what I consider to be the more important and common of the 36 or so environmental diseases of hatchery fish (Table 1). If I can convince some of you to take heed, I think the pay-off would be a better fish and less production costs.

Causal Factors

In any fish culture system the fish is irrevocably oriented to its environment; i.e., most quantitative changes in environmental factors causes often measurable changes in the fish. The most frequently involved environmental changes are water-associated, although management-associated changes have been involved (Table 2).

The most frequent effect of the changes in environmental factors is the stress response. In this the fish is responding to the environmental "insult" by attempting to maintain its status quo - which can be a losing battle - as evidenced by the recognized stress-related diseases (Table 3). These are the conditions I will address in this presentation.

Table 1: Major noninfectious diseases of hatchery-raised fish

Disease	Causal Factor(s)
Environmental Gill Disease	Chronic stress response Chemical irritation Physical irritation
Fin-nipping/"Soreback"	Psychological
Strawberry Disease	Infectious factor(s) Allergic response
Sunburn	Photosensitization
Hypoxia	Exceeding oxygen carrying capacity
Brown Blood Disease	Nitrite toxicity
Gas Bubble Disease	Nitrogen saturation
Traumatic Injuries	Birds Netting Pond cleaning

Environmental Gill Disease (EGD) is a rather complex and not too well understood condition. The majority of episodes are diagnosed as Bacterial Gill Disease (BGD) and treated accordingly with one of the water-administered antibacterial medicaments. In many cases, the treatment regimen and the mortality correct the environmental causal factors. Thus, the diagnosis was correct - a logical but often erroneous conclusion.

EGD is considered, first, to be stress-mediated, and, second, environmentally-mediated; e.g., ammonia (NH_3) levels >0.03 mg/l. The most common stressor is a high population density. By itself; i.e., uncomplicated by pathogens, it is more a debilitating than lethal process. This is what makes the condition economically significant.

Table 2: Direct and indirect causal factors of noninfectious diseases of hatchery fish.

	Direct Causal Factors
Water-Associated:	acidity ammonia nitrite dissolved oxygen organic contaminants inorganic contaminants carbon dioxide suspended particulates
Management-Associated:	trauma
	Indirect Causal Factors
Water-Associated:	pH total alkalinity calcium hardness velocity temperature
Management-Associated:	population density physical handling

Table 3: Stress-related noninfectious disease

Environmental Gill Disease
Frayed fins
Fin-nipping
Soreback
Generalized melanosis

The pathological changes are limited to the gill lamellae. The first change is lamellar hypertrophy; i.e., the lamellar epithelial cells enlarge. This condition is followed by epithelial-capillary separation (ECS) in which the lamellar epithelium (the outside cell layer) separates from the lamellar endothelium (the inside cell layer) and the space fills with fluid from the lamellar vascular space. The final stage is characterized by lamellar hyperplasia; i.e., the lamellar epithelial cells increase in number. This progresses to the point of interlamellar occlusion. This condition is quite recognizable by the incomplete closure of the opercles and the protrusion of gill tissue from the gill cavity.

The primary physiological effect of the foregoing changes has been an increasing difficulty in oxygen uptake and ammonia excretion. In addition, somewhere along the process, one of the saprophytic, aquatic myxobacteria sets up housekeeping on these compromised gill tissues and makes the situation worse. This is the point in time when the fish culturist takes his/her action and "corrects" the situation.

In my opinion, the best treatment regimen is:

1. Stop feeding for at least three days. This reduces the oxygen demand and the generation of solids and ammonia.

2. Administer a 1% salt flush. Even a higher level (2-3%) could be used. For example, just empty the required number of 50 lb bags of slat into the head-end of the pond and do not mix it.

3. Reduce the pond population on day-3.

4. Administer another salt flush.

5. Put the fish back on 50-75% feeding level for a few days then go to full feeding.

In my opinion, the most effective approach to preventing EGD is to:

1. Stay on top of the density carrying capacity of the pond by stocking the pond for take-out not by the "Well, it looks 'bout right" method.

2. Administer a salt flush on a regular basis - once a week is not excessive.

3. Examine the "poor-doers" or "screen-hangers" for signs of EGD - and other problems, for that matter.

Fin-nipping (aka "fin erosion") is a psychological condition of rainbow and steelhead trout, mainly. It is precipitated by management practices which violate the territorial imperative of the fish; e.g., overcrowding and feeding method. The condition (called the "swimming frankfurter" syndrome) is quite common in conservation catchables and smolts.

It is used in resource management circles to identify hatchery and wild fish. In my opinion, this does not legitimize the condition.

There is no effective treatment regimen which will reverse the condition. Thus, the best approach is to prevent it from becoming worse or occurring in the first place. As with EGD, population density control is a key factor. Second, feeding the fish in such a fashion that they do not have to leave their "space" to receive food. This is one of the main drawbacks to using demand feeders in that to receive a meal, a fish must leave its "space" and enter that of another and get nipped in the process. A third control/prevention method is to increase the water velocity to about one body length per second. This gives the fish something else to think about other than biting their transgressors.

Soreback is a sequel to dorsal fin-nipping. In this case the dorsal fin becomes a "target" for reminding a fish that it is in the wrong "space". The situation gets quite worse, often to the point that the vertebral column is visible. Usually this lesion does not become infected with fungus because the continual nipping prevents this.

In summary, most episodes of noninfectious diseases are characterized by:

1. Reduced growth rates
2. Reduced feed efficiency
3. Depression; lack of interest in feed
4. Moderate to high morbidity; i.e., number of affected
5. Low mortality
6. Shallow, rapid respiratory movements.

In most cases, prevention of clinical episodes is accomplished by good husbandry. Good husbandry is not expensive, in fact, it usually results in reduced production costs. Finally, good husbandry begins with believing that the job can be done better to get a better fish.

Control of *Myxobolus sp.* Infection in Spring Chinook Salmon at Entiat National Fish Hatchery

William Thorson
Leavenworth National Fish Hatchery Complex

Spores of the myxosporidian Myxobolus sp have consistently been found in the brainstems of examined spring chinook salmon at Entiat National Fish Hatchery. First reported in the early 1980's, the parasite was monitored for several years. Although the severity of the infection increased steadily, it was not considered a threat to fish health until 1988. John Morrison Olympia Fish health Center (OFHC) examined longitudinal sections cut vertically through the brains of 60 brood year 1986 spring chinook smolts collected March 18, 1988. He found spores in all 60 fish he looked at. The rate of infection was not cause for concern because light infections apparently do not influence fish health. The severity of the infection, however, was cause for alarm. The following scale was used to quantify the degree of infection:

0 = no infection
1 = Slightly infected
2 = 25% nervous tissue displaced
3 = 50% nervous tissue displaced
4 = 75% nervous tissue displaced
5 = 100% nervous tissue displaced

The findings were as follows:

Assigned infection	# of fish	
1	29	
1.5	4	72%
2	10	
2.5	8	28%
3	9	

Infections resulting in greater than 25% tissue displacement occurred in 28% of the fish examined. Although no clear connection between Myxobolus sp. and fish health could be demonstrated, it seemed prudent to attempt to control the parasite. Electron micrographs (John Morrison, personal communication) revealed that the presence of the parasite not only displaced but also destroyed nervous tissue. It seemed reasonable that destruction of greater than 25% of brainstem tissue would impair fish health and fitness for survival outside hatchery environs.

Preliminary data suggested that the infective stage of this parasite occurred during the spring over a finite period. A series of trials were initiated to define the infective period. Definition of the infective period would give a management tool to avoid infection through rearing water manipulation.

All studies were based on the assumption that the Entiat River was the source of the infection and that hatchery groundwater (Packwood Spring plus four wells) was Myxobolus sp. free.

Trial Number Two: The purpose of this trial was to define the downside of the infective period. The procedure was identical to trial number one except that the test was started March 14, 1990 and continued through September 25, 1990.

The results of this trial (Fig. 2) were somewhat surprising. The infection first appeared at roughly the same time in both tests but the infection in trial two was both more severe and prevalent in March than was the infection in trial one. Damage to the nursery building water supply line by construction workers on April 18 resulted in the back-flow of Entiat River water into the naive stock tank for approximately 15 minutes. Later examination revealed that this short exposure led to a low infection in the naive fish (1 of 70). This may have clouded the data, but since the infection was light, the impact was ignored.

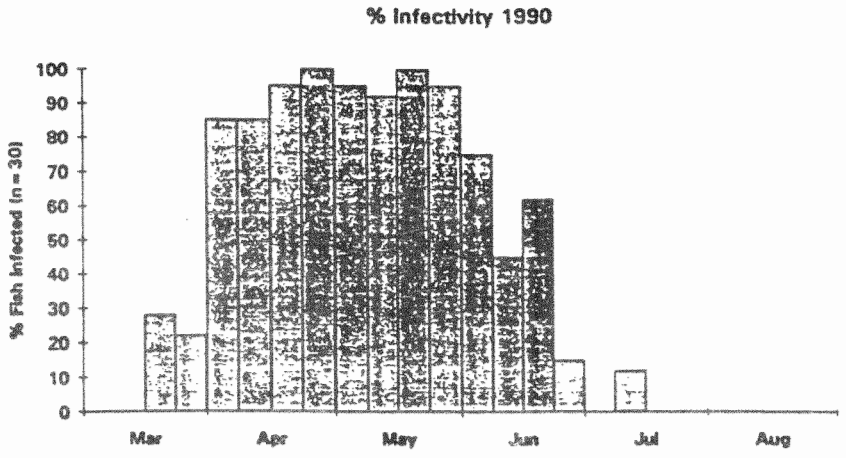


Figure 2. Infectivity of Myxobolus sp. in spring chinook salmon, 1990. Each bar represents one week exposure to Entiat River water.

Trial Number Three: This trial was begun February 20,1991 and continued to August 28, 1991. The procedure was similar to the first two trials except changes in water management eliminating Entiat River water from the raceways during part of the experimental period meant that the live box had to be relocated. It was moved to the Entiat River water presettling basin.

The results of this trial combined with the other two (Fig. 3) give a clear picture of the infective period of Myxobolus sp. at Entiat NFH. The percentage of test fish infected was highest during the months of April, May, and June.

Plotting severity of infection data from all trials (Fig. 3) further clarifies the infective period. Although the infective period extends over the course of the study, infections outside the April - May window are so light they very likely do not affect fish health or survivability.

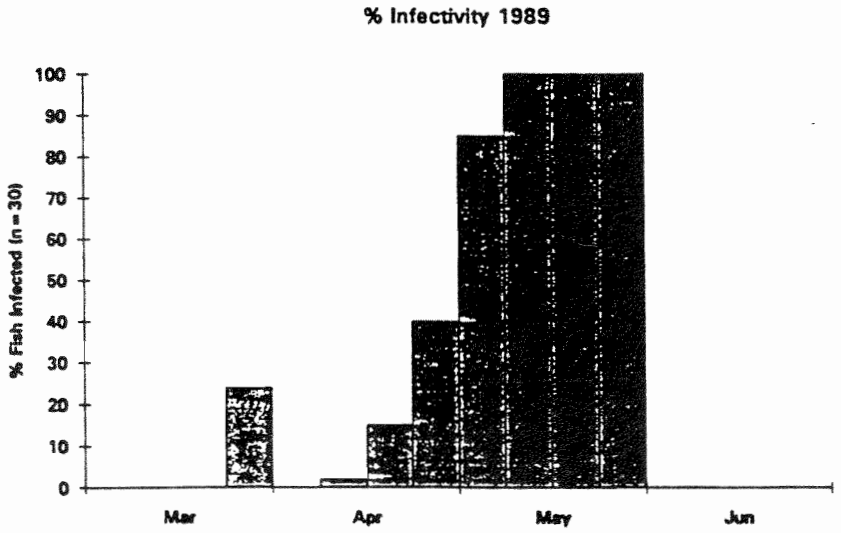
Experimental Procedure/Results

Trial Number One: All fry at Entiat NFH are held in presumed pathogen free well/spring water in the nursery from the time they are spawned as eggs until they are moved to outdoor rearing units. Naive fish used in this study were transferred as fry from production tanks to a designated circular tank and held there until needed.

Beginning January 4, 1989, thirty fish were taken from the stock tank and exposed to Entiat River water by placing them in a live box located at the mid-raceway position in raceway #14. At the same time, thirty control fish were taken from the stock tank and placed into one of two previously disinfected holding tanks in the nursery.

After one week, the thirty fish were taken from the live box, transferred to a treatment tank, and another thirty fish taken from the stock tank and placed in the live box. The fish in the treatment tank were treated with formalin at 1/6000 for one hour immediately on placement in the tank and again two days later. One week after removal from the live box, the fish in the treatment tank were anesthetized, given an identifying fin clip, and transferred to a holding tank. The treatment tank was disinfected and the process repeated using the fish then in the live box. The procedure was repeated weekly from January 4 to May 31. All fish were kept in the holding tanks until September to allow time for spore development. The fish were then sacrificed and the heads taken to the Olympia Fish Health Center for examination.

Results of the first experiment (Fig. 1) showed that the infective period began in mid-April and continued beyond the termination of the experiment at the end of May.



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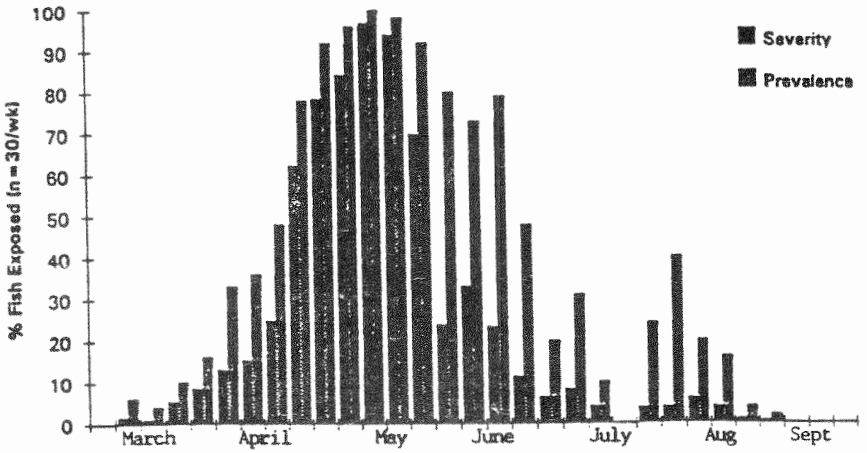


Figure 3. Infectivity and severity of infection of Myxobolus sp. in spring chinook salmon, 1989-91. Severity of infection is based on a scale of 0 equals no infection and 6 equals 100% brainstem tissue displacement. Each pair of bars represents one week exposure to Entiat River water.

Discussion

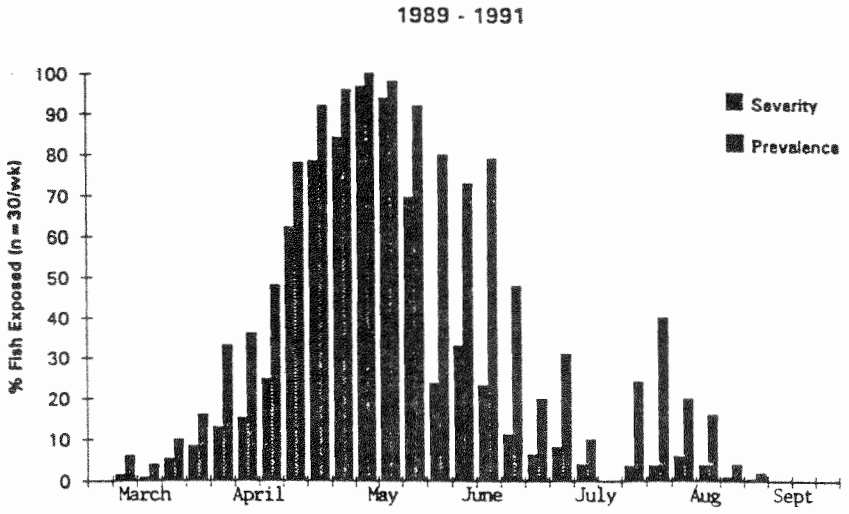
As a result of this series of studies, water management at Entiat NFH was changed radically. Production fish are not exposed to Entiat River water from the time they are hatched until after the window of highest infectivity is closed in June. Entiat river water is then used on an as needed basis.

The reduction in mortality resulting form these changes has been startling. Spring chinook at Entiat NFH begin to show signs of smoltification in March and April of their second year. Mortality historically rose during this time. Prerelease mortality from 1985 through 1991 averaged 1.6% in March and 2.4% in April (smolts were typically released the third week in April). March losses prior to the 1992 release, the first year class to benefit from the change in water management, were 0.25%. No data are available for April because the fish were released early in the month.

A number of factors may have contributed to the dramatic drop in mortality. For example, avoiding exposure of the fish to Entiat River water from birth through June of their first year very likely avoided a host of pathogens in addition to Myxobolus sp..

All of the evidence is anecdotal so conclusive inferences can not be drawn from this study. Common sense, however, tells us that removal of a stressor such as this parasite can only improve fish health and hopefully translate to improved adult returns.

Plotting severity of infection data from all trials (Fig. 3) further clarifies the infective period. Although the infective period extends over the course of the study, infections outside the April - May window are so light they very likely do not affect fish health or survivability.



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The reduction in mortality resulting form these changes has been startling. Spring chinook at Entiat NFH begin to show signs of smoltification in March and April of their second year. Mortality historically rose during this time. Prerelease mortality from 1985 through 1991 averaged 1.6% in March and 2.4% in April (smolts were typically released the third week in April). Losses prior to the 1992 release, the first year class to benefit from the change in water management, were 0.25% in March and 0.24% for April. The smolts were released on April 14.

A number of factors contributed to the dramatic drop in mortality. For example, avoiding exposure of the fish to Entiat River water from birth through June of their first year very likely avoided a host of pathogens in addition to Myxobolus sp..

All of the evidence is anecdotal so conclusive inferences can not be drawn from this study. Common sense, however, tells us that removal of a stressor such as this parasite can only improve fish health and hopefully translate to improved adult returns.

DILEMMA IN AQUACULTURE CHEMICALS

Presented at the 43th Annual Northwest Fish Culture Conference
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(SLIDE 1) I wish to relate a scenario that could become increasingly common as the U.S. Food and Drug Administration (FDA) requires any facility using drugs to comply in full with their regulations. In July 1992, I received a call from the head of the Illinois State hatchery system informing me that 35,000 tiger muskie (7.5" long) were dying from columnaris and bacterial gill diseases because they had no legal drugs for their control. The hatchery manager pleaded for "one-half an aspirin." The hatchery manager considered going for an emergency authorization but, because of budget cut backs, the state could not affort the $25,000 to monitor the residues of the chemical of choice, diquat dibromide, in the fish, water, effluent, sediments, etc. By the time the State would have received authorization in writing, it would have been too late. In addition, Illinois had used their "one time" emergency authorization for diquat in 1991 and could not have received another emergency authorization. The hatchery manager tried everything possible to reduce the stress: density reduction, lowering the water temperature, and adding sodium chloride. Some people have the impression that proper management methods will totally eliminate the need for chemicals or drugs. In this case, and many others, it didn't.

(SLIDES 2 and 2a)
The need is greatest for chemicals that control infectious diseases. Currently, only three therapeutants are registered and available for use and these three are labeled only for controlling a few diseases on a few aquatic species.

Most of the chemicals used in aquaculture either do not have a commercial sponsor or the patent has expired. In addition, most of the candidate compounds identified for potential use and registration in aquaculture do not have commercial sponsors who will support full registrations for those purposes. Few pharmaceutical and chemical firms have shown interest in extending the registration of their products for use in aquaculture because of the high registration costs in comparison to their return on investment. The minimal cost to meet the data requirements for an unregistered drug for on disease and one species is $3.5 million. Obviously, priorities will have to be set.

(SLIDE 3)
How do we begin to tackle this enormous problem? The Working Group on Quality Assurance in Aquaculture Production (Working Group) was formed in part to address these issues. The Working Group is the one group that has representation

from all aquaculture concerns that can act on a national level and is comprised of persons who are knowledgeable about the issues. The Working Group is not advisory to FDA or the U.S. Environmental Protection Agency (EPA), rather it is a national forum or mechanism to identify, discuss, and urge actions on the issues by aquaculture associations and those agencies associated with aquaculture. Working with officials from FDA, the Working Group committed itself to several projects that will lead to producing aquatic species in a manner acceptable to both FDA and EPA.

(SLIDES 4 and 4a)
The first project of the Working Group was the identification and prioritization of chemical needs for public and private aquaculture. In March and April 1992, the Working Group submitted a tentative list of drugs and chemicals that have been selected as the highest priority for FDA registration for use in aquaculture. This list is flexible and can be changed as priorities and needs change. A survey to address the chemical needs of the U.S. Fish and Wildlife Service (Service) was recently completed and the results are being analyzed. (SLIDE 5) Other chemicals that are of concern to aquaculture and resource agencies need to be addressed. The next projects are the determination of jurisdiction and clarification of the status of the priority chemicals. (SLIDE 6) In February 1992, the Fish Health Section of the American Fisheries Society (AFS) requested FDA to declare which agency (FDA or EPA) has jurisdiction over certain compounds. FDA has promised that the answers are forthcoming. (SLIDE 7) On February 21, 1992, the Fish Health Section of AFS formally requested that FDA consider certain compounds that are listed as generally recognized as safe (GRAS) for other uses to be classified for fishery use as either (1) exempt from registration, (2) generally recognized as safe, or (3) not requiring an Investigational New Animal Drug or INAD (i.e., low regulatory priority). (SLIDE 8) From February to August 1992, FDA announced that seven compounds are considered to be of low regulatory priority and will not need to be included under an INAD when used under specified conditions. (SLIDE 9) On the other hand, FDA also produced a list of eight compounds for which they have a high degree of concern because of the potential for human drug abuse or known or suspected human food/environmental/occupational safety concerns and thus these compounds are considered to be of high regulatory priority. FDA has listed fluoroquinolones and quinolones in this category because FDA needs more toxicological data before they will allow their use in aquaculture.

(SLIDE 10) After FDA has determined which compounds will not require INAD permits (i.e., low regulatory priority), all remaining priority compounds considered to be drugs by FDA that are not fully labeled as such will only be allowed for use by FDA under INAD's. These INAD permits will be granted mainly on a blanket basis to producer groups and agencies willing to accept the responsibility of administering these INAD's. Few individual INAD permits will be issued for these priority chemicals because of the paperwork required. Each INAD will have to be renewed on an annual basis. These INAD's will take time. All chemicals defined as drugs that are used or anticipated for emergency use must be covered under an INAD so that the need for emergency use is eliminated or at least reduced. All users of

these identified drugs are included under this INAD process --- public and private production facilities, fishery research and management units, and participants in fishing tournaments, etc. These requirements will not be impossible, but they will add to the workload. The alternative is the loss of the use of that drug. This process is not a panacea, but it is the only technique we have to legally use the chemicals we need. Some chemicals will not be allowed for use. You will have to decide what is high priority.

(SLIDES 11 and 11a) Workshops on requirements for INADs were held recently by FDA in Auburn, Alabama and Copper Mountain, Colorado. (SLIDE 12) The workshops included instructions on establishing a INAD, protocol development, record keeping, responsibilities of sponsors, monitors and investigators, conducting clinical trials and reporting results. More workshops will follow. The Working Group is developing a strategy to coordinate the INAD process and to educate the potential users of the INADs through video tapes and manuals. The Service plans to meet in January 1993 to determine procedures, identify sponsors, monitors, and investigators, and assign development of INAD's and study plans.

(SLIDE 13) The Working Group members are attempting to precisely define the early life stages for each aquatic species produced in public or private aquaculture. This definition will help FDA determine data requirements needed for each drug to ensure the safety of the aquatic species for human consumption. It may mean that some data requirements could be reduced. Resource agencies can benefit from precise definitions of the early life stages of various species because of their release policies involving fingerlings. FDA has determined that no general "nonfood" classification will be granted; rather, FDA has stated, "a situation by situation evaluation (which we are willing to make) may cause the Center [Center for Veterinary Medicine] to conclude that a use of a particular drug in a particular species for a particular life stage, is, if not "nonfood", then at least of low regulatory regulatory priority. Or we may conclude that, for purpose of a new animal drug application, very little or no human food safety data may be required." FDA has classified some fish species or groups as nonfood under certain conditions: baitfish (golden shiners, fathead minnows and goldfish), ornamental and aquarium fish, endangered species, and broodfish.

Working Group members also are identifying production levels of public or private facilities and the losses due to diseases for each aquatic species. The Service and the states need to provide these figures to the U.S. Department of Agriculture. These figures are needed to give pharmaceutical firms some basis for market analysis. Without the involvement of the pharmaceutical firms, the crisis in aquaculture will continue indefinitely.

Another area that needs emphasis is the development of regulations, policies, and guidelines by FDA that more appropriately recognize the unique conditions in aquaculture. (SLIDE 14) For example, crop grouping would enable target animal safety and residue studies to be performed only on one or two representative

species (e.g., rainbow trout and channel catfish) instead of every target species. The Service met with FDA on February 13, 1992 to discuss this concept and developed an action plan to generate the needed data. The action plan is dependent upon public funding. The Service produced 54 species in 1991 and 48 of 50 states have 476 hatcheries that also produce a variety of fish. FDA has estimated that both the public and private sectors culture about 100 different aquatic species. At up to $400,000 for each target animal safety study and the required residue chemistry studies, it is understandable how important this "crop grouping" concept is to aquaculture production.

(SLIDE 15)
The INAD process will only work if there is additional public funding. The INAD's will allow the use of the drugs on a provisional basis until all the data needed by FDA are generated. These data include target animal safety, residue, environmental, and mammalian safety studies. These data must be developed in a timely manner or the INADs will be rescinded. These data (except field efficacy) must be done according to Good Laboratory Practices (GLP). A GLP program is expensive and difficult to develop. Without public funding for these studies, aquaculture will continue to suffer major losses. (SLIDE 16) The International Association of Fish and Wildlife Agencies under Mark Reeff is attempting to coordinate a united public-private funding initiative and has requested a short list of high priority chemicals.
(SLIDE 17)
Much work, coordination, and commitment will be required to initiate the INAD process and to pursue the funding needed to obtain properly registered chemicals for aquaculture. FDA is feeling its way through this process. Their intent is to maintain access to registable drugs for all producers who agree to follow proper procedures under the INAD process. FDS is making a concerted effort to become informed about culture practices. They are funding model studies that will help them make informed decisions on data requirements and study design. Obviously, chemicals that are considered to be of high regulatory priority are not to be used at this time. In this period of time, all aquaculturalists need to become active in the following areas:

1. Identify needed chemicals
2. Prioritize those chemical needs
3. Learn about the INAD process
4. Identify a network for blanket INAD's
5. Provide accurate production figures and disease losses
6. Become part of an information network
7. Support public funding initiatives

THERAPEUTANTS REGISTERED AND AVAILABLE FOR USE ON FISH

FORMALIN (PARACIDE-F; PARASITE-S):

Registered as a parasiticide for use on trout, salmon, catfish, largemouth bass, and bluegill and as a fungicide for use on trout, salmon, and esocid eggs.

OXYTETRACYCLINE (TERRAMYCIN FOR FISH):

Registered as an antibacterial against ulcer disease, furunculosis, bacterial hemorrhagic septicemia, and pseudomonas disease on salmonids and bacterial hemorrhagic septicemia and pseudomonas on catfish and as an antibacterial against gaffkemia on lobsters.

THERAPEUTANTS REGISTERED AND AVAILABLE FOR USE ON FISH (continued)

SULFADIMETHOXINE & ORMETOPRIM (ROMET 30, ROMET-B):

- Registered as an antibacterial against furunculosis on salmonids and against enteric septicemia on catfish.

Slide #2a

WORKING GROUP ON QUALITY ASSURANCE IN AQUACULTURE PRODUCTION

Slide #3

THERAPEUTANTS IDENTIFIED FOR PRIORITIZATION FOR FDA APPROVAL

A. Highest Priority Compounds

1. Sarafloxacin
2. Chloramine-T
3. Copper sulfate
4. Potassium permanganate
5. Erythromycin
6. Oxytetracycline (extension)
7. Povidone iodine compounds
8. Fungicide (unregistered chemical)
9. Quaternary ammonium compounds

B. High Priority Compounds

1. Formalin (extension)
2. Diquat dibromide
3. Benzocaine
4. Amoxicillin
5. Lincomycin
6. Ivermectin
7. Levamisole
8. Pyrethrum
9. Trifluralin (shrimp only)
10. Enrofloxacin
11. Romet-30 (extension)

THERAPEUTANTS IDENTIFIED FOR PRIORITIZATION FOR FDA APPROVAL (continued)

4a

C. Spawning Control/Gender Alteration Compounds

1. Human chorionic gonadotropin
2. Methyl testosterone
3. Epinephrine (molluscs only)
4. L-dopa (molluscs only)
5. Cytochalasin B (molluscs only)

Slide #4a

OTHER CANDIDATE DRUGS FOR AQUACULTURE AND RESOURCE MANAGEMENT

Acriflavine

Diflubenzuron

Fumagillin

Live well chemicals

Malachite green
replacement-protozicide

Marking chemicals

Praziquantel

Transport chemicals

Trichlorfon

JURISDICTION OF FISHERY COMPOUNDS USED IN AQUACULTURE PRODUCTION

(LIST SENT TO FDA ON FEBRUARY 25, 1992 FOR RULING)

Benzalkonium chloride

Benzethonium chloride

Copper, elemental

Copper sulfate

Diquat dibromide

Fenthion

Potassium permanganate

Povidone iodine compounds

Trichlorfon

Slide #6

COMPOUNDS POTENTIALLY REQUIRING NO INAD'S

(LIST SENT TO FDA ON FEBRUARY 21, 1992 FOR RULING OF LOW REGULATORY PRIORITY = LRP)

Benzalkonium chloride
Benzethonium chloride
Calcium carbonate
Calcium chloride (declared LRP)
Calcium hydroxide
Calcium oxide
Copper sulfate
Cytochalasin B
Epinephrine
Garlic
Ice
L-dopa
Magnesium sulfate
Onion
Oxygen
Oxytetracycline to mark fish
Ozone
Penicillin
Potassium chloride
Potassium permanganate
Povidone iodine compounds (declared LRP)
Sodium chlorite
Sodium hydroxide
Streptomycin
Tris buffer

Slide #7

8

COMPOUNDS REQUIRING NO INAD'S WHEN USED UNDER CERTAIN CONDITIONS (=LOW REGULATORY PRIORITY COMPOUNDS)

Acetic acid - parasiticide

Calcium chloride - aid osmotic balance by increasing hardness

Carbon dioxide - anesthetic

Povidone iodine compounds - egg surface disinfectant during and after water hardening

Sodium bicarbonate - introduce carbon dioxide for anesthesia

Sodium chloride - osmoregulatory aid and parasiticide

Sodium sulfite - improve hatchability of eggs

Slide #8

COMPOUNDS OF HIGH REGULATORY PRIORITY

- Chloramphenicol
- Nitrofurans
- Certain Steriod Hormones
- Certain Antibiotics
- Malachite Green
- Central Nervous System Stimulants and Depressants
- Fluoroquinolones
- Quinolones

Slide #9

INVESTIGATIONAL NEW ANIMAL DRUG PERMITS OR INAD'S

Slide #10

HOW TO OBTAIN AN INAD PERMIT

1. A letter, addressed to CVM, specifying the identity, source, integrity, and proposed purpose of the drug

2. Study protocol describing the design of each study

3. Summary of the qualifications of participating investigators

HOW TO OBTAIN AN INAD PERMIT

(continued)

4. Discussion of human food safety considerations

5. Discussion of environmental considerations

6. Three copies of the investigational labeling

Slide #11a

PROTOCOL OUTLINE FOR AN INAD

Study ID and Title

Sponsor

Investigators/Facilities

Proposed Starting and Completion Dates

Purpose, Background

Specific Objectives

Materials

Experimental Unit

Entrance Criteria

Treatment Groups

Treatment Schedules

Criteria to Evaluate the Response

Forms

Recordkeeping Procedures

Disposition of Investigational Animals

Disposition of Investigational Drug

Data Handling/Monitoring

Plans for Data Analysis

Protocol Amendments and Deviations

DEFINITION OF EARLY LIFE STAGES

14

Slide #14

CROP GROUPING

PRIORITY FOR AQUACULTURE AND THE POTENTIAL COSTS AND TIME NEEDED FOR FDA APPROVAL (AS OF OCTOBER 1992)

Priority	Without Crop Grouping	With Crop Grouping
A. Highest Priority Chemicals (9)	$150 million and 245 linear years	$22 million and 30 linear years
B. High Priority Chemicals (11)	$163 million and 262 linear years	$20 million and 30 linear years
C. Spawning Control/Gender Alteration Compounds (5)	$18 million and 37 linear years	$3 million and 15 linear years

Grand Total A, B, C	Without Crop Grouping	With Crop Grouping
25 Compounds	$331 million and 544 linear years	$45 million and 75 linear years

HIGH PRIORITY CHEMICALS FOR FUNDING

SARAFLOXACIN
CHLORAMINE-T
COPPER SULFATE
POTASSIUM PERMANGANATE
FORMALIN (PARACIDE-F;
PARASITE-S; FORMALIN-F)
ERYTHROMYCIN
OXYTETRACYCLINE
(TERRAMYCIN FOR FISH)

ACTIVITIES FOR AQUACULTURISTS

1. Identify needed chemicals
2. Prioritize those chemical needs
3. Learn about the INAD process
4. Identify a network for blanket INAD's
5. Provide accurate production figures and estimates of disease losses
6. Become part of an information network
7. Support public funding initiatives

Slide #17

Regional Investigational New Animal Drug Permits for Erythromycin Injectable and Feed Additive

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Erythromycin is not among the four drugs registered and available for use in aquaculture (Terramycin; Formalin; Romet; and Tricaine methanesulfonate). Since many fish culture facilities in the Pacific northwest are dependent on erythromycin as an injectable and feed additive to control *Renibacterium salmoninarum*, cause of bacterial kidney disease, the only legal way to use erythromycin is through the Investigational New Animal Drug (INAD) process. This paper summarizes the progress toward meeting the requirements for safe, legal, and effective use of erythromycin at fish culture facilities in the Pacific northwest.

Fisheries scientists at the University of Idaho have been involved in research on erythromycin for several decades. In 1989 our research team, funded by Bonneville Power Administration (BPA), began conducting the research necessary and assembling a drug registration package for erythromycin feed additive and erythromycin injectable for use in fish culture. In 1992, at the request of the Pacific Northwest Fish Health Protection Committee, and with additional funding from BPA, we expanded our proposed field trials to include all interested managers of salmon and trout culture facilities throughout the Pacific northwest.

A drug registration package consists of five main elements (Table 1). Many of the elements of the package require that experiments are conducted using Good Laboratory Practices (GLP's), and animals are maintained in a controlled environment and all data are recorded according to carefully designed protocols with quality assurance as a component of all activities. However, very important elements of every drug registration package are data derived from field trials. Field experiments are impossible to conduct using GLP's, but if properly conducted with careful data collection and planning these tests will provide a realistic assessment of the success of the drug use on a larger scale.

Table 1. Elements necessary for a drug registration package according to section 512 of the Act Regarding Minor Use of Animal Drugs, as published in the Federal Register.

Element	Description	Are GLP's required?
Background data	Information from other species	
Efficacy	Dose titration studies	yes
	Field trials	no
Animal safety	Toxicity tests	yes
	Field trials	no
Human safety	Residue, metabolites, depletion	yes
	Safe use - worker safety	no
Environmental safety	Environmental assessment	no
	Field verification	no

At the University of Idaho we designed a system to conduct field trials in the Pacific northwest within the framework of the required elements for INADs established by the U.S. Food and Drug Administration (FDA). The result, if the trials are completed and reported successfully will be more comprehensive drug registration packages for use of erythromycin in fish culture.

We established one regional INAD for erythromycin injectable (INAD 6430) and one for erythromycin feed additive (INAD 4333). Each INAD requires one Sponsor, a Monitor and Investigator. Regional INADs have many Investigators and Monitors. The Sponsor has the ultimate responsibility for shipment, use, disposal of drug and disposition of treated animals. The Sponsor is responsible for all communications with the Center for Veterinary Medicine (CVM) at FDA. For both regional INADs for erythromycin, the University of Idaho is the Sponsor. For regional INADs, we established a formal relationship with any organizational entity (private, tribal, state or federal) that wished to cooperate with the studies. To establish and authorize this communications network a Memorandum of Agreement was signed by authorities within each entity. This agreement defines the chain of authority and the different responsibilities for ensuring safe and proper use of erythromycin.

Each experiment has an Investigator, and for each investigation, a Monitor is appointed (Figure 1). The Monitor ensures that Investigators understand their responsibilities,

visits and inspects facilities involved in the studies, and certifies that the study results are accurate. For most of our INADs, this role is often assumed by a pathologist familiar with the operation, or sometimes a manager of the corporation. The Investigators are the on-site leaders of experiments. They maintain the protocols, keep records of drug receipt, use, inventory and disposal, report results of trials and drug use, ensure that the experimental animals are kept as required, and certify that the data reported are accurate. In most cases within our field trials structure, the hatchery manager is the Investigator. For laboratory studies conducted at the University of Idaho, the Sponsor is the Investigator.

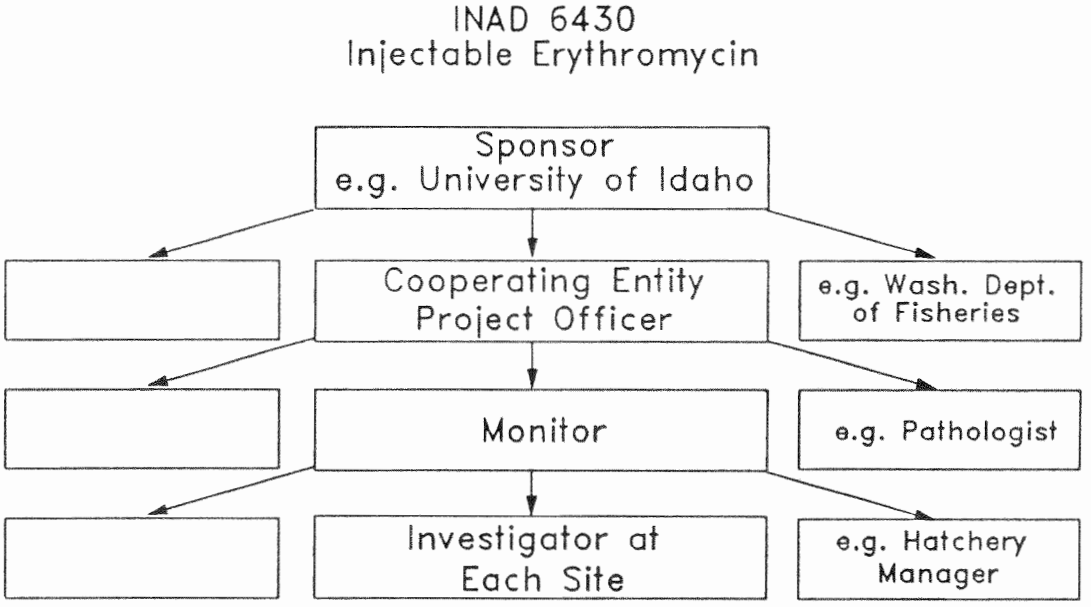

Figure 1. Structure of communications within regional INADs.

For us at the University of Idaho to manage the cooperation and transfer of data from Investigators in agencies or companies rearing salmonids, we put together a database management system. To maintain control of information produced in field trials, we created uniform reporting and inventory forms to be used at all sites, and developed proper labels for the injectable product. The feed product is labeled properly at the feed manufacturer. All experimental drugs must be labeled with the following statement:

> Caution: Contains a new animal drug for use only in investigational animals in clinical trials. Not for use in humans. Edible products of investigational fish are not to be used for food unless authorization has been granted by the U.S. Department of Agriculture or the U.S. Food and Drug Administration.

All facilities must develop a worker safety plan for use of the drug, including posting of Materials Safety Data Sheets (MSDS) for each product. In addition, the use of any experimental drugs must be conducted with consideration of the environmental impact of these investigational uses. FDA requires that all drug users supply information on the potential effluents released following and during treatment, and that all users either produce an environmental assessment or apply for a categorical exclusion from the requirements to conduct an environmental assessment, after demonstrating that the effects are negligible. Field trials must be conducted under a quality assurance plan that ensures that all data are recorded properly and are an accurate estimation of the true conditions.

Field Studies of Erythromycin Feed Additive under INAD 4333.

INAD 4333 was originally authorized in December 1984, through a collective effort of agency personnel from Oregon Department of Fish and Wildlife, U. S. Fish and Wildlife Service, Washington Department of Fisheries, Idaho Department of Fish and Game, California Department of Fish and Game, Oregon Aqua Foods, and the University of Idaho. Other public, tribal and private entities joined INAD 4333 over the next 8 years. Prior to 1992, accounting was handled through the Oregon Department of Agriculture. There were no separate protocols developed for sites, but the standard treatments were authorized for 14 d of administration of therapy at targets close to 100 mg/kg. Often, following the 14 d therapy fish were fed 3 - 4 d with an unmedicated ration and then returned to erythromycin therapy again for 7 d.

The University of Idaho took over organization and reporting for INAD 4333 in early 1992. We identified over 120 sites for experiments at state, federal, tribal and private culture facilities (Figure 2). In order to bring these user groups into compliance with present guidelines, we needed protocols for experiments to be conducted at each site where the drug was used, and standard methods of analyzing the results of these experiments. We used information from our own laboratory tests and limited field trials to establish a list of variables appropriate to address in field trials. We asked Investigators and Monitors to determine which were testable at their stations, since these people were knowledgeable about what could be tested at any one site. Some sites are physically limited in the types of experiments possible. To conduct any trial, one must have at least 4 or more experimental units (Figure 3), since each unit must have replication to separate the effects of the pond itself from the animal's response. The variables we recommended for tests of feed additive include testing of 100 vs. 150 mg/kg dosage, 28 vs. 21 d duration of administration, the number and timing of treatments over the life cycle of the animal, evaluations of differences in base diets, evaluation of the proposed new carrier for erythromycin, and investigations of alternate feeding regimes.

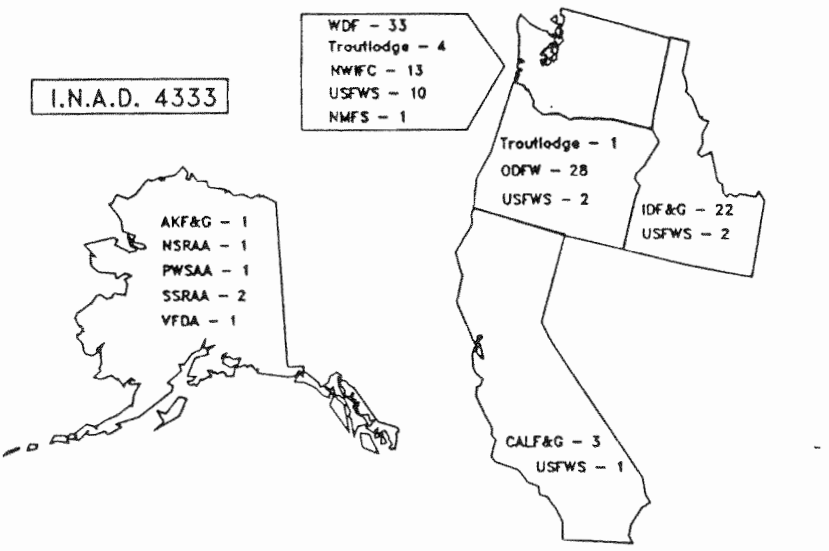

Figure 2. Participants in INAD 4333 by state. Number of facilities within each cooperating entity is listed: WDF = Washington Department of Fisheries; ODFW = Oregon Department of Fish & Wildlife; USFWS = United States Fish & Wildlife Service; NWIFC = Northwest Indian Fisheries Commission; CALF&G = California Fish & Game Department; PWSAA = Prince William Sound Aquaculture Association; IDF&G = Idaho Fish & Game Department; SSRAA = Southern Southeast Regional Aquaculture Association; VFDA = Valdez Fisheries Development Association; NSRAA = Northern Southeast Regional Aquaculture Association; Troutlodge; AKF&G = Alaska Department of Fish & Game; NMFS = National Marine Fisheries Service.

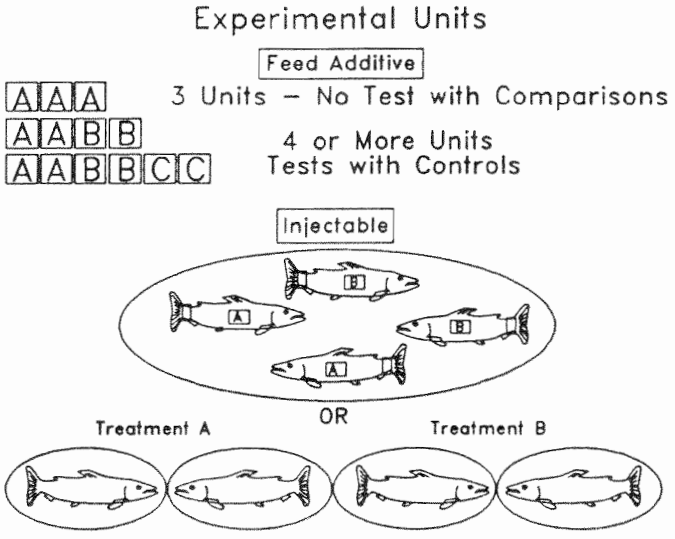

Figure 3. General model for developing design of experiments to assure an adequate number of experimental units for each tretament.

The dosage selected must be balanced with the palatability. It is well known that erythromycin rations are unpalatable, but in laboratory tests, we discovered that the palatability changes depending on the time of year, not just water temperature. We conducted dose titration tests on yearling chinook salmon from the same stock and egg take, but one was conducted in our laboratory during the winter, and one was conducted in the following spring. Fish offered daily rations containing 0, 50, 100, and 200 mg erythromycin/kg body weight refused a larger portion of their ration in the winter tests than during the spring tests, even though the water temperatures were the same in both experiments (Figure 4). In both tests, salmon consumed 100% of the control ration without erythromycin. During the winter tests, fish consumed only 30 - 35% of the feed formulated to contain 200 mg erythromycin/kg. This variation in palatability will affect the effectiveness of a treatment, and can result in a considerable waste of drug and feed. Increasing the duration of drug treatment can be a factor to increase efficacy. We propose field trials to test the application of rations daily for 21 d versus fish offered erythromycin for 28 d. Duration of treatment has consistently been an important factor in studies we conducted on challenged juvenile salmon. Increased duration of treatment may overcome problems of palatability of erythromycin rations. Treatments for 14 d have not been adequate in challenged fish (Table 2).

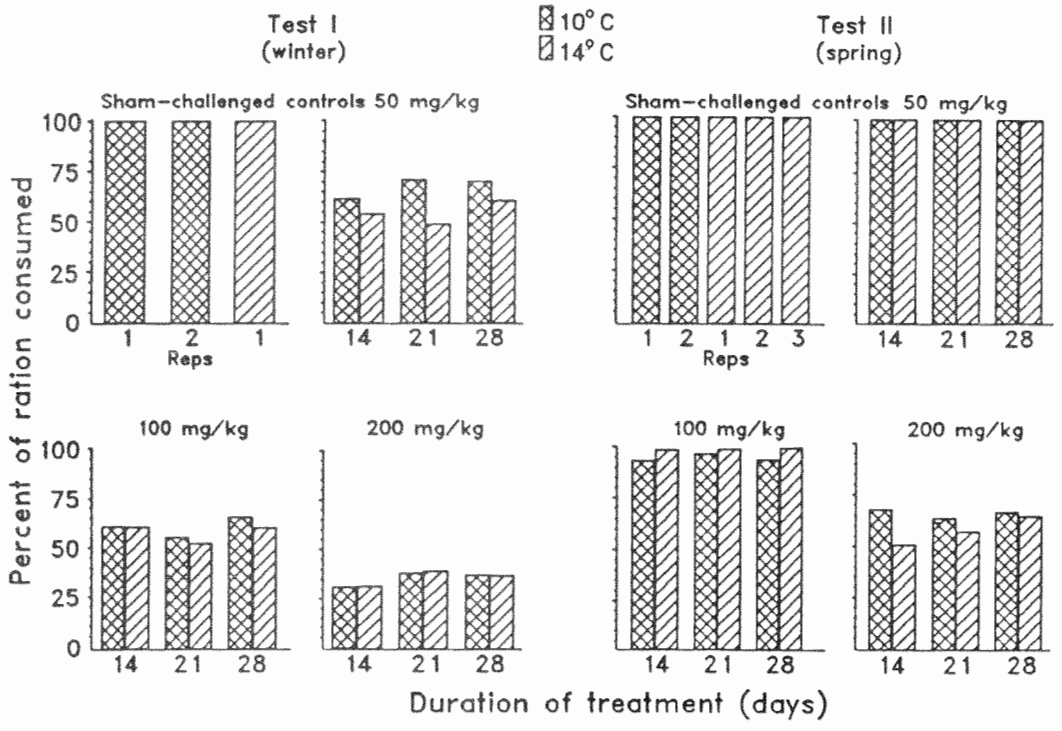

Figure 4. Consumption of daily ration administered to tanks of juvenile chinook salmon during tests of dose titration at the University of Idaho 1992. Three dosages were tested at each of two temperatures.

Table 2. Mean percentage survival in groups of juvenile chinook salmon in two tests of dose titration of erythromycin following acute challenge with *R. salmoninarum*, or in groups of control fish challenged with sterile phosphate buffered saline (PBS), and fed a ration without erythromycin. Treatments with the highest percentage survival are listed, treatments with erythromycin rations for 14 days were not ranked since the survival was poor. Treatments with a letter in common did not differ significantly ($P \leq 0.05$) in the percentage surviving at the end of the test.

Treatment (dosage and duration)	Mean percent survival	Treatment comparison
PBS - challenged control (no erythromycin)	99	A
200 mg/kg for 28 d	92	A
100 mg/kg for 21 d	79	B
200 mg/kg for 21 d	75	B
100 mg/kg for 21 d	60	B

We have conducted several experiments to explore the options of using an alternate day feeding regime to overcome an unpalatable ration in cold water winter conditions. If fish are starved for 24 h between feedings, and then fed to satiation with the erythromycin ration, hunger appears to overcome the unpalatability; additionally, absorption of erythromycin may be enhanced by increasing the residence time for medicated feed in the gut. We propose testing these options in some field trials at facilities that have need to treat fish in low water temperature.

Field Studies of Erythromycin Injectable under INAD 6430.

Although erythromycin was used as an injectable in many hatcheries throughout the Pacific northwest, no regional INAD for its use had been established. Originally, it was incorrectly believed that brood stock fish that were not eaten were exempted from the requirements. However, clarification from FDA made it clear that INADs were required for use of any non-approved drug product. At the University of Idaho, we had secured INAD 6430 in May 1989 for the erythromycin registration research, and determined with advice from FDA that we could expand this INAD to cover the usage throughout the region during field trials. In 1992, we identified nearly 100 facilities from 6 states interested in cooperating with field trials (Figure 5).

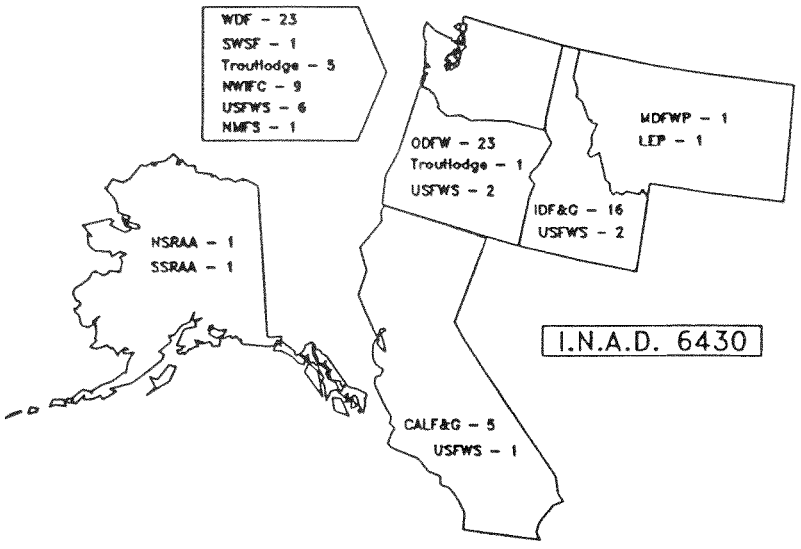

Figure 5. Participants in INAD 6430 by state. Number of facilities within each cooperating entity is listed: WDF = Washington Department of Wildlife; ODFW = Oregon Department of Fish & Wildlife; USFWS = United States Fish & Wildlife Service; NWIFC = Northwest Indian Fisheries Commission; CALF&G = California Fish & Game Department; NSRAA = Northern Southeast Regional Aquaculture Association; SSRAA = Southern Southeast Regional Aquaculture Association; MDFWP = Montana Department of Fish, Wildlife & Parks; LEP = Loons Echo Ponds; IDF&G = Idaho Fish & Game Department; Troutlodge; NMFS = National Marine Fisheries Service; SWSF = Swecker Salmon Farm.

Based on results of our research and that of other scientists, we determined the variables for which we needed data from field tests. We needed tests to evaluate several drug dosages, frequency of administration, intervals between injection and spawning, evaluation of intraperitoneal vs dorsal sinus injection sites, determination of species and race differences in efficacy or toxicity or drug clearance, and testing of adverse effects of administration, particularly jaundice, to collect information on animal safety.

The interval between spawning and injection influences the amount of erythromycin that is placed into the eggs of injected females. In 1990 we administered a single injection of 10 mg erythromycin/kg body weight to groups of chinook salmon at three intervals before spawning. We assayed the erythromycin content of vitellin in samples of unfertilized eggs removed at spawning from females previously injected with erythromycin. We followed up with an assay of the erythromycin in the developing embryos from these same female salmon. The intervals between injection with erythromycin and spawning ranged from 1 - 43 d. Only 53% of the female fish injected 8 d before spawning had detectable erythromycin in the vitellin of unfertilized eggs compared with 90% of the fish injected 1 d before spawning and 99% of the fish injected 15 or more days before spawning (Table 3). However, 6 to 7 weeks after

fertilization, only the group of females injected 15 or more d before spawning had detectable drug in vitellin. To obtain longer term protection against vertically transmitted *R. salmoninarum*, injections should occur 15 - 43 d before spawning.

Table 3. Percentage of eggs with detectable amounts of erythromycin in the vitellin. Samples were obtained from spawning chinook salmon that were injected with 10 mg erythromycin/kg body weight at different intervals before spawning. Samples of developing embryos from the same females were sampled 39 to 42 d after fertilization. Number of fish sampled is in parenthesis.

Sample description	Days between injection and spawning		
	1	8	15 - 43
Unfertilized eggs	90 (10)	53 (24)	99 (77)
Developing embryos	0 (9)	39 (18)	94 (52)

In 1991, we conducted a study to determine the effectiveness of two dosages of erythromycin injected into adult chinook salmon at Little White Salmon National Fish Hatchery. Half (784) of the adult fish were injected with 20 mg erythromycin/kg fish weight and the other half were injected with 40 mg/kg. Treatment groups were identified by colored tags on the caudal peduncle. These dosages were to be repeated one month following the first injection. Two weeks after the first injection, dead fish removed from the ponds exhibited symptoms of jaundice: the fish had yellow skin and livers and hemorrhaging surrounding the eyes. While the jaundice appeared in both the dosage groups, the mortality was more severe in the higher dosage (9% vs 2% mortality one month following initial treatment). The 40 mg/kg dosage was discontinued at the second injection and all fish were injected instead with 20 mg/kg. By the end of spawning, approximately two months after initial injections, mortality in the group treated with at total of 60 mg erythromycin/kg body weight was 30% versus 18% in the group administered 40 mg/kg. This was a surprise to us, because in 1990, we applied three injections of 20 mg/kg and 40 mg/kg each to chinook salmon at Cowlitz Salmon Hatchery, Washington Department of Fisheries, with no losses. This case study at Little White Salmon National Fish Hatchery is an indication of the variability of the response of salmon at different hatcheries and the need for further field trials of dosage to understand target animal safety.

We have examined two routes of administration of injectable erythromycin: dorsal sinus and peritoneal cavity. In laboratory studies of individual fish, application of erythromycin to the dorsal sinus resulted in loss of up to 40% of the drug. Observations in the field have confirmed leakage, but losses have not been well

quantified. In 1991 we injected all fish at Little White Salmon National Fish Hatchery in the peritoneal cavity. Our injection site was midway between the ventral and pectoral fins offset slightly to the left side of the fish. Damage to the egg skeins and testes was reported. After consultation with cooperating pathologists, we have examined a site at the base of the ventral fin that would reduce the risk of scarring to the internal organs especially the egg skein. We are interested to have a more thorough evaluation of this site versus the dorsal sinus (Figure 6).

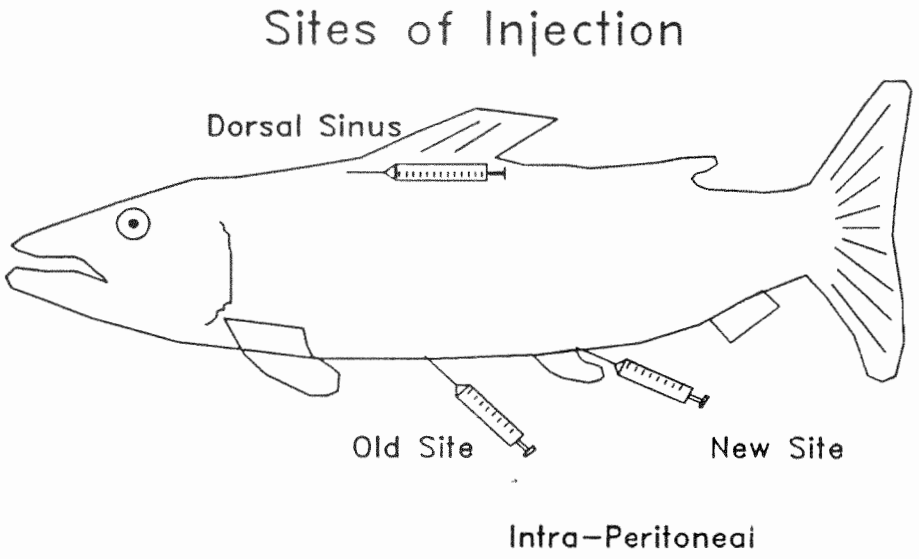

Figure 6. Location of sites of injection tested at the University of Idaho.

Where Will the INAD Process Take Us?

In summary, safe and efficacious use of aquaculture drugs requires that careful studies are conducted in the laboratory and in the field. The regulations required and enforced by FDA will place considerable burden of responsibility on the fish culturists. It is a learning process that we in the Northwest have the opportunity to lead.

NORTHWEST FISH CULTURE CONFERENCE

"PROTOCOLS FOR DISEASE FREE SOCKEYE CULTURE"

Millions of sockeye eggs were taken at the turn of the century by canneries and the federal government. There were few adult returns due to poor fish culture and in hindsight probably fry losses due to Infectious Hematopoietic Necrosis (IHN). Sockeye culture was started again in the mid seventies but by the end of the decade IHN was again a major problem. In 1980 the sockeye protocol was intiated which outlined ways to minimize the effects of the IHN virus. Key points of this protocol is Seperation, Sanitation and a virus free water source.

It is important that equipment and supplies that come in direct contact with the sockeye eggs or fry be disinfected. General work areas need to be keep clean. Footbaths are used at entrances to the sockeye modules.

The sockeye eggtake is designed to minimize the amount of virus brought into the hatchery. Individual females are externally disinfected with 100 ppm iodophor and the eggs are stripped into a container. One disinfected male is used to fertilize the eggs. The eggs are then water hardened in 100 ppm iodophor for a minimum of one hour and then seeded into incubators. The incubator most commonly used is the Kitoi box as it allows maximum separation in a large scale production eggtake.

Prior to opening the incubators for emergence, each unit is checked for problems. Things to look for include premature emergence, mortality and erratic swimming. If a problem is noted the incubator is isolated and a sample of the fry is sent to pathology. If positive for IHN, the unit is destroyed. Experience may dictate that you destroy the unit prior to pathologies findings. If the fry in the incubators are fine then they may be mixed together. Ideally one incubator would be ponded into one rearing container.

With the enactment of the sockeye protocol came a heavy use of chemicals. Iodophor, chlorine and formalin were used extensively to eliminate the IHN virus from all areas in the hatchery. The building was routinely formalin fogged and iodophor and chlorine was used in prodigious amounts. Because of this, several individuals became sensitive to chemicals. In 1988 the "Safer Chemical Use in Alaskan Aquaculture" manual was written to address the chemical over use problem. Use of alternatives to harsh chemicals was encouraged (ie. steam and soap). Getting ourselves to "think clean and not sterile" was important. We did not have to kill every last bug in the hatchery in order to successfully culture sockeye. Using the correct concentration of a chemical when it was used was also an important change made.

IHN AT LYONS FERRY HATCHERY: A CASE STUDY OF VERTICAL TRANSMISSION?

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ABSTRACT

Infectious hematopoietic necrosis (IHN) has occurred at Lyons Ferry Hatchery in 1985, 1989, and 1992. In 1985, IHN virus was probably transferred into Lyons Ferry with the fish. However, in 1989 and 1992 vertical transmission from the steelhead broodstock to their progeny probably occurred. IHN was not seen in all steelhead groups in 1992 despite high IHN virus prevalence in the broodstock. The role of iodophor water hardening, IHN virus titer, and water quality in virus transmission needs to be determined.

INTRODUCTION

Infectious hematopoietic necrosis (IHN) is a highly contagious, deadly virus disease of salmonids that is endemic to the Pacific Northwest. Since the first documented outbreak in a Washington Department of Wildlife (WDW) hatchery in 1981, IHN has caused fish losses at 11 WDW fish culture facilities. IHN outbreaks have occurred at Lyons Ferry Hatchery in 1985, 1989, and 1992.

Lyons Ferry Hatchery is one of the fish hatcheries constructed under the Lower Snake Fish and Wildlife Compensation Plan. The facility is located on the north bank of the Snake river in southeastern Washington. The hatchery site includes both WDW rainbow and steelhead hatchery and Washington Department of Fisheries chinook salmon hatchery. Hatchery operations started in 1982 and steelhead spawning at the hatchery commenced in 1986. The water supply for the hatchery is 8 deep wells which can produce 102 cfs of 51 F water. The facility also has a adult steelhead and salmon ladder-trap and broodstock ponds.

The Lyons Ferry Hatchery (WDW) program consist of 300,000 Grande Ronde stock summer steelhead, 600,000 Lyons Ferry stock summer steelhead, and 375,000 Spokane stock rainbow. The Grande Ronde steelhead are received as eyed eggs from Wallowa Hatchery (Oregon Department of Fish and Wildlife). The Lyons Ferry stock summer steelhead obtained from steelhead that return to Lyons Ferry Hatchery. The Spokane rainbow are received as eyed eggs from the Spokane Hatchery (WDW).

Because of the isolation of IHN virus in the steelhead broodstock stringent spawning procedures are followed. The spawning procedures are as follows:

1. Collect milt from 2 males in a 1 gallon bucket.
2. Incision spawn 1 female into a colander.
3. Collect ovarian fluid sample for viral testing.
4. Place eggs into bucket with milt and add 50 mL well water.
5. After 30 sec, fill bucket with 100 ppm iodophor solution (1:4 egg to iodophor solution)
6. After 1 hr, put eggs into individual bucket incubator.

IHN virus can be transmitted horizontally (fish to fish) and vertically (parents to progeny). Horizontal transmission via a contaminant water supply is the primary mode of transmission (Wingfield and Chan, 1970, Mulcahy et al., 1983). Evidence for vertical transmission is conflicting. Vertical transmission in sockeye salmon has been documented (Mulcahy and Pascho, 1985). However, studies with chum salmon, chinook salmon, masu salmon, rainbow, and steelhead have not resulted in vertical transmission (Amend, 1975; Engelking et al., 1991; Yoshimizu et al., 1989; LaPatra et al., 1991). Determining the mode of IHN virus transmission is essential in viral control.

The purpose of this paper is to document two possible cases of IHN virus vertical transmission in steelhead and to identify factors which may affect the virus transmission.

CASE STUDY

IHN outbreaks have occurred at Lyons Ferry on three occasions in the past 10 years of operations (Table 1).

Table 1. IHN outbreaks at Lyons Ferry Hatchery (WDW).

Date	Species	No. Fish Destroyed	IHN Source
Dec-85	RB	15,000	Fish transfer [1]
Apr-89 & Jul-89	RB & SS	967,000	Steelhead Broodstock [2]
Apr-92	SS	372,000	Steelhead Broodstock [2]

[1] Fish transfer from Tucannon Hatchery
[2] Steelhead broodstock at Lyons Ferry Hatchery

In December, 1985 IHN was isolated from one raceway of Spokane rainbow fingerling that displayed clinical signs and slightly elevated mortality. The raceway of fish were quickly destroyed.

The fish were received from the Tucannon Hatchery (WDW). Probably the IHN virus was transferred into the Lyons Ferry Hatchery with the fish, since IHN had caused mortality in rainbow at Tucannon Hatchery in October and November, 1985.

In April, 1989 IHN occurred in newly feeding steelhead fry being reared in the hatchery building. Initially, IHN virus caused mortality in the fish from the first two egg takes. Later in the summer IHN affected the remaining raceway of Lyons Ferry stock summer steelhead and the disease spread to two adjacent raceways of Spokane stock rainbow. The steelhead were progeny of IHN virus positive broodstock (Table 2).

In April, 1992 IHN again occurred in newly feeding steelhead fry in the hatchery. The disease was confined to two out of five steelhead egg takes. Only the affected fish were destroyed. The fish in the remaining three egg takes are healthy to date. As in 1989, the fish were progeny of IHN virus positive steelhead broodstock (Table 2).

Table 2. IHN virus broodstock isolation compared to fry outbreaks.

Brood Year	Adult [1] IHNV+	Fish Reared from IHNV+	Fry IHN
1986	+	No	No
1987	+	No	No
1988	-	-	No
1989	+	Yes	Yes
1990	+	No	No
1991	-	-	No
1992	+	Yes	Yes

[1] 100 % of the female steelhead broodstock were sampled

DISCUSSION

IHN virus has caused fish mortality on three occasions at Lyons Ferry Hatchery (WDW). The source of the virus in the 1985 outbreak was infected fish transferred from Tucannon Hatchery. In 1989 and 1992, the source of IHN virus was the summer steelhead broodstock. The well water is not a source since over 4.0 million IHN susceptible rainbow have been reared at Lyons Ferry Hatchery in the past 10 years without any problems. Also, when eggs from IHN virus positive female steelhead broodstock were destroyed in

1986, 1987, and 1990 no IHN occurred in the steelhead reared. Thus, two cases of possible IHN virus vertical transmission have been seen in summer steelhead at Lyons Ferry Hatchery.

In 1992, IHN outbreaks have not occurred in all egg takes despite high prevalence of IHN virus in broodstock (Table 3). Fish from three of five egg takes have been successfully reared and are currently 15 fish\lb. The unaffected fish have been subjected to a number of stressors including transfer from troughs to deep tanks in the hatchery building, transfer from deep tanks to outside raceways, and adipose clipping and transfer to the rearing pond yet the disease has not been observed.

Table 3. IHN outbreaks compared to broodstock IHN virus prevalence.

Spawn No	Take Positive	Percent IHN Virus Days	IHN [1] Date
2/04/92	1	79	None
2/11/92	2	96	48
2/18/92	3	83	None
2/25/92	4	83	48
3/03/92	5	92	None

[1] Days post-fertilization when IHN was first observed

Factors effecting the vertical transmission IHN virus need to be examined. Some possible factors include iodophor water hardening,
IHN virus titer, and water quality.

Despite the water hardening in 100 ppm iodophor for 1 hr IHN has occurred. In addition in 1992, when the steelhead eggs reached the eyed stage, the eggs were disinfected with 100 ppm iodophor for 10 minutes and IHN occurred. Chapman and Rogers (1992) suggest that current iodophor water hardening may not result in total egg disinfection. Therefore, modification of the water hardening procedure including the use of higher iodophor concentrations and circulation of iodophor solution through the egg mass needs to be explored.

