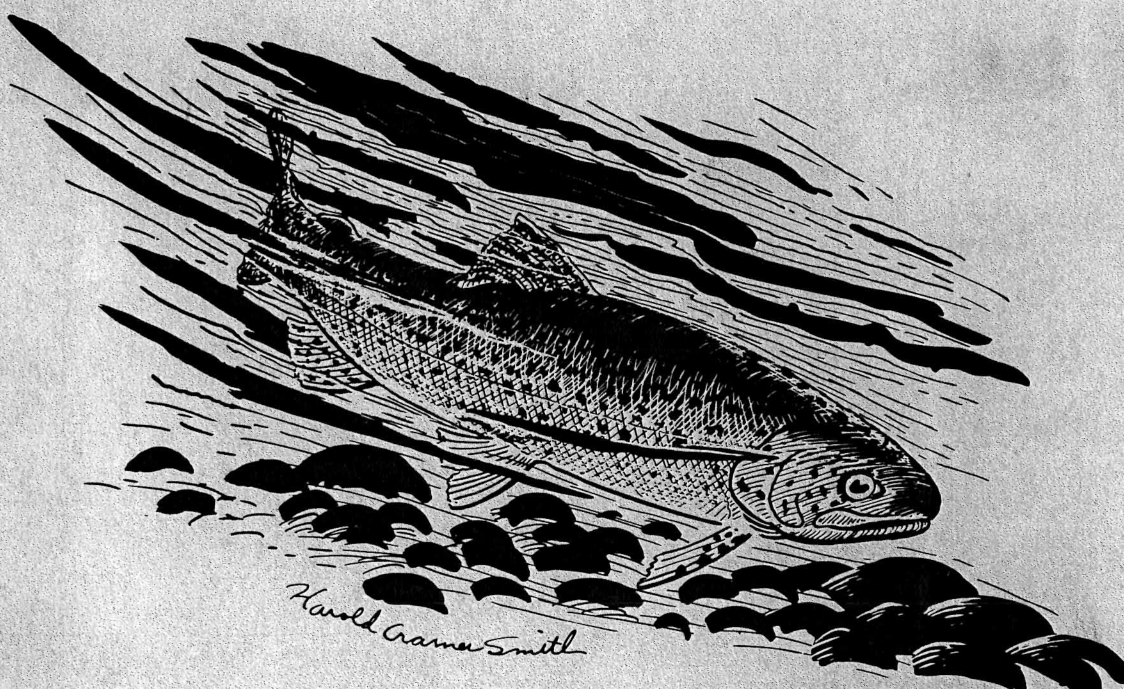
NORTHWEST FISH CULTURE CONFERENCE



Portland, Oregon
December 5-6, 1961

1961

TWELFTH ANNUAL

NORTHWEST FISH CULTURAL CONFERENCE

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A mighty "thanks" is extended to those of you who participated in the fish cultural conference in Portland, Oregon in December of 1961. Your contributions as authors for the following abstracts and your attendance at the meeting contributed to the success of the 1961 conference.

The abstracts as herein presented have been edited only for clarification and typographical errors.

Permission to reproduce any of the enclosed abstracts must be obtained from the respective authors.

Mr. Roger E. Burrows, Salmon Cultural Laboratory, Bureau of Sport Fisheries and Wildlife, U. S. Fish and Wildlife Service, Longview, Washington, was selected chairman for the conference in 1962

Chris C. Jensen
Chairman, 1961

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THE CONTRIBUTION OF HATCHERIES TO ANGLING

William Hagen
U. S. Bureau of Sport Fisheries and Wildlife

A number of examples of successful hatchery stockings of fish are presented. Primarily, it is proposed that those who write and publish on the failures of hatcheries might consider being more objective; i.e., why are the reported hatchery plants not successful and why are changes not recommended to permit more of these fish to enter the catch.

NOTES FROM "COAGULATED YOLK DISEASE CONFERENCE"

Robert Rucker
Western Fish Disease Laboratory

A fish disease, or complex of diseases, usually referred to as "coagulated yolk disease" has resulted in severe losses of salmon and trout for many years. Recently it was thought that a coordinated study of this disease might aid in the solution of the problem. Accordingly, the Bureau of Sport Fisheries and Wildlife invited various interested agencies to participate in a conference in Portland on May 1 and 2, 1961. I was asked to act as chairman.

First, a definition of "coagulated yolk disease" was agreed upon: "A mass or number of masses of denatured protein within the yolk sac of fry and in the body cavity of first-feeding fingerlings." We then listed the possible causes of coagulated yolk. There were twenty men present and twenty causes were listed: bacteria, viruses, protozoa, coelenterates, leeches, electricity, rough handling, pressure (physical and gaseous), light, cold water, warm water, low oxygen, rust, malachite green, cation - Zn, Cu, Al, Cd, waste products, toxins (saprophytic bacteria), heredity, maturity of females, and water composition. Each was thoroughly discussed with supporting evidence, and also evidence to negate each of the factors as the cause. Hence, the picture is definitely confused. Certain factors appeared to be more suspect than others and some groups chose to work on some of these possible causes.

Histopathology: Western Fish Disease Laboratory

This study is to determine the site of affliction, absorption of the yolk (normal and abnormal), and the pathology of these conditions.

Heredity: Little White Salmon Laboratory

This study will utilize two types of incubators, one of which has caused coagulated yolk on two previous occasions. Eggs from individual females will be observed.

Bacteria: Washington State Department of Fisheries and Oregon Fish Commission

This experiment is to determine whether coagulated yolk disease can be induced by subjecting eggs and/or fry to bacteria recovered from afflicted fry.

Temperature: California Department of Fish and Game

Study the effects of water temperature on eggs and fry.

Malachite Green: Little White Salmon Laboratory, Oregon Fish Commission, and Washington State Department of Fisheries

This experiment is to determine the effects upon eggs and fry of various batches of malachite green.

Water Chemistry: Western Fish Nutrition Laboratory

Study the effects of water components on eggs and fry.

THE RELATIONSHIP OF WATER CHEMISTRY TO THE DEVELOPMENT OF COAGULATED YOLK DISEASE IN CHINOOK SALMON LARVAE

A. N. Woodall, Research Chemist
Bureau of Sport Fisheries and Wildlife
Western Fish Nutrition Laboratory

Various heavy metal ions are known to be toxic to fish in all stages of development. It is also known that the galvanic action of natural soft waters is markedly increased by the addition of carbon dioxide. Thus, heavy rains passing through decaying vegetable matter and thence into a water source could create a potentially hazardous condition if the pH were lowered and carbon dioxide content increased. Since hatcheries commonly have both galvanized pipe and brass valves in their water supply lines, which could give rise to toxic levels of zinc and copper, under adverse conditions, the variation in water chemistry is being followed throughout the incubation period at three hatcheries in this area in order to determine if changes observed can be correlated to the incidence of "coagulated yolk" disease.

In addition, the effect of three low levels of zinc and the protective effect of added calcium ion on the embryonic development of chinook salmon is being investigated.

PROGRESS REPORT ON "BAD-EGG" STUDIES

John F. Conrad, Research Division
Fish Commission of Oregon

A condition termed "bad" or "rotten" eggs has been noted by Oregon fish culturists in Columbia River fall chinook females since the early 1940's.

"Bad eggs" are characterized in the fish by a milky-grey or bloody discharge from the vent when females are tested for ripeness. Incision of afflicted females for spawning almost always reveals some or all of the following symptoms: (1) few to many enlarged white (dead) eggs are scattered in small groups or located individually on the surface of the ovarian mass immediately beneath the mesentery, (2) there is usually a cluster of diseased ova located centrally within the ovary at the anterior origin or point of attachment, (3) abnormal sexual maturation is evidenced by the presence of loose, free-flowing eggs in one ovary only or in portions of either or both ovaries, or the eggs of both ovaries are tight in the skeins. Loose eggs from the same ovary may be glassy and hard, with glossy "bulls-eye" patches on their surfaces, or they may appear normal in color, shape, and texture. Sometimes one or both ovaries are bloodshot and are blackish-purple. This last symptom may be due to a severe bruise.

Diseased ova have been observed in steelhead trout and silver and spring chinook salmon at certain Oregon Fish Commission hatcheries during various spawning seasons, but the incidence has been much lower in these species than it has in fall chinook.

"Bad eggs" were observed in many fall chinook ovaries in the canneries at Astoria during the 1960 season. This indicates that the condition is either present in fall chinook in the ocean or develops soon after the fish enter the Columbia on their spawning migration.

Diseased ova were observed in 5 of 28 fall chinook females examined in November of this year at the Oxbow Dam salmon holding pond on the Snake River. Fall chinook have not been artificially propagated in this area in recent years, and I am indeed glad to report that the bad-egg condition in this region is not necessarily of hatchery origin.

At some of our fall chinook stations, especially during years of plenty, all eggs from known bad-egg females are discarded. This practice seems to have evolved through the belief that the progeny of bad-egg females would be, for the most part, weak, abnormal fish, and that the fingerling survival to liberation would be too small to warrant the extra labor required (excessive egg picking, treatment, etc.) during egg incubation and fry development.

In order to test this assumption, an experiment was set up at the Sandy Hatchery during the 1960 spawning season to determine what survival from egg to fingerling liberation could be obtained with eggs from diseased females.

The test animals were from 10 obviously bad-egg fall chinook females spawned at the Oxbow Hatchery. The total yield was 31,866 eggs (actual count). These eggs, with an equal number of eggs from normal females, were transferred to the Sandy Hatchery soon after they were eyed. Incubation of both lots was completed at Sandy, and the resulting progeny were reared to liberation there, in 4 separate hatching troughs--2 troughs to each lot.

The percentage of mortality for both lots is as tabulated in Table I. Mortality from the good eggs, while at Oxbow, is unknown. Total egg, fry, and fingerling mortalities are given for the bad-egg fish, and mortalities are shown for the good-egg lot after arrival at Sandy. The 61.4 per cent fingerling survival in the bad-egg lot is rather impressive. The 36 per cent egg loss in the bad-egg fish represents only the loss from eggs actually collected. If an average fecundity of 5,000 eggs per female is accepted for fall chinook, then 18,134 eggs were retained in the 10 females spawned. This brings the total egg loss, figured on a potential of 50,000 eggs, to about 59 per cent.

Table I

1960 Sandy Experiment, Per Cent Mortality
Eggs to Liberation - 31,866 Eggs = 100%

Good Eggs				Bad Eggs			
Mortality			Survival	Mortality			Survival
Egg	Fry	Fing.		Egg	Fry	Fing.	
1.20	6.50	0.10	92.2	36.0	2.50	0.10	61.4
				50,000 Egg Potential - 10 females			
				59.2			

The significant survival obtained in the small-scale Sandy experiment indicated that perhaps over 50 per cent liberation survival could be expected from some bad-egg females and manifested the need of similar studies to determine if comparable survivals could be economically obtained on a hatchery production basis.

Accordingly, an experiment, now in progress at the Oxbow Hatchery, was designed around two primary objectives: (1) determine if a large-scale replication, at Oxbow Hatchery, of the Sandy experiment would result in a comparable percentage survival and (2) determine the amount of additional labor required for the care of bad-eggs to liberation over an equal amount of good eggs.

Some information on the second objective may be realized from the current Oxbow study, but the experiment can hardly be considered production-wise as only 68,000 bad eggs were taken at Oxbow Hatchery this year.

PROGRESS REPORT ON THE COLEMAN VIRUS PROBLEM

John Pelnar
Coleman National Fish Hatchery
U. S. Bureau of Sport Fisheries & Wildlife

Last year I reported on various facilities made use of in our study of the Coleman Virus Disease, and that a means of by-passing this condition was believed possible.

The one possibility of getting around the trouble appeared to be an increase in water temperature to 56°F. We set up a circulating system in ten-deep type troughs. The water used was the regular creek water having a varied temperature from 45°F. to 52°F. Pumped well water of 62°F. was added to bring the mixed flow to 56°F. Approximately 30 GPM of mixed water was injected into the system and the same amount wasted. The circulated flow was 10 GPM per trough, involving the 10 troughs.

Eyed chinook eggs selected at random from various egg-takes were used in the work. These takes and the controls spanned the major part of the season egg collections.

In all control groups, the virus trouble was very apparent and heavy mortalities resulted.

Eyed eggs placed in the re-circulated water hatched out and passed through the sac stage in apparent normal condition. Upon passing into the fingerling stage, a known number were transferred to regular water and like numbers were retained in re-circulated water. There was no visible evidence of the virus in either group, and length of time in re-circulated water, after passing out of the sac stage, made no difference. It appeared that if the fry remained in 56°F. water to the swimming stage, they did not become troubled with the virus. This repeated itself in all samples of the takes held in 56° water, whereas all control groups did show evidence of virus and most of the production takes at the hatchery developed the virus trouble.

The fish resulting from the re-circulated water works were moved to outside rearing ponds and held over summer. It was further interesting to observe that, while the production groups in adjoining ponds seemed to be constantly troubled with parasites and disease for some time in the spring, these fish from the re-circulated groups appeared to be more vigorous and free from parasites.

A wide selection of egg-takes was used in this program, involving takes number 7, 9, 10, 11, 12, 17, 18, 39, 40, and 42. Control groups were also maintained in the original takes. Approximately 750,000 eyed eggs were used in the re-circulating program and 250,000 in the control groups.

