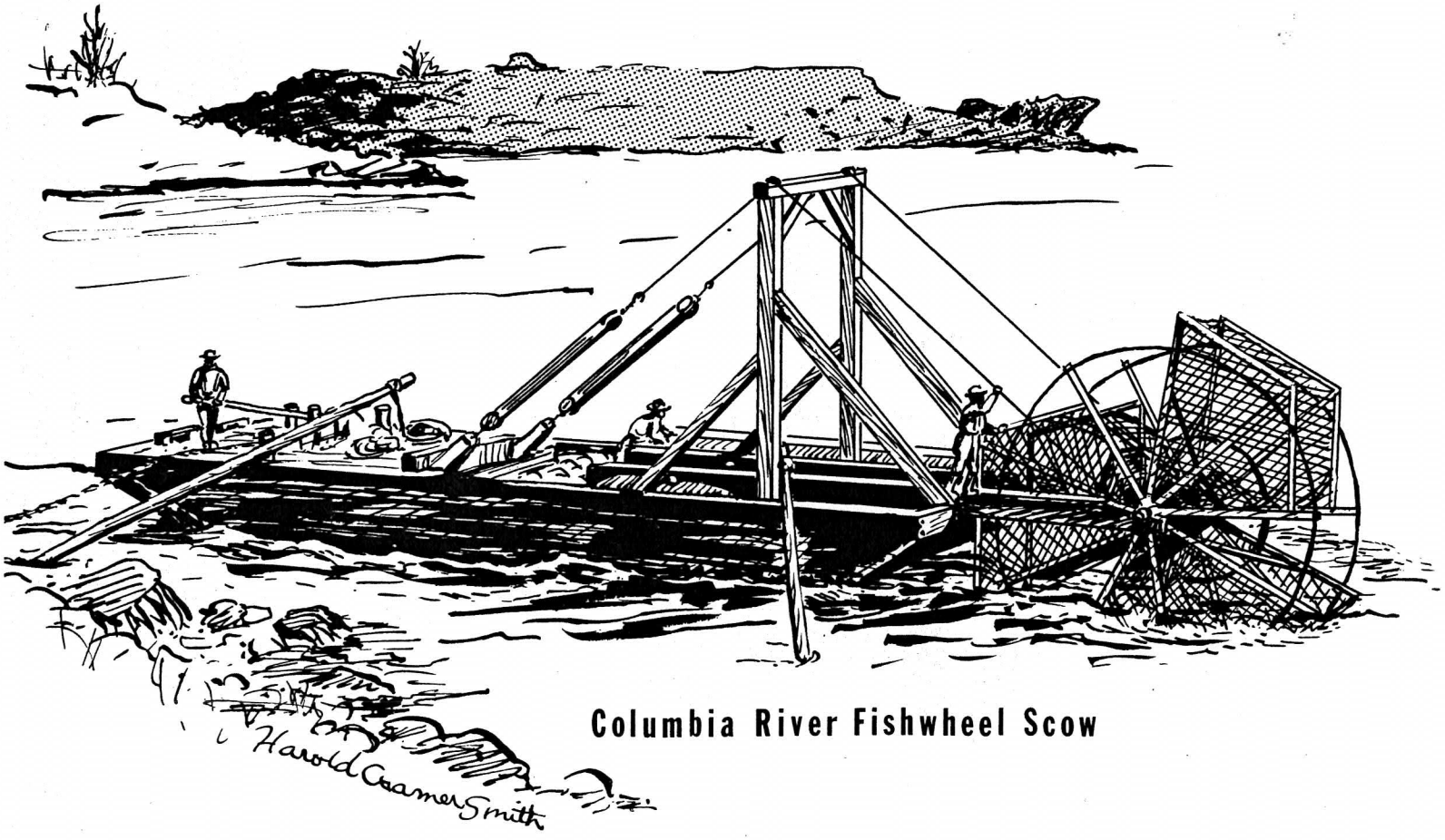
Northwest Fish Culture Conference



Columbia River Fishwheel Scow

PORTLAND, OREGON
December 5, 6, 7, 1979

PROCEEDINGS

of the

Thirtieth Annual

NORTHWEST FISH CULTURE CONFERENCE

December 5 - 7, 1979

Portland, Oregon

Chairman
Ernest R. Jeffries
Oregon Department of Fish and Wildlife

THE NORTHWEST FISH CULTURE CONFERENCE

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

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

PREFACE

The Thirteeth Annual Northwest Fish Culture Conference was held at the Sheraton-Portland, Lloyd Center, Portland, Oregon, from noon December 5 through noon December 7, 1979.

Dr. Jack Donaldson, Director of the Oregon Department of Fish and Wildlife, opened the Conference. He stressed the increasing importance of fish culture in the management programs on the West Coast of the United States and the continued need to improve the survival rates of the fish reared and released.

There were 328 people registered with a few others in attendance. Attendees were from the states of Alaska, California, Colorado, Idaho, Montana, Nevada, New York, Oregon, Utah, and Washington. British Columbia was well represented.

Carl Copper was responsible for all physical arrangements for the Conference and served as contact man with the hotel for reservations, meeting room, coffee serving, payments, etc. He worked with the ladies who sent out the invitations, provided smooth registration, updated the permanent address file, and typed and sent out the Proceedings promptly. Margaret Hanson, Charlotte Harkleroad, Sharon Ruffo, and Evelyn Walton were the young ladies that greeted attendees and made reservations so pleasant.

Jerry Bauer, John Conrad, Harry Lorz, Jim Martin, Earl Pulford, and John Westgate were session chairmen who kept the program moving and on schedule.

Dwain Mills was the projectionist and Howard Drago was the light supervisor.

Special appreciation is given to those noted, to those who presented papers, and all the rest who attended and listened so attentively.

The 1980 Conference will be hosted by Dr. Keith Sandercock, Fisheries and Oceans, Vancouver, B.C. The 1981 Conference will be hosted by the Washington Department of Fisheries.

Thanks to all!

Ernie Jeffries

TABLE OF CONTENTS

TABLE OF CONTENTS
Continued

GENERAL — PAGE NO.

TABLE OF CONTENTS
Continued

GENERAL

TABLE OF CONTENTS
Continued

GENERAL

ANNETTE ISLAND HATCHERY
"OPERATION BOOTSTRAP"

(A Hatchery Progress Report)

Dan Romey - Metlakatla Indian Community

BACKGROUND

A $5-million salmon hatchery is under construction near Tamgas Creek on Annette Island, approximately 20 statute miles southeast of Ketchikan, Alaska. It is the product of about three years of evaluating the needs of the Metlakatla Indian Community for a facility to artificially propagate salmonids. The purpose is to enhance the natural salmon runs on the Tshimpsean Indian Annette Island Reserve.

Tamagas Creek was considered an appropriate site. The ultimate capacity of the hatchery will be 60 million eggs or fry of selected salmonids. The mission of the hatchery program is to rear and release species of salmon that when returning to their release site, will pass through the common fishery of Alaska and can be harvested by the Metlakatla Indian Community and utilize their cannery and cold storage. The goal is to eventually have a hatchery program that will be operated by community members and be self-sustaining from harvest of returning salmon. Capitol construction of Tamgas Creek Hatchery began in 1977 and will be 70% complete by March 1980.

ANNETTE ISLAND HATCHERY

Due to several delays in Tamgas Creek Hatchery construction, a temporary field egg incubation station was needed to establish brood stocks and train Native fish culturists. Time was of essence. Operational funds were made available by the Bureau of Indian Affairs and Administration for Native Americans for this purpose. It led to the acquisition, at no

cost, of an abandoned Coast Guard Post Exchange and fire station building in 1978. The concrete block building was located about a mile across Tamgas Bay from the new hatchery site. Native Fish Cultural Trainees and Aquaculture Students cleaned out, painted, and equipped the building with the necessary plumbing, egg incubators, fish tanks and other essential fish husbandry items. Thus, by necessity, Annette Salmon Hatchery was born. A sign, painted by one of the towns people identifying the building as such, is displayed at the entrance.

Pink, Chum, and Coho eggs were taken in 1978 and the resulting fry cared for in this facility. In the process of keeping ahead of fish development, the small hatchery has been continually updated to meet the fish cultural needs. The water supply is reliable. It is a gravity system via the Coast Guard water main from Yellow Hill Lake. The intake, about 20 feet below the lake surface, provides trash-free water of high dissolved oxygen, low hardness and a suitable temperature range of $4^{o}C$ to $18^{o}C$.

Chum and Pink fry and fingerling were released from the Annette Hatchery in May 1979. Up to that time no overlapping brood year stocks were present demanding pond space, so no problem here-to-fore existed in having to move out one brood year stock to make room for the new. However, with the 1978 brood Coho still being reared for release in 1980, and the 1979 brood eggs hatching, the need became eminent for outdoor rearing ponds. Now came the "crunch": rearing ponds are expensive and the 1979 operational budget did not permit pond construction.

However, it just so happened that when the Coast Guard shifted their base of operations from Annette Island to Sitka in 1977, they removed several duplex housing units but left all of the four-walled concrete foundations behind. Ten of these water-tight units were modified and pressed into service as rearing ponds. The hatchery effluent and water from the nearby fire hydrant

main were piped to the ponds. Each foundation is 2½ ft. deep, 20 ft. wide, 50 ft. long and holds about 15,000 gallons. This system seems to be satisfactory as the 80,000 Coho fingerling (about 1,800 lbs.) in the pilot test pond are responding well to all aspects of fish husbandry.

Work is now underway to make this temporary incubation station into a permanent production hatchery and eventually into a basic salmon cultural development station. The means are available in the immediate area for economically doing so. Most improvements and updating are being done with Fish Culturist labor and with materials left behind by the Coast Guard. The "homemade" Annette Hatchery has a 4 million egg capacity and is now incubating about 3 million eggs. We can rear 3.5 million fry, 2 million fingerling, or about 1 million smolt.

SUMMARY

Having to come up with a suitable facility for immediate fish cultural needs from little or nothing is not new. The thing of note here is that it is being done by people here-to-fore untrained in the fish hatchery profession who are setting out to learn as much as they can, as fast as they can on the job in order to keep ahead of their expanding hatchery development. One trained fish culturist is leading the training and development. The financial accomplishment is that the fish culture program has been developed to the current status for about $120,000. This includes all salaries and material costs for 1½ years.

With this experience, the Native Fish Culturists of Metlakatla will now be able to put the main Tamgas Creek Hatchery into immediate production with only minimal difficulty. The biggest problem will be getting the usual multitude of "bugs" out of a new hatchery.

Thus, "Operation Bootstrap" has provided a comprehensive training program and an additional fish hatchery for the Metlakatla Indian Community at minimal cost.

Marked Chinook Salmon in Kachemak Bay, Alaska

Joe Wallis
Alaska Department of Fish & Game
Sport Fish Division
Homer, Alaska

Eleven marked chinook salmon were recovered in the sport fishery in Kachemak Bay in Southcentral Alaska. Examination of coded wire tags revealed: five from the South Santiam River Hatchery in Oregon; one from the Puntledge River Hatchery, British Columbia; one from Nitinat River, British Columbia; one from Atnarko River, British Columbia; one from Robertson Creek Hatchery, British Columbia; one from Skagit River, Washington; and one from Crystal Lake Hatchery in Southeastern Alaska.

Examination of scales from sport-caught fish showed a variety of life-history patterns. This, coupled with the tag recovery data, shows that there is a substantial population of "feeder" chinook salmon in Kachemak Bay, and that they originate at a number of distant streams.

ANCHORAGE AREA HATCHERIES
PRESENT PRODUCTION AND CONCEPTS FOR THE FUTURE

Gary Wall
Alaska Department of Fish and Game
Anchorage, Alaska

The Anchorage Area Hatchery complex is comprised of three facilities, Fire Lake, Ship Creek (Elmendorf), and Ft. Richardson.

Fire Lake Hatchery, which originally opened in 1953, is located some 20 miles north of Anchorage.

Although this facility is not operational this year due to budget constraints, it typically served as a central incubation center and also had rearing capacity to fingerling stage.

An interesting feature of this hatchery is the recirculation system which uses up-welling biofilters to recondition the water. Styrofoam beads are used as the biofilter substrate.

In FY-79, Fire Lake Hatchery had a permanent staff of 3 culturists; the year's production was approximately 2,000,000 coho fingerling, 400,000 rainbow trout fingerling, and 500,000 grayling fry. The operational budget was $245,400.

The second facility, Ship Creek Hatchery, is located immediately north of Anchorage on Elmendorf Air Force Base.

An unusual feature of this hatchery is the use of heated power plant effluent. Cold water is taken from Ship Creek and used to cool the power plant's condensers. It leaves the condensers between 65° and 85° F. and is discharged

into a 4 acre cooling pond. A portion of the heated effluent is intercepted and mixed with Ship Creek water for hatchery use.

Ship Creek had its start in the early 1960's when the military used four redwood tanks to produce fish for local lake stocking. In the mid-1960's the State became involved in this production and it is now entirely a State operation.

In 1972 the State began rapid development of a native Alaskan rainbow trout broodstock, and because other facilities were not available, the brood fish were held in floating pens in the cooling pond.

In 1974 bonds were approved for new construction at Ship Creek Hatchery. In November 1977, the first phase of construction, consisting of twenty 10' X 75' concrete raceways, water intake and mixing building, and water supply system was completed at a cost of approximately $3.4 million. Upon completion the broodstock were moved to the new raceways and the cooling pond is no longer used for fish production.

Additional construction, which would have included twenty raceways, a recirculation system, and a hatchery building has not been undertaken because the amount of water originally believed to be available could not be developed.

Ship Creek has a permanent staff of 3 culturists. Since 1977, typical production has been approximately 500,000 king salmon smolts, 50,000 to 100,000 rainbow trout fingerling, and approximately 1,500,000 rainbow trout eggs. The 1980 operational budget is $238,000.

The third Anchorage Area hatchery is Ft. Richardson. This facility is located upstream of Ship Creek Hatchery and approximately 5 miles east of Anchorage.

It is, as the name implies, located on the Ft. Richardson Army Reservation. It also uses heated power plant effluent, but unlike Ship Creek hatchery, all rearing is done in the cooling pond which has been divided into ten raceways.

Ft. Richardson has replaced Fire Lake Hatchery as the central incubation station. Incubation is accomplished in Heath stacks which are located in a 10' X 32' trailer. Each stack is furnished with a hot and cold water line which provides maximum flexibility in timing of hatching. After hatching, the fry are ponded in indoor raceways. These raceways are 32' X 4' X 3½'. When loadings reach 400 pounds, the fish are either split into other indoor raceways or moved to the large outdoor raceways. The outdoor raceways are 14' to 33' wide, 120' to 132' long and 4' deep.

Typical production has been 500,000 coho smolt, 50,000 to 80,000 catchable rainbow trout, 250,000 to 1,000,000 coho fingerling, and 100,000 to 300,000 rainbow fingerling. There is a permanent staff of 4 culturists and the FY-80 operational budget is $346,100.

In 1978, a $6.4 million bond package was approved for hatchery construction in Upper Cook Inlet. Most of those funds will be spent at Ft. Richardson. Concepts include a visitor center, broodstock development center, hatchery building which will house incubation and indoor raceways, and large outdoor production raceways. Production goals are 2,500,000 million rainbow trout

fingerling, 120,000 catchable rainbows, 2,000,000 coho smolt, 1,000,000 king smolt, and maintenance of the rainbow broodstock.

A schematic of this concept is presented.

DEVELOPMENT OF GROUNDWATER FOR SALMON ENHANCEMENT CHANNELS

Chester R. Mattson

National Marine Fisheries Service
Auke Bay, Alaska

Introduction

Alaska is unique in having an abundance of groundwater that occur in outwash plains of receding glaciers, in flood plains of formerly glaciated river valleys, and the uplifted coastal plain of the Gulf of Alaska. All have these common characteristics; they originated from glacial action and have porous combinations of silt, sand, and gravel containing subsurface water in formations called aquifers. Water table depths range from a few feet to 10 or more, with seasonal variations. Groundwater is filtered and temperature tempered; and can be developed at reasonable cost for salmon enhancement channels. Fish culturist's nightmares of drought, flooding, freezing, and siltation are greatly reduced and frequently eliminated.

The concept of combining groundwater with salmon enhancement channels dates to spawning ground surveys in the Port Valdez area in 1971 and 1973. At that time two gravel pit excavations included in surveys had developed flows of several cubic feet per second. Pink and chum salmon were spawning in the outlet streams. In 1977 further awareness of the concept developed with observations of a stable groundwater flow in a newly excavated interceptor channel for the Valdez sewage treatment plant. Also, observations of an additional twelve salmon streams originating in groundwater upwellings provided further substantiation for the concept.

Groundwater Characteristics

Groundwater flows have a number of favorable characteristics for salmon enhancement channel use including; 1) dependable flow patterns, 2) minimal

flooding or drought, 3) no siltation, 4) freezing problems are minimized, and 5) salmon, particularly chums, are attracted to upwelling water. The ranges between maximum and minimum annual flows at three sources in Port Valdez did not exceed a three-fold variation, whereas in southeastern Alaska a hundred-fold variation is normal in surface run-off streams. Flooding does not occur on glacial substrate due to the great prosity of the material. Freezing problems are reduced as the water is temperature tempered in passage through the aquifer.

Less favorable characteristics of groundwater include; 1) low levels of dissolved oxygen, 2) presence of undesirable total dissolved ammonia in two instances, and 3) low hydraulic head. Groundwater loses some of its dissolved oxygen due to the biological oxygen demand in the glacial substrate. The dissolved ammonia detected in two streams originated from effluent discharges at a large trailer park in one and in the other from buried debris of old Valdez. Such pollution sources are not characteristic in Alaskan groundwater aquifers. The outwash plains and moraines of glaciers have a low gradient, hence low hydraulic head that limits its use for salmon hatcheries. However, salmon enhancement channels have a low hydraulic head requirement.

Considerations for Channel Site Selections

The first, and major, consideration is the type of enhancement channel desired. Choices include 1) the artificial spawning channel, 2) the artificial incubation channel, or 3) the dual-purpose channel, a new concept. The third channel type is specifically designed to rehabilitate depleted pink and chum salmon streams.

It functions initially as an incubation channel to maximize salmon fry production, and as adult returns improve it eventually becomes a self-sustaining spawning channel.

Site selections will be influenced by a number of factors including; 1) availability of land with either a large area available (spawning channel) or a limited area (incubation channel), 2) quantity of water flow, 3) whether adjacent to a salmon migration route or a terminal harvest area, 4) proximity to a major salmon producing area or stream or removed from a major salmon stream, 5) whether for salmon rehabilitation or introduction of salmon into a new channel, and 6) costs for construction as well as operation and maintenance.

There are three topographical situations in which groundwater can be developed; 1) glacial moraines or outwash fans, 2) braided river flood plains of formerly glaciated river valleys, and 3) the uplifted coastal plains of the Alaskan coast from the Alsek to the Copper River. Factors that must be evaluated per site include; 1) determination of groundwater levels noting seasonal variations, 2) estimated costs of ground preparation, basically the removal of groundcover ranging from weeds and succulent plants to heavy conifer forest, 3) estimated costs of channel excavation, 4) provision of a graded gravel substrate (generally virtually unlimited sand-gravel material in glacial till), and 5) site access or remoteness strongly influencing cost factors.

Considerations for Channel Operations

Factors that must be considered in channel operations include; 1) availability of existing local salmon stocks or the necessity of importing donor stocks genetically and climatically adjusted to the immediate area, 2) genetic considerations with complete natural selection (spawning channels) or complete genetic control (incubation channels), and 3) channel loading densities, spawners with 1.0m^2/pair of pink salmon or 1.7m^2/pair of chum salmon or egg depositions of 2,000/ft^3 or more of channel substrate in incubation channels.

Summary

Potential sites for combining salmon enhancement channels with groundwater are most abundant in the glacial till areas of Prince William Sound, the Alaskan coastline of the Gulf of Alaska, and the northern mainland of southeastern Alaska. Groundwater availability decreases proportionately southward and become negligible in the Pacific Northwest states, at least from glacial substrate sources.

DEVELOPMENT OF A SHEEFISH CULTURE PROGRAM IN ALASKA; EGG TAKE TO FED FRY RELEASE

Irvin R. Brock

Alaska Department of Fish and Game
Anchorage, Alaska

Background: The sheefish occurs in northwestern North America and northeastern Asia, with an isolated population also found in the northern Caspian Sea area. In North America, it ranges from the Kuskokwim River drainage of Alaska north in coastal rivers to the Anderson River near Cape Bathhurst, N.W.T., Canada. In Alaska, sheefish are found in the Yukon, Kuskokwim, Kobuk, and Selawik river drainages where they support a small but potentially valuable sport and commercial fisheries, and an important subsistance fishery.

These fish are anadromous, with the longest migration on record in Alaska of approximately 1,000 miles up the Yukon River system into the Koyukuk River. Spawning takes place in late September or early October as the water approaches 0^{o} C. Maximum ages for Alaskan populations range from 9 to 20 years with age at maturity ranging from 7 to 9 years for males and 7 to 12 years for females. The fish are repeat spawners with spawning occuring every two to three years after maturity is reached. Females live longer than males and attain larger size (up to 60 pounds in the Kobuk-Selawik systems and up to 30 pounds in all other areas). Fecundity ranges from 125,000 to 325,000 with the majority of fish falling in the 125,000 to 175,000 range.

The first egg-take conducted was in 1967 when 200,000 eggs were taken from Koyukuk River stock. Hatching success has varied from 0% to a high of 50%.

The first attempts at experimentally feeding the fry took place in 1972 and 1973 with little or no success. The largest problem encountered in the experimental feeding studies was in getting the fry, which are only 30 - 35 thousand per pound, to accept an artificial food in enough quantity to sustain them.

Clear Air Force Station Hatchery is a planned F.R.E.D. Division facility to be located at Clear Air Force Station, approximately 75 miles south of Fairbanks on the Parks Highway. The hatchery, known as the Interior Alaska Fish Culture Development Center, has been designed with a maximum of flexibility to facilitate research and development of aquaculture technology for king salmon, coho salmon, chum salmon, grayling, sheefish, and other species as desired. Completion of this facility is scheduled for September of 1980. All experimental incubation, rearing, and feeding projects involving sheefish will be conducted at this facility. The sheefish culture program in Alaska has been of minor interest in the past, due to lack of space and funds at existing hatcheries. With the new Clear A.F.S. facility coming on line, a much greater emphasis will be put on developing culture techniques for sheefish.

The slides shown in this presentation are of the 1978 sheefish egg take on the Koyukuk River and resultant unfed fry. It is hoped that the slides will help show the logistics problems and some of the complexities of such a remote egg take.

SO YOU WANT TO DO AN EVALUATION STUDY?

by

Robert Vreeland
National Marine Fisheries Service
Portland, Oregon

Hatchery evaluation studies can be lumped into two categories: 1) comparisons of survival among control and test groups, and 2) determination of survival and contribution of a species of fish from a hatchery or groups of hatcheries. The usefulness of a hatchery evaluation depends on not only how the study is designed and run but on the validity of a number of basic assumptions made before the study begins.

The most common studies are the comparison of survivals among groups of fish given different treatments. The purpose of these types of studies is to determine if the different treatment improves survival. These types of studies may compare different diets, disease resistant treatments, release sizes or timing, etc.

When developing a study five questions must be asked. The questions are: 1) where should the survival be determined? 2) how many fish should be marked? 3) what is the expected catch of marked fish in the fisheries? 4) what is the expected fisheries sampling rate? and 5) how big a difference is to be detected among the groups?

Seven basic assumptions must be made when making a comparison of survival among control and test groups. The assumptions are as follows: 1) the catch of marked fish will be X, 2) the fishery sampling rate will be Y, 3) the differences among control and test groups is due only to whatever is being tested, 4) the fisheries are randomly sampled for marks, 5) there is no loss of marks, 6) all marked fish are recognized, and 7) there are no natural marks like those applied.

With passage of the Fishery Management and Conservation Act, court decisions regarding Treaty Indian fishing rights, and continued negotiations between Canada and the United States over salmon interception, there has been a greater effort to obtain contribution information for wild and hatchery stocks.

Eight basic assumptions must be made when conducting contribution studies. They are: 1) the catch of marked fish will be X, 2) the fishery sampling rate will be Y, 3) marked fish represent unmarked fish, 4) the salmon fisheries are randomly sampled for marks, 5) there is no loss of marks, 6) all marked fish examined are recognized, 7) there are no natural marks like those applied, and 8) survival and behavior are the same for marked and unmarked fish.

Any hatchery evaluation study depends on the validity of the assumptions. When writing study proposals and reports the assumptions should be listed. In this way the reasons for certain procedures used while conducting the studies will be reinforced. Hatchery personnel will see the need for random sampling of fish to be tagged. The need for the highest possible mark quality will be stressed to tagging personnel. Those involved in fishery sampling will better understand the need for random sampling and careful examination of fish for marks. If sampling assumptions are not being met, it should help to emphasize the need for changes in sampling programs. Most of all, listing the assumptions will drive home the point to the investigators that after the fish are marked the work is not done. An active part must be taken in assuring the assumptions are met from the hatchery through the fisheries and back to the hatchery.

HATCHERY EVALUATION IN BRITISH COLUMBIA

Ted Perry

Fisheries and Oceans
Vancouver, B. C.

Twenty million juvenile chinook, coho, chum and steelhead were released from 15 B. C. federal production hatcheries in 1979 as part of the Salmonid Enhancement Program (SEP) Table 1.

Table 1. 1979 Releases of Salmonid Juveniles from Federal Production Hatcheries in B. C.

	No. Released	No. Marked	% Marked
Chum	4,140,000	655,000*	16
Chinook	12,951,000	1,282,000	10
Coho	3,094,000	420,000	14
Steelhead	207,000	188,000	91
Total	20,392,000	2,545,000	

* 88,000 of these were coded-wire tagged; the remainder were fin-clipped.

The objective of these hatcheries, and of all other SEP programs, is to maximize net social and economic benefits for Canadians subject to budgetary and technical constraints. These benefits are measured relative to five accounts designed to represent the impact of SEP in terms of the following priorities of government:

1. National income
2. Regional development
3. Native people
4. Employment
5. Resource and environment preservation

Only the national income account is directly quantified in dollars and cents - the benefit - cost ratio and net national income are indicators used to evaluate the benefits and costs included in this account. The other four accounts are each scored on a relative basis, very good to very poor, between projects. A "good" project is one that has had favourable impacts on the distribution of fisheries benefits or on the initial situation. A "poor" project has had negative impacts on the initial situation. The SEP package includes a wide range of projects, some which were selected on the basis of benefits to the national income account, and some which offer high benefits in one of the other accounts.

Factors used in the five account evaluation system of most immediate concern to the fish culturist are:

1. Operating costs
2. Contribution of adults to the commercial, recreational and Indian food fisheries, and escapement
3. Increase in knowledge of salmonid biology and fish culture techniques

In particular, the culturist wants his hatchery operation, the production of smolts from eggs, to be as efficient as possible; he wants to learn how to improve the operation through applied research and development; and he wants to maximize and assess the contribution of his product. It is the purpose of this paper to review where gains maybe made in the cost effectiveness of the hatchery phase; to review studies aimed at improving the quality of smolts thus increasing contribution; and to outline methods used in the assessment of contribution to permit evaluation of different culture strategies.

The Hatchery Phase - Improving the Product

Survival of fish during the freshwater phase for typical production techniques used in B.C. is generally high (Table 2). Gains to be made by increasing egg-to-fry or fry-to-smolt survival are only fractional.

Table 2. B. C. Design Standards for Survival of Hatchery Chum, Chinook, Coho and Steelhead

	% Survival			
	Egg-Fry	Fry-Smolt	Smolt-Adult	R/S*
Chum	90	80	2	18
Chinook	90	80	3	54
Coho	90	75	15	126
Steelhead	75	70	4	46

* Return/Spawner

The biggest potential for increased cost effectiveness in the hatchery phase is through improved smolt quality. Much of the applied research and development effort in B.C. has this objective (Table 3).

Table 3. SEP - Related Research and Development Activities in B.C. Federal Production Hatcheries

Incubation systems	- water quality
	- egg/fry quality
	- procedures
Rearing systems	- semi-natural*
	- density *
	- freshwater/saltwater*
Japanese-style hatcheries*	
Pink salmon culture techiques*	
Smolt release	- time/size*
	- saltwater challenge*
Disease	- surveys/diagnostics*
	- kd and vibrio vaccines*
	- nutrition interractions*
Diet	- practical dry diets
	- quality control*
	- ration level*
Endocrinology	- controlled reproduction
	- anabolic hormones*
	- controlled sex differentiation
Accelerated growth/smolting	
Genetics	- stock concept
	- selective processes in the hatchery
	- imprinting/homing

* Primary objective improved smolt quality.

It is difficult to judge what the potential net benefits of improved smolt quality are, but recent experience with coho production is instructive. Data from several studies suggest that coho smolt survival in the 40%-50% range is not an unrealistic target. This is two to five times higher than current survival rates for production groups. Thus, depending on the strategy required to improve quality, adult production based on present smolt releases might be at least doubled, or the present adult production might be maintained by releasing fewer smolts. Reduced juvenile populations have obvious advantages with respect to food costs, labour, disease and nutrient concentrations in pond effluents.

