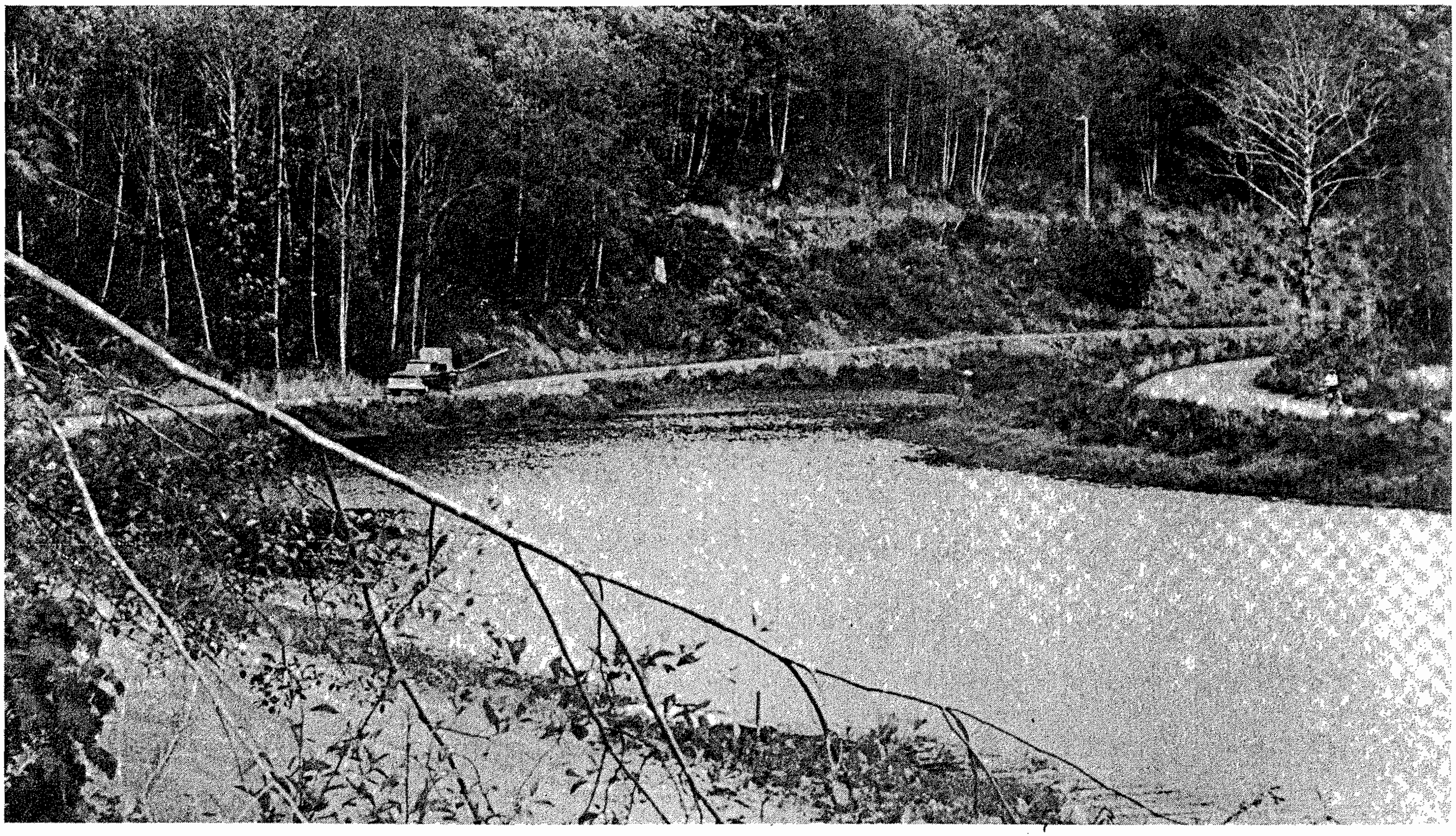
PROCEEDINGS of the Twentieth Annual

Northwest Fish Culture Conference



TYEE MOTOR INN
TUMWATER, WASHINGTON

Dec. 3-4
1969

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

PROCEEDINGS OF THE TWENTIETH ANNUAL NORTHWEST FISH CULTURE CONFERENCE

The Twentieth Annual Northwest Fish Culture Conference was held in Tumwater, Washington, a few miles south of Olympia, at the Tyee Motor Inn. We met in the Big Chief Room for the program, and the larger Skokomish Room for the banquet. A few doubts were felt the morning of the 3rd over selecting the "smaller" Big Chief Room for the meeting place since our attendance was about 300 and some were standing. Later in the morning, however, with an attendance of about 250 all seated, I believe the smaller room, with the speakers closer to the audience, was more conducive to asking questions of the speaker, and discussion, which has added so much to previous conferences and we wish to continue.

We were fortunate to have Clarence Pautzke, former Assistant Secretary of Interior, give the welcome and keynote address. He emphasized the fact that although fish culture in all its facets had advanced tremendously in the last thirty years, that our present level of performance presents as many challenges for the future, with equal or more opportunity for improvement in fish culture.

I am very grateful to Richard Noble and James W. Wood of the Washington Department of Fisheries who were chairmen of the "salmon oriented" and "fish disease" sections of the conference. Both added so much to the conference by their remarks and led discussions on the various papers in the fields of activity of which they are so familiar.

I also wish to take this opportunity to thank Leona Fagerness, who prepared the membership address list and correspondence, and Georgia Boyce and Judy Nastrom for their help in registering and assisting with the arrangements.

My very special thanks, also, to Betty Love, Legal Secretary for the Department, who consented to make multilith transcriptions of the papers for the Conference. The 500 copies of the Proceedings were run and assembled in our own Game Department supply room under the supervision of Barbara Riddle.

The 1970 Conference will be at Portland, Oregon under the Chairmanship of Chris Jensen. Roger Burrows was selected Chairman for the 1971 conference.

John M. Johansen - 1969 Chairman
Washington Department of Game
600 North Capitol Way
Olympia, Washington 98501

TWENTIETH ANNUAL NORTHWEST FISH CULTURAL CONFERENCE

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A DESCRIPTION OF THE DWORSHAK NATIONAL FISH HATCHERY AHSAHKA, IDAHO

John R. Parvin
Bureau of Sport Fisheries and Wildlife

The Dworshak National Fish Hatchery was constructed by the U.S. Corps of Engineers as a part of the Dworshak Dam project to mitigate the losses of spawning and nursery area lost for summer steelhead trout. Initial holding of adults occurred with the fall run appearing in October, 1968. The first eggs were collected on April 29, 1969. The station is sized to release 3,600,000 smolts. As soon as the pool behind the dam fills, a portion of the mission of the station will be to assist in the management of the impoundment.

The water for rearing is pumped from the North Fork of the Clearwater River. The pump station contains 800 HP of pumping capacity. There are five pumps, one of which is a two speed pump. This results in a possible sixteen combinations. The pumping plant will supply from 4,000 GPM to 64,000 GPM in increments of 4,000 GPM. The system is designed to operate automatically. In case of power failure, two 795 HP, 500 kw diesel power units automatically start and pick up the load.

There are 84 Burrows type ponds. Fifty of these can be used within the reuse system. This system is in effect an environmental control system. Approximately 8 to 10% of the water used in the ponds is added as fresh after being filtered, sterilized, and either cooled or heated. Then the water enters the system, goes through the aerators and supplies 15,000 GPM for pond operations. At full flow, this amounts to 25 ponds. The water returns from the ponds, goes through biological filters in which the pH is buffered and the ammonia oxidized to harmless nitrates, then to the aerator. The balance of the ponds are supplied by single pass river water.

The station has a capacity for 10,000,000 eggs. The incubators are of the Heath type. They are supplied by temperature controlled water. After the fry absorb the yolk sac and are ready to feed, they are placed in 64 tanks. As soon as they are feeding readily, they are placed in ponds.

The feeding of the ponds is accomplished by an automated air entraining system. The IBM computor calculates the required feed taking into consideration the variables of fish metabolism. This equipment then controls the feeding process. At the end of the day the system is updated. Expected gains are calculated and the new quantity of feed is fed the next day based upon total requirements for the day.

There is a rather sophisticated instrumentation and enunciator system. Five flow points, five temperature points, six oxygen levels, a pH, and a turbidity sensor report to three recorders in a console in the lobby. Any operational faults are first shown on an enunciator board within the effected building. The computor prints out the fault in red. An alarm is sounded through the P. A. system. If no one resets the alarm, the phones ring in the houses.

OREGON FISH COMMISSION HATCHERY PRODUCTION SUMMARY, 1960-67 BROOD SALMON AND STEELHEAD

Wallace F. Hublou

and

Irving W. Jones
Fish Commission of Oregon
Clackamas, Oregon

Summaries were given concerning the numbers of fish reared, per cent mortality, food conversions and food cost per pound of fish weight gain for each species reared of the 1960-67 broods. Table 1 gives the total or average figures for each species for the 1960-67 broods and the 1967 brood.

The Fish Commission of Oregon started using Oregon Pellets with the 1958 brood coho and spring chinook. Steelhead and sockeye of the 1959 brood and fall chinook and chum of the 1960 brood were the first of these species to receive the pelleted food. Oregon Starter Mash was developed later when it was found that salmon just starting to eat needed smaller particles than the smallest pellets (1/32 inch) manufactured to date. Total amount of Oregon Pellets and Starter Mash fed to date is 15.3 million pounds. A total weight gain of 8.0 million pounds has been reported by the hatcheries for an overall food conversion of 1.9.

Table 1. Production summary, 1960-67-broods salmon and steelhead, Fish Commission of Oregon

Species	Number Fish Reared Per Year (millions)	Average Mortality (%)	Food 1/ Conversion	Food Cost Per Pound of Fish Weight Gain (¢)	1967 Brood Only: Food 1/ Conversion	1967 Brood Only: Food Cost 2/ Per Pound of Fish Weight Gain (¢)
Fall chinook	13.9-26.2	16	1.7	22.0	1.4	21.1
Spring chinook	3.0-7.2	17	1.9	24.7	1.8	26.8
Coho	8.6-14.8	20	2.0	25.3	1.8	27.0
Chum	0.0-0.4	9	1.7	22.8	2.1	31.4
Steelhead	0.3-1.2	18	2.3	28.9	2.1	28.2
Total	--	--	1.9	24.9	1.74	25.9

1/ *Oregon Starter Mash and Oregon Pellets only*

2/ *Food cost = 14.88¢ per pound except for steelhead = 13.50¢*

THE BOGACHIEL WINTER STEELHEAD SEMI-NATURAL REARING POND

Larry L. Barger
Washington Department of Game

This presentation deals with a facility description; production report of last year's program; distribution of migrants; an overall picture of the operation and disease control.

Semi-natural rearing ponds are definitely an important part of our migrant steelhead program in this state. This is apparent through minimal cost of production, high quality fish produced and migration readiness. I feel this, in itself, warrants a steady growth in this type of facility.

The Bogachiel winter steelhead semi-natural rearing pond, located three miles west of Forks in the northwest corner of the Olympic Peninsula, is one of the newest of this concept. It was constructed and is operated by provisions of the Anadromous Fish Act, which provides 50% Federal Funding. The expenditure of $100,500 included the construction of a 5.3 acre pond with a mean depth of 9-10 feet, duplex living quarters connected by an office, double garage, feed storage room, and a storage building. A considerable amount of road was constructed completely surrounding the pond to facilitate the use of a pneumatic fish feeder mounted on a pickup. A concrete outlet structure and holding raceways, trap the outgoing migrants. The outlet water from the pond enters the Bogachiel River approximately 200 yards below the trapping facility and one-half mile above the mouth of the Calawah River.

I believe one of the important factors of rearing ponds is fish distribution. The intake stream drains approximately 3/4 miles of bottom land springs. Small springs supplement the water supply entering under the surface nearly the full length of the pond. In one 250-foot area, five springs from the side hill require culverts under the road to enter the pond. The entry of water to the pond from so many sources tends to keep the fish well distributed.

The water volume varies from 5 c.f.s. in the summer to nearly 15 c.f.s. in the winter and spring and ranges in temperature from 46° to 58°.

Production

The total plant of 289,745 migrants for 1969, the second year of operation weighed 42,330 pounds. Fish averaged 6.8 per pound and range from 7 to 12 inches long. Since the fish weighed 6,720 pounds when transferred in August, 35,610 pounds of fish were produced at Bogachiel.

Total mortality was 17.3%. Eighty three thousand seven hundred and fifty (83,750) pounds of food were fed with a conversion factor of 2.41. Cost of production was 67¢ per pound, including salaries, operations, and maintenance but excluding capital outlay.

The quality of the fish was excellent; migrants were very bright, firm fleshed, and vigorous.

Distribution

During April and May, 1969 these migrants were distributed to 11 major streams of the upper Olympic Peninsula. These include the Hoh and Bogachiel; then heading north and east, the Calawah River; the Sol Duc; Clallam; Pysht; Lyre; Salt Creek; Elwha River; Dungeness and the Dosewallips Rivers.

Operation

The source of fish for stocking Bogachiel Pond is the South

Tacoma Hatchery. The adult steelhead, taken from Chambers Creek outlet four miles from the hatchery, are held in the 56 degree hatchery water to accelerate ripening, eyeing and fry growth. Fish were 700 per pound in May. The fry or small fingerlings are transferred in May to the Aberdeen Hatchery. Aberdeen Hatchery is supplied with a river water source. Three hundred and fifty thousand fingerlings, 46-58 per pound weighing 6,720 pounds, were transferred to Bogachiel Pond in August, 1968. One hundred and forty-five thousand, five hundred and seventy-five (145,575) migrant steelhead at 6-7 per pound weighing 21,755 pounds were planted from the pond in April, and 144,170 at 6.5, weighing 20,575 pounds were planted in May. In comparison, this year's migrants were transferred from the Aberdeen Hatchery the first week of July at an average of 102 per pound and are presently running 11 per pound.

Disease

A slight infection of Pseudomonas Hydrophila or red-mouth disease appeared during the winter. Feeding of medicated food with 1% Sulfamerizine added kept this disease under control with little loss.

Summary

We believe the substantial production of 290,000 migrants of high quality which migrate at their own volition at close proximity to river planting sites, will substantially improve the sports fishery for adult steelhead. Returns of fish this winter will substantiate this prediction.

ENIGMA IN SEA FISH HUSBANDRY

John E. Halver
Bureau of Sport Fisheries and Wildlife

Scientific sea fish husbandry predicts great potential for protein production for the world, and simultaneously presents an enigma to challenge the best brains in nutrition, physiology and fish food technology. Three major roots of the problem soon appear: the farm, the stock, the food.

Sea fish farming research has been accelerated for several years in Japan, Malaysia, Europe and North America. Research in Scotland using warm nuclear power station cooling water to accelerate growth of flat fish will be discussed, and the development work on techniques for rearing sea fish in estuaries, impoundments, cages, bags and bays will be described.

Problems to obtain suitable stock include not only the species and strain but also soon reduce to methods for obtaining young from broodstock. The techniques for holding adult sea fish and inducing spawning through temperature, light and salinity control plus injection of androgens and estrogens will be covered.

Food for tiny larve and for young fry presents another great challenge for sound research plus innovative thinking in fish food technology. The development of the sea fish fry micro pellet balances ration is now being attacked using the best food science technology available in Great Britain, France, Germany, Holland and Sweden. One solution for this problem, one adequate diet for rearing young sea fish, will form the foundation for solving one definable part of the enigma of sea fish husbandry.