No records were maintained of mortality in the control groups as, once visible evidence confirmed that the virus was present and the mortality reached the customary high level, these controls were disposed of.

From the 750,000 eyed eggs in the system, 638,000 fish were placed in ponds number 1 and 6; during March, 50,000 were returned to the hatchery program for release; and the remaining 61,000 were considered mortality from mechanical and system failures. At this time, because of the higher rearing temperature, these fish were considerably older in age than the control groups. There was no evidence of mortality due to the virus.

The 638,000 fingerlings, weighing 2,627 pounds at 350 and 190 per pound, were placed in ponds number 1 and 6, reared therein until July, when 900 pounds at 100 per pound were removed from pond 1 and planted. Pond 6 was split and placed in ponds 6 and 7. They were reared in these ponds into October when the usual fall release is made. From pond 1 we released 196,785 fish weighing 5,178 pounds at 38 per pound. Ponds 6 and 7 produced 11,609 pounds of fish at 26 per pound, or a total of 302,700 fish.

The circulating system produced, from the original 750,000 eyed eggs, 650,000 swimming fish of which 590,000 were yearlings. We had a known mortality of approximately 61,000 during the egg and sac stage largely due to mechanical failures in the system and 39,000 fingerling loss from March to October in the ponds. The total, over-all loss from causes other than the virus was 14 per cent. This is a high loss because of mechanical trouble in the development of the system. However, the present was considerably less than the over-all present mortality in the regular production of the hatchery, which was approximately 20 per cent.

This year we have set up an enlarged circulating system, as will be shown in the color slides. We are operating this system of 144-deep troughs on approximately 720 gallons per minute of fresh water, mixed from creek and pumped water. Four 4-inch pumps circulate the flow and four recovery points are involved. Normally, this section would operate on 2,160 GPM. At this time we have 12 million eggs and fry involved.

COOPERATIVE INVESTIGATIONS OF TROUT HEPATOMA

Alexander M. Dollar
College of Fisheries, University of Washington

Summary Report I - Hepatoma Research
November 22, 1961

At the Interim Meeting in September, 1961, on the trout hepatoma research programs, the College of Fisheries agreed to distribute a periodic report on the progress by the various research groups. This is the first such summary report. The groups represented in this report are the University of Washington, Tacoma General Hospital, Arizona, California, and hatcheries cooperating in the field experimental program.

California

The California Department of Fish and Game reports that there is no new development in the California experiments. No hepatoma has been reported in any lots of trout fed experimental diets at either Darrah Springs or Fillmore Hatcheries. Tissue samples from Darrah Springs have been received by the College of Fisheries for examination, but these examinations have not been completed.

Arizona

Dr. Barger met with us in Seattle the first part of October and explained the status of their studies. Briefly, they are continuing examination of liver samples from fish fed three commercial diets. These samples are taken at regular sampling intervals by P. L. McNeil, Jr. of the Arizona Game and Fish Department from trout held at the Page Springs Hatchery. He has a record of diets, food allowance, growth and gross morphological changes to correlate with the histological studies. One of Dr. Barger's assistants, a microbiologist, is planning to apply a cell culture technique as an adjunct to their hepatoma studies. In addition, the Arizona group is studying transmissibility by surgically implanting tissue from affected trout into other trout. Dr. Barger indicated he would select slides representing the development stages of tumors as represented by his more than 1500 samples. These samples were obtained from fish as young as three months old, and the sampling has continued for more than one year.

University of Washington and Field Experimental Results

The most notable result from the field trials to date is the growth of the control group of fish, Shasta strain, fed the Santa Monica diet. Trout raised in the 52-59°F. temperature range are growing at about the same rate in all locations. There is less than ten days' difference in the growth of these fish at 210 days of age. It is interesting to note that the hatchery having the largest fish at this stage is one of the lower temperature hatcheries. The significance of these results must await histological examination of tissue samples. In most groups of fish fed the Santa Monica diets there are obvious liver changes, and in a number of instances basophilic nodules are becoming apparent. This does not imply that these are true hepatoma. Further samples will be required at a later stage to confirm the nature of the changes.

At only two hatcheries has disease, not hepatoma, caused significant mortality on any of the experimental diets. As yet no antibiotic has been incorporated into diets for disease treatment.

The microscopic examination of liver samples during the past six weeks is reviewed briefly. For the examinations a minimum of five sections per tissue studied are examined before any decision is made regarding histological change. The evident value of using serial sections cannot be overemphasized, since about 5-10% false tumor positives would have resulted from the examination of a single section or a single slide preparation. The majority of these false positives are probably artifacts and would have been reported as Class III - eosinophilic nodules.

An additional feature noted in many trout livers is the presence of foci of chronic inflammatory response. The significance of these latter observations is unknown, and they have not been recorded except in cases where a substantial portion of the liver is involved. Nine of thirty-eight trout fed the control diet (Santa Monica formula) show a marked change. The change is not sufficiently well defined to warrant their inclusion in a specific category other than category VI. They are found to have a significant loss of architecture, anacytosis and widely dispersed sites of neoplasia. Later series of samples should clarify the nature of the change.

Eleven livers obtained from wild rainbow trout in Yukon Territory have been sectioned. These fish were all about 25-27 cm. long and were about 3 to 5 years old (scale measurements). They were caught in a stream between two lakes, neither of which contains rainbow trout. Evidently there was a paucity of food and the fish were suffering from inanition. One liver of the eleven has a well developed tumor, which apparently is a cholangioma. A second sample has a well-defined basophilic nodule, as well as extensive fibrosis and necrotic areas. All the remaining livers show marked degrees of anacytosis and varying degrees of hyperchromasia. It is quite evident that samples from less productive natural areas will require further sampling and comparison with samples from richer bodies of water.

Tacoma General Hospital

The studies at Tacoma General Hospital--Dr. E. M. Wood--are emphasizing the biochemical and chemical tests which can be used to detect tumor development without killing the fish. They have analyzed serum samples for protein and enzymes by chemical and electrophoretic methods. Their program will develop information that can be applied to comparative pathology of the tumors in relation to the physiology of the host. They hope to obtain as much information as possible from an older group of fish having extensive tumor development before these fish die or are destroyed.

This brief summary represents only some of the highlights of the research programs. It is hoped that anyone having information relating to the hepatoma problem will feel free to contribute that information for any future periodic report.

PRELIMINARY OBSERVATIONS REGARDING THE DISTRIBUTION OF CRYPTOBIA IN THE PACIFIC COAST STATES

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Prior to the initiation of this study[1] the four distribution records of *Cryptobia salmositica* Katz, a blood parasite of coho salmon, were from limited locales in the states of Washington, Oregon and California. The two original Washington records were from adult cohos (*Oncorhynchus kisutch*) taken at the Washington Department of Fisheries' salmon hatchery at Soos Creek, a tributary to the Green River, near Auburn, and from juvenile cohos captured in Swamp Creek, a tributary to Lake Washington near Seattle, (Katz, 1951). The only Oregon record was from juvenile coho salmon resident in Beaver Creek which flows directly into the Pacific Ocean south of Newport, Oregon (Davidson, Breese and Katz, 1954). The California records were from several species of fish in the Sacramento and Klamath River drainages (Wales and Wolf, 1955). Wales and Wolf chose to list the observed flagellates as the European species, *Cryptobia borreli* (Laveran and Mesnil).

The Fisheries Research Institute initiated, in 1960, a study of various aspects of the biology of this parasite. As a result, the presence of *Cryptobia* in several watersheds along the Pacific Coast of North America has been determined. In addition these flagellates have been found in several different species of Pacific salmon as well as in other resident fishes.

Blood smears from adult coho salmon were requested by biologists in Siberia, Alaska, British Columbia and Oregon. Some of the material submitted was negative for *Cryptobia*, but positive smears were obtained by Dr. Leo Margolis (Fisheries Research Board of Canada, Nanaimo, B.C.) and by Dr. Don Chapman (Oregon State University, Corvallis, Oregon). Dr. Margolis' positive smears for *Cryptobia* were from Hunts Creek and Chef Creek, on the east coast of Vancouver Island. Dr. Chapman's was from Deer Creek, a tributary of Drift Creek which flows into Alsea Bay, Oregon.

The present investigators assigned to this project have found *Cryptobia* in a single adult coho salmon taken in the gillnet fishery at the mouth of the Puyallup River, in adult cohos taken at Washington Department of Fisheries hatchery operations on the Samish River, the Noosack River, the Satsop River, the Soleduck River, the Willapa River, and the Nemah River.

The incidence of *Cryptobia* in undomesticated yearling coho salmon has been found to be very low, less than 1%, even in areas where the population of the leech vector (*Piscicola salmositica* Meyer) numbered in the thousands. Juvenile cohos in which *Cryptobia* have been found were of normal size and appearance. Because of this, it is believed that further study will establish that *Cryptobia* do not adversely affect the coho populations.

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[1] Supported by National Institutes of Health, Public Health Service Research Grant E-3664.

In addition to coho salmon, Cryptobia have been found in adult chinook, pink and dog salmon. In the fall of 1960 one adult chinook collected at Soos Creek was found harboring a light infection of Cryptobia. James Wood, Washington Department of Fisheries, submitted a smear from a fingerling chinook from the Skykomish hatchery that was positive for Cryptobia. Wales and Wolf (1955) found light infections in adult chinook salmon from California and reported heavy infections and high mortalities in yearling chinooks held at the Mt. Shasta hatchery.

One adult dog salmon taken at the Nooksack hatchery was positive for the parasite. Dog salmon examined at Finch Creek (Hoodsport, Washington) were negative for Cryptobia--although they were being preyed upon by leeches which contained the hemoflagellate in their intestine.

Blood smears from adult pink salmon were made at the Nooksack Salmon hatchery and at Glacier Creek, a tributary of the Nooksack, during September, 1961. A high percentage of the adult pink salmon was found to have extremely heavy infections of Cryptobia.

Observations to date suggest that the five species of Pacific salmon probably vary in their susceptibility to Cryptobia. Pink salmon apparently are readily infected and enormous numbers of parasites are found in their blood. Cohos are also readily infected, but Cryptobia occur only in moderate numbers in their blood (Katz, et al., 1961). Chinooks seem to be resistant to the parasite and are rarely found to be infected. Too few dog salmon have been examined to determine their relative susceptibility, but on the basis of the fish observed we suspect they are comparable to the cohos in this regard.

We have not yet observed Cryptobia in the adult kokanee and sockeye, but relatively few blood smears have been examined.

Cryptobia occurs in other species of fresh-water fish besides salmonids, mainly certain cottids and cyprinids. The hemoflagellate found in cottids originally was believed to be a separate species (Katz, 1951).

Positive infections of either Cottus rhotheus or C. aleuticus have been found at Soos Creek; Voigts Creek, a tributary of the Puyallup; the Elokomin; the Samish River; the Nooksack; the Kalama; May Creek, tributary to the Skykomish; the Satsop; the Tolt; the Dosewallips; the Pysht; the Humptulips Rivers; and Finch Creek at Hoodsport. Tributaries of the Lake Washington drainage now known to contain infected cottids are the Issaquah, North, and May Creeks. One specimen of C. beldingi, taken at Eagle Creek, Oregon, was also positive for Cryptobia. The hemoflagellate has not been found in C. asper or C. gulosus despite the fact that C. rhotheus and C. aleuticus in the same streams are infected. Cryptobia similar in appearance to C. salmositica have been found in the cyprinid, Rhinichthys cataractae, taken at Soos Creek, May Creek, tributary to the Skykomish River, and the Tolt River.

The observations we have made to date strongly suggest that Cryptobia salmositica is widely distributed in the streams of Western Washington and is probably present throughout the salmon streams of the northern Pacific rim. If funds become available, we hope to ascertain this distribution of Cryptobia by making extensive collections in Alaska, British Columbia, Oregon, California and in the Columbia River drainage.

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OBSERVATIONS ON MALACHITE GREEN AND ITS TOXICITY

J. W. Wood and R. L. Westgard
Washington State Department of Fisheries

The handling of malachite green for the treatment of eggs and fish invariably results in the staining of clothing, utensils, exposed skin surfaces, and working area. We have found that reducing agents such as sodium sulfite, sodium bisulfite, sodium meta-bisulfite, sodium hydrosulfite, and sulfur dioxide gas (produced by burning sulfur) will reduce the dye to its colorless form. Of the above, sodium sulfite is least expensive and more readily available than the other sulfite compounds and safer and easier to use than sulfur dioxide. Skin surfaces and work clothing are readily "cleaned" by a solution of sodium sulfite in water or by the dry chemical in the presence of sufficient water. The chemical should be rinsed from colored clothing after "cleaning" to prevent possible discoloration of the dyes in the clothing by the chemical. We have not observed the latter but it may occur with certain dyes used in dyeing cloth. Some color return on skin and clothing is usually noted upon continued exposure to water due to the oxidation of the colorless form of the dye to the colored form and a second "cleaning" with sodium sulfite is sometimes necessary.

Sodium sulfite is readily available at photographic supply stores. We are able to purchase the photographic grade of the chemical at the University of Washington medical stores for approximately $0.25 per pound in 5-pound lots. The price at photographic supply stores is usually higher.