Since past IHN broodstock testing has not examined the IHN virus titer the question of the effect of titer on virus transmission remains. It has been suggested that IHN virus titer may play a role in its transmission (Mulcahy and Pascho, 1985; Meyers et al., 1990). In the future, broodstock IHN virus titer will be determined
and their progeny will be separated according to the parental IHN titer.

The effects of water quality on IHN virus transmission also needs to be explored. Electrostatic interactions plays an essential role of binding of vesicular stomatitis virus (similar virus to IHN virus) to membranes of susceptible cells (Conti et al., 1991). Since the Lyons Ferry Hatchery well water has high conductivity, its role in virus transmission may be important. Experiments with deionized water for sperm activation and water hardening will be conducted.

CONCLUSIONS

1. A possible case of vertical transmission IHN virus has occurred in summer steelhead at Lyons Ferry Hatchery. The disease occurred despite rearing on well water and stringent spawning and incubation procedures in 1989 and 1992.

2. IHN was not seen in all fish in 1992 even though the broodstock had a high prevalence of IHN virus.

3. IHN did not occur in 1986, 1987, and 1990 when eggs from IHN virus positive female broodstock were destroyed.

4. The role of iodophor disinfection, IHNV titer, and water quality in IHN virus transmission needs to be examined.

ACKNOWLEDGEMENTS

Thanks goes to Butch Harty, hatchery manager and the Lyons Ferry Hatchery crew for their diligent efforts to control IHN. Also, Mark Schuck, hatchery evaluation biologist and his staff provided valuable assistance during spawning operations.

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THE EFFECTS OF USING TWO DIFFERENT WATER SOURCES ON THE INCIDENCE OF IHN VIRUS AT DWORSHAK NATIONAL FISH HATCHERY

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INTRODUCTION

Dworshak National Fish Hatchery is located in north-central Idaho at the convergence of the North Fork of the Clearwater River and the Mainstem of the Clearwater River. The hatchery was built to produce steelhead trout (Oncorhyncus mykiss) to mitigate for Dworshak Dam's destruction of the North Fork steelhead's (STT) spawning grounds. Production began in 1969 with the first STT smolts being released in 1970. Production capacity of the hatchery is 2.3 million smolts annually, with a mitigation responsibility of 20,000 adult steelhead into the Clearwater River.

The hatchery has also produced spring chinook salmon (Oncorhyncus tshawytscha) since the early 1980's. Coincidentally, the hatchery began suffering severe losses of steelhead to Infectious Hematopoietic Necrosis Virus (IHNV) beginning with Brood Year 1982. Annual losses have ranged from 25 to 98 percent, with most years' production being significantly affected.

Water for incubation and nursery rearing at Dworshak has historically been pumped directly from the North Fork of the Clearwater River. Many returning steelhead and chinook adults bypass the hatchery's ladder and remain between the hatchery's water intake and Dworshak Dam, just one mile upriver. Any virus shed by these fish into the North Fork could be pulled into Dworshak's water supply, and into incubators, nursery tanks, and rearing ponds. Chronic IHNV problems, then, could be expected.

Several strategies were devised to deal with the virus problem to ensure that mitigation responsibilities were met:

1) All adults were tested for IHNV infection levels, and all high-IHNV positive eggs (with titers above 10^{-5}) were culled. In addition, in the initial years of the problem, fish breaking with the virus were immediately discarded.

2) Use of ozone was maximized, with 32 of 128 nursery tanks receiving an ozonated water supply. The effectiveness of this tactic can be seen when the fact is noted that not a single nursery tank of steelhead on ozone has ever broken with IHN when eggs were disinfected at eye-up.

3) It was generally noted that the larger the fish were when they first broke with the virus, the fewer the losses. Therefore, in order to get steelhead fry as large as possible as quickly as possible, early-rearing water temperatures were maintained at 54°F for 64 of the 128 tanks. Warm water rearing was not available for the other 64 tanks, which received water at

ambient temperatures. One fact worth mentioning is that in one study several tanks of steelhead which buttoned-up on cold water never broke with the virus while cohorts buttoned-up on warm water all broke with the virus during nursery rearing.

4) All STT eggs were also disinfected with iodophor at fertilization during water hardening. The present procedure is 75 mg/l buffered iodophor for 30 minutes. In recent years, all eggs have been disinfected again at eye-up with a buffered 100 mg/l iodophor solution for 10 minutes before being put into hatching jars or trays.

A variety of tanking strategies and studies were conducted to try and control and understand the disease. However, losses were so extensive in the early 1980's that significant portions of Dworshak's early-rearing of steelhead were moved off-station, with eggs being shipped to Kooskia and Hagerman National Fish Hatcheries. These projects would rear the fish to anywhere from 250 fish per pound (FPP) to 30 FPP before returning them for final grow-out at Dworshak. While this approach has been somewhat successful, it was also expensive and time consuming in transporting the larger fingerlings back to Dworshak. It also put Dworshak's program at constant risk. Steelhead could not be returned to the hatchery if certain diseases were detected in the fish while being reared off-site.

NEW WATER SUPPLY LINE

A major long-term goal has been to get a water supply for incubation and nursery rearing that is virus-free, because early-rearing IHN losses were usually more severe than steelhead losses to the virus in outside pond rearing. A water supply line from Dworshak Reservoir for this purpose was proposed some time ago. With the recent construction of Clearwater Anadromous Fish Hatchery (CAFH) directly across from Dworshak on the North Fork of the Clearwater River, it was possible to modify plans for CAFH's water supply lines from the reservoir so that a water supply line for Dworshak's incubator room and nursery could be added. There are now two intakes on Dworshak reservoir, an upper one that can be adjusted to some degree and a lower intake at a fixed depth. The two lines lead to a mixing chamber just upstream from both hatcheries. Each hatchery can chose the mix of upper and lower intake water that produces a water temperature appropriate for its production program.

BROOD YEAR 1992 STEELHEAD PRODUCTION

Brood Year 1992 steelhead were the first brood year to be reared on reservoir water. One bank of nursery tanks (32 tanks) received ozonated river water. In anticipation of what was hoped to be a virus-free water supply, all of Dworshak's early-rearing program remained at Dworshak in 1992, something not possible since 1981.

Nursery rearing was a resounding success. Out of 114 tanks, 3.5 million feeding fry, only one tank broke with IHNV. These happened to be high-IHNV offspring, kept only because they were from early-returning adults. These fish, along with two other tanks of high-IHNV fry, were immediately culled. No other IHN incidents were detected in nursery rearing, confirming hopes for a virtually virus-free water supply. While the kokanee salmon (Oncorhyncus nerka) in the reservoir do carry the IHN virus, incidence is fairly low and, hopefully, insignificant. It might also be mentioned that CAFH's steelhead production in 1992 was reported to have been free of IHNV.

Steelhead at Dworshak are normally moved to outside Burrow's ponds on raw river water when they are about 200 FPP. In 1992 the first fish were ponded on May 22 at 150 to 200 FPP. A slight rise in outside pond mortalities occurred about six weeks after initial ponding. Pond after pond began suffering significant losses, and IHN was soon confirmed as the cause.

LOSSES TO IHNV

When IHN losses became evident, it was decided not to move fish to outside ponds until they averaged at least 100 FPP or until early August. No steelhead were ponded for the next month and a half, until August 11. This necessitated great attention to growth projections and to tank-splitting strategies to prevent high densities in the nursery. These later-ponded fish went out at fairly large sizes, from 50 to 100 FPP. Of the 25 ponds receiving fish after August 11, only two broke with the virus through November 1, 1992, with one pond losing six percent of its population and another just one percent.

The stark contrast in losses can be seen in Table 1 below, with the 1.2 million steelhead ponded between May 22 and June 18 losing an average 30 percent. All 19 of these ponds broke with the virus.

Table 1. Cumulative loss to IHNV (through 11/1/92) - Steelhead, Brood Year 1992, Dworshak NFH.

		Average	
Date Ponded	Number Ponded	FPP	Cumulative Loss (%)
Before 6/20/92	1.20 M	178	30
After 8/11/92	1.73 M	63.7	0

Although two ponds receiving fish after August 11 did break with IHNV, losses were so insignificant that the average loss for these 1.73 million fish pond was essentially zero.

The strategy of growing the steelhead larger and ponding them later worked fairly well this brood year. Losses, however, still approached 400,000 fish. In order to avoid such losses in the

future, and to devise a production program that will ensure meeting program commitments, it is necessary to better understand the relationships between IHN outbreaks and ponding date and between IHN outbreaks and fish size at ponding. It may be that IHN levels vary throughout the year in Dworshak's water supply, and that the insignificant losses in fish ponded after August 11 were simply due to seasonally depressed virus levels.

On the other hand, it may be that losses are less dependent on virus level and more on the size of the fish when first exposed to the virus. An analysis of the present brood year losses was made to determine if a correlation existed between IHN losses and 1) ponding date or 2) fish size at first ponding.

Figure 1 presents a chart depicting the cumulative average percent losses in the 19 ponds ponded between May 22 and June 18. Again, all of these ponds broke with the virus. A regression of the data produced an R^2 of 0.1, which confirms what the chart also demonstrates, no clear correlation between losses and date ponded for this limited set of data. This does not, however, rule out the possibility that later ponding dates may result in fewer losses to the virus. No fish were ponded later at a size of 150 to 200 FPP, so the data set analyzed covered only a four week period.

Another presentation of the data (Table 2) demonstrates the consistency of losses and of the days it takes for a group of fish to break with the virus. In this table, the ponds are grouped by seven-day periods, from May 22 through September 14. The 19 ponds ponded early show consistent average losses of 29.6 to 32.7 percent. Time to break with the disease is also a consistent 40 to 43 days. Ponds receiving fish after August 11 are again shown to have suffered few losses.

Table 2. IHNV losses in steelhead by ponding date (5/22-9/14/92) Brood Year 1992, Dworshak NFH.

===Rearing Units====			Average	
Ponded	Broke w/ IHN	Ponding Dates	Loss (%)	Days to Break
8	8	5/22 - 5/28	30.6	41
3	3	5/29 - 6/4	32.7	40
3	3	6/5 - 6/11	29.7	43
5	5	6/12 - 6/18	29.6	40
0	0	6/19 - 8/10	none ponded for seven weeks	
6	1	8/11 - 8/17	6.1	46
0	0	8/18 - 8/24	-	-
8	0	8/25 - 8/31	-	-
7	0	9/1 - 9/7	-	-
4	1	9/8 - 9/14	1.2	17

Note: Averages given only for ponds that broke with IHNV.

Fish sizes at ponding for the 19 ponds put out in May and June ranged from 149 FPP to 223 FPP. Because all of these ponds broke with the virus and because they were all ponded within four weeks of each other, it was felt that an analysis of the cumulative losses in these ponds might reveal some correlation with the fish size at ponding. Figure 2 presents these data, grouping ponds into five fish per pound increments. The lack of a trend evident in the graph is confirmed by a regression analysis of the data which produced an R^2 value of just 0.01. Again, this lack of correlation may simply be a result of this limited data set.

Another analysis of cumulative loss versus fish size at ponding is given in Table 3. The 19 ponds ponded early and the 25 ponds receiving fish later are grouped into 30 FPP increments. Average cumulative losses (only for those ponds that broke) and the number of days it took an average pond to break are presented. Both losses and days to break were, again, fairly consistent for fish ponded early.

Table 3. IHNV losses in steelhead by fish size at ponding Brood Year 1992, Dworshak NFH.

===Rearing Units====			Average	
Ponded	Broke w/ IHN	FPP at Ponding	Loss (%)	Days to Break
4	4	200 - 229	26.9	46
4	4	170 - 199	33.5	40
11	11	140 - 169	29.6	42
0	-	110 - 139	-	-
6	1	80 - 109	6.1	46
19	1	< 80	1.2	17

Note: Averages given only for ponds that broke with IHNV.

For fish ponded at 109 FPP or less, only two ponds broke with IHN, and only minor losses occurred. These fish were not only larger, however, they were also put out later. So the question remains unanswered, did losses drop because of fish size or because of ponding date?

FUTURE REARING STRATEGY

It would have helped to answer the question in order to plan for Brood Year 1993. Ideally, steelhead would not be put into Burrow's ponds until August 1 each year and until they are larger than 100 FPP. Nursery rearing space and program commitments dictate otherwise, however. For the present, the following steps will be taken to ensure adequate numbers of steelhead are produced and to avoid massive losses to the IHN virus:

1) Eggs from high-titre IHN adults will continue to be discarded.

2) The nursery will continue to use reservoir water only.

3) The initial exposure of young steelhead to raw river water will be delayed, hopefully, until at least July 1 each year.

4) Fish will not be ponded until they reach at least 100 FPP in size.

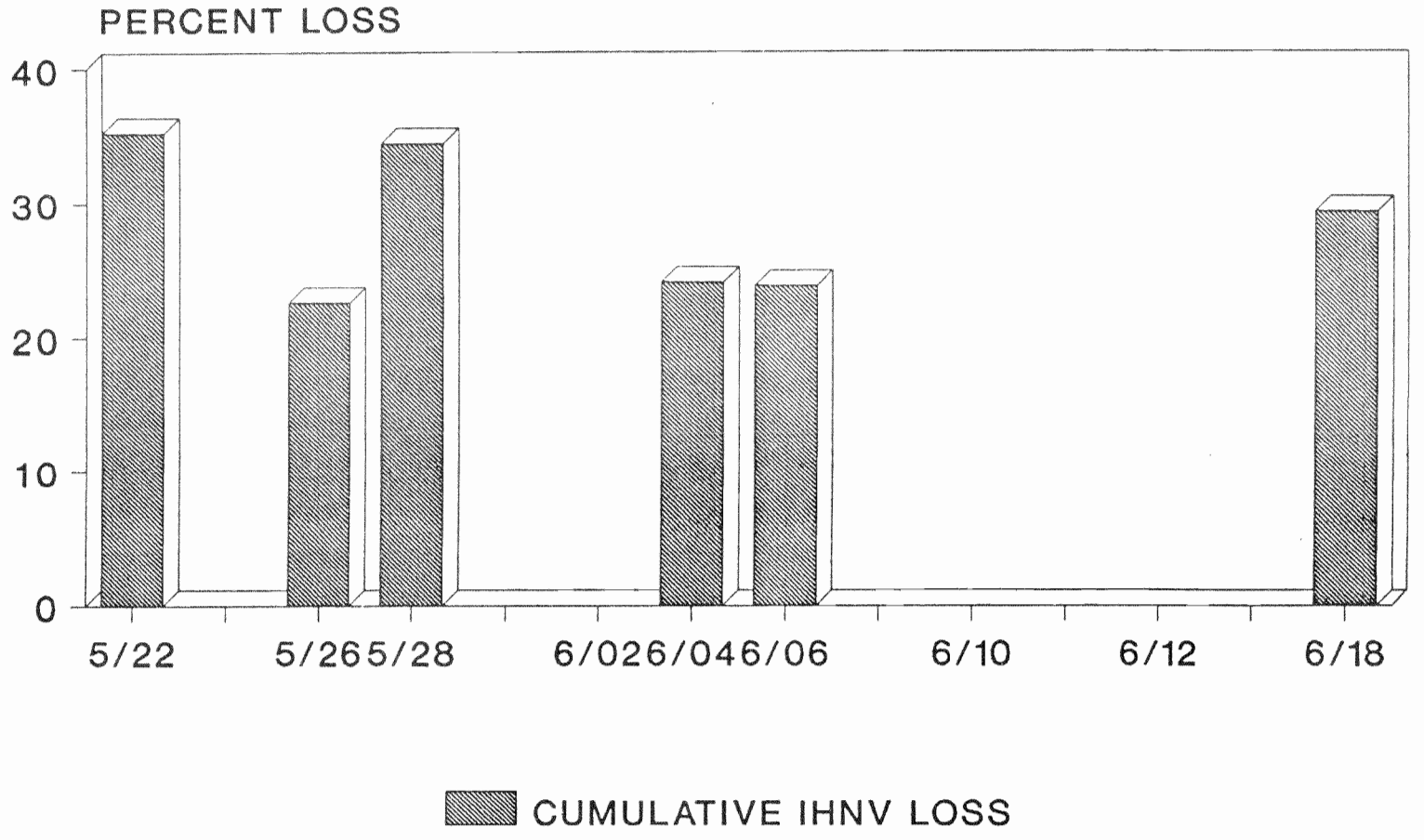
5) Some reduction in initial numbers of tanked fry may occur in order to keep nursery tank densities reasonable. Program committments should not, however, be affected.

While several studies still need to be designed and conducted to further investigate the relation between IHN losses and ponding dates and fish size at ponding, the production of Brood Year 1992 steelhead demonstrated that the use of a virtually virus-free reservoir water supply for early-rearing steelhead at Dworshak can eliminate early losses. It also proved that all production could be kept on station and still meet production goals.

This report could not have been written and the above information could not have been generated without the Dworshak Production Crew. Their professional attitude toward all fish culture duties ensured that mortality records, fish inventories, and related procedures and records were consistently and accurately maintained or accomplished. Thanks are also given to Dworshak Fish Health Center personnel and to the Dworshak maintenance crew for providing services in support of this production program. Acknowledgement is also given to Kevin Sloan for his help in designing and executing graphs.

FIGURE 1.

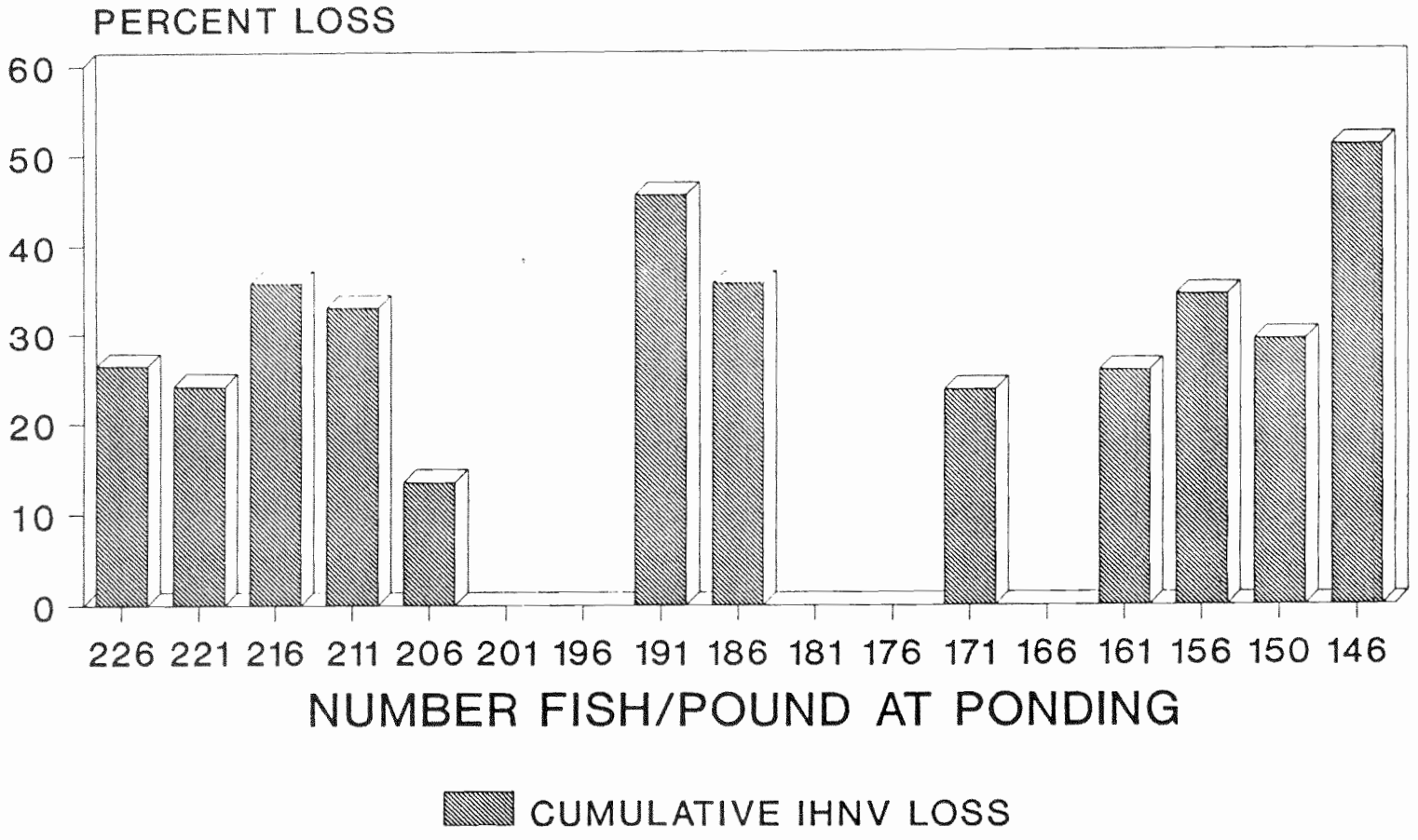
LOSS VS. DATE PONDED
BY 92 STT PONDED < 20 JUNE 92



TO 11/01/92 DWORSHAK NFH

FIGURE 2.

LOSS VS. FISH SIZE AT PONDING BY 92 STT PONDED < 20 JUNE 92



TO 11/01/92 DWORSHAK NFH

PHOTOPERIOD MANIPULATION OF ATLANTIC SALMON

BILL ST. JEAN
HATCHERY MANAGER
STOLT SEA FARM - ROCHESTER, WASHINGTON

The rearing of Atlantic Salmon smolts in Washington State is predominately done in constant 50 degree well water. With this lack of temperature trigger and our natural photoperiod, it is difficult to produce quality smolts that will thrive in our Puget Sound net pens. The Rochester hatchery up until now has had very little heated water capacity. We are currently in the process of installing a heat pump which will have the capacity to heat 300 gallons per minute from 50 degrees to 58 degrees. This will be used to increase growth during early feeding so that a larger size fry can be moved out of our hatchery building. With lack of heated water we have relied on the use of lights on our tanks to stimulate smoltification.

The lighting systems that we use consists of exterior spot lights mounted on the lip of the above ground round fiberglass tanks. We have found that in our crystal clear well water that we need 1 watt of light per .7 sq. ft. of water surface. More light would be required for turbid water. These spot lights intended for yard lighting have proven to be most rugged. We use 150 watt bulbs with two of these lights on a S meter diameter tank. These are plugged into ground fault circuit interrupter receptacles like those installed in bathrooms to avoid the rick of electrical shock to employees. This safety measure is a must to avoid accidents from occurring. Another style of exterior yard lights called "Malibu Lights" could be used, the advantage of these is cost savings since they come in adjustable string lengths of 8-10 lights, less ground fault circuit interrupter plugs are required.

Atlantic salmon eggs hatch in December and first feeding begins in January. Atlantic smolts from Rochester Hatchery average 70 grams of 6.49 fish per pound. Smolts of this size can be produced from January through September of the following year. Our competitors using more heated well water than we have had in the past, are producing smolts as early as October at only 10 months of age. This is becoming the trend in Atlantic Salmon Farming to produce smolts earlier so fish reaches market size of 6 - 10 pounds sooner. Photo period manipulation plays a key point in smolt development of these early S-O smolts, (see chart #1). To produce spring entry S-1 smolts, we use photoperiod day length extensions (see chart #2) to increase the smolt developmentally in regards to condition factors and salinity tolerance, as well as uniformity within the populations. For later entries of S~1-5 smolts, photoperiods are used to reduce the number of precocious (maturing) males. This has worked very well for us in the past. These late entry fish are primarily males up to 80% in some stocks. By extending the day length at the summer solstice, we have been able to reduce the number of maturing males from more than 30% down to less than 15%. We have currently stopped our late entry program. Although the smolts survived in salt water, growth rates were not competitive with earlier entries (chart #3).

Chart #1

S-0 SMOLTS - Upper mode of Yearclass

JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY

(First Feed 24 hour light 16 hour feed)

(24 hour light 12 feed)

AUGUST SEPTEMBER OCTOBER NOVEMBER DECEMBER JANUARY

(Natural light 8 hrs
feed for 6 wks)

(8 hours light
8 feed)
"WINTER" 6 wks.

(14 hour light extending 1/2
hr per wk. 15 min. A.M.
15 min P.M. 5 feedings per day)

Chart #2

S-1 SMOLTS - Middle mode of Yearclass - bulk of population

JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY

(First Feed 24 hour light 16 hour feed)

(24 hour light 12 feed)

AUGUST SEPTEMBER OCTOBER NOVEMBER DECEMBER JANUARY

(Natural light 8 hour feed----------Normal Winter Period

FEBRUARY MARCH APRIL MAY
SMOLT

----------)

(14 hour light extending 1/2 hour
per wk. 15 min A.M. 15 min. P.M.
up to 20 hours 5 feedings per day.)

Chart #3

S-1.5 SMOLTS - Lower mode of Yearclass - runts

JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY

(First Feed 24 hour light 16 hour feed)

(24 hour light 12 feed)

AUGUST SEPTEMBER OCTOBER NOVEMBER DECEMBER JANUARY

(Natural light 8 hour feed---------->

FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST

(Natural light 8 hour feed----------)

(Begin extension of day at summer solstice, 30 min. wk. 15 min. A.M. 15 min. P.M. 5 feedings per day)

Effect of Length and Condition Factor on Steelhead Smolt to Smolt Survival

Jack Tipping and Jim Byrne

Washington Department of Wildlife

Abstract

To determine the influence of length and condition factor on smolt to smolt survival of raceway reared hatchery steelhead, fish in two successive years were measured and marked with Visible Implant tags and released in a small stream 2.6 miles above a weir. Recovery of smolts at the weir indicated fish over 180 mm had higher emigration rates, while those with a condition factor of 0.90 to 0.99 had significantly higher emigration rates than fish with a condition factor of 1.00 and greater.

To determine the relative effects of length and condition factor (plumpness) on smolt emigration rates, two groups of steelhead smolts were tagged and planted above a 100% weir on Snow Creek, a small stream near Port Townsend. In late April 1991 and 1992, respectively, a total of 951 and 1,271 raceway-reared winter steelhead smolts from South Tacoma Hatchery were measured for length and weight and then tagged with Visible Implant tags in the adipose eyelid tissue near the left eye. Two days later, the fish were planted about 2.6 miles above the weir at Snow Creek. Migrants were captured at the weir and tag numbers were read.

For the 1991 release, a total of 73.9% of fish released migrated to the weir. Results indicated small smolts (<180 mm) had fewer migrants than larger fish with the optimum being around 190 mm with little increase thereafter (Table 1). With exception of smolts less than 0.89, smolt emigration decreased with increasing condition factor (Table 2). Significantly fewer fish with condition factors of 1.00 or greater migrated than fish between 0.90 and 0.99. However, in comparing mean condition factor of migrants versus non-migrants by length, no difference was apparent (Table 3). It appears shorter fish had a greater condition factor than longer fish, possibly indicating less readiness to emigrate.

For the 1992 release, a total of 86.2 percent of released smolts were captured at the weir. Fish were held from feed for several days prior to tagging, and overall condition factor was 1.00 versus 1.02 in 1991, which may have influenced migration rate. Again fewer fish less than 180 mm migrated than smolts 180 mm or longer (Table 4). With exception of fish with condition factors less than 0.90, the percent of migrants decreased as condition factor increased (Table 5). Fish with a condition factor of 0.90-0.99 had a significantly higher emigration rate than plumper fish. In comparing condition factor of migrants versus non-migrants, condition factors of migrants were less than non-migrants for fish 180 mm and greater (Table 6). The elevated condition factor of the smaller fish may be reflected in the lower migration rate for shorter fish.

A total of 23 fish were measured for length and weight 19 or more days after release: mean length increased 7 mm while weight was similar. Condition factor decreased from 1.06 at release to 0.95 when recaptured. Only one fish from the 1991 release was recovered in 1992.

In an other experiment conducted at the Cowlitz Trout Hatchery in 1989-1991 using sea-run cutthroat, actively migrating hatchery smolts were intercepted, measured for length and weight and marked with VI tags for two successive years. Results indicated no significant difference in adult returns by condition factor although no returns were observed from smolts with a condition factor of 1.14 or greater.

In conclusion, length plays an important role in emigration, as expected, while condition factor appears to influence the willingness of pond-run smolts to emigrate. However, in actively migrating smolts, it does not appear to affect adult returns except possibly in obese smolts. We currently plan to investigate the potential of increasing emigration rates of hatchery steelhead by altering condition factors through feed manipulation.

Tacoma Public Utilities provided assistance and funding for much of this study.

Table 1. Steelhead migration rate by length, 1991 release.

Length	Smolts Released	Migration Rate
146-159	31	45.2 %
160-169	78	60.3
170-179	102	62.8
180-189	148	71.6
190-199	189	81.0
200-210	183	79.2
220+	105	78.1
TOTAL	951	73.9

Table 2. Steelhead migration rate by condition factor, 1991.

K-factor	Migration Rate
< = .89	70.6 %
.90-.94	80.4
.95-.99	76.1
1.00-1.04	71.8
1.05-1.09	68.8
1.10-1.14	68.1
1.15+	64.9

Table 3. Condition factor of migrants by length, 1991.

Length	Migrants	Non-Migrants
146-159	1.05	1.09
160-169	1.04	1.03
170-179	1.05	1.04
180-189	1.01	1.03
190-199	1.02	1.01
200-209	1.01	1.03
210-219	1.00	1.00
220+	1.01	1.01
AVG	1.02	1.03

Table 4. Steelhead migration rate by length, 1992 release.

Length	Smolts Released	Migration Rate
150-169	32	68.8
170-179	109	79.8
180-189	244	85.7
190-199	381	86.1
200-210	280	85.7
220+	123	95.1
TOTAL	1,271	86.2

Table 5. Steelhead migration rate by condition factor, 1992.

K-factor	Migration Rate
< = .89	81.3 %
.90-.94	89.1
.95-.99	90.4
1.00-1.04	80.2
1.05-1.09	76.1
1.10-1.14	72.9
1.15+	60.0

Table 6. Condition factor of migrants by length, 1992.

Length	Migrants	Non-Migrants
150-169	1.02	1.01
170-179	1.02	1.05
180-189	1.01	1.02
190-199	0.99	1.00
200-209	0.98	1.04
210-219	0.98	1.02
220+	0.98	1.00
TOTAL	0.99	1.02

CHANGES IN SPECIFIC GRAVITY OF COHO AND CHINOOK SALMON, STEELHEAD AND RAINBOW TROUT IN RELATION TO FISH HAULING

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ABSTRACT

Oregon Department of Fish & Wildlife (ODFW) liberation truck gauges are calibrated in pounds of fish, assuming a fish specific gravity of 1.02. Experiments were conducted at the Corvallis Fish Research Laboratory to test this assumption. Specific gravity of four species of salmonids were followed over time; coho salmon, spring chinook salmon, winter steelhead, and rainbow trout. Specific gravity showed a significant ($P \leq 0.05$) decrease over time in all four species studied. Specific gravity at the normal time of release for each species was significantly ($P \leq 0.05$) less than 1.02 for coho salmon, spring chinook salmon, and rainbow trout. Only winter steelhead were not significantly different than 1.02 at their normal time of release. Rainbow trout fed at 1.0% body weight/day for seven months, had significantly higher weights and KFL's, and lower specific gravities than those fed at 0.5% body weight/day. After seven months, coho salmon also showed increased weights and KFL's for higher feeding rate groups, but specific gravities were not significantly different.

After two months at different feeding rates coho salmon and rainbow trout fed at 1% and 2% body weight/day showed significantly ($P \leq 0.05$) higher condition factors and percent lipids than those fed at 0.5% body weight/day. Specific gravities of rainbow trout fed at 0.5% and 1.0% body weight/day were not significant different, even though those fed at 1.0% had a significantly higher percent lipid. Contrary to expected results, coho salmon with higher lipid contents had higher specific gravities. Deflation of the swimbladder caused significant ($P < 0.05$) increases in the specific gravity of all groups. The above results suggest the swimbladder is the main element responsible for adjusting specific gravity in coho salmon and rainbow trout.

INTRODUCTION

Technical services staff in ODFW were asked to evaluate the truck displacement method of enumerating fish. As part of that request various aspects of the method have been evaluated for accuracy and bias. There are three main elements to the truck displacement method; estimating average fish size, loading the fish and reading the truck gauge, and calibrating the truck. The first two elements have been discussed in Walters et al (1991) and Lewis et al (1992). The trucks used by ODFW are calibrated in pounds of fish, assuming a fish specific gravity of 1.02 (Leitritz and Lewis 1976). The experiments cited above, suggested that the specific gravity of fish varied between species and possibly with environmental factors in the rearing cycle. To test this possibility under a controlled environment we raised four species of salmonids at the Corvallis Fish Research Laboratory and followed changes in their specific gravity over the course of a year.

METHODS AND MATERIALS

Fish used in these studies were; coho salmon obtained from Big Creek hatchery, spring chinook salmon from Willamette hatchery, winter steelhead from Alsea hatchery, and rainbow trout from Roaring River hatchery. All fish were brought into the Corvallis Fish Research Laboratory as eggs, disinfected and incubated in well water. Rearing was done in single pass well water at a constant temperature of 12^{o}C. Lighting was from ambient natural light and ceiling fluorescent lights set to a normal photoperiod. No disease problems were noted during the experiments. Fish were reared in circular fiberglass tanks and fed a commercial moist diet. Spring chinook salmon were fed at 1.5% to 2.0% body weight per day. Winter steelhead were fed twice daily to satiation. Coho salmon and rainbow trout were fed twice daily to satiation until November 1991, when a feeding rate study was begun.

On November 20, 1991 the coho salmon and rainbow trout were inventoried and split in to three tanks. For each species, each tank had the same weight and number of fish and the same water flow. Fish were removed monthly to maintain a constant total population weight of 21.2 kg for each coho salmon tank and 13.9 kg for each rainbow trout tank. One tank from each species was assigned to each of the following three feeding rates 0.5%, 1.0%, and 2.0% body weight per day.

Samples of 100 fish were taken once a month from each experimental group. Sampled fish were not returned to the unsampled population until all 100 samples had been taken. Fish were anesthetized with MS-222, fork lengths measured to the nearest 0.1 cm, and weights measured to the nearest 0.05 gm. The

fish were then placed in a graduated cylinder to measure the volume of water displaced. Precision of measurements of water volume displaced varied with graduated cylinder size. All cylinders were calibrated with known volumes of water, based on weight and density of water, and any corrections necessary were made to the displacement volumes. Specific gravity was then calculated as; SG = fish weight/weight water displaced, or approximately SG = grams fish/ml water displaced (Leitritz and Lewis 1976; Poston 1983).

In January 1992, 20 fish from each of the feeding rate tanks were sampled to evaluate the contribution of the swimbladder and body composition (percent water, protein, and fat) to the specific gravity of the whole fish. Rainbow trout fed at 2.0% body weight/day could not be sampled since they were too large for the equipment. Specific gravity was determined as described above, then each fish was sacrificed and cut open along the ventral line from the vent to pectoral girdle. The water displaced by the dissected fish was then measured. The swimbladder was then ruptured and the water displacement again determined, making sure no gas remained in the swimbladder or body cavity. Finally the fish were re-weighed and frozen for proximate analysis.

Proximate analyses were performed on 20 fish from each of the various feeding regimes. Fish were weighed, then dried at 105^{o}C for 24 hours in an oven equipped with an air blower. Fish were then re-weighed and the percent water determined as; ((wet weight - dry weight)/wet weight)100.

Dried fish were crumbled into 100 ml of water and allowed to hydrate overnight at 6^{o}C. After hydration, the tissue was homogenized with a Braun hand blender and transferred to a 1 liter separatory funnel. Two volumes of chloroform/methanol (2/1, v/v) were added and the mixture was extracted by the method of Folch et al. (1957). The lipids were evaporated nearly to dryness in a Buchler flash evaporator then transferred to a pre-weighed evaporating flask. The evaporator flask was washed twice with chloroform and the washings were combined with the lipid fraction. The lipid fraction was then evaporated to dryness with air, and weighed. Percent lipids were determined as; (weight of the lipids/wet weight of the fish)100.

Aqueous fractions from the lipid separation were removed from the separatory funnel into 1 liter beakers and allowed to settle. The supernatant was decanted and evaporated in the flash evaporator to remove chloroform and methanol in the extract. Samples were then taken for protein analyses. The sediment was dissolved overnight in 30% KOH. The solution was homogenized with the Braun hand homogenizer and samples were taken for protein analysis. Protein was determined by the biuret method (Gornal et al. 1949). Percent protein was calculated as; (total grams protein in the extract/wet weight of the fish)100.

Analysis of variance was used to compare means for the proximate analysis data, followed by Tukey's test for comparing individual means, when the ANOVA showed a significant difference. T-Tests were used to compare pairs of means, and experimental specific gravities to 1.02. Regression analysis was used for time series data. Statistical significance was determined at $P \leq 0.05$.

RESULTS AND DISCUSSION

Specific gravity of all four species generally decreased over the course of the experiment (Figure 1). All four species started the experiment at specific gravities above 1.02 and ended below 1.02. Regressions of specific gravity versus month showed a significant negative slope for all four species tested. The R^2 values for regression analysis of specific gravity and month ranged from .32 in coho salmon to .83 in rainbow trout.

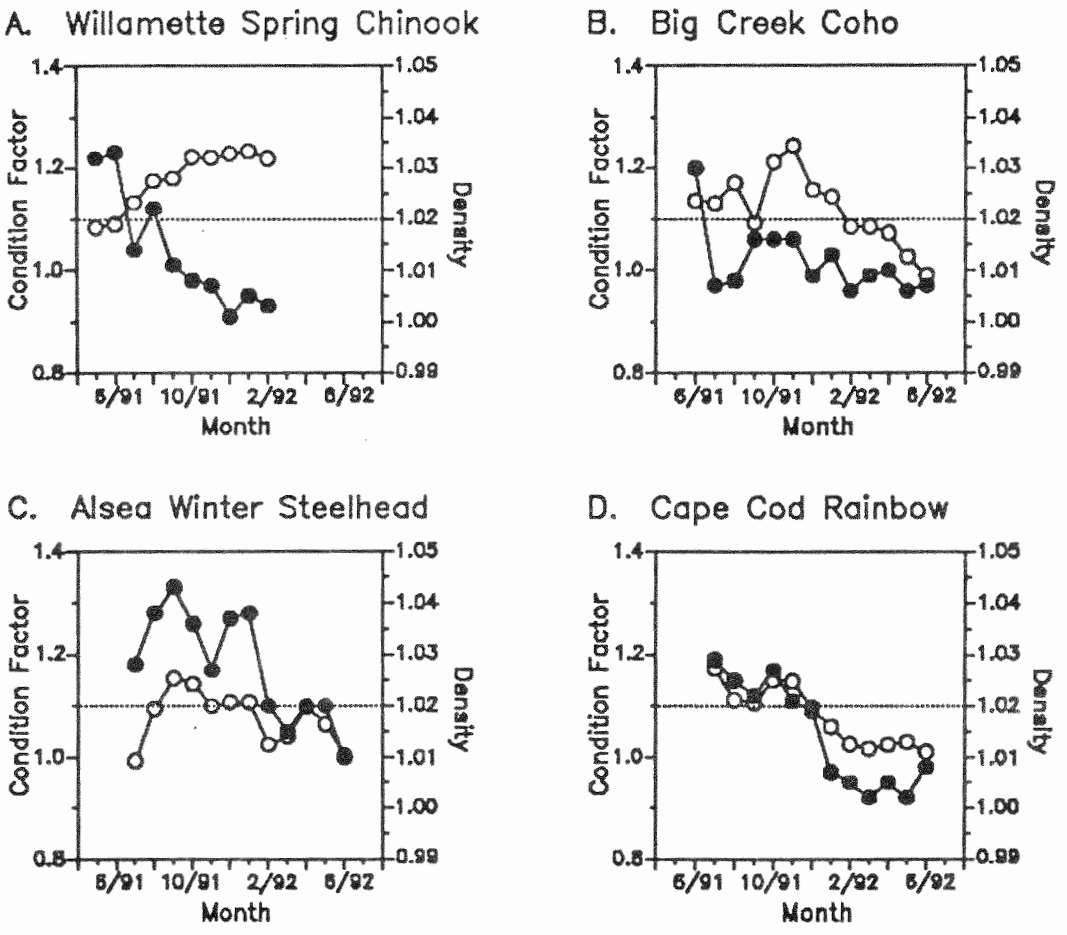

Figure 1. Specific gravity (density) = (weight in gm/water displaced in ml) and condition factor ((weight/length^3)100) over time for four species of salmonids. ● = Density, o = Condition Factor.

Specific gravity of spring chinook salmon showed a fairly linear decrease with time. Coho salmon specific gravity dropped quickly from June to July and then stayed fairly level until the following June. Rainbow trout specific gravity decreased gradually from July to December, dropped abruptly between December and January, then stayed fairly level until June. Steelhead specific gravity rose during the summer, stayed high until spring, then dropped quickly. The steelhead pattern resembles a pattern reported for Atlantic salmon (Pinder and Eales 1969).

Species differences have been noted in other experiments. Saunders (1965) found brook trout to be more buoyant, lower specific gravity, than Atlantic salmon. He attributed this difference to habitat usage. Salmon tending to use faster water habitat whereas the trout used pools. Many species have been shown to decrease their buoyancy (increase specific gravity) in response to current (Saunders 1965; Neave et al 1966; Pinder and Eales 1969; Gee 1968; Berezay and Gee 1978). Comparison of the specific gravity patterns of juvenile steelhead and coho salmon would suggest steelhead are better adapted to habitat with faster currents than coho salmon. This conclusion agrees with Bisson et al (1988) who looked at body shape, fin size, and habitat usage of juvenile steelhead and coho salmon.

To determine if the overall decreasing trend in specific gravity observed in Figure 1 was a result of fish size, graphs of fish size versus specific gravity were done for each sample of fish. No patterns were observed in these graphs. Since the graphs for each sample were somewhat limited in their range of fish sizes, specific gravity of selected size groups of fish were followed over time (Figure 2). Each months sample was sorted into four gram size groups (ie 10 gm = 8 gm to 12 gm) and their average specific gravity calculated. All size groups showed the same general decreasing trend seen in Figure 1. Only the 10 gram rainbow trout group showed any difference from the other groups, having a consistently lower specific gravity than other size groups at the same date. Since the differences in specific gravity do not appear to be related to size they might be related to state of development. Saunders (1965) found Atlantic salmon smolts to be significantly more buoyant than parr, and concluded the difference was not size related. He hypothesized that the increased buoyancy (decreased specific gravity) had biological significance in aiding the down stream migration of smolts. More buoyant fish would be higher in the water column, thus exposed to more current and consequently be more likely to move down stream.

Spring chinook salmon reared at Willamette hatchery were sampled in December 1991. They had a significantly higher specific gravity (1.012) than spring chinook salmon reared at the laboratory, December 1991 (1.001). However, the hatchery fish were much smaller, 39.1 gm for hatchery fish versus 114.6 gm for laboratory fish. Big Creek hatchery coho salmon, sampled in January 1992, were also significantly smaller than those in the

laboratory. However, their specific gravities were not significantly different (P=0.09).

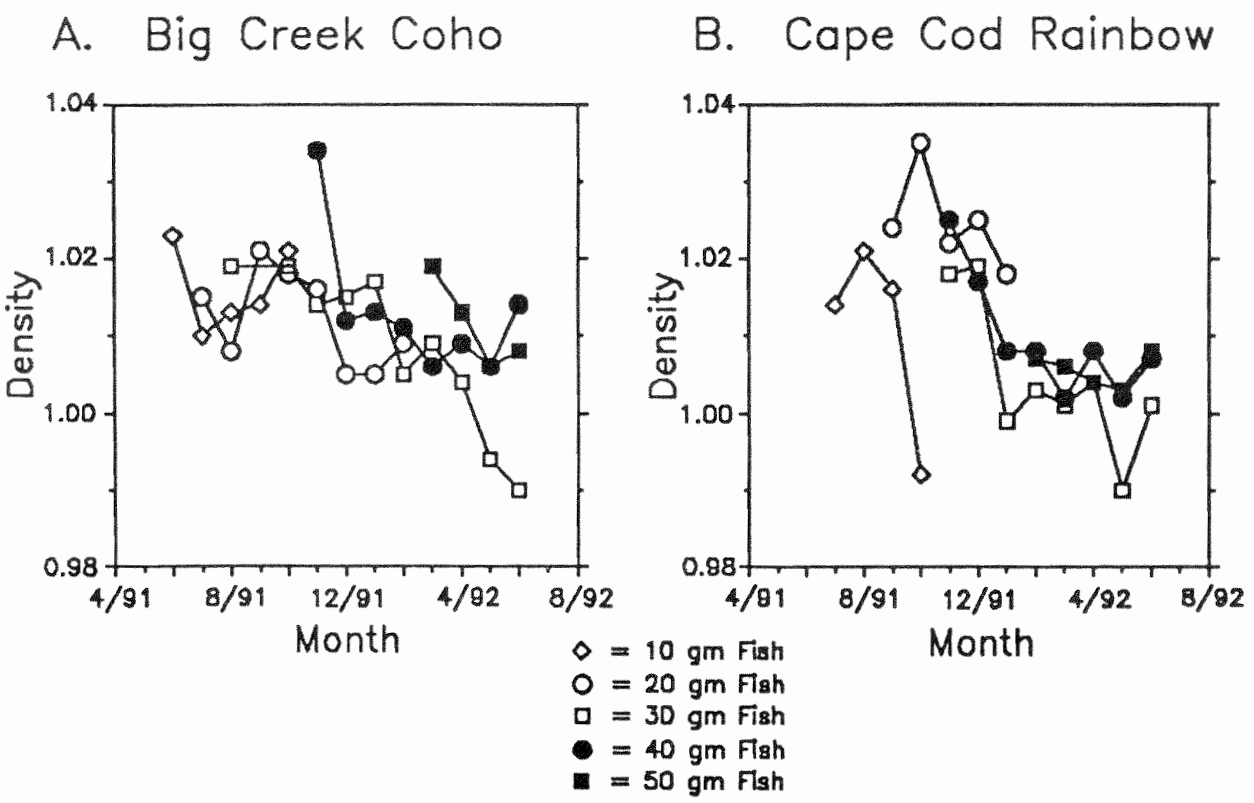

Figure 2. Big Creek coho salmon and Cape Cod rainbow trout specific gravity (density) = (weight in gm/water displaced in ml) over time for 4 gram size groups (ie 10 gm = 8 gm to 12 gm).

Hoar (1939) suggested that condition factor (KFL) was an index of fat content in fish. Since fish lipids are less dense than water (Horak 1966) KFL and fish specific gravity should be inversely related. Spring chinook salmon showed this pattern of increasing KFL and decreasing specific gravity (Figure 1). Coho salmon showed no consistent relationship between KFL and specific gravity. Steelhead and rainbow trout KFL and specific gravity appear to be directly related, both increasing and decreasing together (Figure 1). The chinook salmon were at very high feeding rates compared to the other three species, and although not used in the proximate analysis were very large and probable had very high lipid contents. The lack of an effect of lipids on specific gravity in all but the very high feeding rate fish suggests that only at very high lipid levels do lipids significantly effect specific gravity.

A feeding rate experiment was performed to test whether lipid content influenced specific gravity. The hypothesis in this experiment was that higher feeding rate fish would have larger lipid contents than lower feeding rate fish and that fish with a higher percent of lipids would have a have a lower specific gravity. Horak (1966) reported rainbow trout lipid density to be 0.935 and fat free body density to be 1.100. Therefore, a fish with a higher percent of lipids would be expected to have a lower specific gravity since it would be increasing its percent of lower density components and decreasing its percent of higher density components.

Rearing conditions, and final fish weights, lengths, and condition factors (KFL) for the feeding rate study are reported in Table 1. Sampling of the rainbow trout fed at 2.0% body weight/day stopped in March 1992, because they became too large for the equipment. Therefore, the data in Table 1, for the 2.0% rainbow, is from three months earlier than the other two groups and is not included in the following analysis. Final length, weight, and KFL all significantly increased with increasing feeding rate for both coho salmon and rainbow trout. The increased weight and KFL suggest an increase in lipid content.

Table 1. Rearing conditions and results of coho salmon and rainbow trout feeding rate study. Lengths are fork lengths, KFL = condition factor = (weight/length^3)100

Feeding rate	Flow (gpm)	Volume (ft^3)	Carrying capacity (lb/gpm)	Loading density (lb/ft^3)	Final Weight (gm/fish)	Final Length (cm FL)	Final KFL
			BIG CREEK COHO SALMON				
0.5%	4.4	31.2	10.6	1.5	49.45	17.0	0.990
1.0%	4.5	29.9	10.4	1.6	100.14	20.4	1.140
2.0%	4.5	29.9	10.4	1.6	122.06	21.5	1.186
			CAPE COD RAINBOW TROUT				
0.5%	4.0	30.6	7.7	1.0	49.83	16.9	1.009
1.0%	4.0	29.9	7.7	1.0	144.58	23.1	1.175
2.0%	4.0	30.6	7.7	1.0	151.44[a]	22.7[a]	1.279[a]

a = Data are from March 1992, all other data are from June 1992.

By the end of the experiment, June 1992, specific gravity of the three coho salmon groups were not significantly different from each other but were all significantly less than 1.02 (Figure 3). The lack of a difference between the three groups specific gravities is surprising given the significant differences in size and KFL. Specific gravity of the rainbow trout feeding rate groups were significantly different, and both were significantly lower than 1.02 (Figure 4). Rainbow trout fed at 1.0% body weight/day had a lower specific gravity than the 0.5% group.

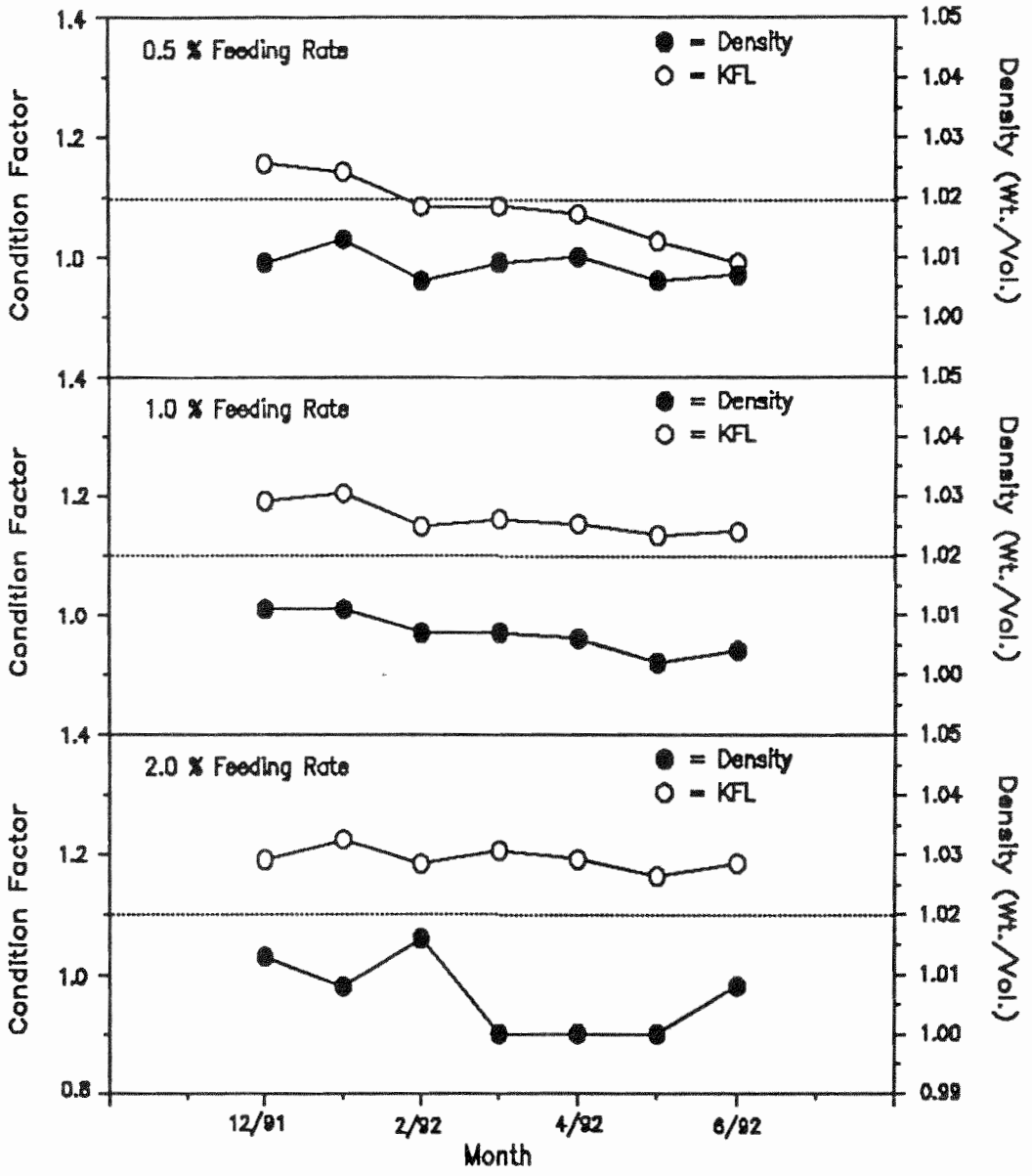

Figure 3. Specific gravity (density) = (weight in gm/water displaced in ml) and condition factor ((weight/length^3)100) over time for Big Creek coho salmon in a feeding rate study.

Condition factor of the coho salmon fed 0.5% body weight/day decreased significantly from December 1991 to June 1992 (Figure 3). Their specific gravity showed no significant trend for the same time period (P=0.26). Coho salmon fed 1.0% body weight/day also had a significantly decreasing KFL and a decreasing specific gravity. If the KFL is an index of fat content as suggested by Hoar (1939) specific gravity of these fish would have been expected to increase. No significant trends were noted in the coho salmon fed 2.0% body weight/day.

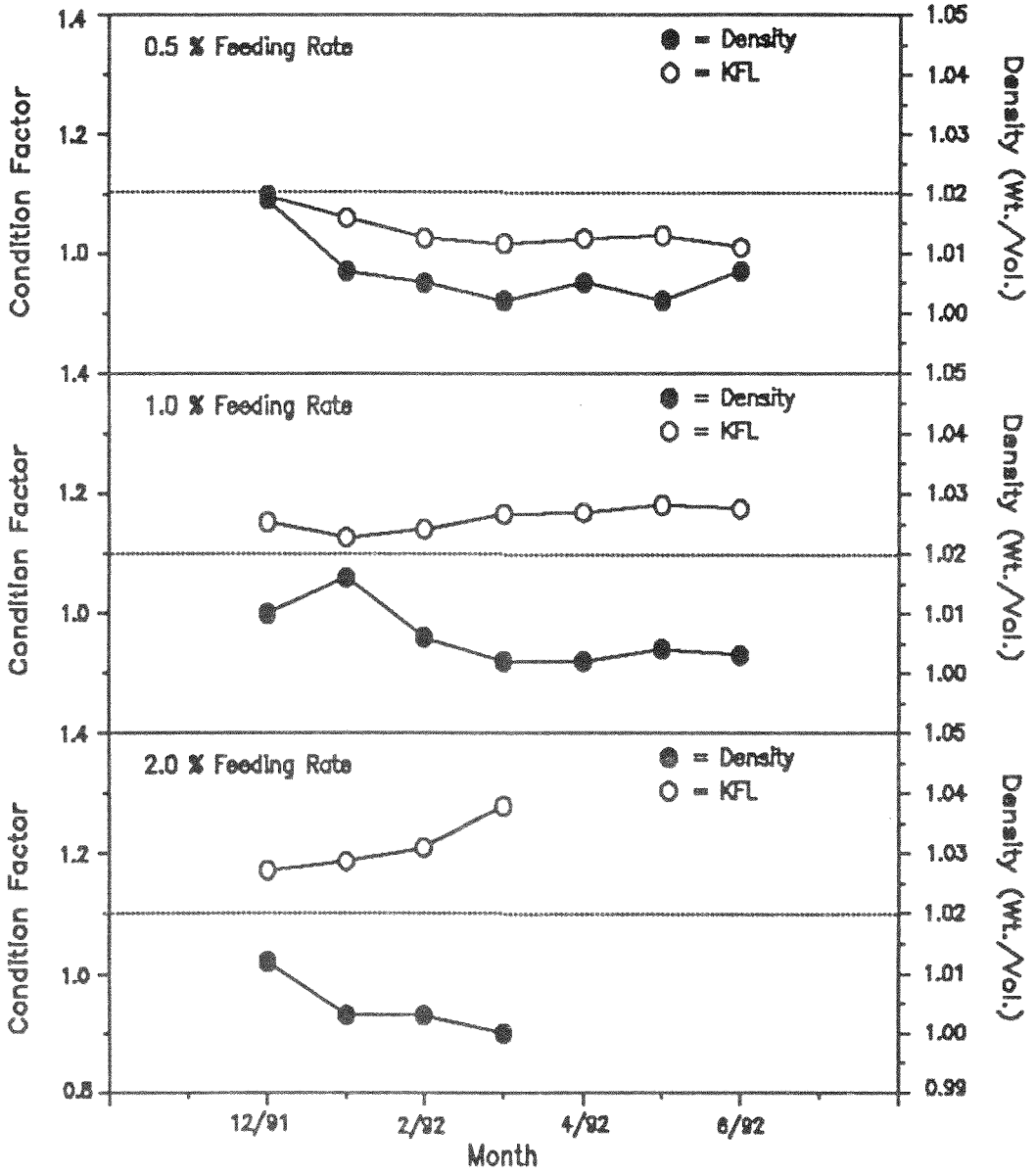

Figure 4. Specific gravity (density) = (weight in gm/water displaced in ml) and condition factor ((weight/length^3)100) over time for Cape Cod rainbow trout in a feeding rate study.

Rainbow trout fed at 0.5% body weight/day showed patterns in specific gravity and KFL similar to coho salmon fed at 0.5%. Both species fed at 0.5% body weight/day had lower condition factors, and thus lower lipid contents than the other feeding rate groups. This suggests that at low lipid levels lipids do not effect specific gravity, or that these fish have reached some minimum specific gravity. Rainbow trout fed 1.0% body weight/day had a significantly increasing condition factor and a nearly significantly (P=0.06) decreasing specific gravity. Due to the small sample size no statistical analysis was done on the rainbow trout fed 2.0% body weight/day. However, they appear to also show an increasing condition factor and a decreasing specific gravity (Figure 4). Both suggesting that for rainbow trout, high lipid levels may effect specific gravity.

Samples for the proximate analyses were taken midway between the January and February 1992 sampling periods in Figures 3 and 4. Results of this sampling are presented in Table 2.

Table 2. Proximate analysis, specific gravity, condition factor, and size data for Big Creek Coho and Cape cod rainbow involved in a feeding rate experiment. Data are mean and (standard error). Samples taken January 1992.

Feeding Rate	Fork Length (cm)	Weight (gm)	Condition factor	Specific gravity		Proximate analysis		
				Swimbladder whole	Swimbladder Deflated	Percent water	Percent protein	Percent lipid
				Big Creek Coho Salmon				
0.5%	13.8	30.11	1.121	1.006	1.024	73.56	20.11	7.63
	(0.3)	(1.76)	(0.018)	(0.003)	(0.006)	(0.28)	(0.46)	(0.61)
1.0%	14.1	35.35	1.218*	1.019*	1.047*	71.91*	19.25	10.27*
	(0.3)	(2.25)	(0.015)	(0.003)	(0.004)	(0.31)	(0.90)	(0.44)
2.0%	15.1*	42.74*	1.215*	1.015	1.038	71.25*	18.57	10.37*
	(0.3)	(2.76)	(0.021)	(0.003)	(0.004)	(0.29)	(0.48)	(0.29)
				Cape Cod Rainbow Trout				
0.5%	15.3	37.54	1.030	1.019	1.037	78.48	18.20	2.60
	(0.2)	(1.48)	(0.007)	(0.004)	(0.003)	(0.28)	(0.53)	(0.28)
1.0%	17.6*	61.50*	1.121*	1.016	1.042	76.63*	18.66	5.31*
	(0.2)	(2.39)	(0.011)	(0.002)	(0.002)	(0.27)	(0.46)	(0.27)

* = Significantly ($p < 0.05$) different from 0.5% feed group.

** = Significantly ($p < 0.05$) different from 1.0% feed group.

The differences in lengths, weights, and KFL's seen at the end of the feeding rate experiment (June 1992) are suggested in the proximate analysis data (January 1992) but are not yet all significant. Significantly higher condition factors for the groups fed 1.0% and 2.0% body weight/day, compared to the groups fed 0.5%, corresponded with significantly higher percent lipids. This suggests that KFL is an indicator of lipid content for coho salmon and rainbow trout. Since percent protein was not significantly different, increased percent lipid in the higher feeding rate groups was attained by decreases in percent water.

In a modeling exercise of the effects of lipid content and swimbladder volume on the specific gravity of Atlantic salmon Taylor (1922) concluded that lipid content was the main means of adjusting specific gravity. Coho salmon and rainbow trout feeding rate groups with significantly higher percent lipids had specific gravities either higher or not significantly different from those with lower percent lipids (Table 2). This was true for both the whole and deflated swimbladder specific gravities. This result is completely opposite of what would be expected if lipid content was the main means of adjusting overall specific gravity. Increased lipid content should have lowered specific gravity. This suggests that lipid content, within the range observed, is not the main factor responsible for changes in specific gravity of coho salmon and rainbow trout.

Deflation of the swimbladder caused a significant decrease in specific gravity in all feeding rate groups for both species (Table 2). From this result and the data above, it appears that the swimbladder is the main element responsible for adjusting specific gravity in coho salmon and rainbow trout. The causes of the higher specific gravity in fish with higher percent lipids and deflated swimbladders need further investigation.

Results of the proximate analysis and feeding rate studies both suggest coho salmon specific gravity is unaffected by lipid content. Results for the rainbow trout are somewhat contradictory. The feeding rate study suggested an inverse relationship between KFL and specific gravity for fish fed at 1.0% and 2.0% body weight/day. However, no relationship was seen for fish fed at 0.5%. The rainbow trout proximate analysis showed no relationship between lipid content and specific gravity. Samples for the proximate analysis were taken early in the feeding rate study. Condition factor, and thus lipid content, was higher in all subsequent samples of the rainbow trout fed at 1.0% body weight/day and all samples of rainbow trout fed at 2.0% body weight/day. Rainbow trout might decrease swimbladder volume to compensate for increased lipid levels. If this is true there must be a point when they can no longer decrease swimbladder volume. Any increases in lipid levels beyond this point would decrease specific gravity. Therefore, it is possible that the relationship between lipid content and specific gravity in rainbow trout was only evident at lipid levels higher than those observed in the proximate analysis.

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Sampling Procedures for Accurate Estimates of Fish Weights in Raceways.

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Determination of fish weights in raceways is an important part of estimating the numbers of fish released in stocking programs. Fish weights are measured by counting the number of fish in a netful of known weight and then calculating the number of fish per pound. Total pounds of fish in a raceway is determined either by weighing all the fish in the raceway or pumping them into a liberation truck and estimating the weight of fish from the displacement of water in the truck. The total pounds of fish multiplied by the fish per pound will then give an estimate of the number of fish in the raceway.

These estimates of population sizes often different by as much as 20% from the estimates based on pond inventories. As part of the Hatchery Practices group of Oregon Department of Fish and Wildlife, we were asked to examine the problems in making population estimates in raceways and to suggest ways to minimize the error in the estimates.

The first source of error that we checked was the accuracy of the scales used to weigh the fish. Scale specifications indicated that the accuracy varied from $\pm$ 2.65% at 3 kg to $\pm$ 0.52% at 13 kg. Repeated meaurements of 2 liter quantities of water indicated that the accuracy at 3 kg was as high as $\pm$ 2.5%, while accuracy at 13 kg ranged from $\pm$ 0.42% to $\pm$ 0.83%. Average basket weights in our studies ranged from 6 to 15 kg (13 to 34 pounds), suggesting that as much as 2% error may result from the scales themselves.

A second consideration was the changes in size that occurred throughout the sampling period. In seven of the eight inventories that we ran in this study, there was no difference in the estimates of fish size throughout the period of measurement (Fig. 1). In one study, however, there was a continuous decrease in size throughout the measurements. The reasons for this are unknown, but it does emphasize that measurements of fish size should be taken throughout the inventory process to make sure that the fish size estimate is truly representative of the population.

Error in weight estimates through displacement guages in liberation trucks has already been discussed by Mark Lewis in an earlier paper, so they won't be considered here.

One of the greatest sources of error that we found was that of the estimates of fish size. Even when there were no continuous changes in fish size estimates over time, there is

still considerable variation in fish size estimates. For example, for an inventory of summer steelhead at Irrigon Hatchery, 20 samples were taken for estimates of fish size. The final size was considered as the actual size of the fish. The data were then sorted randomly in groups of 3, 5, 7, 9, 11, 13, 15, and 20 basket counts. Each sort was performed 20 times and the results averaged. The error of each estimate (95% confidence limit) was then expressed as a percent of the mean. When you plot the results, it can be seen that the error with three basket counts was as high as 9% (Fig. 2). As the number of basket counts increased, the error decreased until it reached a minimum error of about 2% at 15 basket counts.

Does this error reflect a requirement for a certain number of basket counts or simply a percent of the population? Each basket count in this experiment represented about 0.85% of the population for pond 9 or 0.56% of the population for pond 13. A plot of error against percent of the population sampled really did not clear this up (Fig. 2). A different sort of experiment was required.

At Willamette Hatchery, we performed an experiment that looked at the error associated with weighing baskets of spring chinook salmon of different weights. Light baskets averaged 2.5 kg (5.5 pounds) and heavy baskets averaged 6.4 kg (14.1 pounds). Thirty-three samples of each sample size were taken for the same raceway of fish. Data were then manipulated in a similar manner as that with summer steelhead. A plot of error against number of samples indicated that the error might reach as high as 26% with 3 basket samples, but that it eventually reached a level of 5% for samples of 20 baskets (Fig. 3). There seemed to be no major differences in this relationship whether the baskets were heavy or light. However, heavy baskets contained a greater proportion of the population. When the percent population sampled was plotted against the error (Fig. 3), there was a distinct difference between the error associated with heavy and light baskets. This suggested to us that it was the number of baskets that were counted and not the percent of the population sampled. From these data, we suggest that 9-10 basket counts were required to reach an error that was beginning to flatten out at about 5%.

To confirm this, we made another count of three ponds of spring chinook salmon at Willamette Hatchery three months later at the time of release. The results showed a minimum error of about 3-4% after 8-9 basket counts. We concluded that 8-10 basket counts taken throughout the weighing or loading process are required for minimum error in size estimates, but that these minimum errors may vary from 2% to 5%.

A final consideration is the amount of weight that fish lose in the period of starvation from the time of measurement until the time of loading and measurement of displacement. One experiment was performed with summer steelhead at Irrigon

Hatchery that indicated that there was a 1.32% loss in weight for a 24-hour period. We are not particularly confident in these numbers, however, and suggest that additional experiments be performed to determine weight losses for groups of fish held different lengths of time without feeding.

An example of the differences that these sorts of corrections can make is shown in the last two tables for summer steelhead at Irrigon Hatchery. Estimates of fish size, total kilograms of fish, and population are shown in Table 1. The differences between estimate of populations using inventory methods and truck displacements were 3.7% and 6.1% for ponds 9 and 13, respectively. When corrections for weight loss and specific gravity were applied to these measurements (Table 2), errors were decreased to 1.4% and 4.0% for ponds 9 and 13, respectively.

In summary, sources of error in estimates of populations in raceways can come from a number of different sources. Care should be taken to insure that measurements of fish size, displacement, and total pounds are taken as uniformly and accurately as possible. We recommend that 8-10 basket samples should be taken throughout the inventory process for determination of fish size.

Table 1. Pre-liberation inventory of populations of summer steelhead at Irrigon Hatchery, March 1992. Values are means ± standard errors.

	Pond 9	Pond 13
Average Fish Sizes		
Fish per pound	4.52 ± 0.04	4.47 ± 0.04
Grams per fish	100.62 ± 0.90	101.62 ± 0.83[a]
S.E. as % of mean	0.9%	0.8%
Total kg fish		
Feb. 1992 Inventory	1,064.3	2,392.1
Truck Displacement	1,025.1	2,245.3
Population Estimates		
Mar. 1992 Inventory	10,578	23,682
Truck Displacement	10,188	22,230
Inventory-Truck Disp.		
Difference in weight (kg)	39.2	146.8
Difference in number	390	1,452
% Difference in number	3.7%	6.1%

a = Average size and S.E for 15 samples, raw data for 5 samples lost. Average size for all 20 samples was 101.01 gm/fish, used to calculate number of fish.