THE NEW WATER AERATION SYSTEM AT MESCALERO NATIONAL FISH HATCHERY

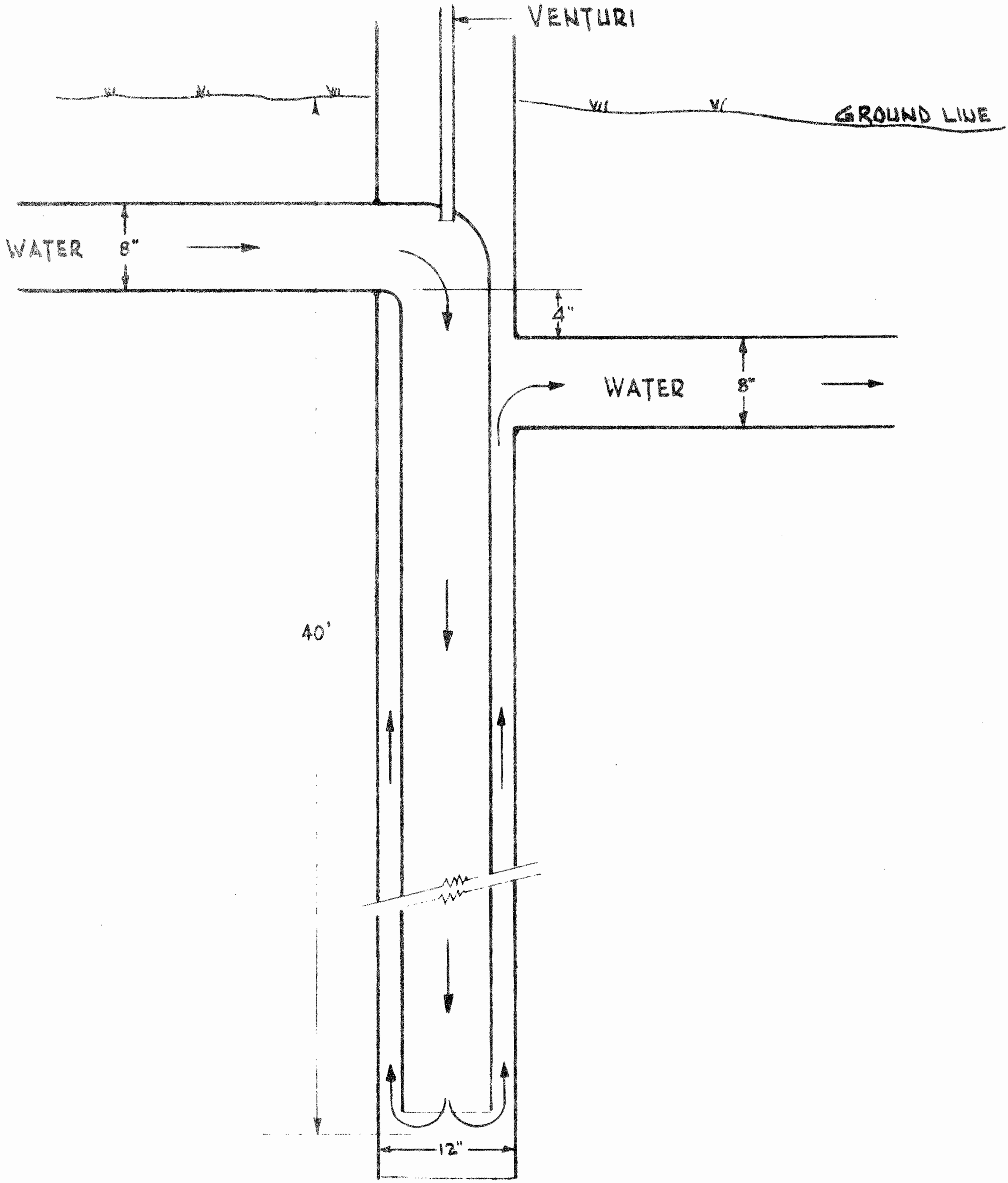
Ivan B. McElwain
Bureau of Sport Fisheries and Wildlife
Springville, Utah

This summary describes the design, operation and also reports the results of a few of the tests conducted on the new U-tube oxygenation system installed at the Mescalero National Fish Hatchery in New Mexico.

The system was designed by Dr. Richard Speece of the Civil Engineering Department at New Mexico State University. It was installed in early 1968 on the 400 gallon per minute water supply to the hatchery building. The water has a constant 55^{o} F. temperature and 6.0 ppm of dissolved oxygen for which the device was specifically designed with the intent to raise the dissolved oxygen concentration to 10.0 ppm. At Mescalero the water is 100% saturated with dissolved oxygen when at 8.3 ppm.

The system consists of a 12-inch vertical casing, 40 feet in the ground with an 8-inch supply line inside terminating near the bottom. Water to the hatchery drops down the inner 8-inch pipeline, splashes off a bottom iron plate and then travels back up the 12-inch casing to another 8-inch line leading to the hatchery building. Air is pulled into the system by venturi action through an air pipe extending above the ground level (Fig. 1).

So far only preliminary tests have been run to determine the physical effects of the system on the small fish in the hatchery tanks. It has also been set up to determine the system's potential for raising production at the station but these tests have not been conducted as yet.


VENTURI
GROUND LINE
WATER
8"
4"
WATER
8"
40'
12"

It was found that when the D. O. concentration was raised above the 100% saturation level to 9.0 ppm or higher, various gas-bubble disease symptoms appeared in the small rainbow trout. These symptoms varied in intensity and type depending on the size of the fish. In the swim-up fry which had been feeding for only a few days, you could see many frantically swimming in circles on the water surface with large distended abdomens caused by a single large air bubble caught in their stomachs. It could be seen that the starter food floating on the water surface was actually collecting hundreds of minute air bubbles which were being ingested by the small fish along with the food. These bubbles would break in the upper gut of the fish to form one or two large bubbles to act as a float for the fish. In the larger fish that had been feeding for three to nine weeks, air bubbles were seen in the alimentary tract but were small in size and appeared to be passing on through the tract and out with the fecal material. However, the fish had considerable gill damage caused by debris suspended by air bubbles in the water. No bacteria were involved due to weekly prophylactic treatments. When the system was operated at 10.0 ppm or 120% saturation of dissolved oxygen, the air bubbles were seen within the tissues of the fish especially behind the eyeball.

Nitrogen gas concentrations were analyzed at the same time using a modified Van Slyke method developed by Dr. George Post at Colorado State University. It was found that the nitrogen gas concentration of the water would increase from approximately 70% saturation before going through the aeration system to 105% or higher when the system operated at maximum.

Even though this device as such has a potential for producing gas-bubble disease, I feel it may be used when operated under certain conditions. If the dissolved oxygen and nitrogen concentrations are determined before hand, by knowing the amount of water involved, the water temperature, and the land elevation, it would be possible to install a system which would bring the dissolved gases of the water just up to the saturation point. As in the case at Mescalero, this may make an additional two or more ppm dissolved oxygen available to the fish. This may greatly increase the production potential at a station.

Also this system has many advantages over other aerator devices. The installation costs at Mescalero were approximately $1,700, some of which could be reduced if conditions vary from those at Mescalero. There is virtually no maintenance required once the device is installed, and it has a potential of service for the life of the hatchery. There are no unsightly structures spoiling the landscape around the hatchery and during the winter there is no danger of freeze-up or during the summer of possible overgrowth by aquatic algae or weeds. Everything except a small part of the 12-inch casing and air tube is underground.

In conclusion I would like to point to this device and other new techniques as a hint to what fish culture will entail in the future. Eventually we should be able to have complete control of the environment aimed at improved fish culture techniques. It will be devices such as this that will make this possible.

THE HEATED WATER SYSTEM
AT
MICHIGAN'S PLATTE RIVER HATCHERY

Cecil L. Fox, P. E.
Kramer, Chin & Mayo
Consulting Engineers
Seattle, Washington

Our work in fish hatchery design is one of trying to provide better solutions to old problems and making possible developments that were not feasible using older concepts. This development is producing fish hatcheries that are becoming more complex in their operation and more predicable in their production. The days where hatchery operation consists of pulling a dam board, dumping some food and hoping for the best are limited. Management is getting to the point of expecting fish at the end of a cycle and it is with this goal in mind that we try to provide those features in a hatchery that will allow the hatcherymen to produce those fish in the best possible manner.

It is this philosophy that has prevailed in the design of the Platte River Hatchery of the State of Michigan. The Department of Conservation with Mr. Brad Durling, Mr. Harold MacSwain, Chief Engineer, Mr. Harry Westers and others have joined us and our Michigan associate, Johnson and Anderson, Inc., Pontiac, Michigan, in designing a hatchery that provides those features that will reduce the number of indeterminates in the overall hatchery production.

An example of one of these features is the heated water system. With air temperatures down to 30 below zero at times and water temperatures down to 32° F. at times, it became imperative to provide heating if we wanted any growth during these periods.

The solution to this problem was found in the locating of a spring water source with approximately 40° F. water in sufficient quantity for incubation and starting and; providing a heating system to raise the temperature of a portion of this 40° F. water to 50° F. In addition to this, we provided a heated hatchery building for housing the fish until they have grown to around 500 to the pound. With the heated water and heat gain from the building, the drain water from the hatchery building is heated and available for reuse in the outside circulating ponds. To show you how this is accomplished, I have some plates and diagrams to show you.

PLATE 1 - PIPING PLAN - HATCHERY BUILDING

This is a plan of the hatchery building showing the general arrangment of the building and primarily the piping systems relating to rearing. Starting from the upper right is the boiler room, then below it is the incubator room. Then to the left of that is the Starting Area with its twelve intermediate tanks and then to the left of these, the Rearing Area with the ten rearing raceways.

The hatchery building has two supply sources of water. These are indicated by the colored lines, the blue being spring water and the dark green being water from the head box which is normally Brundage Creek water.

The bright green color indicates heated water piping and the orange color shows the drain system for this heated water.

PLATE 2 - WATER HEATING SYSTEM SCHEMATIC

This diagram shows the method used for heating the rearing water. In this system, we heat all the water used in this system to 50° F. and do not attempt to blend two different temperatures of water.

To follow the diagram starting at the spring water supply, the water passes through a booster pump, through an automatic filter which removes all particles larger than .005 inch, through the heat exchanger where it is heated to 50^{o} F. and on to the Heated Water Headbox. From here, the first priority goes to the incubator room and all excess overflows the weir and goes to the starting area piping.

The method of heating the rearing water is by circulating 200^{o} F. water from the boiler through the heat exchanger. The temperature of the rearing water is controlled by the amount of boiler water circulated which in turn is controlled by the thermostat located on the discharge side of the heat exchanger. This thermostat and its associated control panel and value control the rate of flow of boiler water as necessary to provide the 50^{o} F. water desired. If this temperature control system fails for any reason, a high-low temperature alarm has been provided here in the Heated Water Headbox.

You may have noted that the building heating system draws from the same boiler. With this system, the hatcherymen has a choice of who he wants to keep warm. However, it really isn't quite as bad as it appears in that the boiler provides for building heat and heating capacity for 600 GPM. Provisions made for the addition of a second boiler when funding is available and this will provide a standby and additional heating for water.

Relating this back to the Hatchery Piping Plan (Plate #1), we see the extension of these piping arrangements. The system provides a two pipe system to every rearing tank in the building.

However, the amount of heated water available is limited and its best use determined by the superintendent.

PLATE 3 - VALVING ARRANGEMENTS IN HATCHERY BUILDING

The method of control at the Starting Tanks is shown here at the top of the drawing, Section "C" shows a side view and the buried pipe locations; the upper pipe is the heated water pipe. Section "D" shows the end view of the supply to the starting tanks. This arrangement provides for either supply or a combination thereof. Sections "A" and "B" at the bottom shows the arrangement at the Rearing Raceways. It is basically the same as that above. We purposely select valves that will show and indicate their degree of opening so that once a program has been established, it will be possible to record this for future use.

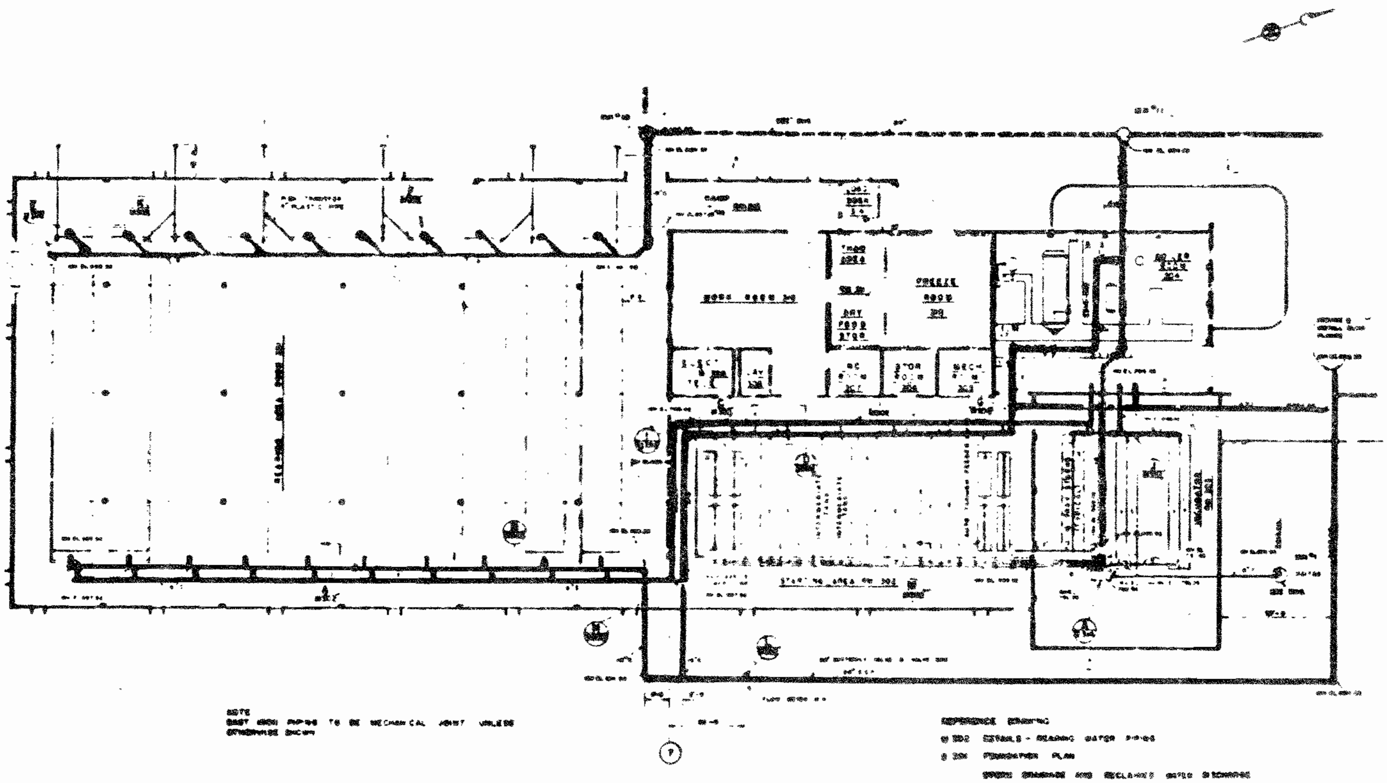
And speaking of future use, that's what we do with the heated water used in Hatchery Building. Here on Plate #1, we have shown the drain system colored in orange. This system is continued to the head box and reuse pump station as shown on this Piping Plan for the next phase of work. (Plate #4) Following this heated water line to the drain diversion structure, the water is diverted to the reuse pumps where it is lifted to the heated water chamber of the head box. From this point, it can be routed or mixed as desired to utilize the heat available.