The use of malachite green at a concentration of 1 p.p.m. for the treatment of adult salmon for columnaris disease and fungus infection was discussed at a previous Northwest Fish Cultural Conference. Subsequently, the dye has been used in treating adult chinook and silver salmon that had to be held for prolonged periods before spawning. However, the use of malachite green in treating silver salmon resulted in a loss of fish at two hatcheries. Observed syndromes preceeding death included lethargy, accentuated opercular movement, loss of equilibrium, and a change in external coloration. The change in coloration was quite distinctive in that the fish took on a calico appearance much like that observed in chum salmon at spawning time. Lethargic fish transferred to fresh, running water all died indicating the toxic reaction was irreversible under these conditions.

In experiments designed to determine the causes of this apparent toxicity it was found that silver salmon were much less tolerant of treatment than chinook. In a 2 p.p.m. dye concentration all adult silvers in a paired experiment died within a two-hour period. Adult chinook salmon in the same experiment successfully withstood treatment for four hours. The adults of both species were of various sizes, some chinook actually being smaller than most silvers, and the toxicity of malachite green to the silvers appeared independent of size.

In previous discussions, zinc has been circumstantially implicated in observed toxicities of malachite green to juvenile salmonids. The analysis in our laboratory of various lots of the dye, including the lot involved in the loss of adult silvers mentioned above, has failed to disclose any sample containing over 0.08% zinc. At a 1 p.p.m. dilution of the dye this would result in a zinc concentration of 0.0008 p.p.m. which is less than observed in most natural water we have tested and about 1/1,000 of that observed in acute zinc toxicity to yolk-sac fry in soft water at one of our hatcheries.

Laboratory experiments on juvenile silver salmon averaging 35 fish per pound indicate that malachite green increases in toxicity with an increase in water temperature. This relationship is shown in Figure 1. It was also found that water hardness influences the toxicity of the dye. This is shown in Figure 2. These curves merely demonstrate relationships and should not be interpreted as recommended treatment procedure for various temperatures and degrees of water hardness. It is obvious that extreme caution must be exercised in the use of malachite green under conditions of soft water and/or warm water. Also, adjustment of treatment level for both the prevention of toxicity and effectiveness of treatment is probably necessary for varying degrees of water hardness, water temperature, and organic matter in the water.

Sodium sulfite added to malachite green treated water in excess of 3.5 parts sodium sulfite to 1 part malachite green considerably reduces the toxicity of the dye. It is suspected that it also reduces the effectiveness of malachite green in treating fungus and columnaris disease but this was not investigated. In one experiment young silver salmon were found to successfully survive a 48-hour exposure to a concentration of 1 p.p.m. of malachite green "neutralized" at the end of one hour with 3.5 p.p.m. sodium sulfite. This suggests that sodium sulfite might be used advantageously under conditions not permitting adequate flushing of the dye from a pond following treatment or to reduce the toxicity of malachite green used in egg treatment where the effluent passes over fish.

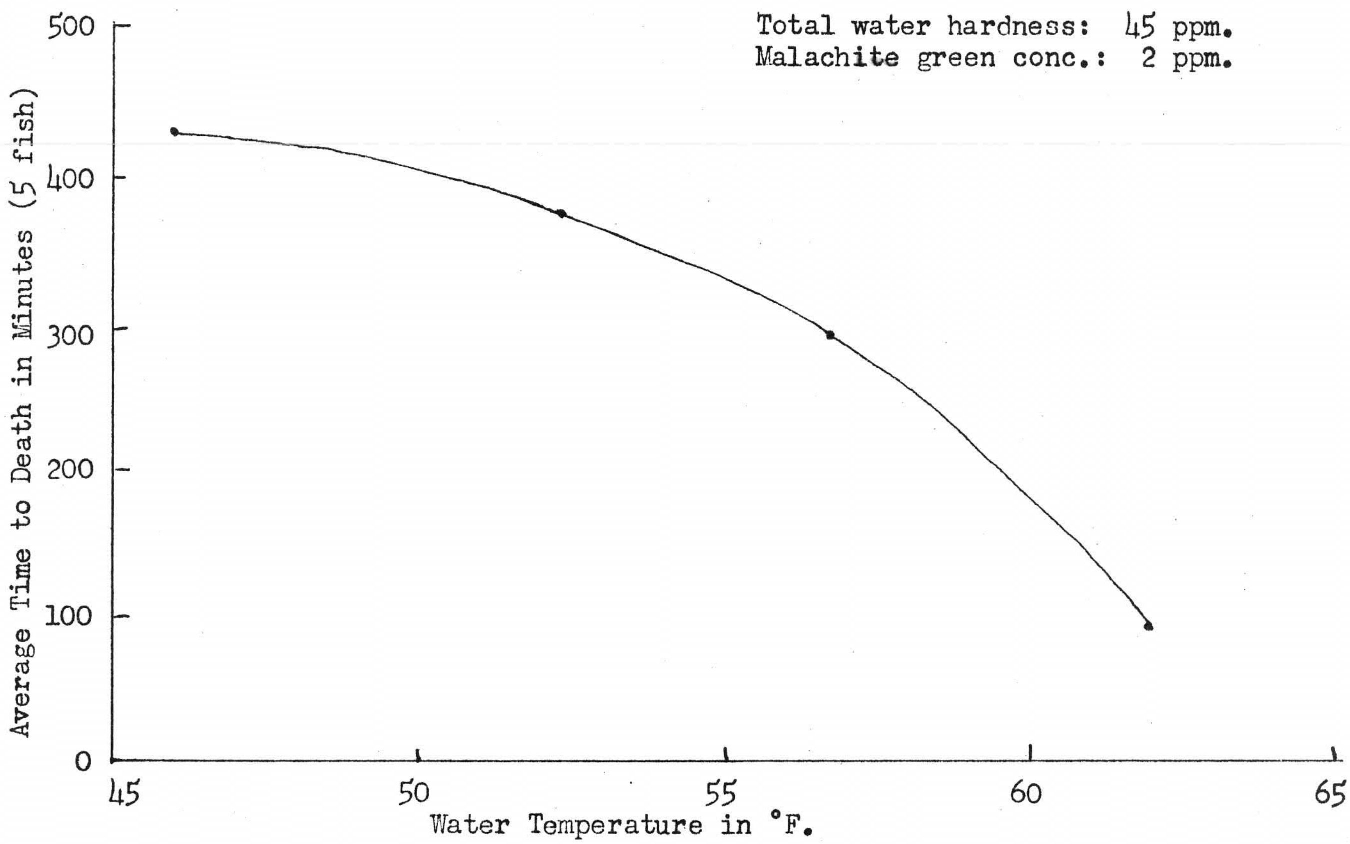


Fig. 1 Water Temperature vs. Toxicity of Malachite Green

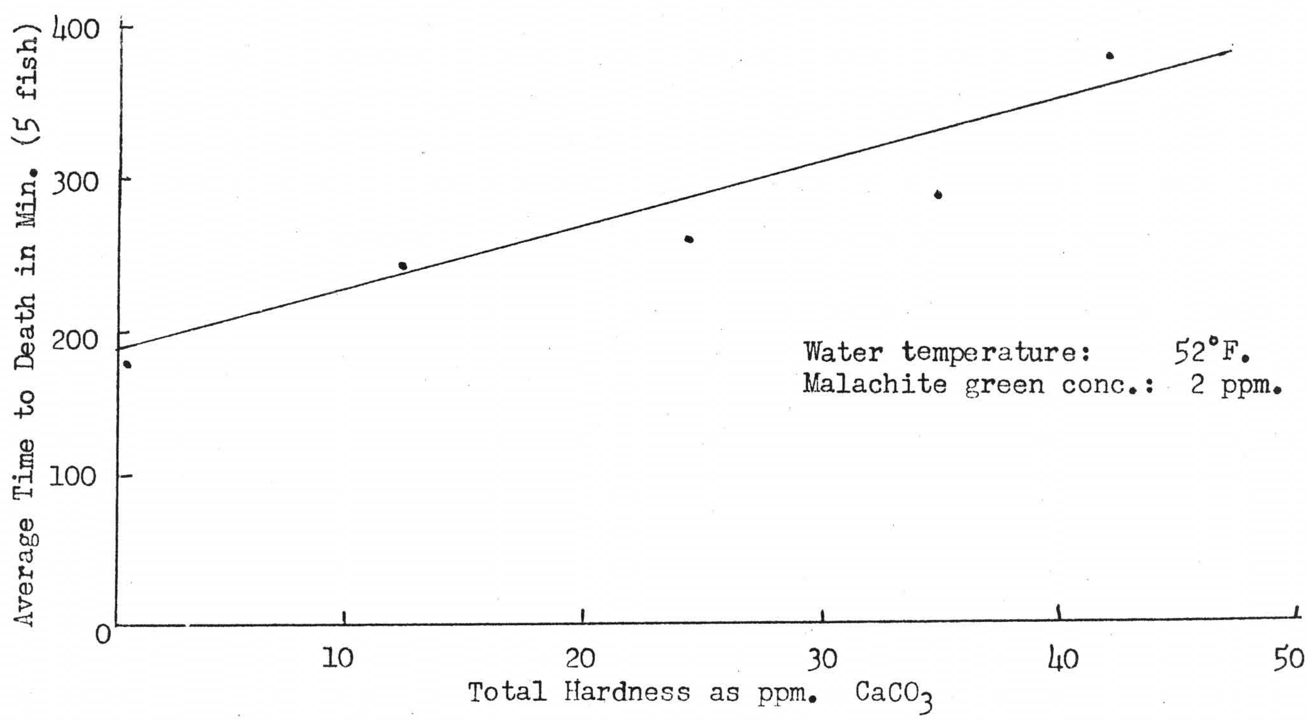


Fig. 2 Water Hardness vs. Toxicity of Malachite Green

IN VIVO EFFECTS OF FEEDING CERTAIN SULFONAMIDES TO SPRING CHINOOK SALMON—A PROGRESS REPORT

Donald Amend, Research Division
Fish Commission of Oregon

Introduction

Since the Oregon Fish Commission is now feeding the Oregon Pellet in production, the need has arisen to develop a better method of treating fish diseases with medicated foods. Sulmet (sulfamethazine) has been used at the rate of 10 grams per 100 pounds of fish in the regular diet of meat; however, experience has indicated that this level is toxic when used in the pellet. With this in mind, a series of four experiments was outlined to determine the toxic level of sulmet to spring chinook salmon as it is used in the Oregon Pellet, and to compare the toxicity, absorption and excretion rates, bacteriostatic activity, and therapeutic effectiveness of sulmet to two of the newer sulfonamides, Gantrisin (sulfisoxazole) and Madribon (sulfadimethoxine). At present only half of the experiments outlined have been completed.

The purpose of phase 1 of these experiments was to determine the level at which sulmet is toxic and to try and minimize the toxicity of this drug by introducing sodium bicarbonate into the diet. Bicarbonate of soda is used in humans to hasten the absorption rate and to help alleviate toxic complications. Sulmet was used at the rate of 5, 10, 50, 100, and 150 grams per 100 pounds of fish. Each group contained 50 fish. One series received sodium bicarbonate at a 1:1 ratio with sulmet and another series received no bicarbonate. Phase 2 was to extend the scope of the first phase, and to compare the toxicity and absorption rate of the two newer sulfonamides to sulmet. Gantrisin and Madribon were fed at the rate of 5, 10, 50, and 100 grams per 100 pounds of fish, and sulmet was fed at the 5-gram level. The drugs were substituted for a portion of the dry meal in the pellet; therefore, the amount of dry solids in the pellet remained the same.