Table 2. Corrected pre-liberation inventory of populations of summer steelhead at Irrigon Hatchery, March 1992. Values are means ± standard errors. Corrections are for possible weight loss between inventory and loading, and fish density (weight in gm/water displaced in ml).

	Pond 9	Pond 13
Average Fish Sizes		
Original size gm/fish	100.62 ± 0.90	101.62 ± 0.83[a]
Corrected size (-1.32%)	99.29	99.68
Total kg fish		
Truck Displacement	1,025.1	2,245.3
Corrected ((kg/1.02)*1.03)	1,035.2	2,267.3
Population Estimates		
Mar. 1992 Inventory	10,578	23,682
Truck Displacement	10,426	22,746
Inventory-Truck Disp.		
Difference in weight (kg)	29.1	124.8
Difference in number	152	936
% Difference in number	1.4%	4.0%

a = Average size and S.E for 15 samples, raw data for 5 samples lost. Average size for all 20 samples was 101.01 gm/fish, used to calculate number of fish.

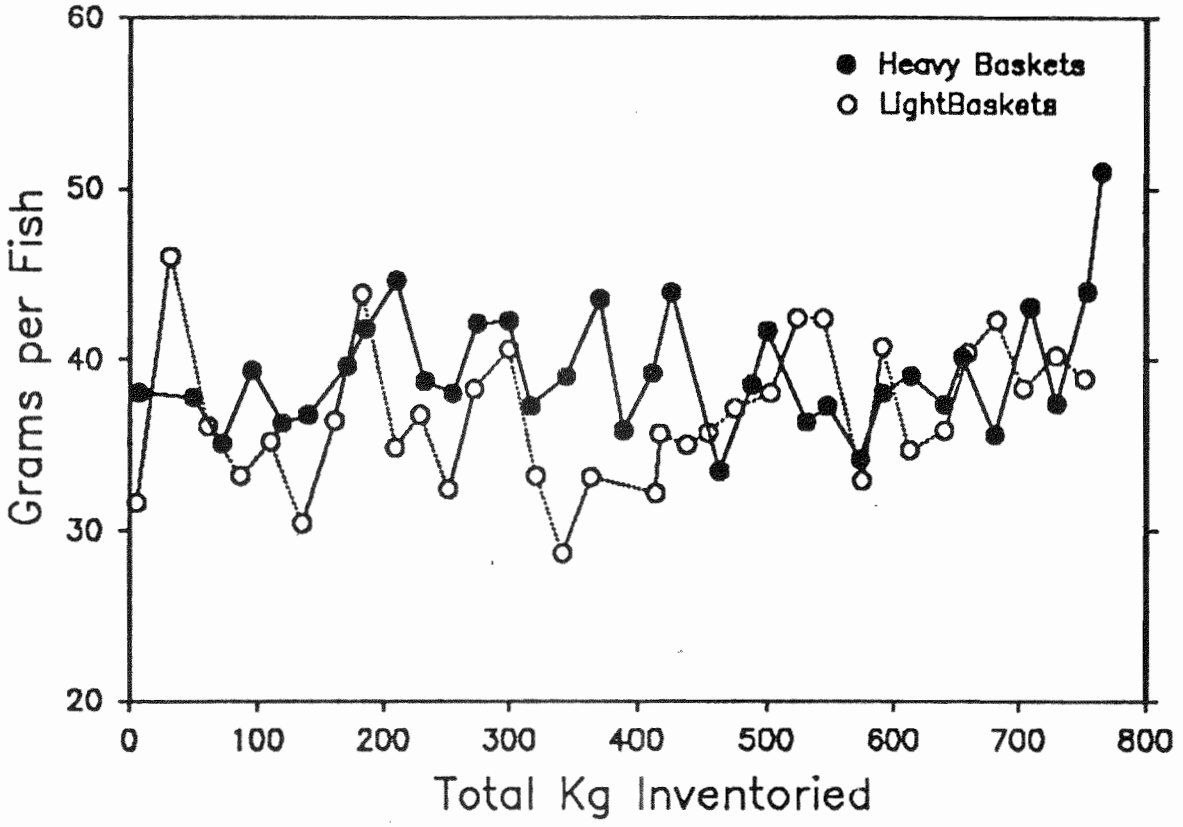

Figure 1. Pattern of average fish sizes (gm/fish) for heavy and light basket samples, chronologically through the sampling

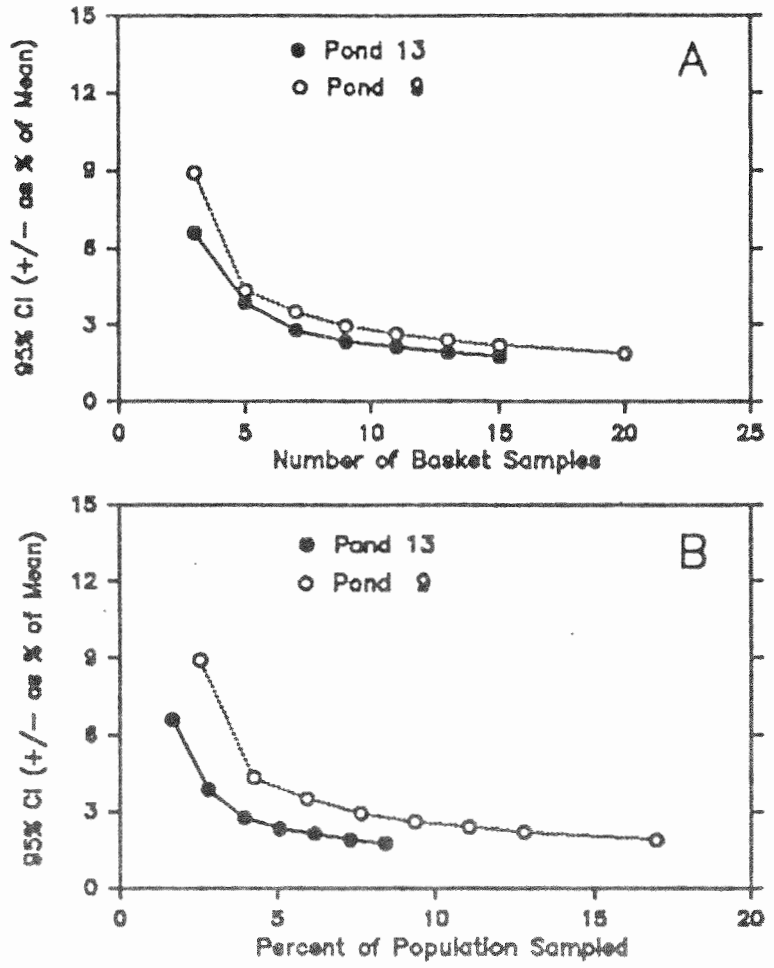

Figure 2. Error estimates (95% CI as % of mean) of average fish sizes for two groups of Irrigon hatchery summer steelhead, March 24, 1992. A. Comparison of error estimates to number of basket samples. B. Comparison of error estimates to percent of population sampled.

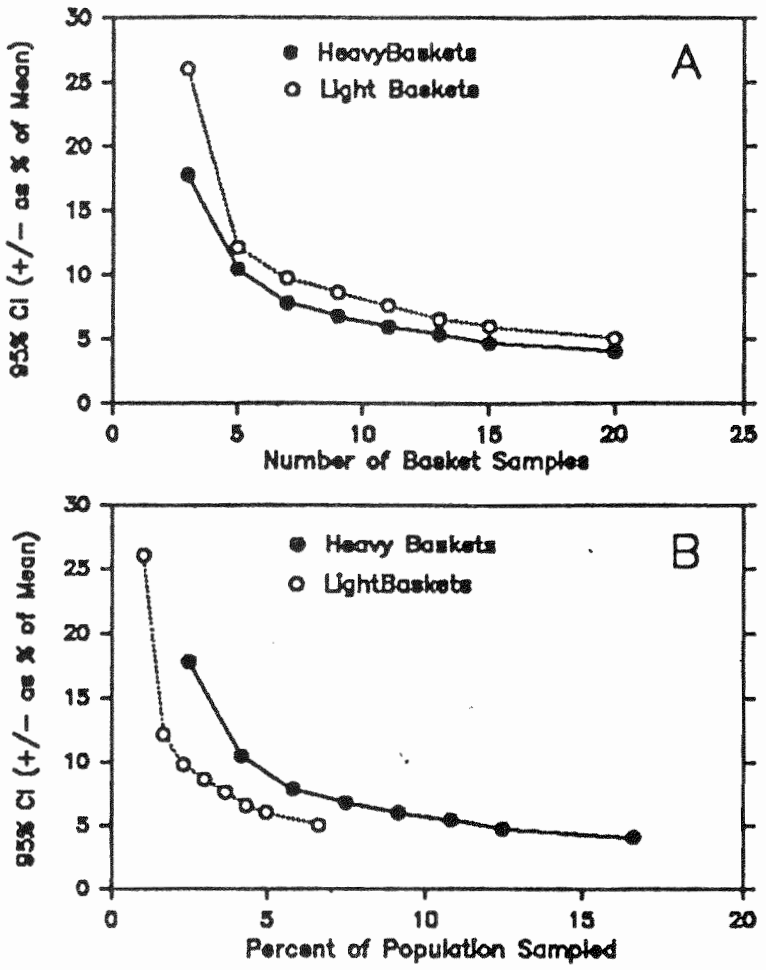

Figure 3. Error estimates (95% CI as % of mean) of light and heavy basket samples for average fish weight. A. Comparison of error estimates to number of basket samples. B. Comparison of error estimates to percent of population sampled.

1992 CHIWAWA RIVER SPRING CHINOOK SALMON BROODSTOCK COLLECTION

by

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Introduction

Washington Department of Fisheries operates several fish stock supplementation facilities associated with the Eastbank hatchery complex located directly above Rock Island dam. One of the main supplementation facilities associated with Eastbank is the Chiwawa Ponds. The ponds are located on the Chiwawa river approximately 1/2 mile upstream from the confluence of the Chiwawa and Wenatchee rivers. The main function of the Chiwawa system is to supplement natural stocks of spring chinook on the Chiwawa river. This involves collecting native broodstock, taking eggs, and rearing to release size spring chinook smolts. The spring chinook returning to Chiwawa travel approximately 600 river miles from the ocean to their spawning grounds. The adults average from 12-15lbs.. Female fecundity averages from 3500 to 4000 eggs. Our goal for the Chiwawa program is to collect 1/3rd of the run for supplementation purposes. For 1992 a runsize of 200-500 adults was estimated. Our goal for 1992 was to collect enough adults to provide 80,000 to 100,000 eggs for the program. For adult collection a temporary floating weir is placed across the river at the hatchery intake site. During the spring of 1992, before any adults had been trapped, the weir was destroyed by debris carried downstream during high spring time runoff. To obtain adults for Chiwawa's program an alternative broodstock collection plan was put into action. This plan involved snagging/gaffing and spawning ripe fish on the spawning grounds as well as transporting green fish to Eastbank hatchery for ripening and subsequent spawning. The remainder of this report will detail the entire broodstock collection process for the 1992 brood Chiwawa spring chinook program.

Methods and Materials

Prior to beginning adult collection operations the river was surveyed for possible collection sites. The collection crews concentrated on a twelve mile section of river located downstream from the Riverbend campground to upstream of the Phelps campground. Two broodstock collection teams worked the spawning grounds from August 4th to August 19th. Each team consisted of 5-6 people. Teams were made up of one gaffer/snagger, one "bobber" and Four seine net holders.

Gaffing poles of 20ft. and 4ft. lengths were used. Both the 20 ft. and 4 ft. gaffs have hooks that are 20/0 size, shark fishing hooks and are 7" long. Hooks were tied to a 3 ft. shock cord which was 1/4" surgical tubing and braided nylon seine twine, this was attached 3 ft. up the gaff pole and anchored. The hook was attached by a steel collar welded to the hook and another steel collar on the wooden gaff pole with a rectangular key in between the two collars to prevent rotation of the hook. The shock cord tension acts at keeping the hook snug up against the pole. Once a fish is gaffed, the design of the gaff allows the hook to separate from the pole. The shock cord between the hook and the gaff pole give you control of the fish with the least amount of injury.

Seine nets of 35 ft. long, 6 ft. high with a lead core bottom line were used to trap fish on the spawning grounds. A 3" mesh size was used on the nets. Large wooden dowels were used on the side of the nets for handles.

Spawning crews walked two mile sections of the target area during a routine survey. Fish were collected daily during two time periods. One time period was from 6am to 1:30pm. The other time period was from 6pm until dark. Early mornings and late evening times produced the best results. All snagging crews walked upriver onto the spawning beds with the gaffer leading the way. Two methods were used to collect the fish. Either gaffers would hook the fish or the fish would be spooked into seine nets set below the spawning beds. One net was set upstream of the collection area, preventing fish from escaping upriver. At times, fish would break though the lower seine and hide in log jams or undercuts along the river bank. This usually occurred when the lower seine was placed in swift moving riffles below the spawning grounds. When fish were spooked into cover the "bobber" would snorkel though the undercut and either spook the fish into a waiting net or snag the fish out of the hiding area with the shorter gaff pole. The "bobber" was dressed in a full dry suit, mask and snorkel.

Fish captured by gaffing or in the seine were kept alive. A 1/8" nylon rope was placed around the peduncle of the fish and the fish was secured to a solid object along the bank of the river. This method allowed the spawning crews to collect a series of fish before transporting the fish back to a central location for holding or spawning.

After a section river had been surveyed the fish which had been caught were transported by 250 gallon tank mounted on the back of a pickup to the central camp area at Atkinson Flats. The following procedure was used for fish transport: After filling the tank with river water we loaded the chinook onto the truck. A tire innertube was used to transport the fish from river to tank. The tube is tied off at one end, leaving the other end open for inserting the fish head first after filling tube partially with water. This eases handling and is less stressful to the fish. After loading no more than 5 fish into the tank the fish were transported to our central camp site. Fish were then transferred to a live pen set in the river close to camp. The live box was roughly 6 ft. by 8 ft. and 5 ft. high. Materials were 1 1/2" PVC pipe for box frame, with heavy nylon netting covering the frame and a opening on top to get the fish in and out. The live box is weighted down in the water by heavy rocks on bottom to keep it from drifting away in the river`s current. The fish were kept in the live pen until spawning or transport to Eastbank hatcherey.

Spawning the chinook at camp usually took place in the evening (temperatures were cooler) under the use of flashlights. All eggs were stripped into 1 gal. ziplock baggies. Milt was placed into quart ziploc bags, with oxygen added. Both eggs and sperm were placed in coolers with wet burlap covering the ice. The gametes were placed on top of the burlap. Immediately after spawning was finished the gametes were transported to Eastbank Hatchery (75 miles away) and were fertilized on a 1:1 male to female ratio. All incubation takes place at Eastbank.

Summary

After 3 weeks of collecting broodstock below Riverbend to Phelps Creek, on the upper Chiwawa River we counted 99 redds. We collected 39 males, and 74 females. 35 of the females were already spawned out. Eastbank Hatchery crew took approximately 38,000 eggs from females transported to the hatchery. 52,000 eggs were taken on-site at the river gaffing operation. At the time of spawning we estimated our egg total to be approximately 90,100 eggs. After reinventory of the eyed eggs at Eastbank the actual total was over 105,000. Egg loss was minimal at only 1.6%.

Acknowledgements

We the crew from the Chiwawa Ponds would like to thank the following Wash. St. employees and their hatcheries, labs, or offices for their help in the collection of the `92 Chiwawa River Spring Chinook Salmon broodstock. They are Ed Argenio, Bruce Ault, Dan Bozorth, Tami Black, Bob Bugert, Ray Cordell, Nancy Decker, Rich Eltrich, Steve Gacek, Sheila Jones, Mary Anne Keithly, Duane Knutson, Glen Liner, Jerry and Scott Moore, Denise McCarver, Patty Michak, Anders Mikkelsen, Gary Osborne, Paul Pedersen, Don Rapelje, Tommy Randolph, Dennis Schott, Greg Travers, Guy Wiest, and Tom Scribner and Jason Rouhl from the Yakima Indian Nation. Also would like to thank again Rich Eltrich for his help with this paper.

OVAPRIM TRIALS USED TO SEQUENCE AND SHORTEN THE SPAWNING SEASON.

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INTRODUCTION

Acceleration of the maturation process in salmonids is desirable for various hatchery purposes (Fitzpatrick et al. 1984). Advantages associated with accelerated maturation include synchronizing egg collections, inducing uncooperative animals to spawn, reducing stress and handling of fish, reducing pre-spawning and post-spawning mortalities, regulating egg incubation and mamaging staff better. (Little 1988).

Hormones control many aspects of reproduction in fish. Gonadotropin Releasing Hormone (GnRH), also known as Luteinizing Hormone Releasing Agent (LHRH), is secreted from the hypothalamus and stimulates secretion of gonadotropin in the pituitary (Sherwood et al. 1988). Gonadotropin secretion is regulated by a dual neurohormonal system in fish. While GnRH stimulates the secretion of gonadotropin, dopamine serves as an inhibitory factor on the actions of GnRH, and also causes an inhibitory effect on the spontaneous release of gonadotropin. In salmonids, the inhibitory effect of dopamine appears to be minimal.

One way to induce mature fish to spawn is injection of GnRH analogs. Injection of native forms of GnRH are not very effective in elevating the plasma concentration of gonadotropin (Crim et al. 1988), or in inducing spawning, due to the rapid breakdown of the peptide in the body (Sherwood et al. 1988). To prolong the life of GnRH in the bloodstream without frequent administration, GnRH analogs that are not readily broken down have been synthesized (Struthers et al. 1985). For GnRH analogs to become more effective, dopamine receptor antagonists have been used to block the inhibitory effect of dopamine.

Ovaprim, a very potent ovulating/spermiating agent (Little 1988) is the hormonal product used in our investigations. Ovaprim was developed in Canada by Syndel Laboratories, the International Development Research Council and university researchers. The active ingredients are a patented, synthetic analog of GnRH and a dopamine inhibitor. Use of a dopamine inhibitor, as in the Ovaprim system, can help fish overcome the inhibitory effect that dopamine has on pituitary gonadotropin release and in this way potentiates the ovulatory actions of GnRH. A problem noted with Ovaprim use by French workers is that in some cases, if not administered at the proper time, it can be desensitizing, and can render the fish unresponsive to future hormonal action (Dr. Hamid Habibi, pers comm.).

GENERAL METHODS

The Allison Creek Brood Trout Station, located in Coleman, Alberta, is operated by Alberta Forestry Lands and Wildlife. The facility rears rainbow trout *(Oncorhynchus mykiss)*, brown trout *(Salmo trutta)* and brook trout *(Salvelinus fontinalis)* brood stocks to provide eggs for Alberta's fish production facilities. The facility is enclosed and equipped to control photoperiod (Photocontrol),. Ground water is the primary water source of which 70% to 80% is recirculated through a settling pond/biological filter system. A heat exchanger provides water temperature control. Rearing temperatures are maintained between 8.5 and 10.0 C.

1988-89 OVAPRIM TRIALS

Our initial experience with Ovaprim resulted from a disturbance to photocontrol systems in October 1988. Mature fish were exposed to light 24 hours per day for an undetermined period of time (up to three weeks). Three-year-old brook trout were expected to start spawning by mid-November. The first spawning did not occur until 9 December, 25 days later than expected. Spawning peaked 21 days later. By day 42, only 40 % of the females (147 of 447) had ovulated and spawned. The ovulation rate per week had dropped to 4.4% (Figure 1). Delayed and aborted spawning was occurring.

In early January 1989 we consulted Dr. Hamid Habibi of the

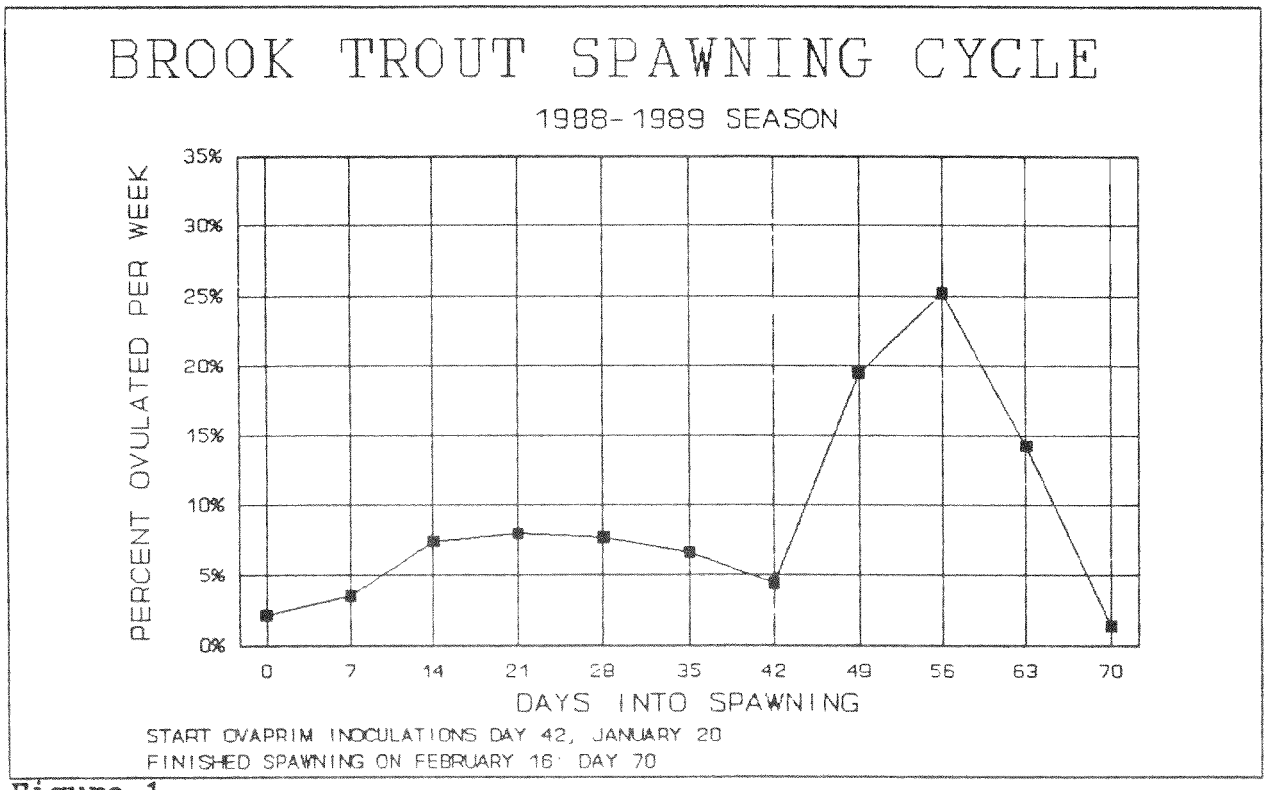

Figure 1

University of Calgary, who was involved in the development and study of the GnRH peptide [D-Arg, Trp, Leu, Pro-Net]-GnRH that is used in Ovaprim (Habibi et al. 1989). Subsequently we assessed the state of the fish ovaries and decided to use Ovaprim to stimulate ovulation. Because of the state of the ovaries, Dr. Habibi suggested we inject our fish with Ovaprim at five times the recommended dosage, with two injections six days apart. With this treatment, Dr. Habibi felt we could stimulate 60% to 70% of the remaining fish to ovulate. Syndel Laboratories produced a concentrated lot of Ovaprim ("Ovaprim Special", with five times normal quanityy of the active ingredient) for our use.

One hundred and forty-nine females were selected to receive Ovaprim inoculations. These fish (group 1) were deemed the "most likely to spawn" by the fish culture crew. This selection was based upon the firmness and fullness of the abdomen and the general condition of the fish. They received Ovaprim injections of 0.5 mL of Ovaprim Special per kilogram of fish on day 42 and day 48. The remaining fish were separated into groups 2 and 3 on day 49. Fifteen of the 119 fish had ovulated naturally. Fifty-four of the remaining 104 fish were selected as"likely to spawn" (group 2). This selection was based on the same criteria used to select fish for group 1. Group 2 received Ovaprim Special injections on day 49 and day 55. The remaining 50 green females were placed in group 3. Nine of these fish had ovulated naturally by day 55. Forty-one fish received one injection of 0.25 mL of Ovaprim Special per kilogram of fish on day 55. The fish culture crew felt that the majority of the fish in group 3 would not spawn, and labelled the group "least

Table 1: Brook Trout Ovaprim Trials 1988-1989

	Group 1			Group 2			Group 3			Control		
	Most Likely to Spawn			Likely to Spawn			Not Likely to Spawn					
	Vol/kg		Day No.	Vol/kg		Day No.	Vol/kg		Day No.			
Injection 1	0.5 ml		42	0.5 ml		49	0.25 ml		55			
Injection 2	0.5 ml		48	0.5 ml		55						
No. of Fish	149			54			41					
Days Post Injection	Ovulated		Day No.	Ovulated		Day No.	Ovulated		Day No.	Ovulated		Day No.
	No.	%		No.	%		No.	%		No.	%	
6-7 Days	57	38	48	27	50	55	23	56	62	15	13	49
10-14 Days	119	80	55	48	89	59	27	66	69	9	18	55
27 Days	131	88	69									
Total Spawned	131	88	69	48	89	59	27	66	69			
Did Not Ovulate	9	6		3	6		14	34				
Mortality	9	6		3	6		0	0				

likely to spawn" (Table 1).

Results

Ovaprim Special inoculations during the 1988-89 spawning season were successful in stimulating ovulation in three-year-old eastern brook trout that had been confused by an interruption in photoperiod control. Ovaprim injections were started on day 42 and one week later the number of females ovulating per week (based on total females at the beginning of the season) increased from 4.4% to 25%. Twenty-seven days after Ovaprim injections commenced, spawning was completed (Figure 1). The average egg size was declining prior to Ovaprim inoculations and declined further after inoculations (Figure 2). Egg fertilities were lower for the Ovaprim-injected fish, but were already declining before the injections. Eyed-egg percentages paralleled the fertility percentages for both pre-injection and post-injection spawners (Figure 3). Egg loss from eyed-egg to swimup was identical for both before and after Ovaprim inoculations. Female fecundity declined slightly after Ovaprim injections (Table 2).

Discussion

Ovaprim Special enabled the station to salvage a year of production after an interruption in photoperiod. Egg size and egg fertilities were reduced but not solely because of the administration of Ovaprim; the interruption in photoperiod had resulted in declining numbers before the Ovaprim injections

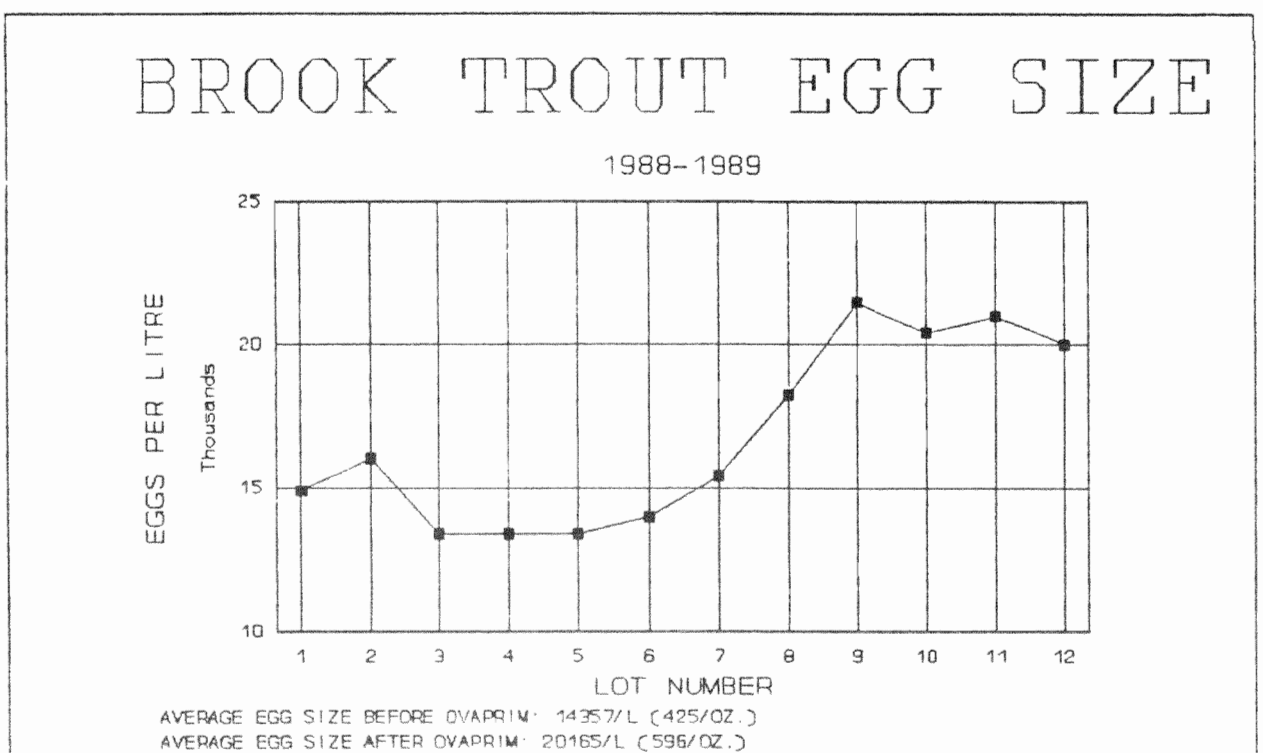

Figure 2

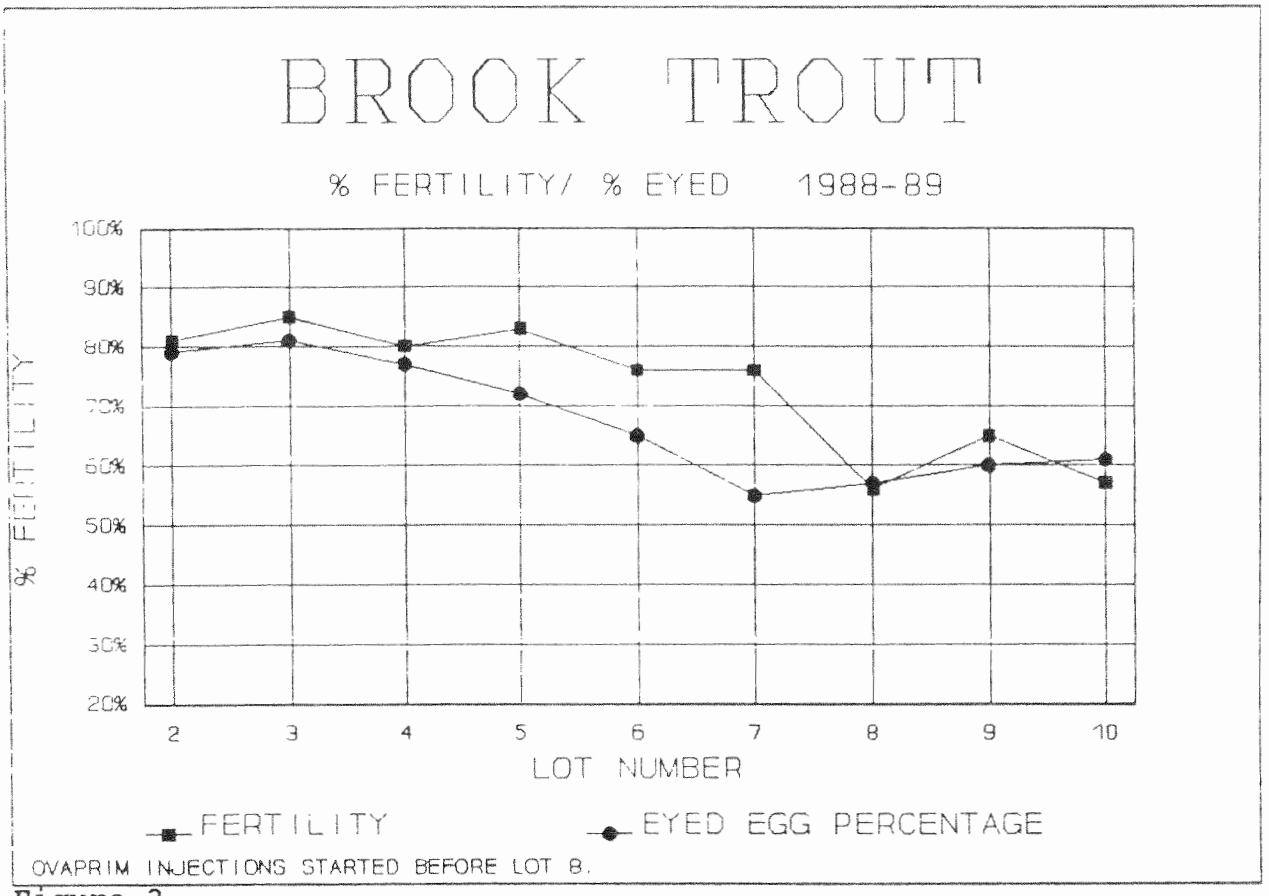

Figure 3

Table 2: 1988-1989 Ovaprim Results

Fish Stock	Age	Fecundity		Fertility (%)		Egg Size (No./L)	
		Before	After	Before	After	Before	After
Brook Trout	3	3 690	2 933	76-84	57-77	14 357	20 615

(Figures 2 and 3). No control group was used, therefore, we have no evidence that these fish would not have spawned by themselves in time. We observed that, once the numbers of ovulating fish had increased from Ovaprim use, the proportion of ovulating fish among the non-injected fish also increased (Figure 4). This increase was not totally unexpected and was probably due to an increase of hormonal products in the water resulting from increased spawning activity. The facility regularly adds spawning products (ovarian fluid and sperm) to the rearing water supply to stimulate fish to spawn. Ovaprim should be applied at recommended dosage and under normal conditions to evaluate the drug's effectiveness as a fish culture management tool.

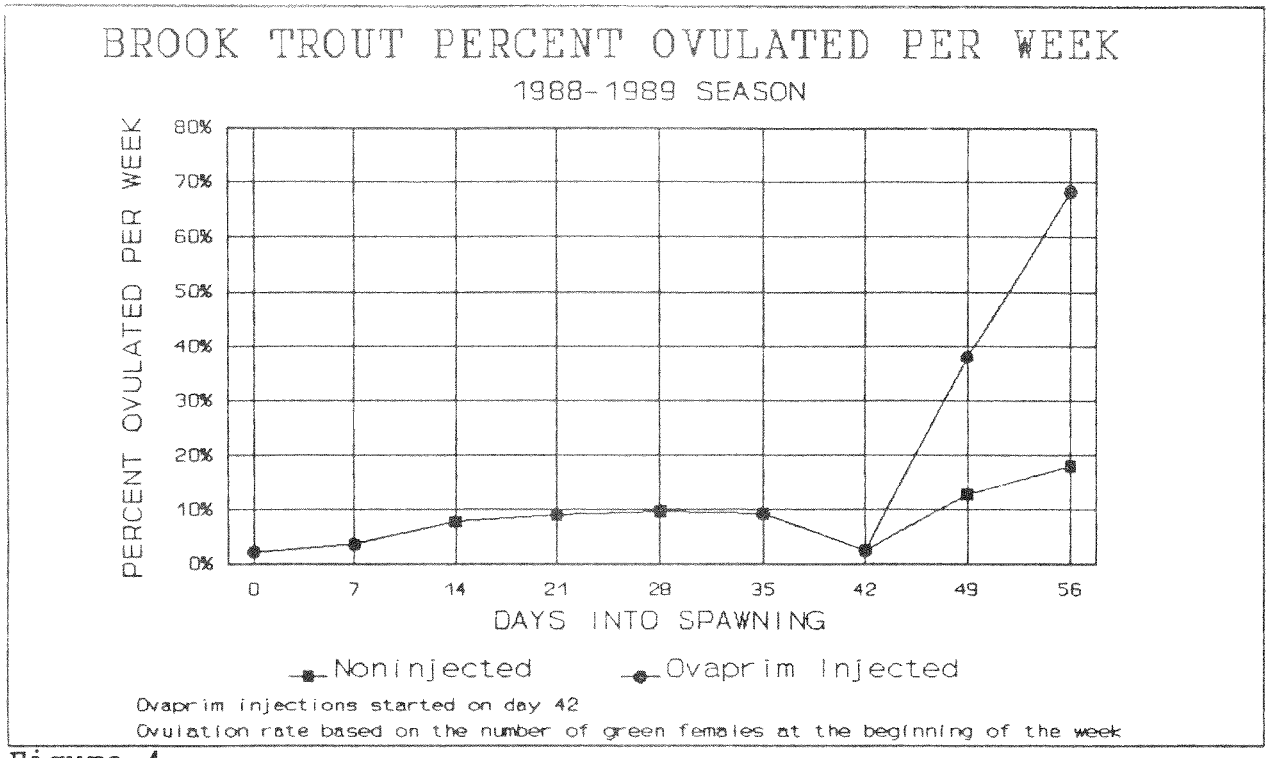

Figure 4

1989-1990 OVAPRIM TRIALS:

Methods

After the positive results achieved in 1988-89, we decided to run controlled Ovaprim trials during the 1989-90 season. The trials attempted to shorten the spawning season for three-year-old brook trout. The trials occured late in the spawning season, once production requirements had been satisfied. Syndel Laboratories provided the Ovaprim and set the experimental design. By the time the Ovaprim arrived the brook trout spawning season was near its natural conclusion. Thus, the planned Ovaprim trials were conducted with three-year-old and five-year-old brown trout.

Fish culture conditions and the number of fish available required slight modifications to the experimental design. Regular strength Ovaprim was used throughout the trials in 1989-90. In addition to the brown trout trials, Ovaprim was used to terminate the spawning season of the three-year-old brook trout.

Five-year-old brown trout

Spawning commenced on December 1, 1989 and peaked on day 21 with an ovulation rate of 26% per week. By day 34 the numbers of maturing fish dropped as the ovulation rate reached 4% per week. Spawning would normally continue for an additional two to four weeks. On day 34, the remaining 50 green females were randomly separated into three groups. Twenty fish each were allocated to groups 1 and 2 and 10 fish, to group 3. Ovaprim injections were administered, as per Table 3. The fish were sorted on days 3,7 and

Table 3: Five-year-old brown trout Ovaprim injection trials during 1989-90 spawning season.

		Group 1		Group 2		Group 3	
	Day No.	Vol./Kg		Vol./Kg		Control	
Injection 1	28	0.5		0.1			
Injection 2	31			0.4			
No. of Fish		20		20		10	
		Ovulated		Ovulated		Ovulated	
		No.	%	No.	%	No.	%
Day 10 After first injection	38	19	95	18	90	3	30
Did Not Ovulate		0	0	0	0	7	70
Mortality		1	5	2	10	0	0
No. of Fish Remaining to Spawn		0	0	0	0	7	70
Injection	38					7	
Day 7 Post-injection	45					6	86
Did not Ovulate						1	14

10 following the first Ovaprim injection.

Results

By day 10, group 1 and group 2, (the Ovaprim groups),were 95% and 90% spawned, respectively, while Group 3,(The control group) showed that only 30% had spawned (Figure 5). Percent fertile and percent eyed were slightly lower for the groups that received Ovaprim injections compared with eggs that were taken before Ovaprim use. Percent fertile and eyed eggs were not measured for control group because of the small sample size. Egg size decreased after Ovaprim use (Table 4).

Table 4: 1989-1990 Ovaprim Results

Fish Stock	Age	Fecundity		Fertility (%)		Egg Size (No./L)	
		Before	After	Before	After	Before	After
Brown Trout	5	5 396	5 965	90	82.5	8 243	7 672
Brown Trout	3	2 873	2 600	89	NA	11 220	11 595
Brook Trout	3	4 950	4 918	75.9	78.3	14 324	14 550

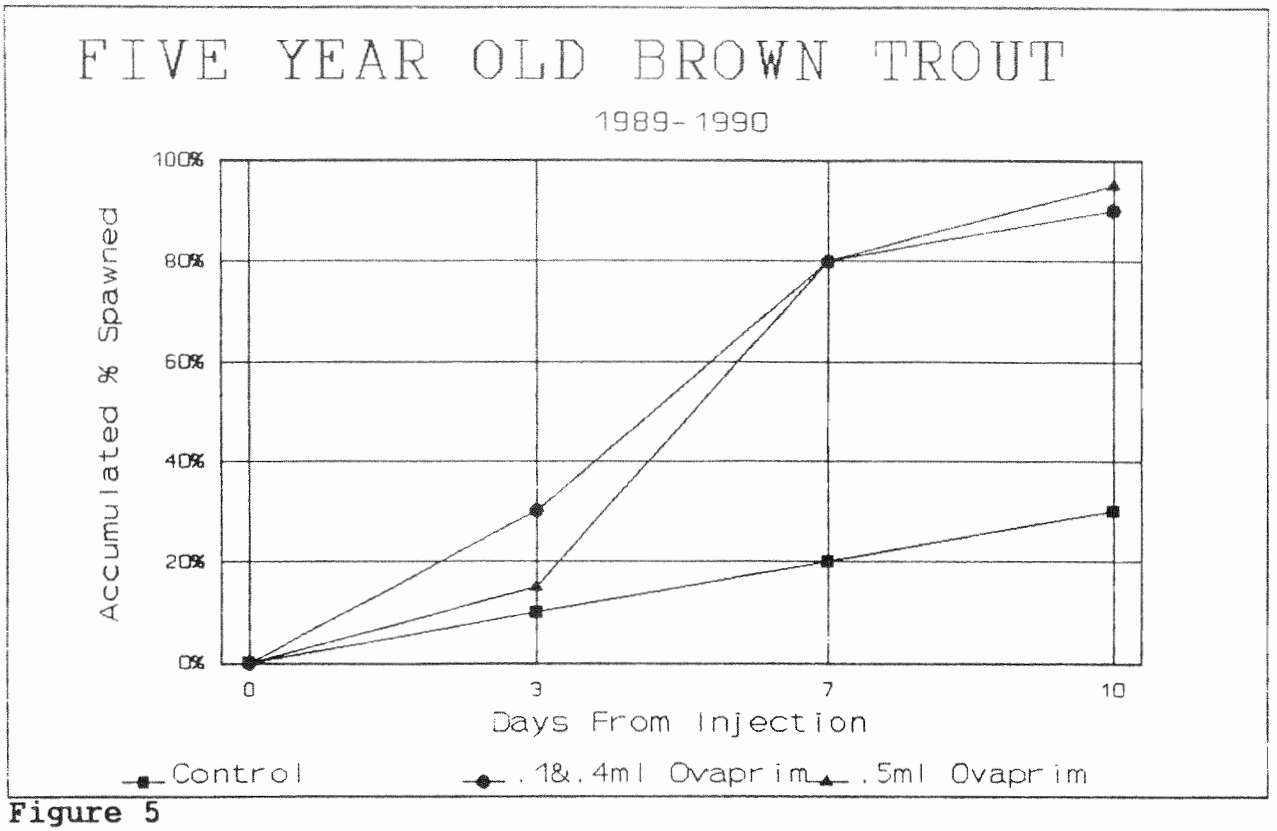

Figure 5

On day 10, the control fish received an injection of 0.5 mL of Ovaprim per kilogram of fish. Seven days later, 86% had ovulated (Table 3).

Discussion

Ovaprim enabled the brood station to shorten the spawning season for five-year-old brown trout brood stock from 79 days to 52 days. This allowed the fish, especially the males, to move out of the spawning mode earlier and resume feeding. The result was much lower post-spawning mortality. The slightly lower percent fertile and eyed from the Ovaprim-injected fish are probably due to the increased handling and associated stress rather than the Ovaprim itself.

Three-year-old brown trout

Spawning commenced on December 1. Spawning peaked on day 28 with a ovulation rate of 24% per week, and quickly dropped to an ovulation rate of 10% per week by day 34. Spawning would have normally continued for an additional two to three weeks. The remaining 24 females were separated at random, into two groups. Ten fish in group 1 and 14 fish in group 2.

Group 1: Received a single injection of 0.5 mL. of Ovaprim solvent,(No GnRH analog) per kilogram of fish.

Group 2: Received a single injection of 0.5 mL. of Ovaprim per

kilogram of fish.
The fish were sorted on days 3, 7 and 13 following the Ovaprim injections.

Results

By day 13, both injected groups were 100% spawned (Table 5). Egg size was the same before and after the injections and did not vary between groups. Egg fertilities were not measured. Eyed-egg percentages were the same for both injected groups, although percentages were lower than egg lots gathered before Ovaprim injections. The lower eyed-egg percentages are probably due to the increased handling of the fish and eggs and because the eggs were incubated in "Heath" incubators. The production lots were incubated in jar incubators, which typically result in better success. The average fecundity dropped by 10% after Ovaprim treatments (Table 4).

Table 5: Three-Year-Old Brown Trout: 1989-90

		Group 1		Group 2	
	No. of Days No. Post-Injection	Vol/kg	Type	Vol/kg	Type
		0.5 mL	Ovaprim Solvent	0.5 mL	Ovaprim
Injection 1	0	No. Ovulated	%	No. Ovulated	%
	3	3	30	6	43
	7	6	60	13	93
	13	10	100	14	100
Mortality		0	0	0	0
Did not Ovulate		0	0	0	0

Discussion

We shortened the spawning season for the three-year-old brown trout (Figure 6; Table 6). All fish had spawned within 13 days of the injections. It is not known whether the spawning season would have naturally finished in 13 days or whether the Ovaprim solvent injections and handling were responsible in initiating ovulation.

Three-year-old brown trout

Spawning commenced on November 22. Spawning peaked on day 13 with an ovulation rate of 27% per week and dropped to an ovulation rate of 1% per week by day 44. Twenty-two fish received an injection of 0.5 mL of Ovaprim per kilogram of fish on day 44. Eight days later the total ovulated reached 54.5%, an ovulation rate of 3.3% per week. The remaining 10 fish were declared surplus and disposed of on day 52 to make room for other broodstocks.

TABLE 6: BROOD STOCK PERFORMANCE

Species	Age	YEAR SPAWNED	FEMALE WT. (kg)	INDIVUDUAL FECUNDITY EGGS/FEMALE	RELATIVE FECUNDITY (EGGS/kg)	EGG SIZE		LENGTH OF SPAWN SEASON	DAY OF OVAPRIM USE
						No./L	No/Oz		
Brown	3	1990-91	1.17	3 344	2 858	12 235	362	58	34
Brown	3	1989-90	1.0	2 806	2 806	11 220	332	58	35
Brown	3	1987-88	0.67	1 798	2 684	13 255	392	69	NOT USED
Brown a	4	1988-89	1.36	3 626	2 592	9 230	273	78	NOT USED
Brown	4	1985-86	1.0	2 827	2 827	12 409	367	81	NOT USED
Brown	5	1989-90	2.07	5 373	2 594	7 932	235	52	35
Brown	5	1986-87	1.8	4 439	2 466	9 230	273	79	NOT USED
Brook	2	1990-91	0.42	1 898	4 518	21 467	634	56	50
Brook	2	1989-90	0.53	2 092	3 947	17 616	521	69	NOT USED
Brook a	2	1988-89	0.47	1 463	3 113	21 370	632	107	NOT USED
Brook	2	1987-88	0.48	1 789	3 727	18 766	555	90	NOT UDED
Brook	3	1990-91	1.36	4 946	3 636	14 350	424	49	39
Brook	3	1989-90	1.27	5 088	4 006	14 300	423	61	54
Brook a	3	1988-89	1.3	4 071	3 180	16 061	475	79	42
Brook	3	1986-87	1.1	3 555	3 232	13 423	397	83	NOT USED
Rainbow	3	1990-91	1.8	3 317	1 843	10 749	318	68	54
Rainbow	3	1989-90	2.26	3 457	1 529	12 129	359	83	NOT USED
Rainbow	4	1990-91	3.5	4 499	1 285	9 617	284	56	NOT USED

a.PHOTOCONTROL PROBLEMS

1990-91 OVAPRIM TRIALS

Methods

In 1990-91 we ran Ovaprim trials on three-year-old brown trout, three-year-old rainbow trout, and two-year-old and three-year-old brook trout. Ovaprim injections were used after 75% of the stock had ovulated. Ovaprim was used at the recommended dose of 0.5 mL Ovaprim per kilogram of fish.

Three-Year-Old-Brown-Trout

Spawning commenced on November 21, 1990. Spawning peaked on

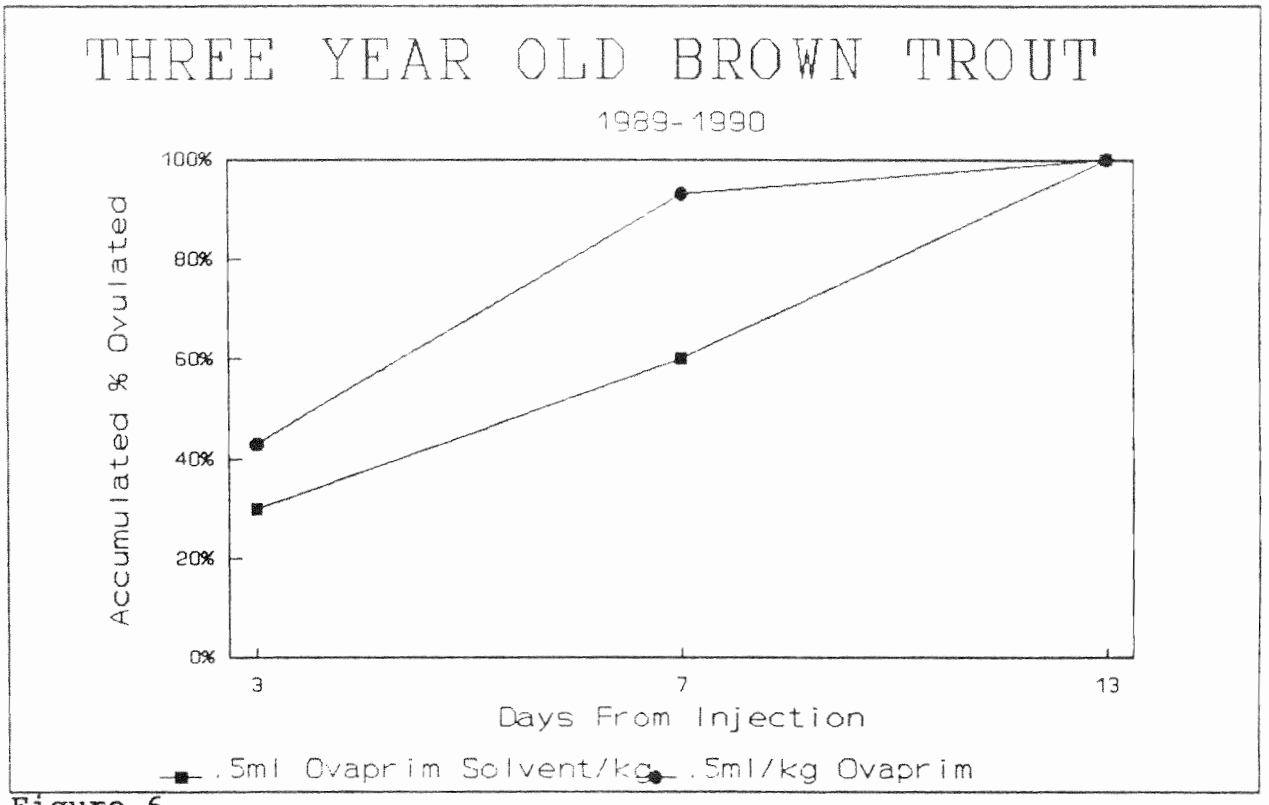

Figure 6

day 22 with an ovulation rate of 14% per week. Spawning dropped to a 13% ovulation rate per week by day 44 (Figure 7), at which time 78% of the brood stock had spawned. On day 44, the remaining 56 females received a single injection of 0.5 ml of Ovaprim per kilogram of fish.

Results

Ninety-one percent of the injected fish ovulated within seven days of the ovaprim inoculations. The remaining nine percent of the fish did not spawn. Egg size, fecundity and fertility remained the same before and after the Ovaprim inoculations. As in previous years we shortened the spawning season (Figure 7; Tables 6 and 7).

Three-year-old rainbow trout

Spawning commenced on October 26, 1990. Spawning peaked on day 35 with an ovulation rate of 15% per week. By day 48 the ovulation rate had dropped to 8% per week. Seventy-eight percent of the brood stock had been spawned by day 55. The remaining females received a single injection of 0.5 mL Ovaprim per kilogram of fish. Nineteen females received a second injection of 0.25 mL Ovaprim per kilogram of fish after seven days, on day 62. Thirteen females received a third injection of 0.25 ml Ovaprim per kilogram of fish on day 68.

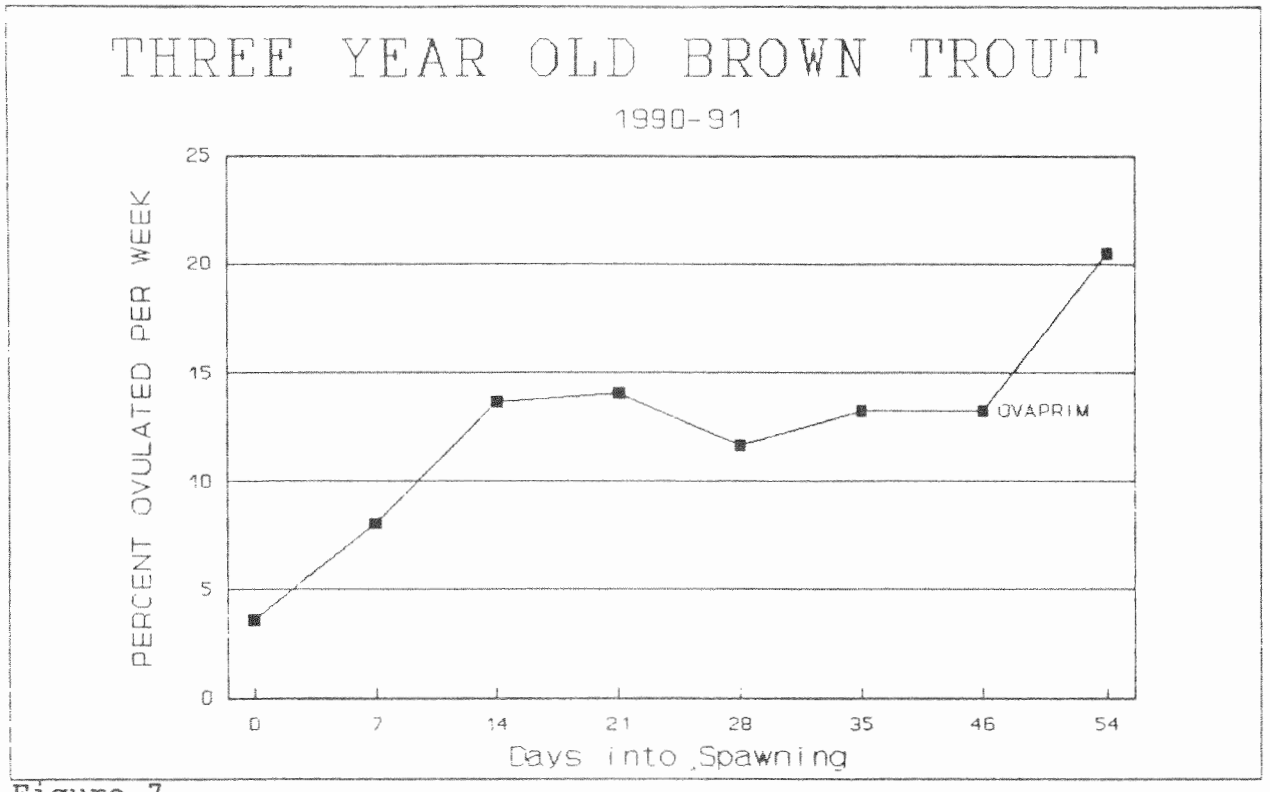

Figure 7

Results

Eight days after injections, 79% of the fish had ovulated.

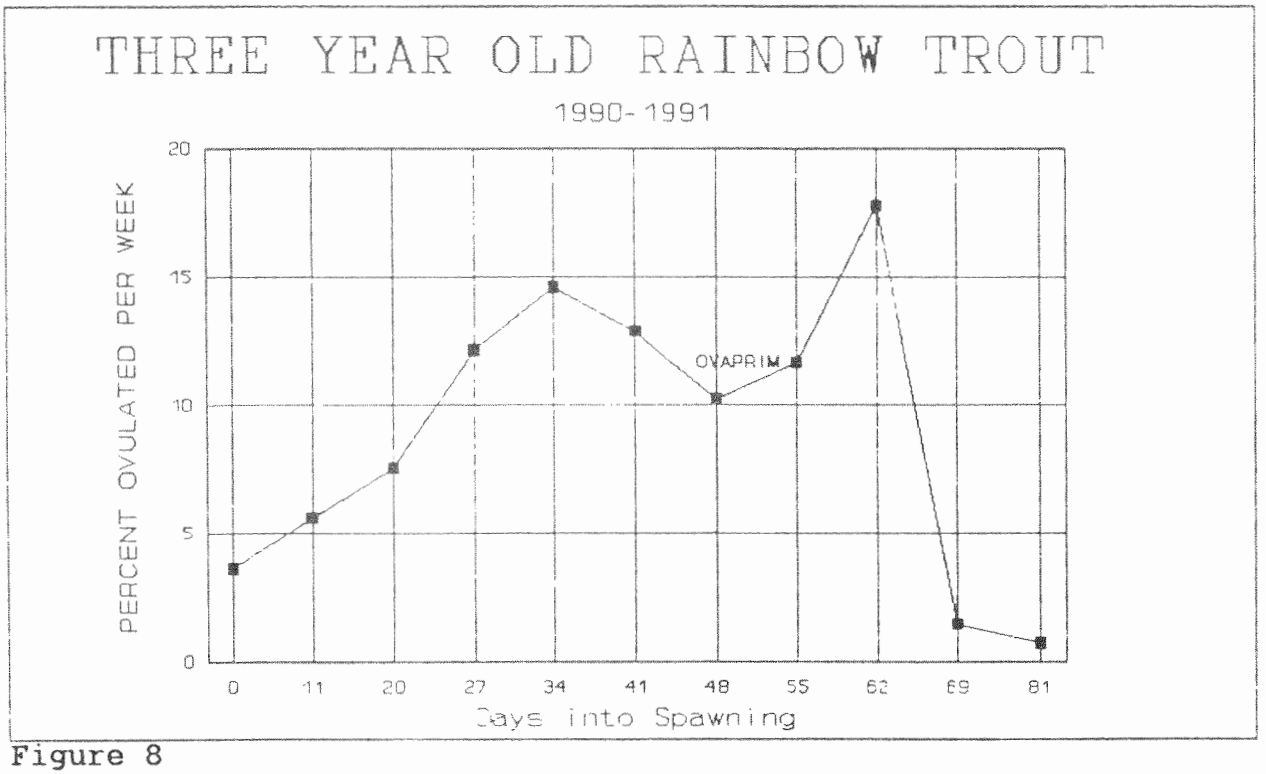

Figure 8

Thirteen days after injections, 86% had ovulated. Eleven percent of the females did not spawn. Egg fertilities were not measured. Egg size and fecundity remained constant before and after the Ovaprim injections (Figure 8, Table 7).

Table 7: 1990-1991 Ovaprim Results

Fish Stock	Age	Fecundity		Fertility (%)		Egg Size (No./L)	
		Before	After	Before	After	Before	After
Brook Trout	2	1 917	2 080	71	NA	21 467	21 467
Brook Trout	3	4 812	4 890	78	77	14 420	14 220
Brown Trout	3	3 364	3 335	91	90	12 207	12 400
Rainbow Trout	3	3 165	3 238	NA	NA	10 830	10 380

Three-year-old brook trout

Spawning commenced on November 8 ,1990. Spawning peaked on day 26 with an ovulation rate of 24% per week. Eighty-six percent of brood stock had spawned by day 40. The remaining females received a single injection of 0.5 mL of Ovaprim per kilogram of fish.

Results

One hundred percent of the injected females ovulated within nine days (Figure 9). Egg size, fecundity and fertilities were not affected by Ovaprim injections (Table 7).

Two-year-old brook trout

Spawning commenced on November 8. Spawning peaked on day 19 with an ovulation rate of 24% per week. By day 40 after spawning started, 81% of the brood stock had spawned. The remaining females were injected with 0.5 mL of Ovaprim per kilogram of fish.

Results

By day 10 after injection, spawning was completed with only 18% of the injected brood stock having spawned. Although we did not lethally sample fish from the unspawned group to check gonadal development we assessed the majority of these fish as still immature attwo years of age. Because of the low numbers of brood stock that spawned after Ovaprim injections, egg size, fecundity and fertility data could not be compared.

OVERALL DISCUSSION ON OVAPRIM USAGE.

Ovaprim has developed into a valuable fish cultural tool at the Allison Creek Brood Trout Station. It allowed the facility to

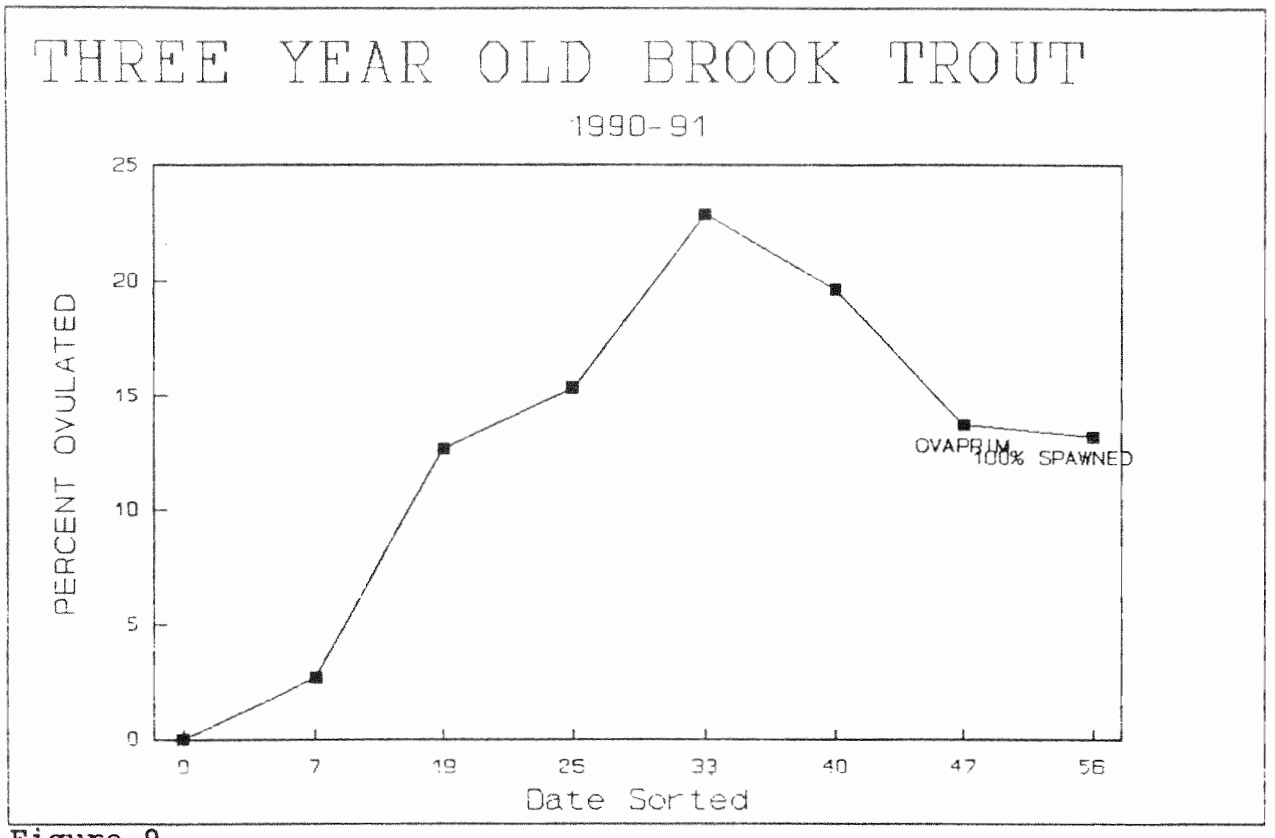

Figure 9

meet its egg production goal in a year when photocontrol problems altered brood stock reproductive cycles. The facility was able to salvage a year of production by triggering ovulation in brood stock that had started to resorb eggs, which could have aborted a year of production.

After the initial Ovaprim usage, the facility has been able to successfully use Ovaprim under normal hatchery conditions. Many advantages and few disadvantages have been identified. Ovaprim has allowed the brood station to shorten the spawning season for all stocks by one to four weeks. This allows the adults, especially the males, to move out of spawning mode earlier and back onto feed. It reduces handling and stress of the fish by requiring less sorting and anaesthetizing of the fish. It allows for synchronizing the last egg takes.

Use of Ovaprim under normal hatchery conditions has not altered egg size or fecundity. Egg fertilities and eyed-egg percentages in Ovaprim-injected fish in 1990-91 were only 1% lower than eggs from non-injected fish. The use of Ovaprim has enabled the facility to lower pre-spawning mortalities and to drastically lower post-spawning mortalities by reducing the stress from handling and spawning. Ovaprim use is now a normal hatchery procedure.

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ALTERNATIVE FERTILIZATION DILUENTS AS SPERM ACTIVATORS

by
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Alaska Department of Fish and Game

Rainbow trout survival from the green to eyed egg stage at Fort Richardson Hatchery has been variable, ranging from 75% to 95%. During the last four spawning seasons, we have monitored fertilization rates on a daily basis by checking egg development to the 4-cell stage to determine if egg survival might have been a result of poor fertilization. These rates were also inconsistent, ranging from 75% to 99%.

Most fish culturists use raw process water to activate rainbow trout sperm during fertilization. At a few experimental facilities, researchers use alternative fertilization diluents as activators when fertilization may be capricious. The most common alternate diluents used were sodium chloride solutions (recommended by Jim Seeb, Alaska Department of Fish and Game Geneticist) and tris/glycine solutions (recommended by Jim Parsons, Clear Springs Foods, Inc.). We tested three solutions against our process water to determine if any would improve our fertilization rates, or at least make them more consistent.

MATERIALS AND METHODS

Fish used in this experiment were Swanson River strain and Big Lake strain rainbow trout held at the Alaska Department of Fish and Game, Broodstock Development Center (BDC). We conducted our experiments with the first fish to become ripe, so that we could use the information gathered during the 1991 production spawning season. All spawning and incubation occurred at the BDC.

The solutions tested were:

#1	2.4g Tris 3.75g Glycine 5.0g NaCl	in 1L process water
#2	2.4g Tris 3.75g Glycine 5.0g NaCl 0.75ml Vitamin C	in 1L process water
#3	7.0g NaCl	in 1L process water
#4	process water	

For each test, we took the eggs of three females, mixed them gently, divided them into four aliquots, and placed each aliquot into a small freezerette container. We took milt from two males, mixed it gently, then poured about 2ml of the milt over each

group of eggs and mixed gently. We then added one of the four fertilization diluents to each container of eggs and milt. The diluents were all kept at about 10C and were selected randomly relative to the time they were used. This test was replicated 12 times.

The eggs were incubated in divided upwelling trays in 10C process water. About 12 hours after fertilization, we checked for development in the eggs by examining at least 175 randomly selected eggs from each group. With this sample size we would be 95% confident that the result we found was plus or minus 5%. A solution of 2 parts EtOH, 2 parts acetic acid, and 1 part water was used to clear eggs. After clearing, the four-cell stage could readily be seen with the naked eye, but often the two-cell and later stages could only be seen with the aid of a dissecting scope.

RESULTS AND DISCUSSION

In six of the replicates, there was no difference among the four fertilization diluents used as sperm activators (Table 1). In the remaining six tests, though, fertilization rates were significantly lower in eggs that were fertilized with sperm activated with process water. Over all replicates, the mean fertilization rate for water was 79%, while the rates for NaCl, T/Gl, and T/Gl+Vit C were all 94% (Figure 1). These results were statistically significant using a one way analysis of variance test ($P=.0001$).

Using a microscope, we also looked at sperm motility and duration of motility in the four diluents. Sperm activated with process water had active, progressive movement for an average of 33 sec. After this time, over 50% of the sperm in one field had ceased moving or exhibited vibratory or circular movement. Sperm activated with any of the other three diluents had extremely active, progressive movement for an average of 98 sec. After this time, 50% of the sperm in one field ceased moving or exhibited vibratory or circular movement.