The pond piping has been designed to allow the dual use in these four ponds on the west side and these seven ponds on the east side. The control valving for these ponds is similar to that for the hatchery building and is shown by this plan and Section shown here (Plate #5).

The heated water system shown here today for the Platte River Hatchery is an answer to a cold water problem that had to be solved before this hatchery development could become economically feasible and produce fish in a predictable manner.

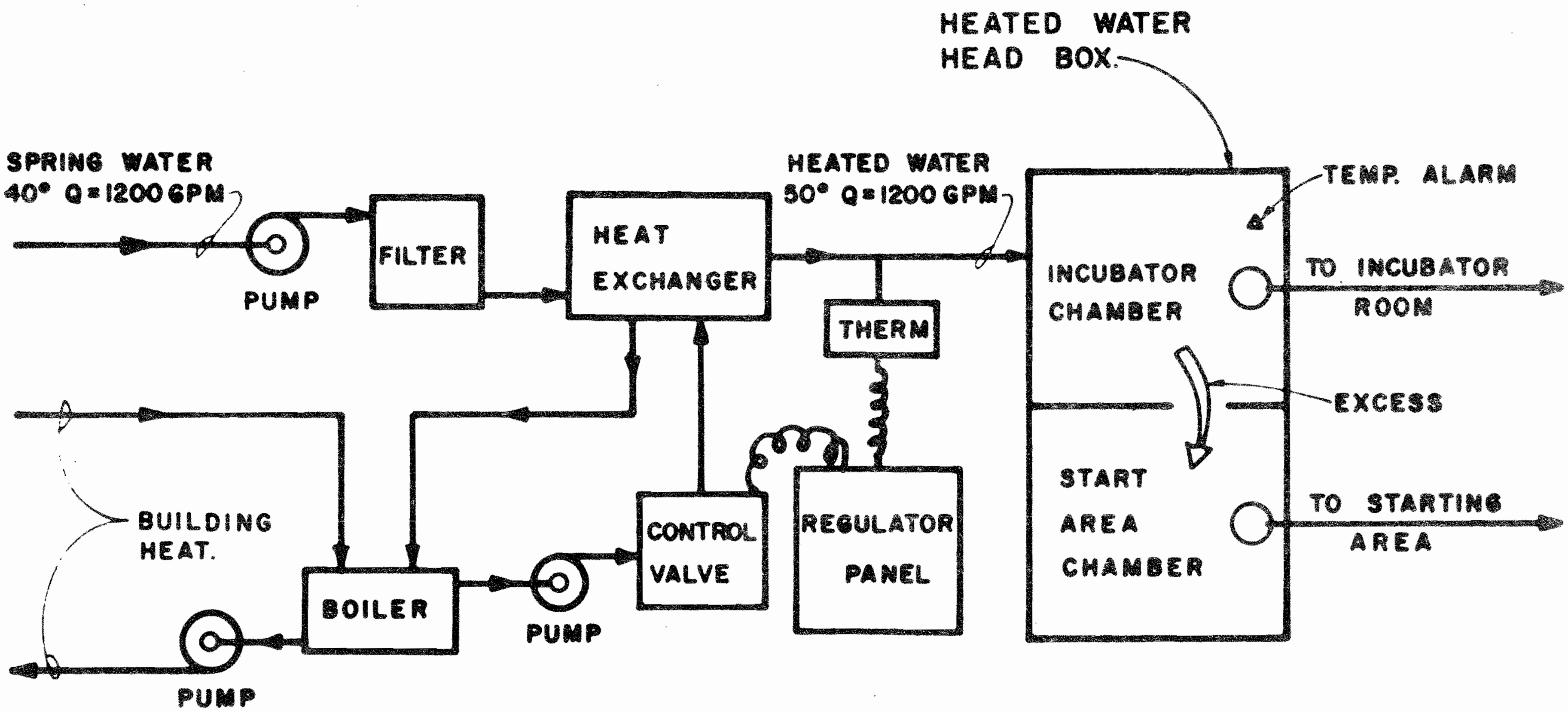
The heated water concept is one worthy of consideration in those areas where heat may be required for a short period of the cycle or during a portion of the development cycle where low temperature water is particulary objectionable such as at the start of feeding. Another consideration is that of the "Degree Day" growth theory. It is possible to provide for large numbers of fish in the early days of growth with reasonably small quantities of heated water.

Heated water systems have a place in many programs and for this reason, we believe they will become more common in future hatchery design.



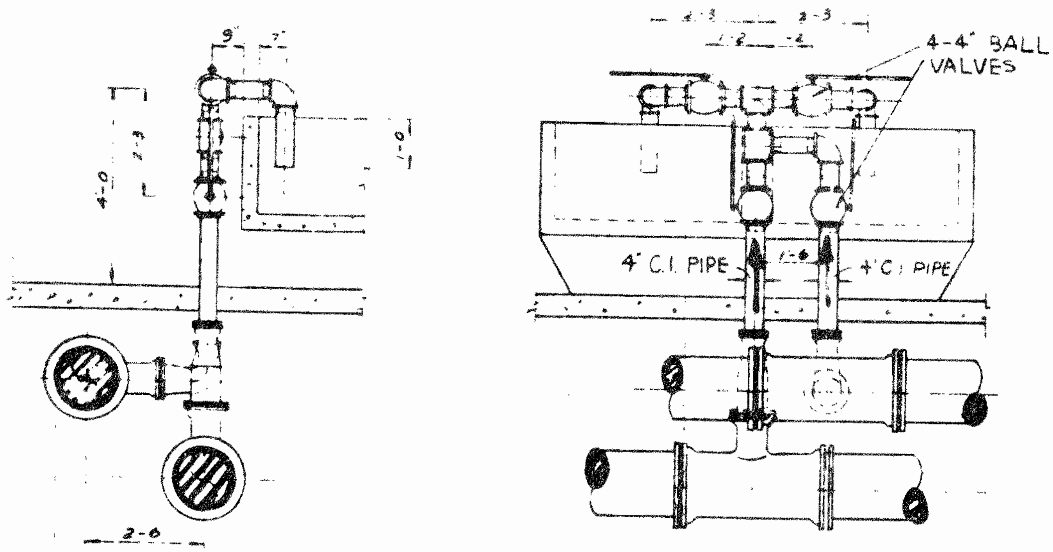
PIPING PLAN – HATCHERY BUILDING

PLATE Nº 1



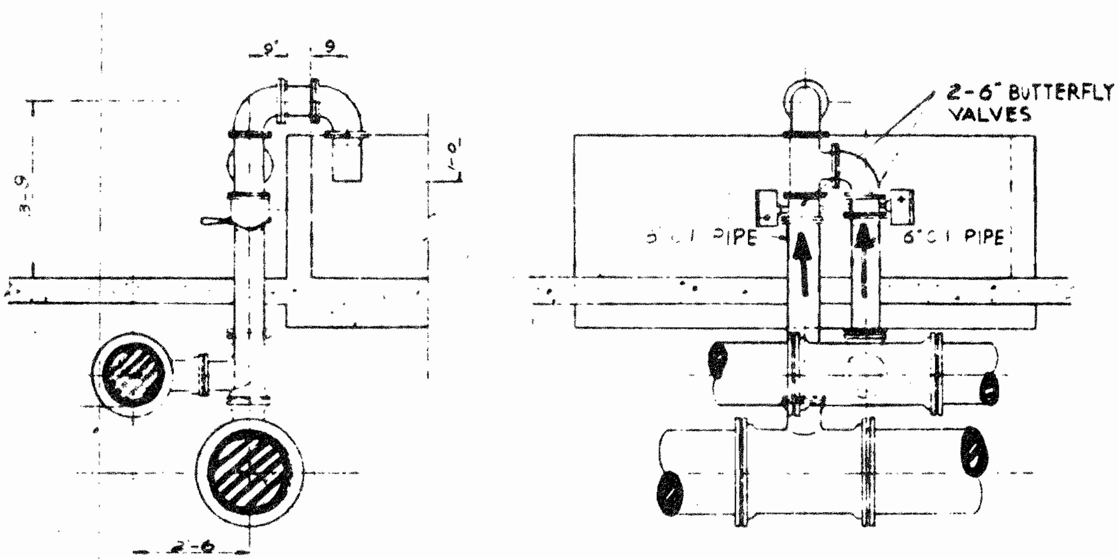
WATER HEATING SYSTEM SCHEMATIC

PLATE № 2



SECTION (C / M301) SECTION (D / M301)

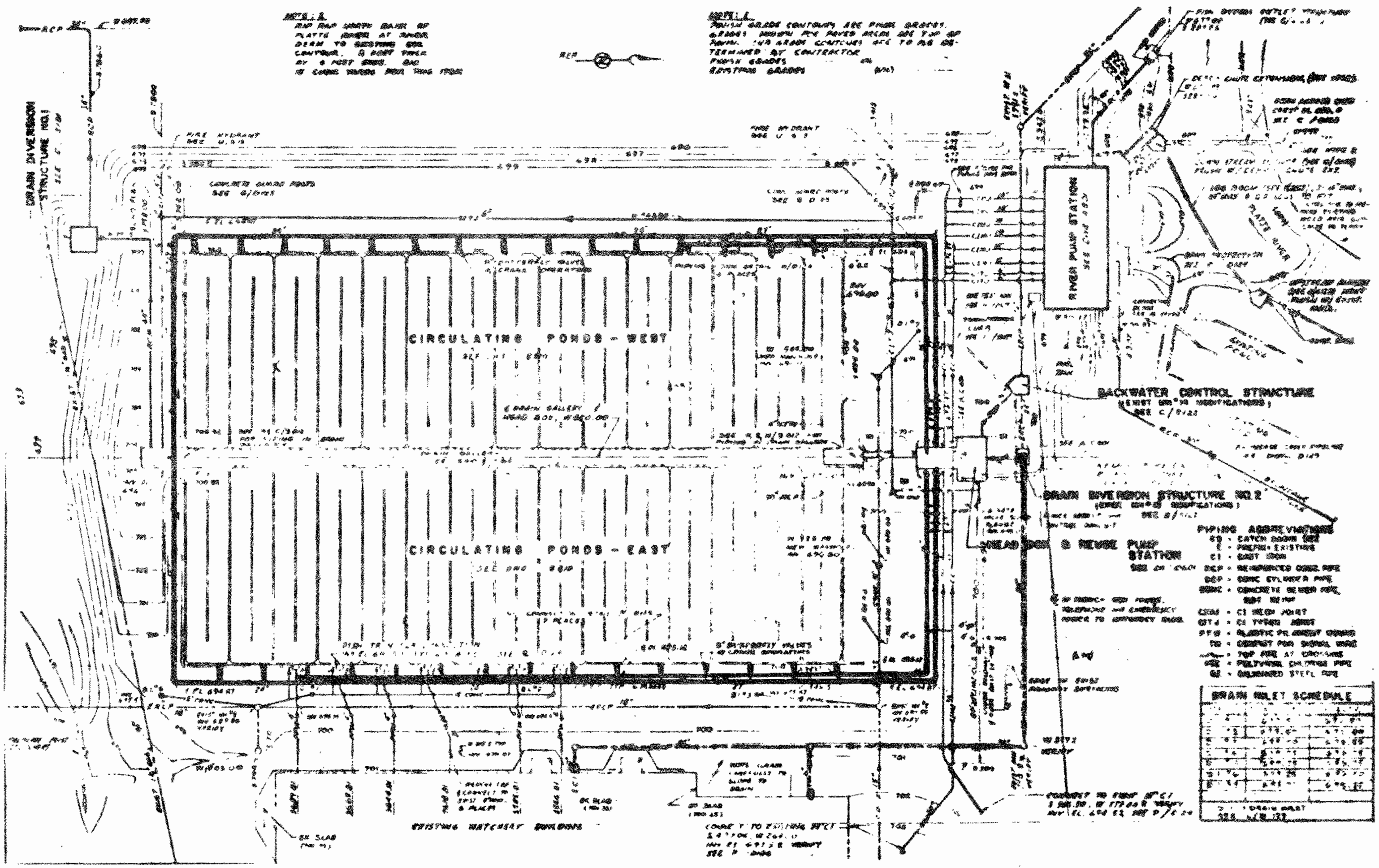
STARTING TANKS



SECTION (A / M301) SECTION (B / M301)

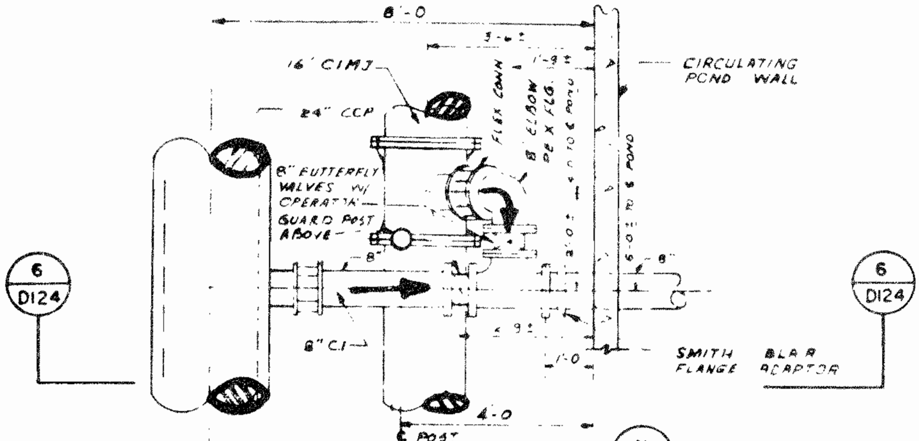
REARING RACEWAYS

PLATE № 3



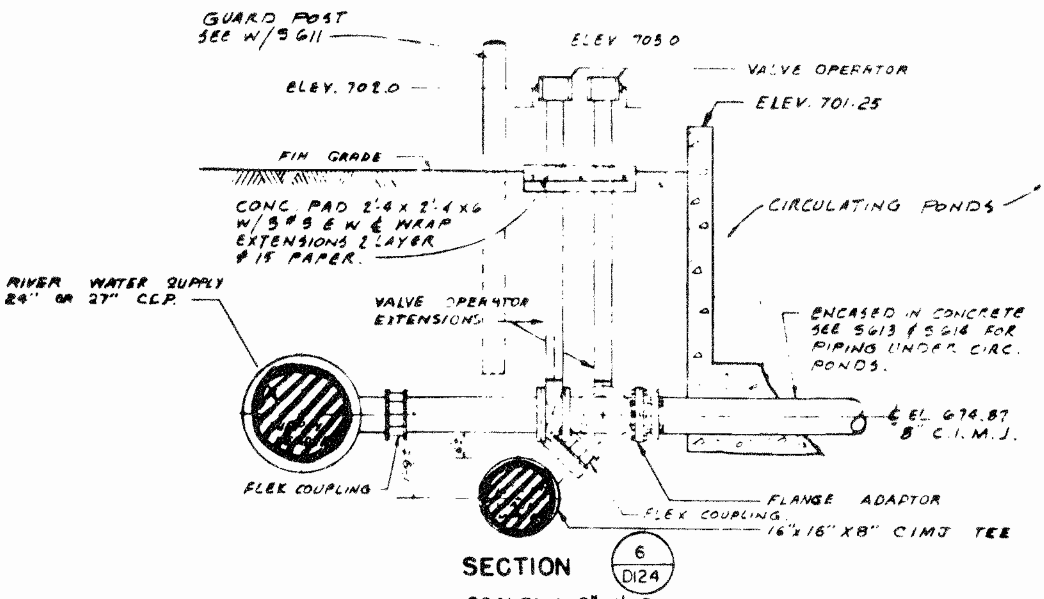
PLAN - REARING WATER

PLATE № 4



PLAN - DETAIL (N/D124)

SCALE: 1/2"=1'-0



SECTION (6/D124)

SCALE: 1/2"=1'-0

PIPING CONNECTION DETAIL (M/D124) D 122

PLATE № 5

ALARM SYSTEM

Fred W. Bitle
Bureau of Sport Fisheries and Wildlife
Leavenworth, Washington

A writer once said a good story is one that has a good beginning, a good ending and keep them as close together as possible.