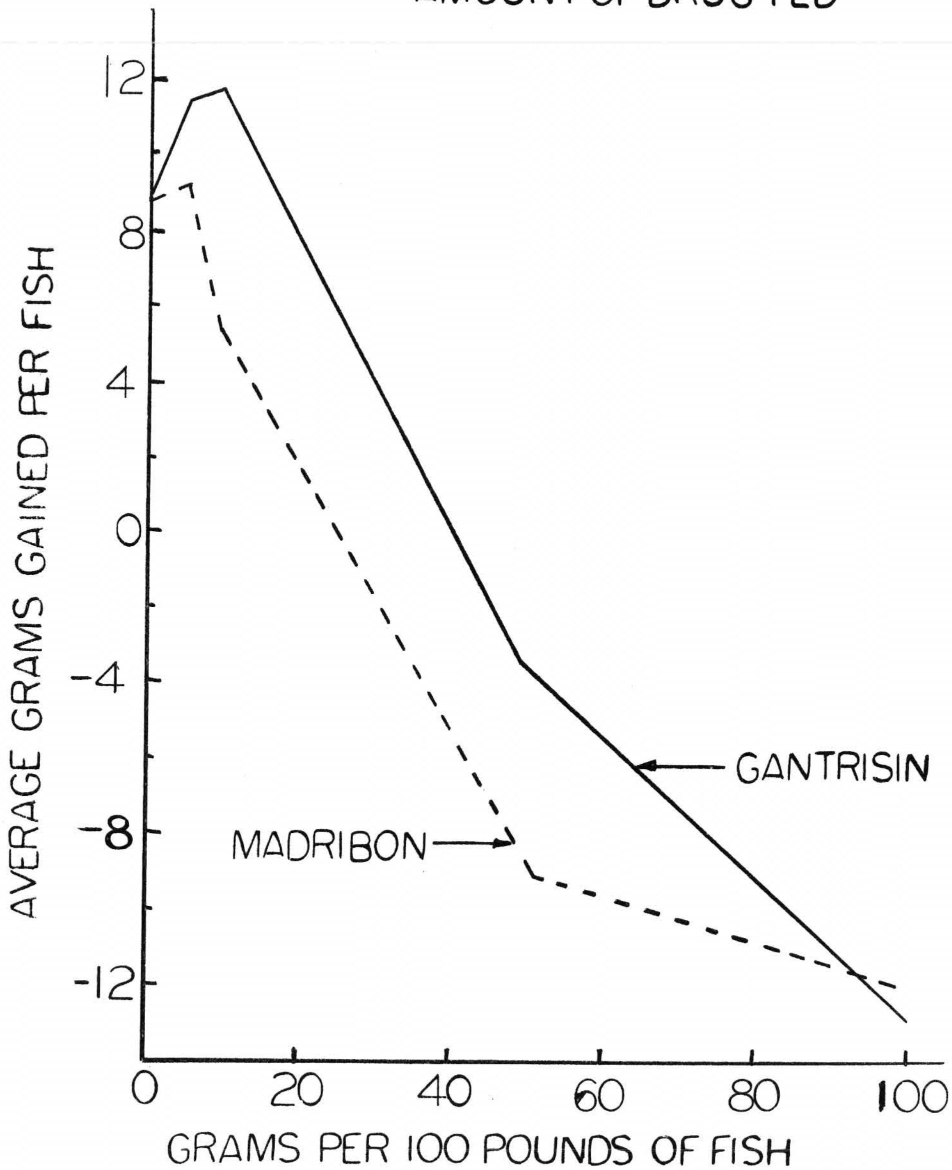
In both phases the average weight gains and mortalities were compared, and the absorption rates were followed in the blood at the two lowest levels of drug fed. The amount of food fed was based on the percentage of the body weight and the water temperature. All lots were fed for 30 days. The first phase was conducted in water temperatures in the low fifties (May-June 1961) and the second phase in the high fifties (July-August 1961).

Results

Growth. In most cases there was a decrease in growth and feeding activity with increasing concentrations of sulfa. Figure 1 illustrates this point and also shows the greater effect of Madribon on the growth rate. Gantrisin showed growth stimulating properties at the 5 and 10-gram levels, but Madribon was only equal to the control at the 5-gram level and showed progressively less growth with increasing amounts of the drug. In the first phase, the 5-gram level of sulmet also showed growth stimulating properties,

FIGURE 1

WEIGHT GAINED IN RELATION TO AMOUNT OF DRUG FED



but the 10-gram level and the 5 and 10-gram level of sulmet with bicarbonate were similar to the control. It was concluded that the reduced growth rates at the higher concentrations of sulfa were due to the refusal of the fish to eat the food and not because of any growth retarding properties. In general, the fish ate sulmet and Gantrisin better than sulmet with bicarbonate and Madribon, especially at the higher concentrations.

Sulmet-fed fish showed less growth than the control in the second phase. It was during this phase that the mortalities were excessive in this lot. The fish ate very well until the mortality rate increased, then they almost stopped eating. The decrease in the feeding activity and the increase in the mortality rate started after the 12th day. Higher water temperatures during the second phase were thought to be the reason for the difference between the two phases.

Toxicity. In all cases there did not seem to be a direct toxicity from any of the drugs tested, but secondary complications, mostly due to gill fungusing, caused mortalities in almost every lot fed sulfa drugs. These secondary complications did not appear until the 12th day and became progressively worse. Over 90 per cent of the mortalities occurred after the 12th day.

In the first phase the mortality rate was low, with most of the fish dying within 10 days after the drug was taken off the diet (Table 1). There did not appear to be any correlation between the concentration of the drug fed and the mortality rate, but there were 27 per cent fewer mortalities in the lots fed sodium bicarbonate. In the second phase the mortality rate was higher with the 5-gram lot of sulmet and the 50 and 100-gram lots of Gantrisin suffering most. With the fish fed Gantrisin there appeared to be a direct relationship between the concentration of the drug fed and the mortality rate. The higher the concentration the more mortalities occurred, and there was a distinct difference between the 10 and 50-gram levels. The fish fed Madribon did not show this relationship as well for they did not eat the medicated food as readily. It was concluded that sulmet at the 5-gram level and Gantrisin above the 10-gram level can be dangerous under the circumstances described in this paper.

Absorption and Excretion Rates. No difference was found in the absorption rates between sulmet with and without bicarbonate. After 14 days of feeding, the concentration of sulmet in the blood steadily increased until it reached a peak then remained relatively constant. In humans, levels between 5 and 15 mg. of sulfa per 100 ml. of blood is considered satisfactory and the 15 mg. level is surpassed only with extreme caution. Figure 2 shows that the 5-gram level of sulmet is within safe limits, but the 10-gram level greatly exceeds the 15 mg. maximum. The results were similar in both phases except that the peak concentrations were reached several days earlier in the second phase. It was theorized that the rate of absorption varied with the temperature of the water and the metabolic rate of the fish.

In the second phase the absorption rates were followed in the blood with all three drugs until peak concentrations were obtained. Gantrisin and Madribon reached peak concentrations within 12 hours in both the 5 and 10-gram levels, but sulmet did not reach peak concentrations until the second day with the 10-gram level and the fourth day with the 5-gram level. The maximum concentration of sulmet in the blood was 3 to 4 times greater than Gantrisin or Madribon in both the 5 and 10-gram lots. Since the bacterial sensitivity

Table 1

Mortality from Feeding Various Levels of Sulfonamides to Spring Chinook Salmon.

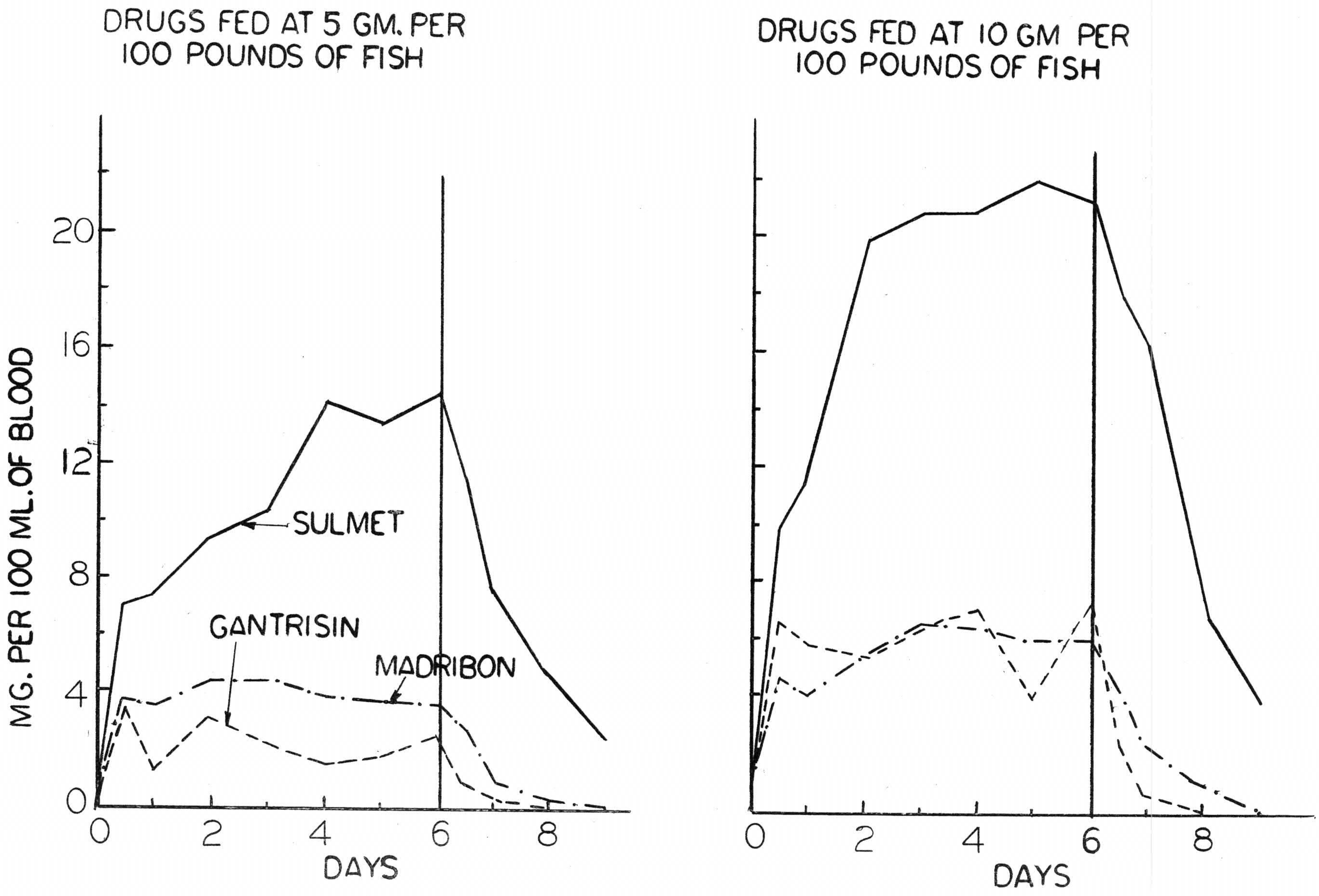
PHASE 1--MORTALITIES

		SULMET-No Bicarbonate					-With Bicarbonate				
Grams per 100 Pounds of Fish	Control	5	10	50	100	150	5	10	50	100	150
Mortality in 30 Days of Drug Feeding	0	3	2	2	1	0	0	0	2	1	1
Mortality 10 Days after Drug was Eliminated from the Diet	0	1	4	3	3	2	1	3	3	1	0
Total Mortality	0	4	6	5	4	2	1	3	5	2	1

PHASE 2--MORTALITIES

		SULMET	GANTRISIN				MADRIBON				
Grams per 100 Pounds of Fish	Control	5	5	10	50	100	5	10	50	100	Total
Mortality in 30 Days of Drug Feeding	0	35	2	8	31	27	5	2	12	12	147
Mortality 10 Days after Drug was Eliminated from the Diet	0	--	0	8	--	10	7	2	5	6	38
Total Mortality	0	35	2	16	31	37	12	4	17	18	185
Day that 50 Per Cent Mortality Occurred	--	28	--	--	25	30	--	--	--	--	

FIGURE 2


DRUGS FED AT 5 GM. PER 100 POUNDS OF FISH
DRUGS FED AT 10 GM PER 100 POUNDS OF FISH
MG. PER 100 ML. OF BLOOD
0
4
8
12
16
20
SULMET
GANTRISIN
MADRIBON
0
2
4
6
8
DAYS

tests have not been completed it is not known at what level these drugs are most active. Because sulmet is so much more concentrated does not mean that it is more effective. Minimum effective levels will be determined for each of these drugs in future experiments.

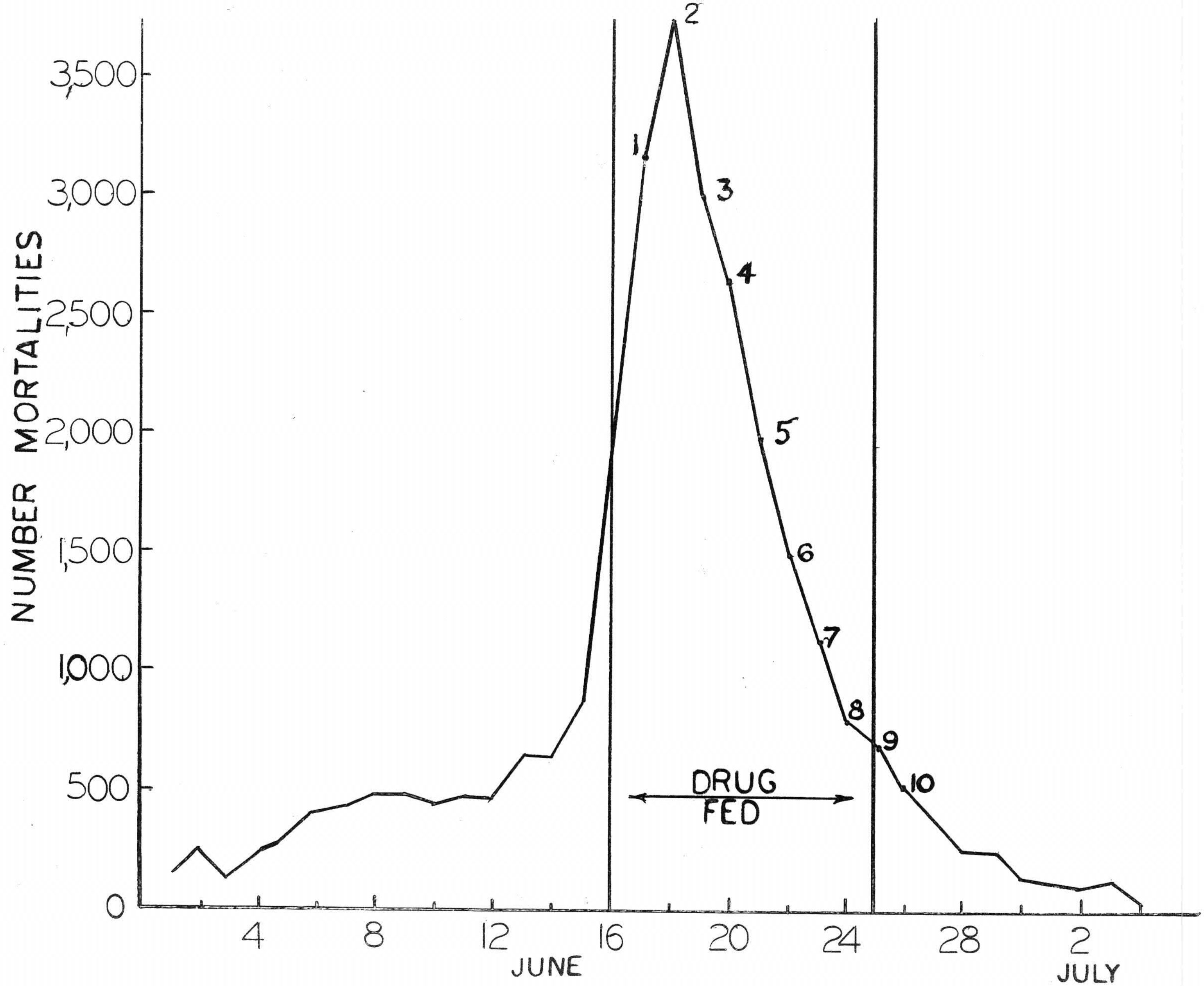
When all the drugs had reached peak concentrations in the blood, the drugs were eliminated from the diet and the excretion rates were followed for three days. The concentration of Gantrisin dropped considerably after 12 hours and was completely eliminated from the blood within two days. Madribon gradually decreased and was not detectable on the third day. Sulmet also decreased steadily but was still detectable in both lots on the third day. Although sulmet was still in the blood, both the 5 and 10-gram levels were below the minimum 5 mg. level stated earlier.