Although we could not quantify the activity, sperm in the three alternate diluents initially moved so rapidly that it was difficult to focus on individual sperm cells until 30 to 45 sec had elapsed. In water, we could immediately focus on the individual cells.

Based on these results, we elected to use one of the alternate diluents as a sperm activator during the 1991 rainbow trout spawning season. We chose the sodium chloride solution because it was the easiest to make and the chemical was readily available. After each day of spawning, we checked the fertilization rate for the day. Fertilization rates ranged from 86% to 96%, with the average over the entire spawning season at 94%. Subsequent green to eyed egg survival in the production hatchery ranged from 88% to 96%, and averaged 91%.

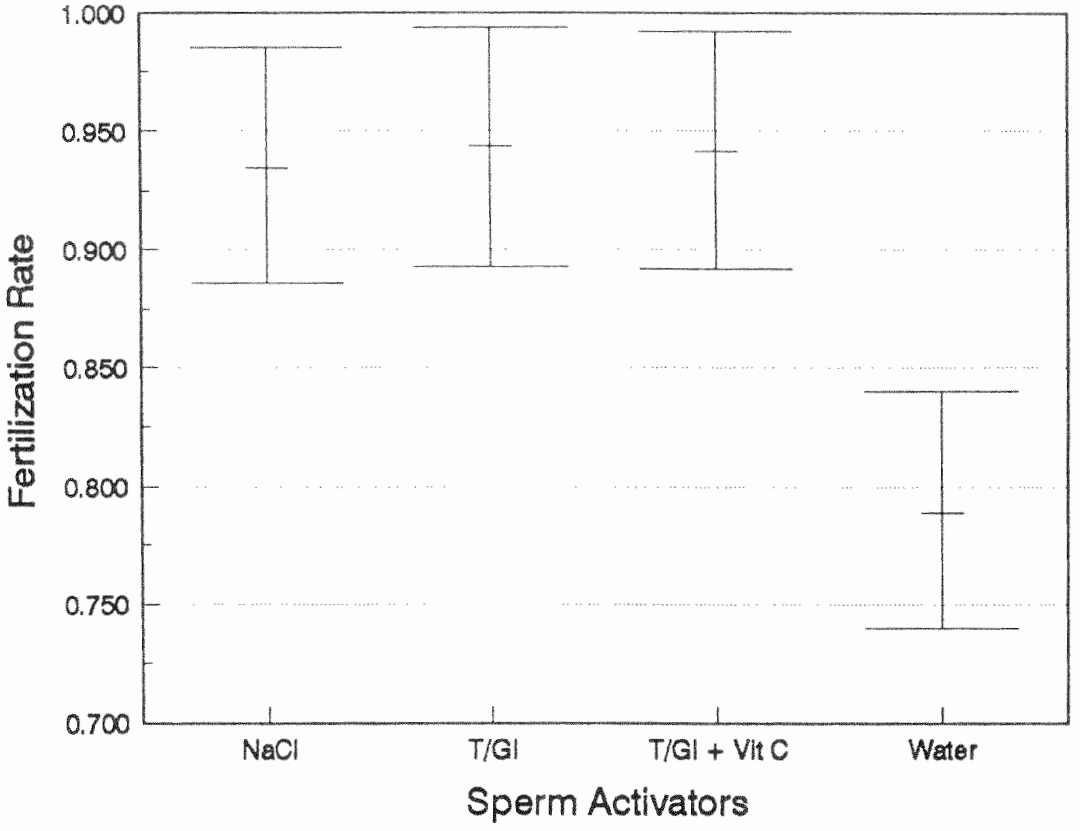
Table 1. Fertilization rates in rainbow trout using four sperm activators.

Group	Water	T/GI + Vit	NaCl	T/GI
BL1	0.929	0.933	0.978	0.955
BL2	0.731	0.893	0.872	0.902
BL3	0.482	0.978	0.972	0.966
SR1	0.565	0.966	0.967	0.984
SR2	0.936	0.941	0.972	0.978
SR3	0.892	0.942	0.867	0.915
SR4	0.921	0.966	0.978	0.967
SR5	0.856	0.863	0.833	0.848
SR6	0.694	0.951	0.932	0.989
SR7	0.730	0.961	0.896	0.887
SR8	0.950	0.938	0.983	0.952
SR9	0.794	0.970	0.972	0.978

T/GI: Tris, glycine, NaCl solution

T/GI + Vit C: Tris, glycine, NaCl, and Vitamin C solution

Figure 1. Mean fertilization rates with 95% confidence intervals.



CEDAR RIVER SOCKEYE PROJECT: FIRST YEAR EVALUATION

Stan Hammer
Washington Department of Fisheries

INTRODUCTION

In the late summer of 1991, the sockeye salmon run to the Cedar River fell to its second lowest total on record (Figure 1), 76,906 returning adult fish (R. Egan, WDF scient. tech., pers. comm., 1992). On September 3 of that year, the Director of Fisheries, Joe Blum, authorized an emergency enhancement action to help this fish population recover. Over a period of only a few weeks, our construction crew built a temporary incubation facility at Landsberg Dam on the Cedar River at river mile (RM) 21.3 (Figure 1A). Spawning crews, augmented by intra-agency personnel and volunteer groups, were organized and egg collection began October 9, 1991. During that spawning season which ended November 20, 1991, a total of 2,326,900 eggs were secured. Fry releases commenced February 8, 1992 and ended March 24, 1992. Fry plants totalled 2,079,100 fish; survival from egg to fry was 89.57%. This report will summarize activities and results of the 1991 season.

The Cedar River originates in the Cascade foothills near Lookout Mountain and flows some fifty-five miles through the hills of southern King County to empty into the eastern shore of Lake Washington at the city of Renton, Washington.

METHODS AND MATERIALS

Egg Collection

Egg collection began October 9, 1991 (Figure 2) and ended November 20, 1991 (Figure 2). Eggs were collected from four sites on the Cedar River. These sites were located at RM's 19.75, 13.5, 10.8, and 4.2, respectively (Figures 1A and 1B). Adult fish were secured by drifting specially designed gill nets through the collection sites. The mesh size of these nets was 122 mm (stretch) with a depth of thirty meshes. Nets of two different lengths (30.0 m and 45.5 m) were used to account for the variability in the width of the river. Crew size fluctuated from seven to as many as twelve depending on location and the size of the net being used. Eggs from ripe females were placed into 453 ml cups which were stored in twenty-six 1 coolers. Green females were tethered on poly-propylene ropes and were transferred to holding pens at Lands-berg Dam in garbage cans fitted with air-stones. Males were spawned just prior to egg transport into 170 ml cups which were stored on ice in coolers for transfer to the incubation site.

Eggs were fertilized, disinfected, and water-hardened in a separate "dirty room" location. Water-hardened and disinfected eggs were then moved to the incubation area or "clean room."

Egg Fertilization

Eggs from the individual females were transferred from the 453 ml cups to 1358 ml bowls prior to fertilization. Sperm from one male was added to the bowls and activated with several

ml of pathogen-free water; eggs, sperm, and water were then thoroughly mixed. Eggs were water-hardened for a few minutes, and sperm from a different male was added and mixed. The eggs were allowed to stand for five to ten minutes before disinfection began.

Egg Disinfection

Egg disinfection began at the river collection site with the spawning of the first female and continued to be a prime concern during all phases of hatchery operations through the planting of the last fry. At the river site, all ripe females were dipped or bathed in a 1:100 concentration of iodophore. These fish were allowed to set for ten to fifteen minutes to allow blood to coagulate before the eggs were taken. Males were spawned alive, and returned to the river. Both spawning knives and hands were disinfected and dried after each female was spawned. After fertilization, eggs were rinsed with a solution of iodophore to remove any excess blood and sperm. The eggs were water-hardened in the solution of iodophore for one hour before they were set down in the incubator trays. Each incubator tray was disinfected before and after egg-picking. Each rearing tub was disinfected before and after fry release. All equipment which came into contact with the eggs was disinfected on a regular schedule. The incubation room was disinfected daily.

Egg Incubation

Eggs were incubated in vertical incubators (eight trays high), and in barrel-style incubators (ten trays high). Vertical

incubators were loaded at 12,000 eggs/tray to both eye and hatch. Barrel trays were loaded at 25,000 eggs/tray to eye and 12,500 eggs/tray to hatch. Eggs were shocked at an average of 700 temperature units (T.U.) or fifty days (Figure 3). Hatchout occurred at an average of 1055 T.U.s or seventy-eight days (Figure 3). Fry were released at an average of 1682 T.U.s or one-hundred twenty-five days (Figure 3). Plastic netting (13mm) was used as a substrate in the vertical incubators, and plastic saddles were used in the barrel trays as substrate.

Marking

All fry at the incubation site were marked by manipulating daily water temperatures to impart a pattern of bands on their otoliths. These otolith patterns will be used to identify both the fry as they migrate into the lake and the adults when they return to the river. Marking the otoliths is achieved by quickly dropping water temeratures over short periods (Volk et al, 1987). The fry were marked with four different patterns: Wide-Wide-Wide (W-W-W), Narrow-Wide-Wide (N-W-W), Wide-Wide-Narrow (W-W-N) and Narrow-Narrow-Narrow (N-N-N). To drop the required temperature of 4.4 C. three refrigerator units with a capacity of removing 10,000 British Thermal Units/Hour (B.T.U./H.)(G. Sanborn, WDF environm., pers. comm., 1992) were used.

Fry Release

Prior to release, fry were removed from incubator trays and placed in circular tubs where they were tempered in river water for eight to ten hours. Each tub was loaded with about 50,000 fry and flow into each tub ranged from forty to sixty gpm. Fry were released into the river at dusk. Initially, the fry were volitionally released, but due to logistical problems we switched to push-out release.

The timing for release of the fry was determined by using the KD Index value, the total number of T.U.s, and personal observation. The KD Index value (Bams, 1967) uses the formula:

$$KD = \frac{10\sqrt[3]{wt(mg)}}{L\ (mm)}$$

to describe the length/weight ratio of the alevin. The mean weights and lengths of two twenty-five fish samples were used to compute the KD Index were then averaged.

RESULTS

Egg Collection

The final eggtake totalled 2,326,900 (Figure 8). The largest daily eggtake (276,000) (Figure 2) was secured October 29. The first eggs were taken October 9, and the final day of spawning was November 20. Eggs were taken from all four collection sites.

Egg Incubation

Egg loss for all groups was 6.1% and fry loss was 4.33%. Egg to fry survival was 89.57%. Fecundity was 2,956 eggs/female. Mean egg size was 7.72 eggs/gram (Figure 4).

Egg Disinfection

One-hundred ninety-eight adult sockeye were checked for IHN. Eighteen fish tested positive for IHN (J. Thomas, WDF virol., pers. comm., 1992) (Figure 5). Eight-hundred fifty-two fish were tested for IHN, and no sign of IHN was found in any of these fish (J. Thomas, WDF virol., pers. comm., 1992) (Figure 5).

Fry Release

Fry were released from February 8 to March 24 (Figure 6). Total fry release was 2,079,100 fish (Figure 8). Mean fry size was 6.38 fry/gram (Figure 4). The KD Index values for fry release was a range from 1.86 to 1,80 (Figure 7).

Wild egg-to-fry survival was estimated to be 9% (D. Seiler, WDF fish. bio., pers. comm., 1992) (Figure 9).

CONCLUSION

Because many people worked very hard, the Cedar River Sockeye Project made notable progress during its first season. Now, we have the incubation facilities and water supply system in place, and we are confident we can incubate eggs and release fry that are uncontaminated by IHN. Our recent experience with these fish leads us to believe we are equipped to make a worthwhile contribution to future enhancement work on the Cedar River Sockeye. Egg to fry survivals are greatly improved using this type of technology (Figure 9).

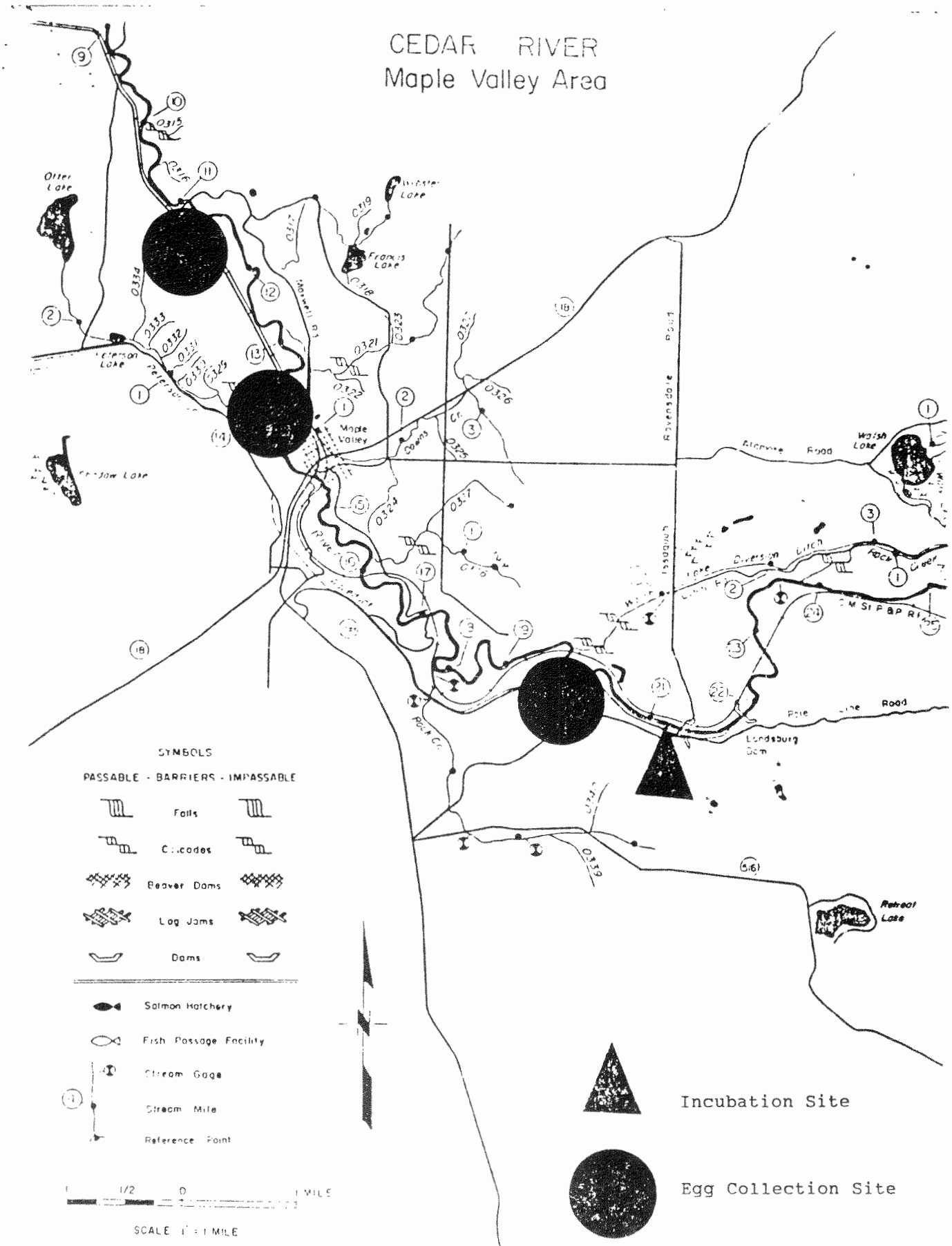


Figure 1A. Incubation Site and Upper River Egg Collection Sites.

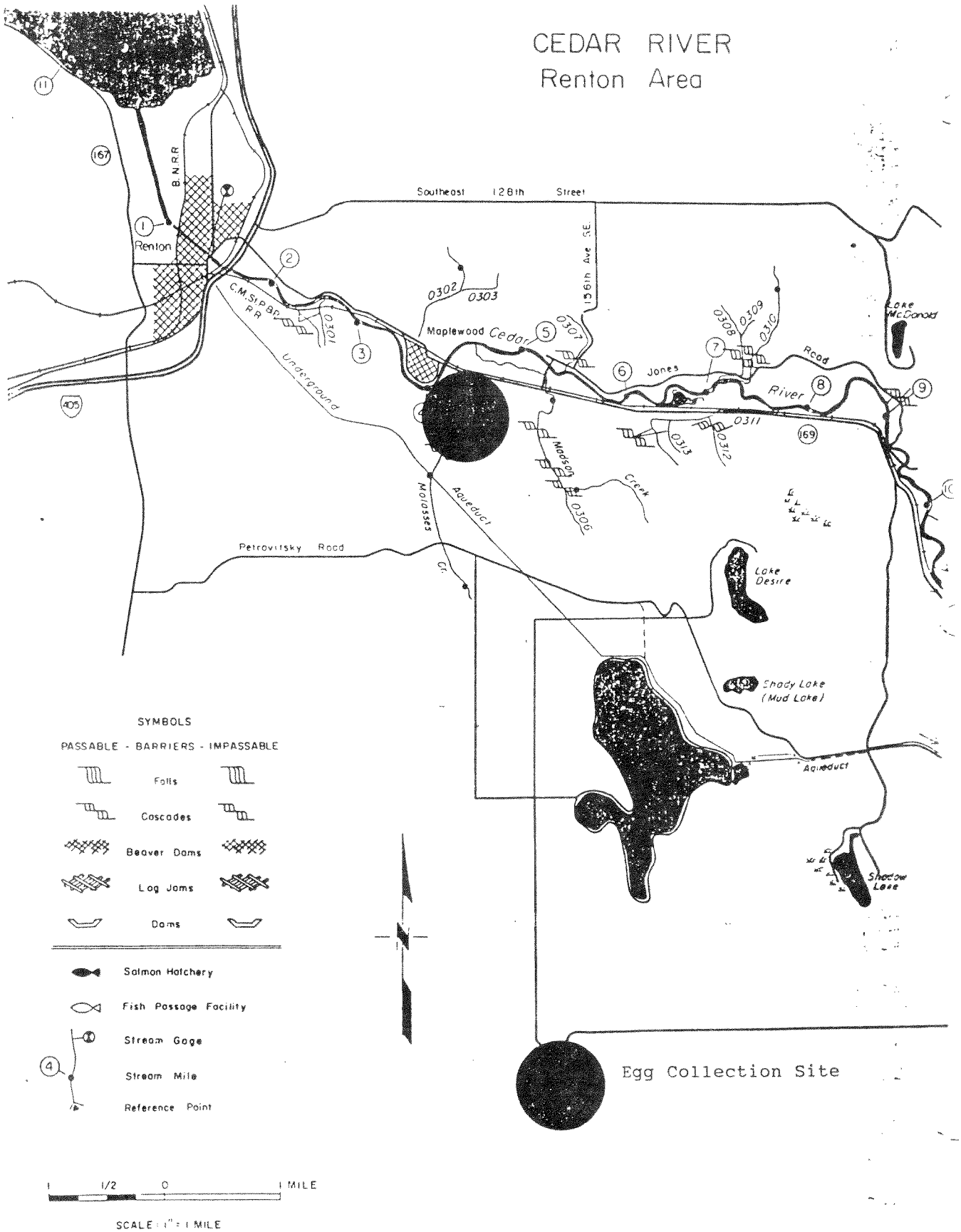


Figure 1B. Lower river egg collection site.

ADULT SOCKEYE RETURN
CEDAR RIVER, WA.

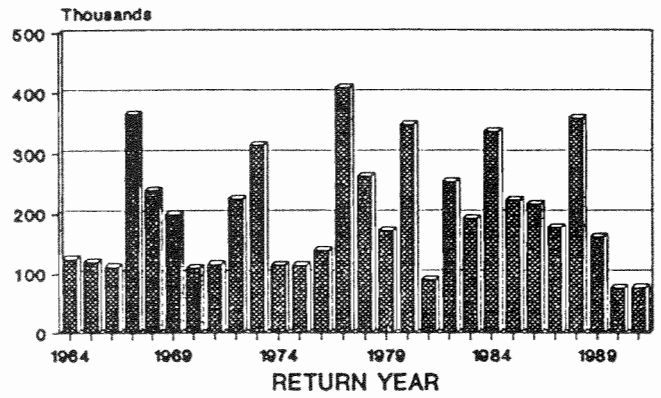


FIGURE 1

1992 SOCKEYE EGGS TAKEN
BY DATE

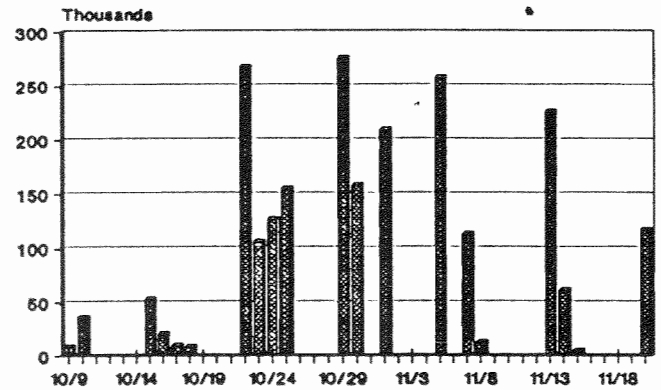


FIGURE 2

1992 EGG DEVELOPMENT
CEDAR RIVER SOCKEYE

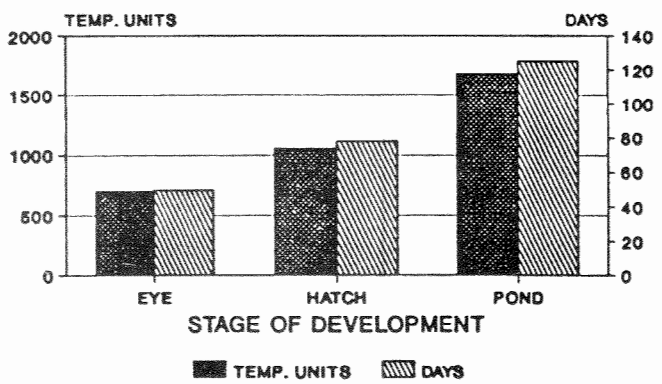


FIGURE 3

EGG/FRY SIZE FOR PACIFIC SALMON

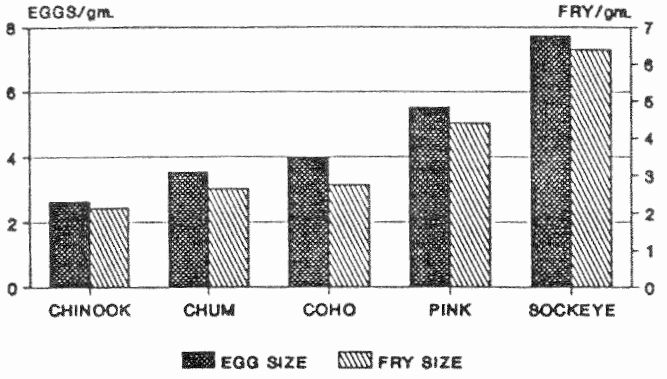


FIGURE 4

IHN PREVALENCE

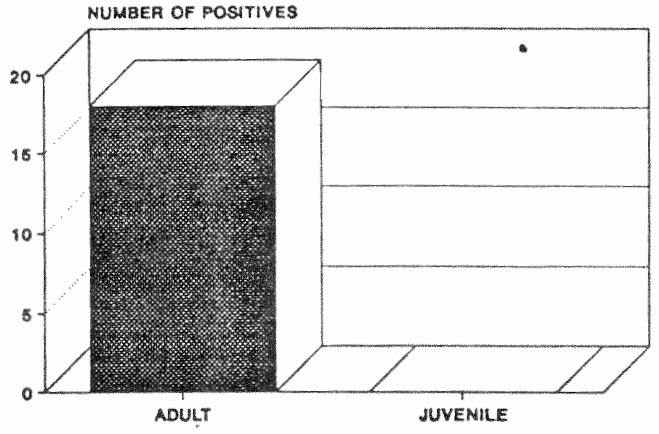


FIGURE 5

1991 BROOD CEDAR RIVER SOCKEYE FRY RELEASES

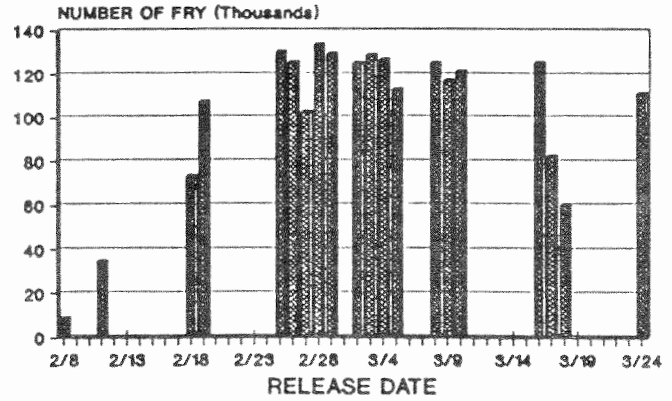


FIGURE 6

KD INDEX VALUES FOR 1991 BROOD FRY AT RELEASE

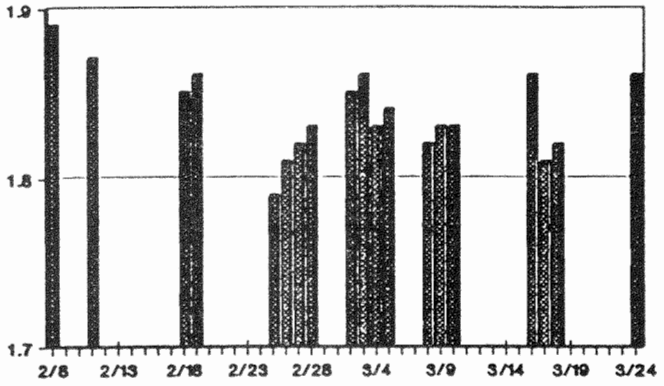


FIGURE 7

TOTAL EGG TAKE/FRY RELEASE

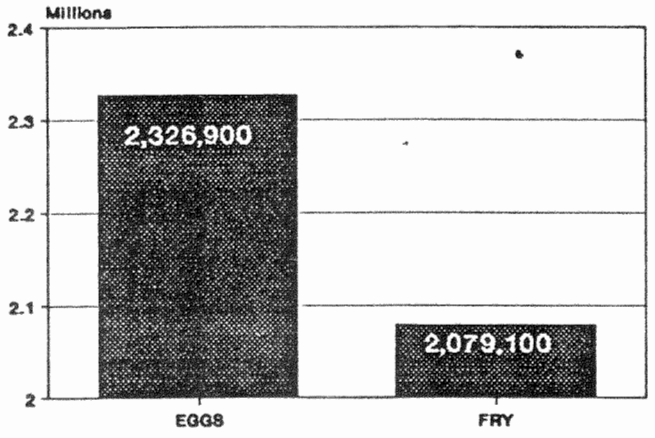


FIGURE 8

EGG TO FRY SURVIVAL

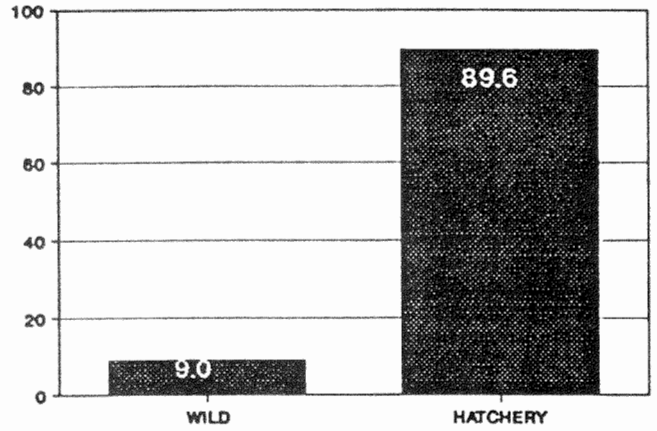


FIGURE 9

ACKNOWLEDGEMENTS

Many people contributed to the completion of this paper. The following people provided invaluable assistance:

* Paul Seidel managed the project and coordinated maintenace and technical support.

* Bob Pape and his construction crew built the incubation facility and the water supply system.

* Don Peterson installed plumbing to interior of incubation room and provided technical support throughout the length of the project.

* Don Rapelje and Bill Duplaga provided essential information on incubation and release methods.

* Kevin Amos and Joan Thomas trained hatchery personnel to disinfect eggs, and they also secured IHN samples during the eggtaking season and during fry release.

* Eric Volk, Gene Sanborn, and Jeff Grim installed the chiller system and directed efforts to chillmark eggs and fry.

* Ron Egan identified the egg collection locations.

* Ed Adams and Trude Sorebo performed all the normal routine hatchery duties. They also made many helpful suggestions, and generally kept the project site from getting into serious trouble.

* Howard Fuss trained hatchery personnel to perform KD Index measurements and analysis. He also critiqued this paper, and provided suggestions for improving the talk.

* Dave Seiler estimated wild fry survival.

* Denis Popochock reconciled data into charts and tables.

* Darrell Mills recommended use of gill net to capture fish.

* Andy Appleby developed the graph and text slides and critiqued the talk.

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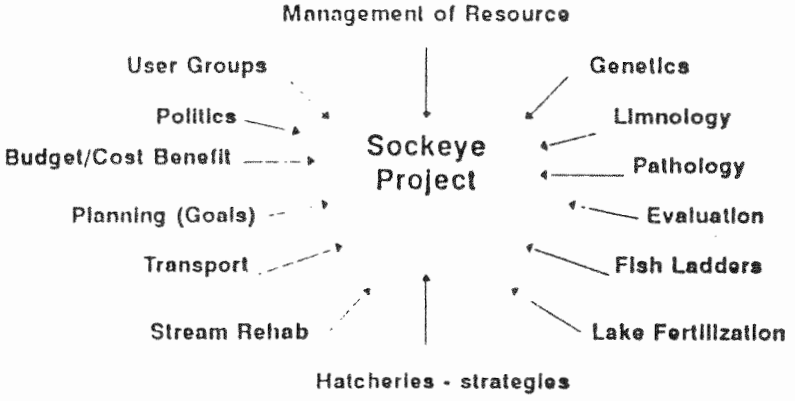
An Introduction to Session E:
Sockeye Salmon Enhancement

By
Session Leader: Terry Ellison
Alaska Department of Fish and Game

The purpose of this introduction is to present a picture of how the different sockeye enhancement projects, presented in this session, share a common ground. The diagram below illustrates a systems approach to sockeye salmon enhancement projects. It is not meant to be comprehensive in scope, but rather is used to convey a concept. System, is defined as, "A group of interacting elements functioning as a complex whole."

System - "A group of interacting elements functioning as a complex whole".



When any type of sockeye enhancement project is undertaken, one of the keys to its success is to evaluate all of the options, not just a single option such as hatcheries. This insures that all of the disciplines such as; genetics limnology, fish culture, and pathology have been considered, as well as input from the user groups, management and budget people. Through this process, the best strategy or combination of strategies to successfully accomplish the project is developed. Each speaker in this session will present a different approach, strategy or combination of strategies that have been successfully used in a sockeye enhancement project.

FIRST RETURNS OF ADULT SOCKEYE SALMON PRODUCED FROM HATCHERY-REARED AGE-ZERO SMOLTS AT AUKE CREEK, ALASKA

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Sockeye salmon eggs were collected fom spawners in the Auke Lake system and incubated and reared at Auke Creek hatchery. The Auke Lake stock of sockeye spawns in August, and juveniles spend 1 to 2 years in freshwater before migrating to sea. In the hatchery, age-zero smolts were produced by accelerating egg and fry development by using surface water fom Auke Creek or subsurface water from Auke Lake; whichever source provided warmer water. The fish were divided into two groups that received identical rearing until 21 days before release, when one group was transferred to seawater net pens in Auke Bay for continued rearing. The other was held in fresh water until release. All fish were released on June 21, 1988. Smolts reared in seawater were 6.2 g and 84 mm at release; freshwater smolts averaged 4.4 g and 75 mm. Growth rates changed seasonally, mostly related to increased water temperature: from January through April growth was 1.2%/day, during May and June the fish in fresh water grew at 2.3 and 3.6%/day, and in seawater averaged 5.2%/day. Sockeye juveniles at 1.1 or 1.5 g could survive in 26 ppt and 28 ppt seawater, respectively. All smolts were adipose fin clipped and tagged with coded wires.

From 1989 through 1992, all sockeye salmon adults entering the fish counting weir at Auke Creek were examined for fin clips, and the returns were subsampled to recover wire tags. Survival of age-zero smolts reared in seawater, 6.2 %, was significantly greater ($P = 0.05$) than that of smolts reared entirely in fresh water, 5.2%. There were no returns of ocean age-1 adults from the seawater release group. Ocean age-3 adults accounted for 94% and 88% of the returns from the seawater and freshwater groups, respectively. Adult sockeye salmon resulting from the seawater release group were significantly larger ($P = 0.05$) than those from the freshwater group at ocean age-2 and -3, but not at ocean age-4.

MAIN BAY SOCKEYE SMOLT PROGRAM

John A. Burke and Terry D. Ellison
Alaska Department of Fish and Game
FRED Division

Main Bay Hatchery is located in Prince William Sound. It is a large facility by Alaska standards, with a consistent supply of IHN-free water; and subsequently the potential to produce a large number of smolts, perhaps as many as 20 million. We felt the risk associated with sockeye culture at Main Bay was acceptable if three key elements were stressed in the culture practices: (1) an IHN-free water supply; (2) appropriate isolation; and, (3) rigorous disinfection at appropriate points in the process.

In 1987 Main Bay began producing sockeye smolts. Eggs, sac fry, and emergent fry were kept isolated in single-incubator lots until the fry had been feeding for at least three months, after which time we felt vertically transmitted virus was not a significant risk. The rearing fry were then mixed with other lots of fish in raceways and reared until the following spring when they were released as yearling smolts. We used each year class of smolts as a production scale experiment to determine the most efficient way to produce adult sockeye salmon. The parameters evaluated were: release of smolts directly from freshwater or release after rearing for at least two weeks in seawater; differing rearing densities in raceways; size of smolts at release; and, time of release. Though some of the results are still preliminary, as the last group of three-ocean adults will return in 1993, it appears that each manipulation had significant consequences.

Seawater and freshwater rearing. These treatments were compared with both the 1986 and 1987 broods. All survival estimates were based on tag recoveries, and should be considered conservative. This is particularly true of the 1986 brood, when there were relatively small numbers of smolts released. An estimated 4.9% of the 1986 brood reared in seawater survived to adult, while only 1.8% of those released directly from freshwater survived. An estimated 15.6% of the 1987 brood seawater reared fish survived to adult, while 16% of those released directly from freshwater survived. Though rearing a smolt in seawater prior to release could affect its chance of survival, it appeared that this was not the only parameter influencing the survival of these fish.

Large and larger smolts. Smolts were reared to two sizes; one group at a mean of 8g and the other at twice that size, 16g. Both groups of smolts would be considered large when compared to most wild populations in Alaska. An estimated 15.0% of the 8g smolts survived to adult, while 15.8% of the 16g smolts survived to adult. Limnologists working with wild smolts in Alaska suggest that the threshold above which the influence of smolt size on survival decreases is 6g. Future work with hatchery produced smolt will be directed at determining this threshold.

Perhaps of more interest than survival to adult, was how the size of a smolt influenced the age fo adults at return. Wild smolts from the same stock weigh only 1 to 2g. An estimated 15% of these fish return as two-ocean adults while 85% are three-ocean adults. When the smolts were 8g, 59% of the fish returned as two-ocean fish and 41% as three-ocean adults. If the smolts were 16g at release, 88% returned as two-ocean adults and only 12% as three-ocean adults. Somewhat unexpectedly, a number of one-ocean "jacks" returned from the group of 8g smolts, while not a single one-ocean fish was recovered from the group of 16g smolts.

At present it is not possible to make conclusions related to **rearing density in freshwater** and **time of release** studies. The three-ocean adults from these studies will not return until 1993. Preliminary results could be used to suggest that rearing densities as high as 67kg/m^3 did not diminish survival to adult; and that the time of release, even within a fairly narrow window (15 May through 5 June), made a significant difference in the survival of the smolts.

Yearling Sockeye Smolt Main Bay

John A. Burke and Terry D. Ellison
Alaska Department of Fish and Game
FRED Division

Treatments:

1986 brood; 1988 release; 330,025 smolts:

1. Moist feed, released from freshwater, 110,900 smolts;
2. Moist feed, released from seawater, 40,270 smolts;
3. Dry feed, released from freshwater, 77,082 smolts; and,
4. Dry feed, released from seawater, 101,773 smolts.

1987 brood; 1989 release; 3,576,600 smolts:

1. Size at release, smaller (7-9g), 1,209,517 smolts;
2. Size at release, larger (14-18g), 617,475 smolts;
3. Released from freshwater, 948,027 smolts; and,
4. Released from seawater, 1,148,287 smolts.

1988 brood; 1990 release; 2,616,498 smolts:

1. Rearing densities @ 1,000,000; 800,000; 600,000; and 400,000 smolts per raceway.
2. Release timing, smolts released on 15 May, 22 May, 29 May, and 5 June.

1987 Brood - Contributions to Commercial Fisheries

Treatment	Smolts	1-ocean "jacks" (%)	2-ocean adults (%)	3-ocean adults (%)	Total
Smaller smolts (7-9g)	1,210,000	1,000 (0.1%)	108,000 (8.9%)	74,000 (6.1%)	183,000 (15.0%)
Larger smolts (14-18g)	618,000	0 (0%)	86,000 (13.9%)	12,000 (1.9%)	98,000 (15.8%)

% of Total Commercial Contribution

Treatment	% return as 2-ocean adults	% return as 3-ocean adults
Smaller smolts (7-9g)	59%	31%
Larger smolts (14-18g)	88%	12%
Wild Coghill smolts (1-2g)	15%	85%

Note: the 1992 tag expansions are preliminary and conservative, and it is likely that actual contributions have been underestimated.

Release from Freshwater or Seawater Rearing

1986 Brood - Contributions to Commercial Fisheries

Treatment	Smolts released	1-ocean "jacks" (%)	2-ocean adults (%)	3-ocean adults (%)	Total harvest
Released FW	187,982	250 (0.1)	1800 (1.0)	1300 (0.7)	3,400 (1.8)
Released SW	142,043	2,300 (1.6)	3,050 (2.2)	1600 (1.1)	7,000 (4.9)

1987 Brood - Contributions to Commercial Fisheries

Treatment	Smolts released	1-ocean "jacks" (%)	2-ocean adults (%)	3-ocean adults (%)	Total harvest (%)
Released FW	949,000	160 (0.0)	104,000 (11.0)	48,000 (5.0)	152,000 (16.0)
Released SW	1,150,000	1,800 (0.2)	120,000 (10.5)	57,000 (5.0)	179,000 (15.6)

Note: the 1992 tag expansions are preliminary and conservative, and it is likely that actual contributions have been underestimated.

1989 Brood - Contributions to Commercial Fisheries

Treatment (Peak RW density)	Smolts released	1-ocean "jacks" (%)	2-ocean adults (%)	3-ocean return in 1993	Total through 1992
1,000,000/RW (88Kg/m^3)	848,544	23,300 (2.8)	76,550 (9.0)	?	100,000 (11.8)
800,000/RW (67Kg/m^3)	642,752	11,400 (1.7)	83,000 (12.8)	?	94,000 (14.5)
600,000/RW (48Kg/m^3)	461,915	11,800 (2.5)	46,000 (10.0)	?	58,000 (12.5)
400,000/RW (33Kg/m^3)	317,793	6,000 (1.9)	40,600 (12.8)	?	47,000 (14.7)

Note: the 1992 tag expansions are preliminary and conservative, and it is likely that actual contributions have been underestimated.

Time of Release

1989 Brood - Contributions to Commercial Fisheries

Date of Release	Smolts released	1-ocean "jacks" (%)	2-ocean adults (%)	3-ocean return in 1993	Total through 1992
15 May	90,775	1,600 (1.8)	8,400 (9.3)	?	10,000 (11.1)
22 May	76,935	2,000 (2.6)	10,600 (13.8)	?	12,600 (16.4)
29 May	96,027	1,200 (1.4)	15,800 (16.4)	?	17,000 (17.8)
5 June	87,147	300 (0.3)	12,000 (13.8)	?	12,300 (14.1)

Note: the 1992 tag expansions are preliminary and conservative, it is likely that actual contributions were greater.

Yearling Sockeye Smolt Main Bay

John A. Burke and Terry D. Ellison
Alaska Department of Fish and Game
FRED Division

Treatments:

1986 brood; 1988 release; 330,025 smolts:

1. Moist feed, released from freshwater, 110,900 smolts;
2. Moist feed, released from seawater, 40,270 smolts;
3. Dry feed, released from freshwater, 77,082 smolts; and,
4. Dry feed, released from seawater, 101,773 smolts.

1987 brood; 1989 release; 3,576,600 smolts:

1. Size at release, smaller (7-9g), 1,209,517 smolts;
2. Size at release, larger (14-18g), 617,475 smolts;
3. Released from freshwater, 948,027 smolts; and,
4. Released from seawater, 1,148,287 smolts.

1988 brood; 1990 release; 2,616,498 smolts:

1. Rearing densities @ 1,000,000; 800,000; 600,000; and 400,000 smolts per raceway.
2. Release timing, smolts released on 15 May, 22 May, 29 May, and 5 June.

1987 Brood - Contributions to Commercial Fisheries

Treatment	Smolts	1-ocean "jacks" (%)	2-ocean adults (%)	3-ocean adults (%)	Total
Smaller smolts (7-9g)	1,210,000	1,000 (0.1%)	108,000 (8.9%)	74,000 (6.1%)	183,000 (15.0%)
Larger smolts (14-18g)	618,000	0 (0%)	86,000 (13.9%)	12,000 (1.9%)	98,000 (15.8%)

% of Total Commercial Contribution

Treatment	% return as 2-ocean adults	% return as 3-ocean adults
Smaller smolts (7-9g)	59%	31%
Larger smolts (14-18g)	88%	12%
Wild Coghill smolts (1-2g)	15%	85%

Note: the 1992 tag expansions are preliminary and conservative, and it is likely that actual contributions have been underestimated.

Release from Freshwater or Seawater Rearing

1986 Brood - Contributions to Commercial Fisheries

Treatment	Smolts released	1-ocean "jacks" (%)	2-ocean adults (%)	3-ocean adults (%)	Total harvest
Released FW	187,982	250 (0.1)	1800 (1.0)	1300 (0.7)	3,400 (1.8)
Released SW	142,043	2,300 (1.6)	3,050 (2.2)	1600 (1.1)	7,000 (4.9)

1987 Brood - Contributions to Commercial Fisheries

Treatment	Smolts released	1-ocean "jacks" (%)	2-ocean adults (%)	3-ocean adults (%)	Total harvest (%)
Released FW	949,000	160 (0.0)	104,000 (11.0)	48,000 (5.0)	152,000 (16.0)
Released SW	1,150,000	1,800 (0.2)	120,000 (10.5)	57,000 (5.0)	179,000 (15.6)

Note: the 1992 tag expansions are preliminary and conservative, and it is likely that actual contributions have been underestimated.

Rearing Densities

1989 Brood - Contributions to Commercial Fisheries

Treatment (Peak RW density)	Smolts released	1-ocean "jacks" (%)	2-ocean adults (%)	3-ocean return in 1993	Total through 1992
1,000,000/RW (88Kg/m^3)	848,544	23,300 (2.8)	76,550 (9.0)	?	100,000 (11.8)
800,000/RW (67Kg/m^3)	642,752	11,400 (1.7)	83,000 (12.8)	?	94,000 (14.5)
600,000/RW (48Kg/m^3)	461,915	11,800 (2.5)	46,000 (10.0)	?	58,000 (12.5)
400,000/RW (33Kg/m^3)	317,793	6,000 (1.9)	40,600 (12.8)	?	47,000 (14.7)

Note: the 1992 tag expansions are preliminary and conservative, and it is likely that actual contributions have been underestimated.

Time of Release

1989 Brood - Contributions to Commercial Fisheries

Date of Release	Smolts released	1-ocean "jacks" (%)	2-ocean adults (%)	3-ocean return in 1993	Total through 1992
15 May	90,775	1,600 (1.8)	8,400 (9.3)	?	10,000 (11.1)
22 May	76,935	2,000 (2.6)	10,600 (13.8)	?	12,600 (16.4)
29 May	96,027	1,200 (1.4)	15,800 (16.4)	?	17,000 (17.8)
5 June	87,147	300 (0.3)	12,000 (13.8)	?	12,300 (14.1)

Note: the 1992 tag expansions are preliminary and conservative, it is likely that actual contributions were greater.

Transboundary River Sockeye Salmon Enhancement

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ABSTRACT

Sockeye salmon enhancement of transboundary rivers was provided for under Annex IV of the U.S./Canada Pacific Salmon Treaty. The actual enhancement activities are done jointly by the Alaskan Department of Fish and Game and the Canadian Department of Fisheries and Oceans. The program was designed to utilize fry stocking to produce an additional 100,000 adult sockeye salmon for commercial harvest on both the Taku and Stikine Rivers. The additional harvest of enhanced fish will be shared by fishers from both countries. Close to 10 million eggs have been collected annually from sockeye salmon stocks on the two river systems. The eggs are transported from their Canadian source to Snettisham Hatchery for incubation and thermal marking. Emergent fry are flown back to Canadian Lakes. Fish culturists at Snettisham have developed and utilized several new techniques as a result of this program. (1) Incubation water is chilled to delay emergence, which must coincide with the Canadian Lakes becoming free of ice. (2) Water temperature is manipulated to thermally mark the otoliths of the fry in the hatchery so that the enhanced fish can be identified in mixed stock fisheries. (3) Fry are transported at altitudes up to 6,000 feet (1820 meters) as they are flown over mountain passes to Canadian Lakes. Since 1990, about 12 million sockeye salmon fry have been planted into lakes on the two river systems. The first return from the international enhancement effort will occur in the summer of 1993.

"GULKANA HATCHERY -

A SYSTEMS APPROACH TO SOCKEYE ENHANCEMENT"

Presented at:

43rd Annual Northwest Fish Culture Conference
Wenatchee, Washington
December 2, 1992

By

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I. INTRODUCTION

The Gulkana Hatchery project has become the largest streamside salmon incubation facility in the world. It incubates more sockeye eggs (35 million plus annually) and produces more sockeye fry (25 million plus annually) than any other hatchery program. This paper will detail development of the facility and its evaluation programs as well as describe the environment in which it occurred ie, "A systems approach to sockeye enhancement".

II. OVERVIEW

The Copper River system encompasses an area of 24,400 square miles with the longest tributary reaching over 300 miles from the sea. Sockeye salmon spawning occurs from less than 10 feet above sea level to at least 3,400 feet elevation with early spawners dead by the first of July and late spawners alive into early April of the following year. The system includes a wide diversity of lakes and streams which provide the spawning and rearing habitat for the salmon species found in the Copper River (Figure 1). A significant portion of the sockeye population spawns and/or rears in glacial rivers or lakes.

Figure 1 shows the locations of various harvest areas with a commercial drift gillnet fishery at the river mouth. Average annual harvest of sockeye salmon in this fishery is 650,000. A dipnet personal use fishery is located approximately 100 miles upstream and a subsistence fishwheel (plus a few dip nets) fishery is located just above the dip net fishery but covering over 100 miles of main stem river channel. The combined take of salmon in these two fisheries is about 130,000. Sport fishing occurs on a number of tributaries; however, the catch of sockeye salmon is not significant (<5,000).

A sonar enumeration site is located 30 miles (Figure 1) from tidewater and is operated approximately 2-1/2 months per year.

Although sockeye, chinook and coho salmon are abundant in the Copper River, species timing reduces the complexity to having only sockeye and chinook present,in quantity, in the river at the same time (Figure 2). Sockeye salmon spawning is distributed somewhat evenly throughout the Copper River drainage. Chinook salmon spawning is located exclusively in the upper reaches of the Copper River while coho spawning tends to be located nearer the river mouth with only limited areas of overlap with the spawning distribution of chinook salmon.

Gulkana Hatchery is located near the headwaters of the Gulkana River, tributary to the Copper River, at just below 3,000 foot elevation and approximately 285 river miles from the Gulf of Alaska (Figure 1). Fish from Gulkana Hatchery production currently contribute over 100,000 fish annually to the commercial, personal

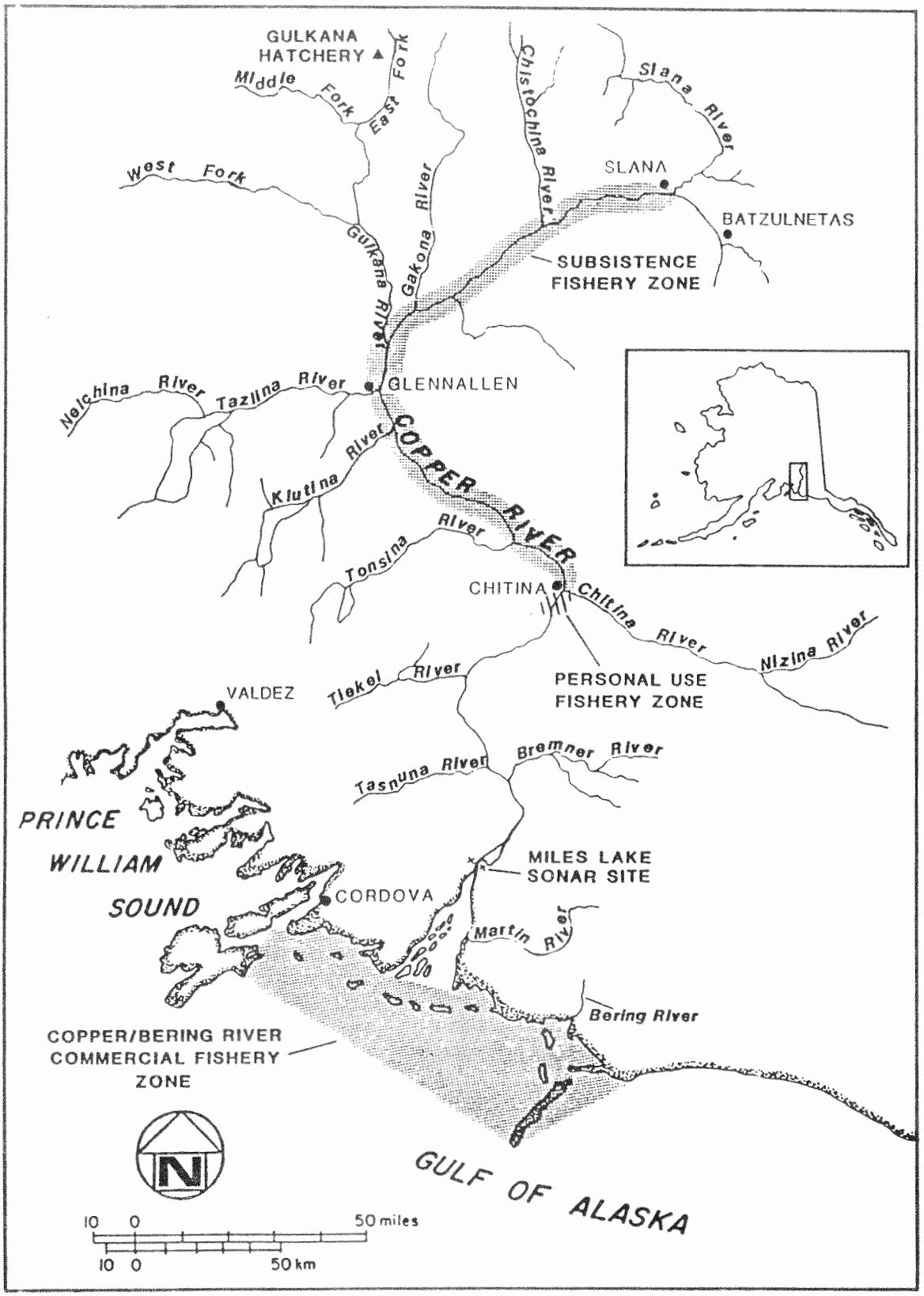

Figure 1. Copper River drainage and fishery harvest zones.

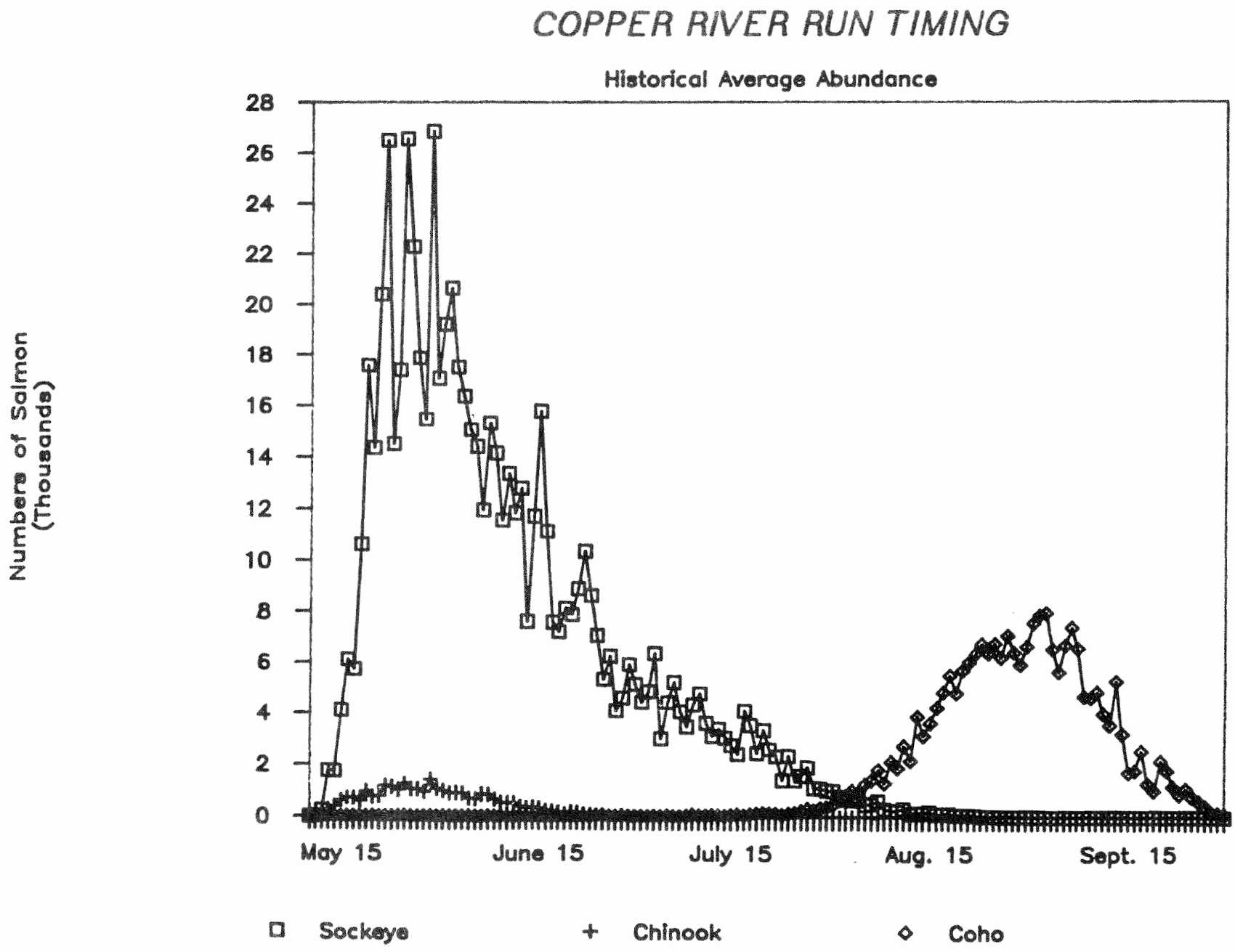

Figure 2. Run timing and abundance by species, Copper River Commercial Fishery.

use, subsistence and sport fisheries (the Gulkana River is a major sport fishing area) plus carcasses from the facility egg take are given to local dog mushers for dog food. The hatchery is situated on a spring which produces a near constant flow and temperature regime (8-9 cfs, 37-42 F).

III. HISTORY

Gulkana Hatchery began as an assemblage of concepts, ideas and observations plus previous authors works, which were applied to a site which appeared to have merit. Present were an indigenous brood stock, a high quality/quantity water supply and significant underutilized nursery areas.

Gulkana Hatchery began as a single Wilson (Bams) incubator box installed in a small spring adjacent to the current hatchery site during the fall of 1973. The installation was preceded by a full year of site evaluation including water chemistry, flow and temperature measurements conducted on a monthly basis. In addition, consultation with staff engineers and biologists plus various experts such as Jack Bailey and Bill McNeil, NMFS, Juneau resulted in a recommended prototype for installation (Figure 3). Eggs from indigenous stock were taken using primitive field methods and placed into the incubator. During the early spring of 1974, fry emerged representing nearly 80% of the eggs taken. From that meager beginning, the facility has grown to the present 35 million egg production unit.

In the process of growing, testing of various substrates, incubator prototypes, intake systems and materials has been a continual exercise. Intake systems began with two incubator units per perforated intake box and increased to five per intake box before the entire system was overhauled and two perforated and slotted pipe intakes 12" x 40' were installed. The system remains entirely gravity fed with no pumps, generators or other moving parts.

The facility distribution system was originally designed to prevent the failure of any one unit from impacting any other (each unit on a single feed line). That characteristic has become critical in the containment of IHN Virus outbreaks. Lateral spread of IHNV contamination has never occurred at Gulkana although 31 individual unit outbreaks have occurred representing less than five percent (5%) of the facilities output. In the past five years, the loss has been less than three percent (3%) due to improved disinfection procedures. Infected units are disinfected and destroyed.

Substrate cleaning initially was done by hand, then by small (home size) cement mixer and finally by commercial cement truck cleaning eight (8) of the eighty (80) cubic yards of substrate in each load. A project that initially took man weeks to complete is now done in a day.

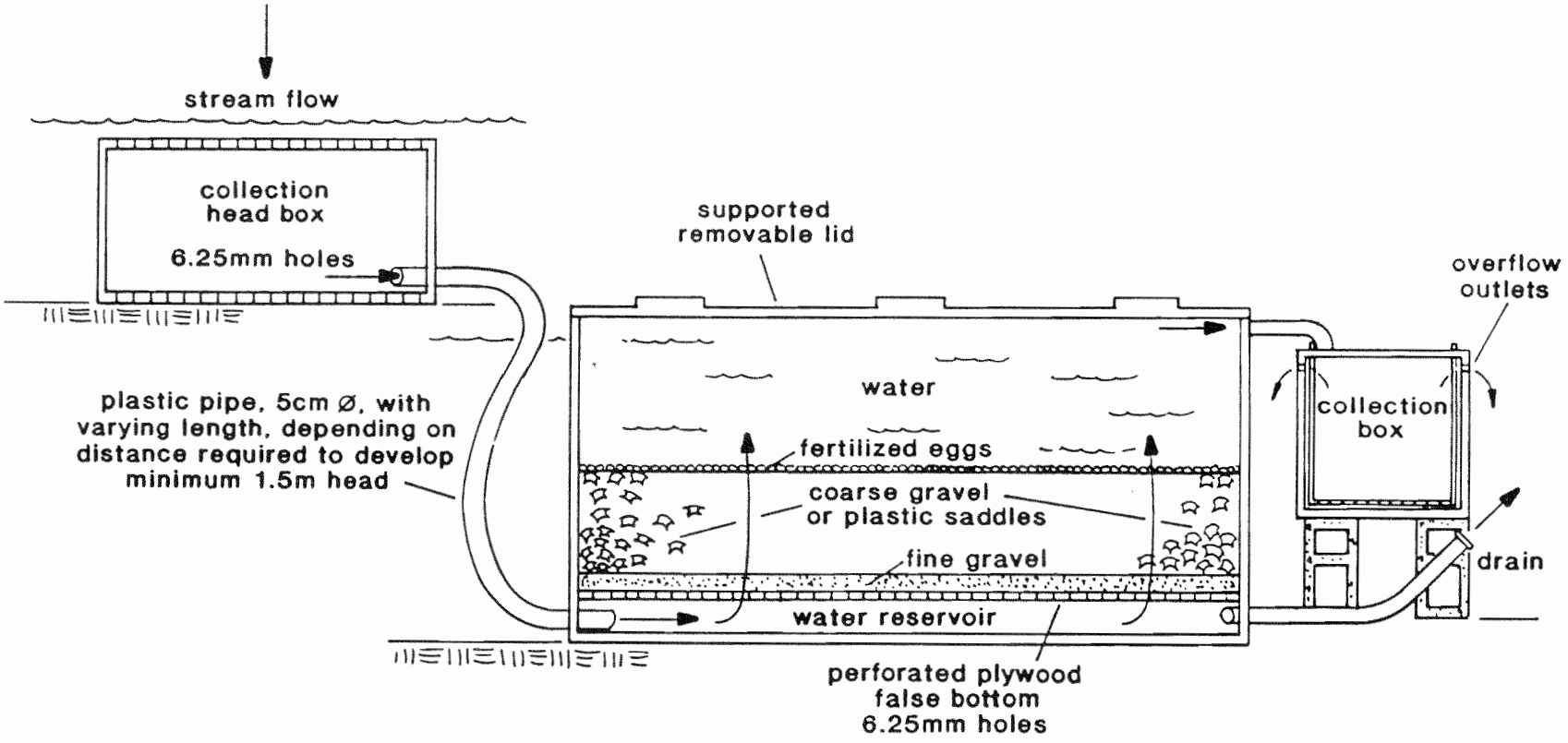

Figure 3. Plywood reinforced upwelling incubation unit currently in use at the Gulkana Incubation site.

IV. CURRENT PROGRAMS

Egg Take

The egg taking and handling methods used at Gulkana Hatchery are standard Alaska Department of Fish and Game, sockeye salmon fish culture policy procedures. Dan Moore presented a detailed description of the methods at this conference (Protocols for Disease-Free Sockeye Culture). The essentials of the policy are: a disease free water source, compartmentalization of incubation units and iodophor treatment of fertilized eggs from individual females as well as disinfection of all equipment used during the egg take. The remainder of the egg taking process at Gulkana Hatchery is fairly routine with the possible exception of the weather conditions. During the course of the egg take, temperatures typically are near or below freezing and not uncommonly reach zero Fahrenheit presenting a challenge to both personnel and equipment. All fish used at the facility are indigenous stock. Egg numbers are estimated volumetrically with subsamples enumerated using a Northwest Marine Technology FC-1 fry counter with appropriate hole size for the eggs being counted.

Eggs are seeded into the incubators at densities of about 16,500 eggs per square foot (500,000 per incubator). The substrate used is graded gravel with 1- 1/2" maximum diameter and 3/4" minimum installed with approximately 9" of substrate depth (Figure 3). Once loaded, the incubators are left unattended, except for occasional flushing of accumulated detritus by partially draining the unit, until fry begin emergence in early April.

Fry Handling

Fry are accumulated in individual collection boxes to allow assessing of potential disease/virus issues before delivery via pipe system to a counting (NWMT FC-1) station. Fry are either released on site, transported via truck or transported via aircraft to reach their nursery lake. Short term feeding of fry occurs to allow accumulation of numbers sufficient for aerial transport. All other fry are released at emergence. All transports are conducted using oxygen support.

CWT Programs

Coded wire tagging and recovery programs are conducted on two of the three enhanced populations with funding for all activities a part of the Gulkana Hatchery budget. Northwest Marine Technology CWT equipment is used for tagging. All tagged fish have their adipose fin clipped. Tagging is currently conducted on migrant smolt where the entire population is enhanced stock production. The CWT program provides evaluation of the timing and contribution rate of the enhanced stocks in various harvest areas.

Limnology/Hydroacoustic Programs

Lake limnology and hydroacoustic programs are maintained to evaluate the impact of fry stocking and assess survival rates of stocked fry. Nick Dudiak's presentation "Sockeye Salmon Enhancement in Southcentral Alaska" describes the typical limnology assessment program used in Alaska thus I will not detail it further here. The hydroacoustic program utilizes equipment and procedures consistent with the program developed by Dr. Richard Thorne at the University of Washington and now with Biosonics, Inc.

Pathology/Fish Health Program

Other than rare coagulated yolk problems in individual incubators, the only fish health issue which has occurred at Gulkana Hatchery is IHNV. Extensive evaluation of brood stock has revealed that from twenty five (25%) to over ninety (90%) percent of the females test positive for IHNV in their ovarian fluids. Farming around the presence of IHNV has been the only option using techniques (Alaska Sockeye Salmon Culture Policy) as described by Dan Moore at this conference.

Annual inspection of the hatchery by the ADF&G, Fish Pathology Section staff is required resulting in an written inspection-recommendation report. Upon the determination of any fish health issue, samples are sent to the Fish Pathology Laboratory with recommended treatment or disposition of the involved lot phoned back to the hatchery manager. Turn around of IHNV sample results has occurred frequently in less than forty eight (48) hours.

Hatchery Production Data Evaluation

Hatchery record keeping is almost exclusively computer based with egg take, fry production, fish transport, limnology, hydroacoustic, smolt/CWT, adult return and adult/CWT records and summaries maintained on Lotus spreadsheets. All records which are collected in daily form such as egg take, fry production and CWT recoveries are maintained so that evaluation of timing relative to survivals and production may occur.

Catch/Escapement Data Analysis

Recording of catch by user group by location, species and date plus escapement (by species) evaluation through sonar and aerial survey methods for both natural and enhanced stock components tends to produce voluminous data files; however, in order to ensure that enhanced stocks do not have an adverse impact on natural stocks, maintenance of these files is mandatory. Typically, 15-20 percent of the user group catches are comprised of enhanced stock production; however, during the latter portion of the commercial fishery, enhanced stocks may comprise over 50 percent of the fish being captured (Figure 4). Knowledge of the proportion of enhanced stock in each fishery through time is essential to protection of

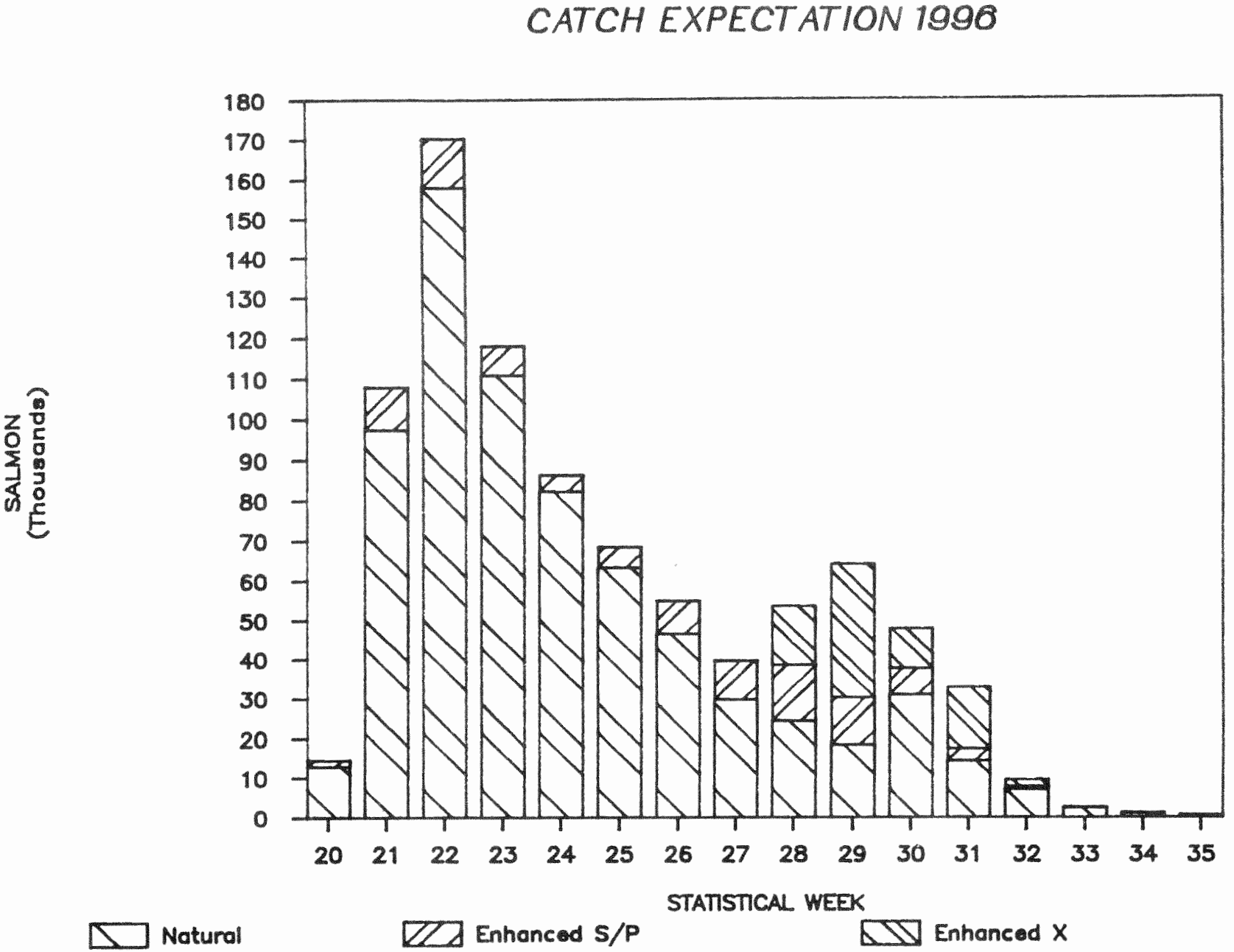

Figure 4. Timing and abundance of natural and two enhanced stocks, Copper River, Alaska.

natural stocks.