Based on preliminary data, studies on rearing of chums and possibly pinks, time of smolt release, size at release and rearing densities appear to offer the biggest payoff.

The Ocean Phase - Determining Contribution

Assessment of smolt quality and of the potential offered through research and development depends on estimate of the harvest of each release group in a variety of fisheries, during all seasons of the year, over two or more years. To provide the stock identification required for assessment, 2,545,000 of the 20,392,000 smolts released from B.C. production hatcheries in 1979 were marked (Table 1). All chinook, coho and steelhead were coded wire-tagged. For chums, one stock was tagged using full length wire tags, most stocks were fin-clipped, and one stock (Thornton Creek) was released unmarked.

Numbers of fish to mark are calculated by statistical methods applied to expected survival and catch rates, assuming 20% sampling of the catch for chinook and coho or site-specific escapement sampling rates. During the past year, Fisheries staff have developed new statistical methods based on the hypergeometric distribution to calculate marking requirements.

Using these methods, it is necessary to mark 20,000 coho or 70,000 chinook smolts to determine with 95% confidence the contribution of typical B.C. production releases. For applied research studies in which two or more release groups are to be compared, we have attempted to standardize the criteria for experimental design as follows - marking effort should be adequate to provide recovery of enough tagged fish to be able to recognize, at the 95% confidence level, a 25% or greater difference between two groups (i.e. control and experimental groups). Using these criteria, marks necessary for typical populations in B.C. are 22,000 coho and 88,000 chinook per release group.

These marking rates are minimal since the catch is considered as a single component. If it is desirable for assessment or management purposes to divide the catch by region or fishery, a proportionally greater number of marks is required. Considering this, present marking targets in B.C. are approximately 50,000 coho and 80,000 - 100,000 chinook per production group.

Outstanding problems with the CWT marking program have been data retrieval and expansion of sport catches. Observed recoveries in the recreational catch are usually expanded to total recoveries using a factor of three. There is no hard basis for this factor, in fact, some work indicates the factor should be at least five and perhaps ten. Thus, estimates of contribution to this fishery are conservative. The data retrieval problem is attributable to the large number of heads processed and to an inefficient data exchange and processing system. The data processing system is now being upgraded. About 40,000 heads were recovered in the Canadian fisheries in 1979, at an average cost of over $10.00 per head, so additional load on the Mark Recovery Program should be considered when determining the number of juveniles to mark. One way to prevent marking in excess of that required to yield reliable data would be to assign recovery costs to the user.

Estimated survival by brood year of marked smolts of the 1971 through 1974 broods from B.C. hatcheries ranges from 1.2% to at least 6.7% for chinook, and from 10.6% to 27.6% for coho (Table 4).

Table 4. Average Survival to Catch Plus Escapement of Marked Smolts from B.C. Federal Hatcheries. (Preliminary data).

Brood	Chinook Survival %	Coho Survival %
1971	1.2	27.6
1972	1.8	20.8
1973	3.1	15.8
1974	6.7*	10.6

* Survival to age 4 only.

Some individual hatchery stocks had a higher rate of contribution than indicated by these average figures, while others did not perform as well. Compared to the anticipated survivals of 1% for chinook and 6.8% for coho when the first modern hatchery in B.C. was built on the Capilano River in 1971, the 1971-1974 broods were very successful. Current design criteria (Table 2) reflect this.

Conclusion

Culture of chinook and coho in B.C. assessed through the Mark Recovery Program, has already been proven successful. Early chum returns to the Japanese-style pilot hatchery at Thornton Creek indicate smolt survival will exceed the 2% design standard. Only hatchery-reared steelhead have not done as well as expected, surviving at rates considerably less than 5%, but higher production rates are anticipated now that rearing criteria for this species have been established. Despite these successes, potential marine survival may be much higher for production releases than experienced to date. Applied research efforts to provide further understanding of the optimal strategies for smolt production will continue to receive support in B.C.; the benefits will be increased cost effectiveness of salmonid hatcheries.

Hatchery Evaluation in British Columbia,
Ted Perry
Fisheries and Oceans
Salmonid Enhancement Program

HATCHERY EVALUATIONS -- WDF STYLE

Bob Foster

Washington Department of Fisheries

Hatchery evaluations are merely a tool to be used to gain information on some aspect of the life of a group of fish raised in a particular environment. This environment may range in size from a particular pond to an entire region or state. The classic hatchery evaluation on a region wide basis is time consuming but if done properly, is beautiful. There are "classical" evaluations which have been done in the past using fin marks for identification. The Columbia River hatchery evaluation programs conducted by all of the Columbia River agencies were notable examples of these. (Wahle et al., 1974, Vreeland et al., 1975, Senn and Noble, 1968.)

Many programs are of a narrow scope yielding limited but specific data while other programs are of a broad nature yielding broad information. Evaluation programs should yield information for input into the decision making process. Evaluations without any means of data retrieval and assimilation are useless.

The use of the binary coded micro-tag has increased the number and scope of marking efforts since its introduction in 1971. The coast wide micro tag data assimilation and retrieval system yields massive amounts of data. These data when compiled yield temporal distribution, spatial distribution and size data. Further work with these data can yield almost complete understanding of the group's performance for input into a group catalog. After compilation of these facts, decisions may be made pertinent to hatchery programming to yield a cost effective operation with the desired fishery results.

Currently Washington Department of Fisheries is involved in random sampling and tagging 5% of all coho and fall chinook released in Southern Puget Sound, 5% of all fall chinook released in the Columbia River and special studies related to diet and time/size of release. The special studies should share equal priority with the broad evaluations because these studies give direction for continued improvement of hatchery operations in the future.

One example of a "special" study is a spring chinook density study performed at Cowlitz Salmon Hatchery. The 1975 and 1976 brood years were involved and preliminary data on the 1975 brood is presented in this short summary.

The study was designed to evaluate different pond loadings in relation to cost effectiveness. Previous evidence had indicated that lighter loadings were conducive to spring chinook survival. Pond loadings were 30,000, 60,000 and 90,000 fish/pond. The ratio of costs were 1:2:3, interestingly when the effects of underutilization and overloading came into the view the ratios of fish caught/dollar spent do not parallel the direct relationship of fish released and dollar spent.

The observed data to date indicate that:

(a) The jump from light loading to medium loading resulted in a in a 45% increase in catch with a 37% increase in cost/fish caught. This indicates under utilization of a lightly loaded pond because catches increase more rapidly than costs. Each fish costs more to put in catch but cost doesn't rise as fast as gain in catch.

(b) The jump from medium loading to heavy loading resulted in a 6% increase in catch with a 28% increase in cost/fish caught. This is obviously beyond the point of increasing returns for increasing investment and we surmise that it is the result of overloading and decreased survival.

In general, as survivial goes down, the cost per catch increases but the rate of increase accelerates as density increases. Assuming a flat rate cost per pound of $1.50 (this is not a valued assumption because of fixed costs) the cost per pond released is:

light	$12,659
medium	25,295
heavy	34,340

The cost per fish caught (observed to date)

light	$59
medium	81
heavy	104

The difference between costs of a light pond and medium pond = $12,636. This $12,636 is distributed over 96 added fish. Each additional fish cost $132.

The difference between costs of medium pond and heavy pond = $9,045. This $9,045 is distributed over 20 added fish. Each additional fish cost $452.

The added catch gained from going to 60,000 fish from 30,000 fish is 29% as costly as going from 60,000 fish to 90,000 fish.

TABLE 1. RELEASE DATA FOR 1975 BROOD SPRING CHINOOK DENSITY STUDY AT COWLITZ HATCHERY.

TREATMENT	TAG CODE	LENGTH X = CM	WEIGHT X = G	WEIGHT X = FISH/IB	IBS/GPN RELEASE	TAGGED RELEASE
LIGHT	13-13-1	21.8	135.15	3.36	4.36	28,746
LIGHT	13-13-4	21.5	135.23	3.36	4.20	27,967
MEDIUM	13-9-14	21.0	124.11	3.66	8.6	61,782
MEDIUM	13-11-4	21.0	124.17	3.66	8.6	61,658
HEAVY	13-9-11	20.5	114.72	3.96	11.3	88,051
HEAVY	13-9-12	20.9	120.90	3.76	12.0	88,691

TABLE 2. OBSERVED RECOVERIES OF 1975 BROOD SPRING CHINOOK FROM THE COWLITZ HATCHERY DENSITY STUDY.

		Recoveries						
		Hatchery		River Sport			Marine Catch	
Treatment	Tag Code	1977	1978	1977	1978	1979	1978	1979
LIGHT	13-13-1	55	14	22	3	14	110	39
LIGHT	13-13-4	93	9	35	9	27	132	35
MEDIUM	13-9-14	229	14	28	4	33	186	51
MEDIUM	13-11-4	173	13	21	8	31	206	50
HEAVY	13-9-11	181	14	22	8	26	164	51
HEAVY	13-9-12	194	4	27	7	40	239	74

TABLE 3. PERFORMANCE STATISTICS FOR 1975 BROOD SPRING CHINOOK FROM THE COWLITZ HATCHERY DENSITY STUDY.

TREATMENT	TAG CODE	OBSERVED CATCH	SURVIVAL	AVERAGE CONTRIBUTION PER POND UTILIZED
LIGHT	13-13-1	188	.65	213
LIGHT	13-13-4	238	.85	
MEDIUM	13-9-14	302	.49	309
MEDIUM	13-11-4	316	.51	
HEAVY	13-9-11	271	.31	329
HEAVY	13-9-12	387	.44	

Literature Cited

Senn, H.G. and R.E. Noble, 1968, Contribution of Coho Salmon Oncorhynchus Kisutch from a Columbia River Watershed Hatchery, Fisheries Research Papers, Washington Department of Fisheries Vol. 3, no.1, 51-62.

Vreeland, R.R., R.J. Whale, and A.H. Arp, 1975, Homing Behavior and Contribution to Columbia River Fisheries of Marked Coho Salmon Released at Two Locations, Fishery Bulletin: Vol. 73, No. 4, 717-725.

Whale, R.J., R.R. Vreeland and R.H. Lander, 1974, Bioeconomic Contribution of Columbia River Hatchery Coho Salmon, 1965 and 1966 Broods, to the Pacific Salmon Hatcheries, Fisher Bulletin: Vol 72, No. 1, 139-169.

Tagging Programs at Spring Creek, Willard and Carson National Fish Hatcheries

by

Steve L. Leek
Little White Diagnostic Laboratory
Box 17
Cook, Washington

ABSTRACT

Several groups of fall chinook salmon have been tagged at Spring Creek NFH since 1973. Group sizes of 250,000 were used on the first two brood years but was then lowered to 100,000. Fish were released at different times and different sizes, mainly March, April, May and August. Sizes varied from 150 to 9/lb. Feeding terramycin prior to release was evaluated for three years. Increasing salt in the diet by 5% was evaluated one year as well as a fed Vibrio vaccine at 5 mg/g for 6 weeks. Submerging in vaccines was tried one year to protect against Vibrio and Enteric Red Mouth. Barging fish to below Bonneville Dam was evaluated for two years. An imprinting experiment was tested one year at the Big White Rearing Facility by dripping morpholine into the water at 5×10^{-5} mg/L. for a two week period.

Four groups of 1975 brood coho salmon have been tagged at Willard NFH. Two groups of 20,000 each were for a barging experiment and two groups of 100,000 each for testing efficacy by submerging fish in Vibrio vaccine.

The 1974 and 75 brood spring chinook salmon at Carson NFH each had three tag groups. Releases were made in September,

mid March and April. The first release had 1, the second release had 2, and the third release had 3 Oxytetracycline marks. Evaluation is going to be made on time of release, tagging mortality and uptake of OTC. The 1978 brood spring chinook salmon, have two groups of 100,000 each to evaluate water hardening eggs in 1 ppm Erythromycin Phosphate for one hour. These will be released April 1980.

SURVIVAL AND CONTRIBUTION OF FALL CHINOOK SALMON FROM ELK RIVER HATCHERY

Paul E. Reimers
Oregon Department of Fish and Wildlife
Charleston, Oregon 97420

In its first 10 years of operation, Elk River Hatchery has been quite successful in producing fall chinook salmon with reasonable rates of survival and good contributions to the ocean troll and river sport fisheries. Survival back to the river has been averaging about 3 to 4%. The Elk River stock has been caught in the ocean from California to Alaska. Enough excess fish have also returned to the mouth of the river each year to allow an extension of both the near-shore troll and river sport fisheries by one month.

Despite the apparent success of the program, some disconcerting fluctuations have occurred in the jack component of the run and a couple of broods have appeared to fail for as yet unknown reasons. A modification in the age at maturity of hatchery fish to reduce the jack return was suspected because jacks have not been used in breeding. However, the addition of sperm from jacks in a sperm pool did not produce a jack return in the first returns of this experiment in the autumn of 1979. We are now puzzling over the possibility of a brood failure associated with factors other than the breeding program.

Since the hatchery was started with wild fish from Elk River and the hatchery rearing program simulated the natural life history of the stock, we felt this was a major factor in the success of the program. Now that the program uses almost exclusively returning hatchery fish for propagation, is there a chance that this is leading us to fluctuating or declining rates of survival? It is too early to interpret what is happening at Elk River, but we believe that the signs suggest a need for renewed imagination on our part to assure that we can maintain or improve on this program.

SURVEY OF BACTERIAL KIDNEY DISEASE IN THE QUILLAYUTE RIVER SYSTEM

by

Eugene T. Manfredi
College of Fisheries
University of Washington
Seattle, Washington

Introduction

The Quileute Fisheries is considering beginning an enhancement program on spring chinook salmon in the near future. Stock presently in the system has been enhanced by the State Fisheries Department using Cowlitz, Cowlitz-Umpqua, and Dungeness stocks. Current "wild" spring chinook in the Quillayute River System are a mixture of these stocks which are known to be susceptible to bacterial kidney disease (BKD), and which may be carriers.

The Quileute Tribe is concerned about the preservation of wild and native salmon stocks, and desires that any enhancement effort have minimal impact on the wild fish. Consequently, a survey of bacterial kidney disease of salmon was initiated to: 1.) assess whether enhancement of the present Quillayute-Cowlitz-Dungeness "wild" stock will serve to increase the incidence of BKD in the system, thus affecting true wild and native fish stocks, and

2.) predict any potential problems with BKD in the Quileute Fishery enhancement facility.

The survey has two major thrusts, the first to document the presence or absence of BKD in salmonids in the Quillayute River and major tributaries including the Soleduck and Bogachiel Rivers (Fig. 1); and, the second to document

whether BKD is an integral part of fluvial ecosystems on the North Olympic Coast regardless of any enhancement activities which may have occurred.

Procedures

1. Adult salmonids are sampled from the Quileute Indian gillnet fishery.

2. Juvenile salmonids and non-salmonid fish are sampled by beach seining in the mainstreams and electroshocking in the tributaries.

3. Incidence of BKD will be compared between the Quillayute System and Ellen Creek. The Quillayute System has been extensively enhanced via the Soleduck Hatchery and Bogachiel rearing ponds. Ellen Creek, on the other hand, is entirely within the National Park and has received no enhancement.

4. Smears from the anterior and posterior kidney are prepared from adult and juvenile specimens and the presence of BKD is determined by the indirect fluorescent antibody technique (IFAT). If BKD is present the bacteria show up as fluorescent (apple-green) rods on a dark background. The bacteria are short rods approximately 0.5 X 1.0 μm.

5. Samples are quantified by counting the number of fluorescent bacteria observed in 150 microscope fields.

Results and Discussion

To date well over 200 fish have been sampled; however, cursory analysis of some of the data suggests a wide occurrence of the kidney disease bacterium. Of 84 fish reported here, 33 demonstrated positive IFAT tests for corynebacteria, or an incidence of 39% (Table 1). Significantly, corynebacteria were found among fish taken from areas of previous or current salmonid enhancement (Quillayute, Dickey Rivers, and Soleduck Hatchery) and from an area which has received no enhancement

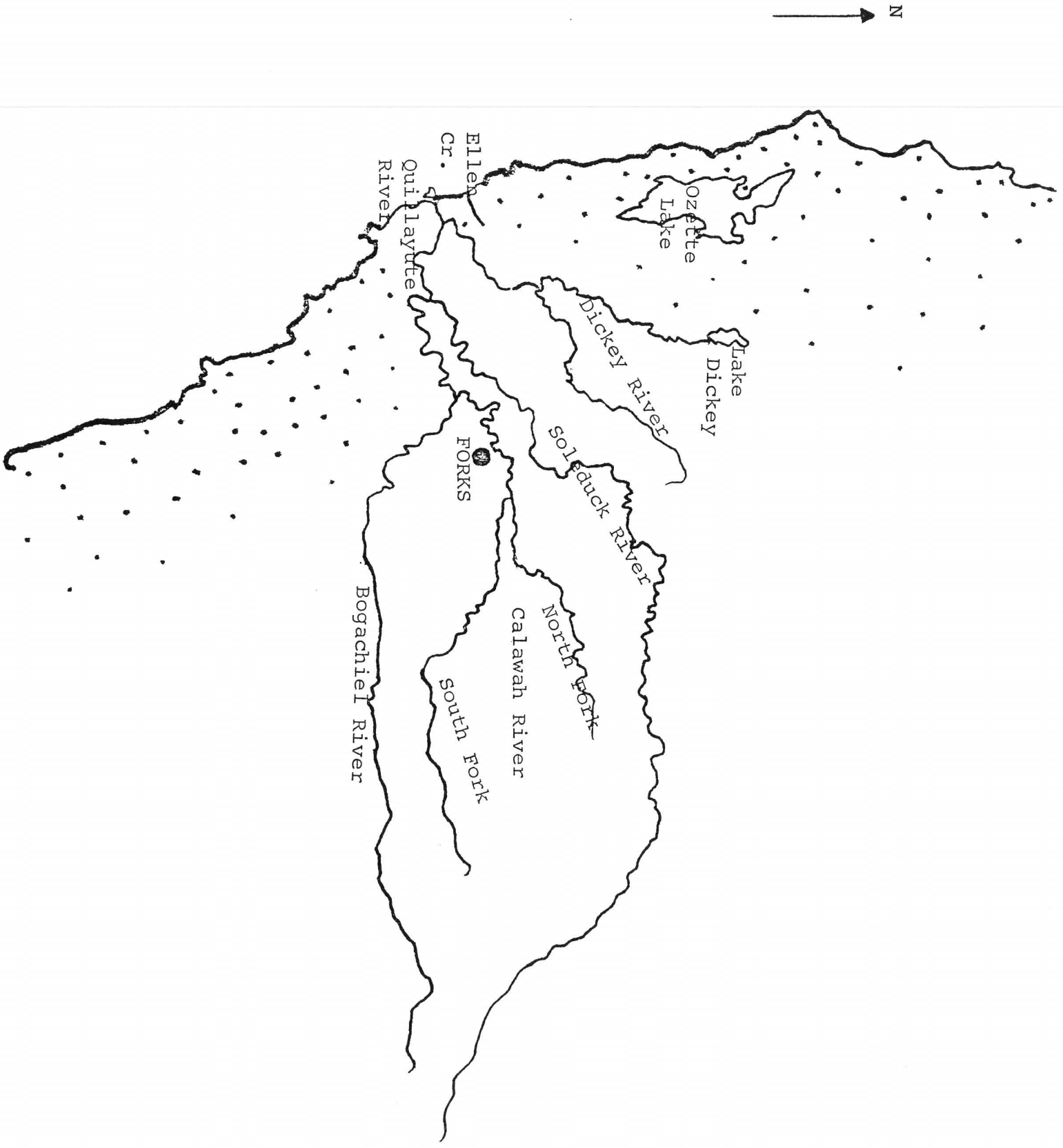


Figure 1. The Quillayute River System.

Table 1. Positive IFAT kidney smears. Number and percent positive by location

Location	No. Fish	No. Positive	% Positive
Quillayute R.			
Salmonids	39	9	23.1
Non-salmonids	6	1	16.7
Soleduck R.	9	8[b]	88.9
Bogachiel R.	1	0	0
Dickey R.	1	1	100.0
Spring Cr.	1	0	0
Gillnet	5	1	20.0
Sport	5	3[a]	60.0
Ellen Cr.			
Salmonids	13	9	69.2
Non-salmonids	4	1	25.0
TOTAL FISH	84	33	39.3

[a]Pink salmon (1), Coho salmon (2)

[b]Hatchery

Ellen Creek. Adult salmonids taken by sport and gillnet combine to illustrate a 40% (4 of 10 fish) incidence of BKD.

Chinook salmon are the most abundant of the fish reported here. Overall they demonstrate a 36% (19/52) incidence of corynebacteria (Table 2). Although sparse, the data suggest a higher occurrence of BKD in adults (8/12, 67%) than juveniles (11/40, 28%). This relationship is interesting when considering the role of carriers among the adult population (see Wimer, Proc. 29th NW FCC 1978).

Most of the adult chinook reported above came from the Soleduck Hatchery, so it is not surprising to find positive samples since these fish are known to be sensitive to and probably harboring BKD. However, juveniles, mainly those taken from the Quillayute River estuary (10/37, 27%), demonstrated a 28% (11/40) incidence (Table 3).

A sampling of juvenile trout taken from Ellen Creek in September 1979 revealed an 89% (8/9) incidence of corynebacteria. Overall, trout demonstrated a 75% (9/12) incidence of BKD (Table 4). Coho salmon juveniles taken from Ellen Creek did not demonstrate (0/4) any positive smears. However, since the sample size is so small no real statement of condition can be made beyond the inference that BKD is more prevalent among trout than coho salmon in Ellen Creek. Adult coho taken from the sport fishery did show positive smears (Table 5).

Non-salmonid fish have also been sampled, including various species of sculpin, and dace. Two samples from sculpins demonstrated positive IFAT tests, one each from the Quillayute River and Ellen Creek (Table 6). Interestingly, the Ellen Cr. positive was a prickley sculpin and the Quillayute River positive a staghorn sculpin.

Non-salmonid fish are being screened in an attempt to assess whether any reservoir of BKD persists in fluvial systems. The occurrence of these positive samples in sculpin suggests a non-salmonid host exists; but, caution requires that the corynebacterium be isolated in pure culture and its relation to pathogenicity determined before any definite conclusions are drawn. Such studies are currently under way. At the least, however, such a finding indicates a cross reacting bacterium with the IFAT procedure.

In general, the data presented here is preliminary, and is offered in the spirit of information exchange. Conclusions

Table 2. Positive IFAT kidney smears in chinook salmon (Oncorhynchus tshawytscha).

	No. Fish	No. Positive	% Positive
TOTAL	52	19	36.5
Juveniles	40	11	27.5
Adults	12	8	66.7

Table 3. Positive IFAT kidney smears in chinook salmon (Oncorhynchus tshawytscha) by location.

Location	No. Fish	No. Positive	% Positive
Quillayute R.	38	10	26.3
Adult	1	0	0
Juvenile	37	10	27.0
Bogachiel R.			
Juvenile	1	0	0
Soleduck R.			
Adult	9	8[a]	88.9
Dickey R.			
Juvenile	1	1	100.0
Spring Cr.			
Juvenile	1	0	0
Gillnet			
Adult	2	0	0
TOTAL	52	19	36.5

[a]Hatchery

Table 4. Positive IFAT kidney smears in trout.

	No. Fish	No. Positive	% Positive
Adults	3	1	33.3
Rainbow	1[a]	0	0
Steelhead	2[b]	1	50.0
Juveniles	9[c]	8	88.9
TOTAL	12	9	75.0

[a]Quillayute R.

[b]Gillnet

[c]Ellen Creek

Table 5. Positive IFAT kidney smears in coho salmon (Oncorhynchus kisutch).

	No. Fish	No. Positive	% Positive
TOTAL	8	2	25.0
Juvenile[a]	4	0	0
Adult[b]	4	2[c]	50.0

[a]Ellen Creek

[b]Sport Fishery/Gillnet

[c]Sport Fishery

and implications may change considerably as more data is collected.

Table 6. Positive IFAT kidney smears in sculpins.

Location	No. Fish	No. Positive	% Positive
Quillayute R.	3	1[a]	33.3
Ellen Cr.	4	1[b]	25.0
TOTAL	7	2	28.6

[a]Staghorn sculpin (Leptocottus armatus)

[b]Prickly sculpin (Cottus asper)

Summary

The date, albeit preliminary, suggest at least:

1. the occurrence of corynebacteria in fish taken from rivers and streams now or previously enhanced, and from an area with no prior enhancement
2. a high incidence of corynebacteria in Cowlitz stocks (Soleduck Hatchery)
3. a presumptive occurrence of corynebacteria in non-salmonid fish (sculpin), or
4. cross reactive IFAT bacteria in non-salmonids.

Effect of Salt Water on Bacterial Kidney Disease in Yearling Coho Salmon

Jim Sanders
Oregon Department of Fish and Wildlife

In the Pacific Northwest BKD has often been diagnosed in hatchery reared salmonid populations just prior to release. Subsequent losses from this disease after the fish enter salt water has been the source of much speculation. This disease agent was diagnosed and thought to be the prime cause of death among coho salmon smolts released from Siletz Hatchery on March 5, 1976. Random samples of these fish were collected just prior to release and placed in fresh and salt water holding tanks. The loss from BKD in the salt water group (17.2 percent) was considerably higher than in the freshwater group (4.0 percent) over the 150 day holding period. Unlike the results in Atlantic salmon (Frantsi et al., 1975) the majority of BKD deaths occurred between 60 and 120 days after the fish entered salt water and gross lesions caused by the KDB were encountered throughout the entire holding period. These observations suggest that in a population of salmonids infected with BKD at release, deaths will continue throughout the salt water phase of their life cycle and could also account for the advanced infections seen in returning adult salmon. This disease picture is perhaps further confirmed by the occasional grossly infected young salmon found or caught by offshore anglers.

Literature cited

Frantsi, C., T. C. Flewelling, and K. G. Tidswell. 1975. Investigations on corynebacterial kidney disease and *Diplostomulum sp.* (eye-fluke) at Margaree Hatchery, 1972-1973. Tech. Rep. Ser. No. Mar/T-75-9. Res. Development Branch, Fish and Marine Serv., Dep. Environ. Halifax, Nova Scotia, Canada.

UPDATE: Erythromycin phosphate water hardening as a control of bacterial kidney disease in chinook salmon (Oncorhynchus tshawytscha).

by

David B. Groman
University of Idaho

In the past few years it has become increasingly evident that repeated efforts, both by injection of adults and water hardening of eggs with erythromycin phosphate, have significantly reduced clinical outbreaks of bacterial kidney disease in the Rapid River chinook salmon population (Klontz 1978, Wimer 1978). However, to date, no examination for the presence of bacterial carriers has been completed to substantiate the effectiveness of erythromycin phosphate therapy. Therefore, the Direct Fluorescent Antibody Technique (DFAT) (Bullock and Stuckey 1975) was employed to screen samples for bacterial kidney disease (Corynebacterium salmoninus) in chinook salmon populations subjected to erythromycin phosphate therapy at the Rapid River Hatchery in Riggins, Idaho. In all cases kidney samples were examined from fish having no apparent clinical signs of kidney disease. The reagents employed for the DFAT were supplied to the University of Idaho by the biologics section of the National Fish Disease Laboratory in Leetown, West Virginia. Criteria for sampling techniques were adopted from procedures established for the detection of disease in fish populations by Ossiander and Wedemeyer (1973).

Results from this survey indicated that approximately 6.7% of spawned adults from the 1974-1975 year classes carried detectable levels of Corynebacterium salmoninus. Of the 297 jack salmon which returned from the 1976 year class, only 4.5% had detectable levels of the bacterium. And, the erythromycin water hardened presmolts examined from both 1977 and 1978 year classes showed no kidney disease organisms. This was also the case for untreated presmolts in the 1978 control group (Table 1).

The inability to detect Corynebacterium salmoninus by DFAT in the presmolt populations from 1977 and 1978 would seem to substantiate the fact that water

hardening was helping to control the disease at the Rapid River Hatchery. However, the presence of kidney disease organisms in both spawned adults and jack salmon, having no apparent clinical signs of this disease, indicated that a carrier state could exist in fish, following erythromycin phosphate therapy. Specifically, injection of the adults during the holding period decreased the number of infective bacteria. The lower bacterial levels decreased the possibility of both clinical disease in the adults and verticle transmission to the eggs (Klontz 1978). Since the jack salmon from the 1976 year class had been water hardened with erythromycin phosphate, the fact that 4.5% were detected as carriers of Corynebacterium salmoninus would seem to indicate that the treatment was not totally effective. However, straying of at least 5% is possible in returning salmon runs and this could account for the presence of the infected jacks. More importantly the 1976 jacks had no signs of clinical kidney disease. This had not been the case in previous years when significant numbers returned with apparent kidney disease. In effect the low level of carriers in the jack population supports the supposition that water hardening in erythromycin phosphate was effective in controlling kidney disease.