Webster states: Noise as loud shouting; clamor, any loud discordard, or disagreeable sound or sounds. Synonymn: Noise is the general word for any loud, unmusical or disagreeable sound.

At Leavenworth, the P.U.D., electrical lines run past the quarters on its way to the main transformer bank behind hatchery.

We have over the years installed safety alarm bells in case of power failure. Bells were not the answer, so we turned to air horns with electrical closurer. When a power failure occurred, the electrical closures would open and the air horns would blow.

We tried two truck horns in a pair which was not satisfactory as the carrying volume was limited. We tried one large horn approximately two feet long; it should wake the devil because it sure wakes the neighbors, but did not arouse some hatchery men.

It became necessary to be sure that at least one man at the residences be awakened to check to see what had happened or had to be done to correct the power outage, whether it was an outage of a few minutes or to be for some duration.

The device was demonstrated at the convention. The cost of the unit was approximately $40 and was designed by a local electrician. When this device would ring the alarm, it would continue until manually reset. This alarm works very well to alert personnel of power failure.

THE TRAINING OF TROUT WITH SOUND STIMULUS[1]

Robert R. Abbott
Fisheries Research Institute

Slides and 3 Minute Movie

For the second consecutive summer, crosses of Donaldson's rainbow x steelhead trout from the College of Fisheries hatchery were conditioned to come to an underwater acoustic stimulus while being reared in a 1/4 acre pond. The sound stimulus consisted of a 150 Hz tone transmitted through an electromagnetic transducer suspended 30 cm. below the water surface. The sound generating equipment consisted of a battery-operated tape recorder, amplifier, and photo switch. A 40 mm long observation blind was constructed along the approach to the pond so that visual cues could be minimized. The training consisted of transmitting a continuous sound for one minute before the feeding and leaving the sound on throughout the feeding. This procedure was repeated three times per day. By the fifth day, some of the fish were coming to the sound source and by the fifteenth day, 90 per cent of the fish were gathering at the sound source within one minute of the initiation of the sound. This ability to concentrate the trout quickly from all parts of a large pond at a convenient point greatly facilitated regular feeding, the proffering of medicated food, and periodic sampling. Though the trout were conditioned at 150 Hz, they responded equally well to 300 Hz. They also demonstrated some ability to hear directionally.

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[1]Supported by Sea-Grant Aquatic Animal Husbandry, Contract No. RD/F/4.

COST ACCOUNTING OF SALMON PRODUCTION IN COLUMBIA RIVER HATCHERY EVALUATION STUDY

Arthur H. Arp
Bureau of Commercial Fisheries
Portland, Oregon

A study of Columbia River salmon hatcheries was initiated in 1959 to evaluate the contribution of hatchery-reared fish to commercial and sport fisheries. Main objective of the study was to determine whether continued construction and operation of hatcheries was economically justifiable. During the evaluation period there would be a moratorium on construction of new hatcheries, but existing hatcheries would be maintained and operated.

The objective would be accomplished by finding the total cost of production for fall chinook salmon for several successive brood years and then comparing the cost of production with the value of the harvest of hatchery-reared fish. The program was broadened a few years later to include coho salmon.

Details of the evaluation program were worked out by a committee which included representatives from Fish Commission of Oregon, Oregon Game Commission, Washington Department of Fisheries, Washington Department of Game, Biometrics Institute in Seattle, and Bureau of Commercial Fisheries in Portland. All these agencies have worked closely in implementing the program.

For accuracy in evaluation it was necessary to find production costs and harvest values separately for each species and each brood year. This required development of a method that would provide a realistic breakdown of costs for each species and brood year. Tables I through V on the following page illustrate the steps in finding production costs.

Fiscal Year 1968

Hatchery Operational Costs

Table I - Number of Eggs and/or Fish (in thousands)

Brood and Species	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Total
1967 Fall chinook	0	0	0	2,585	2,450	2,450	2,385	2,330	2,230	2,000	100	0	16,530
1966 Coho	960	955	955	955	955	950	880	880	845	0	0	0	8,335
1967 Coho	0	0	0	0	1,300	1,485	1,285	995	995	990	990	990	9,030
Total	960	955	955	3,540	4,705	4,885	4,550	4,205	4,070	2,990	1,090	990	33,895

Table II - Percentage of Eggs and/or Fish

Brood and Species	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Total
1967 Fall chinook	0	0	0	73.0	52.1	50.2	52.4	55.4	54.8	66.9	9.2	0	414.0
1966 Coho	100	100	100	27.0	20.3	19.4	19.3	20.9	20.8	0	0	0	427.7
1967 Coho	0	0	0	0	27.6	30.4	28.3	23.7	24.4	33.1	90.8	100	358.3
Total	100	100	100	100	100	100	100	100	100	100	100	100	1,200.0

Table III - Units of Manpower 1/

Brood and Species	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Total	Percent
1967 Fall chinook	0	0	0	66	47	45	47	50	49	54	6	0	364	43
1966 Coho	30	30	70	24	18	18	17	19	19	0	0	0	245	29
1967 Coho	0	0	0	0	25	27	26	21	22	26	64	30	241	28
Total Fish-Work	30	30	70	90	90	90	90	90	90	80	70	30	850	100
Non-Fish Work	70	70	30	10	10	10	10	10	10	20	30	70	350	
Total Manpower	100	100	100	100	100	100	100	100	100	100	100	100	1,200	

Table IV - Pounds of Fish Produced

Brood and Species	Pounds	Percent
1967 Fall chinook	18,930	25.6
1966 Coho	44,103	59.6
1967 Coho	11,000	14.8
Total	74,033	100.0

Table V - Cost of Production at 5 Percent on Investment

Brood and Species	Capital outlay and interest 2/	Fish food and related items	Operational costs other than food 3/	Total
1967 Fall chinook	$17,728.90	$ 6,126.19	$24,105.07	$ 47,960.16
1966 Coho	11,956.70	14,262.55	16,256.91	42,476.16
1967 Coho	11,544.40	3,541.71	15,696.32	30,782.43
Total	$41,230.00	$23,930.45	$56,058.30	$121,218.75

1/ Percent of units of manpower represents total fish work by species and is used to apportion capital outlay, interest and operational costs other than food.

2/ Amortized capital outlay:	$589,000 ÷ 50 years	$11,780.00
Interest on investment:	$589,000 x 5 percent	29,450.00
		$41,230.00

3/ Operational costs include personal services, travel, transportation of things, communication services, rents and utilities, other contractual services, equipment, supplies and materials, and administration.

The tables are records of an actual hatchery operation. Two species of fish were reared in fiscal year 1968, with two brood years for one of the species. Fall chinook eggs and fish remained in the hatchery about seven months, while coho were there for over a year.

Table I shows the number of eggs and/or fish of each species and each brood year in the hatchery each month, and also the totals for both species and both brood years. Table II shows these figures converted to percentages, and Table III shows the breakdown of manpower units required each month for each species and brood year.

Manpower units are broken down to fish work and non-fish work. Only the time spent in fish work is used in the breakdown. This results in greater accuracy in determining production costs by species and brood year. Figure 1 illustrates the distribution of manpower for one year at one of the Columbia River hatcheries.

Table IV shows total pounds of fish produced and the percentage for each species and brood year. Table V shows the final breakdown of production costs. Manpower units are used in the breakdown of capital outlay, interest and operational costs other than food. The breakdown of food costs is based on the percentage of pounds of fish produced, as shown in Table IV. The total costs for each species and brood year, in the final column, will be compared with harvest values of the fish to find the cost/benefit ratio.

Figure 2 shows total production in pounds of fall chinook salmon, and average cost per pound, for the 16 Columbia River study hatcheries during the study period 1961-1967. Statistics for individual hatcheries show more variation, of course, than the combined statistics shown in the graph.

FIGURE I

DISTRIBUTION OF MANPOWER IN HATCHERY ACTIVITIES

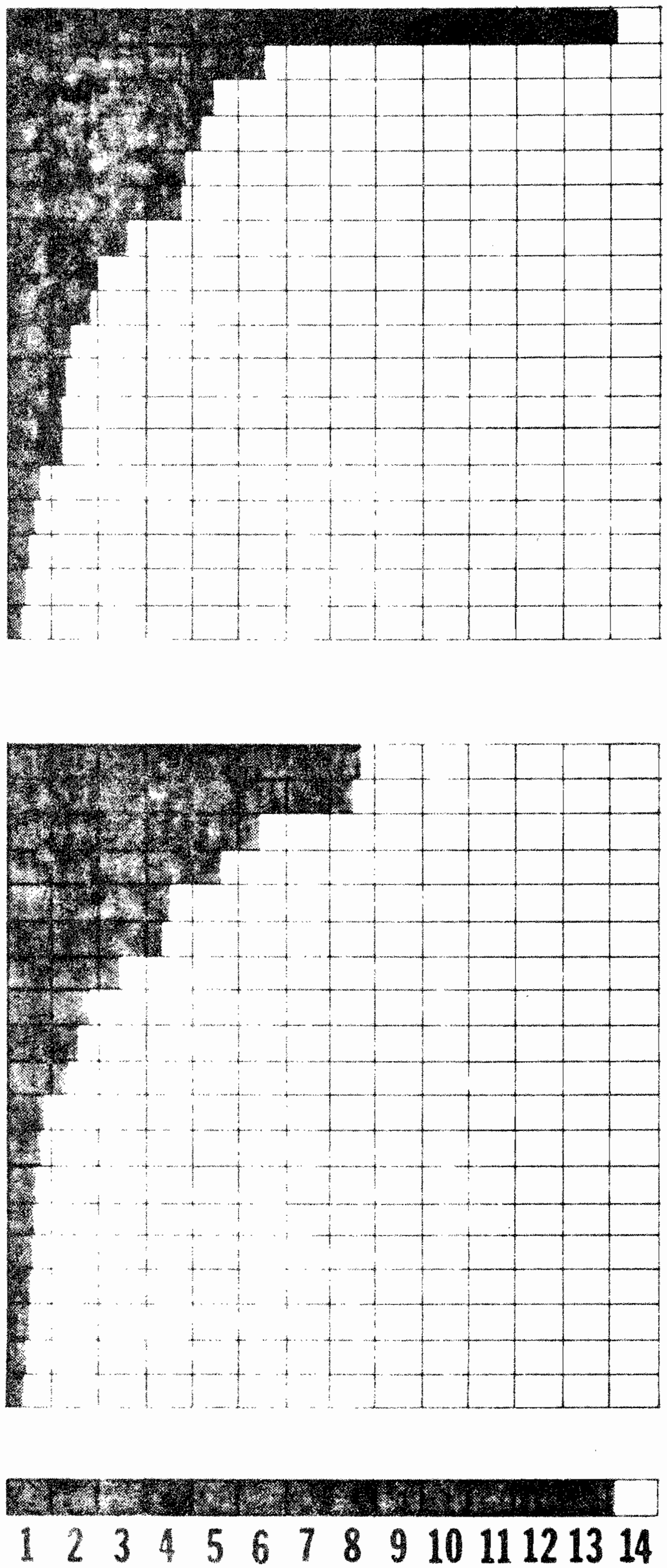
FISH CULTURE:

	HOURS
FEED FISH	1325
TRANSFER/PLANT FISH	559
CLEAN/DISINFECT PONDS	447
PICK EGGS	407
PICK FISH	379
CLERICAL	371
MISCELLANEOUS	263
SAMPLE FISH	200
SPAWN FISH	174
SIZE FISH	148
CLEAN TROUGHS/TRAYS	125
TREAT FISH DISEASES	100
PICK FRY	100
FISH TRAP	60
UNLOAD FEED	43
CHECK INTAKES	31
MARK FISH	25
TREAT EGG DISEASES	20

MAINTENANCE:

	HOURS
PICKUP SUPPLIES	772
CLERICAL	741
EQUIPMENT BUILDING	537
EQUIPMENT REPAIR	462
MISCELLANEOUS	334
CLEAN/MAINTAIN GROUNDS	317
TRAINING SCHOOL	236
SNOW REMOVAL	175
SERVICE EQUIPMENT	153
LAWN MOWING AND CARE	134
REPAIR SCREENS	93
ROAD MAINTENANCE	81
CLEAN BUILDINGS	75
PUBLIC RELATIONS	70
PAINTING	43
REPAIR BUILDINGS	42
REPAIR PONDS	36
HAUL GARBAGE	27
CLEAN EQUIPMENT	25

LEAVE: 1308



HOURS [in hundreds]

COURTESY: JOHN CLAYTON, KLICKITAT HATCHERY, WASHINGTON DEPARTMENT OF FISHERIES

PRODUCTION OF FALL CHINOOK AT COLUMBIA RIVER PROGRAM HATCHERIES

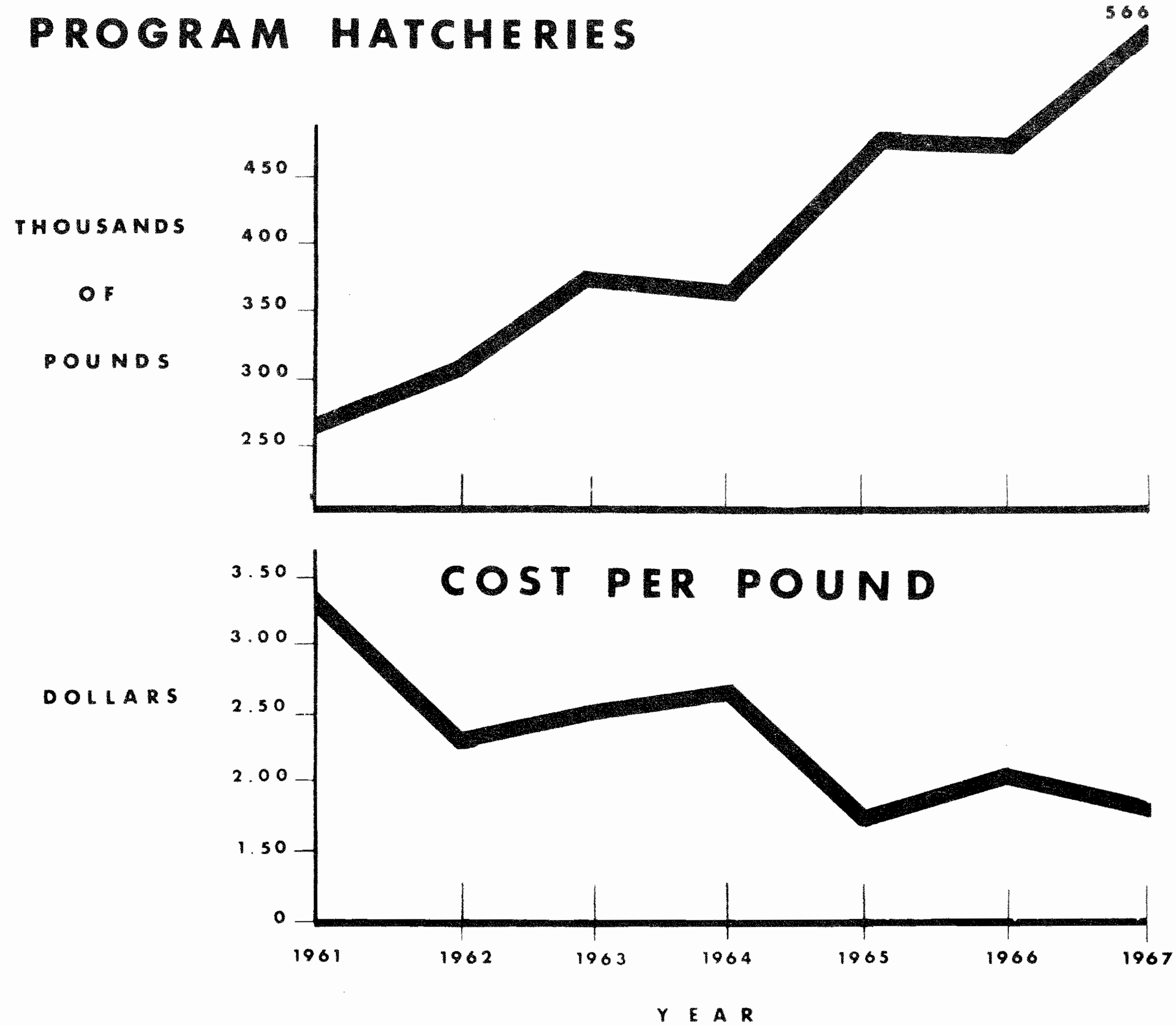


Figure 2.