Integrate "The System"

Integration of the accumulated data as described above is essential to maximizing the enhancement opportunity while minimizing the impact on natural anadromous and resident stocks of fish. Overloading a lake with stocked fry may be only a missed opportunity; however, significant impact on resident lake trout or other species constitutes an outright loss. Excess harvest of natural stocks in the various fisheries, in order to maximize harvest of enhanced stocks (higher allowable exploitation rates) or simply through poor management or inadequate data resource to provide for proper management, constitutes negligence, incompetence or both. A quotation which applies here, "Data is not knowledge, Understanding is knowledge" (source unknown).

V. ISSUES AND CURES

The Gulkana Hatchery program was initiated as a research project and has striven to retain a research approach to problems even at a production level. The greatest single challenge facing the program at this time is lack of adequate rearing space. Potential for improved survivals due to optimizing release timing in nursery lakes and collection of increased fishery timing and contribution rate precision through increased tagging rates and tagging of all release groups, depend entirely on expanded rearing capacity and the resulting ability to choose when to release fry. This, and all other known issues, depend upon financial resources rather than biological unknowns thus the "cures" are more "when" than "how".

VI. SUMMARY

It is the firm belief of the Gulkana Hatchery management staff, and many other management entities that the author's enhancement axiom: **"If you can't afford the evaluation cost, you can't justify the project"** fits all production enhancement projects. Mitigation and restoration projects may be excluded for a variety of reasons but enhancement projects must pay their way or they fail to qualify as **"enhancement"**. The Gulkana Hatchery project has been operated on the basis stated above for twenty (20) years and has a demonstrated benefit to cost ratio (including evaluation costs) in excess of 4:1 even though between twenty five (25) and thirty five (35) percent of the operational budget has been in evaluation components. The "Systems Approach" has verified both the lack of adverse impact as well as the viability of the project.

SOCKEYE ENHANCEMENT IN SOUTHCENTRAL ALASKA; LEISURE AND CHENIK LAKES PROJECTS

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ABSTRACT

The Lower Cook Inlet (LCI) Sockeye Enhancement program has been in operation since 1980. This program involves the stocking of hatchery sockeye salmon fry into selected LCI lakes in order to provide experimental data and primarily enhance area commercial salmon fishing opportunities. Other enhancement or rehabilitation methods used include lake enrichment and fish pass operations. The contribution rate of enhanced sockeye salmon to the total LCI commercial harvest of that species has been significant at 50% to over 80% in recent years. The annual ex-vessel value of the enhanced sockeye production ranges from 1-3 million dollars.

LEISURE LAKE SOCKEYE ENHANCEMENT:

Historically, Leisure Lake had no natural salmon production because of a falls below the lake that presents a total upstream migrational barrier. An experiment was initiated in 1980 involving the annual stocking of hatchery produced sockeye salmon fry to determine optimum stocking levels prior to and after lake enrichment through fertlization. The lake has a surface area of 105 ha and an estimated 21.0 euphotic volume units. Leisure lake supports populations of coastrange sculpin, threespine stickleback, rainbow trout and the annually introduced sockeye salmon fry.

Pre-enrichment Phase:

As expected during the pre-enrichment phase, an inverse relationship between stocking density and freshwater survival and growth rate of fry to emigrating smolt was observed. At the lower lake rearing densities of 5,000 - 10,000 fry/ha, freshwater fry to smolt survival was high at 49% and 37%, respectively. However, when the higher rearing densities of 15,000 - 20,000 fry/ha were reached, fry to smolt survival dramatically decreased to 15% and 9%, respectively.
A corresponding significant decrease in age 1.0 smolt size was also observed. Sockeye stocked at 5,000 fry/ha showed an average age 1.0 smolt size of 96.9 mm and 8.0 g. However, stocking at 20,000 fry/ha yielded only threshold age 1.0 smolt at 53.9 mm and 1.1 g.

Ocean survival of sockeye smolt also decreased with increased fry stocking densities during the pre-enrichment phase. Original lake stocking densities of 5,000 - 10,000 fry/ha resulted in subsequent adult sockeye survival rates of 40% - 42%, respectively, while the higher stocking densities of 15,000 - 20,000 fry/ha yielded ocean survival rates as low as 4% - 5%. These lower ocean survival rates were attributed to the significantly smaller sizes of age 1.0 smolt produced from the high stocking densities.

Enrichment Phase:

In coordination with the FRED Limnology Section, the lake enrichment phase was initiated in 1985. This involves the annual application to the lake's surface of aqueous fertilizer solution of varying percentages of nitrogen and phosphoric acid. This liquid fertilizer is applied to the lake's surface with a boat mounted low volume, high pressure pumping system. Annual application rate is 11,500 l (16,200 kg) or 115 l/day (162 kg/day) during the open water period.
This lake enrichment technique has resulted in a significant increase in macrozooplankton biomass as compared to the pre-enrichment period. At similar 20,000 fry/ha stocking density levels, zooplankton biomass during the pre-enrichment phase increased from less than 100 mg/m2 to over 610 mg/m2 during the annual lake enrichment phase.
As a result, fry to emigrating smolt reversed their previous trend and subsequently increased their survival and growth rates during the lake enrichment phase. Additionally, subsequent adult returns appear to be reflecting increasing ocean survival rates. To date, nearly 800,000 adult sockeye salmon have returned to the project since 1980, providing significant contribution to the LCI area commercial sockeye salmon fishery.

CHENIK LAKE SOCKEYE REHABILITATION:

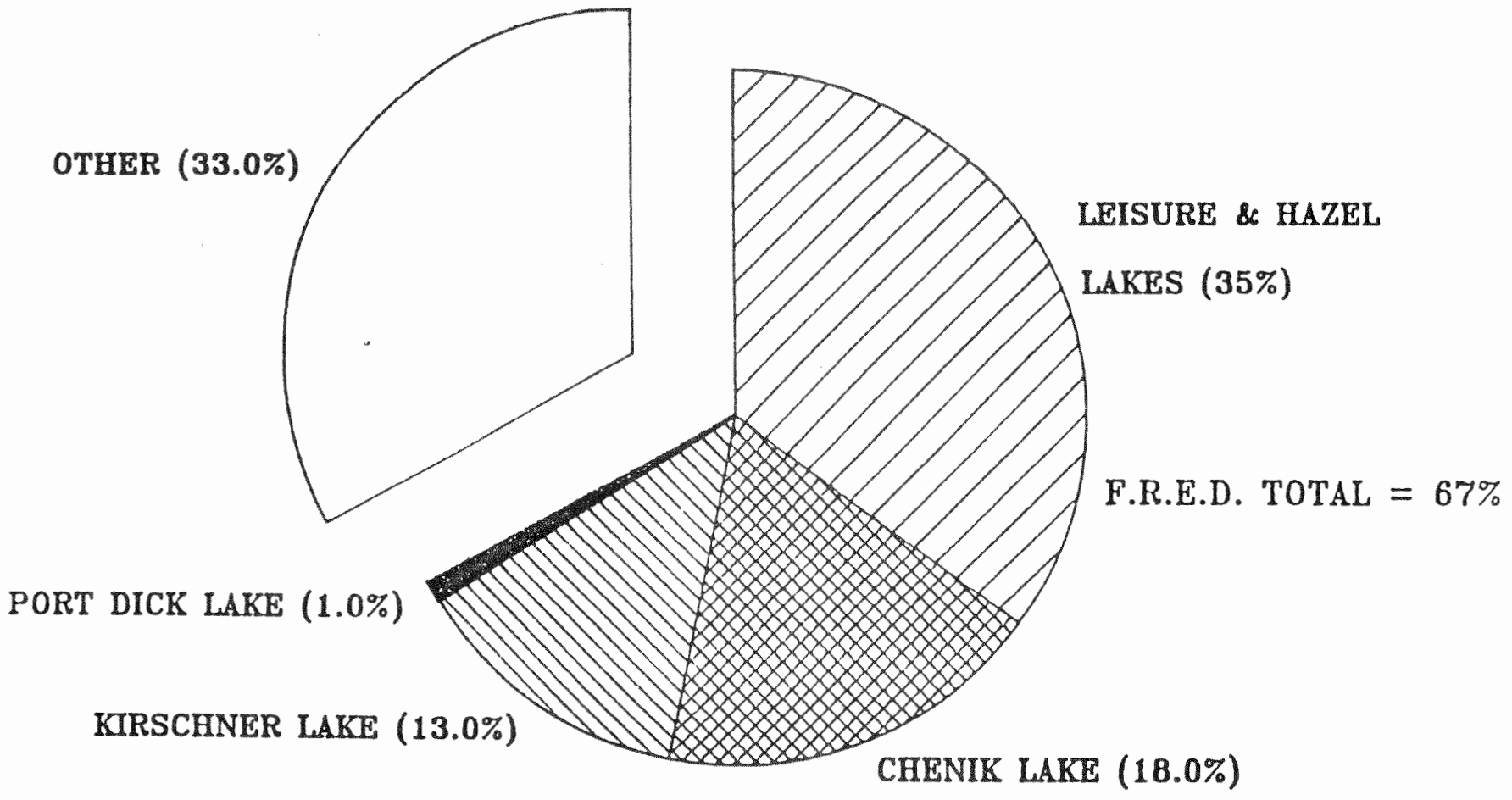
This project involves the rehabilitation of the sockeye salmon run to Chenik Lake where the average annual return through the 1930's was over 75,000 fish. A severe population decline forced a complete closure of the Chenik area fishery beginning in 1952. The returns to the system remained depressed and by the mid- 1970's annual returns were still less than 500 fish. Initial rehabilitation work involved the stocking of 1.3 million sockeye salmon fry from Crooked Creek Hatchery between 1978 and 1981. Additional work involved installation of temporary fish passes at the intertidal mouth of Chenik Creek where a partial migration barrier existed.

Results were significant as adult returns in the early 1980's from the initial hatchery fry stocking marked a 28-fold increase in spawning escapement over average returns since the 1964 earthquake. Additionally, the Chenik area commercial fishery was reopened in 1982 for the first time in 30 years. The increased escapements of the early 1980's had a significant effect on subsequent returns in

1986 and 1987. Over 123,000 sockeye returned in 1986 with the commercial fishery harvesting 111,000 of these. The 1987 total return was over 112,000 sockeye with a commercial harvest of 102,000 fish. These returns contributed approximately 50% of the total LCI commercial sockeye harvest with these levels approaching the historic high returns of the 1930's. The 1988 sockeye return to Chenik Lake Rehabilitation project and the commercial harvest set new historic records at 170,000 fish and nearly 160,000 fish, respectively. Estimated ex-vessel value of the harvest was $2.1 million and again accounted for as much as 50% of the entire LCI sockeye harvest.

This project has continued as a cooperative program with the local Cook Inlet Seiners Association (CISA) and the Cook Inlet Aquaculture Association (CIAA) providing funding for fry stocking, fish pass construction and maintenance, smolt and adult return evaluation and lake enrichment operations.

FRED DIVISION CONTRIBUTION TO THE LCI COMMERCIAL SOCKEYE SALMON HARVEST, 1991

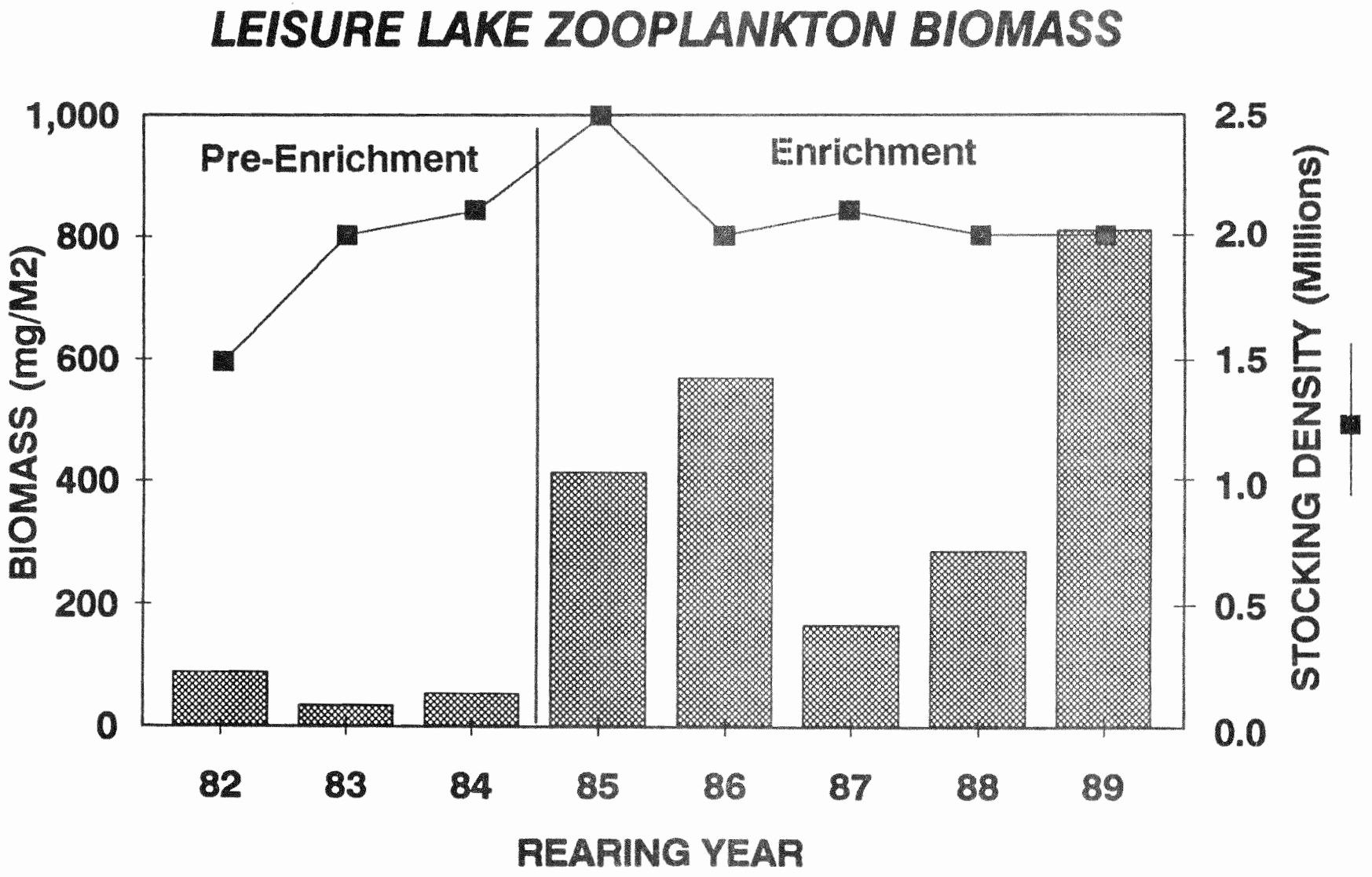


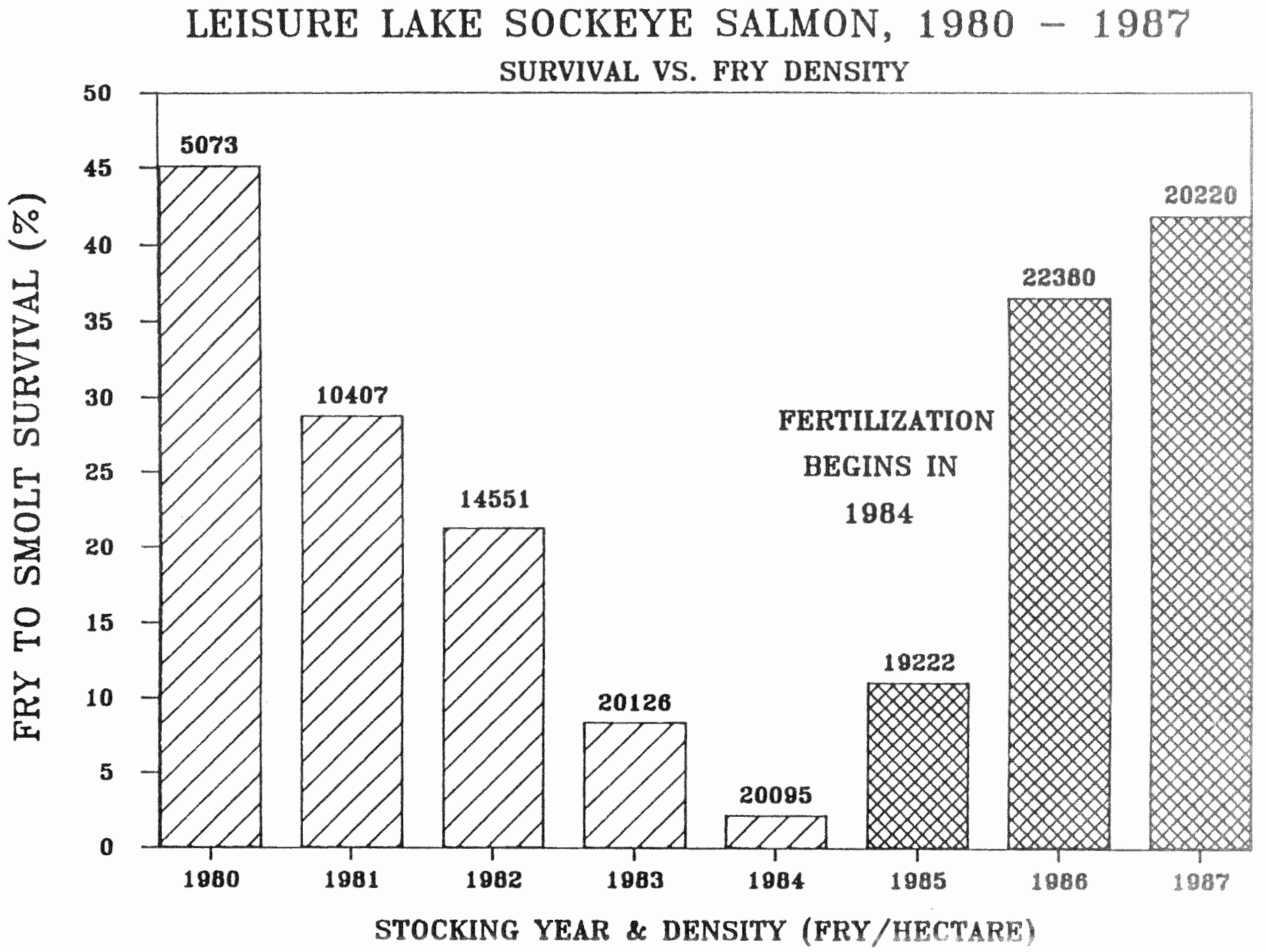
TOTAL SOCKEYE HARVEST = 333,000 FISH NEW LCI RECORD

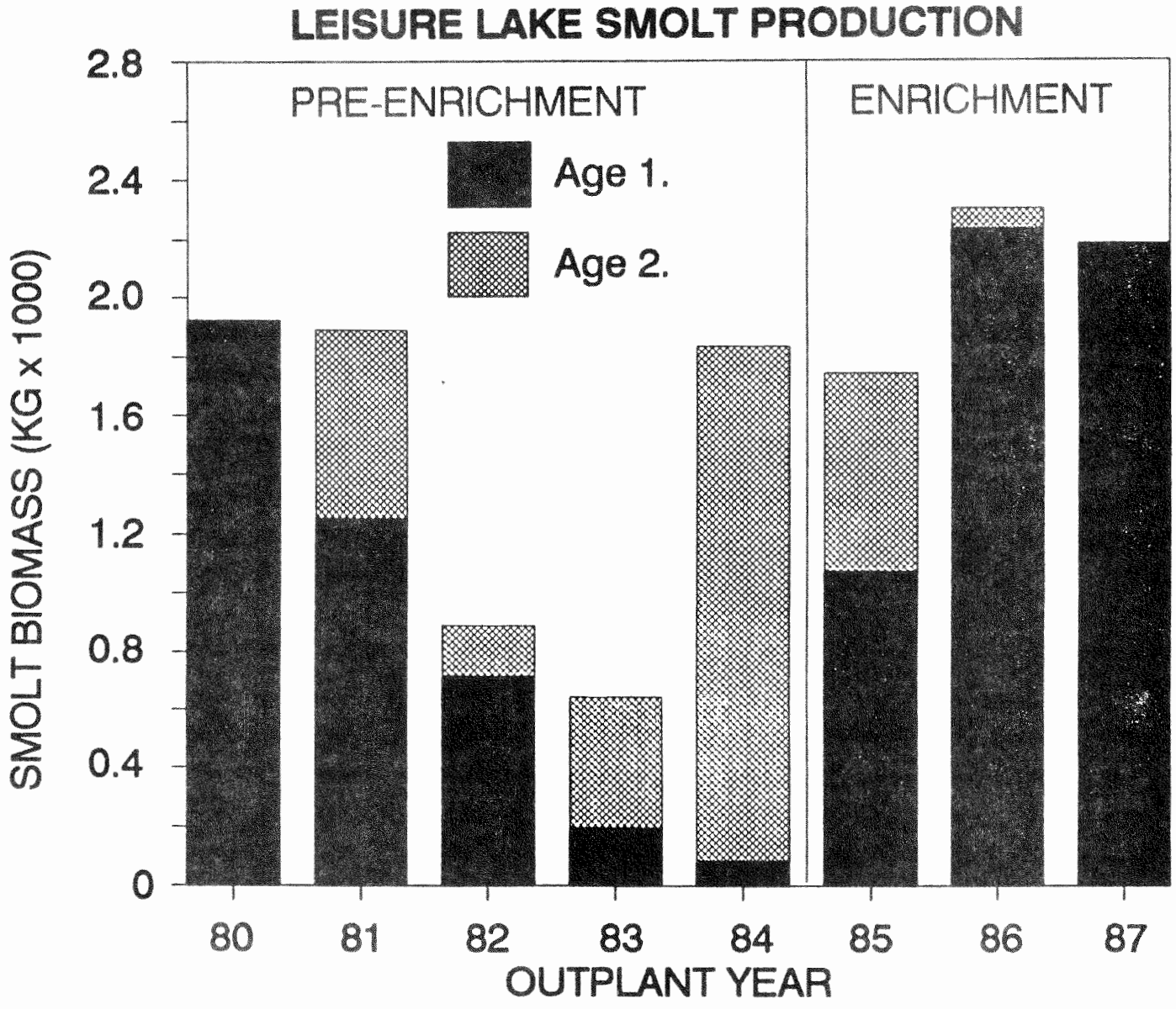
ADULT SOCKEYE RETURN FROM LEISURE LAKE STOCKING

PRE-ENRICHMENT PHASE

FRY RELEASED	SMOLTS PRODUCED	LAKE SURVIVAL	ADULT RETURN	OCEAN SURVIVAL
500,000	245,000	49%	101,800	42%
1,100,000	405,000	37%	165,400	41%
1,500,000	376,800	25%	15,170	4%
2,000,000	309,000	15%	14,520	5%

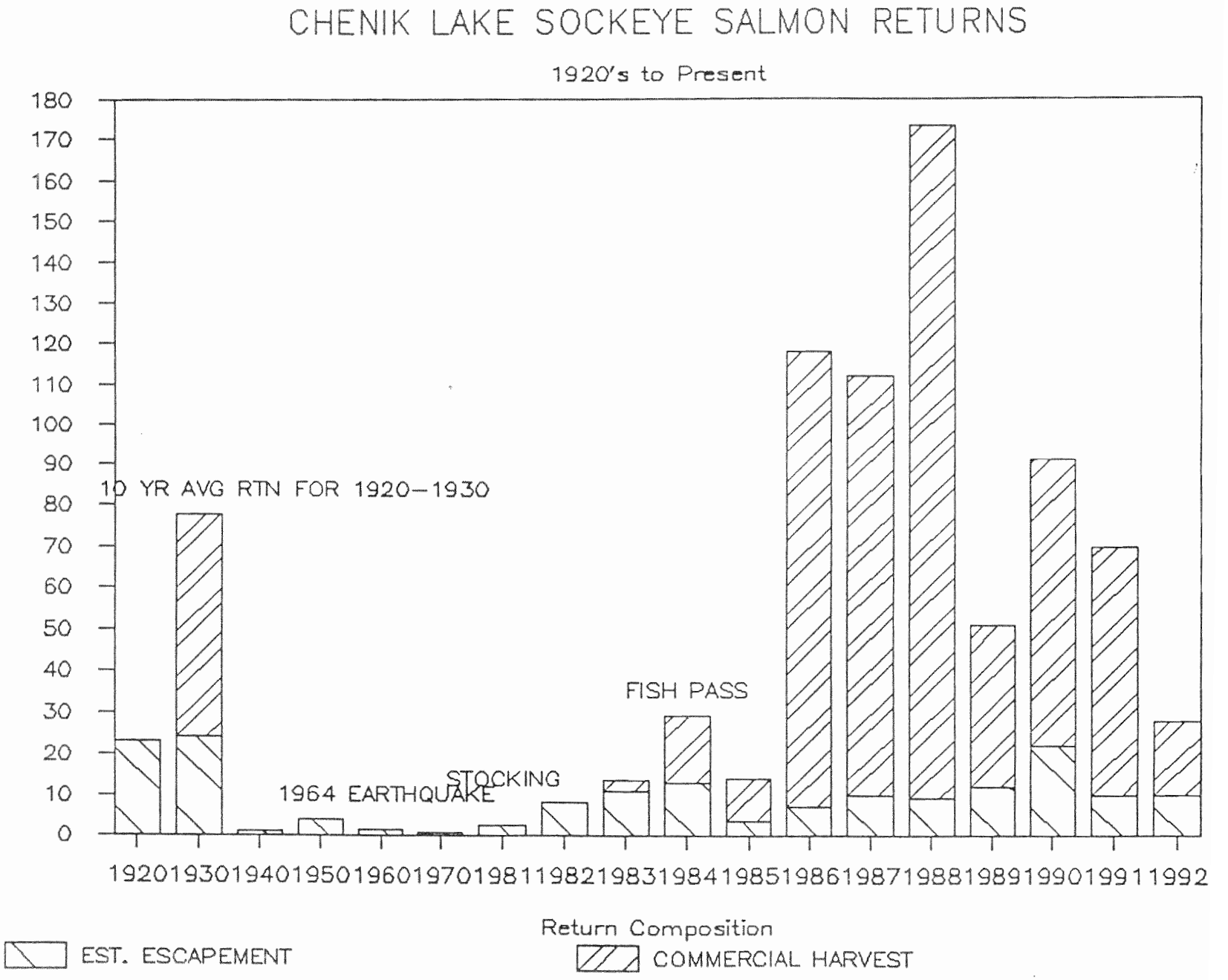

LEISURE LAKE ZOOPLANKTON BIOMASS
1,000
800
600
400
200
0
BIOMASS (mg/M2)
Pre-Enrichment
Enrichment
2.5
2.0
1.5
1.0
0.5
0.0
STOCKING DENSITY (Millions)
82
83
84
85
86
87
88
89
REARING YEAR


LEISURE LAKE SOCKEYE SALMON, 1980 – 1987
SURVIVAL VS. FRY DENSITY
FRY TO SMOLT SURVIVAL (%)
50
45
40
35
30
25
20
15
10
5
0
5073
10407
14551
20126
20095
19222
22380
20220
FERTILIZATION
BEGINS IN
1984
1980
1981
1982
1983
1984
1985
1986
1987
STOCKING YEAR & DENSITY (FRY/HECTARE)


LEISURE LAKE SMOLT PRODUCTION
PRE-ENRICHMENT
ENRICHMENT
Age 1.
Age 2.
SMOLT BIOMASS (KG x 1000)
2.8
2.4
2.0
1.6
1.2
0.8
0.4
0
80
81
82
83
84
85
86
87
OUTPLANT YEAR

SUMMARY OF LEISURE LAKE PROJECT

	Pre-Enrichment	Enrichment
Stocking Density	~2 Million	~2 Million
Number of Age 1.	~113,000	~752,000
Number of Age 2.	~142,000	~7,100
FW Survivorship	13%	38%
Age Composition	44% Age 1.	99% Age 1.
Age 1. Size	1.5 g; 58 mm	3.0 g; 75 mm
Age 2. Size	3.5 g; 76 mm	11.0 g; 111 mm
Age 1. Biomass	140 Kg	2,213 Kg
Age 2. Biomass	310 Kg	78 Kg


CHENIK LAKE SOCKEYE SALMON RETURNS
1920's to Present
RETURNS (Thousands)
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
10 YR AVG RTN FOR 1920–1930
1964 EARTHQUAKE
STOCKING
FISH PASS
1920 1930 1940 1950 1960 1970 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992
Return Composition
EST. ESCAPEMENT
COMMERCIAL HARVEST

AQUACULTURE WATER MANAGEMENT USING VARIABLE SPEED DRIVES

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INTRODUCTION

Whether you are producing products for public species enhancements, or for profit, the need to maximize the resources of a facility are paramount. I would like to introduce a technology that can be a substanial resource management tool, whether it be labor, water, electricity or operating within ever changing effluent standards regulations. This technology is variable speed drives. The technology, its applications in aquaculture and resource savings through its use will be discussed.

What Are Variable Speed Drives ?

Variable speed drives are electrical power controllers that control motor speeds through digital pulse width modulation techniques of the incoming ac power. They directly replace existing motor starters and can control single or three phase electrical loads from 1 hp to 125 hp. See *Figure* 1.

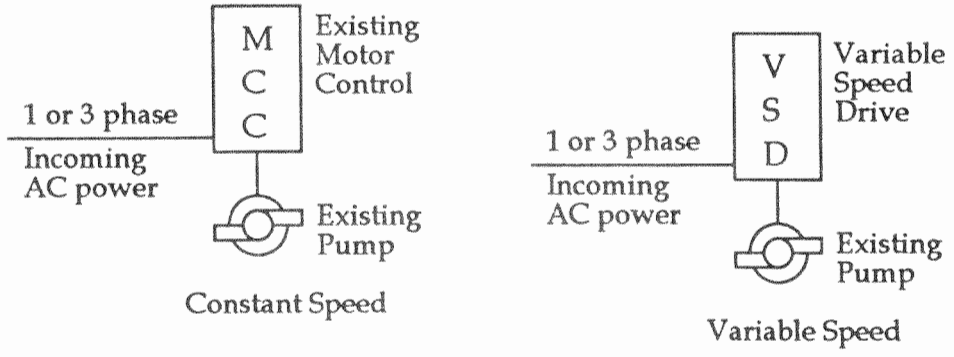


Figure 1

AQUACULTURE APPLICATIONS

1. Temperature Control - Variable speed drives can be used to mix different temperature water sources to produce an adjustable tempered source. The water sources can be mixed or isolated through the use of heat exchangers as shown in *Figure* 2. Heat exchangers allow the aquaculturist to make use of hot water sources that would normally be undesirable for direct use, as is the case with power plant turbine cooling ponds where a large amount of debris exists in the water. Another might be a geothermal source that has high mineral concentration or other undesirable elements.

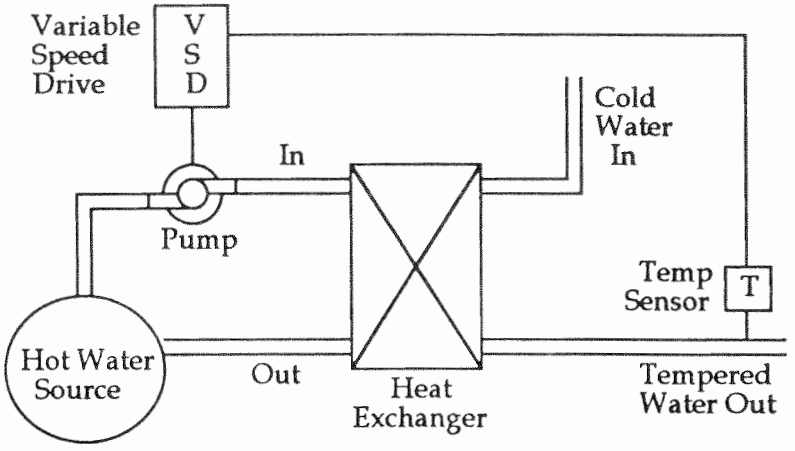


Figure 2

Another method of temperature control with variable speed drives is directly mixing two different temperature sources as shown in *Figure* 3.

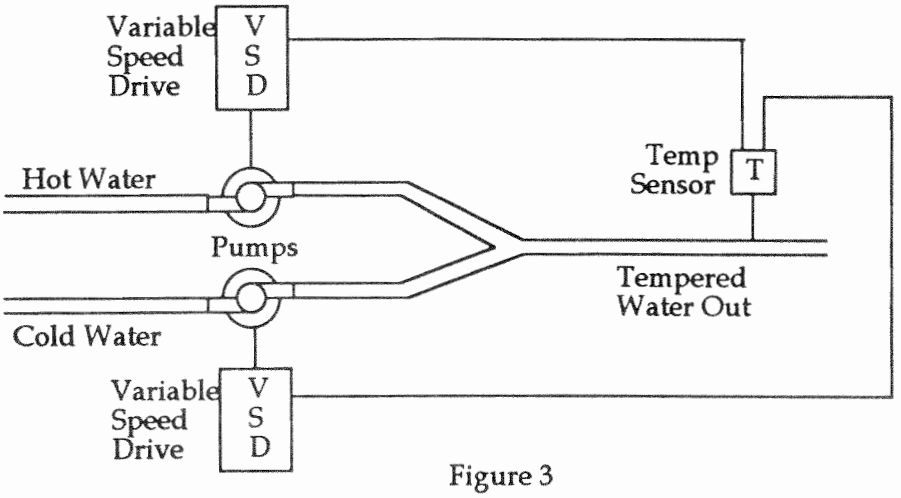


Figure 3

Taking *Figure* 3 a step further, a flow meter could be added to the tempered water line which would allow both the flow rate and temperature to be controlled.

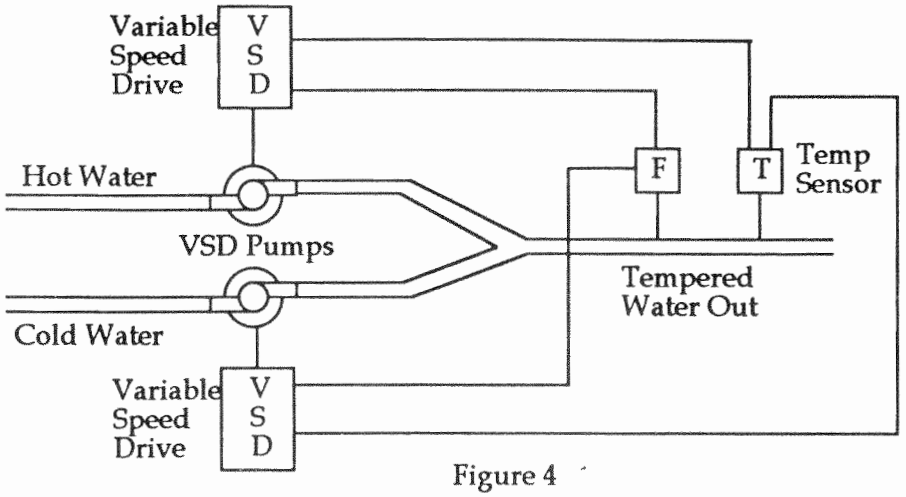


Figure 4

2. DEGAS TOWER LEVEL CONTROL - Variable speed drives can control levels such as in a degas tower. This not only controls the tower level but it allows downstream valves to raceways and tanks to be closed or opened without the need to worry about the supply source. See *Figure* 5.

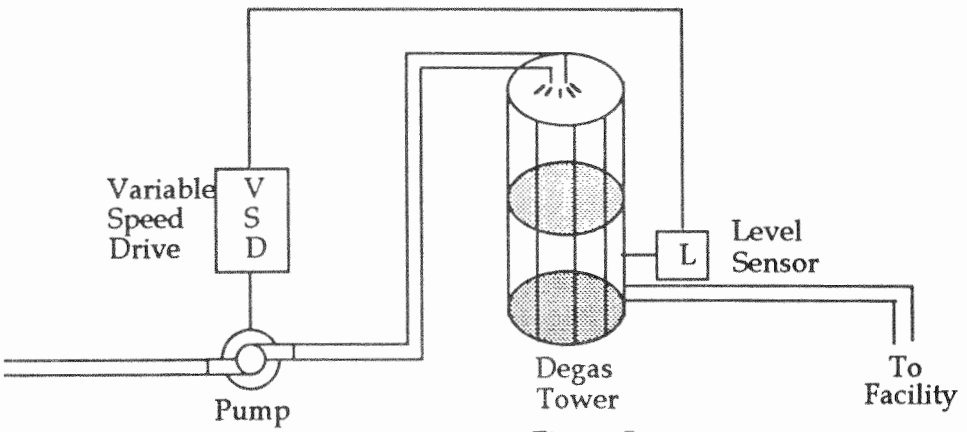


Figure 5

3. WATER EXCHANGE RATE CONTROL - The task of trying to balance the hydraulic or waste removal, and the biological or D.O. demand in a tank or raceway, is one of constant rebalance. Water distribution systems in hatcheries vary widely, but one constant is that the facilities pumping system capacity has been designed for a projected maximum poundage production. Unfortunately, this water capacity-poundage requirement is valid for only for a limited time during a production cycle. This means that the majority of the time the facility is probably wasting a substantial amount of water and power trying to throttle water flow with valves to control the exchange rate. Facilities that have multiple pumps to supply the water, still have resource losses during the year when one pump is not enough, and two pumps is too much. Another resource loss occurs every time labor is used to rebalance water flows to a set of tanks or raceways when one is put in or taken out of service. The following *Figures* will show how variable speed drives can to help eliminate this resource loss.

Figure 6 shows a constant pressure system. This system utilizes a variable speed drive, a pressure sensor and calibrated orifices at each outlet to maintain a constant pressure and known flow.
The system operates in the following manner. The distribution supply pressure is adjustable and maintained by the variable speed pump. With a known pressure, a calibrated orifice can supply a known CF/hr exchange rate. Each orifice is sized to supply the maximum CF/hr exchange rate for the tank or raceway served. Without changing orifices, the exchange rate can be adjusted upwards of 3 times the lowest exchange rate by simply changing the system pressure setpoint. To set a different known exchange rate, you would look in the flow table supplied with the orifice and find the CF/hr you want and then set the system pressure setpoint. This is assuming you want to change the exchange rate on all the tanks currently in service. If you want an individual tank exchange rate to be different than others, you might have a couple of different orifices to provide the exchange rate desired for a given pressure. You would simply change the orifices to meet your requirements. This type of system allows you to put in or take out of service individual tanks or raceways without effecting the exchange rate in other tanks. As an example, if you close off a tank, the system pressure would increase and the variable speed pump would slow down to adjust the system pressure back to setpoint.

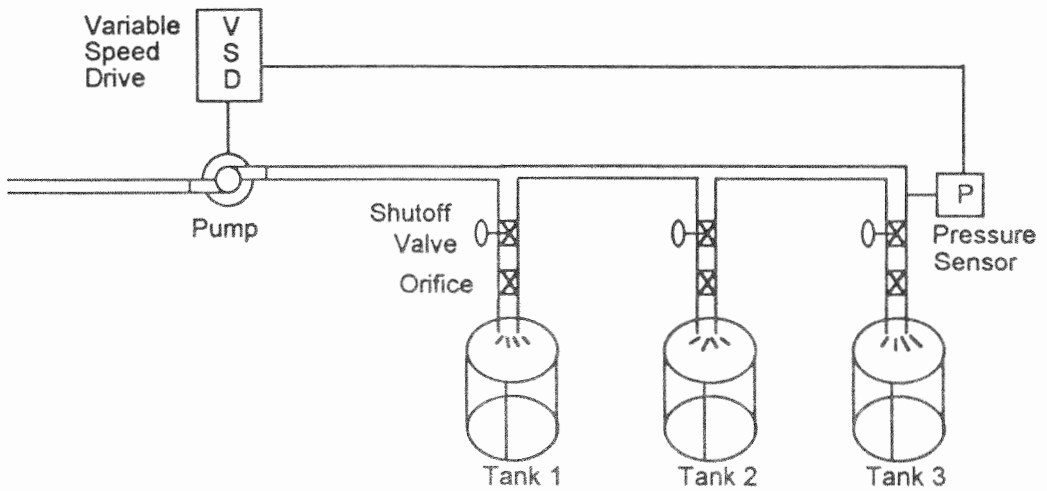


Figure 6

Figure 7 shows a system with a head box using gravity to feed the tanks or raceways. The head box level is controlled by the level setpoint with a variable speed drive and a level transducer. All head boxes have an overflow outlet and on a constant speed pump system a substantial amount of water is over flowed during a production cycle. Even if this over flow water is returned to a reuse sump the power to lift that water to the head box is wasted. A better option would be to control the level in the head box just below the over flow. The system would allow tanks and raceways to be put into and out of use without wasting power or water. If the system has multiple pumps, the pump that meets most of your water demand would become the variable pump. As the water demand exceeds the variable pump capacity, a constant speed pump would be turned on to provide the make up. The variable pump would still be controlling the head box level and would back down the water flow to control the level. This allows each pump's output to be maximized with little waste of power or water.

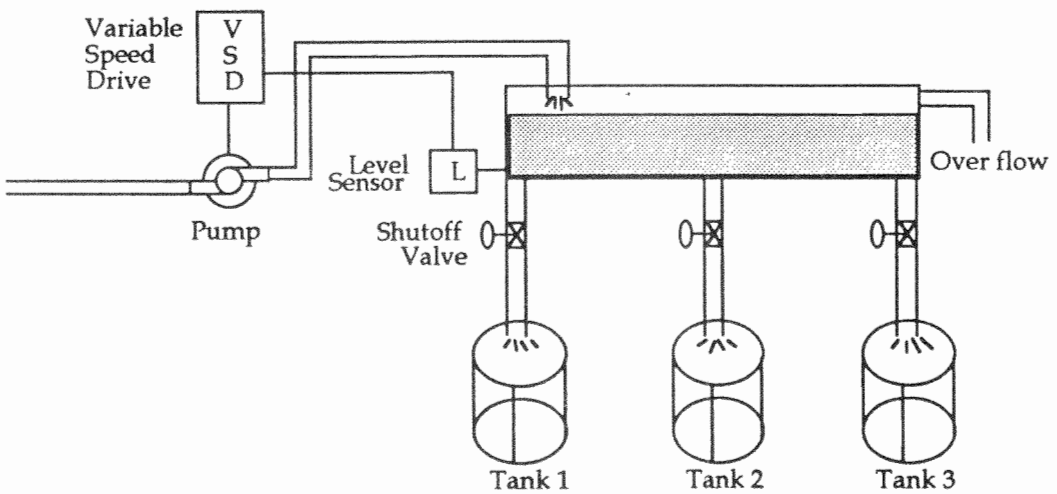
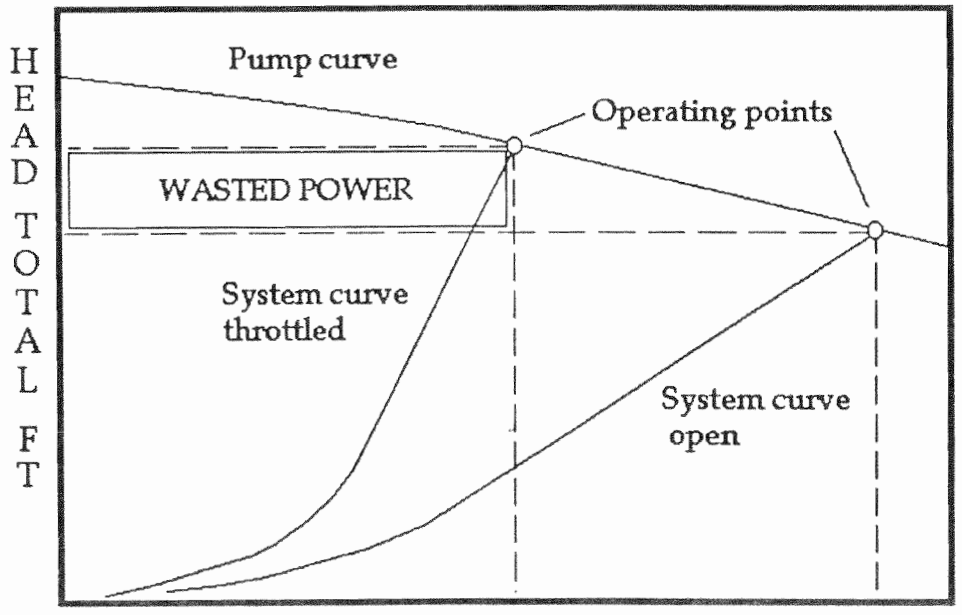


Figure 7

AQUACULTURE APPLICATIONS SUMMARY - There are a variety of ways to apply variable speed drive technology in your facility to improve efficiencies and reduce operating cost. I have tried to show a few. Each facilities water system needs to be viewed as a whole to see how this technology would be best applied for the maximum benefit. One commonly asked question is, "what happens if the sensor or variable speed drive fails". Should a sensor fail there would be no output signal and the variable speed drive, if setup properly, would go to 100% and operate at a constant speed. This would insure that maximum water flow would be supplied. For the second part of the question, "What if the variable drive speed fails?". If the drive is equipped with a breaker-bypass option, you can automatically switch to bypass and reroute the power around the variable controller and supply maximum power to the pump. This would allow servicing of the variable controller while still supplying water to the facility. Now that we have covered some of the applications, I would like to discuss the power savings possible with this technology.

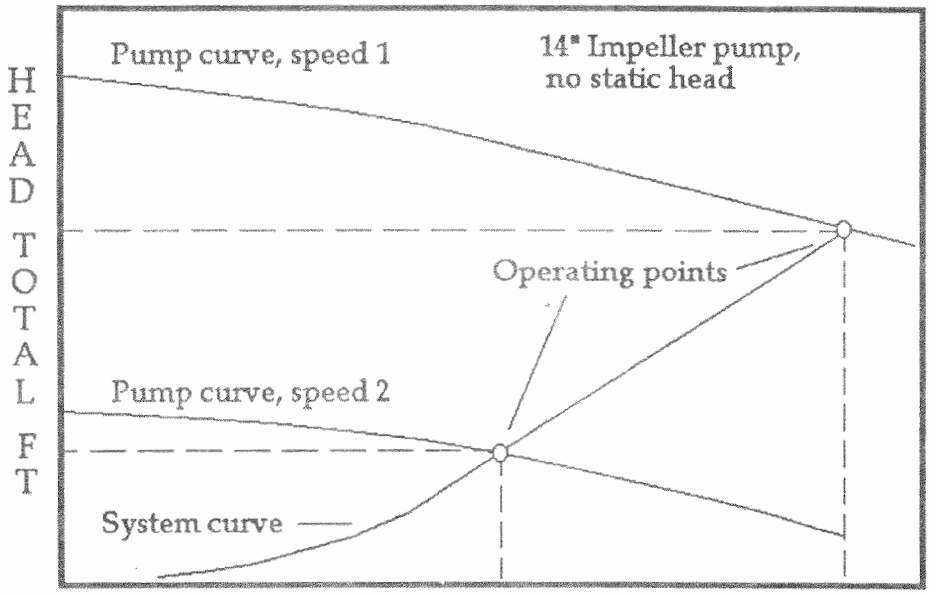
VARIABLE SPEED DRIVE SAVINGS - This is a comparison of a throttled system using valves to control water flow versus a variable speed drive to control the same flow rates. The comparison is based on a 25 hp, 1150 rpm, 14 impeller pump. System static head is considered 0 Ft for these comparisons. When talking about water system curves there are basically two curves. One is called the pump curve which is the pump impeller head curve, the other is the system curve. The system curve is based on pipe length. elbows, fittings, etc. *Figure* 8 shows two different system curves and one pump curve to produce the two flow rates. The throttled system curve line shows a partially closed valve which effectively increases the system head and, in turn, decreases the flow. The open system curve line shows an open valve which decreases the system head and, in turn, increases the flow. The intersection of the pump curve and the system curve is called the natural operating point, because the pump pressure matches the system losses



TYPICAL PUMP AND SYSTEM CURVES FOR PUMP WITH THROTTLING VALVE FOR FLOW CONTROL

Figure 8

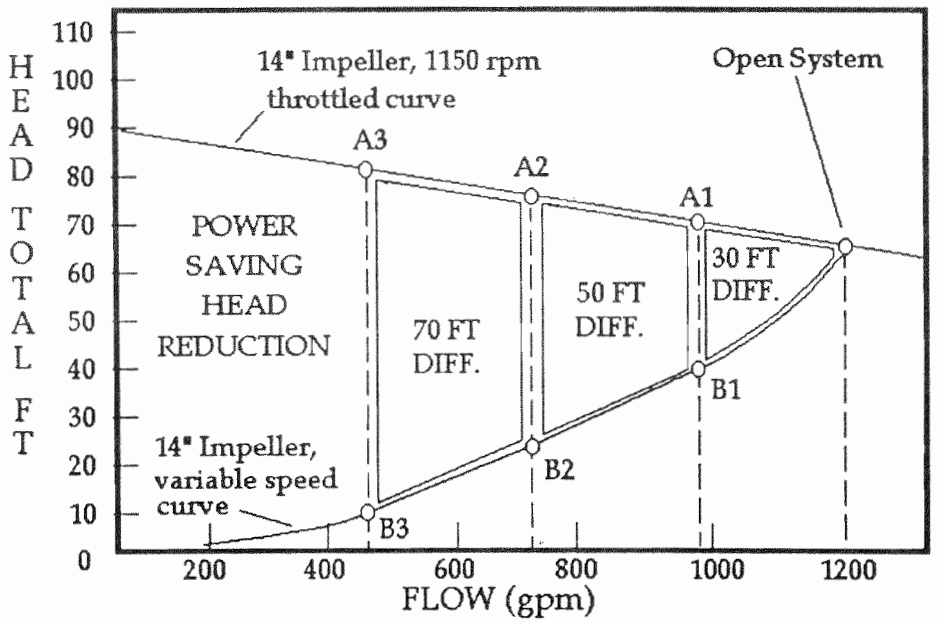
Figure 9 shows two different pump curves and a system curve using variable speed drives. The system curve stays the same as the open system curve in *Figure* 8, but the pump curve characteristics change with a change in speed. Pump curve speed 2 illustrates that the lower gpm flow operating point can be met with considerably less head when using a variable speed drive than in *Figure* 8 .



TYPICAL PUMP AND SYSTEM CURVES FOR VARIABLE SPEED PUMP FOR FLOW CONTROL

Figure 9

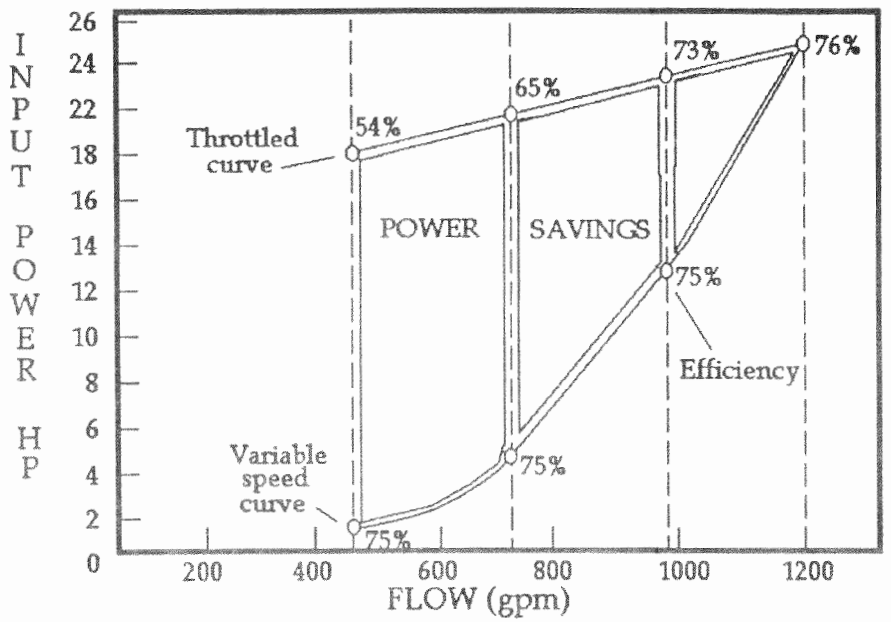
Figure 10 compares a throttled pump versus a variable speed pump at three operating points and illustrates the dramatic head reduction at the lower flow rates. As an example between points A3 and B3 there is a 70 FT head reduction when using a variable speed drive to obtain the low flow rate. This is still based on the 25 hp pump operating with no system static head.



HEAD COMPARISION OF PUMP AND SYSTEM CURVES FOR THROTTLED PUMP AND VARIABLE SPEED PUMP

Figure 10

Figure 11 compares the actual horsepower required to produce the same three flow rates as in *Figure* 10. The percent numbers on the graph are pump efficiencies. The variable speed pump maintains a pump efficiency of 75% while the throttled pump is only 54% efficient at the lowest flow rate. It takes 2 hp versus 18 hp to produce 480 gallons per minute when using a variable speed pump.



COMPARISION OF PUMP HORSEPOWER REQUIREMENTS FOR THROTTLING AND VARIABLE SPEED METHODS

Figure 11

Figure 12 below is a cost comparison to operate both pumps based on these flow rates for one year.

POWER COST COMPARISON

CONSTANTS : MOTOR EFFICIENCY = 85%,
MONTHLY OPERATING HOURS = 720
POWER COST = 7 CENTS PER KILOWATT HOUR

THROTTLED METHOD	
FLOW RATE	% OF TIME
1200 GPM	10%
960 GPM	40%
720 GPM	40%
480 GPM	10%
	100%

VARIABLE SPEED METHOD	
FLOW RATE	% OF TIME
1200 GPM	10%
960 GPM	40%
720 GPM	40%
480 GPM	10%
	100%

YEARLY OPERATING COST
$11,625

YEARLY OPERATING COST
$2,978

YEARLY OPERATING SAVINGS
$8,647

TYPICAL VARIABLE SPEED DRIVE COST PLAYBACK IS 12 MONTHS

Figure 12

VARIABLE SPEED DRIVE SUMMARY -

Using variable speed drives in an aquaculture facility can provide the following results

1. Elimination of flow imbalances between tanks or raceways
2. Provides accurate adjustable water exchange rate control
3. Reduces flow system rebalance labor
4. Reduces effluent loads
5. Eliminates water and power waste.
6. Substantially reduces power operating cost on a permanent basis
7. Variable speed drive cost payback is typically 1 year or less
8. Provides a positive cash flow capital investment

In short , this is the only technology I know of for an aquaculture facility that can pay for itself, eliminate water waste and provides a valuable resource management tool. This technology provides such benefits that every aquaculture facility should have a site application evaluation done to determine what the benefits and payback period are.

USE OF CLINOPTILOLITE MEDIA IN A BIOLOGICAL FILTER AT LAHONTAN NATIONAL FISH HATCHERY

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INTRODUCTION

Since 1973, the Lahontan National Fish Hatchery has been utilizing a submerged bed biological filter system to recondition and recycle approximately 74% of its water used for the production of Lahontan cutthroat trout. The lack of sufficient flow, extremes in water temperature, and the presence of whirling disease in the East Fork of the Carson River, the hatchery's original water source, forced a need to develop a water re-use system for fish production. The system consists of 36, 8x80 raceways, three 10x95 brood ponds, a biological filter, 12 foot aerator tower, and pump station. No provision exists to operate the incubators or hatchery tank room on reuse water; this option is only available with the outside raceways. In the spring of 1991 the bio-filter was modified in an effort to improve ammonia removal efficiency. The modification consisted of dividing the three existing filter bays into six, reversing the pattern of flow to downflow, and replacing the 1 1/2 inch plastic Koch ring media with 5 X 3/8 mesh clinoptilolite rock.

Clinoptilolite, a natural zeolite, has the ability to selectively absorb ammonium ions. As a physical-chemical process, through ion exchange, it has been used to remove ammonia in waste water treatment systems. Its application in fish culture systems has also been described (Johnson and Sieburth, 1974; Smith et al., 1981; Piper and Smith, 1984; Horsch, 1984; Bruin, et al, 1981; Williams, undated). The advantage of using the physical/chemical process in a fish culture system is that ammonia removal is not dependant on temperature, water chemistry or affected by chemical treatments. There are, however, operational aspects associated with using clinoptilolite media in the ion exchange process that detract from its use: the need for frequent regeneration of the media by backflushing with a brine solution, storage of the brine, maintenance of the backflush system and its related plumbing, and regeneration or disposal of the toxic brine solution after backflushing. A biologically mediated filtration system offers a relatively less complex solution for water reconditioning.

A variety of media have been used in biological filters designed to recondition water for fish rearing (Meade, 1976; Owsley, 1977). They include rock and oyster shell, expanded shale, plastic rings, polystyrene beads, polyvinyl chloride modules, etc. Clinoptilolite has also been found to function satisfactorily as a bio-filter medium (Horsch and Holway, 1983; Horsch, 1984). The Pyramid Lake Paiute Tribe has been operating a water recycle hatchery using clinoptilolite media in biological filters since

1986. Clinoptilolite media was chosen for the Lahontan National Fish Hatchery bio-filter system in an effort to improve ammonia removal efficiency.

BIO-FILTER OPERATION

Filter Bed Design and Cleaning:

The bio-filter consists of six individual bays. These bays operate in parallel, but any one may be taken off line for cleaning. Within each bay are eleven inches of clinoptilolite media over six inches of two-inch-plus rock cobble, supported by an aluminum grid. A total of 376 square feet of bed surface area is provided within each bay. Underneath the aluminum grid is a PVC pipe manifold that operates as an air lift pump system for cleaning solids from the media. As the air lift system operates, a stand pipe is removed to direct the cleaning effluent to settling ponds.

During operation, several changes regarding cleaning procedure were made to ensure proper function of the bio-filter. At the start of operation each of the six bays were aerated and flushed once a week for at least twenty minutes. Within the first month of operation, it became apparent that more cleaning was necessary. Solids accumulating at the surface of the filter bed were restricting the flow as evidenced by a steady increase of water head in the filter beds. The daily cleaning time was increased up to forty and fifty minutes. By March it was necessary to increase the frequency of cleaning to twice per week. Twice during operation, in November and February, all the filter beds were taken off line one at a time so they could be cleaned, flushed, and completely drained so solids that had accumulated within and below the media could be removed. At the end of the rearing season the bio-filter beds and filter bays were thoroughly cleaned and then disinfected with a chlorine solution at a level of 250 ppm.

Hydraulic loading:

Flow to the bio-filter is maintained by two pumps providing an estimated 3,200 gpm. This flow provides a hydraulic loading of 1.4 gallons per square foot of surface area per minute and a retention time of 50 minutes. Flow to the raceways includes 1,130 gpm of well water plus 3,200 gpm returning from the bio-filters through the 12 foot aeration tower. This represents the typical configuration for system operation at 74 % water re-use. Two additional wells, at 600 gpm and 325 gpm, are available to adjust the volume of make up water. Two additional reuse pumps, at 1,600 gpm each, are available to control flow through the bio-filter.

System Monitoring:

Influent and effluent ammonia nitrogen (NH4-N), nitrite (NO3), and oxygen concentrations were monitored weekly or more frequently during periods of bio-filter cleaning and when changes in flow were made. Ammonia determinations were made using the Nessler technique. Nitrite was determined using the colormetric diazotization

method. Oxygen levels were monitored using a Nestor instruments, Model 8500, portable dissolved oxygen meter.

System Loading:

The new bio-filter was put into operation on July 26, 1991 and operated until April 14, 1992 for a total of 270 days. The bio-filter was not conditioned prior to its use; but, was brought on line as the fish were put into the raceways. Garden soil was used to inoculate the bio-filter with nitrifying bacteria. Fish were transferred to the 8X80 raceways when they were two inches in length. They were then transitioned from fresh water to re-use water during a period of 28 days. The initial fish load on the system was approximately 1,500 pounds. Although fish were removed from the system each month starting in December, total weight on hand continued to rise through February. Peak fish load occurred in February and was estimated to be 52,000 pounds based on the weight on hand at the end of the month and the weight of fish distributed during the month (Figure 1 and Table 1).

Table 1. Monthly system loading, bio-filter flow, and average percent ammonia nitrogen (NH4-N) removal for clinoptilolite media bio-filter operated at Lahontan National Fish Hatchery during 1992.

Month	Fish (lbs)	Feed (lbs)	Flow (gpm)	NH4-N (ppm)	% NH4-N Removal
Aug	4,950	4,951	3,200	0.20	11.0
Sep	9,657	5,300	3,200	0.21	19.0
Oct	15,966	5,750	3,200	0.27	18.5
Nov	21,693	6,750	3,200	0.32	28.1
Dec	29,408	10,200	3,200	0.60	28.3
Jan	41,556	12,600	4,800	0.69	15.9
Feb	40,382	16,000	4,800	0.74	18.9
Mar	14,438	9,750	3,200	0.44	11.4
Apr	18,558	2,300	3,200	0.23	4.3

Ammonia Production and Removal:

As fish biomass increased in the system and the feeding rate increased, the monthly average concentration of total ammonia nitrogen (NH4-N) leaving the rearing units and entering the bio-filter steadily increased (Figure 2 and Table 1). Monthly average NH4-N production rose from 0.2 ppm in August to a high of 0.74 ppm in February. It began a decrease to 0.44 ppm in March and 0.23 ppm in April as the weight of fish in the system was reduced due to an increase in fish distribution trips (Figure 1 and Table 1).

Periodic monitoring of the fish by the U.S. Fish and Wildlife Service, California/Nevada Fish Health Center did not indicate any apparent problems associated with ammonia

toxicity. Based on the average temperature of 11.1 Centigrade for February and a pH of 7.8, the level of unionized ammonia (NH3) in the rearing unit effluent was estimated to be 0.0116 ppm. This is below the 0.0125 ppm level reported to cause a decline in trout quality.

The monthly average NH4-N removal rate rose from 11 % in August to a high of 28.3 % in December, following an increase in system loading. However, as the system load continued to increase, the removal rate decreased to 15.9 % in January and 18.9 % in February. In March and April the removal rate further decreased to 11.4 % and 4.3 %, respectively.

The rate of ammonia removal by a bio-filter is affected by a combination of factors: organic and nutrient loading, temperature, pH, oxygen concentration, retention time, and hydraulic loading (Liao et al., 1972). The drop in removal rate during March and April is expected since fish weight was significantly reduced and the concentration of ammonia entering the bio-filter was low. The approximately 38 % drop in ammonia removal rate during January and February, a period of peak loading, is mostly attributed to a decrease in bio-filter retention time (Figure 1 and Table 1). An increase in organic nutrient loading at this time may also have contributed to the drop in removal rate.

On January 3, a third reuse pump was turned on in an effort to reduce the load factor on the fish in the system. In past years, when the weight of fish in the system exceeded 30,000 pounds, an additional well (600 gpm) was turned on to supplement 1,130 gpm fresh water flow. The addition of the third re-use pump increased flow through the bio-filter from 3,200 to 4,800 gpm. This resulted in increasing the hydraulic loading of the filter bed from 1.4 gallons per square foot per minute to 2.1 gallons per square foot per minute and a reduction of retention time by one third (50 minutes vs. 33 minutes). Operation of the bio-filter during the rearing of the 1992 year class will be designed to maintain the flow rate and hydraulic loading at the lower values in an attempt to test the system's capability.

Oxygen:

The pattern of dissolved oxygen concentration showed a steady decrease over time dropping from a high of 9.0 ppm to 7.6 ppm (Figure 4 and Table 2). The decline during the early part of bio-filter operation is attributed to the increase in ammonia oxidation. The continued decline observed in March and April, as fish load was reduced, is attributed to biological activity associated with an increasing organic nutrient load in the clinoptilolite media. Although, solids are removed from the re-use system by cleaning one half to one third of the raceways daily, an undetermined amount of organic matter reaches the bio-filter. The downflow pattern and the low void space of the clinoptilolite media combine to promote accumulation of organic matter in the bio-filter. A high level of organic loading could result in an increase in the population of heterotrophic bacteria over the autotrophic bacteria within the bio-filter,

causing a reduction in ammonia removal efficiency and further increasing oxygen demand.

Furthermore, because there exists a potential for solids to obstruct and channel water flow within the filter bed, anoxic areas could be created. This could result in the production of hydrogen sulfide gas. Hydrogen sulfide gas is lethal to fish at very low concentrations. A total loss of the 1986 year class Lahontan cutthroat trout at the Pyramid Lake Fisheries' Numana hatchery was attributed to hydrogen sulfide production within the clinoptilolite filter beds (Paul Wagner, Pyramid Lake Fisheries, personal communication). They corrected the problem by reducing the depth of the clinoptilolite media in the filter bays and by increasing the frequency and intensity of filter bed cleaning.

An environment favorable to the population of autotrophic bacteria must be maintained within the bio-filter for it to function properly. The relation of organic loading, retention time, and bio-filter cleaning regime to the rate of ammonia removal in the Lahontan National Fish Hatchery system needs further consideration so operational procedures can be developed to ensure proper function of the re-use system.

Nitrite:

The concentration of nitrite (as NO3) in the bio-filter effluent remained below the 0.15 ppm level reported to be toxic to yearling trout (Figure 5 and Table 2). The highest monthly average concentration (0.084 ppm) was observed during the first month of operation. The second peak occurred in January at 0.060 ppm. Transient peaks of nitrite in a reuse systems are characteristic in a bio-filter, particularly during startup of the system. The level and frequency of the peaks diminish as the population of nitrifying bacteria becomes developed and the system stabilizes. No apparent problems due to nitrite were observed.

Table 2. Average monthly concentration in parts per million of oxygen and nitrite during operation of clinoptilolite media bio-filter at Lahontan National Fish Hatchery, 1992.

	Nitrite (NO3)		Oxygen	
Month	**in**	**out**	**in**	**out**
AUG	0.066	0.084	8.9	9.0
SEP	0.062	0.076	8.6	8.7
OCT	0.041	0.049	8.7	8.9
NOV	0.032	0.037	8.2	8.3
DEC	0.039	0.046	8.6	8.5
JAN	0.050	0.060	7.8	7.8
FEB	0.040	0.050	7.8	7.8
MAR	0.030	0.030	7.7	7.4
APR	0.010	0.010	7.7	7.6

Summary:

The operation of the bio-filter using clinoptilolite media indicates a higher rate of ammonia removal when compared to the previous four year average (1988-1991) for the 1 1/2 inch Koch ring media (Figure 6 and Table 3). It is difficult to determine if the higher removal rate is due to the clinoptilolite media itself. It simply may be due to an increase in the surface area provided by the small particle size of the media, or it may be associated with the higher ammonia concentration in the bio-filter influent; a result of a higher feeding rate during the rearing of the 1991 broodyear. Approximately 10,000 pounds more feed was fed and the ammonia concentration, at peak loading, was 0.2 ppm higher with the clinoptilolite media than for the previous four year average for the 1 1/2 inch Koch rings.

Proper function of the bio-filter is essential for successful operation of the Lahontan National Fish Hatchery program. During the 1992 season 80,386 pounds of fish were produced on 26 % of the water normally required by a hatchery of its size.

Table 3. Comparison of monthly average percent ammonia removal between clinoptilolite media and four year average (1988-91) for 1 1/2 inch Koch rings.