In summary, it appears that the DFAT results have substantiated the effectiveness of combined erythromycin phosphate injection and water hardening as a therapeutic tool to control bacterial kidney disease in chinook salmon at the Rapid River Hatchery. In the future it is recommended that whenever possible both treated test groups and untreated control groups of salmon be monitored by DFAT, and any positive samples be confirmed by culture (Evelyn 1977). Information obtained from these field trials could help clarify both the effectiveness of erythromycin therapy and the status of the carrier state of Corynebacterium salmoninus in salmonid populations.

LITERATURE CITED

Bullock, G.L. and H.M. Stuckey. 1975. Fluorescent antibody identification and detection of the Corynebacterium causing kidney disease of salmonids. J. Fish. Res. Board Canada 32/11:2224-2227.

Evelyn, T.P.T. 1977. An improved growth medium for the kidney disease bacterium and some notes on using the medium. Bull. Off. Int. Epiz. 87:511-513.

Klontz, G.W. 1978. Control of bacterial kidney disease in adult and juvenile spring chinook salmon at the Rapid River Salmon Hatchery. An Interim Progress Report Covering 1 July 1974 through 30 September 1978. University of Idaho.

Ossiander, F.J. and G. Wedemery. 1973. Computer program for sample sizes required to determine disease incidence in fish populations. J. Fish. Res. Board Canada 30:1383-1384.

Wimer, L.R. 1978. A summary of the bacterial kidney disease program at Rapid River chinook salmon hatchery. Proc. 29th Annual Northwest Fish. Culture Conference, p. 95-101.

TABLE - 1

RESULTS OF DIRECT FLUORESCENT ANTIBODY SCREENING FOR CORYNEBACTERIUM SALMONINUS IN CHINOOK SALMON (ONCORHYNCHUS TSHAWYTSCHA) FROM THE RAPID RIVER HATCHERY IN RIGGINS, IDAHO.

SPECIMEN	YEAR CLASS	TISSUE EXAMINED	CLINICAL LESIONS	ERYTHROMYCIN TREATED	NUMBER EXAMINED	NUMBER CONFIRMED
SPAWNED ADULTS	1974+1975	KIDNEY(K)	NONE(N)	SOME	60	4 (6.7%)
JACKS	1976	K	N	YES	297	13 (4.5%)
PRESMOLTS	1977	K	N	YES	40	0
PRESMOLTS	1978	K	N	YES	60	0
PRESMOLTS	1978	K	N	NO	60	0
PRESMOLTS	1979	(NO DATA AVAILABLE)				

Antibiotic Injection of Adult Spring Chinook Salmon to Reduce Prespawning Losses at Several Oregon Fish Hatcheries

by

R. Holt, M. Smith, J. Zakel and D. Maher

Oregon Department of Fish and Wildlife

High prespawning losses of adult spring chinook salmon are a serious problem at several Willamette River basin adult salmon holding ponds. More than 50% prespawning losses have occurred in Fall Creek Reservoir chinook held at McKenzie Hatchery and spring chinook returning to Dexter Ponds.

Programs involving subcutaneous injections of erythromycin phosphate of adult chinook in Washington and Idaho have reported good success. We began antibiotic injection tests at McKenzie Hatchery in 1977 to determine if the prespawing mortality could be reduced. At McKenzie Hatchery water temperatures rarely exceeded 57°F and most dying adults are infected with the agent of bacterial kidney disease and/or Aeromonas salmonicida. A small group of adults were injected the first year so we could gain experience in the technics of injection. In 1978, 1900 Fall Creek Reservoir spring chinook adults held in one pond received simultaneous injections of erythromycin phosphate (Gallimycin Poultry Formula Improved, Abbott) and spectinomycin (Abbott) at a dose of 5 mg/lb. The injections were given subcutaneously one on each side of the dorsal ridge just anterior to the dorsal fin and administered three times at one month intervals during the holding period. The injection of this combination of antibiotics was recommended by Dr. G. Klontz, University of Idaho.

A similar injection program was used with Fall Creek Reservoir adults held in 1979 except oil base erythromycin phosphate (Gallimycin 200, Abbott) was substituted for the water soluble erythromycin (Poultry Formula). Table 1 shows the prespawning female mortality for 1976 to 1979. There appears to be an encouraging trend in decreased female losses which began when the injection program was initiated in 1978.

Table 1. Prespawning Mortality of Female Adult Spring Chinook Salmon (Fall Creek Reservoir Stock) at McKenzie Hatchery From 1976 to 1979.

Year	Total No. Females	Female Prespawn Loss	% Female Loss
1976	816	446	54.6
1977	1432	1121	78.3
1978	1190	503	42.3
1979	753	245	32.5

The most severe prespawning losses of Willamette River chinook occur at Dexter Ponds where water temperatures reach 59-62°F at spawning time. Columnaris and furunculosis are the most prevalent diseases at this station. Four adult ponds were constructed in 1978 at Dexter allowing us to test the efficacy of various antibiotics to prevent prespawning losses. Unfortunately, equipment failures delayed initiation of the injection program at Dexter in 1978. These delays probably contributed to more handling and hence even greater mortality than seen in previous years. By mid July, about 1350 adult spring chinook had been placed in each pond. A description of the treatment received by each group and resulting

prespawning females loss are given in Table 2. The efficacy of different forms of erythromycin phosphate i.e. oil base (Pond 1) versus water soluble carrier (Pond 4) were compared. Also, oxytetracycline (dose recommended by Mr. Mark DeCew, Washington Dept. of Fisheries) was tested in fish in pond 3 because this antibiotic is often effective in treating columnaris and furunculosis disease.

All groups of injected adults had less percent female loss than the control, while the one injection of oxytetracycline appeared to be most effective. The comparison of losses in the erythromycin oil-base versus water soluble groups probably should not be made because the fish in pond 4 failed to mature properly resulting in increased mortality from additional handling. In 1979 similar results were seen in pond 4 and at that time it was observed that artificial lighting near pond 4 may have delayed maturation.

The injection tests conducted at Dexter Ponds in 1979 are summarized in Table 3. Again, the one injection of oxytetracycline was the most effective, i.e., 43.2% female loss versus 89.4% in the controls. In 1979, the handling of adults was minimized. The controls (pond 3) were counted as they swam into the pond and were not handled till spawning operations began; yet 89.4% of the females died prior to spawning. Once again, the loss in pond 4 was high and these fish were very slow to ripen suggesting the possible effect of artificial light.

Based on the results obtained at Dexter Ponds, oxytetracycline may be the antibiotic most effective to prevent prespawning losses of adult chinook where water temperatures exceed 58°F and columnaris disease is prevalent.

Table 2. Adult Female Spring Chinook Salmon Prespawning Losses at Dexter Ponds, 1978.

Pond	Treatment	No. Times Injected	Total No. Females[a]	Percent Female Prespawning Loss
1	erythromycin (oil base)[b] + spectinomycin[b]	2	696	63.8
2	control		739	98.8
3	oxytetracycline[c]	1	772	46.4
4	erythromycin (water base)[b] + spectinomycin[b]	2	881	88.9

[a]Females that were killed but not ripe are excluded.

[b]The dose administered to each fish was 5 mg/lb.

[c]The dose administered to each fish was 2.5 mg/lb.

Table 3. Adult Female Spring Chinook Salmon Prespawning Losses at Dexter Ponds, 1979.

Pond	Treatment	No. Times Injected	Total No. Females[a]	Percent Female Prespawning Loss
1	erythromycin phosphate[b] + spectinomycin[b]	3	430	63.3
2	oxytetracycline[c] (one injection)	1	444	43.2
3	control		424	89.4
4	oxytetracycline[c] (three injections)	3	454	71.6

[a]Females that were killed but not ripe are excluded.

[b]The dose administered to each fish was 5 mg/lb.

[c]The dose administered to each fish was 2.5 mg/lb.

ANTIPROTOZOAN IMMUNIZATION STUDIES IN THE CHANNEL CATFISH, *ICTALURUS PUNCTATUS*

by

Beverly A. Goven, Ph.D.
TAVOLEK INC.
Seattle, Washington

The antigenic relation between Tetrahymena pyriformis (Ehrenberg, 1830) Lwoff, 1947 and *Ichthyophthirius multifiliis* Foquet 1876 was investigated using various *in vitro* immunologic tests. Tomites of *I. multifiliis* exposed to dilutions of rabbit anti-tetrahymena serum were immobilized in 24 hours. *Tetrahymena* in this test system, were agglutinated at low dilutions and immobilized at higher dilutions. Using an indirect fluorescent antibody test, both organisms showed fluorescence when treated with either rabbit anti-tetrahymena serum or anti-tomite serum. In heterologous crosses, titers of 1:1024 were obtained using the passive hemagglutination test. These results indicate that an antigenic relationship does exist between these two organisms, cross-reacting antigens appear to be localized on the cilia.

Channel catfish *Ictalurus punctatus* Rafinesque were immunized with ciliary and whole cell preparations of *Ichthyophthirius multifiliis* and subsequently challenged with *I. multifiliis*. Similar *Tetrahymena pyriformis* preparations were used to determine if this heterologous immunization would elicit a protective immune response against *I. multifiliis* infestation. Results indicate that various degrees of protective

immunity were induced with all antigen preparations. T. pyriformis ciliary antigens provided the greatest degree of protection. Four doses of antigen, ranging from 25 µg to 2.5 µg were used to determine if the immunizing dosage influenced the degree of protective immunity conferred.

Test for Antigenic Interference with HIVAX* *Vibrio anguillarum* and REMOVAX* ERM Combination Bacterins for Immersion Vaccination of Fall Chinook Salmon and Rainbow Trout

Keith A. Johnson
TAVOLEK INC.
Redmond, Wa.

Vaccination for control of Vibriosis and Redmouth disease have occasionally been done with the same population of fish. In several instances, simultaneous vaccination could have been performed which would have had the benefit of reducing the cost of labor involved in two vaccinations and to eliminate handling the population a second time. The objective of this test was to demonstrate that vaccination of fish with the combination of HIVAX *Vibrio* Bacterin and REMOVAX ERM Bacterin results in a level of protection similar to what would be attained if the vaccines were used separately.

Two species of salmonids were used in two tests. Fall chinook salmon (WDF, Issaquah stock) and rainbow trout (Troutlodge stock) were reared to a size of 1.0 and 2.1 g respectively from eyed eggs. The control groups of 180 each were counted out, immersed for 20 seconds in water only, and held for challenge at 50°F. Three groups of 180 each were vaccinated by 20 second immersion in one of the following licensed vaccines at field dose levels: HIVAX Bacterin, REMOVAX Bacterin, and HIVAX + REMOVAX Bacterins combined. Immersion ratio was set at one pound of fish per liter of diluted bacterin. Fall chinook salmon groups were held for 40 days at 50°F for protection to develop, then divided into three subgroups of 60 fish each. Each subgroup was challenged by the water-borne method in duplicate with one of the following: *Vibrio anguillarum* Type I (7.5×10^4 cfu/ml), *V. anguillarum* Type II (5.5×10^6 cfu/ml), or *Yersinia ruckeri* (1.4×10^8 cfu/ml. Challenged groups were observed for 7 days and dead fish removed daily and cultured for reisolation of the challenge organism. Percent mortality values were calculated for each vaccinated

* Trademark of TAVOLEK INC.

--continued

and control group. Rainbow trout groups were handled in the same manner except the holding period was 33 days and the challenge levels were 9.5×10^5 cfu/ml for V. anguillarum Type I, 4.5×10^6 cfu/ml for V. anguillarum Type II, and 6.3×10^7 cfu/ml for Yersinia ruckeri.

The results of the challenges are presented in Tables 1 and 2. In all cases, the challenge level of control groups were high enough to compare the effectiveness of the vaccines. The data from the fall chinook test (Table 1) indicate that both vaccines which contained the HIVAX Vibrio vaccine protected these fish from challenge with both Vibrio serotypes. The difference in the level of protection between the HIVAX and HIVAX + REMOVAX Bacterin groups was not significant. This indicates that the inclusion of REMOVAX as the combined vaccine did not effect the efficacy of the Vibrio vaccine. Similarly, vaccination with REMOVAX ERM Bacterin protected chinook from challenge with Y. ruckeri regardless of whether the vaccine was used in combination with HIVAX Vibrio Bacterin or alone. Also, vaccination of chinook with REMOVAX Bacterin did not confer any non-specific protection from a Vibrio challenge.

The same conclusions were drawn from the test with rainbow trout. (Table 2). There were non-specific losses in each group due to gas embolism which resulted in fewer fish in each test group.

These tests demonstrated that there was no antigenic interference between HIVAX Vibrio Bacterin and REMOVAX ERM Bacterin. These data were submitted to USDA and approved for the application of these vaccines as a field combination.

Table 1: Test For Antigenic Interference of the HIVAX* *Vibrio anguillarum* Bacterin and REMOVAX* ERM Bacterin Combination in Fall Chinook Salmon (1.9g)

	CHALLENGE ORGANISMS								
	V. anguillarum Type I 7.5×10^4 cfu/ml			*V. anguillarum* Type II 5.5×10^6 cfu/ml			*Yersinia ruckeri* Hagerman Type 1.4×10^8 cfu/ml		
	N	Loss	%	N	Loss	%	N	Loss	%
HIVAX	61	6	10	61	2	3	41	22	54
REMOVAX	64	50	78	60	44	73	47	1	2
HIVAX+REMOVAX	58	8	14	63	4	6	46	0	0
Control	63	51	81	59	41	70	45	21	47

* Trademark

TABLE 2. Test for Antigenic Interference of the HIVAX* *Vibrio anguillarum* Bacterin and REMOVAX* ERM Bacterin Combination in Rainbow Trout (2.1g)

	CHALLENGE ORGANISM								
	V. anguillarum Type I 9.5×10^4 cfu/ml			*V. anguillarum* Type II 4.5×10^6 cfu/ml			*Yersinia ruckeri* Hagerman Type 6.3×10^7 cfu/ml		
	N	Loss	%	N	Loss	%	N	Loss	%
HIVAX	51	5	10	52	7	14	65	40	62
REMOVAX	54	34	63	54	53	98	52	9	17
HIVAX+REMOVAX	50	7	14	34[1]	6	18	59	4	7
Control	54	41	76	49	48	98	58	27	47

[1] Water flow failure killed most of one replicated group.

* Trademark

Renewed Investigation into the Prevention of Furunculosis

by

Steven Roberts
Fishery Resources
University of Idaho

ABSTRACT

The antibacterial disc susceptibility test was used to assay various isolates of Aeromonas salmonicida, the causative agent of furunculosis to several antibacterials. Twenty-five isolates of A. salmonicida from various species and locations were tested. Fourteen antibacterials were utilized including: bacitracin, clindamycin, erythromycin, gentamicin, kanamycin, neomycin, oxytetracycline, SXT (1:5 trimetroprim - sulfamethoxazole), sulfadiazine, sulfadimethoxine, sulfamerazine, sulfathiazole, tetracycline and trimethoprim.

One hundred percent of the isolates were susceptible to erythromycin, gentamicin, neomycin and kanamycin. Whereas, only 68% were susceptible to oxytetracycline and 64% were susceptible to sulfamerazine. The potentiated sulfonamide, SXT was more effective then the sulfonamides with 76% susceptible.

Erythromycin was selected for further study. In vitro minimal inhibitory concentration (MIC) was determined using the agar dilution technique. Nineteen isolates were tested. A mean 24 hour MIC of 3.57 uglml and 48 hour MIC of 3.68 mglml was calculated.

Erythromycin has proven promising in vitro; however, further in vivo testing is necessary to demonstrate its efficacy in the control of furunculosis.

TABLE 1 Summary of Antibacterial Susceptibilities for 25 Isolates of *A. salmonicida*

Antibacterial	Content (ug)	Percent Susceptible
Bacitracin	5*	0
Clindamycin	2	0
Erythromycin	15	100
Gentamicin	10	100
Kanamycin	10	100
Neomycin	10	100
Oxytetracycline	30	68
SXT		
Trimethoprim	1.25	76
Sulfamethaxazole	23.75	
Sulfadiazine	23.75	64
Sulfadimethoxine	250	68
Sulfamerazine	300	64
Sulfathiazole	1000	72
Tetracycline	10	67
Trimethoprim	1.25	12

*content in international units

Measurement of Copper Stress in Salmonids by Increased Susceptibility to a Bacterial Infection

R. J. Baker and M. D. Knittel
U.S. Environmental Protection Agency
Western Fish Toxicology Station
Corvallis, Oregon
and
J. L. Fryer
Department of Microbiology
Oregon State University
Corvallis, Oregon

Much attention has been recently given to the effect of stress on fishes. Various biochemical tests such as elevations in plasma glucose, blood lactate, and serum cortisol have been used to quantify this stress. These indicators, while elucidating the physiological effects of stress, do not address the long-term effects, the most important of which is their effect on the ultimate survival of the fish. This has become increasingly apparent with the addition of many new toxic substances into aquatic systems.

Schreck and Lorz (1978) found that exposure of coho salmon (Oncorhynchus kisutch) to sublethal levels of copper decreased the fish's ability to survive crowding stress at a later time. Environmental pollutants also

have been implicated in naturally-occurring disease outbreaks (Snieszko 1974, Wedemeyer 1970). Low dissolved oxygen levels and increased copper and zinc levels were both thought to have precipitated outbreaks of Aeromonas hydrophila (=A. liquefaciens) infections in natural situations (Haley et al. 1967; Pippy and Hare 1969).

Recent research has shown that copper is an effective stressor in increasing disease susceptibility. Rodsaether et al. (1977) reported that eels endemically infected with Vibrio anguillarum developed fulminating infections when exposed to water containing copper. Hetrick et al. (1979) demonstrated an increased level of infection to infectious hematopoietic necrosis virus in rainbow trout (Salmo gairdneri) when exposed to sublethal levels of copper. Similar results were reported by Knittel (1978) using the bacterium Yersinia ruckeri.

We report here results of research showing that fish exposed to sublethal copper concentrations were more susceptible to Vibrio anguillarum infection than non-exposed fish. The fish exposed to copper were also able to overcome the stress as demonstrated by a decrease in infection susceptibility with time.

MATERIALS AND METHODS

Fish

Test fish were juvenile chinook salmon (Oncorhychus tshawytsha) and rainbow trout (Salmo gairdneri) raised at Western Fish Toxicology Station. Mean weights ranged from 9.9 to 20.2 g for chinook salmon and 15.1 to 25.6 g for rainbow trout. All test fish were acclimated to 17 ± 2 C water prior to copper exposure.

Water Chemistries

Copper toxicity is known to be dependent on water hardness (Chapman and McCrady 1977). Since no control over changing water hardness in the laboratory water supply was possible, the experimental concentrations of copper were adjusted to a given percentage of the 96-hour LC50 for each species of fish at the beginning of each experiment. This enabled us to maintain the copper concentration at a constant fraction of the lethal level during a given experiment even though water hardness may have changed between experiments. All experimental copper concentrations were plotted as Toxic Units (TU) instead of actual concentrations. One TU is equal to the 96-hour LC50 of copper for the species tested. Water chemistry and copper levels were determined daily during each experiment.

Copper Exposure

The chinook salmon were exposed to a range of copper concentrations from 0.0 to 0.56 TU for 96 hours in a serial diluter (Garton in press, Water Research) after which they were transferred to individual bacterial challenge tanks. The rainbow trout were exposed to a range of copper concentrations from 0.0 to 0.77 and 0.0 to 0.95 TU for 96 hours using a similar diluter which delivered varying concentrations directly to the challenge tanks. Rainbow trout were also tested using single concentrations of copper delivered by a modified serial diluter to the challenge tank for varying periods of time.

Infection of Fish

Vibrio anguillarum type I (LS-174) was chosen as the bacterial pathogen because of its easily performed, consistent, laboratory water chal-

lenge. Twenty-four hour cultures grown in TSB (Difco) were diluted with sterile TSB to 0.90 at OD_{525} on a spectrophotometer. The water supply to the challenge tanks was shut off and a predetermined volume of culture (approximately one LD50 dose) was added. After 1 hour, the water was turned on, and the bacteria were diluted out. All mortalities were cultured for the presence of V. anguillarum, and only those from which V. anguillarum was isolated were considered to be actual bacterial mortalities.

Experimental Treatments

Four groups of fish were treated as follows: 1) a copper-stressed group exposed to V. anguillarum; 2) a non-copper-stressed control group exposed to V. anguillarum; 3) a copper-stressed group not exposed to V. anguillarum (stress control); and 4) a freshwater control group which received no copper and no V. anguillarum.

RESULTS AND DISCUSSION

Effect of Copper Exposure on Susceptibility:

The inital experiments examined the effects of several copper concentrations for a set period of time on the susceptibility of chinook salmon to bacterial infection. As seen in a logit plot of the percent mortality due to V. anguillarum infection against toxic units of copper for two replicate experiments (Fig. 1), the high levels of copper did not result in any significant increase in infection susceptibility as compared to controls and in one experiment resulted in a decrease in mortalities at the high copper concentration. The greatest mortalities occurred at 0.15 to 0.20 TU during the 96-hour exposure in both experiments.

Data from the chinook experiments and from similar experiments with rainbow trout were analyzed by a logistic regression model on the Oregon State University CDC 3300 computer. In all four experiments, no significant fit of a linear model could be achieved; however, when a quadratic term was entered in the model, a highly significant fit (α = .005) was obtained for all the data (Fig. 2). The maximum susceptibilities appeared to occur in both rainbow trout and chinook salmon at about 0.09 TU or 9.0% of a 96-hour LC50 concentration for copper.

The median time to 50% mortality (as a percentage of the unstressed control) of copper stressed chinook salmon showed a substantial decline at those concentrations which induced increased bacterial susceptibilities (Fig. 3), showing that not only did more fish die because of copper exposure but they were dying faster.

Likewise, the median time to 50% mortality of rainbow trout decreased in four out of five groups stressed at levels below 0.33 TU of copper (Fig. 4).

Effect of Duration of Copper Exposure on Susceptibility:

Our observation that a progressive increase in copper concentration did not result in a similar progressive increase in infection susceptibility of the fish led us to believe that an acclimation to the copper stress was occurring during the exposure period. To test this hypothesis, experiments were done using a group of rainbow trout exposed to a high concentration of copper and a group exposed to a low concentration of copper, each over varying periods of time. As seen in Figure 5, exposure to a low copper level (0.19 TU) resulted in maximum infection susceptibility after two days of exposure, followed by a gradual decrease in

susceptibility. After four days exposure to copper, the fish still showed an increased infection susceptibility compared to the non-stressed control fish; but by eight days of copper exposure, susceptibility had decreased to slightly less than the control level. Rainbow trout exposed to a higher level of copper (0.79 TU) for varying times (Fig. 5) resulted in a more rapid increase in infection susceptibility with a maximum occurring after one day of copper exposure. Fish exposed for two and four days at this level showed a decline in infection susceptibility from the one-day level. Infection susceptibility after four days exposure was about the same as the control. The increase in mortalities after an 8-day copper exposure was attributed to an exhaustion of the fish's ability to adapt to the high level of stress, and to a decreased sample size due to a 60% copper-induced mortality of test fish prior to bacterial challenge.

A comparison of these two experiments further illustrates the effect we had seen earlier with the varied concentration experiments; after four days exposure to low copper levels, an increased infection susceptibility resulted, but no difference was found between fish exposed to higher copper levels and non-exposed controls. The observation in the initial experiments that the high copper concentration did not result in increased susceptibility was, therefore, due to the time and concentration interaction. In addition, it appeared that both species of fish tested were able to adapt to even the highest levels of copper used if the duration of exposure was not excessive.

Others have shown that copper stress results in increased plasma cortisol levels and that acclimation to the stress appears with prolonged exposure (Donaldson and Dye 1975; Schreck and Lorz 1978). The lymphocytolytic effect of elevated corticosteroid levels in the blood could explain

the phenomenon of immunosuppression after stress in some cases (Weinreb 1958; McLeay 1973); however, our experiments were of short enough duration that no significant antibody response should have occurred. The cause of increased susceptibility in our experiments must be dependent on a suppression of a primary defense system which serves as the first line of defense against the invading pathogen. Further investigation is needed to clarify this.

It is also unknown to us at present whether these results represent a general effect of pollutants on disease susceptibility or if the results are specific to copper exposure. In either case, they illustrate the importance of one environmental toxicant in the interaction between a host fish and a pathogen.

ACKNOWLEDGEMENTS

We wish to thank James Andros and Dr. Donald Pierce for help with statistical analysis, and the chemistry staff of the Western Fish Toxicology Station for analysis of copper samples.

LITERATURE CITED

Chapman, G.A. and J.K. McCrady. 1977. Copper toxicity: a question of form. In: Recent Advances in Fish Toxicology A Symposium. (Ed: R.A. Tubb). pp. 132-151. Ecological Research Series. EPA-600/3-77-085. USEPA.

Donaldson, E.M. and H.M. Dye. 1975. Corticosteroid concentrations in sockeye salmon (Oncorhynchus nerka) exposed to low concentrations of copper. J. Fish. Res. Board Can. 32:533-539.

Haley, R., S.P. Davis and J.M. Hyde. 1967. Environmental stress and Aeromonas liquefaciens in American and threadfin shad mortalities. Prog. Fish Cult. 29:193.

Hetrick, F.M., M.D. Knittel, and J.L. Fryer. 1979. Increased susceptibility of rainbow trout to infectious hematopoietic necrosis virus after exposure to copper. Appl. Environ. Micro. 37:198-201.

Knittel, M.D. 1978. Heavy metal stress and increased susceptibility of steelhead trout, Salmo gairdneri, to Yersina ruckeri infection. ASTM Symposium on Toxic Material in Aquatic Environments. New Orleans, La. 1978.

McLeay, D.J. 1973. Effects of cortisol and dexamethasone on the pituitary-interrenal axis and abundance of white blood cell types in juvenile coho salmon, Oncorhynchus kisutch. Gen. Comp. Endocrin. 21:441-450.

Pippy, J.H.C. and G.M. Hare. 1969. Relationship of river pollution to bacterial infection in salmon (Salmo salar) and suckers (Catostomus commersoni). Trans. Am. Fish. Soc. 98:685-690.

Rodsaether M.C., J. Olafsen, J. Raa, K. Myhre, J.B. Steen. 1977. Copper as an initiating factor of vibriosis (Vibrio anguillarum) in eel (Anguilla anguilla). J. Fish Biol. 10:17-21.

Schreck C.B. and H.W. Lorz. 1978. Stress response of coho salmon (Oncorhynchus kisutch) elicited by cadmium and copper and potential use of cortisol as an indicator of stress. J. Fish. Res. Board Can. 35:1124-1129.

Snieszko S.F. 1974. The effects of environmental stress on outbreaks of infectious diseases of fishes. J. Fish Biol. 6:197-208.

Wedemeyer, G. 1970. The role of stress in disease resistance of fishes. In: A Symposium on Diseases of Fishes and Shellfishes. (Ed: S.F. Snieszko). pp. 30-35. Am. Fish. Soc. Spec. Pub. #5. Wash. D.C.

Weinreb E.L. 1958. Studies on the histology and histopatholgy of the rainbow trout Salmo gairdneri irideus. I. Hematology: under normal and experimental conditions of inflamation. Zoologica 43:145-153.

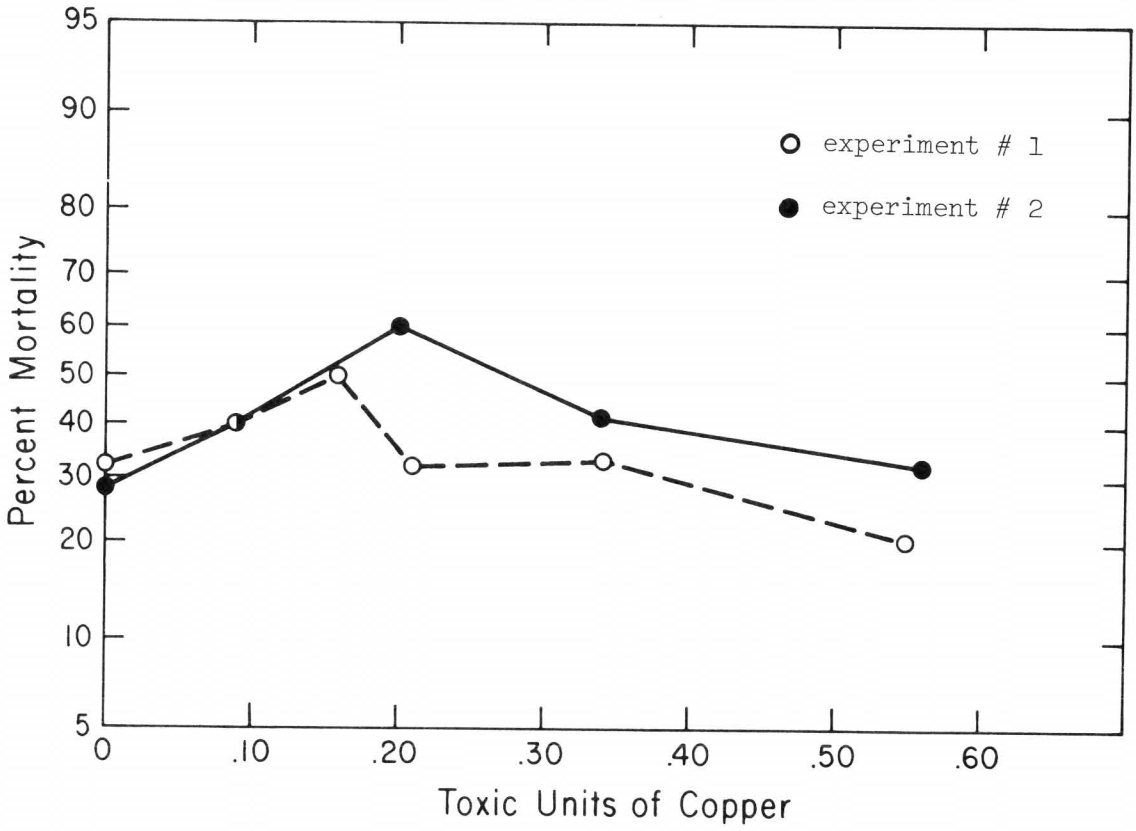


Fig. 1 Logit plot of percent mortality of chinook salmon due to Vibrio anguillarum infection against the toxic units of copper used as the stressor.