SUCCESS OF ARTIFICIAL INCUBATION FACILITIES AND SPAWNING CHANNELS WITH FRASER RIVER SOCKEYE SALMON

Ernest L. Brannon
Int. Pacific Salmon Fish Commission

The International Pacific Salmon Fisheries Commission has directed its fish cultural research primarily toward artificial spawning channels and incubation channels. These facilities have been designed to supplement spawning areas that have deteriorated or are otherwise insufficient for the rearing potential of the large productive nursery lakes.

The Upper Pitt River basin, sustaining years of logging operations, has experienced severe spawning ground deterioration. Consequently the sockeye run had declined from over 40,000 spawners in 1950 to less than 7,000 spawners in 1965. The run was spread out over so much area that an incubation channel was considered the best facility for the operation. The upwelling channel is 700 square yards in area and has a capacity of about four million eggs.

In 1963 operation of the channel was initiated and the adult returns from the combined natural and channel production totaled 135,000 fish. Similarly the 1964 operation contributed in an adult return estimated at 190,000 sockeye, the highest ever recorded. Since the brood years each numbered less than 14,000 spawners, the combined return to spawner ratio has been over 12 to 1.

Weaver Creek, another sockeye spawning area which is extremely inhibited by a limited and deteriorating spawning area, has been the site of the first sockeye spawning channel operation.

The channel is a controlled flow stream, relatively free of fines and provides an area of 21,300 square yards for spawning.

The natural spawning population in Weaver Creek in the recent past has averaged about 10,000 female spawners but produced only 2.5 million fry annually. In 1965 the channel operation was initiated with 2,986 females in the facility, which produced 7.8 million fry. The return to Weaver Creek in 1969 was 59,000 fish, the largest recorded in the history of the run. The total return, including the fishery, was 169,000 fish from 11,000 spawners or a return to spawner ratio of over 15 to 1.

Investigations are being directed to provide the background necessary in anticipation of certain problems that can arise in the nursery lakes from channel operations. Also research continues with pink salmon channel facilities which similarly show considerable promise as secure fish cultural operations.

THE PHYSICAL AND CULTURAL ASPECTS OF THE TEHAMA-COLUSA FISH FACILITIES

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Bureau of Sport Fisheries and Wildlife

Prior to construction of Shasta Dam, the upper Sacramento River salmon and steelhead fishery was limited to spawning migrations in the fall, winter, and spring due to extreme water temperatures reaching into the 70's during the summer months. With completion of the dam, water temperatures have been maintained which produce conditions suitable to salmon and trout throughout the year.

It is known that adult chinook (king) salmon migrate into the upper Sacramento River every month of the year. Peak runs occur from September to mid-December (fall run); mid-December to late March (winter run); and late March to June (spring run).

Other fishes that contribute to the fishery in the upper Sacramento River are rainbow trout, shad, western sucker, Sacramento squawfish, carp, lamprey, several members of the sunfish family, and others.

As part of the Sacramento River Division Central Valley Project, a diversion dam was built across the Sacramento River This dam was designed to divert water into the Tehama-Colusa Canal and Corning Canal for irrigation purposes and includes two fish ladders and two fish counting stations. The dam is located two miles south of Red Bluff. The upstream section of this irrigaton canal will also function as a salmon spawning channel, thereby creating a dual use facility.

A spawning channel is an area of environment control which combines the best elements of a hatchery and the natural spawning stream. Environmental changes often decide whether salmon live or die, and often indicate the destiny of whole runs. By elimination of many of the hazards found in natural streams, channels can produce egg-to-fry survival rates ten times greater than the natural survival.

Included in the spawning facility is a settling basin, located at the head end of the spawning channel, designed to remove silt and fine sands from the inflowing water, and a channel 27,000 feet in length, 100 feet in width, containing selected gravel composition, a gravel cleaning device, electronic fingerling counting system and water quality monitors.

Upon completion, the Tehama-Colusa Spawning Channel will be the largest, most modern salmon facility in the world. If all of the salmon eggs that will be layed in one season, in the spawning gravels, were placed in a row, they would extend from Red Bluff to Los Angeles, or a distance of 512 miles.

The Tehama-Colusa Salmon Spawning Channel and appurtenant fish facilities will provide some 1.9 million square feet of new spawning area. This area will ultimately sustain an estimated average spawning run of 40,000 fish per year which includes the 3,000 fish displaced by Red Bluff Diversion Dam Forebay. It is estimated, on a yield per acre basis, that the salmon spawning area will be worth $30,000 per acre, per year, at full development.

Facilities, land acquisitions, and flows provided by the project will also rehabilitate the lower four miles of Thomes Creek for salmon production. Following an initial build-up period, an estimated 10,000 spawning salmon per year will be maintained in Thomes Creek.

At full capacity, this project will provide an additional 130,000 adult salmon per year for the enjoyment of the sports fishermen and an additional one-half million dollars per year to the commercial fishery.

The project is due for completion in July, 1971, and will cost on estimated eighteen million dollars.

The United States Bureau of Sport Fisheries and Wildlife has been counting the number of upstream bound fishes, by species, since July, 1967, using closed circuit television cameras installed in each fish ladder. Counting takes place sixteen hours a day, seven days a week. 117,260 adult chinook salmon were counted during fiscal year 1968; and 116,678 in fiscal year 1969, together with thousands of other species, such as jack salmon, steelhead, trout, suckers, squawfish, etc.

To accommodate visitors at and near the site, a three-hundred-fifty acre park will be constructed. Plans for the park include many picnic areas, overnight camper and trailer facilities, swimming beaches, boat launching ramps (already installed), adequate parking areas, and a Visitor Fisheries Interpretive Center with closed circuit television and movies showing the migrating and spawning chinooks. The Interpretive Center will also feature a glass viewing wall so that visitors will have the opportunity to be "eye-to-eye" with the salmon and other fish as they ascend the fish ladder.

The educational benefits to be derived here are an interesting and exciting aspect of this facility. It is expected that many schools and colleges will take advantage of the center for field trips and study by science and biology classes.

There will also be opportunities for private enterprise in that approximately one million pounds of salmon carcasses will be collected during the spawning period which could be sold for fertilizers, pet food, etc., and an estimated annual deposition of 16,000 tons of sediment, which will be continuously pumped from the settling basin to a storage area, could be sold for sandy loam.

Surveys of estimated numbers of visitors have been made by Federal, State, and local agencies, and by 1974 it is expected that over a million persons a year will view this spectacle.

THE EFFECT OF DELAYED FERTILIZATION ON TRANSPORTED SALMON EGGS[1/]

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and

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Ninety-two per cent survival of pink salmon (*Oncorhynchus gorbuscha*) eggs shipped from Alaska to Oregon was achieved by storing unfertilized eggs and sperm in separate containers; survival of a second groups of eggs fertilized before shipment was only 40 per cent. Although unfertilized eggs are less subject to mortality from handling than newly fertilized eggs, mortality of stored eggs may result from lowered fertility unless certain precautions are taken.

Provisions of an air space is not essential for storage of eggs, but air is necessary for sperm. High fertility can be maintained for periods up to twenty hours by storing eggs and sperm in iced, insulated containers at 6° C. Dilution of the stored milt with water just before fertilization of eggs also increases fertility.

1/ Submitted to the "Progressive Fish-Culturist" for publication, June 4, 1969.

ADULT SURVIVALS OF SALMON REARED UNDER ENVIRONMENTAL CONTROL

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When we first advocated the reconditioning and temperature control of water in salmon rearing, the question arose as to the quality of the fingerlings which would be produced and ultimately how this would affect the adult survival.

Experiments were designed and conducted to measure the differences in adult survival of fall chinook salmon fingerlings reared in a recirculating environmental control system and those reared in single-pass creek water. In the reuse system the water was reconditioned by removal of the ammonia and carbon dioxide, replenishment of oxygen, and supplementation of the circulating water at the rate of five per cent per minute. The recirculating system was heated also to temperatures not in excess of 55° F.

The experiments were conducted on fish from the 1966 and 1967 brood years. With minor exceptions the experiments duplicated each other. The Abernathy Soft Pellet was fed to both groups for both years. All fish were reared in 75-foot, rectangular, circulating ponds. The water temperature of the creek varied from 32° to 58° F. during the rearing periods and in the reuse system from 50° to 55° F.

In the 1966 brood year experiment, both lots were released May 3, 1967. There were 197,000 fingerlings reared in the environmental control system. These fish averaged 33 per pound and were marked 1/2 anal and left maxillary.

There were 200,000 fish averaging 96 per pound and marked 1/2 anal and right maxillary which were reared on the creek water system. Adult returns were as follows:

		2's	3's
Reuse 1/2 An, LM	Males	29	38
	Females	0	94
	Total	29	152
Creek 1/2 An, RM	Males	6	7
	Females	0	7
	Total	6	14

The percentage return to the hatchery amounts to .09 per cent for the reuse fish and .01 per cent for the creek fish.

In the 1967 brood year experiment 200,000 fish averaging 26 per pound and marked 1/2 dorsal and left maxillary were released from the environmental control system. From the creek system 200,000 fish averaging 80 per pound and marked 1/2 dorsal and right maxillary were released. Both groups were liberated on May 14, 1968. The return as 2-year-olds was as follows:

	Reuse 1/2 D, LM	Creek 1/2 D, RM
Males	441	6
Females	7	0
Total	448	6

In addition, 374 jacks marked 1/2 D, LM were recovered from the Washington coastal fisheries. The combined total of 822 marked fish from the reuse system indicated a recovery of .45 per cent from this lot. The actual return to the hatchery amounted to .22 per cent. We are expecting an exceptional return of 3-year-olds from this group in 1970.

Indications are that environmental control systems are capable of improving the quality of hatchery fish and that such improvement results in a significant increase in adult survival.

QUALITY OF CHUM SALMON FRY AS REFLECTED BY THEIR LIPID COMPOSITION DURING EARLY DEVELOPMENT STAGES

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To study the lipid composition and individual fatty acid variation during the early development of chum salmon, adult salmon were spawned and their eggs graded according to size. The diameter of the eggs ranged from 8.2 mm to 6.7 mm. The fertilized eggs were retained in a Heath Incubator at the Big Beef Creek research station near the town of Seabeck, Washington. Samples of fertilized eggs were taken prior to hatching and following hatching samples were taken every seven days until the yolk was completely absorbed. Sample size for the eggs and sac-fry were taken in numbers of ten to assure adequate amounts for lipid studies.

Chum fry that developed from eggs of 6.7 mm diameter averaged 31.8 mm fork length and weighed 0.19 g while fry from eggs of 8.2 mm averaged 38.9 mm and weighed 0.39 g. The average percentage of total lipids available to the migrating fry was similar but the average amount of total lipids (mg per 10 fry) for the 6.7 mm egg size was 93.9 mg and for the 8.2 mm egg size was 177.9 mg.

Major fatty acids utilized by the fry for energy were palmitic (16:0) and oleic (18:1). The amount (mg per 10 fry) available to the migrating fry was 11.0 mg. and 17.3 mg respectively for 16:0 and 18:1 for the 6.7 mm egg size and 17.1 and 26.5 for the 8.2 mm egg size.

Major polyunsaturated fatty acids utilized by the fry for tissue growth were eicosapentaenoic (20:5) and docosahexaenoic (22:6). The amount (mg per 10 fry) available to the migrating fry was 8.5 mg and 18.2 mg respectively for 20:5 and 22:6 for the 6.7 mm egg size and 16.7 mg and 24.6 mg for the 8.2 mm egg size.

Chum fry prior to migration that developed from the 8.2 mm egg size contained considerably larger amounts of fatty acids available for energy utilization and tissue growth. They had a greater fork length and a greater body weight.

EFFECT OF DIFFERENT REARING TEMPERATURES ON GROWTH OF CHINOOK FINGERLINGS

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Groups of fall chinook fingerlings were reared at 50°, 55°, 60°, and 65° F. to determine which temperature was most favorable for growth and to study the effects of temperature on body form and hematology. Five sizes of fingerlings averaging 1.38, 2.10, 2.70, 5.88, and 8.94 grams were reared for four weeks in three-foot circular tanks and were fed as much as they would consume for the duration of each experiment. Abernathy moist pellets were fed in 1968 and Abernathy dry pellets were fed during 1969.

Of the four temperatures investigated, 60° F. appeared closest to the optimum for growth for all sizes of chinook fingerlings. Fish in 60° water consistantly outgained those held at 50° or 55°. Growth of fingerlings in 65° water was variable, and propagation at this temperature in water reuse and reconditioning systems appears impractical when the increased cost of heating hatchery water supplies an additional five degrees is considered. No differences in conversion were found between fish reared at any of the temperatures; however, the dry pellet fed in 1969 produced lower converstion than the 1968 moist diet.

No difference in the fork length cubed-weight relationship were found between fish reared at any temperature. Regression of fork length cubed in millimeters against weight in grams did not deviate significantly from a straight line with the equation: $L^3 \times 10^{-5} = .2700 + .7721W$. Fingerlings growing at different rates apparently maintain the same relatively constant body conformation. Reasonable accuracy may also be assumed in calculating average fork length or average weight if only one of these variables is known. Determination of rates of increase in weight or length at different temperatures should be helpful in predicting hatchery growth. Close correlation of feeding levels with growth at different temperatures should result in lower hatchery conversions, greater production efficiency, and reduced production cost.

Temperature effects on hematological characteristics were found only in fish averaging four grams or less. In this group, increasing corpuscular counts, hematocrits, and hemoglobin levels were associated with increased rearing temperature.

AN OBSERVATION OF THE EFFECT OF TEMPERATURE ON PARR-SMOLT TRANSFORMATION IN STEELHEAD TROUT

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Winter steelhead fry were reared through the smolt stage, June, 1967 to July, 1968, in constant temperature (12° C) or in a variable temperature cycle (7-18° C) under a natural photoperiod. Fish were sampled semimonthly for length and weight and changes in coefficient of condition determined. Marked fish of migrant size ($\geq$ 16 cm. in fork length) were released from February through June, 1968 in a natural stream. The numbers of fish migrating were determined at a weir four miles below the release site.