Percent Ammonia Removal

Month	Clinoptilolite	Koch Rings
Jul	0.0	20.0
Aug	11.0	17.0
Sep	19.0	9.0
Oct	18.5	8.0
Nov	28.1	16.0
Dec	28.3	9.0
Jan	15.9	12.0
Feb	18.9	10.0
Mar	11.4	15.0
Apr	4.3	0.0

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Increased Effluent Standards Impact Hatchery Design

SLIDE 1

The decade of the ninety's has been labeled by many as the environmental decade. Some call it the green revolution. Industries are becoming environmentally conscious either by voluntary or involuntary means.

And so, the Aquaculture Industry is coming under increasing scrutiny as water resources become limited due to population growth. A dilemma exists today because as these water resources become limited, you the fish culturist are called upon to simultaneously "clean up your act" and produce more fish to meet population demands. This predicament is further compounded by society's demands for a more "natural fish". The theme of the AFS Conference in South Dakota, last September was "Fish culture in the year 2000". In the decades to come, the industry will be challenged to produce a more "natural fish". This challenge is a tremendous opportunity to increase our knowledge in all realms of fish culture. It will certainly force us to cast away many traditional culture methods and technology as new ones replace them.

In essence what I'm saying is the pressure is on! But in order to meet these challenges the Aquaculture Industry must first identify the problems it faces.

Removing solids from the water is only the tip of the iceberg. We must delve deeper to identify and define this problem.

SLIDE 2

Little is known about the impacts fish farm effluent has on receiving waters. This is where we must begin the task of identifying the problem and indeed we are already learning a great deal about these impacts. But how can we develop and enforce the kind of effluent standards society currently demands when we are still gathering information in order to base meaningful conclusions on relevant data. Unless we gain a thorough understanding of these impacts, the result could yield unrealistic effluent standards. And I think everyone in this room understands what that would mean to the industry.

SLIDE 3

Lets take a look at a few states effluent standards. These proposed rules apply to any facility producing more than 20,000 pounds of fish a year either on land or in cages. Additional regulations were proposed to control D.O. at minimal levels of 3 ppm in the lower hypolimnion and 5 ppm in the upper hypolimnion. The Minnesota Pollution Control Agency stated in its introduction to the rules changes "From an environmental standpoint aquaculture has the potential to adversely impact the environment and water quality through deposition of fish waste and excess fish foods in waters of the state.

SLIDE 4

On the other hand, Pennsylvania has divided its territory into a number of regions. Discharge limits vary from region to region depending upon the existing condition of the receiving waters and to some extent the waters ability to assimilate the waste. All states should recognize that uniform regulations are not an appropriate means of addressing the problem. We must recognize a fish farm can have an overall positive or negative impact on its receiving waters.

SLIDE 5

To define the problem we must standardize collection procedures and choose a set of tests and methodology for administering them. This is essential to defining the problem and proposing solutions.

We must quantify solids, phosphorus and nitrogenous waste.

The literature confirms this is a critical need because currently there exists such wide variations in the test results. The multitude of variables, such as feed quality, and type, amount of fish produced, species reared, standing crop and so on make it difficult to draw conclusions from the data. We must come to know what we are dealing with before looking for solutions.

Now, I have attempted to identify and define some of the major elements associated with increasing effluent standards and I'm sure I left some things out. But these are just two of the steps of the process.

SLIDE 6

The next step is to propose solutions to meet future effluent standards. To do this we must invest in technology specifically designed for treating fish farm effluent. Most of the technology available today is borrowed from other industries which are far older than ours.

SLIDE 7

Settling solids is by far the most common practice. Variations such as false floor and baffling hold some promise but they do not appear to be the total long term answer.

SLIDE 8

Settling requires large amounts of space and capital. Storage and handling of the waste are recurrent expenses and will only increase as we progress into the 90's. Another limitation is that nutrient leaching lessens the effectiveness of settling solids.

SLIDE 9

Microscreening is a promising technology and seems to be gaining wider acceptance lately in North America. This particular application is at the outflow of a Danish trout farm.

SLIDE 10

Highly regarded as the most effective solution for handling solids in many parts of Europe, microscreening enables Danish fish culturists to meet stringent effluent standards such as these before you. The concept behind microscreening runs countercurrent to settling in that it removes solids from the rearing waters as quickly and as gently as possible.

SLIDE 11

Microscreens require less space and in many cases can be less expensive than a well designed settling basin. Microscreens can also be retrofitted with finer screens so that as effluent standards become more stringent, the filters can still meet or exceed the regulations with little additional capital cost.

SLIDE 12

Meeting the effluent standards of the future will require refining fish diets to lower phosphorus, and improve digestibility. Improving feeding practices and feeding apparatus will also play a major role in the end.

SLIDE 13

Choosing the proper solutions will be difficult. The answers will not likely be obvious ones. However, if we do our homework the chances of us getting it right will be greater.

SLIDE 14

The final step is to implement the solutions. By taking a proactive posture we will command more control over the process. We must take steps to solve these problems, investing time and money in R&D, grants and committees.

SLIDE 15

To summarize:

Little is known about the impacts fish farm effluent has on receiving waters.

We must standardize collection procedures and choose a set of tests and methodology for administering them.

Quantify solids, phosphorus and nitrogenous waste.

Recognize that uniform regulations will no work.

Develop technology specifically targeted for treating fish waste.

We must refine fish diets to lower phosphorus, and improve digestibility.

Take a proactive posture rather than a reactive one.

These problems are not insurmountable but the aquaculture community must actively involve itself to solve them.

MECHANICAL FILTRATION METHODS FOR AQUACULTURE

ABSTRACT

In the effort to condition water for aquatic culture systems, growers have employed various methods of mechanical filtration for the removal of undesirable solids from the culture water. This report initially overviews mechanical filtration methods currently found to be in use as well as possible systems that would be appropriate. Design parameters are outlined and discussed. A discussion of practical experience with different processes are presented. An evaluation of the effectiveness of solids removal, operation & maintenance, and capitol expenditure are presented and compared.

INTRODUCTION

In the preparation of this report it became apparent that many "possibilities" of processes could be embraced and applied to numerous forms of aquaculture. For the sake of producing a work that will prove useful and concise, a criteria has been adopted that examines mechanical filtration methods for fresh water systems specifically targeting finfish culture. Also a criteria of "apparent current use" of filtration technology within the bounds of fish culture will help eliminate fringe processes.

The term Mechanical Filtration as used within this work is defined as : a physical straining process as those processes containing elements which remove solids by virtue of physical restrictions with out the aid of chemical or biological alteration.

STATE OF THE ART IN AQUACULTURE for filtration can be thought of as a combination of concepts. The first premise in water quality technology is that processes already exist that can create water purity to a level of distillation that approaches absolute purity. It appears that very little is truly "new" only re-discovered in a new light.

INTEGRATION

Operators of functioning culture systems have specific problems facing them that require investment of time and capitol. The addition of any technology that unduly adds to the complexity of the system only serves to weigh down the process and lead to the demise of the facility, even if the process functions correctly. A prudent operator must be cautioned about being swept away by technology just for technology's sake.

Integration into the culture system must be carefully evaluated. Processes have failed simply because it was not fully understood what the effect that a particular process had on the culture system beyond it's specific task. In private enterprise the cost of a system must be paid back by enhanced performance within a reasonable period of time. This is less of a concern in public facilities but should be embraced simply as a proper use of the public trust.

SIMPLICITY in design and operation should be paramount. A criteria where existing situations and forces are exploited should be fully employed. Specifically in mechanical filtration applications, systems that skillfully use existing gravitational forces or the shear force of flowing water with no moving parts will prove to be

the most desirable. This is termed a passive system. Typically it is found that the finer the size of solids removal either a greater energy requirement (water pressure) is needed or a significant increase in filter surface area if water pressure is not readily available. There exists a design point in any given system where the solids removal ability of a passive system exceeds practical limits of cost, size, site restrictions, etc.. The addition of motors, pumps, drive systems and other related components must provide tangible benefits in capitol cost savings, performance, as well as operation and maintenance.

The true test of "State of the Art" will be the effective marriage of several ruling parameters, such as:

Will it do the job it is asked?

Is it cost effective?

Does it integrate with the system as a whole?

Is it energy effective?

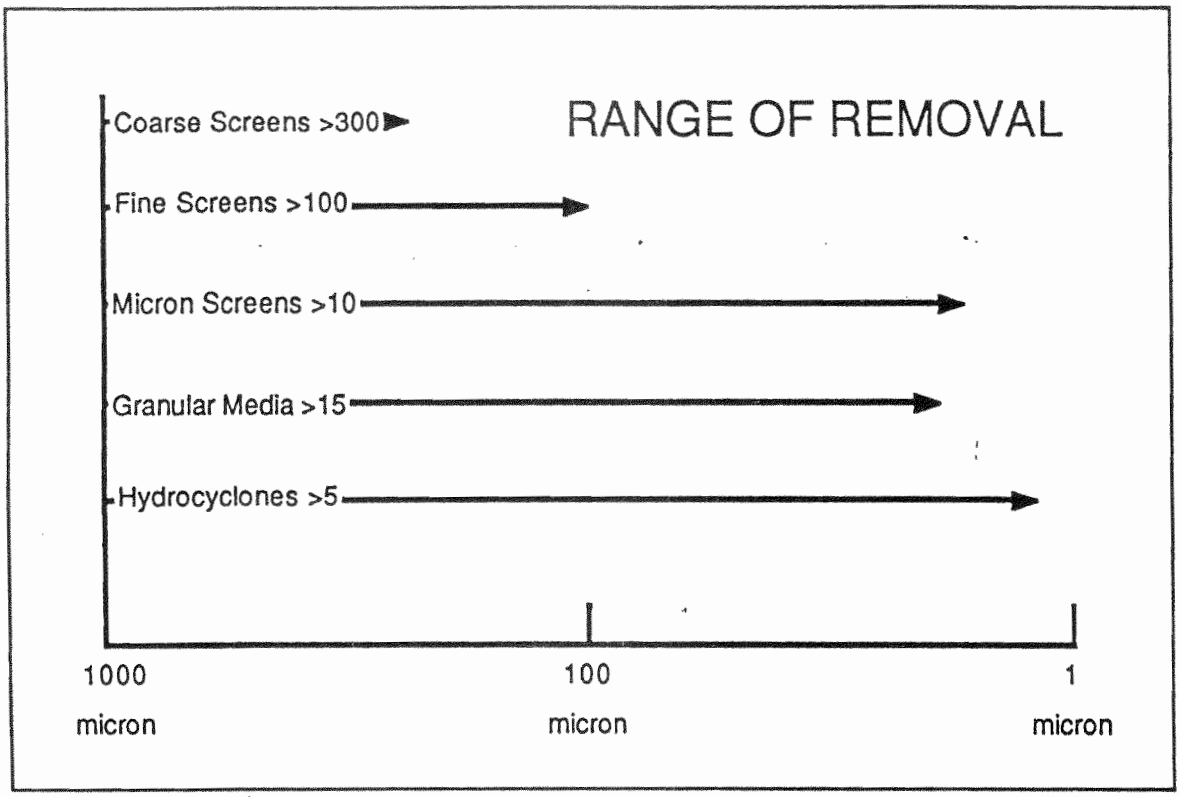
How simply can it accomplish the task?

Can the process be understood and simply managed?

CONSIDERATION OF THE PROPERTIES OF WATER TO BE FILTERED

Specifically, mechanical filtration only has the ability to remove solids that are greater than the porosity of the barrier. Velocities, related turbulence and shear force inflicted upon the water to be treated affect the solid's ability to resist being broken up by the forces employed during fluids transport and filtration.

When considering methods of mechanical filtration for water treatment an understanding of the solids to be removed is crucial


RANGE OF REMOVAL
Coarse Screens >300
Fine Screens >100
Micron Screens >10
Granular Media >15
Hydrocyclones >5
1000 micron
100 micron
1 micron

for the successful implementation of the treatment system. Because most forms of mechanical filtration are sized on pore opening, a thorough knowledge of the quantity (mg/l) and size range distribution (micron) of the solids as well as identification of individual elements will allow for proper selection and sizing of the form of filtration that will be most effective in removal.

Understanding the range of distribution will also greatly assist in selecting an alternate level of treatment if the cost of a given system prohibits the most ideal removal. For instance, if it was determined that 98% of the solids in a given water could be removed by employing a filtration system capable of 10 micron removal but the cost of that system was out of range. By going back and looking at the range of distribution it might be demonstrated that 85% of the solids could be removed (for sake of discussion, an amount of solids removal that would be deemed "acceptable" for the species of hypothetical fish raised) using a size of 20 micron filtration, causing a down sizing of the equipment which in turn fits within the constraints of the equipment budget. The size of mechanical filtration equipment typically increases in relation to decreasing size of removal against a given treatment flow rate.

In terms of how the water routes through a given system, fishculture systems are viewed as either a flow through system, re-use system, or closed system . Each variation of the system produces unique conditions of water quality which in turn influences the decision of what form of mechanical filtration is to be employed, if any.

Any operation that discharges "wastewater" into a public waterway or drainage must comply with prescribed state and federal discharge standards. Depending on the discharge requirements mechanical filtration can greatly assist in a significant level of suspended and settleable solids removal.

When the makeup water for fishculture facilities are drawn from a surface source much of the information that exists for municipal and industrial water treatment can readily be integrated. However when mechanical filtration is employed within the culture system or as effluent treatment from the facility, it is commonly reported among fish culturists that many mechanical filtration methods were simply retrofits of existing municipal wastewater treatment configurations and did not adequately take into account the unique makeup of aquaculture water. Further study by the industry, that specifically focuses on the development of methods for solids removal, is needed.

A flow through or serial reuse facility must draw water in relatively large quantities from an outside source. Water that can be easily drawn from a ground water source (well or spring) is the most ideal situation for fish culture because it is relative pathogen free, siltation free, etc. Mechanical filtration is rarely used.

Sufficient quantities of water may not be readily available from a ground water source. A surface source is typically sought out and exploited (river, lake, or reservoir). Surface water is subject to variables that affect water quality such as siltation caused by

runoff conditions, algal blooms, temperature changes, etc. Surface water is always screened or filtered.

Many river systems throughout the United States are coming under fish impingement regulations regarding the entrainment of indigenous marine life into surface water intake structures. This has caused specific design criteria for water intake structures to be adopted. The designs should consider limiting water velocities and screen openings at the intake structures allowing the aquatic life present to adequately avoid impingement and destruction.

Although there is not a consistent standard being applied throughout the United States, a compilation of most of the studies conducted has resulted in profile screen manufacturers to adopt a design criteria of water velocities passing through the slot openings not exceeding .5 foot per second and the slot opening did not exceed .125 inch (screens are typically profile wire screen). Intake screen designs incorporating these standards have demonstrated that key species of juvenile fish studied were able to successfully avoid impingement.

TYPES OF MECHANICAL FILTRATION

Mechanical filtration equipment takes on many shapes and sizes. For the most part mechanical screening devices incorporate the use of some form of "media" that acts as a barrier for the removal of the targeted solids. The media usually consists of either some form screening or the use of a given bed depth of a selected granular media.

Screening:

Screening media uses a two dimensional plane surface that is presented as a barrier to the water containing the solids. The screening material creates a restriction in pore size that will block the solids of greater size from traveling further. In an ideal condition this would be adequate. Certain solids exhibit fragile characteristics (such as fecal material and excess feed waste) that can easily be broken down by undue shear forces and turbulence. Excessive velocities of raw water applied to filter screen media can cause a breaking down of the solids allowing the solids to pass through and causing a finer distribution of the solids to be retained in the process water.

Thresholds of tolerance have typically been established empirically. The loading rate for the water flow is expressed as a relation of flow to surface area of media presented. Typically this is expressed as gallons per minute divided by square feet of media surface (gpm/ft2). This is also true for granular media filters.

Screening is further broken down into three categories; coarse, fine, and micron. Coarse screening are primarily barriers preventing debris from passing through that would seriously damage equipment down stream. Fine screening is more exactingly applied to allow for control of water velocities passing through the screen. As the need for finer solids removal is required, precision fabrics that provide micron levels of removal are used.

The screening materials are attached to frames that are designed to hold the screen media that will support the screen media while water is passing through. The design of these structures must be able to withstand the existing hydraulic force if the screen were

INTAKE SCREEN SIZING

(% open area /sg. ft.) x through slot velocity = flow

.5 fps maximum through slot velocity
.125 maximum slot opening

to become totally clogged. Site restrictions and cleaning strategies strongly influence the size and shape of the screening device. Shapes commonly used are either flat or cylindrical.

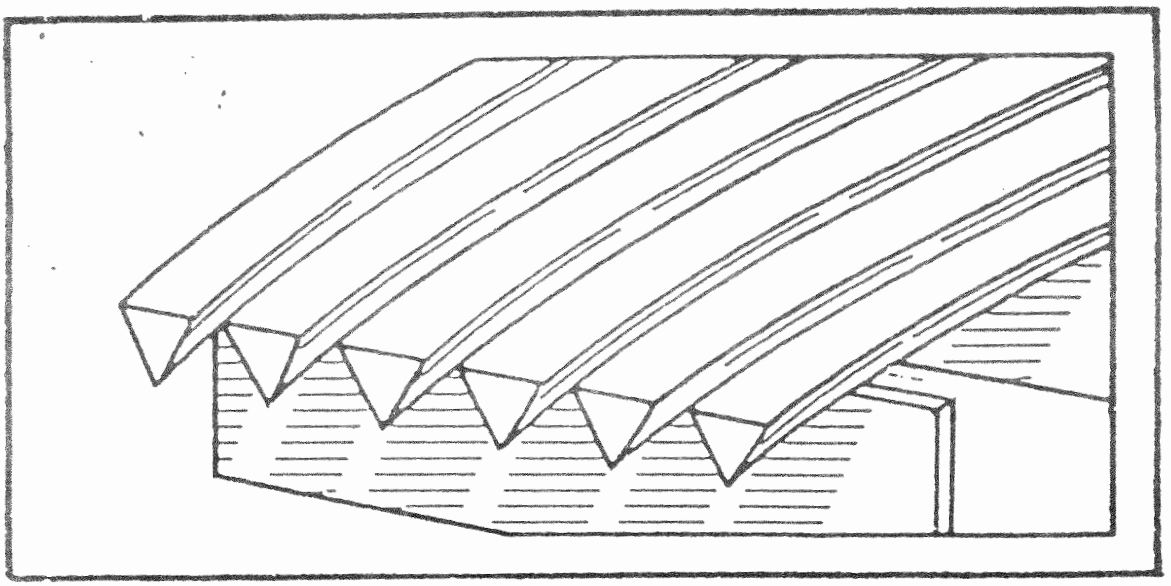
Coarse Screening:

Coarse screening is described as a physical barrier that has a porosity or slot opening greater than 400 microns. Materials that are currently in use today are: woven wire fabric, punched plate, and profile wire screen. Each material is used throughout a fish culture system and has a unique place of application where one material is superior to another. These materials are most commonly available in aluminum, stainless steel, and various plastic resins. Because of the rough duty exacted upon this stage of mechanical filtration plastic is typically not used.

Depending on the specific task and environmental variations, how these materials are used vary greatly. Two definitions are used to describe how coarse screening is applied; passive and active. These definitions primarily provide a loose distinction of the process's ability to employ existing conditions to accomplish it's task as opposed to applying further energy not occurring naturally at the site.

Passive technology employs existing hydraulic forces to keep the screening element clean of debris and inhibit clogging. Design configurations using this passive approach take on three basic shapes, 1) flat plate, 2) cylindrical, 3) side hill.

Up until the late 1970,s "state of the art" for flat plate screening primarily consisted of perforated plate with 5/16" holes



on 7/32" centers. During the 1970's Smith and Ferguson (1978) conducted tests for State of California on various materials to be considered for use on a proposed irrigation diversion project. The tests conducted by the State of California evaluating screening material showed that profile wire exhibited much higher resistance to clogging than perforated plate when used as an intake from a stream or reservoir. Perforated plate is still used in the rearing system extensively. Typically as a barrier to prevent fish from exiting the rearing unit.

State of the art use of flat plate screening material is profile wire placed in the face of an intake vault within the given water source. The slot orientation of the wire is perpendicular to the direction of the by-pass flow. By orienting the slot perpendicular to the by-pass flow the profile wire material only "see's" the slot width and can only apply the velocity that would impinge material for the duration of it's presence over the slot opening. The by-pass flow creates a hydraulic shear that draws material off and away from the screen. Due to the exacting nature of the slot openings, accurate design of through slot velocities can be achieved.

It was discovered during these studies by Smith and Ferguson (1978) in California that cylindrical shaped screens offered the greatest achievement of desired characteristics for submerged intake. The ability to design and control uniform velocity of intake through the screen to a much greater degree was achieved. The theory is that a sphere as a screen element with the water drawn from the center allows for the greatest uniform velocities across the entire screen surface. The cylindrical screen with a manifold drawing

water from the center created a practical design similar to the characteristics exhibited by a sphere. Although the cylindrical screen when used as a submerged intake is termed "passive" an "air back wash" system is sometimes employed to aid in cleaning the screen. This is accomplished by compressing air through a compressor into a receiving tank with a capacity of approximately two times the screens internal volume and quickly releasing (exploding) the air within the screen, blowing debris away and clear of the screening element allowing the debris to settle or be carried away by the ambient currents.

In designs where there is sufficient enough head available side hill screens can be used. Side hill screens create their own hydraulic sheer by water weiring over the top crest of an inverted screen panel and is accelerated in velocity and thinned in depth as it approach the screen. Suspended solids tend to stratify in the thin stream, and fibrous material align themselves with the direction of the flow. Profile wire is used as the filtering element. The slot opening, like the flat plate, is oriented perpendicular to the flow. However, because of the long horizontal slot openings, side hill screens achieve a rapid diversion of water through the screen by hydraulic surface attachment using the coanda effect. That is why this design of screening is sometimes referred to as a coanda effect screen.

"Active technology" is typically employed when site conditions are either so severe with debris, etc... or the passive design cannot be implemented (to shallow, stagnant currents, etc...) simply put, active technology is best described, in coarse screening, as putting the screening material in motion. There is two basic

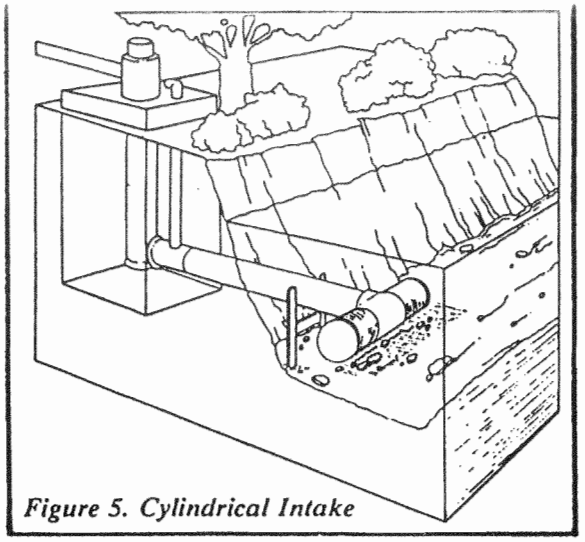


Figure 5. Cylindrical Intake

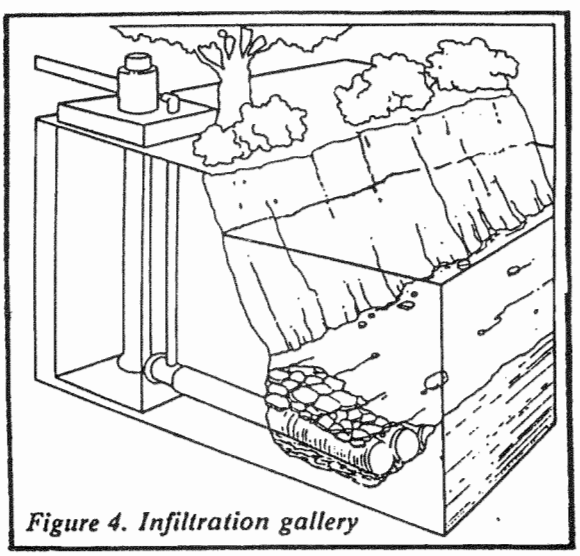


Figure 4. Infiltration gallery

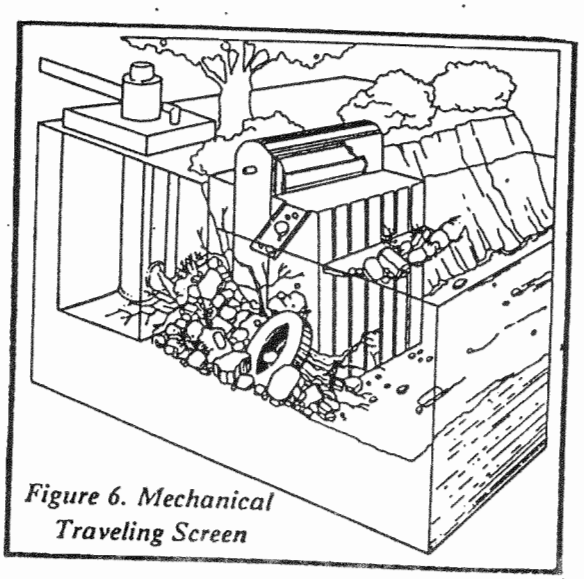


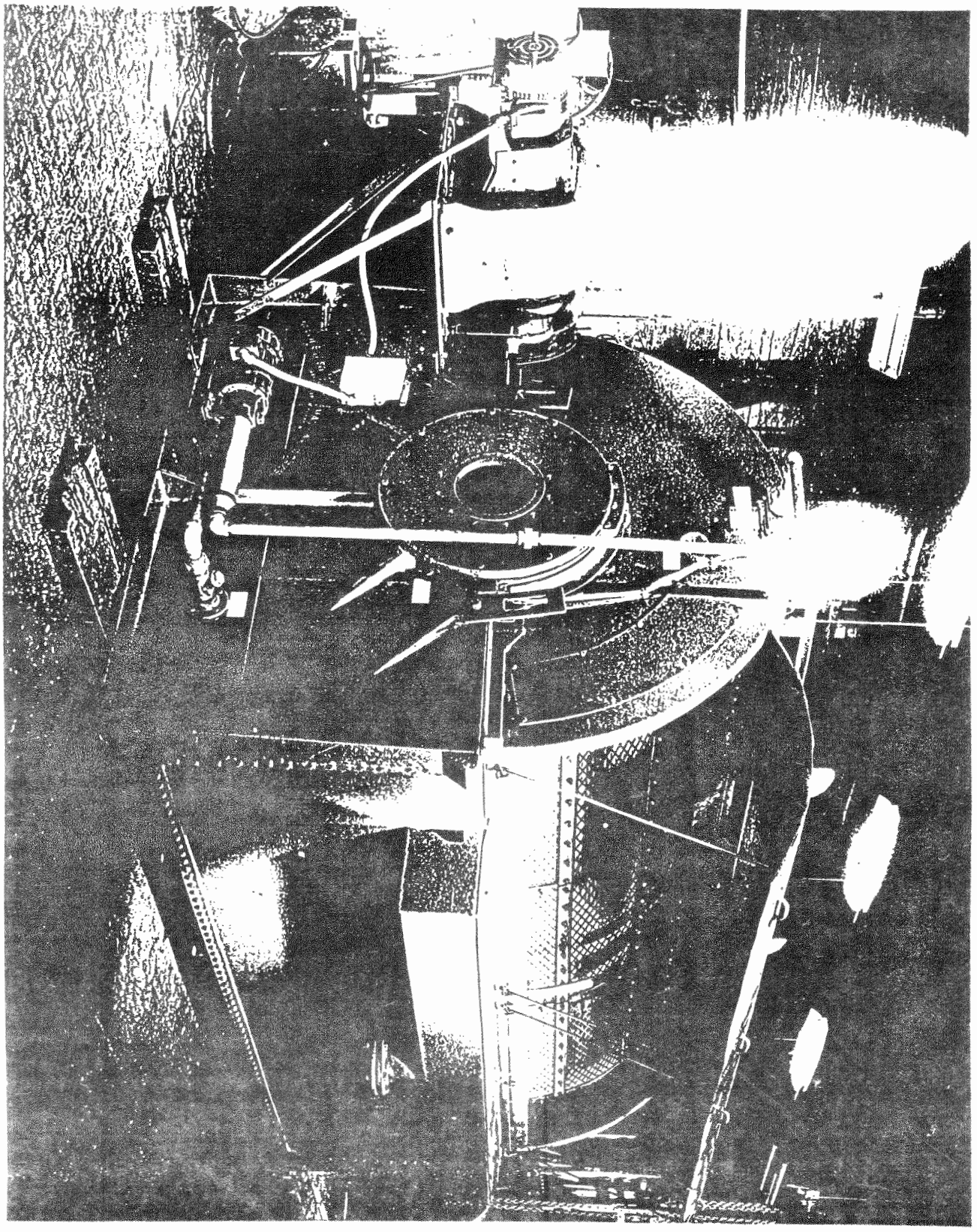
Figure 6. Mechanical Traveling Screen

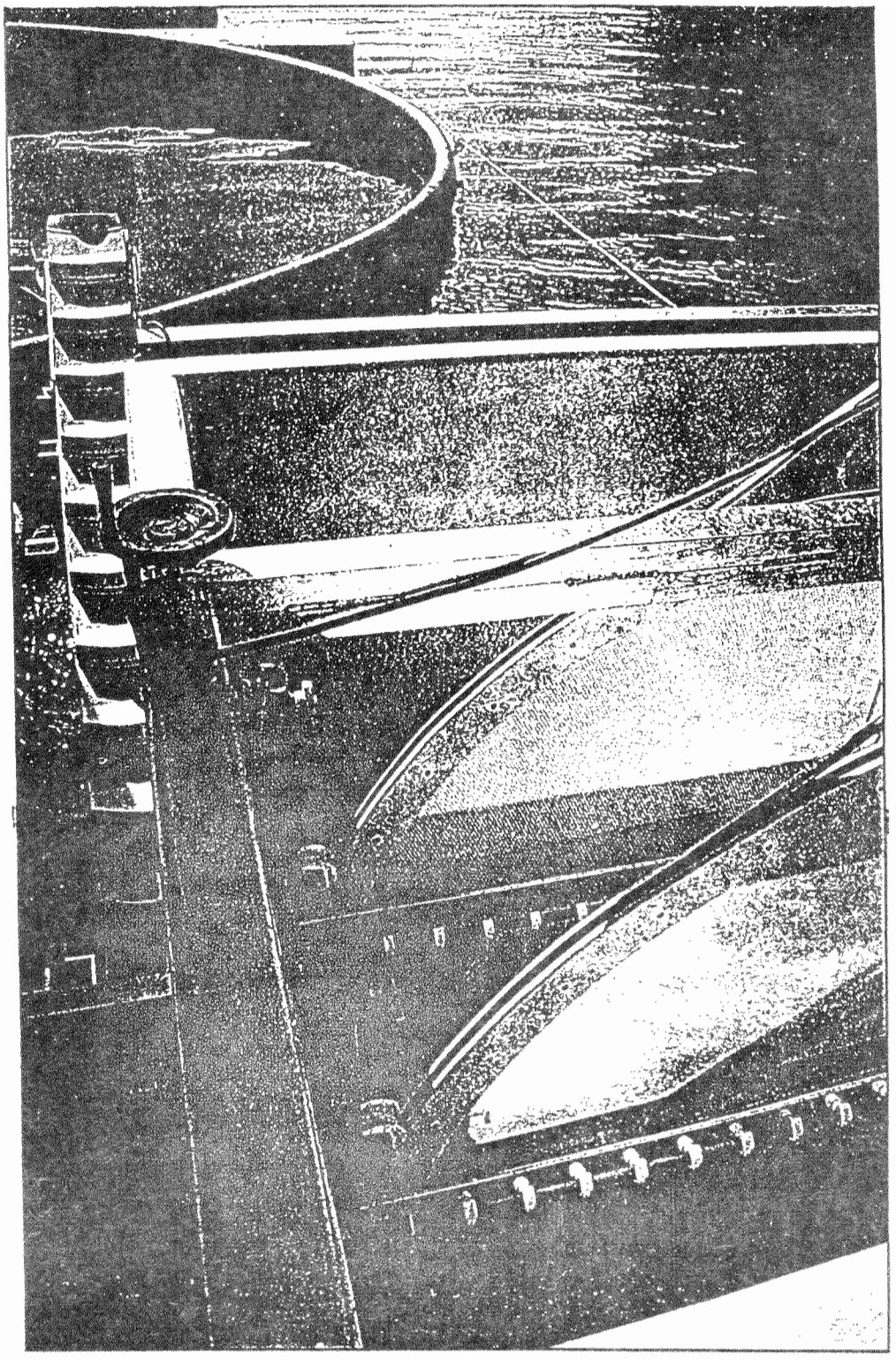
configurations of active screens: 1) Rotating cylindrical screen, 2) Traveling belt or segment screen. The traveling screen has been used extensively for decades throughout for industrial and hydro-electric applications. The design incorporates a series of screen panels that are linked together in a chain or belt and is continuously rotated and cleaned by a high pressure spray bar. In terms of this configuration's use in fish culture applications is exceedingly limited because of it's inherit complexity, extensive maintenance, and high capitol cost.

Rotating drum screens accomplish filtration and simultaneous cleaning by rotating a partially submerged cylinder with the filtering media attached to it's periphery. In coarse screening applications the typical application of a rotating screen is to act as a barrier to prevent or to retain fish in or from a given area. In this particular case debris is simply carried over the top of the screen. Some designs employ baffles to use the current to rotate the screen.

Micron Screens:

As with coarse screens, micron screens share a common use of filter media that is made up of a precision woven fabric that provides a barrier against suspended solids down to a sub micron level. The filter media is available in stainless steel or non-metalic nylon fabric material. Variations occur on how the filter media is presented. In fish culture three major designs of microscreening equipment are prevalent: 1) Rotating drum microscreen, 2) Rotating disk screen, 3) Side hill microscreen (triangle filter).





As with granular media filters, micron screens are sized by a loading rate expressed as gpm/ft2. As an example, situations encountered in raw water intake from a surface source ranging in a solids loading of 10-20 ppm, a 35 micron rated media has a nominal flow rating of 25-30 gpm/ft2 and a 20 micron rated media would range from 10-20 gpm/ft2. The same 20 micron media when used in a recirculation system could expect a nominal loading rate of 6-10 gpm/ft2. The raw water loading rate will vary in relation to fineness of the filter media and the solids loading present in the raw water to be filtered. Manufacturers have developed nominal flow charts based on historical data of existing sites. Micron Filters operate on a headloss of less than 1 foot.

It is recommended by these same manufacturers that on site pilot testing of equipment be conducted whenever possible. This becomes significant in high flow / high solids loading situations. Boucher (1947) developed the sizing equation for microstrainers: $H = (mQCf/A)\ (e)^{nIQ/S}$

where:
H = Headloss across strainer (inches)
Q = Constant rate of flow through (gpm)
Cf= initial headloss (feet)
A = effective submerged area (sq.ft.)
I = filterability index of influent feed
S = speed of strainer (rate of exposure, sq.ft/min)
m = .0267
n = .1337

The key to the successful use of this equation is an accurate determination of the filterability index (I), which is defined as the volume of water obtained , per unit of headloss, when passed through a unit area of standard filter. This can be determined by a laboratory procedure (Mixon 1970) or roughly by field testing (Bisgay 1969).

U.S. FILTER

LYCO, INC.
WASTEWATER DIVISION

9/91

MICROMATIC MICROSTRAINER
NOMINAL FLOW RATING (GPM)

DRUM SIZE (FT.) DIA. X LENGTH	4 X 2	4 X 4	6 X 4	6 X 6	6 X 8	6 X 10	8 X 8	8 X 10	8 X 12	10 X 10	10 X 12	10 X 16	12 X 12	12 X 14	12 X 16
TOTAL SURFACE AREA SQ. FT.	25.13	50.26	75.398	113.09	150.75	188.5	201.062	251.32	301.57	314.159	376.99	502.654	452.38	527.787	603.185
RAW WATER AND RECIRCULATING COOLING APPLICATIONS															
MICRON SIZE															
140	780	1560	2400	3600	4800	6000	6400	8000	9600	12600	15100	20150	18100	21100	24200
94	625	1250	1920	2880	3840	4600	5000	6150	7400	10500	12600	16800	15100	17600	20150
71	470	935	1440	2160	2880	3600	3840	4800	5750	8400	10080	13440	12090	14100	16100
35	390	780	1200	1800	2400	3000	3200	4000	4800	6300	7560	10100	9070	10580	12090
17	310	625	960	1440	1920	2400	2600	3200	3840	5250	6300	8400	7600	8820	10080
*2 13															
11						REFER TO LYCO FOR RATINGS										
9															
TERTIARY TREATMENT WASTEWATER APPLICATIONS															
35	156	312	480	720	960	1200	1300	1600	1900	2100	2560	3360	3070	3500	4000
*1 17	95	190	290	435	575	720	770	960	1150	1260	1510	2020	1820	2120	2420
13															
11						REFER TO LYCO FOR RATINGS									
9															

*1 - OLD PRODUCT NOMINAL MICRON SIZE 21
*2 - OLD PRODUCT NOMINAL MICRON SIZE 6

The rotating drum microscreen consists of a rotating drum-type straining unit that revolves on it's horizontal axis. It is usually driven by a fractional or a low horse power motor together with variable speed control, providing a peripheral drum speed ranging from 25 to 125 feet per minute.
The cylindrical drum has an open inlet while the other end is closed. It is contained in a tank or concrete pit and is positioned so that 50-70% of the drum's surface is submerged.

A sealing ring around the open end of the drum attached to the tank, creates a seal that prevents the influent from by-passing the screens. The water to be filtered must pass radially outward through the screen media.

The periphery of the drum is covered with microscreen panels. Inside the drum cylinder situated above the operating liquid level is a solids collection trough that receives the discharged debris separated from the influent water. These solids are flushed off of the microscreens by spray jets located outside of the rotating drum and mounted so that the nozzles apply their spray perpendicular to the rotating screens. The solids drop inside the trough and are then discharged away from the microscreen unit.

The rotating disk screen as compared to the rotating drum microstrainer is simpler in design. It incorporates the use of two filter disks oriented perpendicular to the water flow. The first screen has larger openings than the second, enabling a balancing of the solids loading to increase removal efficiency of the unit. The disks are held in place vertically by guide wheels as it suspends

from the drive belt. Horizontally the wheels are prevented from moving with the flow and simultaneously sealed by an elastomer sealing strip/channel. The wheels are rotated by a fractional horsepower motor. Particles impinge themselves on the screen face and are lifted out of the water as the disk rotates. Similar to the drum strainer a series of spray nozzles perpendicular to the screen surface spray impinged particles into a debris trough opposite the spray manifold.

The side hill micro screen design employs a shallow angle inverted filter plate (or plates). Water to be filtered weirs over the top crest and flows across the micron screen pushing debris and particles across the screen surface. As the filter plates become clogged with particulate matter, the effluent runs off plates into a channel where two electrical probes lay. As the channel fills the circuit completes and the cleaning cycle is activated. When activated, an electrical motor drums a ram with spray nozzles located above and below the filter plates the length of the unit. The debris and particulate matter is collected in the trough and drawn away from the unit.

Granular Media Filters:

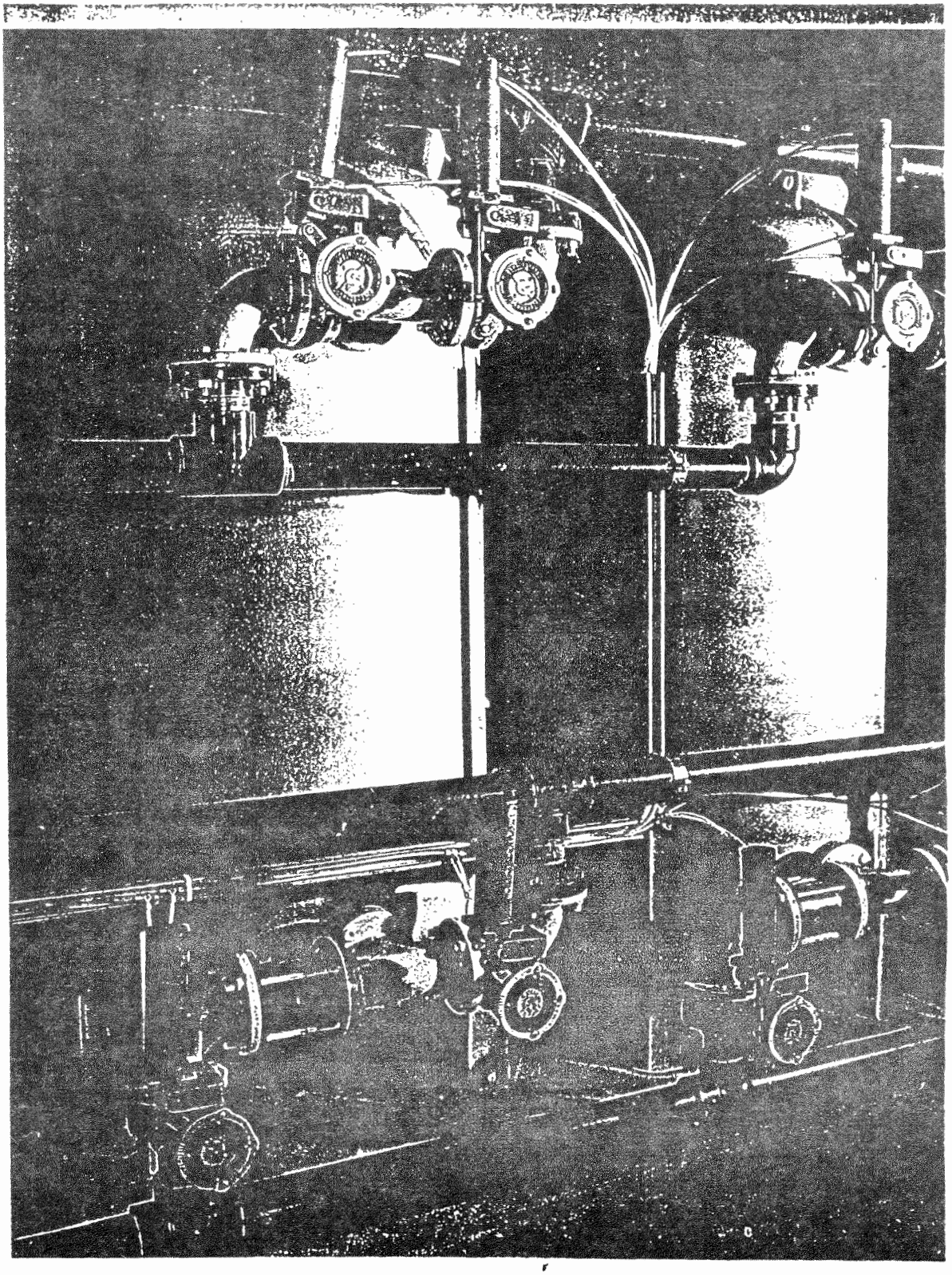
Granular media filters when used without coagulants, as is common in fishculture, is more accurately described as a straining filter. Ths process shares these attributes with the micron screens.

Loading rates for granular media filters when not using coagulants range from 10 - 15 gpm/ft2. The media that is used most commonly to date has typically been a graded silica sand placed over a shallow bed of coarse gravel. This arrangement has proven to be quite adequate for many fishculture systems, typically for preparing raw water before some form of disinfection.

Filters using sand media, when started clean, have an average particle removal of 25 microns. As the filter traps particles it enables a filter removal rate to a threshold of approximately 10 microns when the headloss becomes so great that either drastic decrease in flow rate is experienced or a break through of poor quality water occurs.

Finer removal size can be realized to a limited extent using a multi media approach. (<15 microns) However, the primary benefit enables the operator significantly longer filter runs than a conventional sand filter which tend to trap most of the particulate in the initial top layers.

Some experimentation with different combinations of granular medias arranged in layers (typically two or three besides the gravel bed) have allowed filters to operate for longer runs before they must be backwashed. The principle being that by selecting medias with unique specific gravity differences, with the lightest material stratifying to the top layer followed by the next heaviest material, and so on. Combining the stratification by grading each of the materials of differing particle size, with the lightest specific gravity being the greatest particle size, allows the media



to take greater advantage of the total media depth while still maintaining proper stratification of the media.

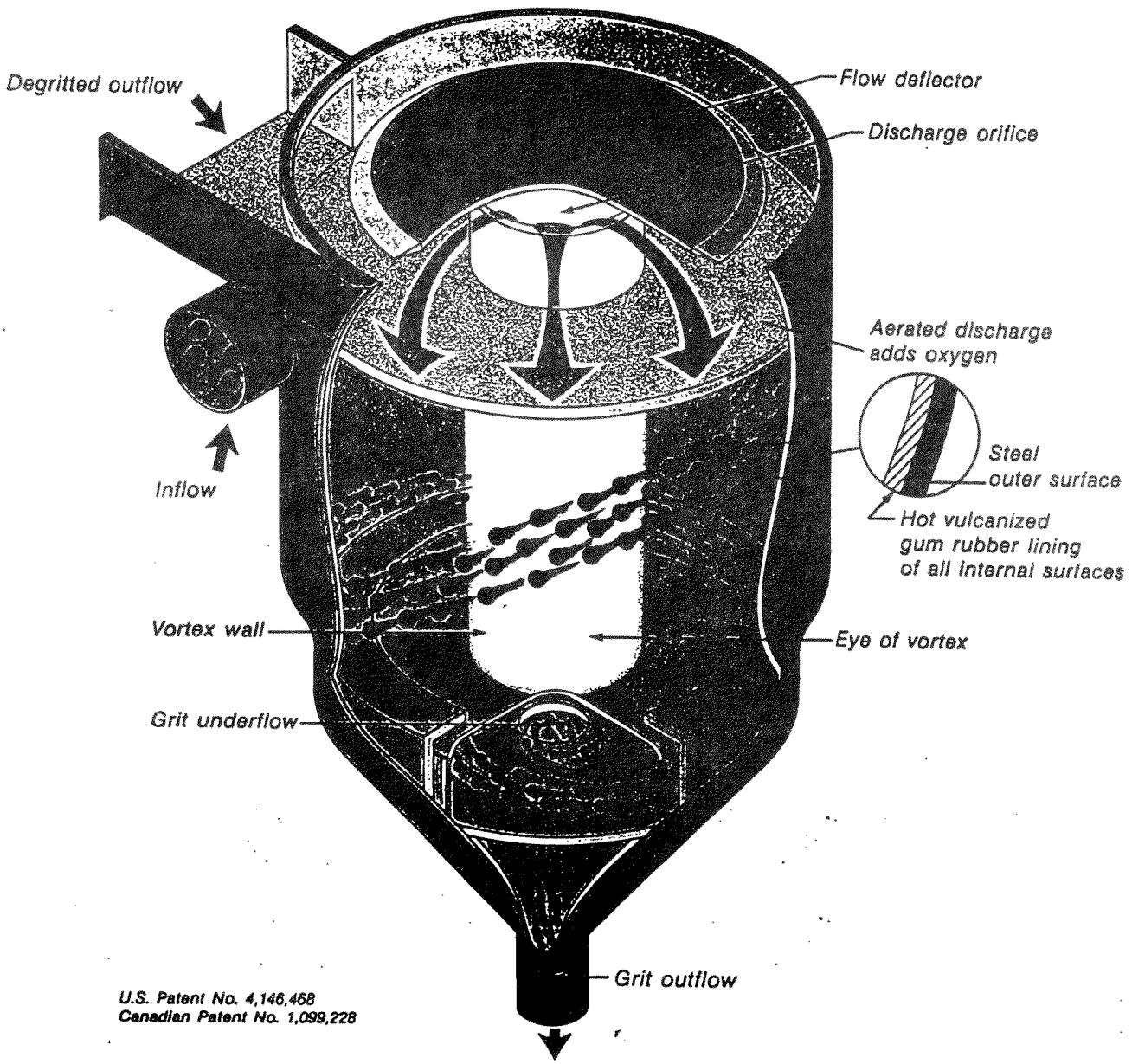
Granular media filters use a vessel that is suitable to contain the media. Typically the filter vessel is cylindrical in shape. A screen capable of retaining the media while still allowing the filtered water to pass is placed at the effluent side of the media.

Granular media filters require between 10 - 30 ft of head pressure to operate.

Swirl Separators and Hydrocyclones:

The hydrocyclone is a hydraulic classification device utilizing centrifugal force to cause a separation of suspended solids from the suspending liquid. The hydrocylone resembles a cone shaped cylinder. Water is introduced towards the top of the unit tangentially. The tangential flow causes a swirling motion within the unit. At sufficient velocities (50 - 60 ft/sec) a vortex forms within the center of the hydrocyclone.

The centrifugal force caused by the swirling water forces the suspended particles to the side wall of the unit and gravity drives the separated particles to the bottom of the unit where it is drawn away. The vortex created by the high velocity within the unit draws the water to the center and following the upward motion of the vortex up and out of the top of the unit.



U.S. Patent No. 4,146,468
Canadian Patent No. 1,099,228

The principle points of design for this process uses centrifugal, gravitational, and vortex forces to function. The specific gravity and ability of the suspended particle to resist breaking up when introduced into the high velocity tangential current becomes the limiting design factor. It is reported among manufacturers of the various versions of the hydrocylone that units should not be expected to remove particles with a specific gravity less than 1.2. Although cyclones can remove particle sizes approaching 5 microns it is limited by the specific gravity of the particle being removed.

There are variations of design for the hydrocylone that are proprietary. The Sprout Bauer Liquid Cyclone & Krebs Cyclone offers up to 5 micron removal of non-organic material at a low capitol cost. However, the pressure differential to operate the unit requires a range from 40 to 120 feet of water head and discharges up to 5% of it's process water to purge solids from the unit. The Eutek Systems "Teacup" uses a lower velocity to accomplish similar results with variations in internal baffling. This allows for a lower pressure differential to operate the "Teacup" (1 to 40 feet of water head) at similar removal ranges of the other hydrocylcones. Discharge of solids at the bottom of "Teacup" unit can be done intermittently, saving process water flow. The Eutek Systems "Teacup" has a higher capitol cost than the hydrocyclone.

In a fish culture system this process would be used for removal of excessive siltation, sand and grit that might cause undue equipment wear or abrasion to the gills of the fish. Because of the high organic content (fecal material and excess feed waste) of the

effluent stream a hydrocyclone would not prove to be effective in removal of suspended solids.

The swirl separator is a version of the hydrocylone that specifically targets organics. The flow is also introduced tangentially but at significantly slower velocity. A vortex does not develop in the center. Water is removed from the unit by means of a cylindrical weir at the center of the unit.

The swirl separator can best be described as an accelerated settling basin. The swirl separator augments the natural gravitational force through utilizing the centrifugal force generated by the gentle swirling occurring within the unit. As with the hydrocylclone specific gravity becomes the limiting factor in a swirl separator. It is reported among some users of the swirl separators an average removal rate of organics from the waste stream to be approximately 30% efficient. The principle of tangentiol flow introduction is being successfully incorporated into circular tank design for the cleaning and removal of solids within intensive culture tanks.

PROCESS DECISION

Various forms of mechanical filtration processes have been presented thus far. Each system has unique operating ranges and application. With the knowledge of the analysis of the water samples taken and capabilities of technologies for removal, a process or processes can be selected. Volume of water to be treated can greatly influence which process will be cost effective.

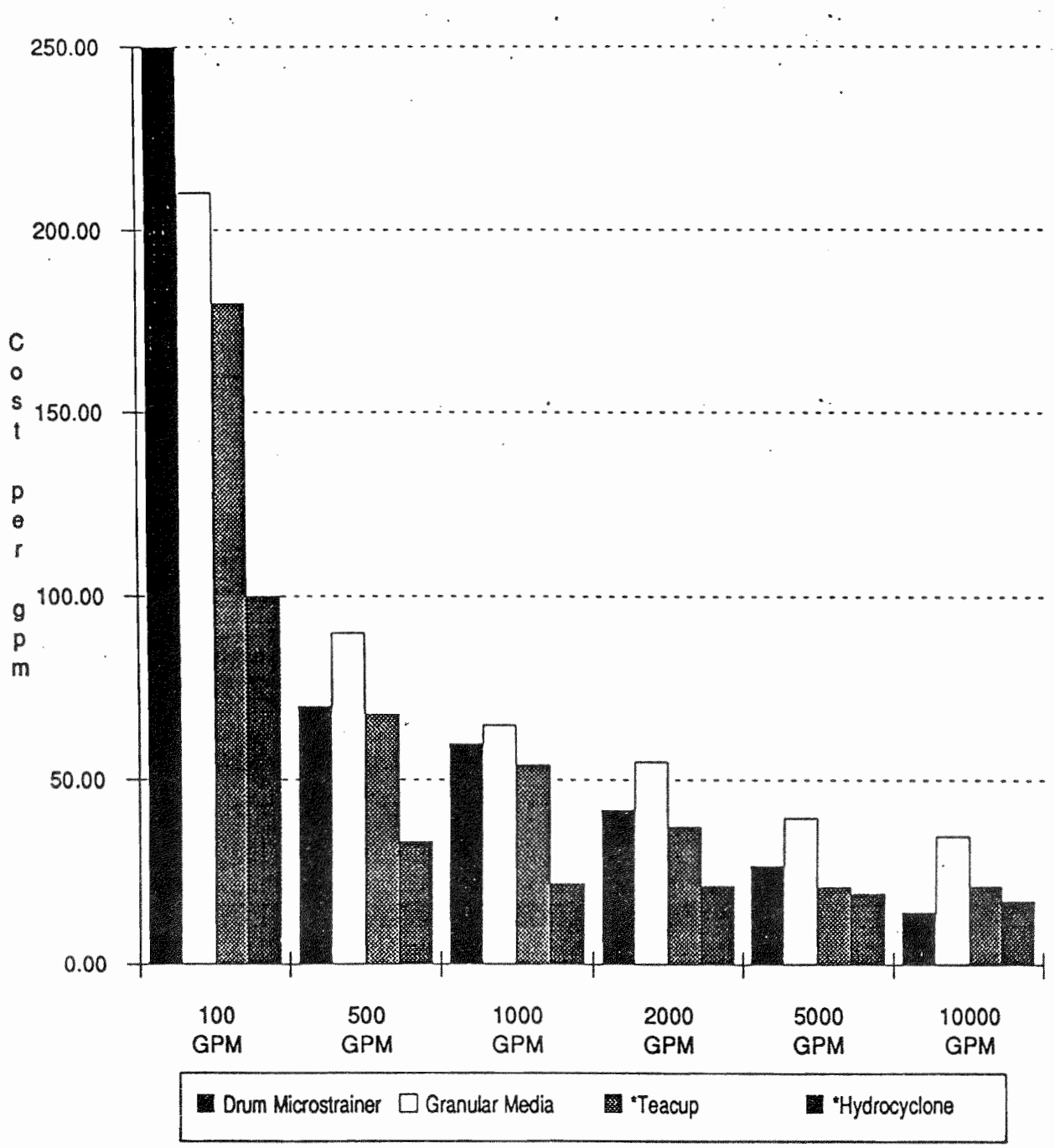
Although a granular media filter may have a high initial energy input it's simplicity, effectiveness and lower capitol costs at lower flow rates may be the ideal choice for a treatment system for an incubation system where only 100 gpm is required.

In terms of fine removal, Micron filters offer the best use of available head energy. However, micron filters are much more sensitive to the breaking down of fragile organics by high sheer velocities against a two dimensional filter media. Also in the lower flow range the capitol cost per gpm is significantly higher than most other systems. This is due in large part of the surrounding support and tank structure. But as the flow rate to be treated increases the cost factor for the tank and support structure drops off significantly. The micron filter becomes the economical choice for capitol expenditure considerations as well.

Hydrocyclones are limited by the type of solids used. It would be the ideal choice for removal of non-organic siltation, sand, etc. but virtually ineffective on any organics present. These devices are also comparatively high energy consumers but low maintenance because of no moving parts.

CONCLUSION

The technologies discussed within this report have all been successfully implemented in various aquaculture situations. However, these same systems have also grossly failed in similar situations. Items like structural integrity of a filter system should not be compromised for lowest capitol cost. Or the addition of pumps or undue mechanization implemented into a facility that is set up on a gravity system if at all possible.


21 micron removal rate
250.00
200.00
150.00
100.00
50.00
0.00
Cost per gpm
100 GPM
500 GPM
1000 GPM
2000 GPM
5000 GPM
10000 GPM
Drum Microstrainer
Granular Media
*Teacup
*Hydrocyclone

There is a need for further study of the behavior of these systems specifically as it applies to the removal of fish fecal material. Also, consideration and study using chemical coagulants (perhaps at significantly lower levels as compared to municipal water treatment) could prove to greatly enhance methods of mechanical filtration in fish culture.

Finally at the risk of being redundant, a thorough knowledge of the water to be treated and proper knowledge, selection and implementation of mechanical filtration technology will assure an effective enhancement to an already properly designed aquaculture facility.

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OXYGEN GENERATION SYSTEM AT FORT RICHARDSON HATCHERY

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ABSTRACT OF SLIDE PRESENTATION

Fort Richardson Hatchery was designed to use only well water for fish rearing. Wellfield studies conducted prior to hatchery construction promised sufficient water availability to supply the facility. After development of the wellfield it was discovered that less than 50% of the required flow was indeed available. Oxygen supplementation was first considered as a means of removing excess nitrogen with the secondary benefit being increased oxygen available for fish rearing.

The system installed was designed to reduce nitrogen gas saturation to below 100% while raising oxygen saturation to a high of 125% of saturation. Two 250 cubic foot per hour oxygen generators were installed by the hatchery staff at a cost of approximately $50,000. The installation included pouring a concrete pad and adding a small building to the existing incubation and early rearing building. Two 15 hp air compressors (rotary screw type) were installed to supply atmospheric gas to the oxygen generators. Both compressors operate constantly, one in a standby mode and the other supplying the oxygen generator with compressed gas. Only one generator is on line at a time with the second acting as an emergency backup. For more information on the system please feel free to contact us at any time, we would be glad to answer any questions you might have.

OXYGEN SUPPLEMENTATION AT WILLAMETTE HATCHERY

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Hydropower development in the Columbia River basin has caused the loss of 5-11 million salmonids. An interim goal of the Northwest Power Planning Council is to re-establish these historical numbers by doubling the present runs of salmonids. At least part of this increase in production will depend upon the wise and efficient use of hatchery facilities. The increased cost of construction has stimulated an interest in increasing the efficiency of production of our present hatchery facilities. One promising method for increased production is the use of supplemental oxygen to rear more fish with available water. The goal of the Willamette oxygen supplementation project is to demonstrate that this can be done with spring chinook salmon and that the survival to adulthood will not be diminished.

Willamette Hatchery was chosen for a number of reasons:

1: It raises spring chinook salmon.
2: It is large enough to accomodate the experiment.
3: It has good returns (about 2%) for chinook salmon.
4. It has low incidence of disease.
5: It is a surface water hatchery, which makes it different from other studies that have been done with oxygen.
6: It has no major dams in the migration path, although Willamette Falls may be considered a major obstacle.

The design for the experiment was set up to test the effects of density and two types of raceways used with oxygen supplementation systems. The control raceways are modified Burrows ponds which normally hold about 30-40,000 fish. These are supplied with water from Salmon Creek at a flow of about 500 gallon /minute (Table 1). The second group is held at half the normal rearing density, but all other conditions are the same. The third group is reared at the standard density but has oxygen added to bring the effluent up to saturation.

A word should be added at this point to explain this design. It is assumed that wild fish survive at much greater rates than hatchery fish. One reason for this is

that they experience oxygen at saturation levels at all times. We proposed to test this out to some degree by adding the amount of oxygen to the raceway that the fish would use during passage through the raceway. As long as this does not get into the danger zones of supersaturated oxygen levels, we felt that this would be the best way to insure that the returns of chinook salmon would approach a maximum.

The fourth group of fish has three times the number of fish as the control raceways. It also has oxygen added so the effluent is at the saturation level.

The final group of fish has three parts, using the Michigan hatchery design, where baffles are used to provide a self-cleaning action to the raceways. Water enters by gravity into the first raceway, is collected into a sump, and pumped into a contact column, where it is re-oxygenated and flows into the second raceway in the series. This is repeated between the second and third raceways. Thus, water is used three times in series with oxygenation occuring at the inflow of each pond.

We are following three aspects of the experiment: water quality, growth characteristics in the raceways, and survival to adulthood.

To date, two broods of experimental fish have been released and the third brood is tagged and rearing under experimental conditions. A fourth and final brood will be released in 1994. No returns from the experimental groups have yet been observed, but adults are expected in the spring of 1993.

At the first releases in March 1991, there were no significant differences in various growth paramenters measured at release. Fish in the third pass Michigan pond looked poorer than others, but were not significantly different in growth, conversion, length frequency, hematocrit, or condition factor. No signficant differences in migration were detected by Dr. Carl Schreck's group from Oregon State University, who were measuring the migration rates of selected groups.

During the second year of rearing, there was a significant difference in size between experimental groups at release. Fish in raceways of lower density tended to be larger than those in more crowded raceways. This may have been due to the presence of bacterial kidney disease, which appeared in the fish shortly before release. Mortalities in all ponds increased substantially in January and February.

Water quality showed significant changes in the experimental raceways in both years. The most significant change was that of pH. The pH of the water after the third pass in the Michigan ponds was signficantly lower than that in other ponds (Fig. 1). The greatest change observed was in August, when incoming water was pH 7.9. Water out of pond 1 was 7.6, out of pond 2 was 7.2, and out of pond 3 was 6.9. Similar drops in pH were observed in the triple

density ponds, with lower turnover. Incoming water was 7.9 while outflow was about 7.

A continuous monitoring system has been installed at the hatchery to monitor the continuously changing levels of temperature, oxygen concentration, and pH (Fig. 2). We expect to be able to get a much better idea of the changes in oxygen consumption and changes in pH with temperature, feeding, size, and pond cleaning with this instrumentation.

Table 1. Characteristics of experimental ponds at Willamette Hatchery.

Group	Number of fish	Final pounds	Inflow gpm	Load pounds/gpm	Pond volume cu ft	Density pounds/cu ft
A	36,000	3,600	500	7.2	3,700	0.970
B	18,000	1,800	500	3.6	3,700	0.486
C	36,000	3,600	500	7.2	3,700	0.970
D	90,000	9,000	500	18.0	3,700	2,432
E,F,G	54,000	5,400	750	7.2	1,850	2,919

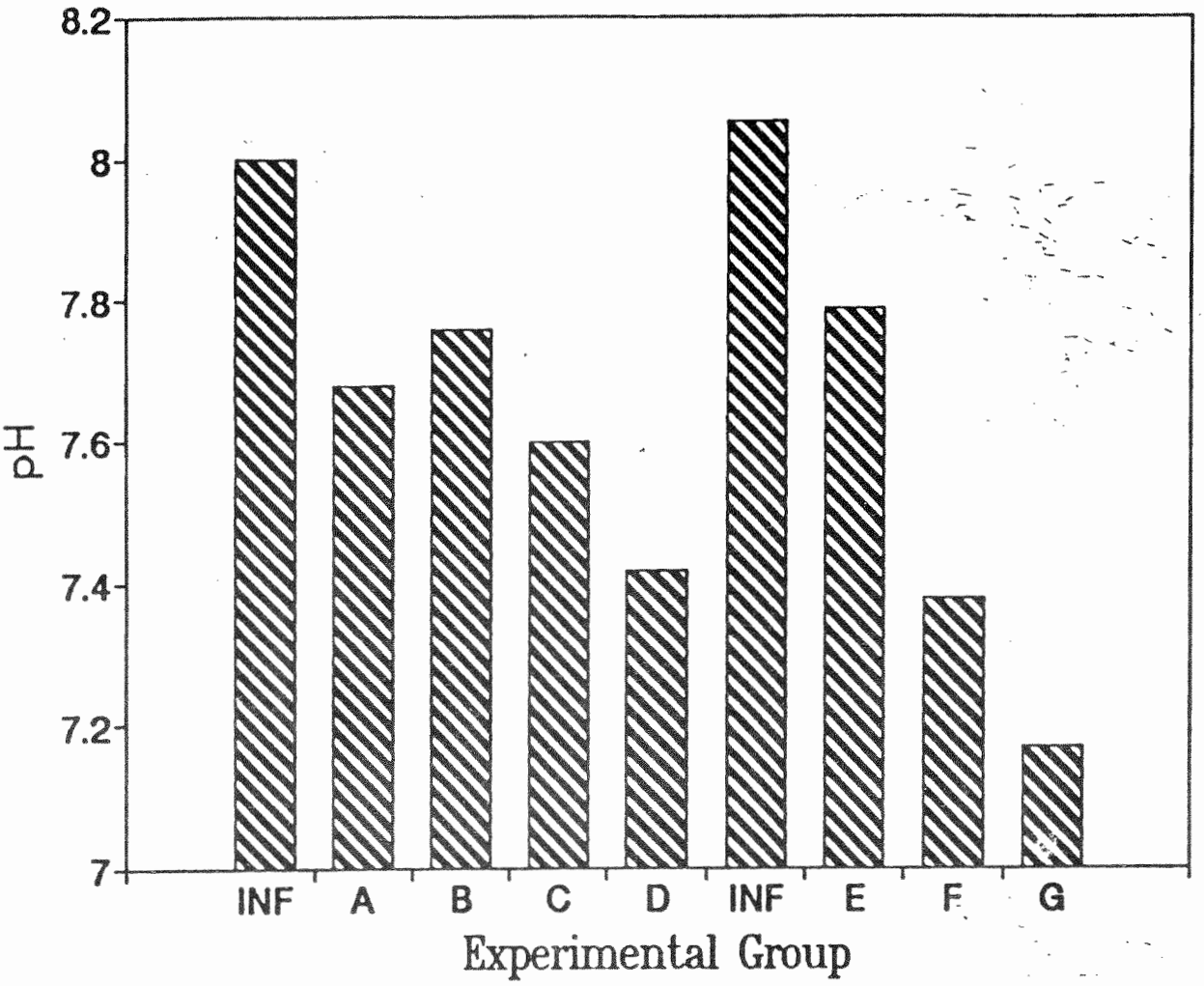

Figure 1. pH at the inflow and outflow of various experimental raceways at Willamette Hatchery on 15 October 1991.

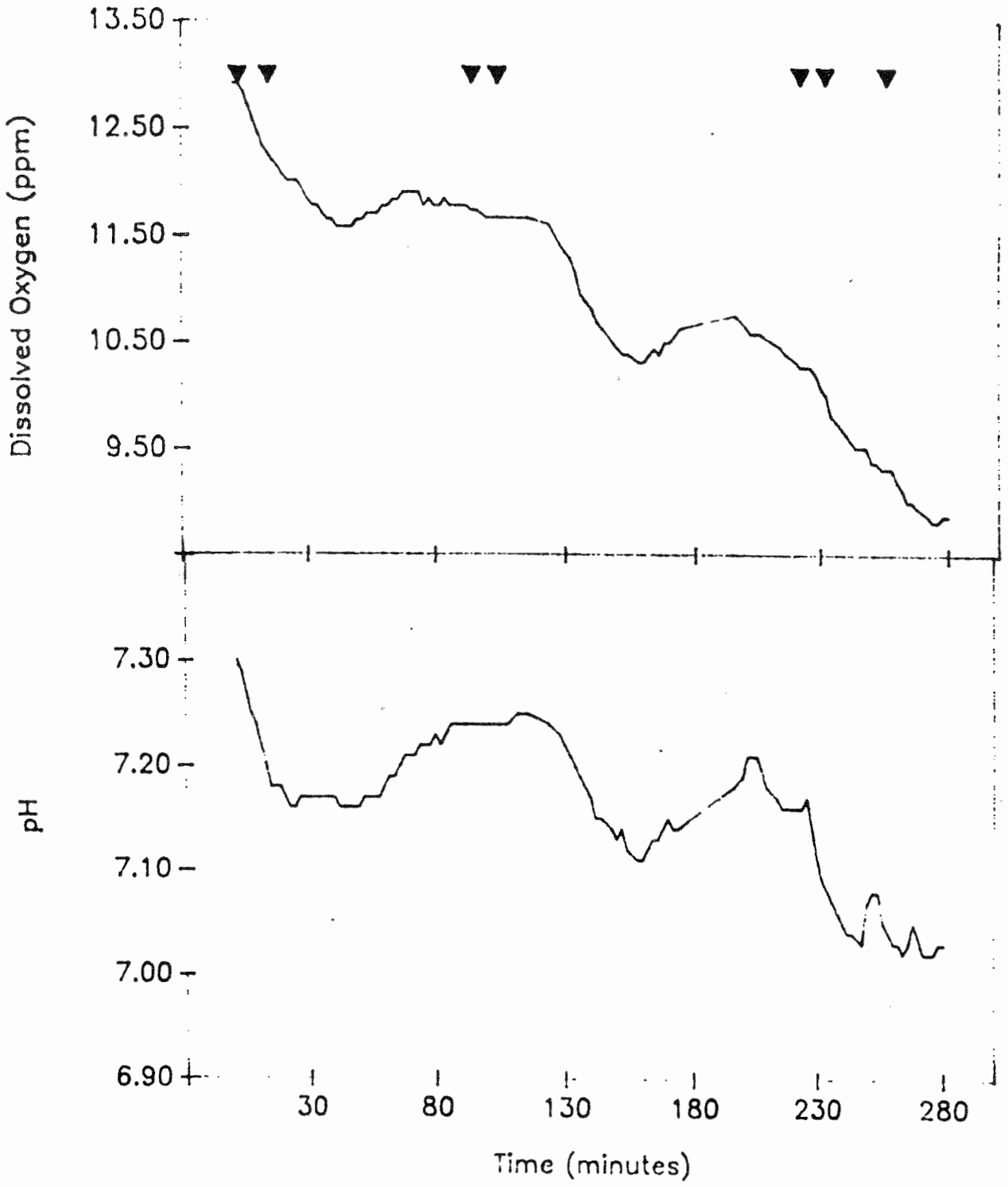

Figure 2. Changes in dissolved oxygen and pH at the outflow of a Group G raceway. Triangles indicate feeding times in the raceways above the measurement point.