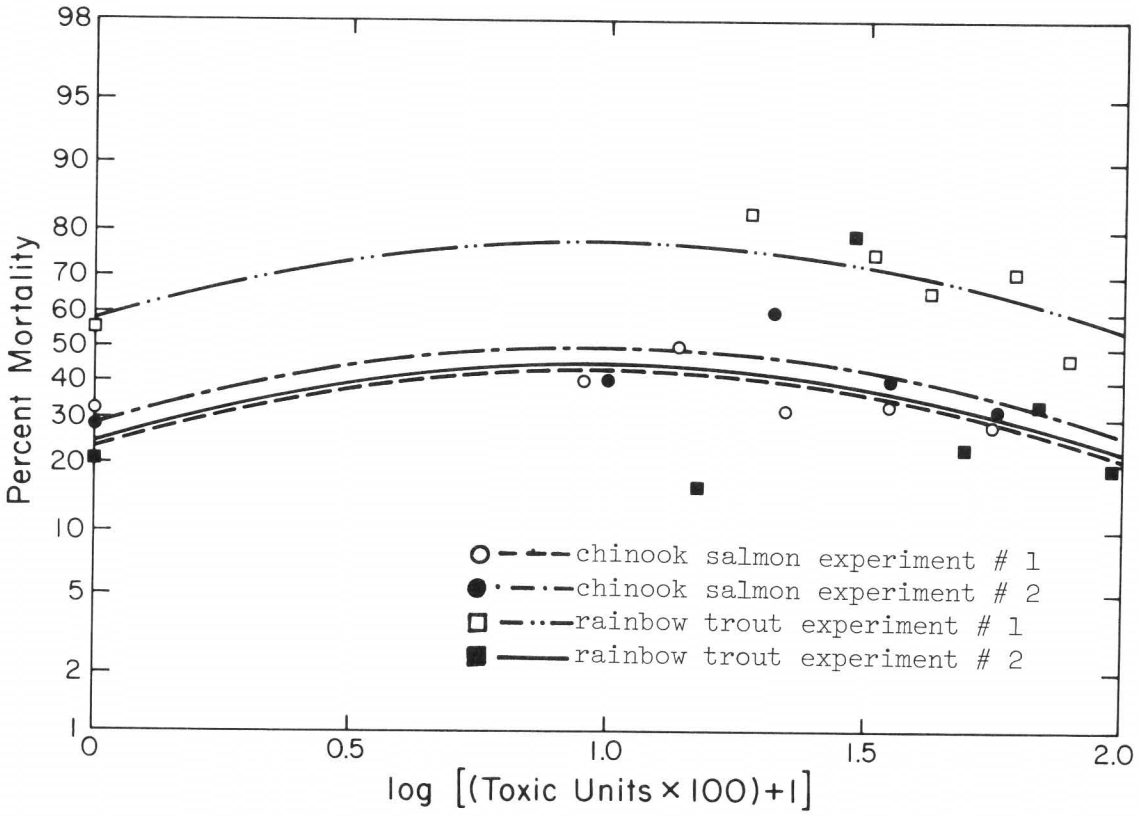


Fig. 2 Computer-fitted curves showing effect of varied copper concentration on the percent mortality due to Vibrio anguillarum infection for chinook salmon and rainbow trout.

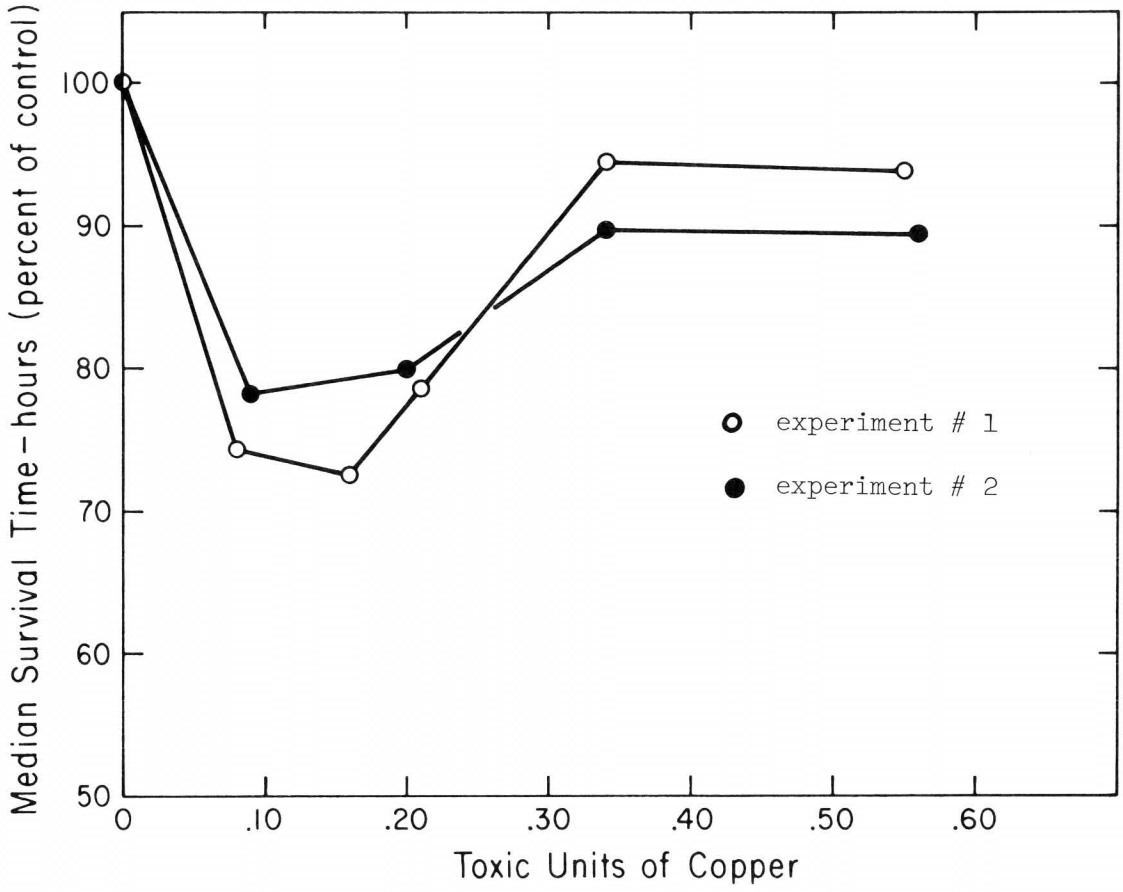


Fig. 3 Effect of varied copper level on median survival times of chinook salmon. Median survival times expressed as a percentage of the unstressed control times.

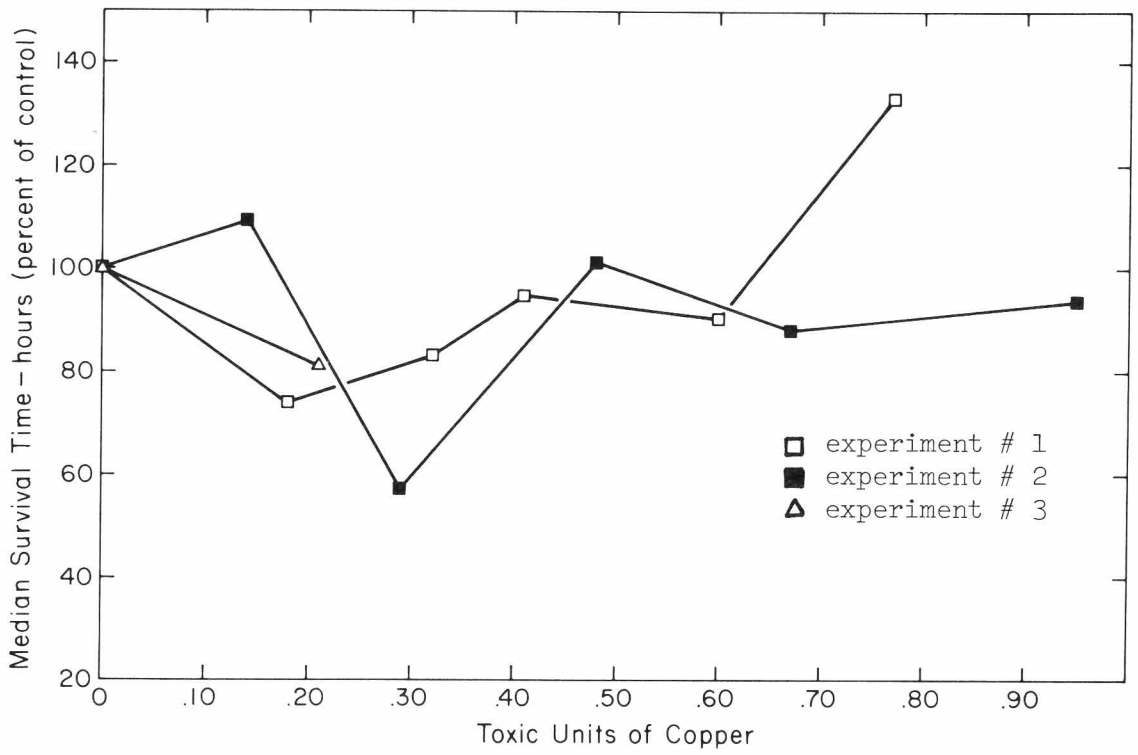


Fig. 4 Effect of varied copper level on median survival times of rainbow trout. Median survival times expressed as a percentage of the unstressed control times.

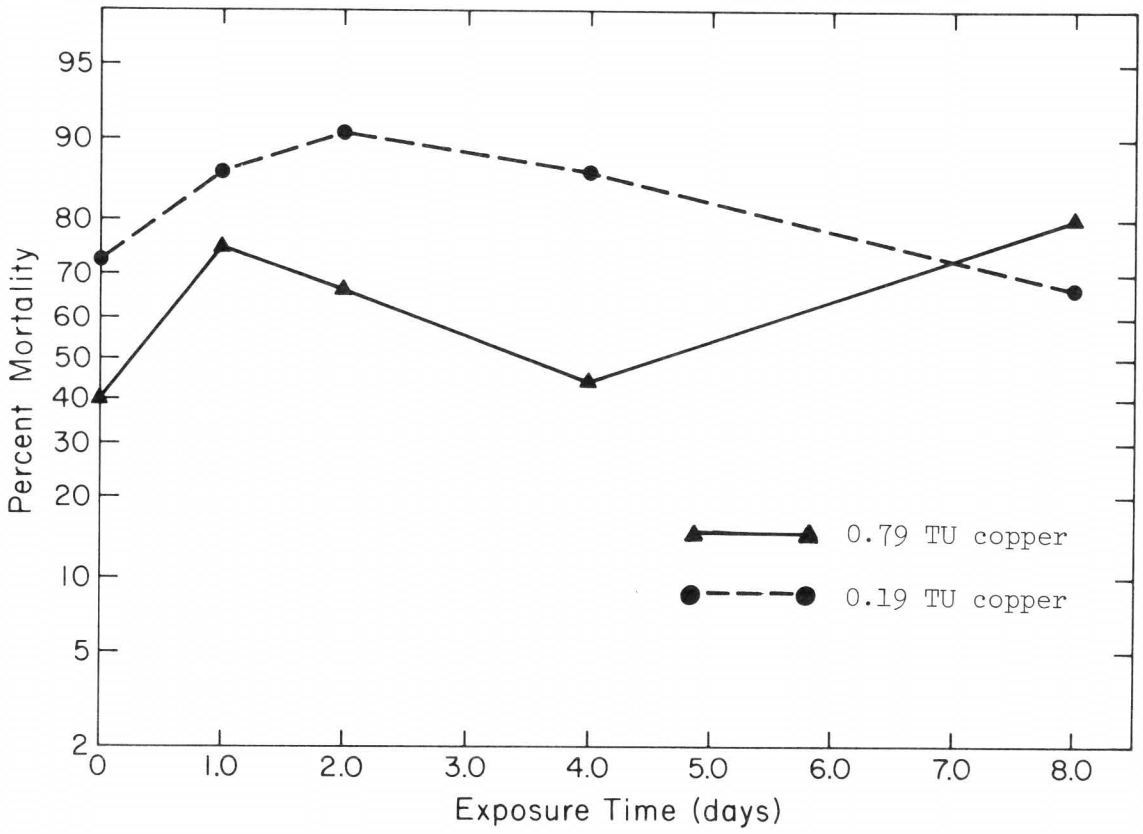


Fig. 5 Effect of the duration of copper exposure on percent mortality of rainbow trout due to Vibrio anguillarum infection for two concentrations of copper.

Recent Developments in Fish Viral Examinations at Oregon Hatcheries

W. J. Groberg, Jr.

Oregon Department of Fish and Wildlife

Disease inspection requirements pertaining to movements of fish or fish eggs by fish culturists have recently become more stringent at the state, federal and international level. Documentation of the absence of certain fish viral agents is a significant aspect of these regulations.

Virus recovery and identification in a sample will usually prevent the concerned regulatory agency from allowing movements of fish or their products from which the sample was taken. This is to prevent dissemination of fish viral pathogens.

Lack of virus recovery from a sample of normal or asymptomatic fish must be interpreted correctly. Certain assumptions concerning the potential for a fish viral agent to manifest itself later cannot be made.

It is desirable to establish a sampling history of a fish population and to study the biological and geographical system which they inhabit to properly evaluate the viral status of a population.

Ceratomyxa shasta, A Major Killer of Columbia Basin Salmon?

Don Ratliff
Portland General Electric Co.

Today I wish to report on studies done on the Deschutes River of Central Oregon to assess the influence of ceratomyxosis on juvenile Deschutes-stock chinook. Information from other areas will also be given, but the main purpose of this talk is to emphasize how much is unknown about this potentially devastating salmonid disease, especially concerning anadromous stocks.

Studies on the relationship between ceratomyxosis and Deschutes-stock chinook have been underway since 1972. These began with simple live-boxing of a group of fish in the Deschutes River, 54% of which succumbed to the disease after 95 days. The effect of exposure period was tested in 1973 and 1974. Hatchery chinook exposed continuously to Deschutes River water in 6 ft tanks, starting before the disease became virulent in May, survived better than those exposed starting after the disease became virulent. However, even the better survival groups had a mortality rate of close to 50%. In 1976 and 1977, groups of 0-age hatchery chinook were exposed for various lengths of time starting the first week of June to determine the effect of exposure time on infection rate. It was found that infection rate was positively correlated with length of exposure, at least for the first 20 days. Infection rates in 1977 increased over time from 2.7% after a 1 day exposure to 69.7% after 25 days exposure.

For the past two years we have attempted to determine the effect of ceratomyxosis on wild 0-age chinook. Every one or two weeks, groups of young chinook were seined from the Deschutes River (rm 95) during the period April through September. These were finmarked for later identification and transferred into 3 ft circular tanks which utilize 10°C spring water free from the infective stage of C. shasta. Fish were fed O. M. P. and mortalities removed daily. Wet mounted material scraped from the posterior large intestine of mortalities was microscopically examined (100x-400x) for the presence of C. shasta spores.

Groups withdrawn from Deschutes River water prior to May in 1978 and June in 1979 suffered no infections from C. shasta. Apparently, exposures up to these times were not severe enough to cause infections in these fish. Infection rates after these dates generally increased with time until the middle of July groups which peaked at 55% in 1978 and 90% in 1979. Infection rates for groups withdrawn after the middle of July decreased over time until September when they approached zero for both years. The peak in the middle of July correlates quite well with the incubation time of ceratomyxosis in these fish. The more susceptible individuals succumb starting in July and thus the population remaining in the river is increasingly resistant over time until fall when all individuals remaining are resistant survivors.

Other evidence points to ceratomyxosis caused mortality of salmonids in the wild. Biologists for the Oregon Fish Commission seined spring chinook smolts from the Willamette River below Oregon City in March

several years ago. These fish had apparent injurys and were transferred to the Clackamas Lab to determine delayed mortality from these injurys. Most subsequently died. However, death was due to ceratomyxosis and not their injurys (Don Swartz, O.D.F.&W., Portland, Personal Communication). On the Nehalem River of Oregon's north coast, ceratomyxosis has been implicated in the failure of hatchery runs of coho and winter steelhead. It has been theorized that it is also a major cause of the decline in wild runs as well (Walt Weber, O.D.F.&W., Seaside, Personal Communication). Zinn, et al. (1977) infected 53% of the Carson stock spring chinook they exposed for only 5 days to Willamette River water containing ceratomyxosis. High infection rates in Carson and Deschutes stocks of chinook are difficult to explain because both stocks have a history of exposure and consequently should have built a genetic resistance.

All fish in the Columbia River below the mouth of the Deschutes River between March and November encounter the infective agent for ceratomyxosis. How ceratomyxosis actually affects any one group of smolts traveling through the lower Columbia is unknown at this time. Because of the long incubation period many fish may look great upon emigrating from the Columbia only to die of ceratomyxosis somewhere in the ocean. Much research is imperitive before we can understand the total impact of this disease and how we might reduce that impact. It seems as if a higher proportion of monies for Columbia River salmonid studies should be directed toward this end.

Anyone wishing more detailed information on work reported in this

paper should write Don Ratliff, P.G.E. Co., P.O. Box 710, Madras, Oregon 97741.

Literature Cited

Zinn, J.L., K.A. Johnson, J.E. Sanders, and J.L. Fryer. 1977. Susceptibility of salmonid species and hatchery strains of chinook salmon (Oncorhynchus tshawytscha) to infections by Ceratomyxa shasta. J. Fish. Res. Board Can. 34: 933-936.

Respiratory Diseases of Hatchery-Raised Salmonids

G.W. (Bill) Klontz
Department Fishery Resources
University of Idaho

Respiratory diseases of hatchery-raised salmonids are a lot like the description of the weather - "Everybody talks about them but little is done about them". During the past 3-4 years we have been studying gill diseases in salmonids and have come up with some interesting findings.

From an initial survey of hatcherymen regarding the occurrences of gill diseases at their particular facilities, the following conclusions were drawn:

1. The chief gill problem of young-of-the-year salmon and trout is bacterial gill disease.
2. Formalin is the best chemical to use for treating bacterial gill disease.
3. Increasing water flow will prevent bacterial gill disease.
4. Treatment of gill diseases is more frequently than not based upon a SWAG diagnosis rather than an examination of the gills, per se.
5. Most outbreaks of gill disease occur in overcrowded ponds.

The results of our studies pursuant to the initial survey conclusions have provided some insights about the aforementioned conclusions.

First, the chief gill disease problem in young-of-the-year salmon and trout IS NOT bacterial gill disease. The main problem appears to stem from a thickened gill epithelium due to either solids (fecal and/or excess, uneaten feed) or to ammonia or both. The bacteria - if present - are frequently common to the water supply and, as such, are opportunists just waiting for a nice, thickened gill upon which to land and set up housekeeping. The bacteria generally are of two types - myxobacteria and true bacteria. The latter is not too common in the Pacific Northwest; nonetheless, the difference must be determined before treatment. The best way to do this is with a gill imprint stained with methylene blue.

Second, formalin IS NOT the best chemical to use for treating bacterial gill disease. In fact, formalin should not be used when ther is marked thickening of the lamellae or when there are degenerative changes in the gill tissues. Remember, formalin is a protein coagulant. A mild chemical such as the quarternaries (Hyamine for example) is a far better medicament because they tend to shrink the tissues as well as remove microbial pests. In my estimation, the best treatment for infectious gill diseases in general is Cutrine or Copper Power.

Third, increasing the water flow is a preventative measure for gill diseases because the water turn-overs per hour and the velocity are increased, thus reducing the exposure of the gill tissues to solids and ammonia.

Fourth, gill diseases are frequently made by the SWAG technique. In fact, treatments often are aimed at the perceived cause rather than the actual cause; namely, an unsuitable environment for the fish. The bacteria, if present, as well as the protozoa and trematodes, if present, should be considered as a sign of the problem as well as part of the problem. Granted, they must be removed but further measures to correct the environmental problems must be taken.

Fifth, most outbreaks of gill disease do occur in overcrowded ponds and deep tanks. In our opinion, the reason that most gill disease outbreaks occur in small fish; i.e., 1000 to 600/lb, is that tank loadings are often loaded by the eyeball technique. That is, until the tank "looks right". Also, deep tanks are difficult to keep clean thus creating high loads of excess feed and fecal materials which interfere with the respiratory process in the fry.

In summary, obviously the best treatment for gill disease is prevention. And the best preventative measures are not exceeding pond loadings, keeping solids from accumulating, spreading out the feeding times, and general attentiveness to detail by the hatchery personnel. However, if an outbreak does occur, then an accurate diagnosis is essential so that appropriate control measures may be applied. Remember, treat the problem - not just the sign of the problem.

Treatment of a Monogenetic Trematode Resistant to an Organophosphate

James K. Flynn
TAVOLEK INC.
Redmond, Wa.

Gyrodactylus elegans on goldfish (Carassius auratus) from a commercial farm were found to be resistant to recommended dosages of masoten, an organophosphate. Controlled experiments suggest that a dosage 100 times the commonly recommended minimal dosage (0.25 ppm) was required to remove trematodes.

Two anthelmintic drugs, T2O2F and T2O2F/K were field tested at two hatcheries against Gyrodactylus elegans on goldfish. Both drugs when used as a bath treatment, proved to be safe at concentrations up to 2 ppm. Twenty-four hour bath treatments of both drugs were effective in eliminating Gyrodactylus at 1 ppm. One hour bath exposures of 1 ppm did not remove all parasites, but 1 hour exposure at 2 ppm was effective at one of the two hatcheries where tests were conducted.

Market and cost analysis are in progress to decide whether FDA registration of one or both compounds will be pursued.

RETURNS OF ADULT COHO SALMON FROM ACCELERATED AND NORMALLY REARED JUVENILES RELEASED FROM ROSEWALL CREEK, BRITISH COLUMBIA

H. T. Bilton

Department of Fisheries and Oceans
Resource Services Branch
Pacific Biological Station
Nanaimo, B. C.

Under normal hatchery operations, juvenile coho are reared for at least 14 months before release to the sea as smolts. Shortening of the rearing period would reduce costs. One means of achieving this would be to accelerate the growth of the fish which would result in production of smolt-sized juveniles at an earlier age. The technique would also decrease generation time if adults matured in their 2nd rather than in their 3rd year of life.

An experiment to accelerate growth of coho was initiated at Rosewall Creek on Vancouver Island. A first release of approximately 10,000 accelerated (6 mo.) and 12,000 normally reared (14 mo.) nose-tagged smolts was made on June 10, 1974. A second release of 12,000 accelerated smolts was made on November 6, 1974, and a third release of 11,000 smolts was made on June 24, 1977. Early maturing male (jack) and normal-sized (adult) coho originating from these releases were recovered in the escapement and in the fishery. The total return of jacks and adults from each release is summarized as follows.

Release	Spring '74		Fall '74	Spring '77*
	Accelerated	Normal	Accelerated	Accelerated
Aver. release wt. (g)	9	19	10	10
Age at release (mo)	6	18	11	7
Jack return (%)	0.03	0.4	0.35	0.08
Jack aver. wt. (g)	331	426	523	230
Adult return (%)	3.3	47.5	6.5	0.25
Adult aver. wt. (g)	2,419	3,004	2,810	1,772
Catch/catch + escapement (%)	84	79	94	-
Benefit-costs	0.8:1	8:1	1.7:1	-

*Escapement only.

Adult returns from accelerated smolts released in the fall are about double those for the spring release (6.5 vs 3.3%), yet both are much lower than returns for normal smolts released in spring (47.5%). Results suggest unrecognized factors reduce survival of accelerated smolts. Based on benefit-costs, all of the data suggest neither spring nor fall release of accelerated (0-age) coho smolts is economically advantageous. Further details of this work can be found in Fisheries and Marine Service Technical Reports currently in press.

Frustrated Fish From Fall Releases: Significance of the Time Window in Alaska.

William R. Heard
Auke Bay Laboratory
National Marine Fisheries Service
Auke Bay, Alaska 99821

Maximum ocean survivals from time-series groups of 1972-, 1974,- and 1975-brood coho salmon smolts released at the Little Port Walter field station on south Baronof Island occurred in the late May early June period. This period coincides with the peak of volitional smolt emigration from natural populations of coho salmon in the same area.

Releases of age 0 and age 1 coho salmon fingerlings into the Little Port Walter estuary in the fall (late August to late October) generally produced poor adult returns. A feature of these fall releases was the invasion of local streams by some of the coho salmon during the overwinter period followed by emigration the following spring as "normal" age 1 and age II smolts. Some of the fall released juveniles also remained overwinter in the local estuary.

One group of 1975 brood accelerated age 0 coho salmon smolts released at 4.8 g in early June, 1976 produced an adult return of 4.0 percent, one-third to one-half the rate for age 1 smolts released at the same time; age 1 smolts, however, were larger at the time of release. Adults from this accelerated age 0 smolt release were 2 year old fish with one ocean annulus. No precocious "jacks" or 3 year old adults were recovered from this group. It appears that for age 0 accelerated coho salmon smolts to be effective in southeast Alaska they should be released at the same "normal" time that maximizes survival of older hatchery and wild smolts.

ZERO-AGE COHO--AN UPDATE FROM OREAQUA

By

William J. McNeil

Oregon Aqua-Foods, Inc.

In 1978, approximately 8.6 million zero-age coho juveniles released by OreAqua into Yaquina Bay, Oregon. Genetic stocks were mostly from Puget Sound hatcheries with small contributions from Oregon coastal hatcheries.

Approximately 42,000 adult coho returned to OreAqua Yaquina Bay facilities in 1979. Return rate was about 0.5% of the number of zero-age juveniles released. This return rate was consistent with that observed in 1978 (0.6%) and 1977 (0.3%).

UNIVERSITY OF WASHINGTON ACCELERATED COHO

E. L. Brannon and L. R. Donaldson

The accelerated coho program at the College of Fisheries was initiated in 1967 in an attempt to produce smolts in 6 months from spawning, a year earlier than standard hatchery practice. Through the use of warm incubation water (52°F) and high quality diet, young coho grow to a weight of 10 to 15 grams and smolt by the first of June. Although returns to the hatchery site were evaluated from early releases, total return success wasn't assessed until the 1973, 1974 and 1975 brood years when through a cooperative tagging program with the Washington State Department of Fisheries 25,000 to 50,000 coho smolts were released with Jefferts-Bergman coded wire tags each year. Total return success, hatchery count plus estimated catch contribution, averaged in excess of eight percent (Table 1) with a mean weight of about 4.5 pounds, made up of two size modes approximating 3 pounds and 6 pounds respectively for Puget Sound resident and ocean resident groups.

The accelerated coho return success based on these experimental releases is at least as good as the survival reported for 18 month coho smolts, with much reduced cost and space required for rearing. Given the relationship observed between size and survival, the return success of University accelerated coho is particularly impressive when one considers the fact that at release they are only 1/3 to 1/2 the size of 18 month hatchery smolts.

Table 1. UW accelerated coho survival.

Brood year	Date released	Number released	Wt. at release(g)	Est. % caught	% return	Total survival No.	Total survival %
1973	6/4/74	29,140	15.1	10.8	6.4	4988	17.2
1974	6/3/75	25,937	9.0	1.7	3.4	1328	5.1
1975	6/3/76	49,997	12.9	2.2	2.2	2196	4.4

Manufacturing larval fish feed particles

J. E. Halver and G. Pigott
College of Fisheries, University of Washington, Seattle, WA 98195

Dry manufactured larval fish feed must have the following characteristics: proper size(10-200μm); acceptance by larvae; density approximately 1.0; water stable for 15-30 minutes; nutrient balanced; readily manufactured from available materials; and reasonably stable on storage and transport. Some success has been achieved using encapsulation techniques and commercial binders for small particles.