The peak period of migratory activity was in early May for both temperature groups. Fish reared in a variable temperature cycle showed greater tendencies to migrate than fish reared in constant temperature with 85% and 49%, respectively, moving downstream in the first 15 days after stocking. The total recovery of fish reared in variable and constant temperature totaled 92% and 68%, respectively.

Smolting winter steelhead lose condition with the lowest value occurring near the peak of migratory activity. While the two temperature groups differed in condition during the rearing period, they were similar in the magnitude and timing of the loss in condition with respect to the migratory period. The difference in migratory urge between the two groups of fish could not be predicted from the change in the coefficient of condition.

EARLY MATURING SOCKEYE AND COHO SALMON FROM THE RELEASE OF LARGE ZERO-AGE FINGERLINGS

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University of Washington
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Sockeye Salmon

During the fall months of 1966, sockeye salmon eggs of the Lake Washington strain were incubated at the College of Fisheries in a closed-cycle incubation system. Incubation temperatures were maintained at 50° F. or above, and the fry were ready to start feeding by late January of 1967.

After a seven-week feeding period, during which the young sockeye increased 700 to 800 per cent in weight, 10,985 fingerlings were marked by removal of the adipose fin and, together with 33,899 unmarked fingerlings, were released into Union Bay on March 15, 1967 (Table 1).

During the fall of 1969 a total of 34 adult sockeye salmon returned to the homing pond on the campus. Seven had no adipose fin and 27 were not marked.

We now assume that the young fingerlings released in March, 1967 fed in the lake until the major out-migration of wild sockeye from the lake occurred in May. After feeding in the sea for the normal two years, these young fish returned as small, but mature, fish and produced about 60,000 eggs, more than enough to continue the program.

Coho Salmon

In the spring of 1968, about 17,000 large coho salmon fingerlings (Table 2) of the 1967 brood year that had been used in nutrition experiments were available for other projects. Rather than discard these fish, we decided to mark them with a thermal brand (X on the left side ahead of the dorsal fin) and release them.

Many of these fingerlings were as large as the wild coho, one year older, that migrate out of the watershed in large numbers during the month of May. After the normal 18 months in the sea, a total of 153 fish had returned and were spawned at the campus pond by November 26, 1969. An additional 33 females and 25 males were counted in the pond on December 1. More coho salmon will return during December and January.

Advantages to Salmon Culture

It is obvious that these pilot experiments could easily be expanded into major production programs with important benefits.

1. By reducing the normal cycle by one year, it would be possible to fill in years of low production.
2. The cost of producing a migrant would be greatly reduced.
3. Much less food would be required, with a better growth-to-maintenance ratio.
4. Disease problems would be largely eliminated, for the fish would be in the sea before the warm summer disease period.
5. Total survival could be increased once the program was perfected.

SOME DEVELOPMENTS IN OREGON STARTER MASH AND OREGON PELLET FORMULATION

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The wet-fish content or Oregon Starter Mash (24%) and Oregon Pellets (40%) detracts from the practicality of these diets. Our mesh often contains lumps too large for fry to ingest, and the pellets may be sticky. Efforts to completely remove wet fish from these formulae have not been successful. However, we developed new formulae with lower levels of wet fish.

The new Oregon Starter Mash, containing 16% wet fish and about 18% moisture, produced excellent results in laboratory tests and limited production feeding trials. The new Oregon Pellet, with 30% wet fish and about 28% moisture, produced good results with spring chinook salmon in the laboratory. Current laboratory feeding tests of the new pellet with coho salmon and limited production trials with spring chinook salmon show much promise.

The problems with lumps and stickiness have been reduced by the new formulations. The new diets will be fed to about half the Fish Commission's production next year.

PROGRESS REPORT ON THE ABERNATHY DRY DIET

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The Abernathy dry diet can be prepared by two different methods. One method using a Dravo pelleting wheel forms a rolled pellet which, due to water being added during pelleting, must be oven dried. The other method which utilizes a pressure pellet mill (California type) does not require oven drying and as a result would be more economical to manufacture. Feeding trials comparing these two types of pellets showed no difference in fish growth and both dry diets were as good or better than the standard Abernathy moist diet.

At current prices the moist pellet costs over 50 per cent more than the pressure type dry pellet. An additional savings of at least 20 per cent can be expected due to a better conversion rate when feeding the dry diet.

Some changes in feeding procedure are necessary when using dry feeds. Smaller sized particles for a given sized fish are required as well as more frequent feeding. The success of dry feeds rests upon the hatcheryman as it will require more care and patience on his part to make the dry diet perform as well as the moist diet.

HAKE (MERLUCCIUS PRODUCTUS) A SOURCE OF PROTEIN FOR HATCHERY FISH NUTRITION

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The estimated standing stock of adult Pacific hake on the Pacific Coast is four to eight billion pounds with a maximum sustainable yield of 230 to 540 million pounds. Recent investigations at Washington State and Oregon State Universities have shown hake meal to be a satisfactory protein supplement for boiler production rations. In view of this large potential protein resource, investigations have been carried out in the past few years to establish and compare the chemical and nutritional characteristcs of hake in its various forms as a source of protein for the nutrition of hatchery fish.

Round hake is generally characterized by a higher moisture and ash content and lower fat level than the wet ingredients that are presently utilized in formulating the Oregon Moist Pellet. As a wet fish ingredient, hake does not provide energy at a level that is comparable to combinations of the presently allowable ingredients. Replacement of the 40% turbot-tuna viscera fraction of the Oregon Moist Pellet with pasteurized hake accompanied by approximately 28% additional fat yielded comparable growth responses and conversions for chinook salmon. Production feeding trials have verified this result.

Autolysis of the wet fish fraction of the Oregon Moist Pellet under specific time and temperature relationships has been considered as a means of improving the economy of handling and storing. Feeding trials with chinook salmon have indicated that autolysis of the 3:1 hake-tuna viscera fraction of the 40% wet fish Oregon Moist Pellet reduces growth response but not significantly ($P>0.05$). Spray dried round hake hydrolysates and West Coast herring meal have yielded equal growth and conversion by rainbow trout as the major source of protein in purified diets.

Commercially produced complete hake meal has been found to compare favorably with West Coast herring meal with regard to its chemical composition. Ash levels are characteristically 40 to 44 per cent higher. Protein amino acid composition, pepsin digestibility and ϵ-amino lysine content available to reaction with 1-fluoro-2, 4-dinitrobenzene have been found to be at least equal. Growth responses and conversions by rainbow trout fed purified test diets containing commercial complete hake and West Coast herring meal as the major source of protein were shown to be equal. Casein produced significantly ($P>0.05$) better dry weight feed and protein conversion than either fish protein source. Growth response did not vary significantly.

Hake meal appears to be a good potential source of protein for nutrition of hatchery fish. The addition of pasteurized hake to the allowable wet ingredients in the Oregon Moist Pellet appears to be acceptable if it is accompanied by additional energy in the form of fat.

PROGRESS REPORT ON CONTRIBUTION OF HATCHERY PRODUCED SPRING CHINOOK AND SUMMER STEELHEAD TO THE NORTH UMPQUA RIVER

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Hatchery produced spring chinook and summer steelhead were major contributors to the record runs for each species in the Umpqua River during 1969.

The 1969 runs of spring chinook and summer steelhead were the highest on record at Winchester counting station since its construction in 1946. The spring chinook run reached a high of 20,777 fish, while the summer steelhead run will end at approximately 15,000 fish. Figure 1 illustrates the combined two runs for 1969, approximating the historical total for both runs with hatchery contribution more than 50 per cent of the total.

Table 1 depicts the improvement in the spring chinook salmon run and shows the increasing contribution of hatchery-released fish. The run of 20,777 fish compares favorably with the reported historical total of 25,000 fish and nearly doubles the previous high count of 11,730 fish achieved in 1965.

Table 1

Spring Chinook Counts at Winchester Dam, 1946-1968

Period	Average Run	Averages for Hatchery Contribution Number of Fish	Percent of Run
1946-1950	2,745		
1951-1955	5,908	929	15.7
1956-1960	5,355	822	15.3
1961-1965	8,671	1,911	22.0
1966-(1969)	11,586	3,895	33.6

Fish of hatchery origin made up 45.0 per cent of the 20,777 spring chinook run. The 1965 brood made up a majority of the 1969 returns, and the total for the three years of returns approximates 8 (7.8) per cent of the number released. The 1965 brood year group consisted of 88,000 smolts released in late February 1967 at 4.8 fish per pound. The return figure of nearly 8 per cent of the number released is actually greater, as it does not include fish taken in extensive sport and commercial fisheries. In the 1965 brood year lot, visual smolt characteristics were correlated with size of fish and time of release. From the visual characteristics, it was believed that the fish were released four weeks late. The high rate of return, however, revealed that the smolts were released at the proper time.

Last year it was reported that the 1966 brood year fish were hand-graded periodically during a 6-week period, and at each grading those individuals with smolt characteristics were released. Returns from the 1966 brood year chinook have totaled 5,559 through 1969, or 3.3 per cent of the number released. This total, however, contains only those fish which have passed through the counting station. Approximately 30 per cent of an average run of fish is viewed at the counting station two years following release.

With the improvement in the quality of fish released and the ability to recognize smoltification characteristics, a program to sample and record condition factors was initiated starting with the 1966 brood year fish. There appears to be a definite correlation between a condition factor of 1.10 and visual smolt characteristics at Rock Creek Hatchery. Table 2 presents part of the physical data taken during the parr-smolt transformation period for the 1967 spring chinook brood as compared with the 1966 brood in parenthesis.

Table 2

Physical Data for Umpqua Spring Chinook
Parr-Smolt Transformation

Date	Fork Length (Inches)	Fish per Pound	Average Condition Factor	
October 23, 1968	6.16	10.5	1.19	
November 21, 1968	6.67	8.1	1.16	(1.18)
December 17, 1968	6.95	7.5	1.10	(1.16)
January 13, 1969	7.11	6.6	1.16	(1.11)
February 7, 1969	7.24	6.4	1.13	(1.18)
March 3, 1969	7.46	5.8	1.13	(1.13)

The 1969 run of 15,000 summer steelhead not only exceeds the previous high count of 6,185 fish but also the reported historical high of 12,500 fish. Table 3 illustrates the increasing summer steelhead run and high rate of hatchery contribution.

Table 3

Summer Steelhead Counts at Winchester Dam, 1946-1969

Period	Average Run	Number of Fish	Percent of Run
1946-1950	3,149		
1951-1955	3,439		
1956-1960	2,395	822	34.3
1961-1965	3,874	1,339	34.6
1966-(1969)	7,795	5,113	65.6

Fish of hatchery origin made up 73.0 per cent of the run of 15,000 summer steelhead in 1969. Marked fish contribution by brood year was 0.8 per cent for 1965, 44.8 per cent for 1966, 49.2 per cent for 1967, and 5.2 per cent for 1968 brood year fish.

As in the spring chinook program, data on condition factors, visual smolt characteristics, etc., are being taken on summer steelhead. Table 4 presents a segment of the data taken from the 1968 brood reared at Bandon Hatchery. Our present program of releasing smolts ranging from 5 to 7 per pound in March is showing returns of 4 to 8 per cent of the number stocked.

Table 4

Physical Data for Umpqua Summer Steelhead
Parr-Smolt Transformation

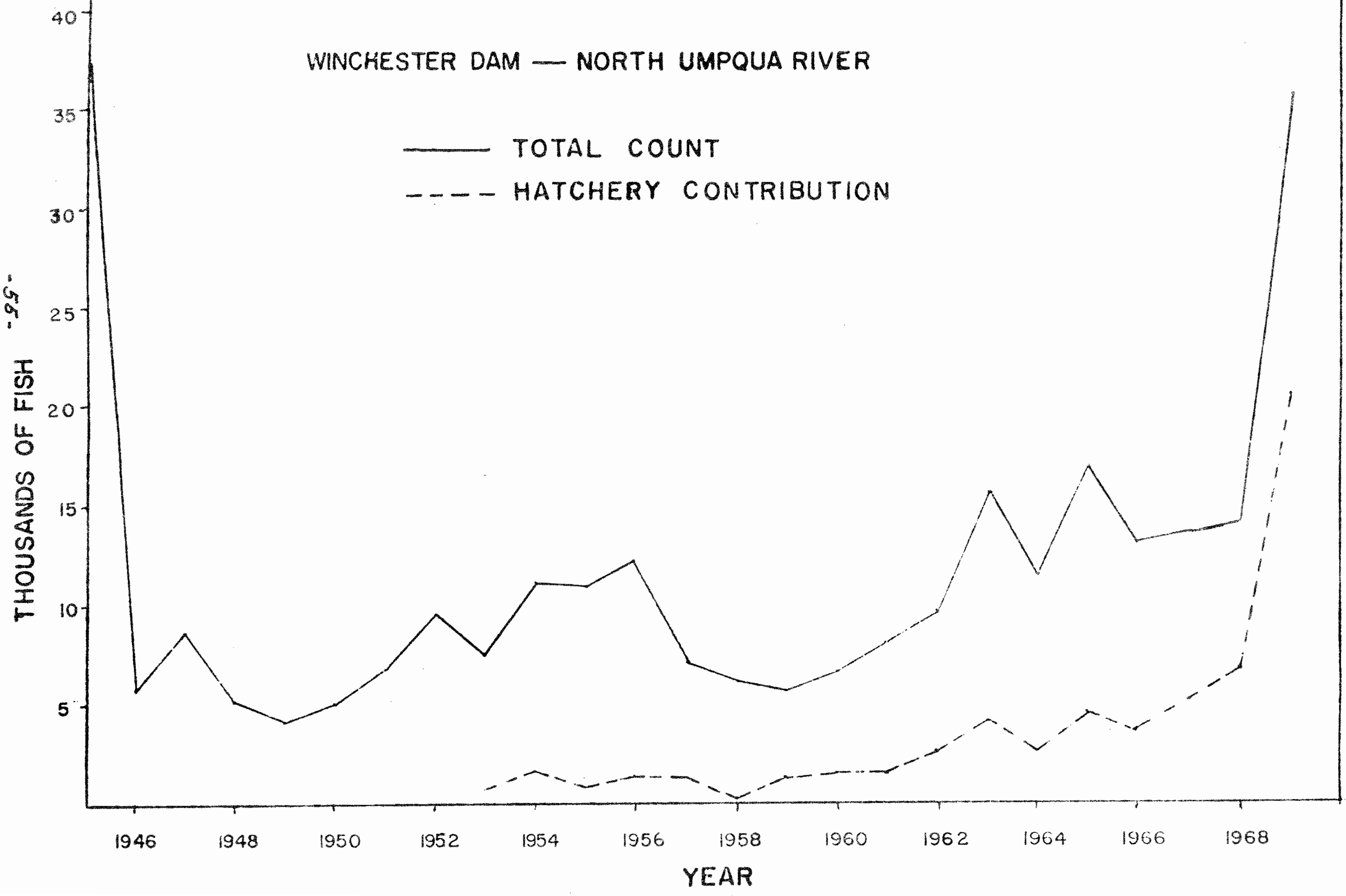
Date	Average Fork Length (Inches)	Fish per Pound	Average Condition Factor
December 11, 1968	6.66	9.6	1.044
January 14, 1969	7.09	7.0	1.107
February 10, 1969	7.28	6.6	1.068
March 5, 1969	7.56	6.1	1.061

Recent experiments have been directed toward returning the adults to specific areas. At the start of the program, releases were made at Winchester (114 river miles from ocean), while releases today are spread out between Winchester and Steamboat (167 river miles from ocean). Although a lower rate of return has been achieved from the upper river releases, the contribution of hatchery fish to the angler creels has increased from less than one per cent to more than sixty per cent. An expansion to the stocking program will utilize upper river tributaries, as well as a spread-out pattern in the main stem between Winchester and Steamboat.