Conclusions

Pellet feeding seems to be an effective way of delivering drugs to fish. Some caution should be taken when feeding sulmet at the 5-gram level, especially at warm water temperatures. The 5-gram level of sulmet gave more favorable blood concentration, less mortality, and the fish ate the medication more readily than at the 10-gram level. An example of the effectiveness of the 5-gram level is given in Figure 3 which shows how it arrested a furunculosis epidemic at the Siletz Hatchery. The period of recovery from this epidemic coincides with the timing of the sulfa absorption data obtained in these experiments. Until the rest of the experiments are completed we will not be able to determine which drug will be the most effective and economical to use.

FIGURE 3

1961 SILETZ HATCHERY FURUNCULOSIS EPIDEMIC (SILVERS)
SULMET FED AT 5 GM. PER 100 POUNDS OF FISH



THE VIABILITY OF SILVER SALMON OVA AND SPERM AFTER HOLDING THE KILLED ADULTS FOR VARYING PERIODS OF TIME AS DETERMINED BY HATCHING SUCCESS

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The increased interest in the artificial propagation of the salmon species, offers of salmon eggs from commercially caught salmon, and the desire of undertaking added hybridization studies of salmon instigated an experiment designed to determine the effect on egg fertility of holding killed adult female and male silvers for various time periods.

The normal hatching procedure of artificially taking salmon eggs, by the Washington State Department of Fisheries, is to collect the "ripe" adults from the holding pond or trap, kill the fish, bleed the females and hold the dead fish in a water bath until the spawn is taken.

"What would be a detrimental holding time before egg removal from the female," is a question often asked by beginning and experienced hatchery men alike.

Smith and Quistorff, in their article, "Survival Capacity of Spermatozoa of the Chinook Salmon and Steelhead Trout," stated that chinook spermatozoa stored under the experimental conditions could be of use in practical fish culture after 5.0 hours retention in the dead males at stream temperature or after 2.5 hours storage in sealed vials at stream-water temperature. Steelhead milt stored in sealed vials for 2.5 hours resulted in hatching loss of 96.8 per cent and chinook milt stored in the same manner and for the same time resulted in a hatching loss of 9.6 per cent.

In the Minter Creek Biological Station Progress Report - Fall, 1956, p. 41, a sperm and egg viability experiment by R. J. Wiles demonstrated that chum spermatozoa, collected and held in a dry jar, sealed and held at water temperature (44°F.) for 2.5 hours resulted in a hatching loss of only 2.7 per cent.

The question not only concerns spermatozoa but also ova, and the experiment was designed to provide information concerning both ova and spermatozoa.

Methods and Materials

A total of six Heath egg and fry incubators, with 8 individual trays per stack, were set up on a spring water supply at the Washington Department of Fisheries, Green River Hatchery located near Auburn, Washington.

The physical structure and capacity of the incubators made it possible to have three primary groups--A, B, and C (2 stacks per group) with eight paired trays per group. This permitted testing the following: eggs from females held for specified time periods and fertilized with sperm from fresh males (Group A), eggs from freshly killed females and fertilized with sperm from males held for the specified time periods (Group B), and eggs from females which were held and fertilized with sperm from males held an equal time (Group C). The tests will be referred to by Group A, B, and C in the remainder of this paper.

The time periods used in the test were set up in a series of 0-2-4-6-8-12-18-24 and 32 hours with one replication for each time period. The eggs from each female maintained their identity and the fecundity of the females represented the number of eggs utilized for each period.

Procedure

A group of adult silver salmon was seined from the Green River holding pond and placed into a confined pen on November 22, 1960 for use in the fertility experiment. At 8:45 a.m. on this date, 28 females were tested for ripeness, killed and bled under normal hatchery procedures and placed into a water bath for holding along with an equal number of males. An additional 14 gravid females were held alive for use in Group B and 14 males held alive for use in Group A.

The six male and six female silvers utilized for the first time period (zero hour or control) were spawned immediately (8:45 to 9:15 a.m.), the eggs from each female being kept separate and sperm from two males used to fertilize the eggs from each female. The fertilized eggs were placed into trays and the trays inserted into the stacks under the designated Groups A, B, and C. The second egg-take (2-hour time period) started at 10:45 a.m. and was completed at 11:15 a.m., and the eggs from silvers representing Groups A, B, and C were placed into the designated trays. Technique and procedures were the same as for the control lot. The same procedures and time intervals were followed for the holding periods of 4, 6, 8, 24, and 32 hours.

The eggs were not counted at spawning time; the actual number in each tray was to be determined at the end of the experiment by counting the surviving fry when placed into rearing ponds and adding egg and fry loss that had been "picked off."

Rather than jeopardize any more silver eggs than necessary and to have hatching space for the 32-hour period, holding times of 12 and 18 hours were delayed until the general pattern of survival could be observed in the time periods under study. On December 5, 1960 fertility of eggs from several time periods in each group was checked by emersing a sample of 5 eggs in a glycerol solution and checking for development of the blastodisc. In Group A the 5 eggs from each of the lots held for 0, 4, 8, and 24 hours were tested and obvious mortality was observed only in the eggs held 24 hours. In Groups B and C complete mortality was indicated at the 6-hour period and heavy loss at the 4-hour period.

Using the fertility check as an index, the 12 and 18-hour time periods in Groups B and C were deleted from the experiment and the remaining test periods were completed on December 7, 1960. (Group A - 12 and 18-hour periods).

Results

The egg and fry survivals were used as the means of measuring the viability of ova and spermatozoa in the respective groups and time periods.

Although these tests were conducted under the heading of one experiment, in reality each group--i.e., A, B, and C--represents a separate test. The results are presented by group using the results from zero hour as the control for comparison. This is done in spite of the fact that a significant difference in survival of the individual control lots does exist--as determined by chi square. The average survival of 93.03 per cent (range 86.14 to 96.4 per cent) of the combined egg take (18,963) in the zero hour is used as the control figure for survival from egg to ponding of fry.

<u>GROUP A</u> - Representing female silver salmon which were killed for spawning and held for specified time periods and the eggs fertilized with spermatozoa from freshly killed males.

In Group A the silver eggs that had been held up through the 12-hour period but were fertilized with fresh milt had a successful hatch. Eggs in at least one replication within each time period demonstrated a survival as high or higher than the control. In the time periods 2, 4, and 12 hours, survival of eggs from one replication was significantly below the paired group and the resulting total survival on combined lots was thereby slightly lower than the control group. The success of the corresponding replication indicates that holding time was not the factor causing the abnormal loss.

The survival of eggs after 12 hours of holding the females was very poor (zero - 41 per cent) and would not be applicable to hatchery operations. The survival from the fry stage to the time the experiment was concluded--fry placed into ponds--was not greatly different up through the 24-hour holding period which indicates that holding time has very little effect (short term) upon the fry if the hatch is successful.

<u>GROUP B</u> - Representing male silver salmon which were killed for spawning and held for specified time periods and silver eggs from freshly killed females were fertilized by the spermatozoa from these held males.

In Group B it becomes obvious that the holding of the males was the determining factor in fertility. It was obvious from the results in Group B (Table 2) that beyond the 2-hour period the male spermatozoa were not effective in fertilizing eggs. The combined replications in the 4-hour lot gave an average survival of 43.52 per cent which suggests that the time limit of holding male silver salmon spermatozoa under the test conditions would be some place between the 2 and 4-hour period. As a safety factor, however, it would not be recommended that males be held after killing for more than the 2-hour period.

<u>GROUP C</u> - Male and female silver salmon killed and held for respective time periods before spawning.

The results from Group C (Table 3) reiterated the conclusions formulated in Group B and followed the same pattern, demonstrating that the male spermatozoa are ineffective after holding between 2 and 4 hours. The 4-hour holding time resulted in 40 to 43 per cent survival in both Groups B and C. The fry that did hatch proceeded to develop normally and the mortality in this stage was not significantly different than in the control lots.

Conclusions

The experiment demonstrated that gravid female silver salmon could be killed and held in river water (temperature 42-44° F.) for 12 hours and the eggs still be successfully fertilized with milt from freshly killed males, resulting in a fry survival similar to the control lot of 93 per cent.

It was determined that the male silver salmon killed and held in the same manner as the above mentioned females lost their viability after holding between 2 and 4 hours.

When holding time became a factor in mortality the loss occurred principally during the egg stage. Once the eggs had hatched, there was no excessive mortality observed in the fry stage until the 32-hour holding period.

The information gained from this experiment could be effectively utilized when abnormal conditions exist at egg-taking sites or hatcheries and perhaps eggs that would otherwise be lost could actually be saved.

TABLE I

GROUP A - Female Silver Salmon Killed for Spawning and Held for Specified Time, Eggs Fertilized with Fresh Milt.

Time Held in Hours	Total Number of Eggs	Egg Loss	Per Cent Survival to Fry	Fry Loss	Per Cent Survival Fry & Ponding	Total Survival Per Lot	Total Survival Lots Combined
0	3,250	70	97.85	68	97.86	95.76	95.45
0	2,981	84	97.18	61	97.89	95.13	
2	2,934	330	88.75	37	98.58	87.49	90.31
2	3,260	80	97.55	153	95.19	92.86	
4	2,638	766	70.96	21	98.87	70.16	84.41
4	3,686	156	95.77	48	98.62	94.45	
6	3,701	178	95.19	104	97.05	92.38	91.80
6	2,783	179	93.57	71	97.27	91.02	
8	3,633	280	91.88	29	99.28	91.22	91.65
8	2,498	146	94.16	47	98.00	92.28	
12	3,023	333	88.98	81	96.99	86.30	87.54
12	3,014	206	93.17	132	95.30	88.79	
18	1,923	1,875	2.50	4	91.67	2.29	4.31
18	2,227	2,039	6.06	53	71.81	4.35	
24	3,383	1,856	45.14	135	91.13	41.12	35.76
24	2,665	1,737	35.01	152	83.62	29.28	
32	2,086	2,084	.10	1	50.00	0.05	22.07
32	3,986	2,084	47.72	563	70.40	33.59	

TABLE 2

GROUP B - Male Silver Salmon Killed and Held for Respective Time Periods and Spawned with Females that were not Held.

Time Held in Hours	Total Number of Eggs	Egg Loss	Per Cent Survival to Fry	Fry Loss	Per Cent Survival Fry & Ponding	Total Survival Per Lot	Total Survival Lots Combined
0	3,282	69	97.90	49	98.47	96.40	93.61
0	3,308	256	92.26	47	98.46	90.84	
2	3,583	137	96.18	84	97.56	93.83	91.60
2	2,843	127	95.53	192	92.93	88.78	
4	1,781	1,571	11.79	5	97.62	11.51	43.52
4	1,944	499	74.33	24	97.99	72.84	
6	3,964	3,903	1.54	2	96.42	1.48	2.43
6	3,414	3,288	3.69	1	99.21	3.66	
8	4,037	4,037	---	--	---	---	.22
8	2,372	2,357	.63	1	93.33	.59	
12	none	---	---	---	---	---	---
12	taken	---	---	---	---	---	
18	none	---	---	---	---	---	---
18	taken	---	---	---	---	---	
24	3,195	3,194	.03	---	---	---	---
24	3,388	3,388	---	---	---	---	
32	3,237	3,213	.74	2	91.66	.68	.44
32	2,708	2,704	.15	0	100.00	.15	

TABLE 3

GROUP C - Male and Female Silver Salmon Killed and Held for Respective Time Periods and Spawned.