We have approached the problem by exploring various protein and starch binding techniques and have incorporated double drum flash dryer processes to enhance starch binding, starch-protein binding, and protein-protein interactions of the plastein type reaction. Flakes produced with flash dried slurries of frozen krill, fish protein hydrolysate, starch, wheat, rye, rice, middlings, brine shrimp, and yeast could be pulverized and screened into particles of 10-30; 30-70; 70-150; and 150-300μm size.

A standardized water stability test mixing 1 gm of particles into 100 ml water, standing the suspension for 15 or 30 minutes, then filtering and weighing the residue, disclosed water stability of particles to vary between 40 and 85% of dry weight tested. Measurements of the soluble components recovered and assayed after drying indicated solution occured within 10 minutes. Nutrients solubilized were in approximately the same ratios as proximate analysis of flake particles.

Digestibility coefficients for protein and Metabolizable Energy of components were measured. No significant differences in DE or ME were detected in freeze dried or drum dried components but oven dried protein was much less available to rainbow trout test animals.

Fish protein hydrolysate was made under acidic conditions in the presence of endogenous proteases supplemented with pepsin. This partially digested material furnished polypeptides for starch and plastein binding during slurry and flash drying reactions. Steam pressure and drum rotation rate determined flash drying time and temperature parameters. Flakes were prepared at 50 and 60 % crude protein content at 50, 60, and 80 psi using 16 combinations of ingredients. Water stability tests indicated 3 of 48 treatments would be satisfactory for acceptability test trials with larval fish. Low viscosity chitosan was added as an auxillary binder to improve water stability in some preparations.

A vitamin and marine oil supplement was incorporated into the apparently best preparation and these particles were tested for acceptance and for short term survival studies with marine fish larvae.

Acceptance of a drum-dried feed by marine fish larvae.

David A. Wolf and J.E. Halver
College of Fisheries, University of Washington, Seattle, WA 98195

One major limiting factor in marine fish culture is the production of seed stock. Development of an acceptable composite feed which allows least cost formulations and which can be altered to suit the needs of different species will facilitate commercial rearing of fish larvae to stocking size. Drum-dried feeds are one possibility. The purpose of this investigation was to determine whether a drum-dried feed would be accepted by first-feeding marine fish larvae.

Larvae were kept in 20 l cylinders with 300 µm nylon screen bottoms. Inlet tubes were attached to the walls of the containers, creating a gentle circular flow of 500 ml/min. Fish were fed particles about 75 µm in diameter 8-12 times daily. Cylinders containing unfed larvae were used as controls. Periodically larvae were sampled and examined under a dissecting scope. The number and position of feed particles were recorded.

Feed particles were found in 80% (156 of 196) of the starry flounder (*Platichthys stellatus*) larvae examined. Mean fullness (number of particles/maximum capacity of larvae) was calculated at 55%. Acceptability by sand sole (*Psettichthys melanostitchus*) was 88% (202/229), with 57% fullness. Redfish (*Sciaenops ocellata*) were found with food in the gut 86% (118/137) of the time, with 53% fullness. Small numbers of flathead sole (*Hippoglossoides elassodon*), *P. stellatus* ♂ /*H. elassodon* ♀ hybrids, ling cod (*Ophiodon elongatus*) fed 500 µm particles, and cabezon (*Scorpaenichthys marmoratus*) fed 300 µm particles were also tested, with similar results. Ten day feeding trials with flatfish at yolk sac absorption showed that significant numbers of larvae fed the drum-dried feed survived, whereas few of the controls lived more than two days.

These results indicate that drum-dried feeds are readily ingested by first-feeding marine fish larvae, as small as 2.5 mm total length. It is probable that a number of species can be successfully reared from the egg to stocking size using drum-dried feeds with refinements in feed production and the development of better rearing techniques. Applications may also be found as starter feeds for chum, pink and Atlantic salmon.

Production Test of Anchovy, Menhaden and Tuna Oils in Oregon Moist Pellet

Dwain E. Mills

Oregon Dept. of Fish and Wildlife

The reduced production of herring meal in recent years, and the accompanying reduction in herring oil, at times make it difficult for Oregon Moist Pellet manufacturers to find adequate quantities of herring oil that meet specifications.

Short term laboratory experiments at Clackamas indicated that anchovy menhaden, and tuna oils produce acceptable results as lipid supplements in the Oregon Moist Pellet under the conditions at the Clackamas Lab.

We conducted our production test at Marion Forks Hatchery with spring chinook. Marion Forks is one of our coldest water hatcheries and we feel this is the severest test we can give a diet.

We fed five diets to replicate lots of 20,000 spring chinook. The diets were all made at the same time from the same lot of ingredients. Herring oil was used as the control and soybean oil as a negative control. All of the oils were added to the diet at the 6% level.

Table 1. Results of Spring Chinook Production Feeding Trial with Anchovy, Menhaden and Tuna Oils.

Oil	Avg. Fish Wt. Gain (%)	Conversion	Mortality (%)	Fork Length (mm)	Hematocrit
Herring	492.9	1.68	0.33	136.4	36.0
Soybean	405.3	1.98	0.68	132.3	38.5
Tuna	499.7	1.87	0.47	137.9	37.3
Menhaden	435.8	1.78	0.43	134.8	37.3
Anchovy	456.4	1.98	1.02	133.8	31.4

The only variable that was significant in this trial was the mortality of the fish fed anchovy oil.

Based on these results, anchovy oil is the only one that we might be hesitant about using.

We are also conducting a survival trial with coho at Sandy Hatchery with anchovy and menhaden oils.

Results of the coho survival trial and the spring chinook feeding trial will be used to decide which of these fish oils will be allowed in the Oregon Moist Pellet.

ASCORBIC ACID IN MOIST PELLETIZED FISH RATIONS

David L. Crawford
Seafoods Laboratory
Department of Food Science & Technology
Oregon State University
250 - 36th Street
Astoria, OR 97103

John W. Westgate
Oregon Department of Fish and Wildlife
17330 S. E. Evelyn St.
Clackamas, OR 97015

Jean P. Lagasse
Oregon Department of Fish and Wildlife
39800 S. E. Fish Hatchery Road
Sandy, OR 97055

Marked losses of ascorbic acid occur during the preparation, frozen storage and thawing of the Oregon moist ration. Its decomposition is concentration and temperature dependent. Example ration matrix under laboratory conditions showed a potential loss through preparation at ambient room temperature to the pelletized frozen state of from 18.9% (5 min) to a range of from 25.8 to 34.8% after 30 min (estimated production time for a 1000 lb batch of formulation). Ascorbic acid decomposed according to a linear function in the frozen state (-17.5^{o}C; 0^{o}F) at an estimated rate of 0.7 µg/100 gm at an estimated rate of 0.7 µg/100 gm ration/day producing a potential loss of 63 mg/100 gm over a 90 day storage period. Losses during thawing prior to feeding were markedly dependent upon thaw temperature. A 16 hr thaw period simulating hatchery practices resulted in a loss of 29.9-53.7% of the ascorbic acid content of the frozen pellet; at 25^{o}C the loss ranged from 89.2-97.2%.

A commercial source of ascorbic acid protected with a coating of partially hydrogenated soybean oil (30% wt/wt) (Durkote vitamin C 150-

70; Durkote Foods, Inc., Strongsville, Ohio) showed a marked improvement in stability through preparation, frozen storage and thawing over the crystalline product. Comparison in identical formula yielded a 32.5% loss in crystalline ascorbic acid over a 3.4% loss for the fat coated product over a 20 min prepration schedule. The crystalline product decomposed at a rate of 0.7 µg/100 gm ration/day at -17.5°C (0°F); the decomposition rate for the fat coated product was 0.2 mg/100 gm ration/day. Losses during a 16 hr thaw of 53.7 and 97.2% for the crystalline product over 14.8 and 24.7% for the fat coated product were observed at 2 and 25°C, respectively.

Feeding trials presently in progress have verified the availability of the fat protected source of ascorbic acid. Spring Chinook fingerlings were held in 53°F spring water for 84 days on an Oregon pellet-2 ration containing a vitamin supplement devoid of ascorbic acid. Liver levels were depleted from 128.8±6.6 to 18.9±3.9 µg/gm according to a well defined experimental function ($y=129.123e^{-.02357\ x}$, $r=-.9894$; $P\leq.001$). Fish allocated to 41°F water regimes after 77 days on the ascorbic acid "free" ration possessed liver levels of 28.4±2.6 µg/gm at 84 days. After feeding Oregon pellet-2 ration supplemented with 100 mg crystalline and fat coated (Durkote Vitamin C 145-50) ascorbic acid, liver levels rose to 200.7±3.9 and 216.9±14.8 µg/gm at 53°F and 279.4± 10.6 and 270.0±24.0 µg/gm at 41°F, respectively, after 21 days on ration. After 77 days on ration, liver ascorbic acid levels for fish fed crystalline and fat coated sources of ascorbic acid were 214.9±6.4 and 211.4± 10.3 µg/gm at 53°F and 251.1±22.8 and 276.7±24.7 µg/gm, respectively. Over the 56 day time period liver ascorbic acid levels varied little with

respect to time or source of dietary ascorbic acid. Levels in livers from fish held at 41°F averaged 62 µg/gm higher than at 53°F. Liver ascorbic acid levels for control fish continued to be depleted during this time period to 4.3±0.9 and 12.0±2.8 µg/gm at 53 and 41°F, respectively, after 77 days on ration. No visible indications of ascorbic acid deficiency were observed for control fish after 161 days on ration. Ration levels during this 77 day feeding period were depleted during frozen storage from 67.6±1.2 and 88.6±3.2 µg/100 gm to 5.1±0.2 and 33.9±1.2 mg/100 gm for crystalline and fat coated source of ascorbic acid, respectively.

The results of this continuing feeding trial to date indicated: (1) Sources of ascorbic acid protected with a solid fat coating are readily available to salmonids even at low water temperatures, (2) Reduced metabolic rates at low water temperatures greatly increase the levels at which ascorbic acid is maintained in body tissues, (3) The relationship of dietary and tissue levels of ascorbic acid is markedly affected by body tissue status, (4) Use of ascorbic acid protected with a fat coating could markedly reduce dietary levels required for maintenance of physiologically adequate levels.

HAGERMAN, IDAHO NATIONAL FISH HATCHERY AS A STEELHEAD HATCHERY

David Bruhn
Fish and Wildlife Service
National Fish Hatchery
Hagerman, Idaho

HISTORY

The Hagerman, Idaho National Fish Hatchery commenced operation in the early 1930's. The constant 59^{o} F. water supply, flowing at a rate of 70 cubic feet per second, provided optimum conditions for salmonid propagation. During the early years of operation several species of trout and salmon were reared. These included rainbow, brown, cutthroat, brook and lake trout; grayling; Chinook and Kokanee salmon; and steelhead trout.

During the fifties, sixties, and early seventies the primary species were rainbow and Lahontan cutthroat trout. These trout were stocked in State and Federal managed waters in Idaho, Nevada, Oregon, and Washington. In recent years, however, the Service has emphasized stocking rainbow trout for Federal managed water only. Service policy now states that rainbow trout production will be further curtailed and that by 1983 the Hagerman hatchery will virtually be out of resident trout production.

PRESENT AND FUTURE

1. Snake River Fall Chinook

With the scaling down of resident trout production the hatchery is again producing anadromous fish. In 1979, the hatchery reared and released Snake River fall Chinook as part of an egg bank program for these fish. Snake River fall Chinook is a stock of fish presently under

study by the fisheries agencies as a candidate species for possible protection under the Endangered Species Act. Production of fall Chinook salmon as an egg bank program is expected to continue into the foreseeable future.

2. Steelhead Trout

The U.S. Army Corps of Engineers, as a part of the Lower Snake River Fish and Wildlife Compensation Plan, has been searching for the hatchery sites in Idaho; as well as in Oregon and Washington. As the Hagerman National Fish Hatchery would soon be operating considerably below capacity, an agreement was reached in 1978 between the Corps, Fish and Wildlife Service and Idaho Fish and Game to conduct a steelhead rearing pilot project at Hagerman. Objectives of the pilot project were to evaluate diets, fish densities, etc. relative to the quality of steelhead produced. In addition, recommendations were to be submitted to the Corps for engineering design for an expanded rearing facility at Hagerman.

Approximately 91,000 pounds of steelhead smolts were reared, and released in 1979 under the pilot project. Smolts averaged 216 millimeters in length and 97 grams each (4.68 fish per pound) after an average of eleven months of rearing. Monthly length increases averaged 0.72 inches with the most rapid growth occurring in September (1.1 inches) and the least growth in March (0.36 inches).

Fish health was monitored quarterly by the Service's Hatchery Biologist project, Dworshak National Fish Hatchery and by contract with the Rangen, Inc. Research Laboratory, Hagerman, Idaho. Their findings were that an excellent quality smolt was produced.

Smolt quality was monitored and evaluated by the Idaho Cooperative Fisheries Unit, University of Idaho, Moscow, Idaho. A separate published report covers their findings. As a general comment, these were some of the best quality steelhead smolts observed by I.C.F.U. personnel. Their downstream migration from the upper Salmon River to Lower Granite Dam on the Snake River reflected this quality.

As a result of the information derived from the pilot project the Hagerman hatchery is now annually producing 100,000 pounds of steelhead for the Lower Snake River Compensation Plan. Additionally, the Corps of Engineers is proceeding with construction design to enlarge the Hagerman facility to accommodate an annual steelhead production of 350,000 pounds (1.75 million smolts). These steelhead smolts will be released in the Lemhi River (tributary of Salmon River) south of the town of Salmon, Idaho. Construction of the expanded Hagerman project is scheduled for 1981; contingent on appropriations to fund the construction.

EFFECTS OF SIZE ON STEELHEAD SMOLT OUTMIGRATION

David V. Buchanan

Research and Development Section

Oregon Department of Fish and Wildlife

Approximately 500,000 hatchery steelhead smolts were marked by fin removal or application of fluorescent spray dye each year before their release into tributaries of the Willamette River system in 1976, 1977 and 1978. A downstream migrant trap built by Portland General Electric Company was monitored every Monday, Wednesday, and Friday beginning March 15 and ending July 15 for 6 hours per day starting 1 hour after sunrise. This trap was located at Willamette Falls in a hydroelectric plant and was 200 to 340 km downstream from the hatchery release sites of steelhead smolts. There are 13 hydroelectric turbines operating at the plant, and each turbine uses approximately 12.3 m^3/sec of water for a total of 160 m^3/sec (approximately 6,000 cfs). Previous tests indicate most of the fish that move into the forebay are shunted to turbine 13 and about 12.5% of the water and fish passing through turbine 13 is further diverted into the trap and collection box.

The length frequency distribution modes of 11 separate steelhead smolt groups were determined at upper Willamette hatcheries before their release in 1977. Length frequency modes were again taken when fish from these same groups were captured at Willamette Falls. The modes at the trap were always 2 to 5 cm larger than the modes at release. We believe that four possible causes for this difference could exist: 1) Monitoring at the hatcheries may be sampling only the smaller portion of the hatchery population at the time of release. 2) Size selection at the Willamette Falls trap may be selecting

only the larger fish. 3) Hatchery smolts may grow during their emigration. 4) The larger smolts of a release group may exhibit better survival rates during the freshwater phase of this emigration.

In 1978, a length frequency distribution was made immediately before release, the sample size was increased to approximate 200 fish per sample and standard crowding and sampling techniques were used to reduce the possibility of sampling error at release. Doug Cramer of the Portland General Electric Company, ran three experiments to test possible size selection at the Willamette Falls trap. Steelhead smolts from 14 to 23 cm in length were released into the forebay immediately above the trap and sampled as they passed through the trap. He determined the trap was not size selective for steelhead smolts. We believe these results eliminate size selection at the trap as a possible bias for size differences between upriver release and emigration to Willamette Falls.

A group of 78,000 Skamania smolts was reared in two adjacent concrete ponds at Alsea Hatchery to test effect of size at release on emigration rate and success and to test the possible rate of growth during emigration. These fish were hand-graded into small (<17 cm), medium (17-19 cm) and large groups (>19 cm) 1 month before their release. Each group was marked with a fluorescent dye for identification at Willamette Falls. A length frequency distribution taken at Alsea Hatchery on April 25 immediately prior to release indicated that the three test groups had grown an average of 1 cm in the 30 days between grading and release time. All three of our size groups immediately migrated downstream 200 km to Willamette Falls. Peak migration occurred 1 to 2 weeks after release (Fig. 1). No difference in rate of migration occurred between those fish in each group arriving at the falls.

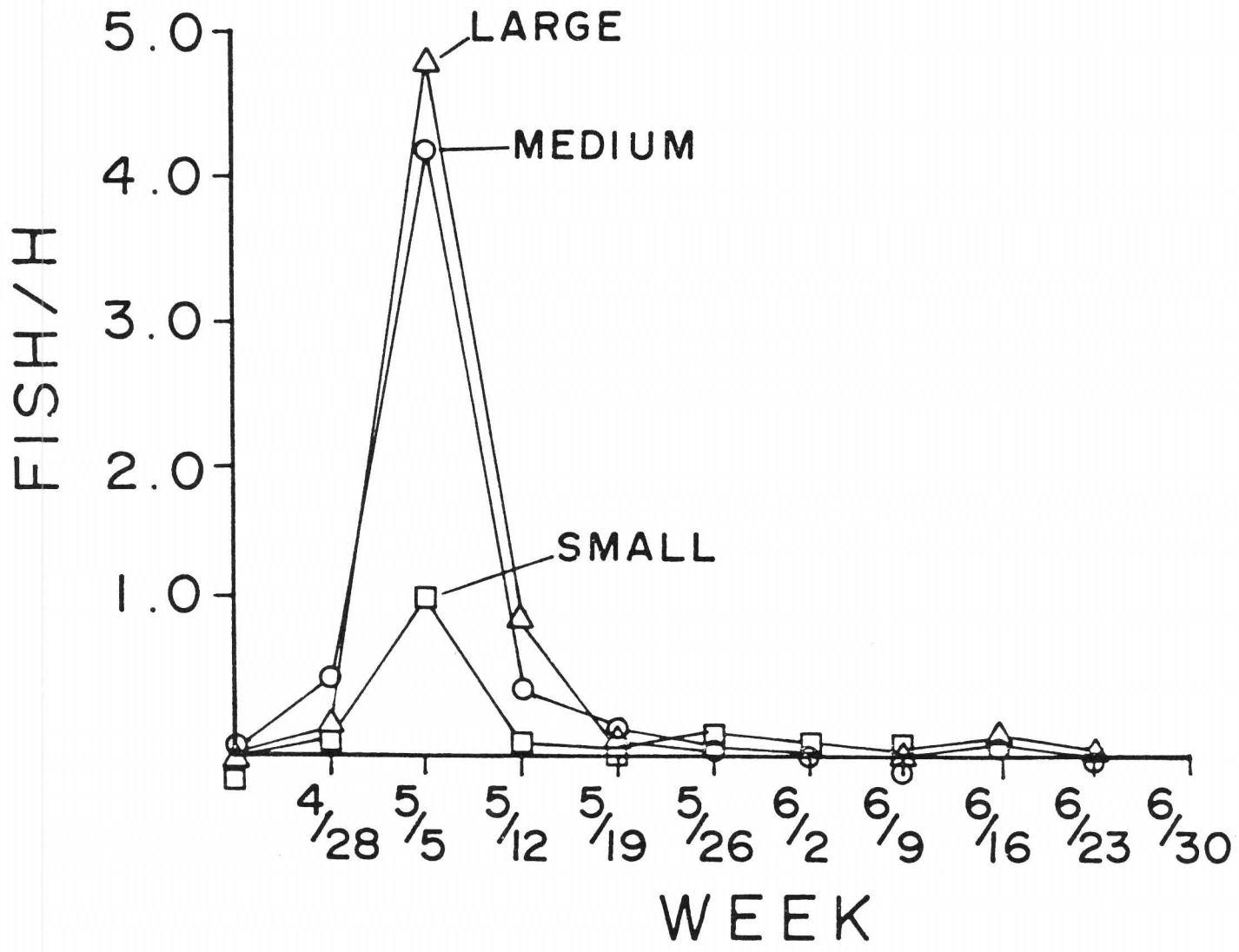


Fig. 1. Catch in fish per hour at Willamette Falls outmigrant trap for groups of Skamania steelhead smolts graded into small, medium, and large sizes and released in the upper Willamette system in spring 1978.

The medium and large smolt groups were more successful in passing the Willamette Falls trap than the small group (Table 1). A chi square contingency table was used to test differences in ratios of numbers of small, medium, and large smolts observed and not observed at Willamette Falls. No significant difference was found ($x^2 = 0.38$, d.f. = 1) between the medium and large test groups. When the medium group was compared to the small group the medium sized fish survived significantly better ($x^2 = 16.10$, d.f. = 1 at 99.5%). The smolt groups emigrating past Willamette Falls exhibited modes of 17 to 18 cm, 18 to 20 cm and 20 to 22 cm for small, medium, and large groups, respectively. It appears that few of the fish in the small group that were less than 17 cm migrated.

Table 1. A comparison of small, medium, and large Skamania steelhead smolt groups observed migrating past Willamette Falls in spring 1978.

Smolt group	Number marked smolts released	Number marked smolts captured at Will. Falls	Percent marked smolts captured at Will. Falls.
Small (≤18 cm)	17,093	25	0.15
Medium (18-20 cm)	28,066	98	0.35
Large (≥20 cm)	28,381	108	0.38

We believe measurable growth did not occur with Skamania smolts released in the Willamette River system during their 1978 spring emigration to Willamette Falls because peak movement past the falls occurred within 7 to 14 days after release. Also the medium and large test groups did not grow between release and arrival at the falls. It appears that the smaller fish from each release group are not emigrating or surviving during the freshwater phase of outmigration. This may suggest that a size threshold exists for hatchery smolts released into the Willamette basin.

We marked over 1.4 million Skamania summer steelhead smolts, ranging from 10 to 30 cm in length and released them in the upper Willamette system from 1976 through 1978. Lengths were sampled prior to release on 1,002 Skamania smolts from 11 marked groups in 1977 and 3,108 Skamania smolts from 13 marked groups in 1978. Lengths were also taken on emigrating smolts captured 200 to 340 km downstream at Willamette Falls during the three test years (Table 2). In 1977, 25% of all Skamania smolts sampled prior to release were less than 17 cm, yet this size group comprised of only 1.0% of the Skamania smolts sampled at Willamette Falls. Lengths of 13% of the fish sampled in 1978 were less than 17 cm, yet only 1.5% appeared at the falls.

These data suggests that Skamania smolts released into upper Willamette tributaries below 17 cm have a low success rate to Willamette Falls. Fish released between 17.0 to 17.9 cm had fluctuating success to Willamette Falls. In 1976, only 0.8% of the smolts sampled at Willamette Falls were in this size group, while in 1978, 5.1% of the smolts sampled were between 17.0 to 17.9 cm. We believe the most successful emigration occurs to Skamania smolts greater than 18.0 cm at release.

Over 200,000 native Willamette winter steelhead smolts were reared at Marion Forks Hatchery and released into the North Santiam River from 1976 to 1978. Lengths were taken on 431 Willamette smolts captured at Willamette Falls during these years. In 1977, 20.5% of the Willamette smolts sampled prior to release were less than 18 cm, yet this size group comprised only 1.2% of the Willamette smolts sampled at Willamette Falls. Lengths of 7.1% of the fish sampled in 1978 were less than 18 cm, and only 1.5% appeared at the falls (Table 3). Hatchery fish from the Willamette stock may need to be greater than or equal to 18 cm before good emigration to Willamette Falls can occur.

Table 2. A comparison of length frequencies of Skamania summer steelhead smolts sampled prior to hatchery release and again sampled at Willamette Falls during spring 1976-78.

Year sampled	Location		Percentage by length frequency (cm) <15	15	16	17	18	19	20	21	22	23	24	≥25	Total
1976[a]	Willamette Falls	Number	8	0	1	6	52	145	218	148	96	47	25	15	761
		Percentage	1.1	0	0.1	0.8	6.8	19.1	28.6	19.4	12.6	6.2	3.3	2.0	
1977	Hatchery release	Number	54	60	140	210	211	136	102	51	25	9	2	2	1,002
		Percentage	5.4	6.0	14.0	20.9	21.1	13.6	10.2	5.1	2.5	0.9	0.2	0.2	
1977	Willamette Falls	Number	1	1	10	33	103	183	260	248	203	117	51	26	1,236
		Percentage	0.1	0.1	0.8	2.7	8.3	14.8	21.0	20.1	16.4	9.5	4.1	2.1	
1978	Hatchery release	Number	128	78	205	420	581	597	463	299	174	103	41	19	3,108
		Percentage	4.1	2.5	6.6	13.5	18.7	19.2	14.9	9.6	5.6	3.3	1.3	0.6	
1978	Willamette Falls	Number	1	4	12	58	168	256	260	190	93	45	27	21	1,135
		Percentage	0.1	0.3	1.1	5.1	14.8	22.6	22.9	16.7	8.2	3.9	2.4	1.8	
Total	Willamette Falls	Number	10	5	23	97	323	584	738	586	392	209	103	62	3,132
		Percentage	0.3	0.2	0.7	3.1	10.3	18.6	23.6	18.7	12.5	6.7	3.3	2.0	

[a] *No smolt lengths were taken prior the 1976 hatchery release.*

Table 3. A comparison of length frequencies of Skamania summer steelhead smolts sampled prior to hatchery release and again sampled at Willamette Falls during spring 1976-78.

Year sampled	Location		Percentage by length frequency (cm)												
			<15	15	16	17	18	19	20	21	22	23	24	≥25	Total
1976[a]	Willamette Falls	Number	1	1	1	0	3	6	9	14	11	6	1	2	55
		Percentage	1.8	1.8	1.8	0	5.5	11.0	16.4	25.5	20.0	11.0	1.8	3.6	
1977	Hatchery release	Number	4	4	9	24	36	49	33	16	11	8	4	2	200
		Percentage	2.0	2.0	4.5	12.0	18.0	24.5	16.5	8.0	5.5	4.0	2.0	1.0	
1977	Willamette Falls	Number	1	0	0	2	7	21	41	47	59	24	21	18	241
		Percentage	0.4	0	0	0.8	2.9	8.7	17.0	19.5	24.5	10.0	3.7	7.5	
1978	Hatchery release	Number	6	2	10	37	100	181	182	141	72	29	13	10	783
		Percentage	0.8	0.3	1.3	4.7	12.8	23.1	23.2	18.0	9.2	3.7	1.7	1.3	
1978	Willamette Falls	Number	0	0	0	2	15	16	37	25	22	12	5	1	135
		Percentage	0	0	0	1.5	11.1	11.9	27.4	18.5	16.3	8.9	3.7	0.7	
Total	Willamette Falls	Number	2	1	1	4	25	43	87	86	92	42	27	21	431
		Percentage	0.5	0.2	0.2	0.9	5.8	10.0	20.2	20.0	21.3	9.7	6.3	4.9	

[a]*No smolt lengths were taken prior the 1976 hatchery release.*

COORDINATION OF CODED-WIRE TAGGING ACTIVITIES AT FEDERAL HATCHERIES IN THE COLUMBIA BASIN

By

Steven K. Olhausen
U.S. Fish & Wildlife Service
Fisheries Assistance Office
Vancouver, Washington

Responsibility of coordination of coded-wire tagging activities for Federal hatcheries in the Columbia Basin has recently been turned over to Fisheries Assistance Office Vancouver, a division of the U.S. Fish & Wildlife Service. Prior to the re-organization one person was assigned to handle all tagging coordination activities in Region One. With an increase in coded-wire tagging activities projected for the Columbia Basin, as well as other areas throughout Region One (Washington, Oregon, Idaho, and California.) the need to fragment regional responsibilities has come about.

Regional and area tag coordination responsibilities are outlined as follows:

1. Regional tag coordination with overall responsibilities throughout Region One is centered in Olympia, Washington. The regional coordinator will coordinate all service tagging activities with the PMFC and in turn inform ATC of any new P.M.F.C. policies. All tags are ordered through the RTC.

2. Puget Sound/Coastal Washington area tag coordination is also centered in Olympia, Washington.

3. California area tag coordination is based out of Red Bluff, California.

4. Columbia Basin area tag coordination is handled by FAO-Vancouver with responsibilities involving all tagging activities at 13 Federal hatcheries in the Columbia Basin.

The Columbia River tag coordinator (ATC) will:

- Order tags through the RTC.

- Send a copy of a completed tagging summary sheet to the RTC within one month of the release date for each tagging group.

- Send a summary calendar year CWT releases to the RTC by December 1, of the release year. This yearly release information will be included in the PFMC "Pacific Coast Coded Wire Tag Release" report.

- Maintain, through Hatchery Biologists, proper and consistent hatchery rack sampling techniques and reporting methods.

- Dissect out and read the tags and report this information to the RTC.

- Regional CWT release information from Region 1 National Fish Hatcheries will be available from the RTC approximately one month after release of a group. The RTC will accomodate requests from any agency concerning

USFWS releases.

- Preliminary information on proposed USFWS CWT release groups will be available from the RTC at the time the tags are requested by the ATC or at any time from the ATC.