Use of Ozone for Disinfection of River Water

George F. Nandor
Clackamas River Fish Hatchery

In the Spring of 1992 an ozone disinfection system was installed in the egg incubation room at the Clackamas River Hatchery. The system was installed in order to provide disease free water for the incubation and early rearing of a wild stock of Clackamas River Winter Steelhead. Approximately 45,000 fingerlings were reared in 2 Canadian type rearing troughs from the swim up stage to a size of 200 fish per pound. The system was operated from May through August, 1992. No diseases were encountered in these fish during this period.

The installed system delivered between 40 and 50 gallons per minute of ozone treated Clackamas River water. It consisted of a 1 horse power water pump, an ozone generator, an in line injector to inject the ozone into the water, a 6 feet tall contact chamber and an ultra violet light radiation unit for neutralizing the ozone.

Equipment Used:

Ozone generator package which included pump, injector, static mixer, contact column and ozone generator with controls.
Vendor: **Aquatic Ecosystems, Apopka, Florida**
Cost: **$6900.00**

Ultra violet light unit for ozone destruction. 180 watts (16 - 30 watt bulbs with quartz sleeves), 115 volt AC, 5.6 amps, 4 inch inlet and outlet.
Vendor: **Ideal Horizons Inc., Rutland Vermont**
Cost: **$3450.00**

Electrical control panel installation and wiring all units to be operational.
Vendor: **Local contractor**
Cost: **$1400.00**

PVC pipe, fittings, valves and miscellaneous parts.

Cost: **$800.00**

Total Cost of Installation: $12,550.00

Electrical Power cost to operate the system was approximately **$100.00** per month.

Measurement of residual Ozone in the treated water:

Before Ultra Violet Light	**After Ultra Violet Light**
.3 ppm	< .01 ppm

Measurement of dissolved oxygen in the water at 63 degrees F (saturation = 9.7 ppm) using a portable DO meter was 11.0 ppm after exposure to the ozone and the ultra violet light treatments. Increase in DO levels was a desirable side effect of the treatment system!

Bacterial plate counts were done by the hatchery pathologist using TSA and TYE media.

Raw river water: **300 - 500 bacteria per ml.**

Treated river water: **virtually 0 bacteria per ml.**

The fish were fed BioMoist Grower fish feed manufactured by Bioproducts. The cumulative food conversion for the three month rearing period was **1.0.**

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FISH CULTURE WITH OZONE, AFTER ONE YEAR

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BACKGROUND

The Cowlitz hatchery located on the Cowlitz River in South Western Washington, was constructed in 1967 by Tacoma City Light (TCL). The hatchery mitigates for fish lost due to the construction of Mayfield and Mossyrock dams. Operation is by the Washington Department of Wildlife, with funds provided by TCL.

Water for hatchery operation originates from nine wells and the Cowlitz River. Well water is capable of supporting less than 15 percent of summer time demand.

Hatchery smolt production goal have been: 750,000 winter-run steelhead, 220,000 summer-run steelhead and 80,000 sea-run cutthroat. The 1986 mitigation agreement specifies a minimum smolt length of 180 mm for steelhead, and 210 mm for sea-run cutthroat. All smolts are released into the Cowlitz River.

Steelhead and sea-run cutthroat fingerling reared at this hatchery, historically have a significant mortality rate due to Ceratomyxa shasta. Survivors are often severely infected, small, emaciated, hemorrhaging at the vent and weak, often less than 35 percent survive to smolt. Late spawning winter-steelhead and sea-run cutthroat incur the largest mortality rate with regular winter steelhead having the most resistance.

To meet the mitigation goal of 1,050,000 smolts, it became necessary to take in excess of 3,000,000 eggs, and utilize well water beyond its expected capacity.

In 1984 a study was begun by biologist Jack Tipping to determine the minimum effective ozone dose required to inactivate the infective stage of C. shasta. Based on the results of this study Tacoma City Light constructed an ozone plant, beginning production in June 1991.

The facility was designed to meet the following criteria:

Flow (maximum)	20 cfs
Dosage (average)	1.5 mg/l
Detention time	15 minutes
Ozone contactor residual concentration	0.1-0.2 mg/l
Effluent ozone concentration	<0.01 mg/l

The facility receives water from the Cowlitz River, ozonates the water in a four celled contactor/mixing structure, strips residual ozone from the ozonated water in two forced-air packed- tower stripping units and repumps the water to the hatchery. The relift pumps can provide 5, 10, 15 or 20 cfs of water depending on the combination of three pumps used.

Ozonated river water use begins in June when well water capacity is exceeded. Ozonation continues until river water temperatures fall below 10 c., (normally late November or early December).

The goal of the facility is to produce the required number of healthy smolts, efficiently, that will return mitigation numbers of adult steelhead and sea-run cutthroat to the river.

Two seasons of operation have been completed with one group of smolts released.

OPERATION

The 1991 season, being the first, was approached with cautious optimism. Rather than reducing egg numbers to that required for rearing in treated water, extra eggs were retained, realizing, if the plant operation was successful, extra fish would be produced.

To evaluate the success of ozonated water, rearing procedure deviated little from the previous two years. All sea-run cutthroat and 49,000 summer-run steelhead were retained on well water through out the summer, while the balance of the fingerling were reared on ozonated water. Rearing lake density was reduced 30% anticipating increased survival.

Feeding procedures were not altered until it became obvious that changes were required. By mid December largest fish were placed on a trout diet rather than salmon diet. Feeding frequency for larger fish was reduced to two days a week in February.

A Department of Wildlife pathologist inspected fish for evidence of C. shasta monthly. Prior to planting all lots of fish were sampled and organosomatic values recorded.

The 1992 rearing on ozonated water began on June 12, 1992 and ceased November 23, 1992. Operation was based on a C. shasta free water source. All lots of fish were exposed to ozonated water during some stage of their rearing. In addition a control group of 100 late-spawning winter-run steelhead fingerling were retained on untreated river water.

OBSERVATION

The following data is for fingerlings reared during 1991 on ozonated water and released as smolts during April and May 1992. Unfortunately the hatchery design does not allow a controlled experiment where ozonated rearing could be compared directly

with unozonated rearing. The hatchery either has treated or untreated river water.

Monthly necropsies by pathologist Leni Oman revealed a reduction in clinical signs of C. shasta when compared to observations for preozone rearing. On occasion swollen intestines filled with a milky fluid were noted but, rarely thickened or inflamed. Suspicious sporoblast-like cells were also noted but no mature spores. Ozone reared fish displayed a marked increase in fat content.

The overall survival for steelhead from alevin to plant increased 41 percent. Alevin to smolt survival increased 84.8 percent, and the percent of fish planted as smolts increased 34.7 percent. (Table 1.) Overall survival may have been enhanced by increased hazing of fish eating birds, in addition to rearing on ozonated water.

Conversion of feed to fish growth showed marked improvement for ozone reared fish (Table 1). This too may have been affected by increased bird hazing and a milder than normal winter. Fish fed more aggressively than prior years when much effort was required getting feed into fish. Ozone reared fish were placed on a lower protein diet and the frequency of feeding reduced to control growth.

Increased survival, better growth and the ability to use a less expensive feed reduced the feed cost per smolt planted (see table 1). The average steelhead smolt feed cost was reduced 34.1 percent when compared to the two previous years rearing with out ozone.

Extrapolated feed savings based on one years production is $52,500. Caution must be excersized when making any projections based on one years operation however it is a exciting prospect.

At this time (November 27, 1992) the 1992 use of ozonated water seems to support the 1991 observations. Symptoms of C. shasta have not been observed by pathologist Larry Durham in ozone reared fish. A small lot of 100 fish on raw river water have displayed progressively increased symptoms of C. shasta since August 28, 1992.

SUMMARY

Based on one release of smolts and two summers operation it appears the following may be expected:

Increased survival from alevin to smolt, lower feed cost per smolt released, and a apparent healthier smolt. Having two C shasta free water sources provides the opportunity to match fish to water temperature for more efficient culture. It also appears that feed cost reductions may be equal or close to operation cost of the ozone plant.

The 1993/94 return of adult winter-run steelhead will be the first return from ozone reared smolts. The success or failure of the ozone rearing can be further evaluated at

that time.

Table 1 summarizes fish culture for the Cowlitz hatchery before and after ozone. Before ozone is the average of 1990 and 1991 releases.

Table 1. Summary of fish production before and after ozone

	AFTER OZONE	BEFORE OZONE
Hindgut inflammation		
WSH	8.5%	79.0%
SSH	20.0%	50.0%
Overall Survival		
WSH	81.3%	52.8%
SSH	80.8%	62.1%
Alevin to smolt		
WSH	78.%	38.2%
SSH	79.3%	47.9%
Percent of April/May plant smolts		
WSH	96.5%	72.4%
SSH	98.2%	72.2%
Pound of feed per pound of smolt		
WSH	1.44 LB	2.41 LB
SSH	1.42 LB	2.42 LB
Feed cost per smolt		
WSH	$0.097	$0.158
SSH	$0.093	$0.132

FLOATING FISH WEIR AT KOOSKIA NFH
INSTALLATION AND OPERATION

1. Kooskia NFH is located in north central Idaho approximately 75 miles southeast of Lewiston. The facility is located on Clear Creek, just upstream of its confluence with the Middle Fork Clearwater River. The hatchery produces up to 800,000 spring chinook salmon smolts and is dependent on adult return to Clear Creek for this production. No other egg sources are utilized.

2. The hatchery was constructed and fish production began in 1969. Beginning in 1976 an electric weir was installed and operated to trap adult salmon entering Clear Creek. One negative effect, caused by the electric current, is a broken back to the adult fish. Often this injury is fatal, resulting in fewer brood fish for our program.

3. During the summer of 91 we began to explore our options to eliminate this problem. The decision was made to purchase and install a floating fish weir.

4. Two -by facilities were visited that had been using this type of weir: Tucanon FH in shington and Powell Satellite Salmon collection facility in Idaho.

5. Using s information gathered from these site visits we began work by fabricat d installing a 6" steel H beam on which to mount the weir. Fastenin s were drilled, gussets welded, and the beams hoisted into position.

6. (BLANK HOIST SLIDE)

7. Beams were anchored to an existing concrete sill which tranversed the creek.

8. Gabions were constructed to provide a definitive boundary for the side of the weir.

9. Th e of a heavy equipment was necessary to move material, making the gabions more stable and secure, and to eliminate erosion during high water.

10. All of the initial work in the creek was performed during the fall and winter when water flows were at a minimum.

11. An order was sent to the manufacture and the weir was delivered to the hatchery.

12. Panels were unloaded and connecting brackets, which we fabricated from 4" angle aluminum, were attached.

13. The key feature to the operation of this weir are the resistance boards. Though these panels are temporarily floating upside-down, when right side up resistance from water moving downstream pushes the panels upward. The greater the downstream water velocity the higher the panel ends are pushed out of the water.

14. Panels were placed into position with the 4" angle hooking onto the H beam. Each panel connects to another with tubing, which allows for them to remain flexible. The weir was now in place for collecting the late segment of a summer steelhead run.

15. At the sides we attached netting to make the weir complete. The trap entrance and attraction water outfall is directly opposite the left side of the weir. We believe this positioning to be most favorable for movement of fish into the trap.

16. Within twenty four hours after the weir was installed our troubles began. Local fisherman expressing their rights to fish at the trap entrance threw boulders onto the weir in an effort to spook fish which they believed were swimming underneath it.

17. Panel veins were broken and stainless steel spacing clips were damaged on four of the eighteen panels. At a cost of approximately $1,200.00 per panel we are hoping this type of activity will not happen again. Incidentally the fishermen were arrested.

18. The next problem occurred as chinook salmon began to return to the creek. It was our best guess, that with low flow conditions we were experiencing in Clear Creek, fish were jumping onto the weir. As you can see the outcome was fatal.

19. In an effort to lift the downstream end of the weir styrofoam floats were made and fastened to the underside of each panel. This resulted in lifting the end of the panels approximately 12" out of the water.

20. Much to one's dismay the problem was not solved and fish continued to become stranded on the weir.

21. Early one morning I watched, hoping to witness something that would give me a clue to help solve the problem. Much to my surprise I observed a salmon swim through the one inch spacing between panel veins. The veins flexed as the fish forced its way upstream.

22. Next, we removed panels from the creek, removed floats from each panel, and utilized nine of the panels for their parts.

23. Using these parts the remaining nine panels were reinforced with spacing brackets, spaced at 17 inches, a distance approximately one-half that of the

manufactures design. Additional parts were ordered from the manufacturer so that all panels could be put back into operation. I might add the company forgot our order, thus parts were delivered 2 months late.

24. After putting the reinforced weir back into the creek it appears that the problem has been solved. We now believe we have a weir that will operate to our satisfaction.

25. We believe we have solved the main problem of fish escaping the weir. However, we anticipate new problems will occur and expect that annual maintenance will be costly and time consuming.

27. I would encourage those of you considering this type of weir to closely examine your budget, needs, and time available to install and maintain such an item.

Consideration also needs to be given to non-targeted species which might be effected by a resistant board floating weir.

Thank You

PROTECTING JUVENILE SALMON AND STEELHEAD TROUT FROM GULL PREDATION UTILIZING AUDIO AND VISUAL DETERRENTS

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ABSTRACT

With the listing of the Columbia and Snake River salmon (Oncorhynchus spp) as threatened species, many private and governmental organizations in the Pacific Northwest have taken steps to promote conservation of these fish. Predation by ring-billed gulls (Larus delawarenis) and California gulls (L. californicus) has been identified by fish and wildlife biologists as significant to juvenile salmon and steelhead trout (Salmo gairdneri). Predation often occurs at fish rearing facilities and at hydroelectric dams where migrating fish become disoriented as they pass through the turbines and fish bypass structures. Animal Damage Control has effectively assisted fisheries managers in controlling predating gulls through the installation of overhead wires and the use of hazing devices.

Government Surplus, A Good Way to Stretch a Lean Budget

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Abstract

A Federal government program is described that distributes property declared excess to an agency's needs to other Federal, State, and local government organizations at no cost to the recipient party. However, many people think this property is junk, and shy away from surplus programs. This paper describes the merits of surplus programs, the type of materials available through them, and the process which transfers ownership of the materials.

The federal government's annual budget is over one trillion dollars. The defense department alone spends close to 300 billion dollars per year. It is not surprising that when that much money is spent, a fair amount of material and equipment is bought that was not absolutely necessary. The typical government agency budgeting process almost encourages the acquisition of unnecessary equipment and materials. If an agency does not spend its full budget, the budget is shrunk the following year by the unspent portion. This results in a year end buying spree by agencies for equipment and materials that they often did not really need.

The intent of this paper is not to try and reform government inefficiency. Instead it will describe how a frugal agency can benefit from other agencies wasteful practices. The first step is to change your mind-set to equate "surplus" with "excess" instead of with "junk".

Surplus property has three general origins. Most surplus material is used, but still has a useful life. Either the program that had a need for the item ended, or the program that had the item upgraded their equipment, making their old equipment available for another agencies use. Military base closures will create a huge source of materials of this nature. A second source is brand new equipment that was purchased for a program that never got started or that ended sooner than planned. Materials purchased for Desert Storm are a good example of new materials of this nature. Tremendous quantities of new material was available following Desert Storm's short life. The third origin of surplus goods is when the useful life of a piece of equipment or material has been used up. Materials of this nature are "junk" and are not worth putting any effort into obtaining.

Most materials purchased by the government are of high quality. Examples of materials and equipment that are commonly available through surplus channels are: vehicles, heavy equipment, laboratory equipment, structural steel, electrical cable, generators, boats, paint products, hoses, pumps, and office equipment. Essentially anything you could ever buy has been bought by the government, and is being stored somewhere until it is gotten rid of.

The transfer of federal property is taken care of by the General Services Administration (GSA). The GSA is the agency that is dealt with directly if you are a Federal or Tribal organization. GSA has a staff of coordinators who spend their time in the field visiting surplus yards and warehouse sites to locate materials requested by agencies. State's usually have their own staff of property coordinators, who state agencies should deal with. The State coordinators ultimately deal with GSA. Individual organizations can also conduct their own search for materials.

The department of defense is one of the largest movers of surplus materials. Property disposition yards are often located on military bases, and is known as the Disposition, Reutilization, and Marketing Organization (DRMO) on the base. Access to the DRMO area on a military base is usually easily obtained at the front gate. Bases with DRMO's are scattered throughout the west, but their biggest concentration is in California (Figure 2).

The transfer of federal property to other agencies occurs by completion of a Standard Form 122. Completion of this form is essential for a piece of property to separate ownership from a federal warehouse. GSA is essentially the owner of all Federal property until they sign the Form 122 which transfers ownership. The requesting agency and the GSA must sign the Form 122. Requirements that agencies require from their staff prior to signing a Form 122 vary a great deal. Some agencies make it quite difficult to obtain surplus property, while other agencies encourage the process. GSA's requirements are usually quite reasonable. GSA's goal is to find a new owner for property and to facilitate that process. If no federal, state, or local government agency requests the property it proceeds to a public auction sale.

Time limits exist on the transfer of all Federal property. Once a requestor locates a piece of federal property, he notifies a GSA coordinator to hold that property for him. The requestor then has 10 days in which to prepare a signed Form 122 delivered to GSA. When GSA signs the requestor's Form 122, the requestor has 10 days to pick up the property (figure 1). If the first requestor does not meet the time restrictions, then a second requestor can bump the first requestor, or the item can be sold to the public.

The rules of the surplus process are in constant change, so contact your state or federal surplus coordinator to learn the latest requirements (table 1). The government's recent goal is to accelerate the movement of property through the disposition process and place the property in a public sale status.

The surplus program has been a tremendous benefit to many organizations. Even agencies that have too much money can benefit, because it provides an avenue to dispose of their spoils. It is worth the time of any agency to see what benefits this program can bring.

Table 1. GSA Federal Coordinators.

California	Richard Jaka	(510) 273-6061
WA, OR, ID	Dale Mock	(206) 931-7571

Figure 1. Flow diagram of property tansfer process and time restrictions for action to occur.

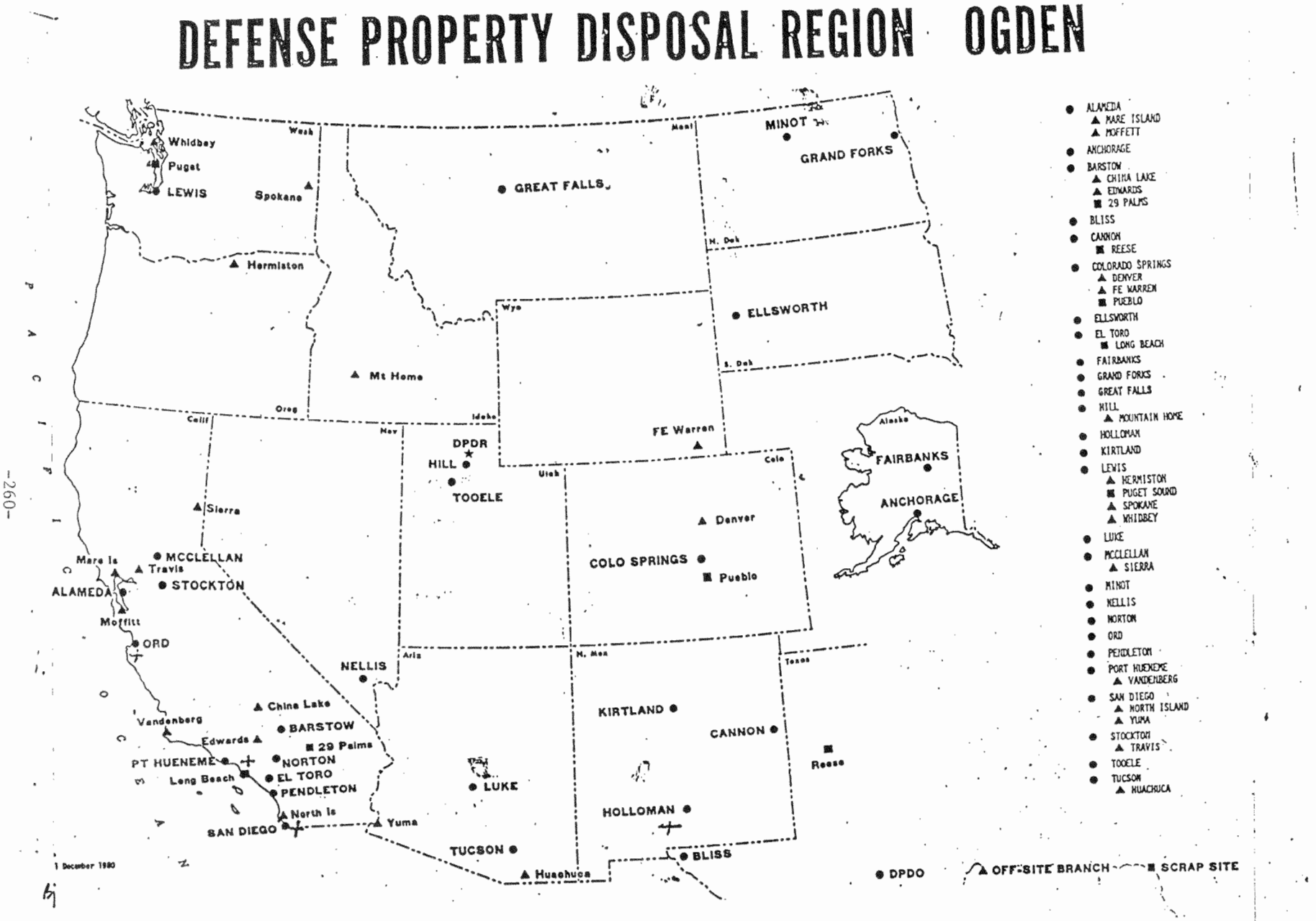

Figure 2. Location of surplus property yards in the West.

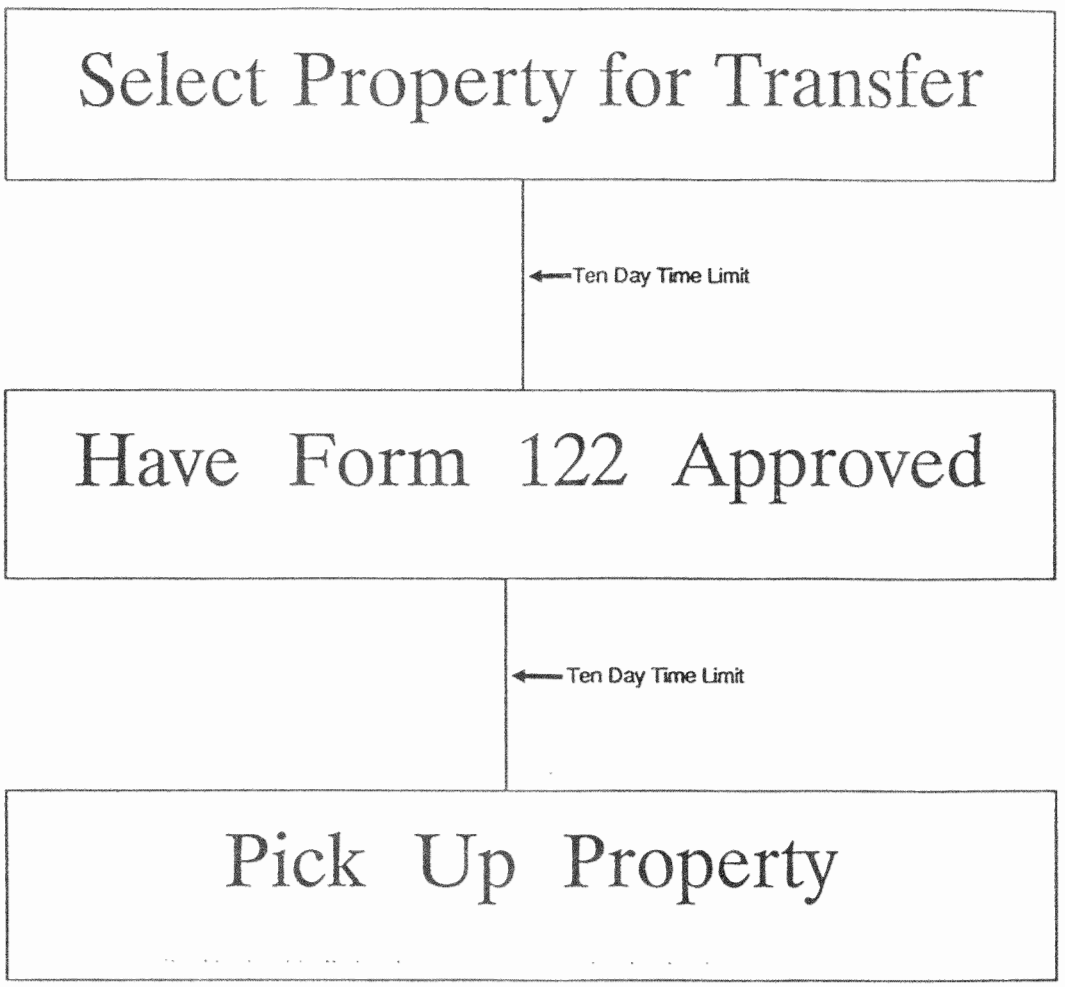

Figure 1. Flow diagram of property tansfer process and time restrictions for action to occur.

IMPRINTING SALMON IN SALTWATER IN SOUTHCENTRAL ALASKA

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Abstract. - Supplemental production of hatchery-produced chinook *Oncorhynchus tshawytscha*, coho *O. kisutch*, and pink salmon *O. gorbuscha* offers additional opportunities for increasing numbers of anglers who utilize Kenai Peninsula fisheries. Although the Homer Spit was selected because of high accessibility to anglers, the site lacked an adequate freshwater imprinting source. Therefore, we assumed an artificial imprinting cue would be required to imprint salmon smolts and provide a homing stimulus for returning adults. The goal was to attract them to a general offshore area to minimize the potential for a congested fishery.

Since 1984, nearly 1.5 million chinook salmon smolts have been imprinted and released into a small saltwater inlet. Over 18,700 chinook salmon adults have returned since 1985 to provide over 43,500 angler/days of effort in this road-side fishery. Returning adult chinook salmon homed back to the inlet where they were released, rather than to the imprinting station anchored offshore. Short-term saltwater rearing and release of later run chinook, pink and coho salmon has also been conducted to extend sport fishing opportunities on the Homer Spit throughout the summer. The Alaska Department of Fish and Game and cooperators, the City of Homer, and South Peninsula Sportsman's Association were co-recipients of the Sportfish Management Award for 1990 for the best enhancement project in the nation from the American League of Anglers and Boaters. Results

demonstrate that biologists may have more options for creating new salmon fisheries in marine locations than previously believed because of the lack of freshwater for imprinting.

INTRODUCTION

Many of Alaska's sport fishing opportunities exist in remote locations that are accessible to only few anglers, while readily accessible fisheries have become overcrowded. New angling opportunities can be created by developing new fish populations for existing access. Large numbers of anglers, that comprise approximately 40% of the statewide total, are concentrated along the limited highway system on the Kenai Peninsula, in Southcentral Alaska. In response to this large angling effort, the Alaska Department of Fish and Game (ADF&G), Division of Fisheries Rehabilitation, Enhancement and Development (FRED) Division, and the Sport Fish Division have attempted to create new fisheries for these anglers.

The Homer Spit was selected for sport fisheries enhancement because it is highly accessible to the large numbers of residents and tourists who are already attracted to the area. Unfortunately, no adequate freshwater discharge for salmon imprinting is available on Homer Spit, so this project was originally designed to use the synthetic organic chemical, morpholine[1], as an imprinting agent during the smolt stage and as a homing stimulus for returning adults. The original goal of this project was to subsequently use a morpholine "drip station" to create an adult chinook salmon return adjacent to Homer Spit to provide a shallow water troll fishery.

The imprinting technique has been used on salmonids in Lake Michigan (Cooper et. al. 1976; Cooper and Scholz 1976; Scholz et. al. 1975 and 1978) and summarized by Hasler and Scholz (1983). Other experiments have been done with chinook and coho salmon in California (Hassler and Kucas, 1982). These studies have demonstrated some success in imprinting salmonids with morpholine in freshwater systems. To our knowledge, however, the Homer Spit experiment may be the first reported attempt to use this chemical as an artificial imprinting agent in saltwater for chinook salmon and the first to attempt to decoy returning fish to a more favorable marine sport harvest location. Subsequently, short-term saltwater rearing and release of hatchery-produced pink salmon fry and coho salmon smolts were also conducted without artificial imprinting to extend sport fishing opportunities throughout the summer.

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[1]Statement of brand names, model numbers, or sources of materials does not represent endorsement of the product or company by the Alaska Department of Fish and Game.

STUDY AREA

The Homer Spit salmon enhancement site is located in the fishing and tourism community of Homer, on the southern tip of the Kenai Peninsula, in Southcentral Alaska (Figure 1). The Homer Spit is a naturally-occurring 7.2km long gravel bar or "spit" that extends into Kachemak Bay in lower Cook Inlet. The project site is a small saltwater, intertidal inlet located approximately 5.8 km from the base of the Homer Spit (Figure 1). This inlet is approximately 100 x 60 m in size, with a maximal depth of approximately 3 m at mean-low tide. There is no freshwater discharge into this inlet except limited surface runoff during rainfall.

METHODS AND MATERIALS

The chinook salmon spawning operation is conducted at the Crooked Creek Hatchery, and the eggs are transported to the Elmendorf Hatchery in Anchorage where heated water is available to accelerate development to produce smolts in less than one year. The smolts in one raceway were exposed to morpholine for 30-38 days each year from 1984 to 1988. The pumped exposure concentration in the raceways was adjusted to 5 x 10^{-5} mg/liter of morpholine following the calculation of Scholz et. al. (1975).

After imprinting, smolts are transported by tanker truck to the Homer Spit and released into the small saltwater, intertidal inlet. Floating 3.7 x 3.7 x 3.7 m net pens have been anchored in the inlet to hold a portion of the smolts released in 1985 through 1992. The penned smolts are held for 5-7 days and fed 3.5-mm Oregon Moist Pellet[1] frozen fish food.

Coho salmon smolts are handled similarly to the chinook salmon smolts, however, it requires an additional year to produce coho smolts at Elmendorf Hatchery. Coho salmon smolts have not been imprinted with an artificial agent prior to release. Late run chinook salmon broodstock originates from the Kasilof River, which is also located approximately 96 km north of Homer. Spawning, incubation and rearing to the smolt stage is conducted at the Crooked Creek Hatchery as a two year cycle. Late run chinook salmon have also not been imprinted with an artificial agent prior to release at the Homer Spit.

Pink salmon fry are also released at the Homer Spit site to diversify species return and timing. Fry are transported by skiff mounted transport tanks from Tutka Lagoon Hatchery, which is located in Tutka Bay, approximately 19-km southwest of the Homer Spit. These emergent fry are also held for approximately 20-30 days in floating net pens and fed Alaska Dry Pellet[1] fish food by volunteers. The pink salmon fry are not artificially imprinted prior to release.

A floating morpholine "drip station" was anchored just offshore of the Spit (Figure 1) to provide attractant for returning adult chinook salmon. The concentration of morpholine and the drip rate were gradually increased during the 1985-1988 adult returns. The decoy station was not operated after 1988.

The numbers of fish returning to the inlet were periodically estimated by aerial surveys when water conditions allowed. On several occasions an instantaneous population estimate was made by seining, marking, and recapturing fish in the inlet. The sport harvest was estimated periodically by multiplying the number of anglers by the average catch per angler.

RESULTS

JUVENILE RELEASES

Since 1984, over 1,498,600 chinook salmon smolts have been imprinted and released (Table 1). The project began in 1984 with an initial direct release of 80,000 smolts and has expanded to a release of over 190,000-226,000 smolts in 1988 - 1992. In 1985, 1986 and 1987, approximately 50% of the smolts were held in net pens for 5-6 days prior to release and in 1988 and 1989, over 80% of the smolts were held in pens before release (Table 1). Since then, over 81-100% of the smolts were held in pens (Table 1.) The mortality rate of chinook salmon smolts during the short-term rearing period has been less than 1% except in 1989, when the smolts had unusually high sodium-ion blood plasma levels prior to release. Mortality was an estimated 20% of the entire 1989 release. The average sizes of the smolts have ranged from 16.5 to 20.3 g except in 1986 and 1990 when they averaged 13.8 g. and 14.8 g, respectively (Table 1).

Since 1988, over 539,930 coho salmon smolts have been released into the inlet on Homer Spit after a 5-7 day short-term rearing program(Table 2). Over 1,849,000 pink salmon fry were also released from the Homer Spit since 1987 (Table 3). In most years fry nearly doubled their size, exceeding the 0.45 g size during the 20-30 day short-term rearing period.

ADULT RETURNS

A total of over 18,700 adult chinook salmon have returned to the Homer Spit since 1985. These have provided over 43,500 angler days of effort (Table 4). An estimated 3,300 chinook salmon returned to the Homer Spit in 1988, which was the first year that all four age classes of chinook salmon returned since the original release in 1984. The age composition of the 1988 return was 3% age 0.1, 25% age 0.2, 57% age 0.3, 15% age 0.4.

Similar results were observed through 1992. The highest return at 3,500 chinook occurred in 1991. The mean smolt to adult ocean survival for five year's data was 2.5%.

The chinook salmon returns have generated a very popular and intense sport fishery. Since, 1988 sport fishermen have annually expended approximately 7,500 angler/days of effort to harvest an average of 3,000 chinook salmon, with an average catch rate of 0.40 fish per angler/day. Successful angling techniques included light to medium tackle with small artificial lures, flies, salmon egg clusters, herring, or shrimp. Current regulations allow limited periodic snagging, opened by "emergency order," as a legal angling method after 23 June. This provides an effective means of harvesting the remaining chinook, pink and coho salmon when they quit biting during the last third of each species run.

Although the adult return morpholine drip station was in position and operating during the 1986-1988 chinook salmon returns, there was no conclusive evidence that the chinook salmon were orienting to that station. Only twice during 1987 and 1988 were small schools of fish observed briefly down-current from the drip station. Considering these limited results, the drip station was discontinued in 1989.

An estimated total of 18,600 adult coho salmon returned in August-September 1989-1991 from over 339,330 smolts released in 1988-1990, yielding an average ocean survival rate of 5.3% (Table 2). The highest survival rate (8.1%) occurred in the 1991, return from the 1990 release of nearly 123,000 coho smolts (Table 2). This is encouraging data from the initial releases of the coho salmon smolts portion of the project. These smolts returned and homed to the small saltwater inlet where they had been previously reared and released, without exposure to morpholine imprinting.

Since 1988, over 17,600 adult pink salmon have returned to the Homer Spit from a total release of 1,849,000 fry. In 1988, over 4,500 adult pink salmon returned yielding an ocean survival rate of 1.5% (Table 3). In 1989, the survival rate was over 3.3% with an estimated adult pink salmon return of 10,000 fish (Table 3). This was the highest return rate of pink salmon in the history of this project. Similar to most local area pink salmon stocks, recent returns to the Homer Spit have been low at 0.1 to 1.1% survival. The pink salmon adults also homed to the small saltwater inlet where they had been previously reared and released, without artificial imprinting.

DISCUSSION

The highly-visible, roadside fishery created by this experimental salmon smolt and fry release program on the Homer Spit has generated intensive fishing effort, successful results, and very positive public response. To date, over 86,000 angler/days of effort have been expended in this road accessible fishery (Table 4). Local residents, as well as tourists from other parts of Alaska, other states and many foreign countries have

participated in this fishery. The City of Homer, Homer Harbormaster Office, Port and Harbor Commission, South Peninsula Sportsman's Association and Cook Inlet Seiners Association have been very cooperative and supportive of this project. Many local merchants have described a significant increase in seasonal business that is directly related to this and the other enhanced fisheries around Kachemak Bay. The sequential returns of chinook, pink and coho salmon have provided angling opportunities through out the entire sport fishing season (Table 5) in a location where only minimal angling opportunities previously existed.

The Homer Spit Sportfish Enhancement Project is funded by the Dingell-Johnson/Wallop-Breaux federal funding system and as such has received national recognition and an award from the American League of Anglers and Boaters. The Alaska Department of Fish and Game, the City of Homer and the South Peninsula Sportsman's Association were co-recipients of the Sportfish Management Award for 1990 for the best fishery enhancement project in the nation. As a result of this project's national recognition and economic benefits to the local community, the City of Homer is planning to expand the small lagoon to provide for increased angling opportunities.

Although there is no freshwater available in the small inlet for imprinting, returning adult chinook, pink and coho salmon homed to the small inlet where they were released, rather than to the morpholine drip station. Most of these fish are harvested either in the small inlet, the intertidal channel or the adjacent shoreline during flooding tides. Unfortunately, relatively few chinook salmon are taken by trolling in spite of our attempt to imprint them to the drip station to spread the fishery over a larger area, rather than the confined area of the small inlet on the Homer Spit.

We are uncertain if the fish were adequately imprinted to morpholine as smolts. We believe, however, that the adults did not home to the morpholine drip station because the concentration rate was not strong enough. The massive water volume movements from tidal exchanges (+6.6 to -1.5 m) probably dilute and export the concentration so it cannot be readily detected by the returning salmon. Also, it is likely that unique chemical characteristics associated with the intertidal inlet (e.g., organic matter; metal scraps on the bottom; chemical preservatives from wood in an old barge and pilings; sand and gravel; etc.), impart a stronger influence on imprinting and homing than the exposure to morpholine.

It is most important however, to note that chinook, coho and pink salmon fisheries can be created by releasing the juvenile fish in highly saline waters without the influence of a freshwater imprinting source.

Another aspect of the imprinting and homing mechanism that we have been particularly impressed with is the apparently brief imprinting period required. All of the chinook salmon smolts released in 1984 and more than half of those released in 1985-1987 were released directly into the inlet. Some were observed migrating out of the inlet within

several hours. None of these treatment lots were marked, so there is no estimate of differential survival; however, at another project site, Halibut Cove Lagoon, where treatment lots were differentially marked, the survival of chinook salmon reared in pens for 14 days was approximately 30% greater than those released directly into a large lagoon with freshwater discharge (Dudiak et. al. 1987). The increased survival advantage may result from better imprinting, better recovery from transport stress, or both.

Although the effectiveness of morpholine imprinting in saltwater appears to be low, the overall success of the Homer Spit Project is evident with the estimated mean survival rate of 2.5% for the chinook salmon smolts released from 1984 to 1988. This is comparable to the 2.4% average survival rate for chinook salmon smolts released and imprinted to freshwater at Halibut Cove Lagoon. As many as 5,000 adult chinook salmon are expected to return in 1993. Survival rates for pink and coho salmon have also been encouraging, and as many as 10,000 adult pink salmon and 10,000 adult coho salmon could also return in 1993.

These results demonstrate that management biologists may have many more options available to create new salmon fisheries in locations previously believed unacceptable because of the lack of freshwater for imprinting. If the chinook salmon had imprinted to morpholine as we had previously thought necessary, we may have been able to decoy them to another harvest location or alter their behavior pattern to create a new troll fishery in the vicinity of Homer Spit which would have been unique in this area. Never-the-less, a fishery that has yielded over 15,500 salmon in 1989 has been developed in a highly accessible location that extends from mid-May to October where none previously existed or was believed possible.

ACKNOWLEDGEMENTS

This project was primarily supported by funding provided by the Dingell-Johnson/Wallop-Breaux Federal Aid in Sport Fish Restoration Program, Contract No. F-27-R, R-5. It was recognized by the American League of Anglers and Boaters as the foremost fisheries management project in the nation in 1990.

The authors wish to thank Darrell Keifer and his staff at the Elmendorf Hatchery complex for producing and transporting the salmon smolts; Tutka Lagoon Hatchery staff for the pink salmon production for the area fisheries; and the Crooked Creek Hatchery staff, managed by Bob Och, who provided the chinook and the coho salmon eggs for the project. Mark Dickson, Fishery Technician III, played a major role in assisting all transports and pen rearing logistics. Dr. Allen Scholz, Eastern Washington Univ., provided technical comments about the use of morpholine as an imprinting agent. The City of Homer, Homer Harbormaster Office and the Homer Port and Harbor Commission continue to be very cooperative and supportive of this project. The Cook Inlet Seiners Association has provided financial assistance while the South Peninsula Sportsman's and

Homer Charter Boat Associations provided volunteers to help feed and release the smolts.

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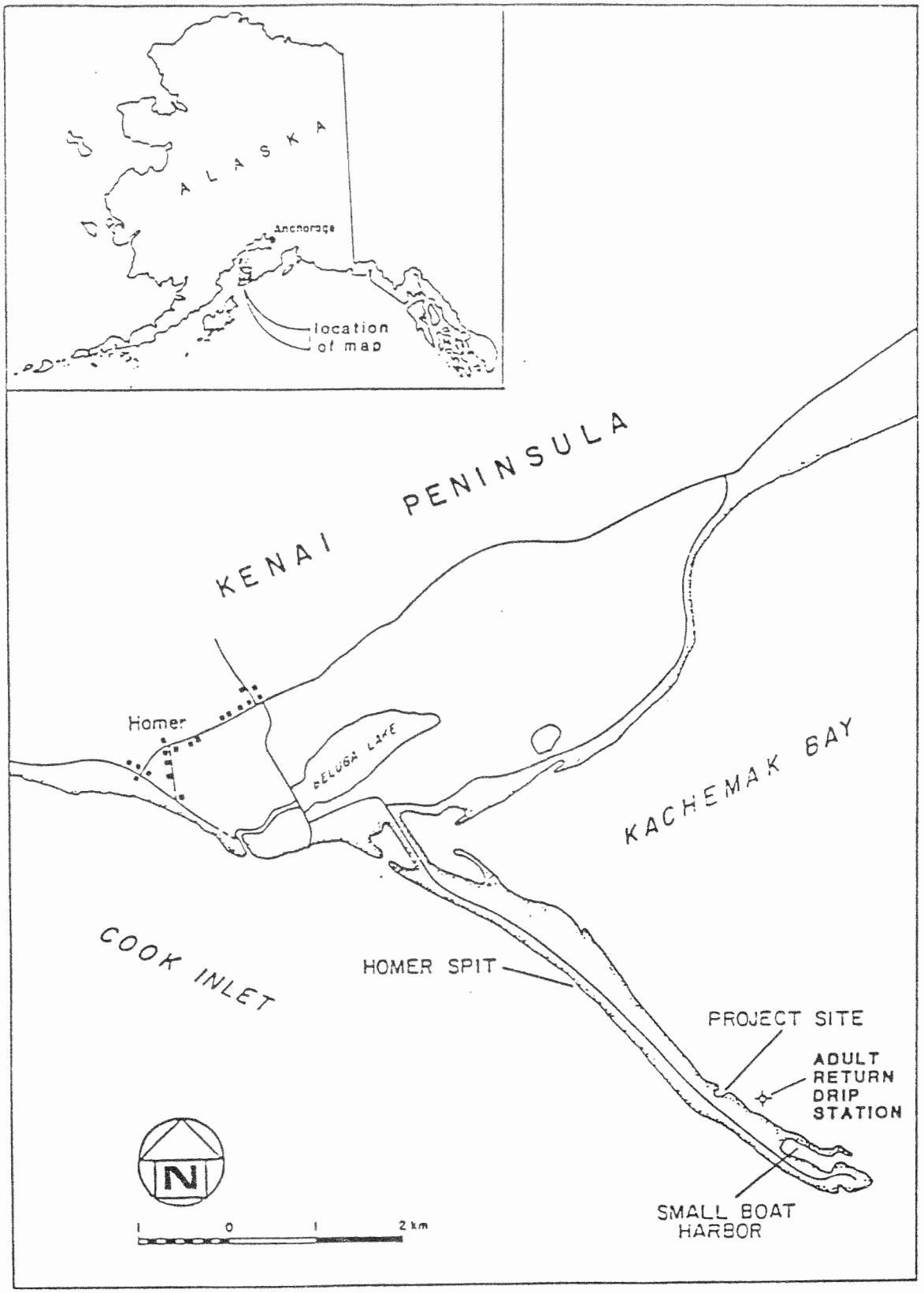


Figure 1. Homer Spit Salmon Enhancement Site.

Table 1. Chinook salmon smolt releases and adult returns, Homer Spit, 1984-1992.

Release Year	Smolt Release Date	Treatment	Number Released	size (g)	Estimated Adult Return by Year 1985	1986	1987	1988	1989	1990	1991	1992	Total	Estiamted Survival %
1984	12 June	None	80,000 a	17.8	400	300	580	500					1,780	2.2
1985	11 June	None	79,700	18.8										
	15 June	Pen fed	72,500	18.8										
	Subtotal		152,200			1,000	790	1,880	700				4,370	2.9
1986	10 June	None	52,300	13.8										
	15 June	Pen fed	51,600	13.8										
	Subtotal		103,900 b				630	820	1,500	600			3,550	3.4
1987	8 June	None	49,900	17.0										
	13 June	Pen fed	53,900	17.0										
	Subtotal		103,800					100	500	1,000	900		2,500	2.4
1988	9 June	None	47,650	18.0										
	12 June	Pen fed	170,250	18.0										
	Subtotal		217,900						300	500	1,700	1,100	3,600	1.7
1989	8 June	Pen fed	116,360	16.5										
	14 June	Pen fed	55,560	16.5										
	14 June	None	41,380	16.5										
	Subtotal		213,300 b							100	700	1,200	(2,000)	Preliminary
1990	29 May	Pen fed	107,845	13.8										
	5 June	Pen fed	102,440	15.9										
	Subtotal		210,285								200	500	(700)	Preliminary
1991	3 June	Pen fed	96,850	18.8										
	10 June	Pen fed	94,065	20.3										
	Subtotal		190,915									200	(200)	Preliminary
1992	27 May	Pen fed	115,525	17.5										
	15 June	Pen fed	110,800	19.0										
	Subtotal		226,325											
	TOTALS		1,498,625		400	1,300	2,000	3,300	3,000	2,200	3,500	3,000	(18,700)	Avg. 2.5

a Estimated number of live smolt released after deducting transport mortality.

b Smolt had unusually high sodium-ion blood plasma levels before release. Mortality after release was estiamted at 20% of the entire release group.

Table 2. Coho salmon smolt releases (after pen-rearing) and adult returns, Homer Spit, 1988-1992.

	Smolt Release					
Release Year	Date	Number Released	size (g)	Year	Adult Returns Number	Estimated Survival (%)
1988	1 June	62,550	21.8	1989	2,500	4.0
1989	26 May	77,770	20.0	1990	2,300	3.0
	2 June	76,070	21.4	1990	3,800	5.0
	Subtotal	153,840			6,100	3.9
1990	25 May	56,635	24.8	1991	4,000	7.0
	28 May	66,310	23.6	1991	6,000	9.0
	Subtotal	122,945			10,000	8.1
1991	27 May	59,985	21.5	1992		
	31 May	40,044	23.8	1992		
	Subtotal	100,029				
1992	3 June	60,124	23.4	1993		
	8 June	40,446	25.3	1993		
	Subtotal	100,570				
	TOTALS	539,934		1989 - 92	18,600	Avg. 5.3

Table 3. Pink salmon fry releases (after 20-30 days of short-term rearing) and adult returns, Homer Spit, 1987-1992.

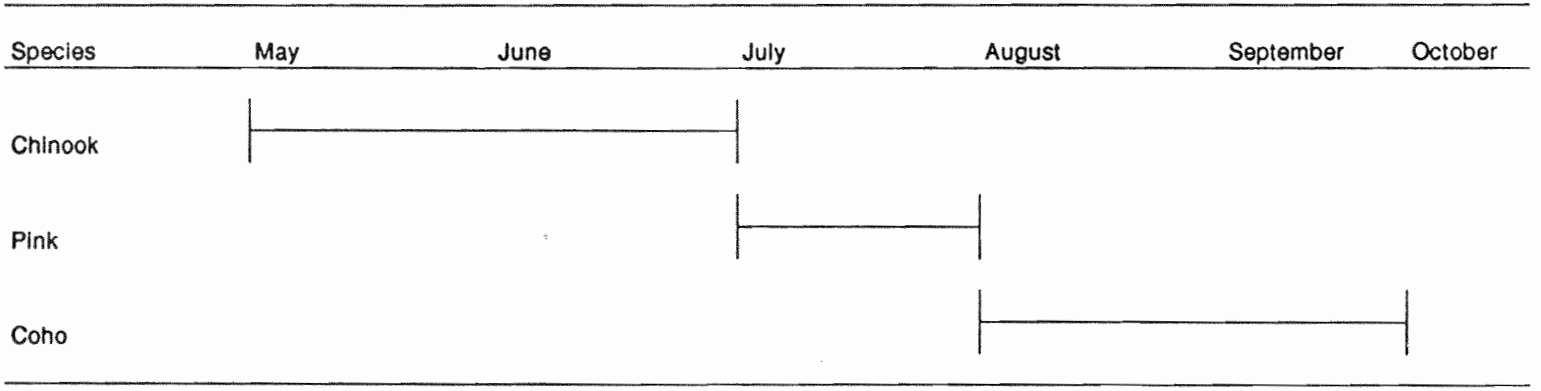
	Fry Release					
Release Year	Date	Number Released	Size (g)	Year	Adult Returns Number	Estimated Survival (%)
1987	2 June	295,000	0.40	1988	4,500	1.5
1988	1 June	300,000	0.46	1989	10,000	3.3
1989	7 June	330,000	0.45	1990	600	< 0.1
1990	13 June	304,000	0.45	1991	500	< 0.1
1991	13 June	320,000	0.49	1992	2,000	0.6
1992	10 June	300,000	0.46	1993		
	TOTALS	1,849,000	0.45	1988-92	17,600	1.1

Table 4. Harvest and angler effort directed toward enhanced king, pink and coho salmon stocks in the Homer Spit fishery, 1985-1992.

	King Salmon		Pink Salmon		Coho Salmon		TOTAL	
Year	Days Fished	Harvest	Days Fished	Harvest	Days Fished	Harvest	Days Fished	Harvest
1985	unknown	400						400
1986	unknown	1,300						1,300
1987	6,000	2,000					6,000	2,000
1988	7,000	3,300	5,000	4,500			12,000	7,800
1989	7,000	3,000	6,000	10,000	6,000	2,500	19,000	15,500
1990	6,500	2,200	3,000	600	6,000	6,100	15,500	8,900
1991	8,000	3,500	2,500	500	10,000	10,000	21,500	14,000
1992	9,000	3,000	3,000	2,000	(Data will follow season)		(12,000)	(5,000)
TOTALS	43,500	18,700	19,500	17,600	(22,000)	(18,600)	(86,000)	(54,900)

( ) = Preliminary

Table 5. Homer Spit salmon return timing.



HATCHERY SURVIVAL TACTICS
or
WHY HATCHERIES MUST EDUCATE

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Historically, hatcheries were only expected to turn out huge quantities of fish. Most managers and culturists believed that mission was best accomplished by locking themselves inside fenced compounds. Visitors were not welcome, and questions were only answered if the "tourist" could corner an uninterested staff member. While the primary focus of hatcheries must remain fish culture, education is becoming critically important to gain public support for continued hatchery operations. A variety of factors are now culminating in the imminent closure of several hatcheries and more closures may follow if fisheries personnel do not educate the public about hatcheries. Education, both among staff and the public, must be used as a hatchery management tool. Hatchery staff must seize public interest, through drop-in visitors and the resident community. Fish culturists and managers must remember to serve people as well as fish. Leavenworth National Fish Hatchery Complex provides several examples of how hatcheries can serve the local community, and teach people why hatcheries must remain open.

Some hatchery personnel might argue that their job is to raise fish, not to teach people about fish. These skeptical personnel would certainly agree that hatcheries were constructed and operated to raise fish, but why raise fish? Hatchery staff raise fish because fishery resources are important to people. Culturists and hatchery managers actually care for fish only as a public service. Virtually all hatcheries are funded by ordinary citizens, ignorant of fish culture, and therefore, they inherit a responsibility along with the money. As an analogy, private companies manufacture products, but also report on their operations to stockholders. When people pay their taxes or electric bill or buy hatchery fish in the supermarket, they become hatchery "stock holders." Because hatchery staff are entrusted with funds to care for a public resource, their job requires reporting and communicating to the public about the hatchery, its performance and its role in fisheries management. When staff neglect the basic educational component of their jobs, they fail to achieve the hatchery's mission.

Fisheries management evaluations lead to petitioning for the addition of several salmon strains to the endangered species list. Current economic, political and cultural trends may conspire to place hatcheries on the endangered species list as well. The slowing economy impacts everyone, including hatcheries supported by tax dollars. Agencies are now closing and down-sizing many hatcheries to meet budget cuts. Newly elected officials may approve plans to close even more hatcheries. Meanwhile, the environmental movement strengthens, and concern grows over endangered

species, especially salmon. Since the listing, all fisheries management decisions and hatchery operations have fallen under intense scrutiny. Hatchery staff stationed hundreds of miles away from endangered salmon runs must defend their every procedure. Newspapers exaggerate concerns into stormy scandals regarding increased electric rates and hatchery problems, simply to sell copies. Under these grim conditions, public opinion is easily swayed and many hatcheries are being abandon or risk extinction.

A recovery plan must be designed and executed for the continued health and survival of hatcheries. Fish culturists and hatchery managers must use education as a management tool. Hatchery staff must enhance and embellish the traditional hatchery functions and attitudes. The entire crew must realize that education is a critical part of their job; their responsibilities are to people as well as fish. Strangers at the hatchery should be perceived and treated as guests or visitors, not as a tourist nuisance. Hatchery staff must recognize that taking a little time to talk with visitors has great value. Leavenworth National Fish Hatchery Complex staff have been instructed to greet any visitors they encounter during the work day and make an effort to answer and encourage questions. Educating staff about the educational aspect of their job is fundamental to hatchery survival.

Hatchery staff must in turn educate visitors. The most basic need for visitor education is safety while touring a hatchery. Slippery floors, narrow walkways, dark rooms, deep water, and hazardous chemicals treatments are concerns at essentially every hatchery. Staff must also plan for broodstock security. The most effective method for managing visitor behavior is to explain the desired behavior and the reasons behind it. For example, a sign reading "Keep out" is negative, and may only serve to generate curiosity. A sign apologizing that an area is temporarily closed during a medicinal treatment will be much more effective and well-received. Visitor education is crucial to ensure human and fish safety.

Education is also important in terms of natural resource use. Some hatcheries face closure not only because of budget constraints, but because of habitat deterioration. Some downstream habitats cannot support released fish and some hatchery water sources are too degraded. These habitat problems are caused, either directly or indirectly, by people. Natural resource education is the most efficient way to change and correct behavior that leads to habitat destruction and eventually the demise of hatcheries.

Hatcheries must educate as a survival tactic, and an effective method of education is to capitalize on current public interest. Whether urban or remote, hatcheries are a destination for curious visitors. Staff must plan for and welcome these visitors. Several techniques can be used to draw visitors to a hatchery and make them feel welcome. Signs along the nearby highways and roads will direct visitors to the site. An open gate, with posted visitor hours, will suggest an invitation. All visitors, including those with mobility restrictions, are interested in seeing the hatchery. Leavenworth NFH converted public restrooms to meet handicap

accessibility standards, and two major viewing areas are ramped to accommodate all visitors. Because people enjoy visiting hatcheries, staff should make these facilities open and available.

Every element that hatchery visitors encounter should encourage them to investigate, ask questions, look around. At Leavenworth NFH, a videocassette recorder plays "Your National Fish Hatchery," which ends by encourages visitors to "become informed and involved. After all, this is your hatchery." Interpretive signs and exhibits can effectively communicate information without constantly requiring staff time. Offering a guest registry also helps promote a feeling of hospitality. These guest books can range from elaborate scrapbooks to a simple spiral-bound notebook. Brochures also help educate visitors, guide them through the facilities and foster a sense of welcome. Leavenworth NFH offers visitors a variety of brochures, from glossy, full-color booklets to one-page fact sheets created on the hatchery typewriter. New facilities, built exclusively for visitor use, will be appreciated and used if they are well-publicized. For example, an out-dated, unused pond at Leavenworth NFH has been converted into a major visitor attraction. A ramp was excavated and paved parallel to the pond, which allows visitors to look through underwater windows and see fish at close range underwater. Thousands of visitors a year ask to see big salmon, so a ramp and viewing platform were built overlooking the adult holding pond. Each of these elements takes advantage of natural curiosity to educate people about hatcheries.

Curiosity among community members can be used to recruit support for a hatchery. Many hatcheries must rely heavily on volunteer workers during especially labor-intensive times, such as spawning and incubation. When the hatchery has an established presence in the community, volunteer recruitment is easy. Hatchery staff represent a variety of backgrounds and interests, and these natural differences should be cultivated to network into the community. Leavenworth NFH Complex staff are involved in Boy Scouts of America, Kiwanis, Trout Unlimited, Ducks Unlimited, coaching and officiating school sports and the American Fisheries Society, just as personal hobbies and interests. Staff members can represent the hatchery at these community functions and can tap their connections to recruit volunteer labor for the hatchery.

Another important tactic is to use the local media to communicate hatchery involvement in the community. Instead of receiving potshots on the latest controversial issue, hatchery staff must take a pro-active media stance to maintain credibility. Many community members may not be intimately involved in the hatchery, and therefore can be easily swayed by media opinion. Every hatchery event should be given significance in the local newspaper. Leavenworth NFH is frequently in the news, either explaining operations, featuring new staff, describing programs, or dedicating new facilities. This exposure constantly reminds neighbors how important the hatchery is to the community. Issaquah State Salmon Hatchery cleverly maintains a returning adult salmon count each week in the newspaper. This fish count, while seeming simple, gives the hatchery deserved recognition for its important role in

salmon production. This media exposure demonstrates tot he public that hatcheries are a good investment for their tax dollars. Using the local media to gain praise is another important hatchery survival tactic.

The media is an important tool to communicate with people. Hatchery staff, while developing survival tactics, must remember to serve people as well as fish. Fish don't pay taxes; fish can't vote. Hatchery facilities, properties and equipment can be used for many community functions, and Leavenworth NFH is a good example. School children will plant trees around the grounds for Arbor Day. The local Boy Scout Troop holds weekly meetings in a hatchery building. Little League plays their games in a small field at Leavenworth NFH. Visitors lunch at picnic tables throughout the grounds. Anglers use a small boat launch on hatchery property. Handicap anglers can take advantage of the ramped fishing platform over the river. Cross-country skiers maintain and use ski trails that wind through the grounds. A one-mile loop trail with blinds provides wildlife viewing opportunities, and the accompanying brochure describes the hatchery's history. A senior softball team maintains a ball diamond at the hatchery. None of these extra services competes with or inhibits fish culture, yet they all serve the community. Local residents will fight a proposed hatchery closure if that means they would lose a major element of the community.

Hatcheries can also serve their communities by sponsoring special events. The Leavenworth NFH Complex has hosted Boy Scout camp-outs, children's fishing derbies, Open House activities and the Return of the Salmon Festival. The Boy Scout troops just need a grassy place to pitch their tents, and then perform service projects at the hatchery in return. Children's fishing derbies attract many families. These derbies provide an excellent opportunity to educate people about fishing regulations and techniques, fish conservation, and hatchery's role in providing fish for recreation and food. Leavenworth Complex's Open Houses invite local neighbors to spend a weekend afternoon touring the hatchery, watching spawning operations and salmon dissections, and learning more about the hatcheries' mission and operations. Every hatchery's chance for survival could improve from conducting special events, because they generate community understanding and support.

Another hatchery survival technique is to serve the community through schools. Washington's Superintendent of Instruction adopted an environmental education mandate for all state schools. Hatcheries can serve schools by helping teachers meet this environmental education mandate and simultaneously educate students about the importance of hatcheries. Fish culture facilities can be popular field trip destinations. Simple classroom presentations, explaining hatchery operations, fish biology, or career opportunities, are greatly appreciated by teachers from preschool through collegiate levels. Leavenworth NFH conducts a Steelhead Program with the local middle and high schools. Students, with staff supervision, assume the daily care of about 100,000 steelhead, including spawning, feeding, fin clipping and eventual release. Direct benefits to the hatchery include: volunteer labor, recruitment and evaluation of potential employees, and a sense of fisheries stewardship among the students. This Steelhead Program enabled hatchery staff to pick extremely qualified and previously-

trained applicants for summer Youth Conservation Corps jobs. Leavenworth NFH is also serving the local schools by planning to host an alternative high school on the grounds. This alternative high school will be staffed by school district personnel, but located at the hatchery so that students may complete special hatchery projects as part of their graduation requirements. Hatcheries, while cultivating a sense of community, will improve their "fitness" among government agencies by serving schools.

Another important event Leavenworth NFH uses to serve schools and the local community is the Return of the Salmon Festival. During the second weekend in October, the hatchery grounds are transformed into an almost carnival atmosphere, with salmon and fisheries resources as the star attraction. The first Return of the Salmon Festival attracted 8,000 visitors. Last October, the gate count numbered over 10,000 visitors, who traveled from all over the state. The event was created for families, to educate people about the salmon life cycle as well as the salmon's cultural and regional importance.

The only remaining criticism for using hatcheries to educate the public may be the cry for funding and time to perform such grand programs. Two simple solutions quickly dispose of this excuse. First, hatchery education programs do not need to start as lavish, extravagant, or glitzy products. For most hatcheries, educating the public is such an alien idea that a modest, unpretentious program represents a significant progression from traditional attitudes. Hatchery staff can produce simple, but helpful, informational sheets or maps, for example. The second solution is equally persuasive. To accomplish other, grander projects, hatchery staff can establish partnerships. A partnership is simply a relationship between two or more people who decide to combine some or all of their skills, labor, money and talents to accomplish a project for a common benefit. Partnerships can provide money, student transportation, materials, equipment, educational support, or whatever is needed to complete an educational project. Leavenworth NFH Complex participates in several partnerships, including Methow Valley as a Classroom, Kids in the Creek, Kinderfest, Kids Day for Conservation and the Salmon Festival. Methow Valley as a Classroom is a partnership with that enables high school students to earn credits through community service experiences. Winthrop NFH hosts one high school student each year. Kids in the Creek (KIC) will be a all-day field trip for high school students to study watersheds. KIC partners include Leavenworth NFH, Chelan County Conservation District, U.S. Forest Service, Washington Department of Ecology and three school districts. Kinderfest is a community carnival for children, and Leavenworth NFH creates an educational display for it each year. Four thousand students attend Kids Day for Conservation to explore and play through displays with conservation themes. Leavenworth's Kids Day partners include Ducks Unlimited, local radio stations, U.S. Forest Service, public utilities, fire departments and Pepsi-Cola. With enough partnerships, hatchery staff can connect with funding and talents to make projects a reality. Educational partnerships can provide another survival strategy for hatcheries.

Performance of rainbow trout fed low-phosphorus diets.

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Phosphorus is an essential dietary nutrient for fish, and the minimum requirement for rainbow trout has been found to be slightly over .5 % of the diet.

Many fish feeds contain much more phosphorus than needed, mostly due to the high levels of fish meal included to provide the quality protein that fish need. The excess phosphorus is wasted in the feces and urinary excretions of the fish. Hatcheries in many states are coming under scrutiny with regard to their phosphorus effluents. We need diets that will maintain normal growth rates and allow hatcheries to meet phosphorus discharge restrictions.

A trial was conducted at the USFWS Bozeman Fish Technology Center to compare growth rates and phosphorus utilization in fish fed one of several diets.

Four diets were included in the test; (1) Silver Cup Trout Feed, manufactured by Murray Elevators, was the control diet. (2) Danish Silver Cup, manufactured by European associates of Murrays', is used on that continent to reduce hatchery effluent waste products by feeding at a conversion of 1. (3) Diet T2M.5P,a low-phosphorus, open formula diet developed at Tunison Lab of Fish Nutrition, Cortland, NY, and (4) diet MNR-89G, another low phosphorus, open formula diet developed at the University of Guelph, Guelph, Ontario.

Each of the diets was randomly assigned and fed to 3 lots of Arlee rainbow trout for 13 weeks. Each lot contained 40 fish of an initial weight of 96 grams and length of 7.8". The fish were held in 20-gal aluminum troughs, each receiving 1 gpm of 46° F spring water.

We adjusted the feeding rates every week in order to acheive a feed conversion ratio of 1.0. This seemed to be the fairest way to compare weight gain and phosphorus utilization and discharge between diets. The fish were hand fed 4 times a day at a slow enough pace to minimize wasting of feed. All mortalities

were weighed so that they would be included in our calculations of phosphorus utilization at the end of the trial.

Our Silver Cup sample had a phosphorus content of 1.09%. The Danish Silver Cup was highest at 1.54% of diet, T2M.5P was much lower with .83% phosphorus, and MNR-89G was the lowest with .77% phosphorus.

Protein content of Silver Cup and Danish Silver Cup were about the same at about 43% of diet; T2M.5P was the highest at 53.9% and MNR-89G the lowest at 39.9%.

Costs of the diets were; .23/lb for Silver Cup; .31/lb for Danish Silver Cup; .29/lb for T2M.5P; and .255/lb for MNR-89G.

All the values shown are means of three replicates for each diet. After the trial ended, a 15 fish sample was taken from each lot. The carcasses were completely dried, and analyzed for phosphorus. Since phosphorus is determined on dried tissue, we had to have the moisture contents to calculate live weight phosphorus content.

Phosphorus content of the Silver Cup group was .46 % of body weight, which was unchanged from that of a 40-fish sample taken from the pooled group at the beginning of the trial. Phosphorus in Danish Silver Cup fed fish was a little higher at .48% (remember that this diet also contained the most phosphorus), while phosphorus content of carcasses of fish fed T2M.5P and MNR-89G were significantly lower at .42 % of body weight.

Fish fed T2M.5P had the best growth, gaining 107 grams per fish in 13 weeks. More than doubling their initial weight. Next was Danish Silver Cup with 101 grams of gain per fish. MNR-89G was next with 95 grams of gain per fish, and then Silver Cup with 92 grams of gain per fish. Fish fed these last two had significantly less gain than T2M.5P fish; Danish Silver Cup was in between the others.

Average length after the trial was 9.9", for an increase of 2.1" in 13 weeks at 46° degrees F.

We were able to acheive feed conversions close to 1.0 for all the diets, which is what we wanted for comparing phosphorus useage.

Survival was good for all lots, with MNR fish the lowest at 94%. We calculated how much phosphorus was ingested by the fish over the course of the trial by multiplying the total weight of feed fed each lot by the phosphorus content of the respective diet. The Silver Cup fish received 41 grams per tank during the

entire trial, Danish Silver Cup fish got a greater amount; 58.7 grams, T2M.5P a lesser amount, 34.6 grams, and MNR-89G the least amount, 28.7 grams per lot.

From the total weight gained by each lot of fish and the amount of phosphorus found in the carcasses, we calculated how much of the phosphorus ingested was retained by the fish. We assumed the rest was discharged into the effluent waters either in solid form via the feces, or in soluble form through urinary excretions.