In summary, the two fish runs have increased from 2,000 fish (their low points) to 20,777 spring chinook (45.0 per cent hatchery in origin) and 15,000 summer steelhead (73.0 per cent hatchery origin). We continue to be encouraged with the direction our programs for these two species are leading.

FIGURE 1

COMBINED COUNTS FOR SPRING CHINOOK AND SUMMER STEELHEAD



PRELIMINARY REPORT ON THE USE OF ANTIBIOTICS TO CONTROL BACTERIAL INFECTIONS IN ADULT SALMON

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Washington Department of Fisheries
Salkum, Washington

A mortality of 35% occurred by mid-June 1968 to the adult spring chinook salmon (Oncorhynchus tshawytscha) held at the Cowlitz Salmon Hatchery. Of the total mortality, 60% were infected with bacterial kidney disease, 60% with furunculosis (Aeromonas salmonicida) and 40% with columnaris (Chondrococcus columnaris).

Tests showed that subcutaneous injections of erythromycin (50 mg), neomycin sulfate (100 mg), chloramphenicol (250 mg), oxytetracycline (50 mg), penicillin G procaine (200,000 units), penicillin G benzathine (150,000 units), and dihydrostreptomycin (250 mg) were non-toxic to adult spring chinook.

An experiment was conducted to test the efficacy of three antibiotics against the multiple infection. The water temperature range, during the 8 week test, was 53-59^{o} F. The fish in one pond received 3 injections, another pond received 2 injections and a third pond was a non-injected control. The infections were given at 2-3 weeks intervals, in conjunction with the spawing procedure. Each 2 cc. injection contained 200,000 units of penicillin G procaine, 250 mg of dihydrostreptomycin and 50 mg of oxytetracycline. At the fifth week, adults from each pond were tagged and placed in one pond. A small amount of tag loss occurred, but it wasn't enough to significantly alter mortality and spawning data. Table 1 shows that subcutaneous injection of these antibiotics reduced mortality and increased the number of viable eggs but caused an excessive number of deformed fry.

Table 1. The effect of antibiotic therapy on 1968 adult spring chinook mortality and spawning.

	Number of Injection		
	0	2	3
Per cent - total mortality	44	33	20
Per cent - female mortality	36	26	14
Ratio - viable eggs*	1.00	-	1.45
Per Cent - deformed fry	0	-	15

In 1969, a similar experiment was conducted. Forty and 70% of the mortalities were infected with furunculosis and bacterial kidney disease, respectively. The same antibiotics and dosage were injected at 2-3 weeks intervals. All injections were completed prior to the spawning period. The test was conducted for 16 weeks and the water temperature range was 46-56° F. These antibiotic injections reduced mortality and increased the number of viable eggs and fry. Adults receiving 2 injections had fewer deformed fry than those receiving 3 injections, (Table 2).

Table 2. The effect of antibiotic therapy on 1969 adult spring chinook mortality and spawning.

	Number of Injections		
	0	2	3
Per cent - total mortality	34	26	18
Per cent - female mortality	28	21	14
Ratio - viable eggs*	1.00	1.11	1.26
Ratio - viable fry*	1.00	1.12	1.27
Per cent - fry deformed	0	3	18

This study is being continued to find and eliminate the specific cause of the deformities.

ACKNOWLEDGEMENTS

Dr. G. W. Klontz, Western Fish Disease Laboratory, and Dr. E. R. Grazin, Ritter and Duby Veterinary Hospital, provided essential information on the use of injectable antibiotics. Superintendents R.J. Wiles, N.B. Dedman and the Cowlitz Salmon Hatchery personnel provided labor and coordination essential to the experiment.

* per original female

PROGRESS AGAINST VIBRIOSIS IN SALTWATER REARING AT LINT SLOUGH

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Mass mortalities of fall chinook, coho and steelhead in the Lint Slough rearing facility at Waldport, Oregon during 1968 and 1969 were attributed to *Vibrio anguillarum* by Dr. John Fryer of the Department of Microbiology at Oregon State University. Up to 98 percent of the fall chinook, coho and winter steelhead stocked were lost. Control would require either pretreatment or oral application of a drug in a supplemental diet. Experiments were conducted to test the effect of three drugs and a vaccine against vibriosis.

A series of eight nylon net pens were suspended in Lint Slough and 20 fiberglass tanks were set up, each supplied with saltwater pumped directly from the impoundment. Each pen was constructed of 1/8-inch mesh, woven nylon netting and measured 10 feet wide, 20 feet long and 6 feet deep. They were supported by an external wooden framework. A catwalk around the pens and over the center led to automatic feeders and facilitated removal of dead fish.

The fiberglass tanks of 3-foot diameter with a capacity of 100 gallons could be supplied with a flow of fresh and/or saltwater. Aeration was provided by compressed air.

Furanace(P-7138) treatment

The first experiment was designed to test four micrograms of Furanace (P-7138) per kilogram of fish per day, fed continuously in the diet as a control for vibriosis. Groups of 3,000 fall and spring chinook, coho and steelhead were fed the test diet while similar groups were fed Oregon Moist Pellet to provide a control. The experiment was terminated on June 30 after 71 days of treatment.

Oral treatment with Sulmet and terramycin (TM-50) at concentrations generally recommended for other bacterial diseases did not produce significant protection in this experiment when compared with control groups (Figure 2). Figure 3 suggests that 50 and 75 milligrams of Furanace (P-7138) per kilogram of fish per day might have produced some protection. The low mortality in control groups makes it difficult to determine if treatment produced any degree of protection against vibriosis. It is not known whether the differences in size or previous history of the second group of experimental fish influenced their resistance to vibriosis as demonstrated by difference in mortality rate of control groups.

A comparison of survival rates in Figure 1 suggest that four micrograms of Furanace (P-7138) provided little protection against vibriosis.

Comparison of Furanace (P-7138) Sulmet and terramycin (TM-50)

The second experiment was designed to compare levels of Sulmet, and terramycin (TM-50) with a range of Furanace (P-7138) concentrations in the diet for the control of vibriosis. Treatments tested included 5 and 10 grams of Sulmet per kilogram of fish per day for 14 consecutive days. Terramycin (TM-50) was fed at rates of 27 and 35 grams per hundred pounds of fish per day for 10 consecutive days, then every third day thereafter. Furanace (P-7138) was fed at concentrations of 5, 15, 25, 50, 75, 100 and 200 milligrams per kilogram of fish per day for 14 consecutive days. All groups were fed Oregon Moist Pellet on days not scheduled for treatment. Two groups of fish were fed control diets.

Diets containing drugs were prepared by mixing 132 grams of powdered gelatin, the drug, and 468 grams of Clark's dry ration in 900 grams of boiling water. The mixture was cooled in freezer cartons then pressed through a steel plate containing 1/8-inch diameter holes in order to produce bite size pellets.

One hundred spring chinook averaging 43 fish per pound were tested in each tank and exposed to Vibrio in 12 ppt saltwater two days before receiving the medicated diets. Mortality rates between 90 and 100 percent occurred within five days. Delayed treatment was not effective in preventing vibriosis.

The experiment was repeated with spring chinook from the Oregon Game Commission Cedar Creek Hatchery averaging 17 fish per pound. Conditions were similar except medication was started three days before exposure to Vibrio.

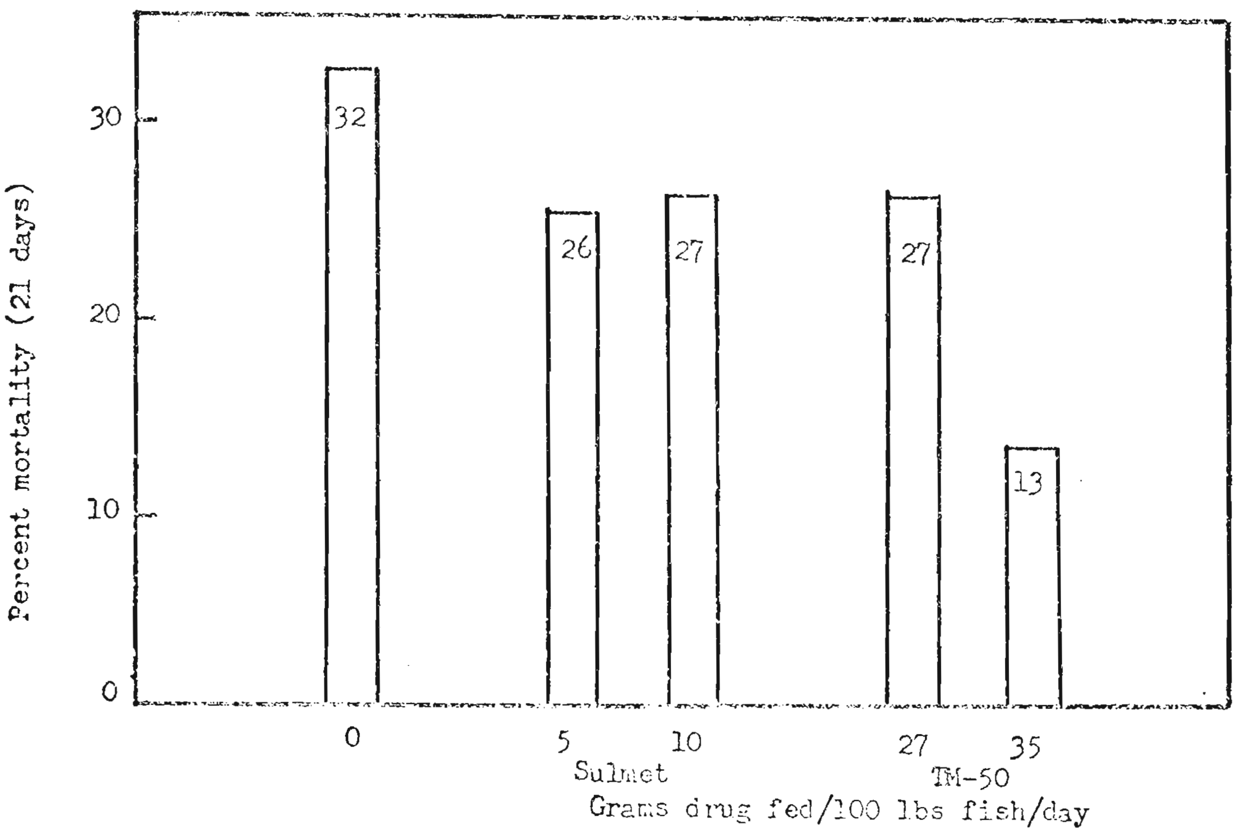

Figure 2. Comparison of Sulmet and TM-50 for control of vibriosis at Lint Slough.

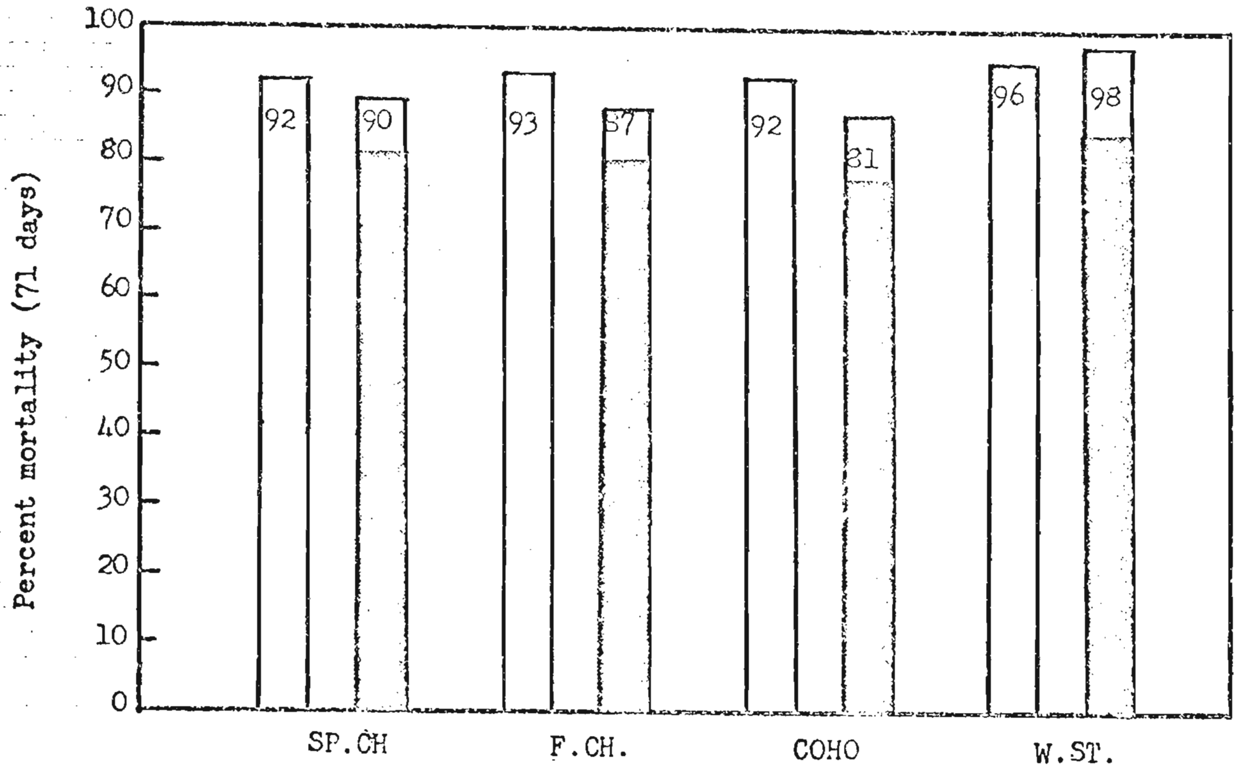

Figure 1. The effect of 4 micrograms of P-7138/Kg/days (dark bars) on the control of vibriosis in saltwater at Lint Slough. Open bars represent control groups of salmonids.