Up until recently mark coordination in the Columbia Basin was centered around those hatcheries located in the Bonneville Pool and the Lower River. Now, coordination has expanded to include all 13 Federal hatcheries in the Columbia and Snake River systems. With other Federal and State fishery agencies, as well as universities marking fish at Federal hatcheries, the need for total coordination is at hand.

The U.S. Fish & Wildlife Service is in the process of finalizing a policy statement for coded-wire tagging in Region One. The Columbia Basin is included. The policy statement outlines the procedures and rules by which agencies, including the U.S.F.W.S., will follow in marking any fish raised at a Federal hatchery. Those rules are outlined as follows:

1. CWT proposals will be filed with the appropriate ATC prior to funding. Proposals shall be submitted one year in advance of tagging.

2. After review and inclusion of comments, the ATC will send a copy of the proposal to the RTC who will in turn review it, add any comments, and route to the appropriate Area Office for a final decision.

3. Color coded tags are not used within Region 1 USFWS CWT programs and are not acceptable for use on Service fish by other agencies. This

restriction is imposed due to inaccuracies and difficulties associated with tag reading as well as difficult tag application.

4. Other agencies shall be required to secure and use their own agency code for tags implanted at USFWS hatcheries. This will avoid unnecessary routing and verification of marine tag recoveries through service channels.

5. The ATC, with imput from the Hatchery Biologist and Manager, will determine whether or not tagging should be initiated or continued when fish health is jeopardized by coded-wire tagging procedures. If it is determined by these individuals that the procedures are detrimental to fish health, tagging will be stopped. Tagging may continue when the problem is alleviated.

6. The designer of an experiment is responsible for collecting the pertinent recovery data as it becomes available and completing a report. Copies of the coded-wire tagging experiment report should be sent to the ATC, RTC, and Area Office.

NEW DEVELOPMENTS IN THE PRODUCTION AND USE OF SALMON PITUITARY EXTRACTS FOR INDUCED SPAWNING

T. G. Owen
Syndel Laboratories Ltd.
Vancouver, B. C.

Preparation of Pituitary Materials

We are attempting to purify a number of hormones from salmon pituitaries with particular emphasis on GTH*. In the process, a number of useful by-products are being prepared. These include acetone dried pituitaries (sADP) which provide the most economical source of GTH for induced spawning where lab facilities are available to produce an extract of the powder. A lyophilized pituitary extract is readily soluble and is a convenient form of GTH to use in the field. The lyopholized gel filtered extract is a purer source of GTH and should be useful where multiple injections are required and it is not desirable to introduce large quantities of foreign protein. The lyophilized glycoprotein preparation is equivalent to Dr. E. M. Donaldson's SG-G100 (1) and is suitable for studying the physilogical effects of GTH while the purified gonadotropin should be useful for biochemical studies such as sequencing and RIA production. The remaining preparations have all been of interest to researchers for some time. These are: isotocin, crude prolactin and growth hormone and purified prolactin, growth hormone, vitellogenic hormone and thyrotropin.

To date, the following preparations are available: acetone dried pituitaries (sADP), lyophilized pituitary extracts, lyophilized gel filtered extracts and the lyophilized glycoproteins. Work is continuing on the other preparations and it is hoped that they will be available by April 1980.

*Abbreviations: GTH - gonadotropin, cAMP - Cyclic AMP, IBMX - isobutyl methyl xanthine, HCG - human chorionic gonadotropin, sADP - acetone dried salmon pituitaries.

Collaboration with other laboratories for the assay of the hormones other than GTH is in progress. All of the GTH sources are now assayed by Syndel by measuring the augmentation of cAMP in immature salmonid ovaries by GTH (2). In this assay, the GTH is bound to a membrane receptor which activates adenyl cyclase to produce cAMP. The cAMP may then activate a protein binase which, through a series of steps, ultimately increases the breakdown of glycogen to glucose. In any case, in the presence of GTH and IBMX (which inhibits diesterase conversion of cAMP to AMP), cAMP levels are elevated up to 10-fold in vitro.

The cAMP levels are determined by a competitive binding assay. In this assay, a constant amount of labeled cAMP and protein kinase are incubated with varying amounts of unlabeled cAMP. Protein kinase - cAMP complexes are formed and isolated and the amount of labelled cAMP bound to the kinase is determined by liquid scintillation counting. In this way, a standard curve can be constructed and the amount of cAMP in unknown samples can be determined.

These assay results are compared to the cAMP augmentation caused by Dr. Donaldson's SG-G100 which seems to have become an unofficial standard. Since his preparations are compared to National Institute of Health standards in the chick bioassay (1), we are able to relate the GTH activity of our preparations indirectly to an international standard.

Use of Pituitary Materials

-Salmon

Some work was conducted in 1978 by Dr. Donaldson's group using our sADP and frozen pituitaries (3). During this study, it was observed that egg production was significantly facilitated by using pituitary preparations. In a control group, prespawning mortality reached 42% while the use of frozen pituitaries at a rate of 10mg/kg and 50mg/kg on Days 0 and 3

respectively and sADP at a rate of 1.5 and 6.5 mg/kg on Days 0 and 3 reduced this prespawning mortality to 13% and 0% respectively. Essentially, the fish in all groups died in the same period of time but spawning was accelerated so that the fish could be stripped before they died instead of the reverse. The net result was a significant increase in the yield of eggs from the treated groups compared to the control group.

-Other Species

In 1977, Dr. W.E. Vanstone was successful in inducing the milkfish (Chanos chanos) to spawn in captivity in the Philippines (4). In this work, sADP was injected 2 or 3 times at a rate of 10mg/kg each time. Each injection also contained 150 I.U. of HCG which could probably be eliminated if more salmon pituitary material was used. In addition, work is currently being conducted in the Philippines at Ilo Ilo on the acceleration of maturation in the milkfish. Using a pellet implantation technique, sADP is administered at a rate of 10 mg/kg every 3 weeks for up to 6 months. This is equivalent to injecting 0.5 mg/kg daily or 1.5 mg/kg every 3 days.

This work on milkfish indicates that sADP will work on species other than salmon if appropriate increases in dosages are used to compensate for species specificity. For example, the dose required for milkfish to spawn (20-30 mg/kg) is 2.5 to 3.75 times higher than the 8 mg/kg required for salmon (3). However, our own work has revealed that the increase required to overcome species specificity is not as high as we had originally thought.

During a recent trip to Southeast Asia in September and October, 1979, some trials were conducted at Bogor in Indonesia. Three common carp and four Puntius were injected once with an amount of lyophilized pituitary extract equivalent to 15mg/kg of sADP. One control fish of each species was injected with an extract of fresh carp pituitaries obtained from donor fish according

to the standard methods used in Bogor. By the next day, all of the carp except one which was injected with the salmon preparation has spawned. Only one Puntius spawned. It had been injected with the salmon preparation. On Day 3, an injection of 10mg/kg of sADP was given to all of the fish which had not spawned. The last carp spawned the next day but the Puntius had not. We left Indonesia that day and have not heard yet if the Puntius did eventually spawn.

From this information, it is possible to conclude that a reliable source of gonadotropin and other hormones would greatly benefit aquaculture projects by facilitating egg production. As more work is done and complete dose-response information becomes available for a variety of species, it will be possible to predict the amount of material required for a given species in a particular situation. We are a long way from having this information but a start has been made. For example, it is now known that carp and Puntius can be induced to spawn at lower levels of sADP than originally thought necessary from the milkfish data. The incomplete spawning observed for carp and Puntius may have been due to lack of maturity rather than lack of sufficient hormone recognition in these species. Perhaps with more careful environmental manipulation to induce maturity, a greater proportion of the fish would have spawned. Only further experimentation can answer this question. To this end, we are involved in collaboration with a number of facilities in Southeast Asia who have agreed to establish the levels of sADP required to induce spawning in a number of species. The data should provide valuable insight into the practical application of induced spawning.

Acknowledgments

We thank the Canada Department of Fisheries and Oceans for the Cooperative Projects with Industry grant which has enabled us to conduct the hormone purifications and GTH assays. In addition, we extend special thanks to Dr. E. M. Donaldson who has provided us with invaluable technical and moral support and allowed the use of some of his data in this paper. Finally, Dr. W.E. Vanstone provided us with the milkfish data and contributed to the organization of our experiments and collaborations in Southeast Asia.

References

1. Donaldson, E.M. 1973. Reproductive endrocrinology of fishes. Amer. Zool. 13: 909-927.

2. Idler, D.R., Hwang, S.J. & Bazar, L.S. 1975. Fish gonadotropin(s). I. Bioassay of salmon gonadotropin(s) in vitro with immature trout gonads. Endocrine Res. Comm. 2: 199-213.

3. Hunter, G.A., Donaldson, E.M., Dye, H.M. & Peterson, K. 1979. A preliminary study of induced ovulation in coho salmon (Oncorhynchus kisutch) at Robertson Creek salmon hatchery. Canada Fisheries and Marine Service Technical Report No. 899.

4. Vanstone, W.E., Tiro, L.B. Jr., Villaluz, A.C., Ramsingh, D. C., Kumagai, S., Dulduco, P.J., Barnes, M.M.L. & Duenas, C.E. 1977. Breeding and larval rearing of the milkfish Chanos chanos (Pisces: Chanidae). Technical Report No. 3. Aquaculture Dept. Southeast Asian Fisheries Development Center.

CONCEPTUAL REDESIGN OF MID-COLUMBIA SPAWNING CHANNELS TO RACEWAYS

By V.W. Kaczynski

CH2M HILL

200 S.W. Market, 12th Floor

Portland, Oregon 97201

ABSTRACT

CH2M HILL performed a study for Grant, Chelan, and Douglas County PUD's to determine the present limitation and future potential for salmonid culture at all their facilities along the mid-Columbia River. Subsequently, we performed preliminary engineering and biology studies to conceptually redesign these facilities to optimize production. These studies were actually a joint effort between the PUD's, Washington State Departments of Fisheries and Game, and CH2M HILL. The facilities involved were:

Washburn Island Rearing Pond

Chelan Falls Hatchery

Wells Hatchery and Spawning Channel

Turtle Rock Spawning Channel

Rocky Reach Annex Hatchery

Priest Rapids Hatchery and Spawning Channel

This project dealt with the conceptual conversion of the three spawning channels (Wells, Turtle Rock, and Priest Rapids) to more traditional rearing raceways. We believed this topic would be of interest because of the very large production potential of these facilities and because of the hybrid raceway-pond loading criteria that evolved for the conversion. The Turtle Rock spawning channel has already been modified and is now operating as four independent rearing raceways.

At Wells, Turtle Rock and Priest Rapids, the three spawning channels were all similar in design and in conceptual operation. They differed mainly in the number of sections involved. Basically, they were very large, concrete-lined channels with serial flow-through spawning sections. All used Columbia River water directly. The spawning sections contained a mixture of large gravel to small cobble and were separated by deeper drop sections. The drop sections were used to maintain hydraulic head for the spawning sections and to provide resting and hiding spots for adults. They also contained small drains for dewatering. An adult holding pond was located at the upstream end of each facility.

These spawning channel facilities were designed and constructed to replace chinook salmon spawning habitats inundated by hydroprojects. Operationally, the fish were supposed to take care of themselves; that is, the facilities were designed for seminatural fish culture. Lost spawning habitats were simply replaced by artificial spawning channels.

These facilities generally did not provide the production desired. Fish behavior, suboptimal temperatures, and disease (aggravated by the flow-through serial design) were the major problems identified. Neither the PUD's nor the state agencies were satisfied with the channels' performance. All three facilities subsequently experimented with more traditional methods of fish culture, combined with using sections of the spawning channels as raceway rearing vessels. This strategy appeared to hold promise.

During the course of the study, spawning channel mitigation goals were converted into raceway mitigation goals; these goals amounted to some 116,000 pounds of chinook fry at 40 fish per pound (4,640,000 fry), a figure never achieved by the combined facilities in terms of numbers or poundage. provide resting and hiding spots for adults.

The design of the three spawning channels was reasonably basic, and it appeared that a double manifold system (one water supply, the other waste effluent) could make the serial spawning channel sections into independent raceway vessels once the cobbles and gravels were removed and suitable piping, headers, screening, and drains were provided. This proved to be true by using the intermediate drop sections for both head boxes and drains, and the conversion costs estimated were minimal. This task was relatively straightforward. The independent nature of the redesigned sections would dramatically reduce disease potential, thereby dramatically increasing production potential.

The most difficult aspect was the establishment of raceway criteria: full use of water supply and space at as safe a loading density as possible to minimize costs.

Columnaris, white spot, snail trematode (eye fluke), Dermocystidium, Saprolegnia, and a bacterial gill disease had all been previously identified as disease problems in the spawning channels at the warmer summer temperatures.

All parties involved thought that conservative rearing criteria would be necessary because the main water supply

was untreated Columbia River water. However, in addition to potential disease, Columbia River water contains much natural food: zooplankton and drifting insect larvae and pupae. Fish culturists often remarked on the fast growth rates that the river water provided. Also, the fry would have to go into river water eventually. Some natural selection within the rearing sections was probably a good thing.

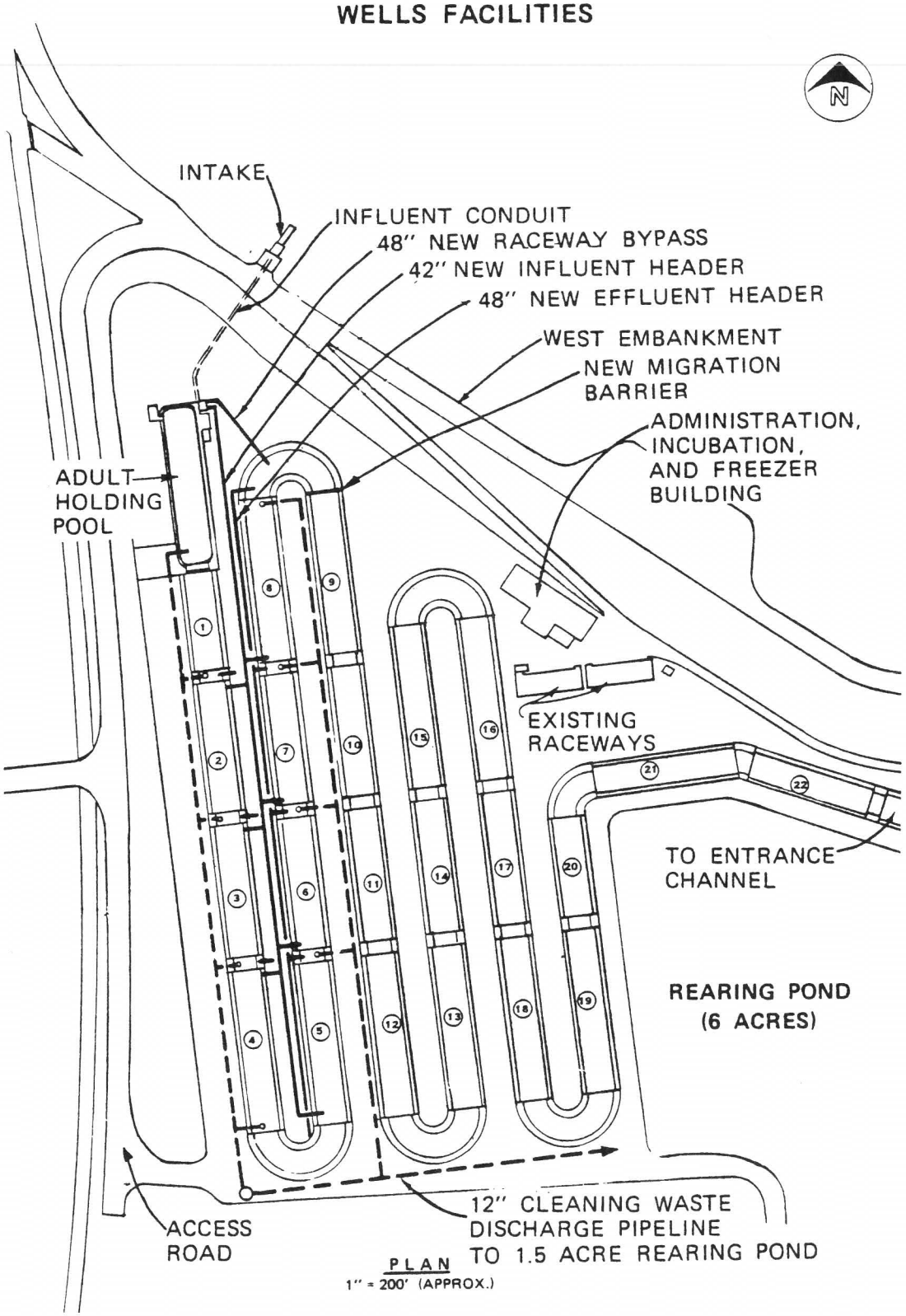
Eventually, all parties agreed upon a general set of very conservative criteria for the three facilities. These criteria were hybrid between pond culture criteria and raceway culture criteria. Minor individual differences were tailored for the differences in raceway volumes and water supply capacities for the three facilities.

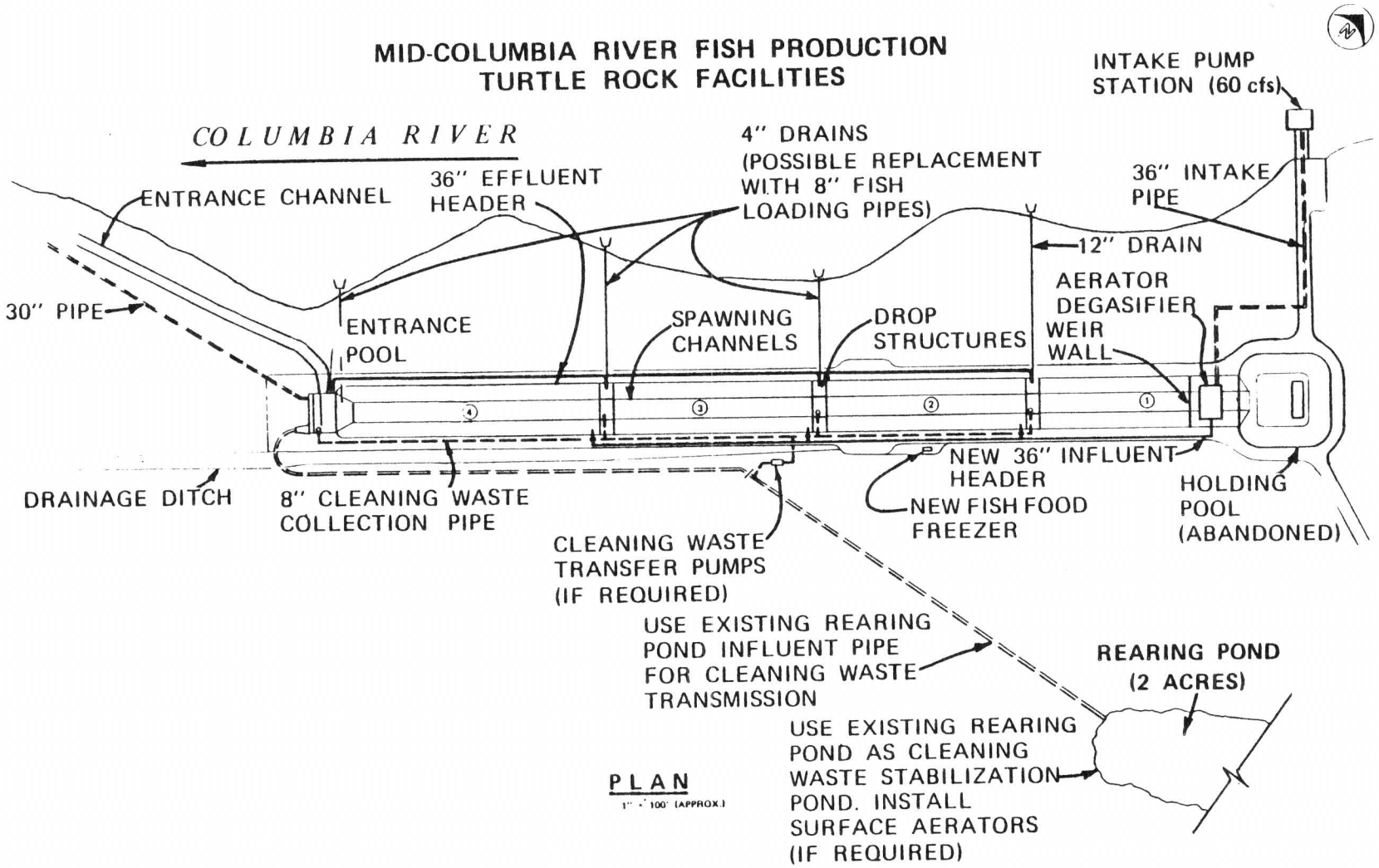
Because of suboptimal winter temperatures retarding early development rates and potential summer disease problems later in the year, it was desirable to accelerate egg incubation and early fry rearing in well water as much as possible. In theory, this could be accomplished satisfactorily at Priest Rapids and at (Rocky Reach Annex for) Turtle Rock, but not at Wells. Provisions for egg incubation and early fry rearing were determined individually for the three facilities because of significant differences in existing facilities and well water supplies.

* * *

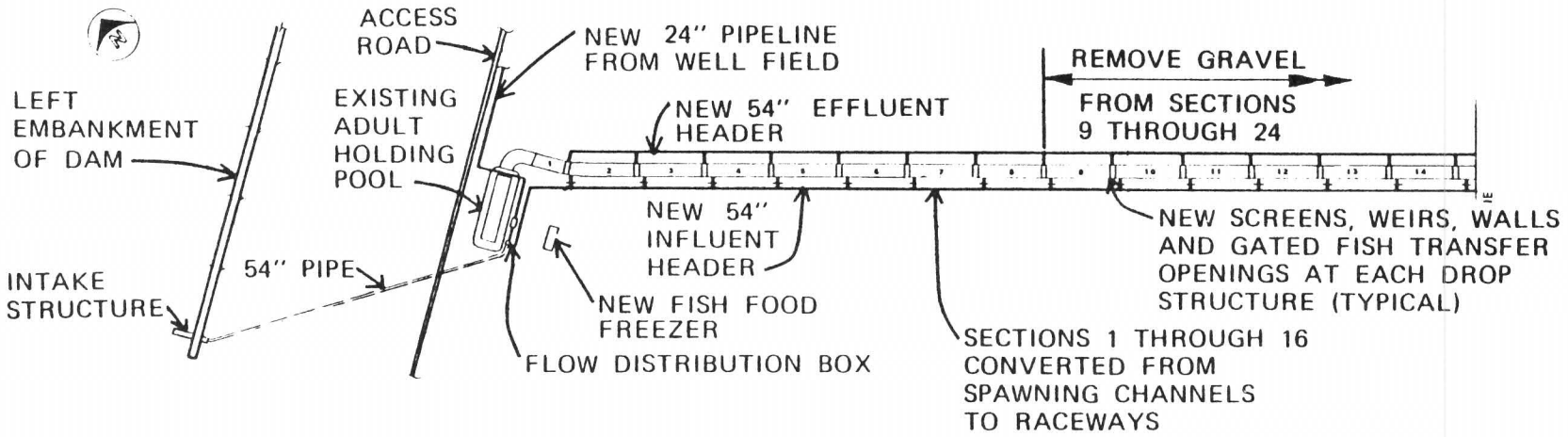
Several slides were presented that showed the facilities, conceptual redesign layouts, rearing operational strategies, and loading criteria. Several figures follow.

MID-COLUMBIA RIVER FISH PRODUCTION WELLS FACILITIES

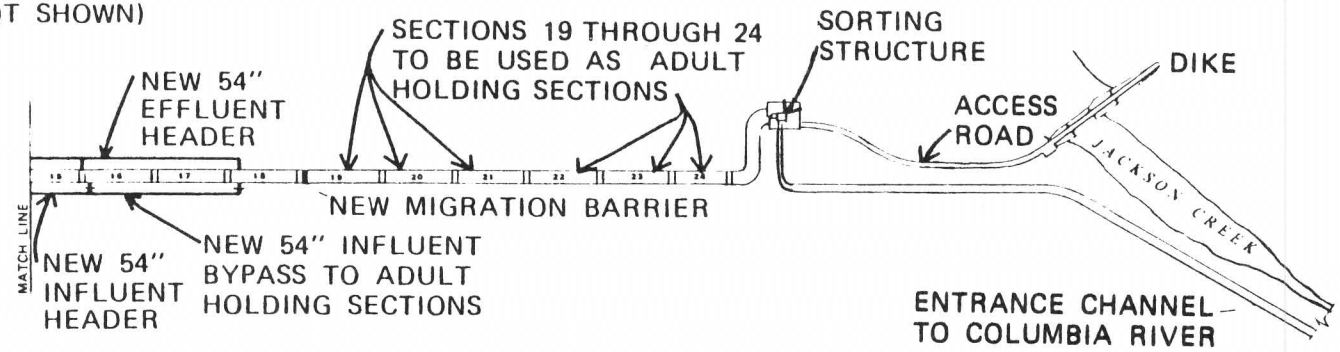



MID-COLUMBIA RIVER FISH PRODUCTION
TURTLE ROCK FACILITIES
COLUMBIA RIVER
INTAKE PUMP STATION (60 cfs)
4" DRAINS (POSSIBLE REPLACEMENT WITH 8" FISH LOADING PIPES)
36" EFFLUENT HEADER
ENTRANCE CHANNEL
36" INTAKE PIPE
12" DRAIN
AERATOR DEGASIFIER
30" PIPE
ENTRANCE POOL
SPAWNING CHANNELS
DROP STRUCTURES
WEIR WALL
NEW 36" INFLUENT HEADER
NEW FISH FOOD FREEZER
HOLDING POOL (ABANDONED)
DRAINAGE DITCH
8" CLEANING WASTE COLLECTION PIPE
CLEANING WASTE TRANSFER PUMPS (IF REQUIRED)
USE EXISTING REARING POND INFLUENT PIPE FOR CLEANING WASTE TRANSMISSION
REARING POND (2 ACRES)
USE EXISTING REARING POND AS CLEANING WASTE STABILIZATION POND. INSTALL SURFACE AERATORS (IF REQUIRED)
PLAN
1" = 100' (APPROX.)