Of the 41 grams fed to Silver Cup fish, about 42 % was retained by the fish, meaning 58 % was apparently discharged into the water.

Fish fed Danish Silver Cup retained only 33⅓ % of the 58.7 grams of phosphorus they ate, thus 66⅔ % was released as waste products. T2M.5P and MNR-89G fish both retained over 50% of the phosphorus they ingested, thus expelling a greatly reduced amount into the effluent waters.

In the last 2 columns we show the amount of phosphorus released to effluent in grams per kilogram of weight gain, and per kilogram of feed fed. T2M.5P and MNR-89G fish released just 3.7 - 3.8 grams of phosphorus per kilogram of weight gain, about half of what was released by the Silver Cup fed fish, 6.4 grams, and much less than the 9.6 grams/kilogram of weight gain discharged by fish fed Danish Silver Cup. The figures for phosphorus discharged per kg of feed fed were very similar.

Other good,low-phosphorus feeds have appeared on the market since this work was done almost two years ago. Progress is being made in reducing effluent phosphorus while maintaining good fish growth.

I thank Chris Nelson of Murrays for his support of this project and Dr. Young Cho of University of Guelph for his support and advice. Also thank my co-authors, Bob Koby of Bozeman Fish Technology Center, and George Ketola of the Tunison Laboratory of Fish Nutrition.

Preliminary Data[1] on the Effect of Dietary Protein and Lipid Levels on the Growth and Reproductive Performance of Rainbow Trout Broodstock.

The culture and management of broodstocks involves a number of specialized areas of knowledge including genetics, nutrition, rearing, spawning, fertilization, and egg incubation. Of these disciplines, the nutritional requirements of broodstocks is perhaps the most poorly understood. Although extensive research has been conducted to determine the nutritional requirements of salmonids, the majority of such work has been directed at young, rapidly growing fish. Formulated fish diets have been developed that contain protein, fat (lipid), carbohydrate, vitamins, and minerals in a ratio based on current knowledge of fish energetics and nutrient requirements. These diets yield excellent growth and acceptable conversions in juvenile salmonids. However, diets that specifically address the nutritional requirements of broodstocks are virtually nonexistent. In general, broodstock diets currently in use today are little more than grower diets with supplemental vitamins and minerals, and these additions are based not on scientific data but rather on the perception that they may be of benefit.

The primary objective of this research is to determine the effect and interaction of various dietary protein and lipid levels on the reproductive performance of rainbow trout. Other objectives of this study include determining if dietary protein and lipid levels can be adjusted to limit somatic growth without negatively affecting gonadal development and reproductive performance and ascertaining if dietary protein and lipid levels can be altered to reduce the cost of the diet without negatively affecting reproductive performance.

Six experimental diets were formulated in a 2 by 3 factorial treatment arrangement. The main effects are protein and lipid level. There are two levels of protein, 32 and 43%, and three levels of lipid, 9.3, 12.3, and 15.3%. Each of the two protein levels was combined with each of the three lipid levels to formulate the diets. Each diet was randomly assigned to two tanks (a total of 12 tanks) on May 1, 1991.

A final pre-spawn inventory of all fish was conducted on September 16, 1991. Survival in all treatments was excellent (1-2 fish mortality/tank). In all cases, the fish nearly doubled their weight during the study period. However, no difference in weight gain was observed with respect to any of the 6 experimental diets (Figure 1). This result was certainly not expected. The fish were

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[1] The data are from the first year of a two year study

spawned on 5 separate occasions over an 11 week period. Overall spawning success was excellent, with percent eye-up consistently over 90%. Surprisingly, statistical analysis of data collected did not indicate any significant differences with respect to egg size, percent eye-up, or relative fecundity between treatment groups (Figures 2,3, and 4). The reproductive performance of fish fed a low protein, low lipid diet (LPLL) was virtually identical to that of fish fed a high protein, high lipid diet (HPHL). If these data remain consistent during the second year of the study, they will indeed raise some interesting questions as to the dietary requirements of broodstocks.

Protein and lipid are often considered the two most important components in fish diets. However, to date, the relative importance of these two diet components as they relate to broodstock performance is unknown. There is currently a growing awareness among broodstock managers that large fish producing a larger volume of large eggs may not be as desirable as smaller fish yielding a higher relative fecundity. It is possible that by adjusting the protein and lipid levels in the diet of broodstocks, somatic growth could be limited while reproductive performance is maximized. Such a diet would also lead to a substantial reduction in feed cost, which is a major expense at all brood facilities.

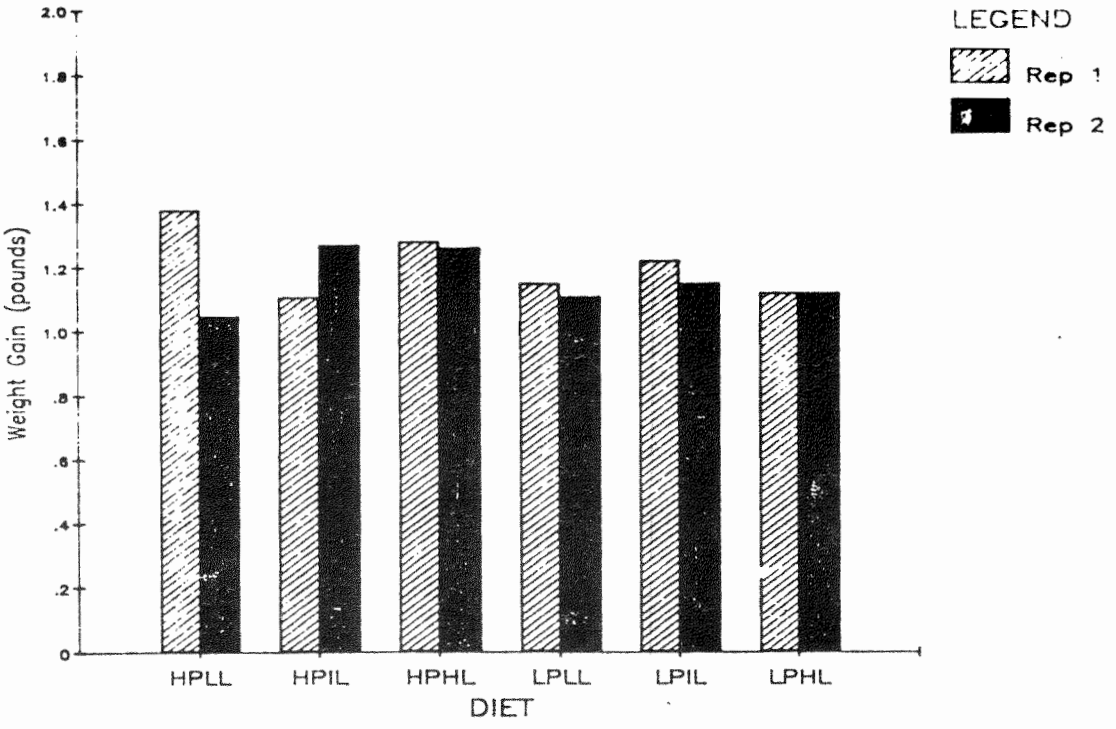

Figure 1. Effect of dietary protein and lipid levels on weight gain.

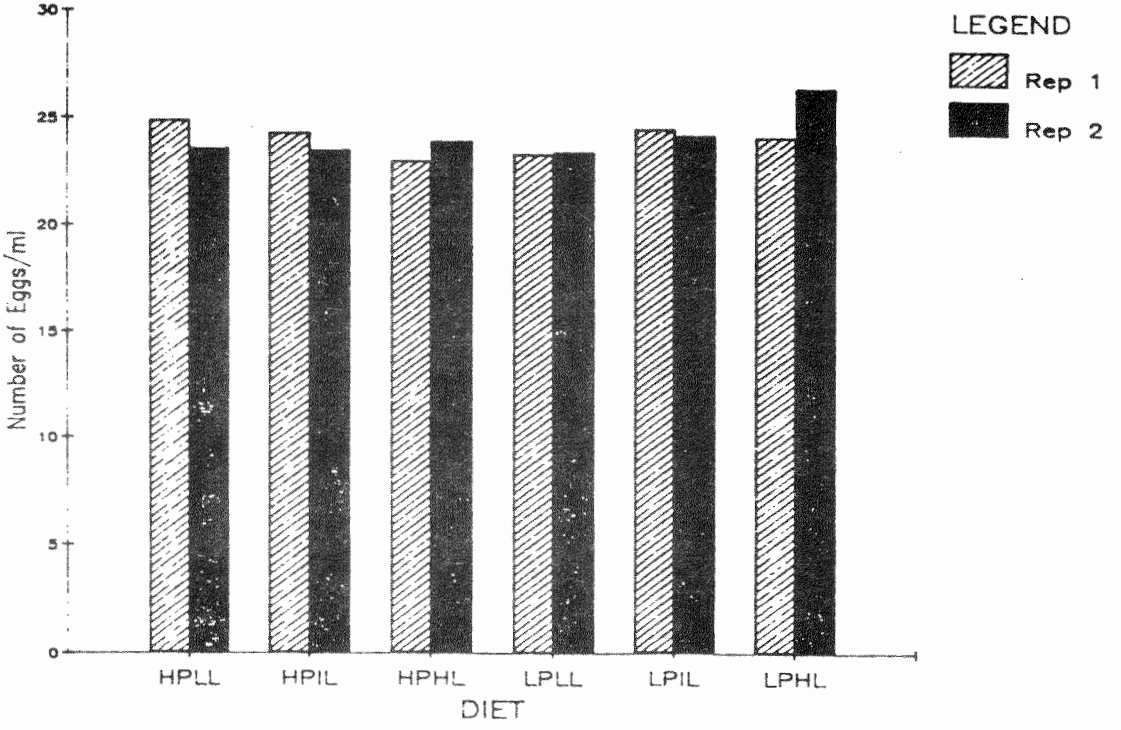

Figure 2. Effect of dietary protein and lipid levels on egg size (number of eggs/ml).

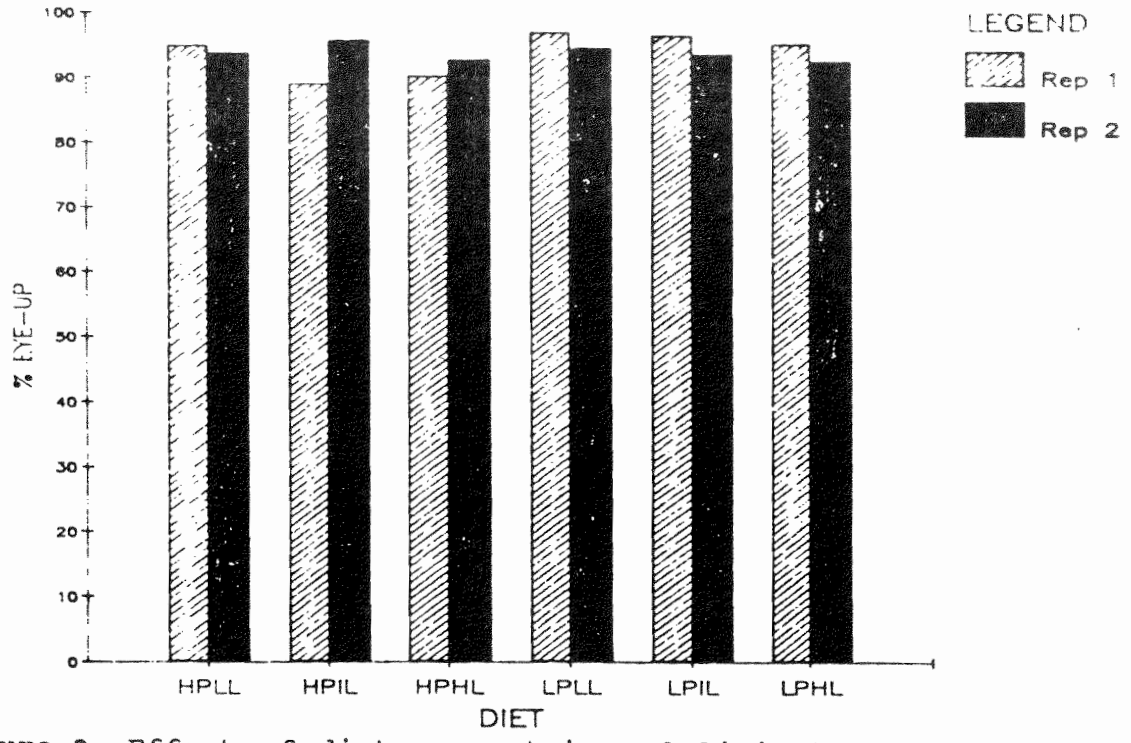

Figure 3. Effect of dietary protein and lipid levels on percent eye-up.

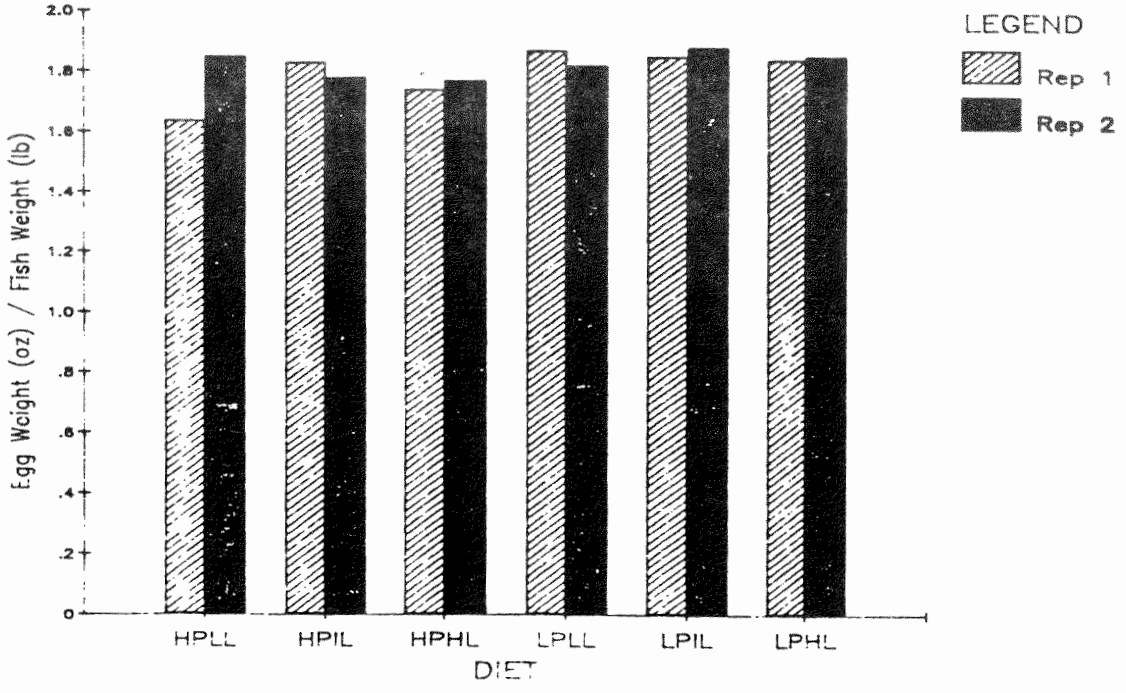

Figure 4. Effect of dietary protein and lipid levels on relative fecundity (egg wt/fish wt).

FISH TRANSPORT - ALASKAN STYLE

Mike Fallon
Alaska Department of Fish and Game

Alaska's transport system includes common and sometimes unique methods in reaching the destination for release. Snowmachines, helicopters and fire buckets, plastic bags and aerated Coleman coolers are a few of the novel ways that have been used.

Though no loading records have been broken much of the challenge involves the logistics of getting there. Flight schedules and tides are frequently considered when organizing the sometimes daily plan of departure. Considering the vast area of the state and its limited road system, can result in travel distances of up to 500 miles. Transport by air can also result in up to several hours of preparation and flying time up to 800 miles. Hatcheries in southcentral Alaska have recently began utilizing the Cessna 188 "Ag-wagon" or the SR-7 Thrush, which hold 200-300 gallons of water respectively. Though it is critical not to release at less than 200 feet, this quick distribution of fry and fingerlings over a large area of a lake, greatly improves survival from predation. Typical loads of 1 lb./gal. for sockeye fry and fingerling are now standard. The common Reif and Eagar tanks are generally used on our large transport vehicles and trailers. Liquid oxygen is used in conjunction with the relatively new and durable Point Four ceramic airstones. A recent improvement to our hose discharge system at release has been accomplished using a 6" - 4" Kamlok reducer. This results in a slower discharge time but the handling and loading of the 10 to 20 feet of hose is much easier.

Collectively the public hatcheries released nearly 250 million fish into over 500 lakes and rivers. Furthermore, the release area represents thousands of miles of transport as previously mentioned. To put it in perspective, if Washington state had proportionately the same ratio of roads to total square miles as Alaska, then it would have only 3 roads that would cross the state!

Extraction of Coded-wire Tags at Lyons Ferry Salmon Hatchery

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Lyons Ferry Hatchery operated by the Washington Department of Fisheries funded through the Lower Snake River Compensation Plan of the US Fish and Wildlife Service, began operation in 1985. A priority for the program is to maintain the genetic integrity of the Snake River fall chinook salmon. With the recent listing of these fish as a threatened species under the Endangered Species Act the preservation of genetic integrity of the stock is critical. Coded-wire tags recovered after spawning in 1989 revealed that as much as 40 percent of the fish spawned were not from the Snake river basin that year. This has made it necessary to read coded-wire tags prior to fertilizing eggs to determine the origin of the fish used in hatchery production. Our goal is to spawn Lyons Ferry origin fish together to maintaining the genetic integrity of the Snake River stock. Stray salmon as well as un-marked salmon are mated together and their progeny are shipped to other WDF hatcheries outside the Snake River Basin for rearing and release. The techniques we have developed may be useful for other hatchery programs for similar purposes of genetic control of broodstock or for any hatchery program that desires the ability to track individual fish through spawning and incubation.

During the past three years we have tried several ways of tracking fish through the spawning procedure. Some thing have worked better than others. This presentation will highlight the results of three years of trial and error and present you with some of our best ideas. I will also point out a few things that did not work so well. Bear in mind that we are continually trying to improve our procedures-if you have any suggestions to improve our process please let me know.

In 1991 we separated salmon that voluntarily returned by week of arrival by using different colored electrical wire ties around the caudal peduncle of the salmon to designated week of arrival. We noted substantial injuries and pond mortalities as a result of using electrical ties. We did not see any evidence of different arrival timing for strays compared to Lyons Ferry origin fish. Consequently we chose not to use wire ties in 1992.

Ripe fish are sorted weekly according to the presence or absence of the adipose fin. Un-marked fish are killed and set aside to be spawned with other un-marked fish or stray fish and kept separate from Lyons Ferry origin fish. A key to our system of tracking marked fish is using unique numbers to identify individual fish. This number is assigned when the fish is killed just prior to the taking of gametes and stays with the progeny of that fish until ponding. Three types of tags are used to keep

the number with the carcass, head and gametes of each fish. The first tag is stapled to the tail of the fish. We use waterproof tagboard with number written with a permanent marker. Last year some of the tags were lost because they got soggy and fell off. This year we laminated one side of the tagboard after writing the numbers on. This substantially decreased the number of lost tags. Using tagboard for tags instead of some kind of plastic tag allows us to leave the numbers on the carcass when they are disposed of. Semen from males is collected in plastic bags an I.D. number is written on each baggy with a grease pencil for each male spawned. Oxygen is added to the bag and the bag is placed into a cooler labeled for semen of unidentified stock origin. Females are bled on the sorting table. The fish are then measured, weighed, scale sampled, and snouts are cut off. One new thing this year was to weight some of the fish. We used a bag we had made to safely move fish out of traps.

It is made of a heavy duty 18 ounce vinyl tarp. At this time a label made of write-in-the-rain paper is filled out with the fish number, length and weight data. This label stays with the head as it continues on. The carcass is then set aside until after the coded-wire tag has been read. Females (which are not yet spawned) are place in a holding rack in the coring area. The head is then passed on to the coring area. The corer will dissect the head to find the coded-wire tag and pass the paper label with the coded-wire tag on to someone who will read the coded-wire tag and record the data. The data label is then discarded.

Once the coded-wire tag has been read and the origin determined the fish number is written on a dry erase board according to the fish's origin. Another person reads the board, and if the fish was a male, moves the semen to either the cooler of known Lyons Ferry semen or to the cooler for strays. The person then erases the number from the board. Females can then be moved to a Lyons Ferry origin rack or to the stray/un-marked rack to be spawned by the hatchery crew. When someone from the hatchery crew is ready to spawn her, her number is written on a small plastic tag that clips to a bucket into which she is spawned. As the eggs are fertilized using the semen from the cooler the male number is written on the back of the same plastic tag. This plastic tag will stay with the eggs throughout incubation until the eggs are hatched and ponded.

Assigning individual numbers to each fish and using that number on all data forms allow us to identify the progeny of individual fish and correlate that to coded-wire tags, scales, genetic, and virology data collected on the parents.

Spawning at Lyons Ferry Hatchery involves the co-operative efforts of many people from the hatchery crew, the evaluation crew, the tag recovery lab, and harvest management.

CONSIDERATIONS FOR THE USE OF ULTRAVIOLET IN FISH CULTURE

Ultraviolet has two primary uses in fish culture: Disinfection of water supplies and ozone destruction. The common thread is disinfection, with the difference in categories simply being what part of the process an ultraviolet system is placed and used.

DISINFECTION

Surface water for production water at fish culture facilities draw certain risks of contamination from waterborne pathogens. In some instances, dramatic effects caused by newly introduced pathogens into the watershed will cause complete shutdown of a facility, eradication of it's stock, and chlorination of all rearing vessels. The fish culture facility is virtually paralyzed and out of commission until some means of disinfection can be incorporated or replacement ground water source can be developed.

What the fish culturist requires is a dependable means of controlling and eradicating the pathogen that is present within the water source. Ultraviolet irradiation is a known effective and practical means of attaining this goal. By properly implementing an ultraviolet disinfection system, the targeted pathogen can be eradicated effectively without producing any harmful residuals.

ULTRAVIOLET THEORY

Ultraviolet achieves disinfection by radiating high intensities of ultraviolet light for a given amount of time. Ultraviolet light radiation when emitted within a given curve of the ultraviolet spectrum will disrupt and mutate the deoxyribonucleic acid (DNA) of microorganisms. The predominate action of DNA absorption by ultraviolet energy peaks at the 254 to 265nm range. Additional technical information is supplied in the Ideal Horizons article titled "Disinfection Liquid Purification By UV Radiation And It's Many Applications".

Muelemans and Luckiesh established the curve of "germicidal effectiveness" (Chart 1). This curve determines the percentage of light wave energy emitted that is relevant to disinfection.

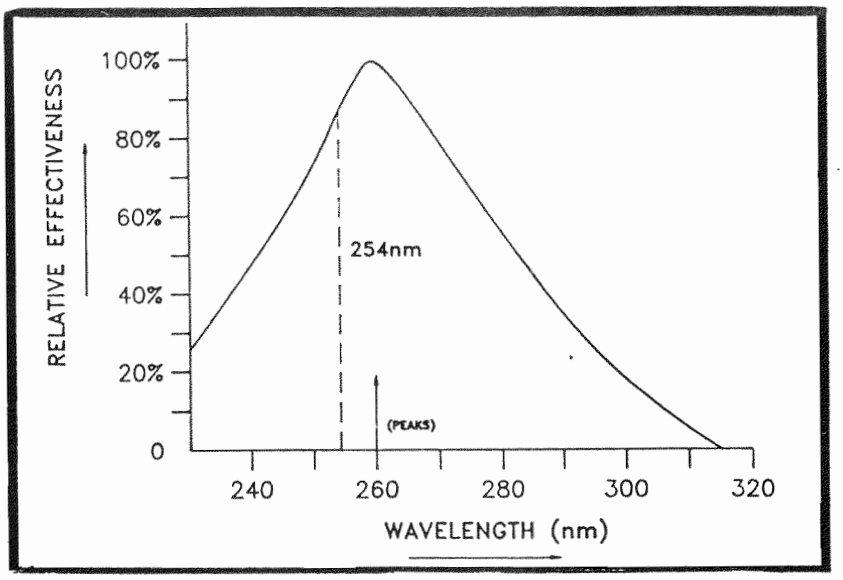


Chart 1 - Germicidal Effectiveness Curve

DESIGN FOR TARGETED PATHOGEN AND SITE CONDITION

When considering an ultraviolet system as the sole means of disinfection several parameters must be established. Identification of the target pathogens that are encountered will allow for proper ultraviolet irradiation dosages to be determined. Each microorganism exhibits a given resistance to ultraviolet light penetration. The amount of energy required within the germicidal effective curve to disrupt the DNA of the target organism is defined as "ultraviolet dosage applied". This is most commonly measured in microwatt seconds per square centimeter (μws sec/cm2) of ultraviolet energy irradiated within the 254 namometer wavelength.

MINIMUM REPORTED ULTRAVIOLET DOSAGE FOR INACTIVATING FISH PATHOGENS
(micro-watt seconds per square centimeter @ 254nm)

Pathogen	Dosage (μws/cm2)	Reference
IHNV (CHAB)	20,000	Yoshimizu, Takizawa, Kimura
IHNV (RTTO)	30,000	Yoskimizu, Takizawa, Kimura
IPNV (Buhl)	150,000	Yoshimizu, Takizawa, Kimura
CSV	100,000	Yoshimizu, Takizawa, Kimura
CCV	20,000	Yoshimizu, Takizawa, Kimura
OMV (00-7812)	20,000	Yoskimizu, Takizawa, Kimura
Aeromonas salmonicida	3,620	Normandeau
Bacilus subtilus spores	22,000	Nagy
Sarcina lutea	26,400	Nagy
Saprolegnia hyphae	10,000	Normandeau
Saprolegnia zoospores	39,600	Normandeau
Costia necatrix	318,000	Vlasenko
Myxosoma cerebralis	35,000	Hoffmann
Ceratomyxa shasta	30,000	Bedell
Trichodina sp.	35,000	Hoffmann
Trichodina nigra	159,000	Vlasenko
Ichthyophthirius tomites	100,000	Hoffmann

Chart 2

As shown in Chart 2 there is a wide differential for ultraviolet dosage applied to control the various pathogens considered. Identification of the targeted pathogens is the crucial starting point that will determine required dosage of the ultraviolet system.

Most industrial literature that exists for ultraviolet disinfection systems are sized for 30,000 $\mu ws/cm^2$ at the end of lamp life. This is an accepted standard for disinfection of drinking water and industrial applications. However, in many cases the sizing charts found in the ultraviolet equipment literature would not be adequate for fish culture related pathogens (such as Myxasoma cerebralis, IPN, etc).

Because disinfection by ultraviolet is accomplished by light wave energy, anything that might refract or inhibit it's transmission must be considered. Accurate knowledge of the seasonal turbidity fluctuations of the water is critical. This parameter is known as ultraviolet transmittancy of water. The worst case situation must be projected and the system designed to deliver the required ultraviolet dosage at the lowest projected transmittancy (or highest turbidity).

By establishing required ultraviolet dosage for the site turbidity (transmittancy) the ultraviolet equipment can then be accurately sized.

It is of equal importance in the sizing of the equipment to design the ultraviolet units for the required ultraviolet dosage based on end of lamp life (EOL). An ultraviolet light lamp degrades in energy output as it ages. This is caused by a "solarization" of the quartz housing due to the high intensity of the ultraviolet output energy. The industry standard for EOL of an ultraviolet arc lamp is when the lamp has diminished to 60% of it's original output. Also, careful evaluation of the rate the lamp declines is imperative. The standard should be the EOL at 8760 hours (1 year).

A typical design specification for selecting an ultraviolet system for a hypothetical fish culture application might look like this:

- 40,000 $\mu ws/cm^2$ at 254nm at rated flow
- 90% water transmittancy
- EOL 9000 hours at 60% original output

Once these specifications are established--along with determining the flow rate of the water to be treated--a specific sizing, cost, and footprint of the equipment can be accurately assessed.

Chart 3 - Equipment estimating sizing parameter chart based on 40,000 - 60,000 - 90,000 - 150,000 - 180,000 $\mu ws/cm^2$

ULTRAVIOLET WATER DISINFECTION EQUIPMENT ESTIMATING SIZING PARAMETER FOR TARGETED FISH CULTURE PATHOGEN DESTRUCTION

Ultraviolet Dosage System Design Requirements*					
MODELS	*40,000 µws/cm²*	*60,000 µws/cm²*	*90,000 µws/cm²*	*150,000 µws/cm²*	*180,000 µws/cm²*
	GPM	GPM	GPM	GPM	GPM
EP-2L	48	32	21	13	11
EP-4L	88	59	39	23	20
EP-10S	123	82	55	33	27
EP-12S	144	96	64	38	32
EP-8L	198	132	88	53	44
EP-10L	258	172	115	69	57
EP-12L	313	209	139	83	70
EP-16L	398	265	177	106	88
EP-20L	518	345	230	138	115
EP-24L	586	391	260	156	130
EP-32L	998	665	444	266	222
EP-40L	1038	692	461	277	231
EP-48L	1258	839	559	335	280

See Equipment Specifications List for All Standard Features

* Minimum ultraviolet dosage based upon 90% water transmission at rated flow @ 254nm at end of lamp life.

Chart 3

OZONE DESTRUCTION

Ozone use for disinfection in fish culture has increased in popularity. Although both ultraviolet and ozone are used in fish culture for disinfection they are not in direct competition with one another as one might assume. When viewed objectively site specific considerations, physical sizing limitations, economics, etc. will cause the appropriate system to emerge. Even when ozone is selected as the primary disinfection mechanism, ultraviolet has a potential role to play as an ozone destruct device for residual ozone levels in water.

Ultraviolet ozone destruction units produce complete removal of ozone by catalyzing the decomposition of ozone to oxygen. As with disinfection, efficient destruction of ozone occurs within a given effectiveness curve (Chart 4). Ozone destruct with ultraviolet radiation is most effective in the range of 250 to 260nm.

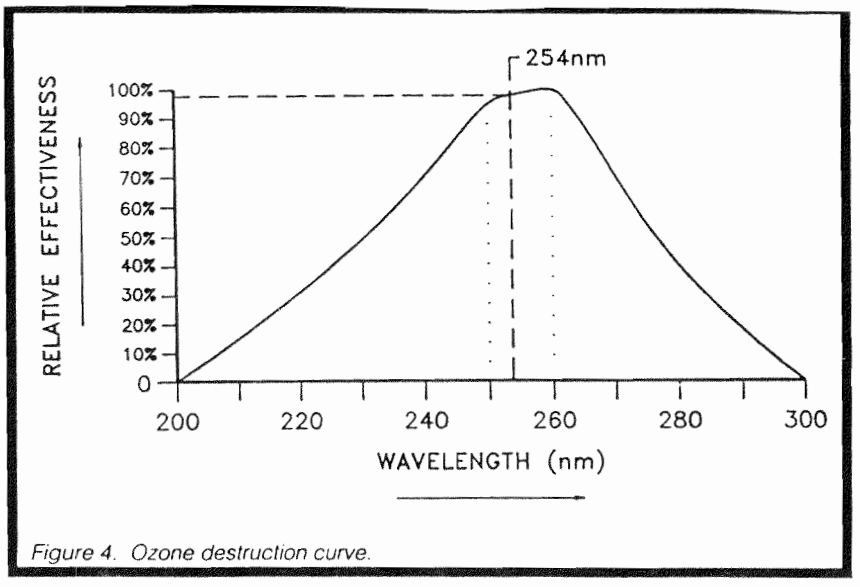


Figure 4. Ozone destruction curve.

The 254nm lamp, which has the highest ultraviolet energy output in this range, is the lamp choice for ozone destruction. An average ultraviolet system design dosage of 90,000 $\mu ws/cm^2$ is required to reduce measurable residuals ranging from 1.5 to 0.5 mg/l down to non-detectable. An average residual of less than 0.5mg/l would require 60,000 to 75,000 $\mu ws/cm^2$ dosage. Ozone destruction dosages varies in proportion to the residual and desired levels of removal.

Ozone residual can be readily reduced by air stripping. However, an ultraviolet destruct system has certain advantages that an air stripper cannot properly address. These advantages are:

* The ability to be placed in a pressure line without having to dissipate head pressure.

* Ultraviolet Ozone Destruct Systems do not produce an ozone offgas (which in turn has to be destroyed as well).

* On larger systems capital and operational costs are typically less than a cross current stripper tower.

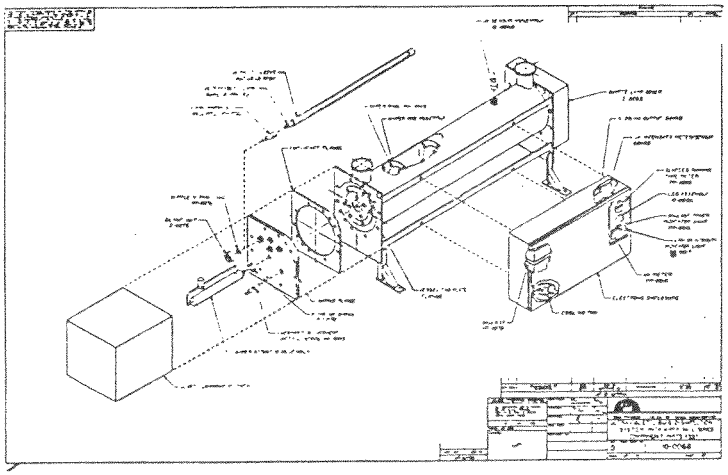
* The ultraviolet systems also provide back-up pathogen destruction.

EQUIPMENT CONSIDERATIONS

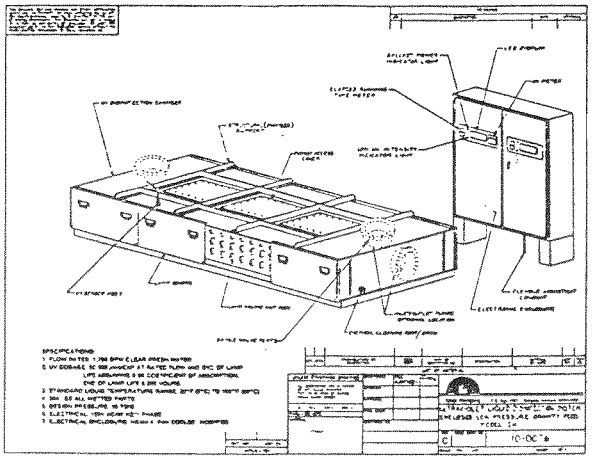
Prefiltration

In most cases, when surface water is used, some form of mechanical filtration is employed before the ultraviolet unit. This might take the form of granular media filter or micron screen. Average sizing of filtration is in the range of 15 to 25 micron filtering capability.

Vessel Construction



Pressure Vessel Design



Gravity Vessel Design

Ultraviolet unit vessels are available in a variety of shapes and sizes. This allows the units to be placed in most site situations such as low head requirement or insertion in a pressure line, etc. Custom configurations can be obtained by communicating the site restriction data to the representative of the factory.

Quartz Sleeve Wipers

When filtration is not available or inadequate, a quartz sleeve wiper system should be considered. A wiper system has the ability to clean the quartz sleeve of an ultraviolet system without having to shut it down. Smaller systems can be operated by hand whereas the larger system employs the use of an actuator (typically pneumatic). The actuator can be linked to a solenoid valve which in turn allows the system to be actuated automatically, via timer, intensity monitor, PLC or computer.

Intensity Monitor

Ultraviolet systems can be reliably operated simply by operating them within their rated EOL. However, certain applications require the operator to have immediate feedback. The intensity monitor measures the light wave energy emitted into the chamber. This is accomplished by a specialized photocell that employs the use of a light filter which excludes all wavelengths other than 254nm. This then is displayed on a meter as percentage of output.

A low ultraviolet system alarm notifies the operator when ultraviolet dosage is below acceptable levels. The trending of solarization of the lamp can be observed. However, more important it gives the operator immediate feedback to water quality changes (turbidity spikes).

CONCLUSION

In many other industries ultraviolet disinfection and ozone destruct systems are successfully designed, implemented and operated for years. Ultraviolet is extremely effective for fish culture as well. All credible ultraviolet equipment manufacturers provide service, technical assistance for applications sizing, equipment specifications and free water analysis for ultraviolet transmission absorption testing. By taking the time up front to understand the characteristics of ultraviolet and determine proper sizing, the original goal of pathogen control is readily realized.

WHAT IS THE DIFFERENCE BETWEEN LOW PRESSURE AND MEDIUM PRESSURE ULTRAVIOLET SYSTEM DESIGN

The ultraviolet industry "standard" has been challenged within the last several years by certain companies within the U.S. introducing "medium pressure, high output lamps" contained within their equipment vessels. These companies promise higher output, fewer lamps, and lower maintenance to paint a persuasive picture.

Considering the fact that medium pressure technology is available to all manufacturer's of ultraviolet equipment and could be readily offered by them, a question immediately jumps out. Why don't the majority of ultraviolet manufacturers offer medium pressure in their product lines?

To afford a reasonable and objective comparison of the low pressure mercury vapor (LPMV) lamp and the medium pressure high intensity (MPHI) lamp, each system must conform to a given site condition and comparable performance specifications. The primary objective of ultraviolet equipment for disinfection is to produce ultraviolet light wave energy at wavelengths that will effectively mutate or destroy the DNA of the targeted pathogen. Each pathogen exhibits a given resistance to the ultraviolet light wave energy. The ability for the ultraviolet energy to overcome this resistance is termed "ultraviolet dosage applied". Ultraviolet dosage is defined as a specific amount of energy irradiated within a given space and time. We will use microwatt seconds per squared centimeter (μws/cm2).

At this point we will assume the reader is familiar to site condition parameter considerations such as ultraviolet transmittancy, ultraviolet dosage requirements, lamp chamber geometry, etc. (further information is available in Ideal Horizon's publication "Disinfection: Liquid Purification by U.V. Radiation, and It's Many Applications").

We will use a system design evaluation criteria that will consider:

- Output of ultraviolet lamps
- Power consumption
- Ultraviolet lamp life
- Maintenance
- Capital Cost
- Operating characteristics

The performance specification of the two ultraviolet lamps being evaluated are:

	Low Pressure (LPMV)	Medium Pressure (MPHI)
Lamp Watts	65	2500
Germicidal Watts	23.4	163
KWH/Max. pwr.	.065	2.50

Table 1

ULTRAVIOLET LAMP OUTPUT

The output of a given ultraviolet lamp is defined as the watt energy that is irradiated from the arc lamp, expressed in wavelength units. Expressed in nanometers (nm) the germicidal effectiveness is defined as the output of the ultraviolet lamps within the Meulemans & Luckiesh Curve. The energy radiated within this curve is the only power that is relevant to disinfection.

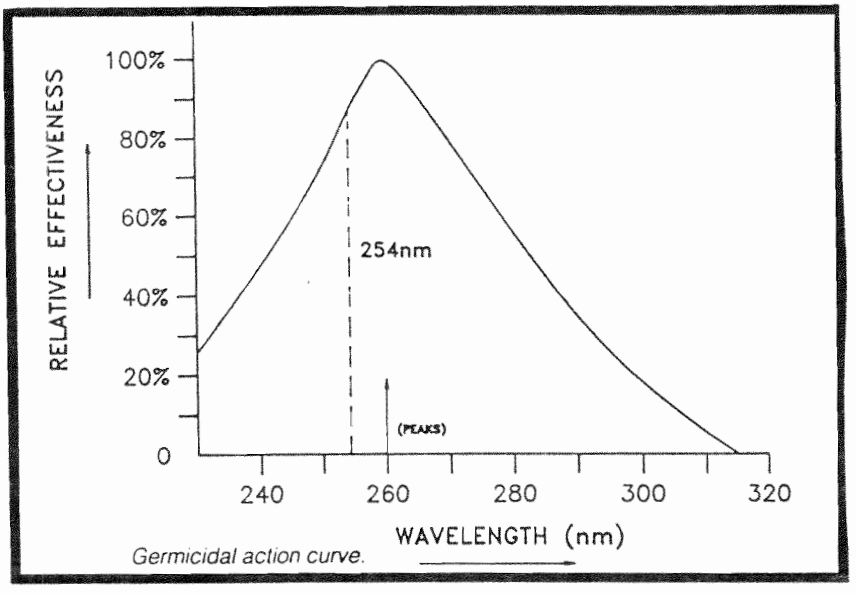


CHART 1

Both style of lamps initially lose a significant amount of energy to power being given off as heat energy. Of the total input power from both arc lamps the LPMV lamp converts 36% of the input lamp watts to germicidal effective watts as opposed to the MPHI lamp which converts 7% of its input wattage to germicidal watts.

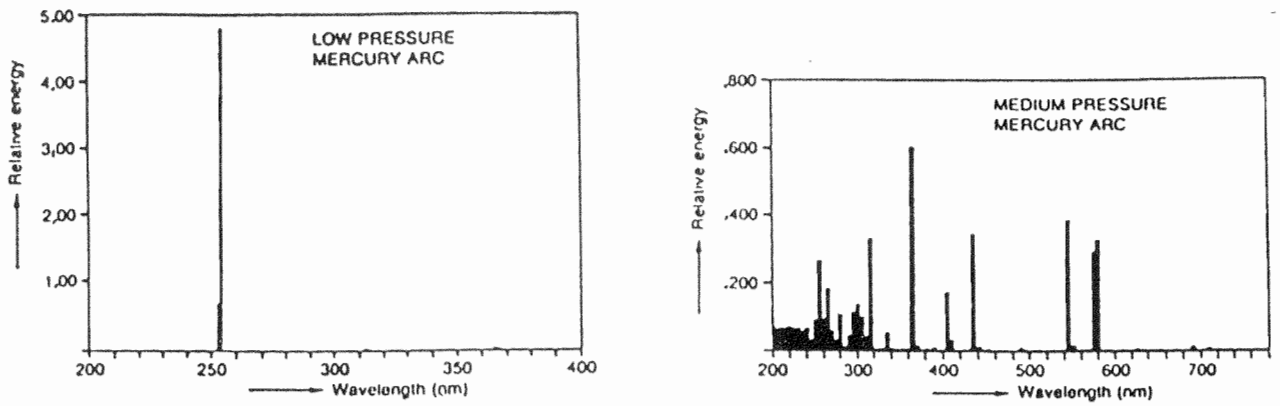


CHART 2

By examining the spectral distribution (see Chart 2) of both lamps, it becomes obvious why such a large differential germicidal efficiency exists. 85% of the spectral irradiation emanating from the LPMV lamp falls within Muelemans & Luckiesh Curve; whereas the MPHI lamp emanates across an extremely broad band beyond the range of any germicidal usefulness.

Because the MPHI lamp embraces such a large wattage input, even at 7% efficiency, fewer arc lamps can be used. At their full rated power, the ratio of arc lamps required for any given dosage applied is seven LPMV lamps for every one MPHI lamp when operated at their full rated power. This lamp ratio has been substantiated empirically by several field proposals and installations in which LPMV and MPHI systems were considered. A recent proposal for ultraviolet equipment to the State of Washington embraced a request for 180,000 $\mu ws/cm^2$ dosage applied to a flow rate of 450 gpm. This resulted in a 12 lamp system using the MPHI lamp and an 80 lamp system using the LPMV lamp. The lamp ratio between the MPHI and the LPMV is often used as a selling point. However, caution must be advised when evaluating sales information. In some instances the information presented by a company touting medium pressure arc lamp determined MPHI/LPMV lamp ratio solely by input watts which resulted in an <u>erroneous</u> 1 to 36 lamp ratio.

<u>POWER CONSUMPTION</u>

Because the MPHI lamp only converts 7% of its input wattage to effective germicidal output, a significant difference in power consumption develops between the LPMV and MPHI arc lamp. For instance taking the system example as proposed to State of Washington:

	LPMV	MPHI
Lamps:	80 lamp system	12 lamp system
KWH:	5.2 KWH	30 KWH
Annual Power Consup.	45.552 KWH	262,800 KWH
Annual Elect. Cost at .09 KWH*	$4099.68	$23,652.00

* National Avg.

Table 2

The MPHI lamp system consumes power at a rate of nearly six times that of the LPMV system. The annual power cost differential of $19,552.32 then becomes a major consideration.

LAMP LIFE

All ultraviolet lamps begin to degrade from the first moment they are energized. This degradation is mainly caused by a gradual solarization of the quartz material that results in a percentage reduction of ultraviolet output. The deterioration of the MPHI arc lamp occurs at a rate of 10% to 15% per 1,000 hours operation. Whereas the LPMV lamp deterioration rate is 3% to 4% per 1,000 hours. The accepted standard of end of lamp life (EOL) in germicidal applications is defined as when the lamp has reached 60% of its original output. At that time it has reached EOL and must be replaced. This is critical because the EOL point of the lamp is exactly at the minimum allowed ultraviolet dosage applied. If allowed to run beyond this point, the system becomes substandard and pathogen destruction is limited.

Again using the Washington system example:

	LMPV System	MPHI System
No lamps	80	12
Bulb Life*	9000 hours	3000 hours
No# annual change	1	2.92
Annual bulb consump	80	35

* Full rated power

Table 3

When considering the MPHI system, the operator can be led to believe that they are servicing a 12 lamp unit. When comparing the LPMV system on an annual operational basis the MPHI system actually requires 35 lamps annually. Average replacement lamp cost of an MPHI lamp is $375.00 compared to a LPMV lamp average lamp cost of $85.00. The differential of annual lamp replacement costs for the Washington system places the MPHI system at $6,325.00 higher than the LPMV system. It must be noted that MPHI system company has developed a means of stepping the power input in three stages. The primary benefit that is claimed is extended lamp life.

(1) MPHI Arc Lamp	KW	EOL
Power Level 3	2.3	3000 hours
Power Level 2	2.1	6000 hours
Power Level 1	1.7	9000 hours

Table 4

Although this extends the lamp life of the MPHI lamp it also proportionally reduces its germicidal output therefore increasing the amount of lamps required to maintain the required dosage applied. This in turn affects the lamp ratio difference in relation to the LPMV lamp.

MPHI SYSTEM	Lamp Ratio (LPMV to MPHI)
Power Level 3	7 to 1
Power Level 2	6.44 to 1
Power Level 1	5.25 to 1

Table 5

Equating that to the Washington system:

MPHI SYSTEM	Lamps Required for System Dosage	Annual Number of Lamps	Annual Lamp Replacement Cost
Power Level 3	12	35	$13125.00
Power Level 2	13	20	$ 7500.00
Power Level 1	16	16	$ 6000.00

Table 6

Although it might seem readily apparent that the MPHI lamp should be operated at power level 1 to extend lamp life and reduce annual replacement cost, a couple of reasons neutralize any benefit gained in lamp life. One reason is the significant increase in capital cost to add lamps to the MPHI system (capital cost will be addressed further on in this report). Secondly, because the MPHI arc lamp is a high output lamp, dropping the lamp below its rated power setting will create a sputtering that compounds the solarization problem. This condition draws into question the validity of the power level 1 setting being able to truly achieve the 9,000 hours EOL.

Another justification for power level stepping of the MPHI system is allowing for step up of power in the event of turbidity spikes in the water quality. This has certain appeal; however, any system should to be designed to provide the specified ultraviolet dosage applied at the site's worst case scenario, which results in a system being designed at its highest power output. LPMV systems have been arranged in banks that can be switched separately allowing for similar power stepping.

MAINTENANCE

Another of the "advantages" that is proposed by companies of the MPHI systems is the significant reduction in maintenance based on the fact of the MPHI systems using "fewer lamps". Upon closer examination, along with the considerations outlined to this point, this claim is put in proper perspective. Since both systems have quartz sleeve wiper options and state of the art methods of sleeve seals, the dominant annual maintenance consideration is change out of the lamps. A conservative estimate of the time that is required to remove and replace an arc lamp would be approximately 2 minutes. Looking at the Washington system, it equates as follow:

	LPMV System	MPHI System
No# Lamps	80	12
Service time/hrs	2.7 hrs	.4 hrs
Labor cost*	$32.40	$4.80

* Labor cost at 12.00/hr Table 7

The cost differential in labor equates to $27.60 in savings using the MPHI system.

By evaluating all of the projected annual costs of the Washington system objectively, a proper perspective is gained. The answer to the original question asked at the beginning of this report now becomes clear.

	WASHINGTON SYSTEM		
Table	LPMV System	MPHI System	Ratio
No# of lamps	80	12	7 to 1
Table 1 Annual pwr cost	$4100.00	$23652.00	1 to 3.5
Table 3 Lamp rep. cost	$6800.00	$13125.00	1 to 1.9
Labor cost	$32.40	$4.80	7 to 1
TOTAL PROJECTED ANNUAL OPERATING EXPENSE	$10932.40	$36781.80	1 to 3.36

Table 8

CAPITAL COST

When considering the capital cost of an ultraviolet system, a relative relationship can be established with capital cost and amount of lamps contained within the proposed system. Based on a compilation of several encounters in the market place, a reasonable estimate can be established of capital cost for each system. The LPMV ranges from $1,000 to $1,200 per lamp. The MPHI system ranges from $8,000 to $11,000 per lamp. Both systems include wiper systems, thermistors, and intensity monitors. Since the ratio of capital cost between the LPMV system and the MPHI system is 1 to 8.6 as opposed to the lamp ratio of 7 to 1 it can is quickly concluded that the capital cost of the MPHI system will be consistently higher than a LMPV system.

WASHINGTON SYSTEM

	LPMV System	MPHI System
Projected Capital Cost	$88,000	$114,000

Table 9

As mentioned earlier in the discussion on lamp life, the cost savings in lamp life extension (table 6) of $7,125 would be overshadowed by an increase in capital cost of $38,000. It would require over five years of operation before a cost benefit could be realized.

OPERATIONAL CHARACTERISTICS

The function and operation of the LPMV system and the MPHI system are virtually identical. Options incorporating wiper systems, intensity monitors, thermistors, automated controls, and computer interface are available on both systems with only minor variations between the two systems. However, one significant difference is worthy of noting. In the event of a power blink, the MPHI system requires a cool down period before the lamps can re-ignite and come to the full power. This can take up to 10 minutes for the MPHI lamp as opposed to the nearly instantaneous restart of the LPMV lamp. This leaves a MPHI disinfection system at considerable risk if it is located in an area that has frequent power interruptions (even momentarily).

CONCLUSION

The old adage "what you see is what you get" is the view that has fostered misunderstandings of the differences between the low pressure mercury vapor systems and medium pressure arc systems. Although it is true that a medium pressure system uses "fewer lamps" and requires "less maintenance", when performance and costs are quantified, the cost to own and maintain the medium pressure system far outweigh any other consideration. This is especially poignant when you realize that both systems are virtually identical in method of disinfection: disinfection by ultraviolet irradiation within the Muelemans & Luckiesh Curve for germicidal effectiveness.

1992 NORTHWEST FISH CULTURE CONFERENCE

DOORPRIZES

DONATION BY	DONATION	RECEIVER
Afishianaado Gallery	Ray Troll T-shirt and Book	Lloyd Charlie
Alaska Department of Fish and Game and Alaska Wilderness	10 Magazine Subscriptions and Cookbooks Gourmet Jellies	Dee Talotta Bryan Kensha Bruce Auldt Doug Burton Wendy Campbell Ruth Gates Jeff Moss Harry Bjorklund Steve Gross Jerry Dedloff
Alaska Flaggs Kenai Charters	Salmon Trip	Mark Lewis
Alaska Magazine	3 Subscriptions	Terry Erion Rod Henderson T. Dittenholer
Anglers Workshop	2 Aluminum Bats	Ron Reeves James Stone
AQUA Technologies	Partial Donator of Shotgun	Bruce Brown
Argent Chemical Labs	Partial Donator of Shotgun and 2 Books	Bruce Brown Bruce Bolding Butch Harty
Asplund's	Fanny Pack	Graham Ball
Athletic Supply	Hat	Mike Fallon
B & D Tackle	Fishing Lures	Jay Haskins
Beebe Orchards	Apples	Paul Waterstrat Paula Austin Robert Biernan

DONATION BY	DONATION	RECEIVER
Berkley & Co.	Fishing Line and Powerbait	Neal Turner Chuck Dunn Steve Gacek Pat Chapman
Bill's Fishin' Hole	Spinning Reel	Marvin St. Peter Bill Herschberger Marvin St.Peter
BioProducts	Prints	Trent Stickell Marc Barbiar Ken Philiipson Ian Baker
	Knives	Max Wooley Ann Grannam Alf Haukenes Charlie Smith Glen Ward Perry Wood
Blue Chelan Apples	Beach Towel & Cup & Hat	Mel Engelhardt
Blue Dun Fly Fishing	T-shirt	Mel Engelhardt
Bob Feil Boats & Motors	Anchor Cranker	Dennis Isaac
Bob Paulsen Guide Service	Guided Steelhead Trip - Satsop R.	Don Haerling
Bonair Winery	Wine Glasses	Dani Klontz
Cabela's	Spinning Reel	Lewis Hoffmeister
Canned Foods Grocery	Insulated Mugs	Mike Fallon
Christensen Net Works	2 Waterproof Hats	Steve Gacek Chuck Dunn
Congdon Orchards	Apples	Don Edsall Ken Eperson Don Johnson Nancy Wageman Sam Woods Butch Cobb
Corrosion Controllers	Flip Stick	Sharon Vendshus
Deer Mtn Hatchery	T-shirts, Canned Salmon, Sweatshirt	Kelly Wilcox Rusty Eschler

DONATION BY	DONATION	RECEIVER
Don Hill Boats	Wood Boat Model	Keith Johnson
Duckworth Boat Co.	Boat Cushion & Mooring Line	
Eaton Hill Winery Hyatt Vineyards	12 Bottles Wine 12 Bottles Wine	Mike Manson, Scot Lusted, W. Orr, D. Owsley, Ed Forner, R. Dolge, F. Pesquera, L. Peterson, D. Routledge, C Busby
Engineered Products	Partial Shotgun Donation	Bruce Brown
Expeditions Intl, Inc.	Attache Case	John Mason
F.M.S.I. Marine Goods	Propane Heater and Cooker	Dan Bears
Fish Pro, Inc.	Graphite Fly Rod Outfit	Kevin Sloan
Frank Amato Publications	Books	Wayne Stidronsky
G*Loomis	Discount on Fly Outfit	Kevin Sloan
Grant Road True Value	Smoke Detector	Art Brown
Hooked-On-Toys	Rod & Reel Combo	Larry Durham
Horizons Edge Winery and Hyatt Vineyards	Wines	Mike Manson, S. Lusted, W. Orr, D. Owsley, E. Forner, R. Dolge, F. Pesquera, L. Peterson, D. Routledge, C. Busby
Jansport	Assorted Packs	C. Christianson
Jensorter	Aladdin Thermos	Bob Kellar
LaCrosse Footwear	Hip Boots	Ed Enos
Lamiglass	Ultra Light Spin Rod	Tim Peone

DONATION BY	DONATION	RECEIVER
Larry's Smokehouse	Smoked Salmon Filets	B. Otto, D. Teffan, J. Reuth, B. Zimmerman, G. Mendel, B. Nyara
Larry's Sport Center	Fly Reel	Mark Galloway
Les Schwab Tires	Front End Align Certificate	Terry Jones
LFSI	Life Vest	Susy Walker
Liberty Orchards	Aplets & Cotlets	Mike McCloud
Luhr*Jensen & Sons	Assorted Lures	Jeanie Robanske, Steve Gacek, Chuck Dunn
Lyle's Boats	Plastic Worms	G. Ball
Moore Clark Co.	Partial Shotgun Donation	Bruce Brown
	Tackle Box	Glen Liner
	Light	Dick Anderson
	Filet Knife	Ron Mayo
	Rod & Reel	Paul Aagrud
Mountain Gear	Hats & Compass	Bill Tansley
Mountain Wholesale	Hand Painted Pin	Marilyn Scott
Irv Brock	Partial Shotgun Donation	Bruce Brown
	Halibut Trip	Leslie Schaffer
Mike Fallon	Partial Shotgun Donation	Bruce Brown
Nick Dudiak	Alaska Halibut Trip	Leslie Schaffer
Northwest Marine Tech.	Microwave Oven	Kevin Karras
Oregon Department of Fish and Wildlife	Framed Print	Roger Waren
P.R.A. Manufacturing	Belt Feeder	Joan Thomas
Pacific Boatland	Ice Chest	Keith Pratt

DONATION BY	DONATION	RECEIVER
Pendleton Woolen Mills	Beaver State Wool Blanket	Reese Voskailen
Phil's Sporting Goods	Tackle Box	Jay Haskins
Point Four Systems	Partial Shotgun Donation	Bruce Brown
Propp's Rod & Fly Shop	Hat/Calendar/Box	Keith Pratt
R.E. Redman & Sons	Apples	Dee Talotta, B. Shake, S. Turner, K. Hashagen, J. Rockowski, R. Morinaka
Rangen, Inc.	Camera	Ted Daggett
Recreational Equipment, Inc	Hip Packs	Gordon Sanford, Al Jensen, Neil Todd
Reeder Rods	Ultralight Rod	Marvin St. Peter
Reiff Fibergalss	Tackle Box	Joe Blodgett
River City Spice Tea and Coffee	Gift Certificate	Scott Zirjacks
Rocky's House of Guns	Sweat Shirt Gun Discount	Glen Mendel Bruce Brown
Sage	Fly Rod	Loren Jensen
SAV-MART	Aladdin Thermos	Ray Brunson
Silver Bew Fly Fishing Adventures	Hat and Box with Flies	Bob Jones
Silver Cup Feeds	Framed Duck Stamp Print Assorted Washington Wines	Bruce Bachen Tami Black, Bryan Quinton, Carol Coleman, Rich Holt
Sir James	Assorted Hand Tied Flies Pocket Weather Radio	Kevin Sloan Jorge Villarreal

DONATION BY	DONATION	RECEIVER
Sisson Shooters Supply	Misc. Neat Stuff	Jim Muse
Stan's Merry Mart	Thermos Cooler	Jack Palmer
Stemilt Growers	Apples	Registration Table
Sunset Bait & Tackle	Sweat Shirts	Greg Davis, Bill Hutchinson
The Boat Shop Marina	Life Vests	Steve Stout
The General Store	Coffee House Mugs and Rack	Mike Fallon
The Greased Line Fly Shop	Assorted Flies	G. W. Klontz
The Leatherman Tool Group	Lg. Leatherman	Andy Whitener
The Lunch Basket	Gift Certificates	Glen Liner, Bill Hutchinson, Greg Davis
The Mallory Company	Back Brace	Steve Jones
The Morning Hatch Fly Shop	Assorted Flies with Box	Hal Bolt
The Outdoor Sportsman	Hats	L. Charlie, C. Dunn, E. Forner, M. Babiar, M. Monson, S. Gacek, D. Burton, S. Gross, W. Campbell
Trout, Inc.	Apples	Rock Greenland, Del Brown, Dee Talotta, Paul McCollum

DONATION BY	DONATION	RECEIVER
Upper Columbia Chapter Trout Unlimited	Smoked Salmon Filet	Al Jensen
Valdez Fisheries	Shotgun Contributor	Bruce Brown
GI Joes - Vancouver	Kershaw Knife	Jack Palmer
Video Productions & Services of Yakima	Video Transfer	Ray Bass
VWR Scientific	Hydrophone Greenhouse	Lance Ross
Warren Water Broom	Screen Broom	Dennis Moore
Washington Department of Wildlife	Duck Print	Bruce Bachan
Washington Hills Cellars and Silver Cup Feeds	Assorted Wines	
Western Outdoors	Magazine Subscription	Stan Woody
Windsor Publications	Laminated Posters	S. Mattison, K. Peterson, M. McGee, D. Lain, V. Janson, Jack
Wolf Supply Co.	T-Shirt	Brian Zimmerman
Worden Winery	Wine Bag & T-Shirt	Wayne Stidronsky
Wright & McGill	Hook Assortments	C. Dunn, S. Gacek, N. Turner, P. Chapman, B. Herschberger
Zeigler Brothers	Belt Feeder	Jack Tipping

Contact List	Contact Person	Attended
Aqua Seed Corporation 1515 Dexter Ave N Suite No. 406 Seattle, WA 98109		
Argent Laboratories 8702 - 152nd Ave NE Redmond, WA. 98502	Eliot Lieberman 206-885-3777	yes
Bioproducts P.O. Box 429 Warrenton, OR. 97146	Russ Farmer 503-861-2256	yes
Christensen Networks 4074 Sucia Drive Ferndale, WA. 98248	Scott Christensen 206-671-8060	yes
Common Sensing P O Box 203 Clark Fork, ID. 83811-1541	Brian G. D'Aoust 208-266-1541	yes
Electronic Data Solution P. O. Box 31 Jerome, Id. 83338	Lorie Fullmer 208-324-8009	yes
Faivre of America 833 9th St Santa Monica, Ca. 90403		
Harrington Mfg. Co P. O. Box 2306 Twin Falls, Id. 83301-2306		
Industrial Plastics 740 S. 28th St Washougal, WA. 98671	Jim Ochs 1-800-634-5082	yes
J. L. Eagar, Inc. P. O. Box 476 N. Salt Lake, Ut 84054	Roy Eager 1-800-423-6249	yes
J. L. Darling Rite 2212 Port of Tacoma Rd. Tacoma, WA. 98421		

Jensorter, Inc 20225 Harvest Lane Bend, OR. 97701	Gregg or Cathy Jensen 503-389-3591	yes
Magic Valley Heli-Arc Box 511 Twin Falls, Idaho 83301-2306	Linda Owens 208-733-0503	yes
MariSource P. O. Box 9037 Tacoma, WA 98409	Chris Roth 206-475-5772	yes
Moore-Clark P O Box M LaConner, WA 98257	Scott McKnight 206-466-3131	yes
Neilsen Metals Industries 3501 Portland Rd. NE Salem, OR 97303		
Nelson & Sons, Inc P O Box 57428 Murray, Utah 84157-0428	Chris Nelson 1-800-521-9092	yes
Northwest Scale Systems 2100 W Broadway #5 Eugene, OR 97402		
Ozone Research & Equipment P O Box 30222 Portland, OR 97230		
PRA Manufacturing, Ltd. P O Box 774, Station A Nanaimo, B.C. V9R5M2	Wayne Gorrie 604-754-4844	yes
Protect A Cover 12310 Hwy 99 Bay 123 Empire Industrial Park Everett, WA 98204	Dennis Frank 206-742-5350	yes
Purina Mills, Inc 1125 Paulson Road Turlock, CA 95380		
Rangen, Inc P O Box 706 Buhl, ID 83316	Caroline Peterschmidt 208-543-6569	yes
Reiff Manufacturing Rt 4, Box 183 Walla Walla, WA 99362	Steve Reiff 509-525-1081	yes

Smith-Root, Inc 14014 NE Salmon Creek Ave Vancouver, WA 98686		
VMG Industries 2175 Meadows Court Grand Junction, Co. 81503	Bruce or Karen Marshall 303-242-8623	yes
Waring Marine, Ltd. 3113-2nd Ave Port Alberni, B.C. V9Y4C4		
R W Beck & Associates 2121 4th Ave Seattle, WA 98212		
Flex-A-Lite Consolidated P O Box 9037 Tacoma, WA 98409		
Net Systems, Inc 7910 NE Day Rd W Bainbridge Island, WA	Kurt Swanson 206-842-5623	yes
Mitsubishi International 1201 Third Ave. Suite 3700 Seattle, WA 98101		
Aquatech Systems P O Box 4315 Bellingham, WA 98101		
Marinka International 1919 East Calhoun Seattle, WA 98112		
Sverdup Corp. P O Box 369 Bellevue, WA 98009		
Innovac Technology, Inc 1123 W 53rd Seattle, WA 98107		
Summit Technology 615 2nd Ave. #580 Seattle, WA 98104		
BioMed Research 1720 130th Ave. NE Bellevue, WA 98005		
Global Aqua 11405 Gate Rd. S		

Olympia, WA 98502

Floy Tag & Manufacture — Krisine Mechals/Donald Amick
1-800-843-1172
P O Box 85357
Seattle, WA 98105

Northwest Marine Tech
Shaw Island, WA 98286

Parall Company
7225 Tahiti Rd
Jacksonville, Fl. 32216

Jerry Zinn
P O Box 299
Rt 3
Buhl, Id 83316

F-L Products Inc
P O Box 9416
Tacoma, WA 98409

Babbington Enterprises
Rt 1, Box 264
Hagerman, Id 83332

Joonas AgriTech
3046 McMillan Rd
Abbotsford, B.C. V256A8

Fort Babine Enterprises
P O Box 2292
Smithers, B.C. V0J2N0

Sound Environmental, Inc
P O Box 355
Tacoma, Wa 98401

Bill Nelson Co.
1549 NW 49th
Seattle, WA 98117

EnerTech
17508 48th St. SE
Snohomish, WA 98290

Star Valley Trout Ranch
P O Box 1266
Afton, Wyo. 83110

PCI Ozone & Control Systems — Robert Saville — yes
1 Fairfield Cresent — 201-575-7052
West Caldwell, N.J. 07006

Lummi Fisheries Supply, Inc
851 Coho Way
Bellingham, WA 98225
Terry Crump
206-734-3336
yes

Aquatess
1350 East Kent Avenue
Vancouver, B C V5x2y2

Red Ewald, Inc
P O Box 519
Karnes City, Texas 78118-0519

Cresent Research Chemicals
4331 E. Western Star Blvd
Phoenix, Az. 85044

Aqua Fauna Bio-Marine, Inc
P O Box 5
Hawthorne, CA 90250

Ryan Instruments, Inc
P O Box 599
Redmond, WA 98073-0599

Fresh-Flow Corporaton
Rt. 1, Hwy 28 SW
Cascade, WI 53011

Point Four Systems, Inc.
2702 Clarke Street
Prt Moody, B.C. V3H121
Rob Barratt
604-936-9936
yes

International Aquaculture Supply, In
5307 4th Ave S. Suite B
Seattle, WA 98108

Zeigler Bros., Inc
Box 95
Gardners, PA 17324
Maxine Maughlin
717-677-6181
yes

Doug Ernst
Bio Resource Engineering
Oregon State University
Corvallis, OR 97331-3906

Aqua Technologies
2004 SE 21st Court
Cape Coral, FL 3399
Ray Rutledge
206-568-7954
yes

Coffel t Manufacturing, Inc
1311 E. Butler Ave
Bldg B
Flagstaff, AZ 86001
Norman G Sharber
yes

Corvallis Microtechnology 413 SW Jefferson Ave Corvallis, OR 97333	Matt Lehman	yes
Engineered Products P O Box 10 Philomath, OR 97370	Stephanie Smith/T R Gregg 503-929-3225	yes
Ideal Horizons P O Box 1707 Rutland, VT 05701-1707	Jesse Rodriguez 802-773-4346	yes
The Mallory Company 1814 Baker Way Kelso, WA 98626	Avery Loy/Ramona Ainslie 1-800-426-6830	yes
Western Chemical 1269 Lattimore Rd Ferndale WA 98248	Ron Secor 206-384-5898	yes
Warren Water Broom Rt 4 Box 543C Astoria, OR 97103	Dell Warren 503-458-6694	yes
Alaska Industrial Resources 15 Central Way Kirkland, WA 98033	Gerrit Boyle 206-889-1205	yes
Afishionaldo Gallery 1900 W Nicherson Suite 101 Seattle, WA 98119	Suzanne Guerro 206-283-50782	yes
Zeigler Bros., Inc P O Box 95 Gardners, PA 17324-0095	717-677-6181	yes

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, H.
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	Washington Dept. of Fisheries	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	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	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, B.C.	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 Dept. and University of Idaho	Parrish, E. & Klontz, G.
1984	Kennewick, Washington	Washington Dept. of Game	Gearheard, J.
1985	Tacoma, Washington	U.S. Fish & Wildlife Service	Forner, E.
1986	Springfield, Oregon	Oregon Dept. of Fish & Wildlife	Bauer, J.
1987	Fife, Washington	Washington Dept. of Fisheries	Ashcraft, W.
1988	Richmond, B.C.	B.C. Ministery of Environment	Peterson, D.
1989	Glenendon Beach, OR	National Marine Fisheries Service	Smith, R.Z.
1990	Boise, Idaho	Idaho Dept of Fish & Game	Hutchinson, B.
1991	Redding, California	California Dept. Fish & Game	Hashagen, K.
1992	Wenatchee, Washington	Washington Dept. of Wildlife and Alaska Dept. of Fish & Game	Kerwin, J. and Brock, I.