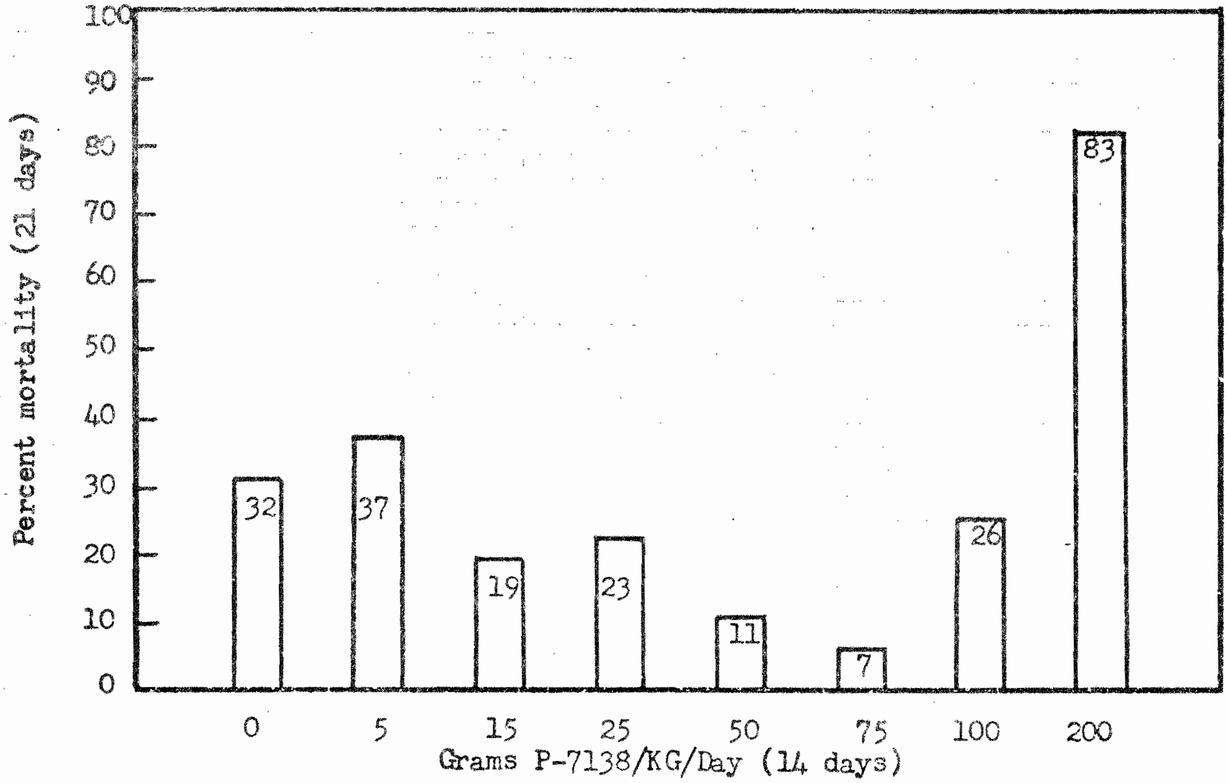

Figure 3. Oral treatment of Furanace (P-7138) for control of vibriosis in spring chinook fingerlings at Lint Slough.

ORAL IMMUNIZATION OF SALMONID FISH FOR CONTROL OF VIBRIOSIS*

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and

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During 1968 the causative agent of vibriosis in populations of salmonid fish from the Oregon State Game Commission's salt water rearing facility at Lint Slough was diagnosed as *Vibrio anguillarum*. Subsequent experiments at our laboratory have dealt with the development of an oral vaccine (administered via the diet) against *V. anguillarum* which would provide protection from this disease for salmonids reared in salt water impoundments. A preliminary experiment indicated that a vaccine prepared with cells of *V. anguillarum* and fed so that each fish received 300 ug during a 14 day period appeared to confer significant protection to fish. Further experimentation employing levels of vaccine at 100,200, and 300 ug per fish over a 14-day period has again indicated that vaccination against vibriosis is feasible.

The use of vaccine boosters fed after the initial 14 days did not appear to enhance protection already afforded the experimental animals. Experiments concerning oral immunization of salmonids for disease protection are being continued at this laboratory.

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* This work was supported by the Oregon State Game Commission.

** Paper presented by J. L. Fryer

SEROLOGICAL TYPING AND CONTROL OF CYTOPHAGA PSYCHROPHILA THE CAUSITIVE AGENT OF BACTERIAL COLD-WATER DISEASE [1/]

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A characterization study of 25 myxobacterial strains isolated primarily from cold-water diseased salmonids, deformed juvenile coho (*Oncorhynchus kisutch*), and adult coho salmon was conducted. Morphological, cultural, and physiological tests showed these isolates to be closely related. Six of these isolates were examined for their ability to produce fatal infections in juvenile coho salmon when injected subcutaneously near the adipose fin. All six strains produced death in fry with gross pathology identical to that observed in typical clinical cases of bacterial cold-water disease. A serotyping study of five of these isolates demonstrated that all possessed common antigens and were serologically homologous. The data concerning isolates from both the deformed juvenile coho and adult coho salmon indicate that these organisms are identical to the causitive agent of bacterial cold-water disease *Cytophaga psychrophila*.

A nitrofuran, Furanace, was tested for its *in vitro* and *in vivo* activity against the agent of bacterial cold-water disease. Furanace (P-7138) had a minimal inhibitory concentration of 0.06 ug/ml for *C. psychrophila*.

In vivo experiments at Siletz Salmon Hatchery were conducted from January to March 1969. Yolk-sac fry were bathed in P-7138 at concentrations of 0.0 (control), 0.5 and 1.0 ppm for one hour every

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1/ This work was supported by the Fish Commission of Oregon, Portland, Oregon

third day. Once the fry were transferred to the concrete raceways, the 0.5 ppm treatment was continued twice a week. This 0.5 ppm P-7138 treatment applied throughout the cold-water disease period resulted in losses of less than 1.0% compared to 42% in the control group.

During this same period, terramycin incorporated in Oregon Moist Pellets (OMP) was evaluated for its ability to control bacterial cold-water disease. One group received no medication (control) and two groups received the terramycin at a level of 30 gm/100 lbs. fish/day for four weeks followed by 15 gm/100 lbs. fish/day for the duration of the experiment. Fry in one of the treated groups had previously been exposed to 1.0 ppm P-7138 treatments (for a one hour period every third day) as yolk-sac fry. A 29% loss due to bacterial cold-water disease was suffered in the control group. The terramycin treated group lost 14% and the group initially exposed to P-7138 followed by terramycin treatments suffered only a 2.1% loss. These results indicate that treatment of the yolk-sac fry with 1.0 ppm P-7138 followed by administration of terramycin medicated OMP greatly reduced the loss of fish due to bacterial cold-water disease.

A PROGRESS REPORT ON FURANACE (P-7138)

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Western Fish Disease Laboratory

Furanace (P-7138), a nitrofuran, has been tested on a variety of fish pathogens. The most successful treatments have been against myxobacterial infections. Single or two daily 1-hour treatments at 0.5 or 1.0 ppm active ingredient effectively controlled cold-water disease, myxobacterial gill disease and columnaris disease under a variety of production trials. Treatments against _Aeromonas_, _Pseudomonas_, _Vibrio_, and protozoan infections appear less effective.

Experiments show that drug concentration, frequency of drug administration, and water temperature affects the toxicity of Furanace. Single 1-hour treatments up to 10 ppm are not toxic, but multiple treatments administered 24 hours apart can be toxic and the death rate increases with each treatment. Also, higher water temperatures result in increased death rates when more than one treatment is administered. However, using recommended dosage levels and under normal hatchery conditions, no toxicity has been observed.

Palatability problems were encountered when the drug was fed to coho salmon at 25 mg/kg and above.

The drug may be commercially available in 1970. Caution must be exercised to prevent the misuse and abuse of this new drug. It should be used only after the disease has been diagnosed and excessive treatments should be avoided.

OCCURRENCE OF THE PROTOZOAN FISH PARASITE CERATOMYXA SHASTA IN THE COLUMBIA RIVER BASIN AND THE ULTRASTRUCTURE OF THE SPORE 1/

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The purpose of this report is twofold, (1) to summarize results from the *Ceratomyxa shasta* distribution studies and (2) to describe the ultra-structure of the spore stage of this parasite.

Live-box experiments with juvenile salmonids indicates that infections caused by *C. shasta* could occur in portions of both the Deschutes and Columbia River basins. Major exceptions in the Deschutes River basin were the mainstream Deschutes River above its confluence with the little Deschutes and in the Metolius River. Although infections were not found in fish recovered from the Metolius River, other observations suggested the infective stage of *C. shasta* was present. This parasite was found in fish recovered from Suttle Lake. Suttle Lake is drained by Lake Creek which then flows into the Metolius River. The occurrence of the disease in the Crooked River may result from contamination with irrigation water originating from the mainstream Deschutes River near Bend, Oregon. Numerous observations have indicated that juvenile fish become infected with *C. shasta* in the lower Deschutes near its confluence with the Columbia River. All live-box experiments in the Columbia River with juvenile salmonids have indicated that infections with *C. shasta* occur only in the Columbia River below its confluence with the Deschutes River. Juvenile salmonids can become infected with *C. shasta* in other tributaries of the lower Columbia River, principally the Cowlitz River. Examinations of juvenile salmonids reared in Oregon coastal river hatcheries have never revealed the occurrence of *C. shasta* infections and infected adult salmon have only been observed in streams (Trask and Nehalem Rivers) adjacent to the Colubmia River.

Results obtained with previously unexposed migrating adult salmon indicated that they can become infected with C. shasta. This tends to explain why infected adult salmon can be found in numerous Columbia River tributaries after migration through the lower Columbia River. Adult salmon infected with C. shasta have been found as far inland as Oxbow Dam on the Snake River.

Ceratomyxa shasta is widespread in salmonid fish throughout the Columbia River basin; however, results indicate the infectious stage of this disease is located in rather restricted areas. This information tends to suggest the infectious process involves one or more factors which are only present in certain locations within the area studied. These observations support those of Schafer (1968) in which he suggested the spore of this parasite may not be directly infectious to fish and that transmission may involve some stage other than the spore.

The ultrastructure of the spore of C. shasta was examined by electron microscopy. Penetration of the embedding plastic into the spore was possible only when the specimens were placed in 10% formalin for an extended period of time.

The valves of the spore form knobs at the suture line similar to those of other myxosporidians. A septate desmosome was identified between the two valves similar to that described in Hydra (Wood, 1959). Within the sporoplasm are two vescicular nuclei with nucleolei, endoplasmic reticulum, electron dense circular bodies, mitochondria, and possibly ribosome packets. The polar capsule and filament of C. shasta are morphologically similar to those of other myxosporidians.

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1/ This work was supported by the Fish Commission of Oregon, Portland, Oregon.

A NITROGEN GAS DISEASE CATASTROPHE

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and

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A severe fish loss occurred at the FCO South Santiam Hatchery located immediately below Foster Dam on the South Santiam River, on September 5, 1969. About 271,000 yearling spring chinook and 114,000 fingerling summer steelhead, approximately 75 and 100% of the stock on hand, died of gas embolism.

The hatchery water supply flowed from two pipelines in the dam forebay. One line arose in the hypolimnion and the other from the epilimnion. These two join to form a single line supplying mixed water at 56° F. to the hatchery.

The pool elevation was such that the upper line was partially exposed and the grating guarding the opening into it was nearly plugged with debris. The upper line was not full of water so that a gas-water mixing chamber was created at this 3.3-foot opening.

In late September and early October, experiments were conducted to determine safe procedures for running this water supply system and to simulate the conditions during the fish loss. A summary of the results of the simulation experiments are included below.

Water Analysis

When the conditions of September 5, 1969 (the date of the large fish loss) were closely approximated the per cent saturation levels of N_2 gas were found to be 175 in the screening box and 152 in the Burrows ponds.

Pathology 1/

Gas emboli were seen in the fins, under the epithelium of the roof of the mouth, dorsal aorta and gill filaments. In most cases massive gill damage occurred.

Behavior

Fish did not appear to be aware of the lethality of the environment in which they were found. Morbidity occurred 2 minutes after they first showed signs of abnormal behavior.

Mortality

The first fish died between 85 and 115 minutes after exposure and an LT 100% (N = 476 fish) occurred at 295 minutes.

A paper which further details the above data is being prepared for publication.

1/ Fish used for biological assay were spring chinook fingerlings, averaging 20 per pound.

SCOLIOSIS AND LORDOSIS OCCURRING IN SALMONIDS

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Western Fish Disease Laboratory

Scholiosis and lordosis have been observed frequently in hatcheries. Etiologically the various diseases which may result in the spinal curvature can be categorized as follows:

1. Protozoan
   a. Myxosoma cerebralis - whirling disease of trout
2. Fungal
   a. Ichthyosporidium (Ichthyophonus)
3. Bacterial
   a. Cytophaga psychrophilia - (Cold-water disease) or ("low temperature disease") or ("peduncle disease")
4. Viral
   a. Sockeye salmon virus diseases
      1) Columbia River sockeye diseases
      2) Oregon sockeye disease
      3) Infectious Henatopoietic necrosis
5. Nutritional
   a. Vitamin C deficiency
6. Idiopathic
   a. Whirling coho disease
7. Miscellaneous
   a. Genetic
   b. Injury

THE PACO FISH TRANSFER PUMP

James G. Leach
Pacific Pumping Company

History

The pump industry has developed the most efficient method of transferring liquids and products during the past century, with the exception of gravity.

One of the developments of the pump industry has been the food handling pump -- an especially designed clogless centrifugal pump -- used to transfer fruits and vegetables in all aspects of the food processing industry.

Dead fish and seafood have been pumped with this type of equipment since the late thirties; however, in the mid-fifties studies were made on the effect of live fish being passed through hydraulic turbines and pumps.

In 1967, the State of California, Department of Fish and Game, purchased one of our 5" pumps and ran exhaustive tests at one of their hatcheries near Sacramento. Their Anadromous Fisheries Administration Report 69-1 (March, 1969) on "The Effects of Pumping Juvenile King Salmon Through a Pump" attracted the interest of several other fisheries departments. Early this spring additional tests were conducted with their unit by the State of Oregon, near Astoria, Oregon.

As a result of these tests, Pacific Pumping Company designed and built a complete trailer mounted pumping unit with the proper power unit and speed reduction in order to offer a complete fish transfer unit to the industry.

In addition, the pumps were further modified so that within the pump impeller and volute the curvatures are of such design that there is minimum wall contact. Each impeller and volute is hand finished and polished to assure any imperfections in the castings are removed to provide the smoothest water passages possible.

Since June, there have been additional tests with the 5" pump and larger units on different species of salmon and larger salmon, the last of which was concluded in September pumping 14 to 19" long Coho or Jack Salmon. Our short film which we are making on fish transfer shows some footage of this latest test.

Our 6" pump was used in Northern California in a series of successful tests on transferring Channel Catfish. Additional tests have been made in Stuttgard, Dumas, Kelso and McGehee, Arkansas, at various governmental agencies experimental farms, and large commercial farms. Transferring of Channel Catfish up to 19-1/2" long was successful without any damage to the fish. A detailed report will be written later.

THE MOVIE - "THE PACO FISH TRANSFER PUMP"

Federal and state agencies have since 1949 been cooperating in developing and increasing the salmon and steelhead runs in the Columbia River. Recently, a special team of state and federal agencies planted 6.5 million fall Chinook in a step toward developing salmon in the Willamette River.

The PACO fish transfer pump played an important part in this transfer. Loading a fleet of six stocking trucks with a combined carrying capacity of 6,000 lbs. of fish required new methods deviating from the old dip net and weight method.

Here, at the White Salmon Hatchery, the fish are crowded into one end of the pond, pumped into a separation box at the rate of 300 lbs. per minute so they are never handled and are only out of the water for a split-second during their drop from the separation box into the tank truck. The weight and number of fish in each truck is then determined by the displacement of the water in the truck.

This joint effort by the U. S. Bureau of Sports Fisheries and Wildlife, Oregon Fish Commission, Oregon Game Commission, and Washington Department of Game delivered the fish in their refrigerated trucks over the Bridge of the Gods, through the City of Portland to a destination on the Willamette River near Corvallis.

The footage shows further testing of the 6" fish transfer pump at the Bonneville Fish Hatchery. Each year salmon called Coho or Jack Salmon return with the mature salmon and have to be separated. These salmon are 14" to 19" in length. Tests were made over several weeks, pumping and repumping these larger salmon to determine the mortality rate. The results were excellent and during September a demonstration was made to state hatchery and governmental officials showing the capabilities of this pump. After pumping 500 salmon, they were contained in a front loader and dumped to examine them for damage and to see if any of the salmon had to be tagged.

Further footage of film will be made as more varieties of fish are successfully transferred.