MID-COLUMBIA RIVER FISH PRODUCTION PRIEST RAPIDS FACILITIES

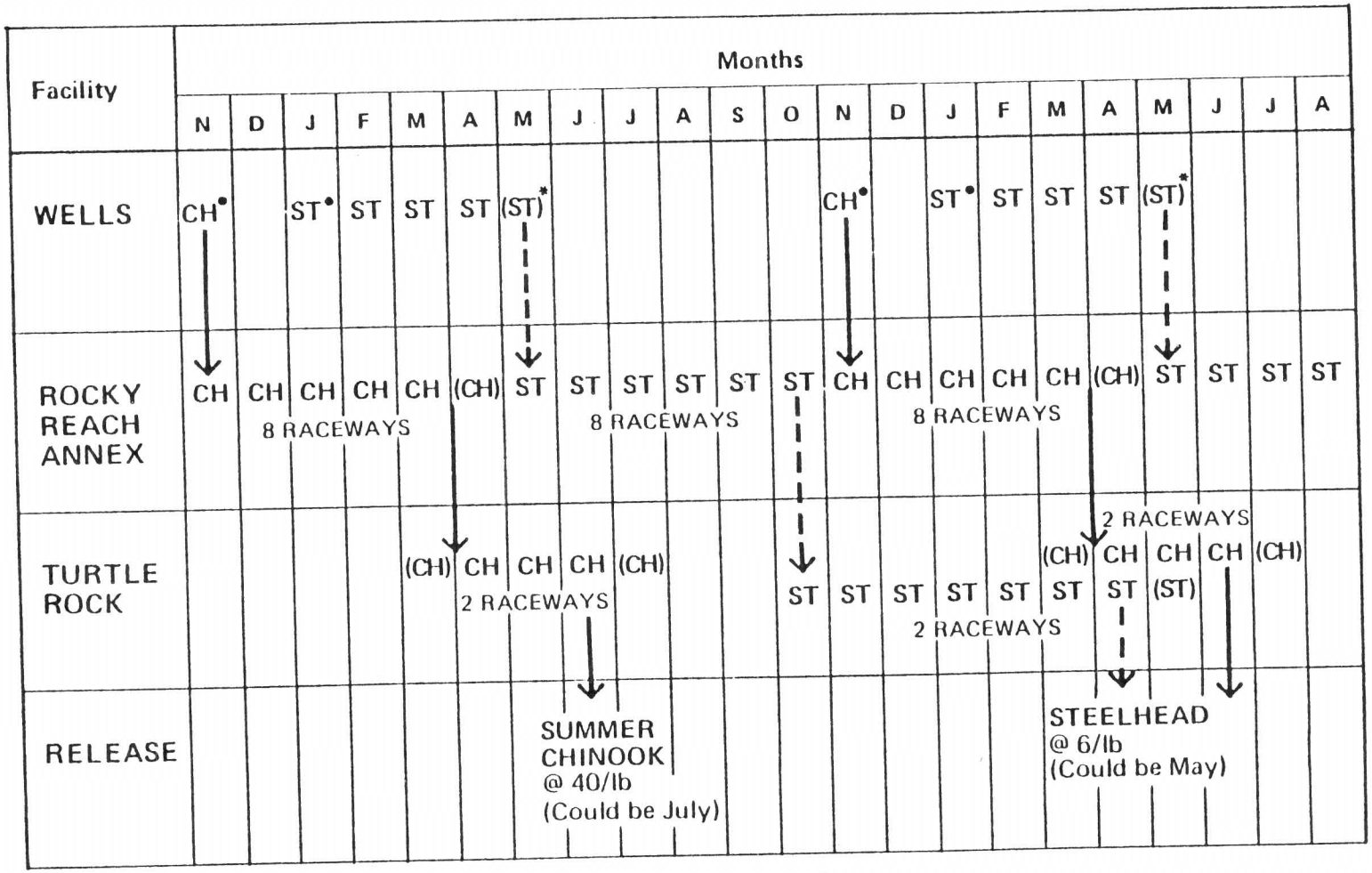


(CLEANING WASTE TO STABILIZATION POND PIPING NOT SHOWN)

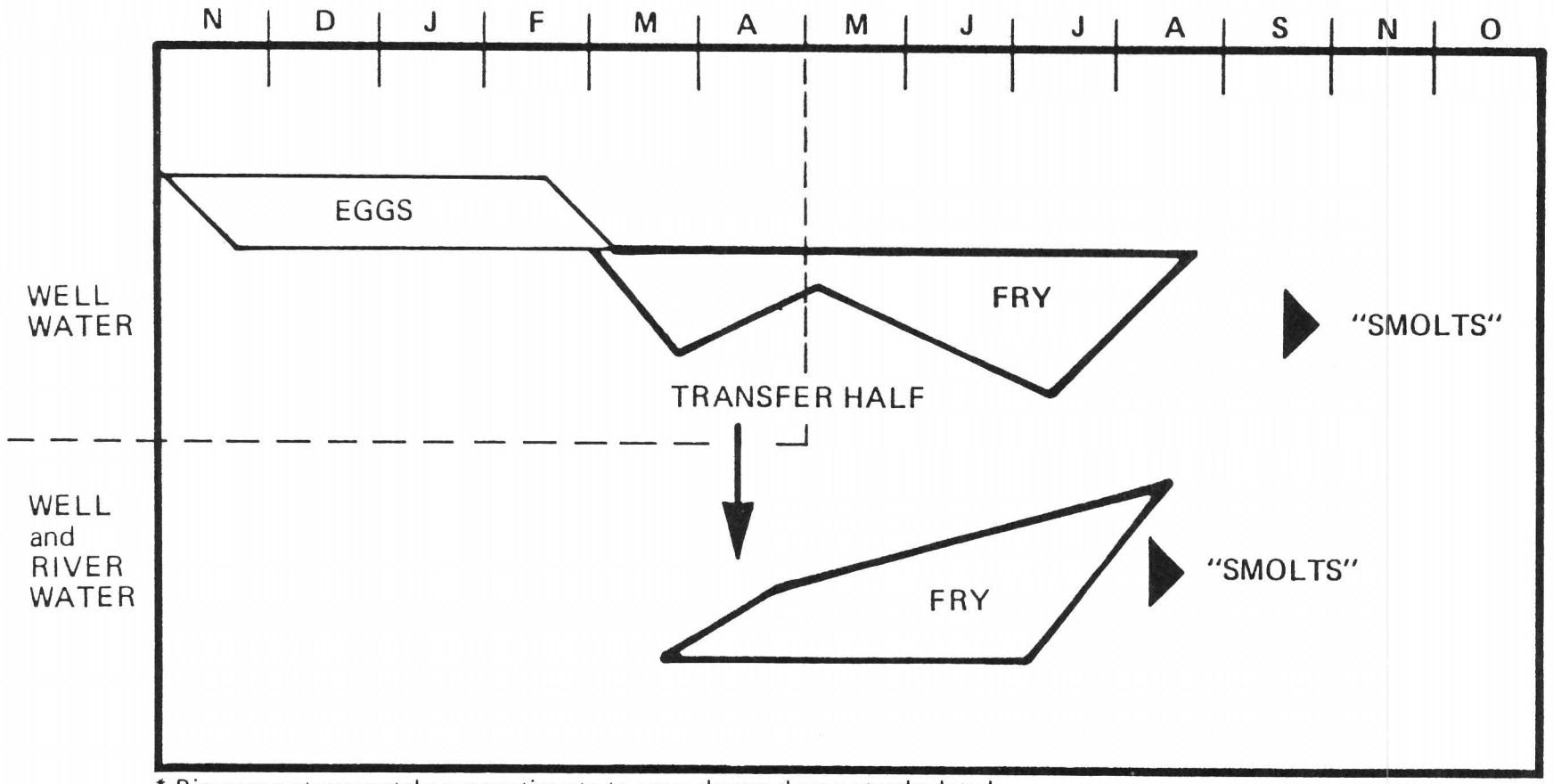


OPERATIONAL STRATEGY

Maximize Production of Steelhead Trout and
Summer Chinook at Rocky Reach Annex/Turtle Rock



GENERAL PRODUCTION STRATEGY FOR FALL CHINOOK AT PRIEST RAPIDS FACILITIES*



* Biomass not accurately proportionate to area; degree days not calculated.

GENERAL LOGISTICS TABLE FOR CHINOOK REARING AT MID-COLUMBIA FACILITIES

	Early Fry		Late Fry
Size at Transfer/Release	250/lb		40/lb
Maximum Loading Density	0.45/lb/ft^3		0.75 lb/ft^3
Maximum Velocity	0.04 fps		0.125 fps
Maximum Loading Rates			
Well Water	4,500 lb/cfs		4,500 lb/cfs
River Water	3,200 lb/cfs		3,200 lb/cfs
Cross Sectional Area		120-190 ft^2	
Sectional Length		200-250 ft	
Sectional Volume		27-38,000 ft^3	
Maximum Carry per Section			
Pounds	9-10,000 lb		20-28,000 lbs
Type of Limitation	volume		volume
Flow per Section (max.)	2.5 to 4.0 cfs		7.5 to 15 cfs
Water Detention Time	3 to 4 hr		0.5 to 1.2 hr
Water Turnover Rate	0.3 to 0.4 x/hr		1 to 2 x/hr
Total Carry			
Fish	24,400,000 fry		21,972,000 fry
Pounds	97,600 lb		913,800 lb
Total Conversion Cost (as of January 1979)		$5,000,000	

Use of a Clinoptilolite Ammonia Removal Filter in a Recirculating Salmon Rearing Facility

William J. Bruin, Laura M. Mumaw and John W. Nightingale
Seattle Aquarium, Seattle, WA

The Seattle Aquarium has reared chum, coho, and chinook fingerlings for educational display purposes since 1977. The rear-release program occurs in a ladder which winds around the display facility to empty into Puget Sound and is fed by water pumped in from Puget Sound. A 9500 gallon section at the head of the ladder, termed the raceway, can be isolated and filled with fresh water to rear salmon fingerlings. Salmon in the rear-release program are obtained shortly before smolting. At the appropriate time they are imprinted on morpholine, introduced to salt water, and released down the ladder to sea.

Fresh water in the raceway rearing facility is obtained from city water lines, passed through a sand filter to remove particulates, and subsequently dechlorinated in activated carbon filters. The limited amount of available fresh water necessitated the use of a recycling water system. Filters containing clinoptilolite (clino), a zeolite mineral shown to be highly efficient in ammonia removal (Williams, 1973), were incorporated in the system (Table 1). Clinoptilolite functions as an ion-exchange medium, showing a high affinity for ammonium ions. When saturated with ammonia, clinoptilolite can be recharged using a sodium chloride solution in which the concentration of sodium ions greatly exceeds that of the ammonium ions being displaced. Major advantages of such a physico-chemical ammonia removal filter over a biological filter are its relative independence from factors such as temperature

and the presence of antibacterial agents, and its ability to function at maximum effectiveness almost immediately.

The raceway water system (Fig. 1) consists of 90% recirculating water flow and 10% fresh water input. Recirculating water is passed through two sand filters operating in parallel. 45% of this water is subsequently passed through two clinoptilolite filters operating in parallel before returning to the raceway. Salt water from Puget Sound serves to backwash the clino filters when necessary. Flow meters (Eagle Eye Portable Meter, Model 77C) were installed in June 1979 (Fig. 1). Measured flow rates are shown in Table 2. The clino filter flow rate is within the 12-15 bed volumes/hr recommended by the supplier.

Dissolved oxygen (YSI Model 57 DO meter), salinity, temperature (YSI-SCT Model 33 meter), pH (Orion Model 407A pH meter), and ammonia (Strickland & Parsons, 1972) are monitored in the raceway, the clino influent, and the clino effluent lines. If these parameters reach potentially dangerous levels, steps are taken to correct them. A value of .005 ppm unionized ammonia (the form toxic to fish) is taken as the maximum allowable ammonia level (Spotte, 1970; Rice, 1977).

In 1978 a total of 32,000 chinook and coho fingerlings were reared in the raceway. Quantitative aspects of ammonia removal for that season are difficult to interpret because operating procedures were still being refined and standardized. Nevertheless, the clino filters worked efficiently to keep the raceway ammonia at acceptable levels.

By the 1979 season procedures for operating the water reuse system were

Ammonia determinations were made at 2 hour intervals for the first 48 hours. When it became apparent that values were not fluctuating greatly, sampling frequency was decreased to 4 hour intervals. Figure 2 shows the daily variation in raceway ammonia levels, averaged from seven days. Values were lowest early in the morning, rising shortly after the first feeding (5 am).

Performance of the clino filters was assessed by comparing average daily values of ammonia in the clino influent and effluent lines (Fig. 3). In the course of both weeks the influent ammonia level gradually rose and levelled off at .45 ppm while the effluent level began rising about the fifth day to .1 ppm. Backwashing occurred on the seventh day. By using the difference between the clino influent and effluent ammonia levels, and multiplying by the flow rate through the clino filters, the theoretical amount of ammonia accumulating in the filters can be calculated (Fig. 4). By the seventh day of operation 750 grams of ammonia had been filtered out of the raceway water.

The ammonia measured in the backwash solution is shown in Fig. 5. This curve is reproducible and has been obtained many times. A large peak is seen in the first 5 minutes; the bulk of the ammonia appears to be removed within the first 90 minutes. This curve is also plotted as a function of bed volumes of backwash water (Fig. 5). Most ammonia is removed in the first 40 bed volumes (10,4000 gals). The amount of ammonia recovered in the backwash solution can be calculated by integration of the area under the curve.

A balance sheet of ammonia production and removal in the raceway system

well defined. A new clinoptilolite material, designated clino 1010, was placed in the filters. From February 13 to April 11, 1979, 13,000 coho fingerlings (127 kg initial weight) were reared in the raceway. Water quality parameters were monitored as described previously for two weeks while the clino filters were kept off line (Table 3). Water quality parameters for the succeeding 43 days (Table 4) with the clino filters in use differed primarily in increased temperature, concomitant decrease in oxygen, lower pH, and reduction in ammonia. The latter two appear to be a function of clino filter operation. The greatest unionized ammonia value (.001 ppm) was well below our chosen limit. Clino filters were backwashed every 14 days. After a 3 hour saltwater backwash (salinity $28^{o}/oo$, pH 7.8), the first few volumes of freshwater run through the filter had an unusually high pH and visible turbidity, apparently due to very fine suspended matter. This phenomenon had not been observed with the clino used in the 1978 season. A 30 minute freshwater rinse after the saltwater backwash was therefore instituted as standard backwash procedure.

A more quantitative study of clino filter performance was undertaken with the subsequent rearing of a group of 30,000 chinook fingerlings (118 kg initial weight). Salmon were fed 5.5% of their body weight of OMP II daily (2.2 kg at 5 am, 11 am, and 5 pm). Flow meters were installed and flow rates as well as water quality parameters were monitored daily during the experimental period of 14 days (June 20 - July 3, 1979) (Table 5). Note the seasonally high temperatures and lower dissolved oxygen levels. Clino filters were backwashed once a week. Unionized ammonia values in the raceway did not exceed .002 ppm.

for one week is presented in Table 6. Similar results were obtained the following week. A conservative factor (f) of .0203 is used to convert food consumed into ammonia produced by the fish (Liao, 1976; Speece, 1973). Based on these figures, the capacity of the clino filters was 1.1 g ammonia per kg of clinoptilolite with a breakthrough value of .1 ppm ammonia (i.e. the level of ammonia in the clino filter effluent prior to backwash was .1 ppm). Functional capacity of the clino filters is undoubtedly higher since raceway levels of unionized ammonia were maintained below the desired level (.002 ppm) and clino filters were still operating at 80% efficiency prior to backwash.

Further experimentation on the operating characteristics of the clino filters will be conducted during the 1980 rearing season.

REFERENCES

Liao, P. E. 1976. Personal communication.

Rice, L. 1977. Salmon culture. In Small Streams and Salmonid: A Handbook for Water Quality Studies. Dyckman, C. and S. Garrod, eds. pp. 165-217. UNESCO, Paris.

Speece, R. R. 1973. Trout metabolism characteristics and the rational design of nitrification facilities for water reuse in hatcheries. Trans. Am. Fish. Soc. 102 (2): 323-334.

Spotte, S. H. 1970. Fish and Invertebrate Culture. Wiley-Interscience, N.Y.

Strickland, J. D. H. and T. R. Parsons. 1972. A Practical Handbook of Seawater Analysis. Fish. Res. Bd. Canada Bull. 167.

Williams, W. G. 1973. Evaluation of clinoptilolite for ammonia removal. Technical Reprint No. 33. Kramer, Chin, and Mayo Inc. Seattle, WA.

TABLE 3. WATER QUALITY FOR COHO (Feb. 13-27, 1979)
(without clinoptilolite filters)

	$T^{o}C$	pH	NH_4-N (ppm)	DO(ppm)
Mean	7.9	7.2	0.66	10.0
Range	7.0-8.9	6.9-7.3	0.40-0.90	9.2-11.2
S.D.	0.5	0.1	0.16	0.5

13,000 coho fingerlings; 127 kg. initial weight

TABLE 4. WATER QUALITY FOR COHO (Feb. 28-Apr. 11, 1979)
(with clinoptilolite filters)

	$T^{o}C$	pH	NH_4-N(ppm)	DO(ppm)
Mean	10.0	6.8	0.23	8.7
Range	8.0-11.2	6.5-7.2	0.10-0.75	6.4-11.5
S.D.	1.7	0.2	0.12	1.4

13,000 coho fingerlings; 127 kg. initial weight

TABLE 5. WATER QUALITY FOR CHINOOK (Jun. 20-Jul. 3, 1979)
(with clinoptilolite filters)

	$T^{o}C$	pH	NH_4-N(ppm)	DO(ppm)
Mean	17.9	6.7	.43	5.4
Range	17.0-19.8	6.5-7.0	.21-1.0	3.4-6.9
S.D.	0.6	0.1	0.11	0.6

30,000 chinook fingerlings; 118 kg. initial weight (.9 kg. fish/gpm. flow)
186 kg. final weight (1.4 kg. fish/gpm flow)

TABLE 1. CLINOPTILOLITE FILTER CHARACTERISTICS
(two in parallel)

SURFACE AREA:	9.8 sq. ft.
BED DEPTH:	42 in.
BED VOLUME:	34.3 cu. ft., 256 gal.
CLINOPTILOLITE WEIGHT:	848 kg.

TABLE 2. FLOW RATES IN RACEWAY WATER SYSTEM

RACEWAY CAPACITY:	9500 gal.
OVERFLOW RATE:	13 gpm., 12 hr. turnover
TOTAL RECIRCULATING FLOW RATE:	120 gpm., 1 hr. turnover
CLINOPTILOLITE FILTER FLOW RATE:	50 gpm., 3 hr. turnover

Figure 2.

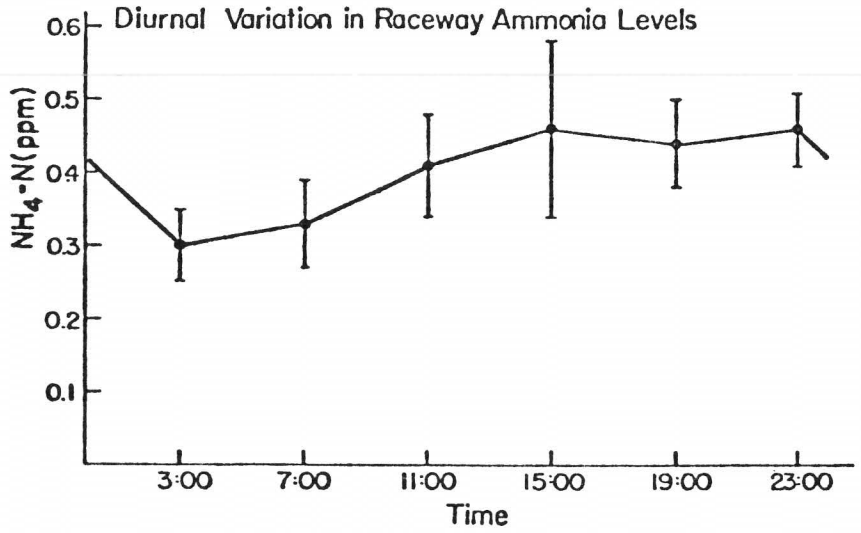


Figure 3.

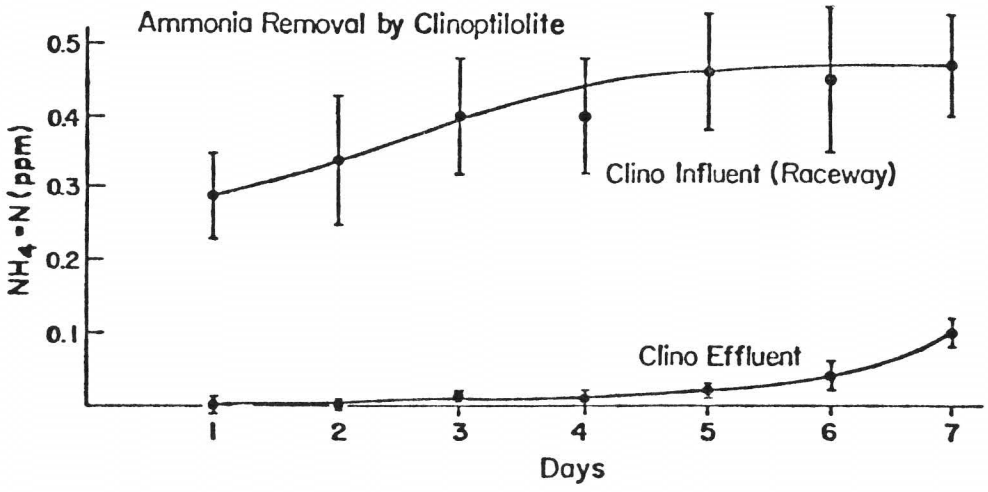


TABLE 6. AMMONIA PRODUCTION AND REMOVAL (Jun. 20-26, 1979)

	NH_4-N(g)
Produced from Food (f=0.0203)	980
Removed by Clinoptilolite (790 g.) + Discharged in Overflow (210 g.)	1000
Recovered in Clinoptilolite Backwash	910

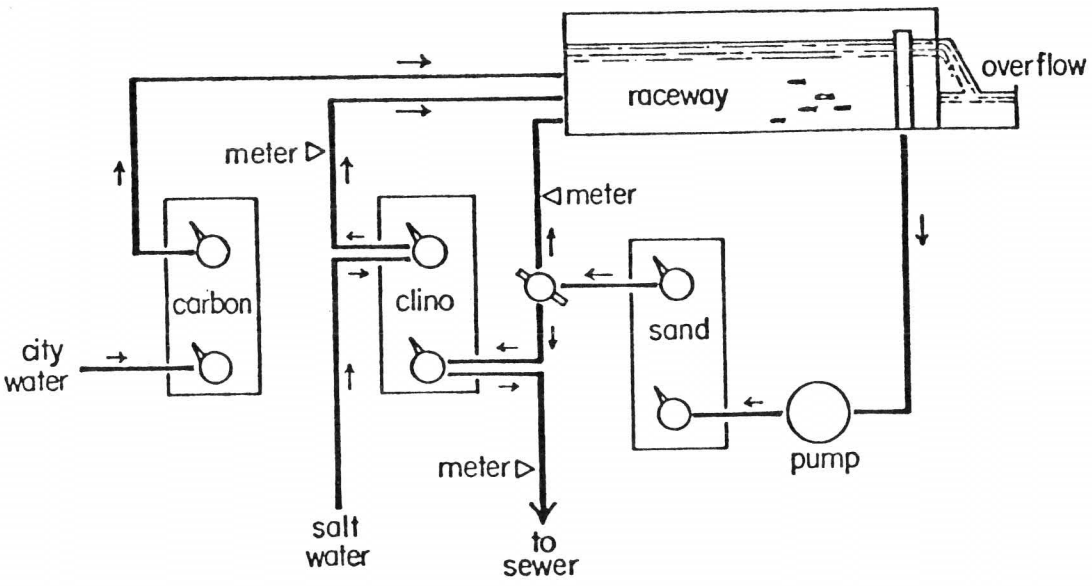


Figure 1. Schematic of raceway water system.

Figure 4.

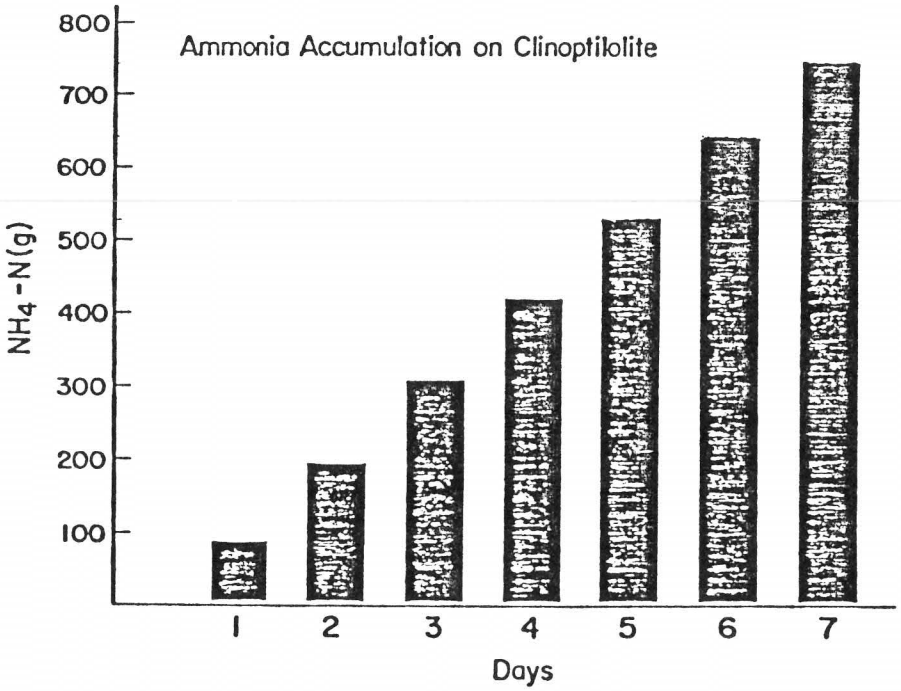
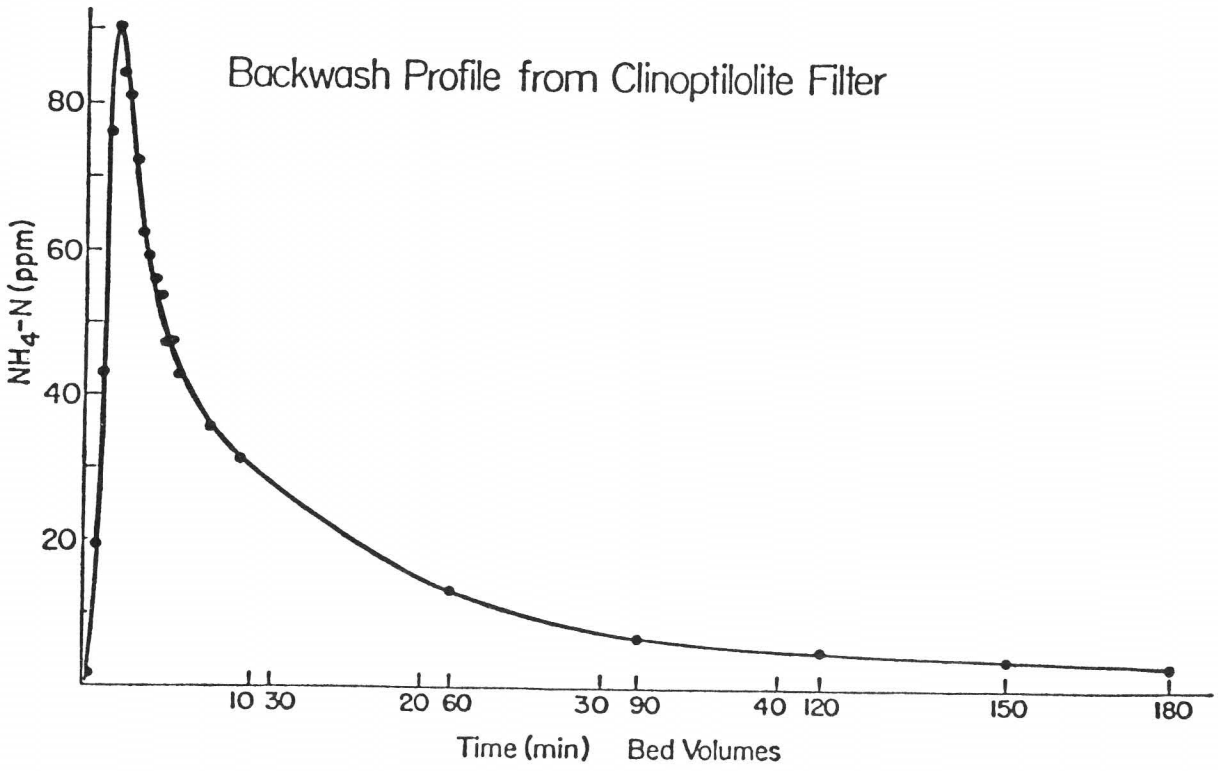


Figure 5.



The Effect of Rearing Density on Subsequent Survival of Capilano Coho

F.K. Sandercock and E.T. Stone

Fisheries and Oceans, Salmonid Enhancement Program

An experiment was conducted at Capilano Salmon Hatchery, North Vancouver, B.C. to determine the effects of rearing density on survival of 1975 brood coho. Because of an accident involving chlorination of the Capilano Hatchery water supply, all fish used in this experiment were derived from eyed eggs transplanted from the Big Qualicum River Project on Vancouver Island. These eggs were incubated in Heath trays (∿ 7500 eggs/tray) until March 10-17, 1976 at which time the fry were transferred to 6.5m long fibreglass troughs to commence rearing. Loading rates for these troughs were ∿ 35,000 fry/m^3.

Rearing

The fry were fed O.M.P., based on the standard feeding schedule and by June 15, 1976 had reached an average size of ∿ 3g. Beginning June 15th the fry were loaded into Burrows ponds (75' x 17' x 3') at four different density levels, 572 fish/m^2, 761 fish/m^2, 910 fish/m^2 and 1,072 fish/m^2. At ponding the fish had accumulated 1,450-1,500 (^oC) temperature units.

Standard hatchery rearing practices were followed and all groups were maintained on the O.M.P. schedule from ponding until January 20, 1977.

From January 21st until March 7th, 1977 all four groups were fed 42.8% of the recommended feeding rate (daily ration 3 days/week). From March 8, 1977 until release in June the feeding rate was 71.4% of the recommended amount (daily ration 5 days/week).

Between March 16 and March 28, 1977 randomly selected fish from each of the four groups were marked by removal of the adipose fin and a binary coded wire tag injected into the snout. As the fish were marked they were re-introduced back into the pond from which they had been taken. Knowing the total number of marked fish in each pond (23 -33% of each group were marked) a new population estimate was made using the mark to unmark ratio from a minimum sample of 5,000 fish per group.

During the course of rearing, mortalities were recorded in each of the ponds and ranged from 1.0 - 3.4%. However, the population estimates based on the mark to unmark ratios revealed discrepancy losses of 11.7%, 11.3%, 18.6% and 13.0% for the low to high density groups respectively. Since we were unable to determine at which point these losses (if real) occurred, it was assumed that the number of fish in the pond at release was the calculated number and for purposes of comparison of the four groups this number was used to express the density of fish reared.

By September 1977 some of the marked fish had shown up in the sports fishery as jacks and others had returned to the hatchery. During 1978 marks were recovered in the B.C. sport and commercial fisheries, in the U.S. Sport and commercial fisheries (mostly Washington) and in the escapement back to the hatchery. The total number of marks observed per 10,000 marks released was 1,348, 1,036, 985 and 717 for the low to high density groups respectively.