Time Held in Hours	Total Number of Eggs	Egg Loss	Per Cent Survival to Fry	Fry Loss	Per Cent Survival Fry & Ponding	Total Survival Per Lot	Total Survival Lots Combined
0	3,311	418	87.38	41	98.58	86.14	89.86
0	2,831	116	95.90	48	98.23	94.20	
2	2,555	239	90.65	17	99.27	89.99	93.40
2	3,567	134	96.24	14	99.59	95.85	
4	3,263	3,052	6.47	9	95.73	6.19	40.98
4	4,041	1,223	69.61	22	99.22	69.07	
6	3,609	3,598	.17	0	100.00	.17	1.31
6	3,332	3,243	2.67	4	95.51	2.55	
8	2,895	2,893	.07	1	50.00	.03	---
8	3,166	3,166	.00	---	---	.00	
12	none	taken	---	---	---	---	---
12	none	taken	---	---	---	---	
18	none	taken	---	---	---	---	---
18	none	taken	---	---	---	---	
24	2,658	2,658	.00	---	---	.00	---
24	3,895	3,895	---	---	---	---	
32	3,260	3,260	---	---	---	---	---
32	2,596	2,596	---	---	---	---	

EGG AND FRY CABINET TESTS
WATER AND AIR TEMPERATURE FLUCTUATIONS

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An experiment designed to clarify some of the questions that pertain to incubation in vertical, individually supplied water container tray units was set up at the Green River Hatchery near Auburn, Washington. Equipment used is manufactured by Heath Tecna-Plastics, Incorporated, at Auburn, Washington and is sold for incubation and hatching of salmon and trout eggs.

Questions regarding this type of equipment to be tested were as follows:

(1) At zero degrees F., air temperature and spring or ground water supply temperatures of approximately 50° F., what would the temperature drop be in individual trays from 1 to 16 with water inflow at 6 GPM? (standard flow used)

(2) What would the temperature drop be at 4 GPM? (acceptable flow used)

(3) What would the temperature drop be at 2 GPM., adequate flow in some instances? (minimum flow used)

(4) Would flowing exposed water surfaces as exist with this type incubation cabinet to a cold air volume in an incubation room affect room temperatures at various flows in GPM., and if so, how much?

(5) Would the incoming water temperature at the top tray be so changed, when compared to temperature of water in the bottom, or the 16th, tray using such incubation equipment, that actual hatching would be altered in the cabinet on a single lot of eggs which were taken simultaneously?

(6) Would ice "accumulation" at the tray spilling sections alter water temperatures markedly?

Experiments were further prompted due to a decision to develop ground or well water at the Samish Hatchery where winter air temperatures may fall to zero F. in the incubation area, and where anticipated water temperatures from ground supply is assumed to be near 50° F.

With the above questions unanswered, we set about to establish artificially, as near as possible, a condition or conditions that would simulate those that could occur at Samish, or elsewhere, during incubation periods. With the able assistance of Stephan Fallert, Superintendent at the Green River Hatchery, we set up the following experiments designed to answer, in part, questions we had been asking ourselves in regard to vertical egg and fry cabinet incubation with inclement temperatures.

A 16-tray vertical egg and fry cabinet was loaned to the Hatchery Section through the courtesy of Heath Tecna-Plastics, Incorporated, manufacturers of egg and fry cabinets in Auburn, Washington. Water supply was taken from a spring source at the hatchery. Water temperature reading was approximately 50° F. throughout the first experiment mentioned in this report. Water supply temperatures for the second test were 42° F.

It was decided to set up the cabinet in the hatchery ice plant cold room (regular operating temperature is 0° F.) and to run spring water and/or creek water from outside the ice plant cold room through a water hose into the top tray of the cabinet, down through the 16 trays and into a receiver pipe to a point outside the ice plant cold room for a continuous running water supply. After some experimentation with calibrating a regular hose bib faucet to which a hose could be attached, we were able to preset the flow through the supply hose at 6 GPM., 4 GPM., and at 1.6 GPM., continuous flow. In each of the flow tests, a second outflow measurement was made to assure us that the flow had not changed from the calibrated setting, or to indicate the extent it had changed, if any.

Complete filling of the cabinet outside the ice plant cold room was accomplished at a flow rate of 6 GPM. so that the rate of interchange could be established; i.e., the time interval involved in completely filling an empty 16-tray egg and fry cabinet unit with water. This proved to be 10 minutes at water flow of 6 GPM., for a total amount of water required to fill a 16-tray cabinet unit of 60 gallons. The time of interchange then, for the experiments, was determined for the various flow rates to be as follows:

At flow of 6 GPM. - 10 minutes interchange time.
At flow of 4 GPM. - 15 minutes interchange time.
At flow of 1.6 GPM.- 37½ minutes interchange time.

It was assumed the higher water flows would produce somewhat more efficient interchange of water; however, this was not checked at the time the experiment was run.

The following charts are a breakdown of tests run at the Green River Hatchery using an egg and fry cabinet--on September 8, 1961 using spring water at 50° F. and on November 21, 1961 using creek water at 42° F.

Remarks

From initial and subsequent tests run at the Green River station ice plant, it appears that vertical cabinets for incubation of fish eggs and fry maintain fairly constant water temperatures when measured at points of inflow and outflow under conditions set up for experimental purposes.

It also appears that, in any closed incubation room, water temperatures would no doubt affect incubation room temperatures when at or near those existing during the first experiment.

Such testing will be helpful in setting up future cabinet assemblies where air and water temperatures approach those tested and cabinet performance under these conditions is unknown.

Time at Start	Time Checked	Total Elapsed Time	Flow in GPM	Minutes Inter-Change Time	Temp. Spring Water	Temp. Top Tray	Temp. Bottom Tray	Average Temp. Outside Air	Temp. Ice Plant Air	Temp. Expended Outside Water Flow	Projects
8:25 a.m.	-	0	6	10	50° F.	50° F.	50° F.	70° F.	8° F.	48° F.	(A)
	9:00 a.m.	25 min	6	10	50° F.	50° F.	48° F.	70° F.	8° F.	48° F.	(A)
	9:40 a.m.	1 hr 15 min	6	10	50° F.	49° F.	48° F.	70° F.	10° F.	47° F.	(A)
	11:25 a.m.	3 hrs	6	10	50° F.	50° F.	47° F.	70° F.	10° F.	47° F.	(A)
11:50 a.m.	-	0	4	15	50° F.	50° F.	47° F.	70° F.	12° F.	47° F.	(B)
	1:30 p.m.	1 hr 40 min	4	15	50° F.	50° F.	47° F.	70° F.	9° F.	47° F.	(B)
2:00 p.m.	-	0	1.6	37½	50° F.	51° F.	46° F.	70° F.	9° F.	45° F.	(C)
	3:30 p.m.	1 hr 20 min	1.6	37½	52° F.	50° F.	46° F.	70° F.	9° F.	45° F.	(C)
	4:00 p.m.	2 hrs	1.6	37½	52° F.	50° F.	46° F.	70° F.	9° F.	45° F.	(C)

(At 4:10 p.m. equipment was dismantled and experiment discontinued)

Time Check	Tray No.	Project (B)	Project (C)
1:30 p.m.	1	50° F.	
	8	49° F.	
	12	48° F.	
	16	47° F.	
2:00 p.m.	1		51° F.
	8		48° F.
	12		46° F.
	16		46° F.
3:20 p.m.	1		50° F.
	8		48° F.
	12		47° F.
	16		46° F.

Tests run September 8, 1961.

Time at Start	Time Checked	Total Elapsed Time	Flow in GPM	Minutes Inter-Change Time	Temp. Spring Water	Temp. Top Tray	Temp. Bottom Tray	Average Temp. Outside Air	Temp. Ice Plant Air	Temp. Expended Outside Water Flow	Projects
12 noon			6	10	42° F.	42° F.	42° F.	44° F.	0° F.	42° F.	AA
	1:10 p.m.	1 hr 10 min	6	10	42° F.	42° F.	40° F.	44° F.	4° F.	40° F.	AA
1:10 p.m.	2:05 p.m.	55 min	6	10	42° F.	42° F.	40° F.	44° F.	4° F.	40° F.	AA
2:15 p.m.	-	-	4	15	42° F.	42° F.	40° F.	44° F.	4° F.	40° F.	BB
	3:25 p.m.	1 hr 10 min	4	15	42° F.	42° F.	40° F.	44° F.	2° F.	40° F.	BB
3:30 p.m.	-	-	1.6	37½	42° F.	42° F.	40° F.	44° F.	2° F.	40° F.	CC
	5:30 p.m.	2 hrs	1.6	37½	42° F.	42° F.	38° F.	44° F.	2° F.	38° F.	CC

Time Check	Tray Number	Project AA	Project BB	Project CC
2:05 p.m.	1	42° F.	42° F.	42° F.
	8	41° F.	41° F.	40½° F.
	12	40° F.	40° F.	39° F.
	16	40° F.	40° F.	38° F.

Tests run November 21, 1961.

RAINBOW TROUT SPAWN TAKING

Fred W. Bitle
Winthrop National Fish Hatchery
U. S. Fish and Wildlife Service

The Winthrop National Fish Hatchery, for the past decade, has played an integral part in supplying rainbow trout eggs to federal hatcheries in this region. Surplus eggs have been made available to other Bureau regions and to states within the region. As hatchery manager for the last six seasons, I have had my share of the multitude of problems associated with spawn taking, egg shipments, brood stock care, and feeding. Our egg-take for the past six years has been recorded on a 35 mm slide and will be shown later.

Brood stock history

Originally adults (3 and 4-year old fish) were transferred to Winthrop from State of Washington, Department of Game's hatchery at Spokane in 1951. These fish were of Cape Cod, Massachusetts strain, and with some brood stock selection we are at present producing a very good egg of high vitality. Our losses from green egg to hatching vary from 7.5 to 9 per cent. At Winthrop this strain of rainbow becomes sexually mature in January and spawn-taking operations carry over into March.

The need to provide earlier eggs caused us to start a second brood stock of the Roaring River strain from Scio, Oregon State Game Commission Hatchery. The first eggs from this strain are taken in mid-November and egg taking continues until the first of the year. Both strains of trout are essentially 3-year spawners.

Diet

We have gradually converted all of our brood stock to a dry diet. Brood stock are fed the special brood stock pellet.

Spawn taking

All our brood stock are anesthetized before taking eggs. Best results, after several years of experimentation with various anesthetics, have been obtained from MS-222 at .25 grams per gallon of H_2O. MS-222 has a faster reaction time to anesthetize the fish, and the fish appear to revive much faster when placed in fresh water. As a necessary precaution, we make it a practice to rinse fish and spawn takers' hands before taking the eggs. I have a few slides to show you later on this.

Problem

Our persistent problem at Winthrop is a mortality experienced annually by adults AFTER spawning. The mortality is associated with a fungus which develops on the "spawn outs" in "blue slime" patches above the lateral line. This "blue slime" usually develops 4 to 5 days after spawning and is more prevalent among the males. We have tried prolonged-dip and flush methods with salt and malachite green at various concentration levels but with little success. We believe the fungus problem is associated with cold water and the reduced vitality of the fish associated with spawn taking. Handling of the fish is probably a factor, but by arranging our fish in the brood stock ponds, we have reduced handling to a minimum. I personally believe this fungus problem could be licked if I could place my "spawn outs" in warmer water and get them back on feeding shortly after spawning.

Now I would like to show some slides covering our spawn-taking operations.

Egg-take record
Spawning shed
Converted raceways
Spawn-taking shots

Rainbow Eggs 1955 - 1960
Winthrop National Fish Hatchery, Washington

Year	Number Eggs	Females Spawned	Eggs per Female	Per Cent Eye	Per Cent Hatch	Per Cent to Feeding
1955	3,313,506	1,229	2,696	89.2	88.7	87.9
1956	4,158,969	1,545	2,963	95.8	91.1	88.3
1957	3,421,067	1,233	2,775	92.1	92.0	91.7
1958	1,286,390	671	1,917	79.0	Shipped as eyed eggs.	
1959	2,900,557	1,596	1,817	92.6	Shipped as eyed eggs.	
1960	2,851,505	1,456	1,958	93.0	*97.9	*94.3

* Based on survival of eggs held at Winthrop.

BROOD STOCK FEEDING AND ASSOCIATED MORTALITIES

Harry W. Baker, Jr.
Ennis National Fish Hatchery
U. S. Fish and Wildlife Service

Over the years much has been done, or should I say attempted, at developing domestic brood stock. With varying results, it still appears that there is much to be desired in this phase of the hatchery operations. Among the things probably most desired in brood stock would be improved fertility of eggs, less deformity among fry, and lower spawning mortality.

It is this speaker's opinion that the lack of desired results over the past years is due, primarily, to the lack of a totally efficient diet. We can certainly assume that the requirements of brood stock, producing eggs, are considerably different from the requirements of fish being reared for planting. I have no knowledge of nutritional research being conducted on brood stock requirements; i.e., in relation to protein, carbohydrates, etc. I believe this phase of fish culture should be given more attention.

The Ennis National Fish Hatchery at Ennis, Montana has been in the brood stock business, in varying degrees, since about 1937 and has experienced various results. However, it was not until about 1953 that we stepped up our egg-production program to meet the requirements of some of our other hatcheries and at this time are producing approximately 5,000,000 eyed rainbow trout eggs annually. During these years, our fertility of eggs has ranged from about 90 per cent to 52 per cent. The higher percentages were obtained in the earlier years of our egg production when the brood stock was not subjected to crowded conditions and were held in ponds where considerable quantities of natural foods were available. Going back briefly, to the year 1956, we have the following percentages of survival to the eyed stage: 1956 - 52.7 per cent, 1957 - 59.9 per cent, 1958 - 62.7 per cent, 1959 - 66.3 per cent, 1960 - 57 per cent, 1961 - 76 per cent. During the spawning season of 1961, which includes eggs taken from December 1960 to February 1961, it will be noted that there is a marked increase in fertilization. We attribute this fact to the limited use of malachite green as a fungicide. In past years it had been a practice to start malachite green treatments the second day of incubation and treat daily until eggs were fully eyed. During the 1961 season, no treatment was begun until the eighth day and every other day thereafter. Sixteen days are required for eyeing eggs at Ennis. Also, with the restricted use of malachite green, fewer numbers of deformed fish were noted.

Our brood stock facilities at Ennis consist of three concrete ponds 110' x 10' over-all length (includes head trough and tail trough), the fish-holding area of each pond being 100' x 10'. Each pond is constructed so that it may be set up into four sections; and each pond has a minimum water supply of 450 gallons per minute at 54°F.

In September of 1960, in conjunction with a series of feeding experiments, our brood stock, which consisted of three age groups, were sectioned off into three equal groups for each age group and one section of each age group was given a different diet. Two brands of commercial feeds and one meat diet were used. The meat diet consisted of 20 per cent beef liver and 40 per cent each of beef spleen and beef lungs. This feeding experiment gave us an opportunity to evaluate the differences in fertility of eggs and mortality of the different diets. At the beginning of this feeding experiment, the age groups were 18 months, 30 months, and 42 months. This experiment is still being carried on and will run at least through the 1962 spawning season. We expect further, interesting results.

Throughout this experiment we have maintained graphs of mortalities and records of egg fertilization for each of the groups, which we will now refer to.

PROGRAM OF THE ABERNATHY SALMON CULTURAL LABORATORY

Roger E. Burrows
Salmon Cultural Laboratory
U. S. Fish and Wildlife Service

On March 1, 1961 the Salmon Cultural Laboratory was relocated from the Entiat River in north central Washington to Abernathy Creek in southwestern Washington. The relocation of the laboratory has allowed for the improvement of the facilities available for research and for the expansion of the experimental program.

At Abernathy the facilities consist of a service building housing the biological and chemistry laboratories, offices, library, diet room, cold storage, garage, and workshop; a hatchery building with forty-two 6-foot, circular tanks, a 4,500,000-egg incubator, 8 deep troughs, and working space for experimental installations; a concrete-floored outside experimental area; twelve 8 x 80-foot raceways; and a 20 x 80-foot, concrete adult holding pond. Two water supplies are avaialble. Abernathy Creek is subject to temperature variations from 35° to 72° F. and 1,400 GPM. of well water at a constant temperature of 53° F. The piping system is such that either well water, creek water, or any mixture of both may be supplied to any pond, tank, or trough.

The staff consists of five biologists, a chemist, secretary, janitor, nutritionist consultant, hydraulics consultant, and three maintenance fish culturists.

The primary objective of the experimental program of the laboratory is to improve the efficiency of artificial salmon propagation. We are not so much interested in the survival of the fish during propagation as the effect of propagation on survival after liberation. To this end our research is being directed toward evaluation of the physiological differences imparted by diets and environment during rearing and the effect of these differences on adult survival. Ultimately we hope to be able to establish the quality standards of hatchery fish necessary fpr maximum adult survival. Our immediate program consists of feeding trials, studies of rearing pond environments, measurement of fingerling characteristics, determination of the significance of fingerling characteristics, and methods for sex control in salmon.

The experimental program for 1961 was restricted to some extent by the relocation of the laboratory and hampered by disease problems encountered at the station. Abernathy Creek is infested with the digenetic trematode Nanophyetus salmincola. The cercariae and meta-cercariae of this parasite caused excessive mortalities in the experimental fish and forced the abandonment of the diet trials after 14 weeks of feeding. In addition to the trematode, we encountered furunculosis and a gill amoeba during the rearing period. The latter two are quite easily controlled; the trematode, however, presents a more difficult problem.

The greatest mortality encountered from the trematode cercariae was during the latter part of June and forepart of July and correlated with the reduction in creek flow and increase in water temperature. We assume that a population explosion in 1961 created an atypical situation. In 1962, well water will be available to both temper and dilute the creek water and reduce the incidence of infection in the large-scale experiments. The diet trials will be conducted on well water exclusively. We are investigating the possibility of filtering the water by means of mechanical microstrainers which will eliminate the cercariae from the water supply.

Despite the difficulties encountered, the 1961 experiments produced some very interesting results. In the feeding trials conducted on fall chinook fingerlings, a composite meal consisting of 35 per cent salmon meal, 30 per cent dried skim milk, 20 per cent cottonseed meal, and 15 per cent wheat germ meal was supplemented with a 50/50 beef liver-hog liver mixture at levels varying from 10 per cent to 50 per cent of the diet. Two protein levels--20 per cent and 25 per cent--and three caloric levels--1300, 1650, and 2000--were tested with and without vitamin supplementation. The protein intake was controlled by the addition of water and the caloric intake increased by the addition of peanut oil. Caloric content was calculated on the basis of availability as developed by Phillips. All diets were bound by the addition of CMC and ricer fed.

The results after 12 weeks of feeding are as follows:

1. The 25 per cent protein diets produced significantly greater gains and higher protein deposition than the diets fed at the 20 per cent protein level.

2. At the 20 per cent protein level, an increase in the caloric intake from 1300 to 1650 calories per kilogram resulted in a significant increase in the growth rate and an increase in both protein and fat deposition. A sparing action on the protein by the addition of energy calories supplied as peanut oil is indicated.

3. Increasing the caloric level from 1650 to 2000 calories per kilogram, while retaining the protein level at 20 per cent, did not increase the efficiency of either the protein utilization or the total gain above that of the 1650 calorie-20 per cent protein diets. A protein calorie-energy calorie relationship of one to one appears to be near optimum at the 20 per cent protein level.

4. Meat supplementation as low as 10 per cent was adequate for the maintenance of chinook salmon when used in conjunction with the composite meal fed.

5. Vitamin supplementation made no measurable contribution to either growth or survival under the conditions of the experiment. In this experiment the tanks were outside and supplied with creek water. The contribution of the natural food available may have been sufficient to fortify a marginal diet.

6. Normally, the Entiat meat-turbot-viscera-meal control diet has produced growth comparable to the best experimental diets. In these trials, every one of the experimental diets produced growth rated equal to or better than the Entiat control.

While this experiment will have to be repeated on cercariae-free well water, we are very much encouraged with the results of the 1961 trials.

The first experiment designed to define a fingerling characteristic necessary for adult survival was conducted this year. Two groups of fall chinook fingerling were reared on different diets to produce differences in fat deposition. The Cortland meat-meal combination, which is a high protein-high calorie diet, was fed to produce a high fat deposition; and an Entiat diet, which was a low protein-low calorie diet, was fed to produce a low fat deposition. Both groups were fed for a 4-month period, marked, and released. At the time of release, the proximate analyses of the two groups were as follows:

	Per Cent Wet Weight				Dry Weight	
Diet	Water	Protein	Lipid	Ash	Protein	Lipid
Cortland	76.31	16.79	4.98	2.30	71.60	21.23
Entiat	78.24	16.56	4.18	2.36	75.10	17.87

A difference of 19 per cent in fat deposition existed between the two groups. Wood, in comparing wild and hatchery fall chinook salmon fingerling, reports as follows:

	Per Cent Dry Weight	
	Protein	Lipid
Hatchery	70.2	19.9
Wild	77.7	15.1

It will be observed that the Entiat diet fish closely approximate the composition of wild fish and the Cortland diet fish that of the hatchery groups analyzed.

There were 175,000 Cortland diet fish, averaging 18.5 per pound, marked right ventral and 181,000 Entiat diet fish, averaging 29.0 per pound, marked left ventral. The difference in adult returns to Abernathy Creek in 1964 will serve as the measure of significance of differences in fat deposition.

Next year the difference under test will be stamina -- the difference to be created by rearing pond environment.

Studies of improved rearing facilities were limited to further tests of the recirculating and conventional 8 x 80 raceways. In paired experiments, the recirculating raceways showed a 10 per cent increase in weight of fish produced after 7 weeks of feeding. Fish reared in the recirculating ponds showed higher stamina and lower fat deposition than their conventional counterparts due to the increased exercise required of them.

Tests of methods for measuring differences in hatchery fish have continued. The stamina tunnel is proving to be a very useful tool. The significance of differences in performance within and between groups is being determined. Particular emphasis is being placed on the cause of differences within groups. So far, the results have been negative. The reaction device which measures the speed of reaction of individual fish to an external stimulus is being tested to determine the variables which may be encountered in this measurement method.

The first phase of our most recent experiment, that of developing a method for the control of sex in salmon, is in progress. Dilutions of two female hormones have been used to surround samples of eggs during the water-hardening period. In this manner we hope to introduce the hormones into the perevitteline space and subject the embryo to the hormones during the early period of development. Yamamoto has demonstrated that the sex of the medaka may be controlled by feeding either male or female hormones and actual sex reversals accomplished. We hope to be able to control sex either by hormone exposures during development or by altering the pH during fertilization. Our objective is to produce hatchery populations containing at least 75 per cent females so that hatchery releases will have a higher productive potential.

The program for next year will be expanded to include a more detailed study of the effect of environment on the physiology of salmon fingerling. This phase of our investigations was neglected to a large extent in 1961 due to lack of facilities.

METHODS FOR EVALUATING PROTEIN QUALITY

Warren E. Shanks
Western Fish Nutrition Laboratory
Bureau of Sport Fisheries and Wildlife

In the past year, four methods for measuring protein quality were evaluated. The goal has been to develop a simple laboratory method applicable to studies of fish nutrition. Protein efficiency ratio (P.E.R.) has been widely employed in other areas of animal nutrition, and is probably the simplest method for measuring protein quality. A requisite for such studies is a basal ration common to all diets, which satisfies all nutritional requirements except protein. Because salmonids apparently require higher protein levels than other experimental animals, it was necessary to establish an optimal level for such studies. (Studies with rats are normally conducted at levels of 6% to 12% protein.) Accordingly, protein sources ranging from dry meals to fish tissues were tested in duplicate at four levels ranging from 14% to 43%. The experiments ran for 12 weeks. Analysis of the results revealed maximum protein efficiency was obtained at levels of 15% to 25%. Maximum gain was not necessarily obtained at these levels. Future experiments will be run at an intermediate level. (20%). The range in protein efficiency observed encourages us to believe that properly controlled studies will provide a qualitative tool for measuring protein quality.

Net protein retention (N.P.R.) is a modification of P.E.R. and includes a control group which receives the basal ration (no protein) only. Ingestion of the diet by salmon must be confirmed before this method can be considered a valid measure of protein quality.

Nitrogen balance studies appear to hold most promise for quantitative evaluation of protein quality. A plot of nitrogen balance versus intake shows a linear relationship over a narrow range near the point of nitrogen equilibrium. Individual proteins may be evaluated in this manner. Potentially evaluation of production diet quality may be feasible since accurate N.B. studies provide a precise measure of protein requirements in terms of a specific ration by determining the minimum intake which will maintain nitrogen equilibrium.

An experimental plexiglass aquarium was described and briefly discussed.

ENZYME STUDIES AT THE WESTERN FISH NUTRITION LABORATORY

C. B. Croston, Biochemist
Bureau of Sport Fisheries and Wildlife
Western Fish Nutrition Laboratory

Because enzymes promote most of the biochemical reactions occurring in living organisms, studies of the enzyme systems tell us what reactions occur and the metabolic pathways followed in the conversion of food to energy and tissue in a given animal.

The digestive enzymes of salmon caeca have been found to include lipases, carbohydrases, and proteases. The proteases have been separated by column chromatography into several fractions which resembled known mammalian enzymes although there were minor differences in properties. One salmotrypsin, however, had properties considerably different from any known natural trypsin.

The alkaline phosphatase level in the blood sera of fingerling chinook salmon was found to be influenced by the zinc and/or phosphorous content of special diets. Ocean caught adult silvers had almost double the average phosphatase activity of chinooks. Chinooks at the end of the spawning run showed no significant change in the average values which, however, were higher for females than for males.

BLOOD STUDIES ON STEELHEAD TROUT (*Salmo gairdneri*)
I. MEASUREMENT OF BLOOD VOLUME AND PLASMA VOLUME UTILIZING IODINATED ALBUMIN (I^{131} HSA)

F. P. Conte, H. H. Wagner and W. L. Bradford
Oregon State University, Oregon State Game Commission
and Oregon Technical Institute

The estimation of blood volume has been investigated in a variety of animals. The values given for most vertebrates, expressed as percentage of body weight, usually lie between 5 and 8 per cent. However, the bony fish is a consistent exception in that results published to date indicate that the bony fish group possesses a blood volume which lies between 1.5 and 2.5 per cent. Therefore, one might conclude, from published results, that the bony fish possesses a more efficient circulatory system than other vertebrates in that it requires a smaller volume of transport fluid per unit mass of animal in order to carry on all of the metabolic functions that are necessary for life.