The impact of the density effect on survival can clearly be seen if we examine the relative food costs for producing fish from each of these groups. Using only the observed number of marks (and not the expanded contribution to fisheries) and adjusting for the unmarked contribution from each group (to account for all fish fed prior to release) the food costs were as follows:

Density Group	Adults + Jacks	Adults Only
Low	$ 0.17	$ 0.22
Med. - Low	0.24	0.32
Med. - High	0.25	0.31
High	0.33	0.39

Over the range of densities used in this experiment, it would appear that it is possible to produce the same number of adults from about half as many smolts.

Density Group	No. fish/pond	No. fish/m^2	No. fish/m^3
Low	56,097	500	666
Med. - Low	74,522	664	885
Med. - High	82,102	731	975
High	101,176	901	1,201

These compare to a loading rate for coho of 1,153 fish/m^2 as recommended by Wedemeyeret al 1976*, assuming a size at release of 20g, a flow rate of 600 U.S. gpm and a maximum temperature of 14°C.

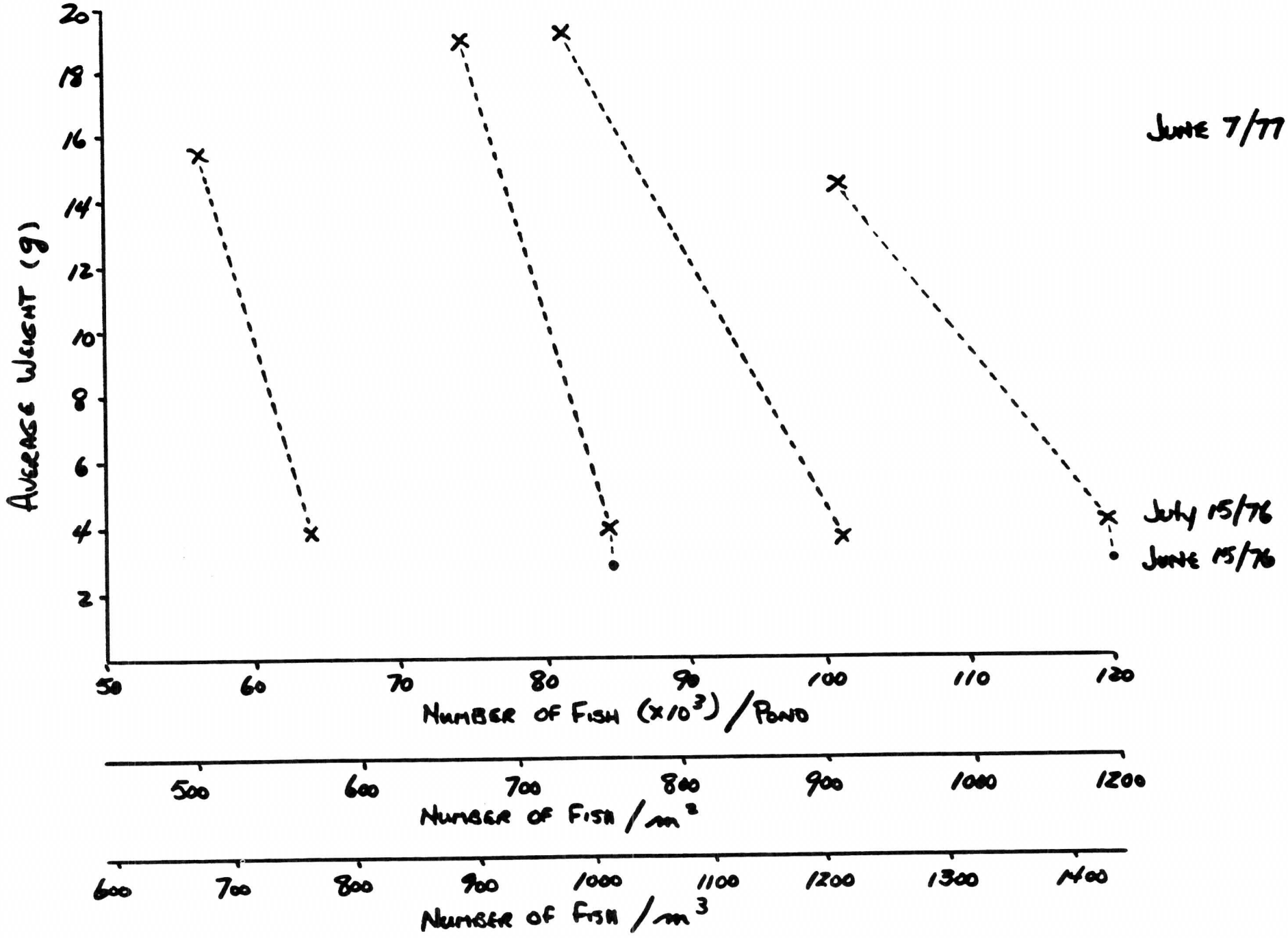
On the evenings of June 6 and 7, 1977 the pond screens were removed and the fish allowed to emigrate. The following day the few remaining fish were removed and the ponds drained.

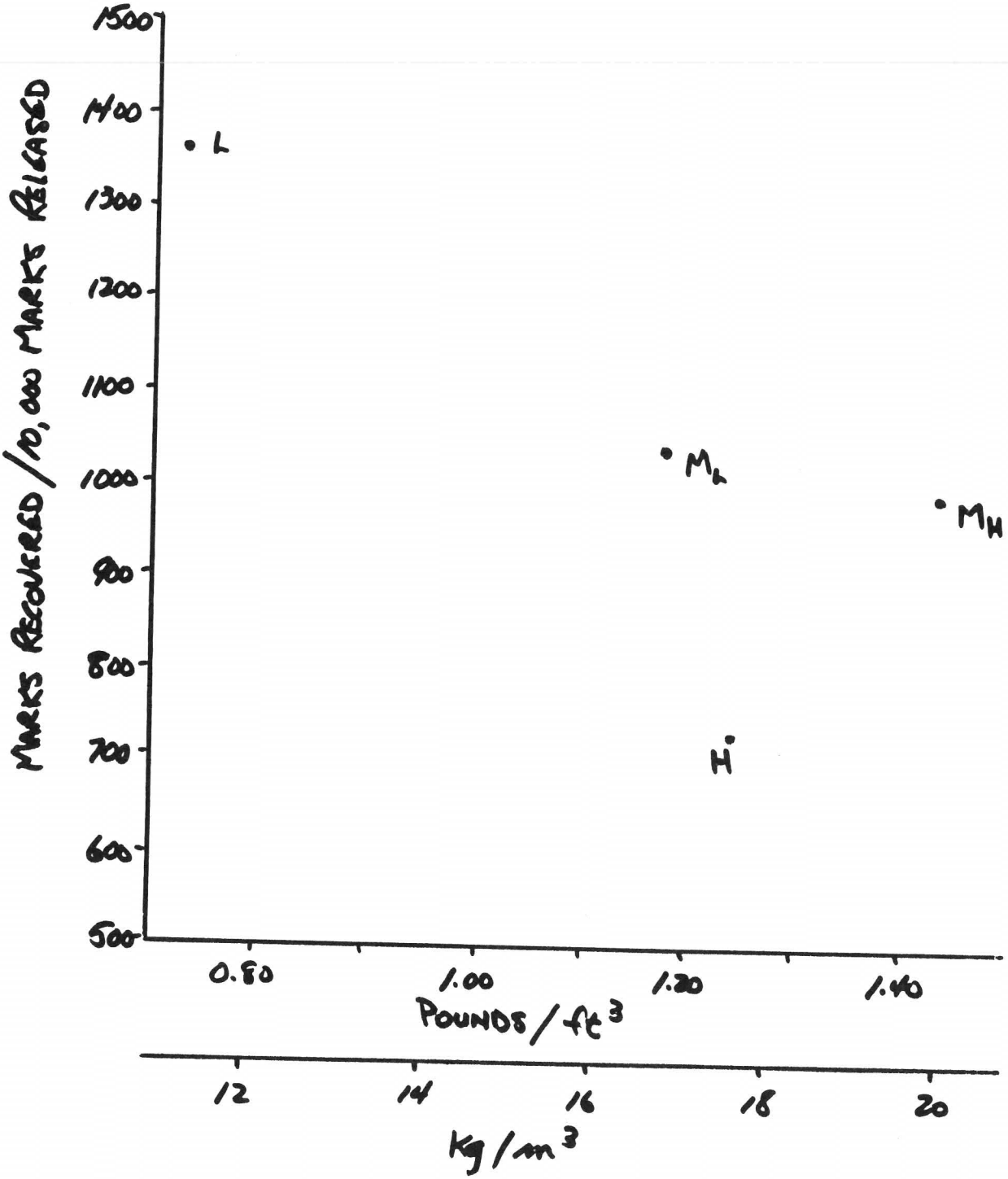
Survival

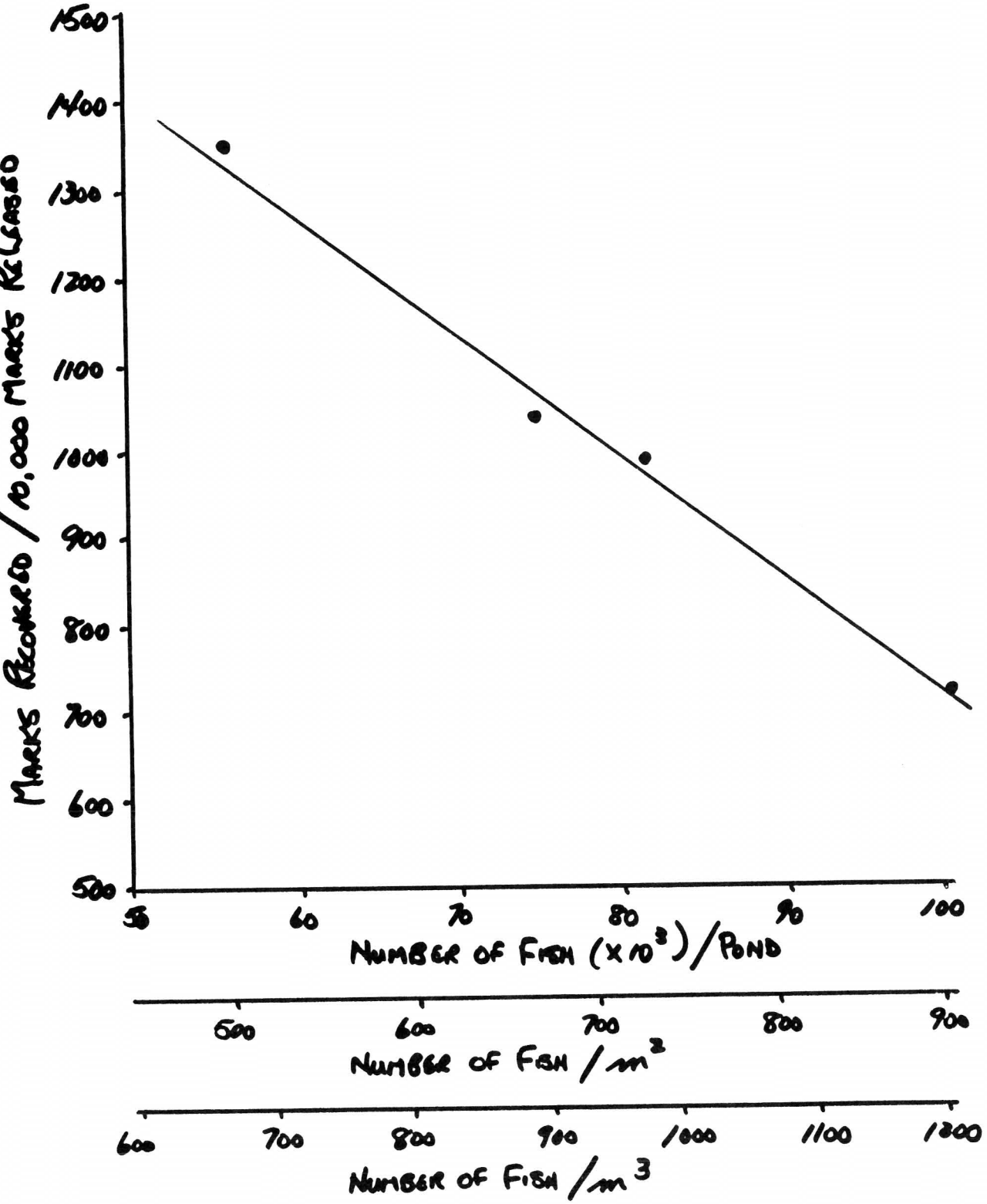
To compare the relative survival between the four groups it was decided to use only the number of marks observed in the fishery and in the escapement and not the expanded values as adjusted for sampling rates in specific fisheries.

---

*Wedemeyer G.A., F. P. Meyer and L. Smith, 1976 Environmental Stress and Fish Diseases 192 pp. T.F.H. Publications Ltd.


AVERAGE WEIGHT (g)
20
18
16
14
12
10
8
6
4
2
JUNE 7/77
JULY 15/76
JUNE 15/76
50
60
70
80
90
100
110
120
NUMBER OF FISH (x10³) / POND
500
600
700
800
900
1000
1200
NUMBER OF FISH / m²
600
700
800
900
1000
1100
1200
1300
1400
NUMBER OF FISH / m³


MARKS RECOVERED / 10,000 MARKS RELEASED
1500
1400
1300
1200
1100
1000
900
800
700
600
500
L
M_L
M_H
H
0.80
1.00
1.20
1.40
POUNDS / ft³
12
14
16
18
20
Kg / m³


MARKS RECOVERED / 10,000 MARKS RELEASED
1500
1400
1300
1200
1100
1000
900
800
700
600
500
50
60
70
80
90
100
NUMBER OF FISH (X 10³) / POND
500
600
700
800
900
NUMBER OF FISH / m²
600
700
800
900
1000
1100
1200
NUMBER OF FISH / m³

REGRESSION EQUATIONS

Y = Marks Recovered/10,000 Marks Released

$Y = 2104 - 0.0138x_1$ $\qquad r^2 = 0.99$

Where x_1 | 100,000 / 50,000 = No. Fish/Pond

$Y = 2104 - 1.551x_2$

Where x_2 | 900 / 450 = No. Fish/m^2

$Y = 2104 - 1.162x_3$

Where x_3 | 1200 / 600 = No. Fish/m^3

A SIMPLE GROWTH MODEL FOR HATCHERY SALMONIDS

by

George K. Iwama and Arthur F. Tautz
Ministry of Environment
Fish and Wildlife Branch
British Columbia

ABSTRACT

A simple growth model for hatchery salmonids, within growth stanzas, was developed from models proposed by several workers using a variety of approaches and data sources. This model is expressed in its predictive form as $w_t^b = w_o^b + Gs\ t$, where w = individual weight, b = 0.333, Gs = growth slope, and t = time in days. The relationship of Gs to rearing temperature (T) was approximated by Gs = T°C/1000, for temperatures between minimum and optimum growth rate, from the works of Banks (1971), Elliott (1975), and Haskell (1956). The equality of the weight exponent in this equation to the slope of the lines describing the negative relationship between log specific growth rate to log weight was shown by algebraic manipulation and logarithmic transformation of the differential equation $dw/dt = kW^{\chi}$ where $b = 1-\chi$. The value of 0.333 for b was found to be within the range reported in the literature for this parameter and the predictive accuracy of this model was acceptable when tested with growth data from British Columbia hatcheries. Applications of this model in growth related problems in routine fish culture are also presented.

RETENTION TIME IN CIRCULATING PONDS

By

Philip Downey
Fishery Resources
University of Idaho

An important water-container interaction of fish culture is the retention time of ponds. Retention time has been used to calculate pond loading indexes in noncirculating ponds (Klontz et al. 1978) and has been used to determine the exposure time of fish to different drug therapies.

The formula for filling time (i.e., replacement time) of a pond is normally used to estimate the retention time of noncirculating ponds. However, the flow patterns of circulating ponds are different than that of noncirculating ponds. The objective of a circulating type of flow in a pond is to produce a homogeneous water mass. Consequently, a typical filling time model does not accurately estimate retention time in circulating ponds. Another mathematical model predicting retention time in circulating ponds has been proposed and is based on mathematical model developed by Rainey (1967). The model for a homogeneous water mass is:

$$Tr = -\frac{V}{R} \times Ln(C_t/C_0)$$

Where Tr = retention time (in minutes)

V = volume of the pond (in cubic feet)

R = water inflow (in cubic feet per minute)

C_0 = concentration at time 0

C_t = concentration at time t

References

Klontz, G.W., I.R. Brock and J.A. McNair. 1978. Aquaculture techniques: Water use and discharge quality. Tech. Compl. Rept., IWRRI, Univ. Idaho.

Rainey, R.H. 1967. Natural displacement of pollution from the Great Lakes. Science, N.Y. 155, 1242-1243.

PREDICTING THE SIZE-RELATED GROWTH POTENTIAL OF KAMLOOPS TROUT IN AN AQUACULTURE SYSTEM

By

Richard Focht
Fishery Resources
University of Idaho

Recent studies have shown that current methods of calculating feeding rates may not be as reliable as once thought due to errors in the estimation of growth rates and/or feed conversion (Klontz et al. 1978).

The objective of this study was the development of a model to predict the size-related growth potential of trout in an aquaculture system. Kamloops trout were used in this study. Groups of trout were fed one of four feeding levels and one of two diets (dry or moist). Growth data were analysed for the different groups with respect to the average weight of fish and linear regressions were calculated. Growth rates were expressed as the instanteous rate of growth (Ricker 1979):

$$G = (\ln(w_2)-\ln(w_1))/(t_2-t_1)$$

Where: $\ln(w_2)$ = natural logarythm of weight at time t_2

$\ln(w_1)$ = natural logarythm of weight at time t_1

The lowest feeding level appeared to be different from the other three in terms of growth rate (Fig. 1). This implies that the three highest feeding levels provided enough food to obtain maximum allowable growth.

The instantaneous growth rate for trout being fed a dry diet is:

$$G = 0.0381695-0.00018325 \times (w_1)$$

The instantaneous growth rate for trout being fed a dry diet is:

$$G = 0.03932962-0.00017846 \times (w_1)$$

With these values the weight of fish at the end of a growing period can be calculated by solving for w_2:

$$w_2 = w_1 e^{Gt}, \text{ where } t = \text{the number of days.}$$

REFERENCES

Haskell, D.C. 1959. Trout growth in hatcheries. New York Fish and Game Journal 6(2):204-237.

Klontz, G.W., I.R. Brock and J.A. McNair. 1978. Aquaculture techniques: Water use and discharge quality. Res. Tech. Compl. Rept. Proj. A-054-IDA.

Ricker, W.E. 1979. Growth rate and models in Fish Physiology, Vol. VIII, Bioenergetics and Growth (Hoar, W.S., D.J. Randall, and J.R. Brett, eds.). Academic Press, New York, San Francisco and London.

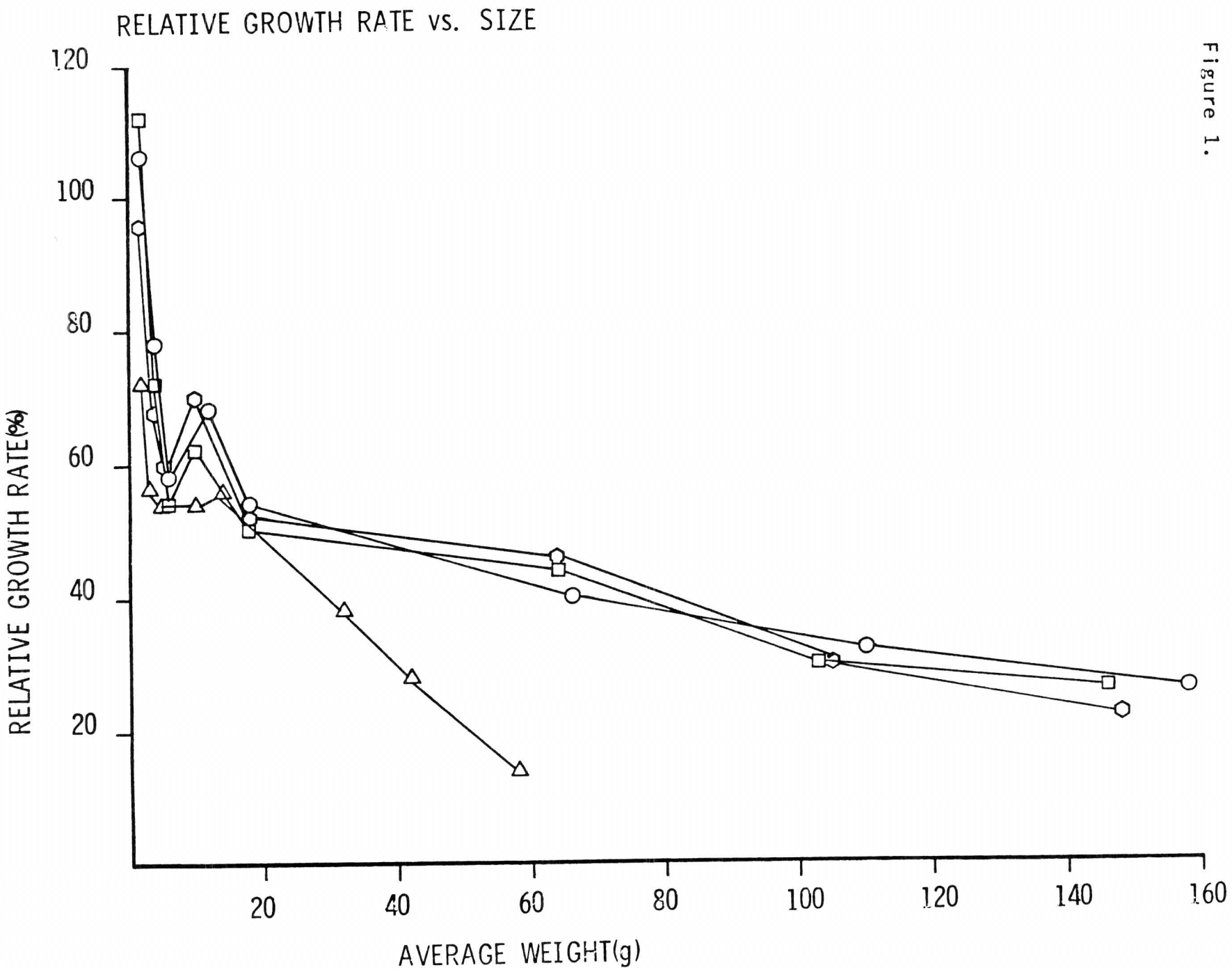

RELATIVE GROWTH RATE vs. SIZE
120
100
80
60
40
20
RELATIVE GROWTH RATE(%)
20
40
60
80
100
120
140
160
AVERAGE WEIGHT(g)

Figure 1.

GEOTHERMAL AQUACULTURE: ITS POTENTIAL IN THE PACIFIC NORTHWEST

John G. Woiwode

ABSTRACT

An evaluation of geothermal aquaculture demonstrated significant commercial potential. Growth rates of cultured channel catfish and common carp were high throughout the study. Various physiological and morphological parameters were monitored; no differences were detected between fish reared in geothermal or fresh water. The potential for geothermal aquaculture in the Pacific Northwest looks promising.

A Method of Pond Inventorying

G.W. (Bill) Klontz
Department of Fishery Resources
University of Idaho

Any fish culturist who has dealt with pond inventory records knows, first hand, the frustration of not knowing exactly the numbers of fish or the total weight of fish in a pond. Most will agree that a +/- 5% discrepancy between what is actually in the pond and what is on the record from sample counts would be nice; but the discrepancy is often +/- 15-20%.

Obviously, the best method of determining the pounds of fish in a pond is by weighing the entire lot. In practice, this is not realistic. Therefore, the sample counts must be relied upon.

There are many techniques to inventory a pond of fish. If any are applied consistently the error becomes a constant and can be reliably used. If, however, more than one method is used on a particular facility, the error is not a constant and becomes a major factor in being unable to accurately forecast growth, be it length gain or weight gain.

The inventory method to be described offers a way in which the reliability of the sample count can be tested with a high degree of validity. The method has been evaluated at state and federal hatcheries with varying degrees of acceptance.

The fish to be inventoried should have not been fed during the previous 18-24 hours to minimize the effects of the handling stress inherent in the crowding and weighing processes.

At the majority of trout and salmon hatcheries where pond inventories are done, the common practice is to crowd the fish to the lower end of the pond. While the pound-counts are being done, one of the hatchery staff sweeps the pond and the debris - excess feed, fecal material and accumulated biological growth - exits the pond through the crowded fish. This is a very poor practice in terms of maintaining the health of the fish.

A better method is to place a screen a few feet below the water intake after making certain that the area above the screen is free of fish. The fish are then crowded from the lower end of the pond to the point where the fish obscure the bottom edge of the crowding screen. Next, a live box (3' x 3' x 2' high) is set into the pond on the downstream side of the lower screen. Five dip nets of fish are placed into the live box and one sample for weighing and counting is removed. The rest of the fish are released below the downstream screen. This practice is repeated five times. Thus, five samples of fish are subsampled from five groups of fish.

For sample weighing small fish (1.5-3 inches) a metric beam balance should be used rather than an avoirdupois spring scale. The fish are dumped into a container of water tared to zero on the balance and weighed to the nearest 0.5 g (0.0011 lb). At least 100 g of fish should be weighed per sample.

For sample weighing larger fish (3-6 inches), 2-3 lb (900-1300 g) samples should be weighed to the nearest gram (0.0022 lb). Samples of fish more than 6 inches should be done to the nearest 10 g in 5-10/lb (2.25-5.5 kg) increments. Recall that 1 oz. equal 28.5 g; thus, if a one pound sample were weighed to the nearest ounce, the error could be 6.3%, while the error for weighing to the nearest 10 g could be 2.2%.

An alternative to using weight as a criterion for sample size, one can use numbers of fish. In general, each sample should contain at least 150-250 fish. There should also be at least a 90% agreement among the individual pound-counts. Also, the most accurate pound-count is obtained by dividing the total number of fish counted; i.e., the total of all the samples, by the sum of individual sample weights. A common practice currently is to divide the number of fish in each sample by the weight of the sample, which results in taking a mean or average of a mean.

At least one - and preferably two - of the pound-count samples are anesthetized and the fish measured to the nearest millimeter. From this data the range of lengths, the mean length, and the length frequency can be determined. The purpose of the range and mean of lengths is obvious; however, the length frequencies are a measure of the validity of the sample to be representative of what is actually in the pond. Thus, if one assumes that there is a normal distribution of length frequencies, the mean and the median should be equal. If they are not, this indicates that the samples were selective for a particular size of fish which further increases the error in calculating the total pond weight and fish numbers.

The sample count data is then used to estimate the total pounds of fish in the pond - provided the initial stocking weight and number are known and the accrued mortality subtracted. If these data are not known, it would be advisable to weigh all the fish in the pond in addition to obtaining the pound-counts.

From our studies, the following recommendations may be made:

1. Determine the length (mm) frequency, distribution, range, mid-range, mean and median at each sampling. Unity of the mean and median is more significant than unity among mean, median and mid-range because mid-range values are from two extremes.
2. Crowd the fish to one end of the pond with a screen rather than "herding" them with a net. This will minimize the size selection bias.

3. Grade the fish when the length range exceeds 50% of the length range of the previous period. After grading, a new length distribution and pound-counts must be done.
4. Weigh the fish into the pond rather than removing a certain weight to reduce the biomass to the prescribed level.
5. Determine the biomass (weigh all fish) at the end of every fourth growth period.
6. For sample weighing small fish (1.5-3 inches) use a metric beam balance rather than an avoirdupois spring scale. Also, at each sampling, the balance or scale should be calibrated using at least three reference weights covering the range of the samples to be weighed. Samples of small fish should be weighed to the nearest 0.5 g (0.0011 lb), 3 to 6 inch fish samples should be weighed to the nearest gram (0.0022 lb), and samples of fish more than 6 inches should be weighed to the nearest 10 g (0.022 lb). Recall that 1 oz. equals 28.5 g; thus, if a one pound sample were weighed to the nearest ounce the error will be 6.3%, while the error for weighing to the nearest 10 g will be 2.2%.
7. In sampling fish for no/lb estimates, a minimum of five samples should be weighed and counted. Each sample should contain 150 to 250 fish. There should be at least 90% agreement among the individual pound-counts. The most accurate pound-count will be obtained by dividing the total fish counted by the total weight, rather than by calculating the mean no/lb from each pound-count.

	Pond 22		Pond 24	
Lbs. - actual	137.25		163.25	
No. - actual	4963		6108	
No./lb. - grab	27.3	29.3	32.0	33.8
Lbs. - estimated	245.0	228.8	142.6	135.0
No./lb. - 5X5	36.16	36.13	37.45	36.4*
Lbs. - estimated	137.3	137.4	163.1	167.8

* The agreement between the median length and the mean length was 0.97. The corrected no./lb. would be 37.53, thus predicting a pond weight of 162.7 lb. or 0.997 agreement.

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