The present study undertook to measure the volume of blood and plasma of steelhead trout and utilized radioactively labeled albumen (I^{131}) to determine if steelhead trout, one representative of the bony fish, conforms with teleost in general or with the other vertebrates.

Results obtained place the blood volume at 6.3 ± 0.6 per cent of the body weight and the plasma volume of 3.5 ± 0.5 per cent of the body weight. Thus, the values determined are higher than those that have been previously reported in the literature for bony fish (Osteichthys), but in agreement with the subphylum vertebrata as a whole.

COMMERCIAL PASTEURIZATION OF SALMON VISCERA AND ITS POSSIBLE EFFECTS ON THE INCIDENCE OF FISH TUBERCULOSIS

A. THE COMMERCIAL PASTEURIZATION PROCESS

Duncan Law
Oregon State University

"Don't stand there! Do something about it!" This has been the admonition of fisheries pathologists toward the use of raw salmon viscera and carcasses in hatchery diets. Yet the Alphonse-Gaston act goes on. "After you Sir! After you Sir!" Some fish culturists feel that there is insufficient evidence relating to disease and raw salmon products to merit removal of this excellent growth promoting food item. Others infer that we in Oregon may have a related disease problem, but for them no apparent related disease problem exists as the result of feeding raw salmon products. A third group feels that accurate data on thermal death times and procedures are lacking and that such data is essential before any general pasteurization program can be adopted.

At a previous meeting of this group, I described a method we had developed for the pasteurization of salmon viscera. Times and temperatures used were borrowed largely from milk pasteurization and enzyme inactivation data. Evaluation of milk quality is based on total bacterial count. This is based on the assumption that the more bacteria present, the greater the risk of pathogens.

The first series of slides shows a typical total bacterial count on a raw salmon viscera sample as compared to a pasteurized sample. This sample was incubated at 37° C. The total viable count was 22,800,000. There was no count on the pasteurized sample. The second slide shows the same sample incubated at 15° C. The total viable raw count was 15,600,000. Again there was no pasteurized count. We felt this "prima facie evidence" was sufficient to start a program on. The Oregon Fish Commission, at this point, eliminated the use of raw salmon products. At the same time, the commercial firms handling raw salmon viscera were advised that only viscera pasteurized according to specifications were acceptable for bid.

Several plants adapted, developed, and modified procedures for producing pasteurized salmon viscera on a commercial scale. These included the R. V. Moore plant in La Conner, Washington, Bioproducts Inc., Warrenton, Oregon, and Bumble Bee Seafoods, Astoria, Oregon. The system most similar to the original laboratory method was installed by Bumble Bee Seafoods. The next series of slides shows the apparatus as it now stands.

The next slide shows a diagrammatic-flow sheet of the operation. I might point out that a number of pitfalls in pasteurization of viscera came to light during the initial operations of these plants. Among these are the necessity to lower the temperature of the product as rapidly as possible after pasteurization and elimination of any bacterial contamination whether this be due to dead ends or inadequate clean-up. Even despite these precautions, an occasional heat resistant organism gets into the system and creates a problem.

Fortunately this has only happened on two or three occasions. By problems, I mean the literal "blowing-up" of sacks of pasteurized viscera. Reed White will ruefully testify to this. Scraping pasteurized viscera off four walls is not regular hatchery procedure.

B. EFFECTS OF PASTEURIZATION ON FISH TUBERCULOSIS

John Fryer
Oregon Fish Commission

The 1956 brood of silver salmon reared at the Klaskanine Hatchery was divided into two groups--one group received raw salmon products and the other received pasteurized product. At release, both groups were marked so that they could be identified when returning as adults. Fish from this brood year returned in 1958 and 1959 and were examined for tuberculosis by Wood and his group. The entire 1957 brood of silver salmon reared at this station received pasteurized salmon products in the diet and were marked at liberation. These fish have since returned and have been examined for tuberculosis.

To date, a total of 656 marked silver salmon have been examined for tuberculosis at the Klaskanine Hatchery--299 of these fish received raw salmon products and were found to be 93 per cent tuberculous, and 357 of the fish examined received pasteurized salmon products in their diet and were found to be only 9 per cent tuberculous.

From 1956 through 1959 at the Nehalem Hatchery, a total of 210 adult silver salmon, representing fish of the 1953 through 1956 brood years, were examined by Jim Wood for the incidence of tuberculosis. Of this number, 193 or 92 per cent were found to be infected with this disease. During these brood years, raw viscera was fed in the diet at this hatchery. The 1957-brood silver salmon were fed a diet containing pasteurized salmon viscera. These fish returned in 1960 and a sample of 50 adults were examined for tuberculosis and 16 or 32 per cent were found to be infected.

Table 1 summarizes the information available at this time concerning the incidence of tuberculosis in silver salmon fed raw and pasteurized salmon viscera.

From the information available, it appears that the pasteurization process now in use has significantly lowered the incidence of tuberculosis in silver salmon.

Table 1

THE INCIDENCE OF TUBERCULOSIS IN SILVER SAIMON FED RAW AND PASTEURIZED SAIMON VISCERA

Year	Number Examined	Number Infected	Per Cent Infected	Remarks
		KLASKANINE HATCHERY		
1958-60	Adults 115	112	97	All fish marked
	Jacks 184	167	91	Raw viscera in diet
	Total 299	279	93	
"	Adults 145	25	17	All fish marked
	Jacks 212	6	3	Pasteurized viscera in diet
	Total 357	31	9	
		NEHALEM HATCHERY		
1956-59	Adults 140	123	88	Unmarked
	Adults 70	70	100	Marked
	Total 210	193	92	Raw viscera in diet
1960	Adults 50	16	32	Unmarked Pasteurized viscera in diet

SUMMARY OF PELLET FEEDING

Reed G. White
Oregon Fish Commission

The Oregon Fish Commission is now feeding Oregon Pellets to all silvers, spring chinook, and steelhead fingerling after the fish reach an average size of 300 per pound. The starting meat diet for the present crop of fish was approximately 40 per cent pasteurized viscera, $12\frac{1}{2}$ per cent beef liver, $12\frac{1}{2}$ per cent pork liver, 15 per cent beef spleen, and 20 per cent tuna viscera.

The best measure of the quality of fish produced is by the number of adults that return to the fisheries. The first crop of pellet-fed silvers, other than experimental lots, has been returning to the fisheries this summer and fall. The poundage of troll caught silvers is higher in 1961 than for any one of the previous three years. The calculated number of silvers caught by anglers varies somewhat, but all estimates are high as compared to the previous three years.

The total 1958 brood pellet-fed silver yearlings liberated in 1959-1960 were 3,778,000 fish. Our records are incomplete at this date, but we are assured of a minimum silver egg-take of 26 million. There were enough adults permitted to escape above hatchery traps for natural spawning to produce another two million eggs. There was an unknown number of adult salmon that escaped above some of the traps during freshets. There will probably be more adults arriving at some of the stations; therefore, the 28,000,000 potential egg-take is a minimum number. The very limited stream survey reports to date do not indicate a large escapement in streams that are entirely supported by natural spawning. Our confidence in the quality of pellet-fed silvers produced seems to have been justified, but a complete analysis cannot be made until our records are complete.

The formula for the Oregon Pellet is essentially the same as in previous years. It is approximately 60 per cent meals and vitamin premix, 20 per cent tuna viscera, and 20 per cent turbot or pasteurized salmon viscera. The complete formula appears in Table I.

A feeding chart is used as a guide to determine the amount of feed required and the frequency to feed. The feeding frequency for fish 300 per pound or larger varies from four feedings per day, seven days per week to one feeding every other day. About 90 per cent of the present crop of fish are now being fed once every other day. A feeding chart appears in Table II.

Oregon Pellets were fed to some 294,000 steelhead in 1961. The conversion rate from feeding 54,098 pounds of pellets was 2 pounds of pellets to produce a pound of fish. The percentage of mortality for this group of fish was somewhat obscured by grading activities, liberations, and transferring to different ponds. It was considered to be satisfactory, however.

Some three million 1960 brood fall chinook were fed Oregon Pellets at two of our hatcheries this past spring. This was a production experiment. The results appear in Table III.

The results from feeding pellets to some three million spring chinook appear in Table IV and for eight million silvers in Table V.

Summary

1. The return of 1961 adult silvers to the fisheries indicates a good quality of 1958 brood yearling fish liberated.

2. A feeding chart that regulates the frequency of feeding as well as the amount to feed per day will produce uniform results.

3. Oregon Pellets can be fed successfully to spring chinook, fall chinook, steelhead, and silvers. Blueback have been fed pellets in previous years with equal results.

Table I. Formula of Oregon Pellets

Ingredients	Per Cent
Meal Mix	
Cottonseed oil meal	23.0
Herring meal	21.0
Crab and shrimp solubles	6.0
Wheat germ meal	3.6
Distillers dried solubles	2.4
Antioxidant-Vitamin Premix	1.5 1/
Wet Mix	
Tuna viscera	20.0
Pasteurized salmon viscera	20.0
or	
Turbot (alternate ingredient for salmon viscera)	20.0
Corn oil	1.8
Choline chloride	0.7
	100.0

1/ Ingredients antioxidant-vitamin premix	Guaranteed potency per pound of premix (mgs.)
Antioxidant (A dry product shall be used)	
Butylated hydroxyanisole (BHA)	2,268.0
Butylated hyroxytoluene (BHA)	2,268.0
Vitamins (USP)	
D-alpha tocopheryl acetate 1/	9,827.8 (I.U.)
Ascorbic acid	23,586.7
Biotin	15.7
B_{12}	1.6
D-calcium pantothenate	2,830.4
Folic acid	188.7
Inositol	49,138.9
Menadione	157.3
Niacin	5,031.8
Para-aminobenzoic acid	7,862.2
Pyridoxine hydrochloride	471.7
Riboflavin	1,415.2
Thiamine hydrochloride	629.0
Total antioxidant and USP vitamins	105,693.0
Allowable carrier per pound	347,897.0
Total	453,590.0 Milligrams

1/ 89,156 milligrams of type F-50 shall be used. No substitutes will be allowed

Table II

Oregon Pellet Feeding Chart with Feeding Frequency Incorporated.
(Feeding level expressed as percentage of body weight to feed per feeding day)
Fish Size -- Fish/lb.

Ave. Water	500 -- 300		300 -- 200		200 -- 135		135 -- 90		90 --60		60 -- 40		40 --25		25 & larger	
Temp. °F.	%[1]	F.	%	F[2]	%	F	%	F	%	F	%	F	%	F	%	F
35	2.7	7/5	2.3	7/4	1.8	7/2	1.6	6/1	1.3	5/1	1.4	E/1[3]				
6	2.8	"	2.4	"	1.9	"	1.8	"	1.4	"	1.4	"				
7	2.9	"	2.5	"	2.0	"	1.9	"	1.5	"	1.6	"				
8	3.0	"	2.6	"	2.1	"	2.0	"	1.7	"	1.8	"				
9	3.2	"	2.7	"	2.2	"	2.1	"	1.8	"	1.8	"				
40	3.4	"	2.8	"	2.3	"	1.9	7/1	1.6	6/1	1.3	5/1	1.4	E/1	0.8	E/1
1	3.6	"	2.9	"	2.4	"	2.0	"	1.8	"	1.3	"	1.4	"	1.0	"
2	3.8	"	3.0	"	2.5	"	2.1	"	1.9	"	1.4	"	1.4	"	1.0	"
3	4.0	"	3.1	"	2.6	"	2.2	"	2.0	"	1.5	"	1.6	"	1.2	"
4	4.2	"	3.3	"	2.7	"	2.3	"	2.1	"	1.7	"	1.8	"	1.2	"
45	4.4	"	3.5	"	2.8	"	2.4	"	2.2	"	1.8	"	1.8	"	1.4	"
6	4.6	"	3.7	"	2.9	"	2.5	"	2.3	"	2.0	"	2.0	"	1.4	"
7	4.8	"	3.9	"	3.0	"	2.6	"	2.5	"	2.1	"	2.2	"	1.6	"
8	5.0	"	4.1	"	3.2	"	2.7	"	2.6	"	2.2	"	2.4	"	1.6	"
9	5.3	"	4.3	"	3.4	"	2.8	"	2.7	"	2.4	"	2.4	"	1.8	"
50	5.6	"	4.5	"	3.6	"	2.9	"	2.8	"	2.1	6/1	1.8	5/1	1.8	"
1	5.9	"	4.7	"	3.8	"	3.0	"	2.9	"	2.2	"	2.0	"	2.0	"
2	6.2	"	4.9	"	4.0	"	3.2	"	3.0	"	2.3	"	2.1	"	2.2	"
3	6.5	"	5.1	"	4.2	"	3.4	"	3.2	"	2.5	"	2.2	"	2.4	"
4	6.8	"	5.4	"	4.4	"	3.6	"	3.3	"	2.6	"	2.4	"	2.6	"
55	7.1	"	5.7	"	4.6	"	3.8	"	3.5	"	2.7	"	2.5	"	2.8	"
6	7.5	"	6.0	"	4.8	"	4.0	"	3.7	"	2.8	"	2.7	"	3.0	"
7	7.9	"	6.3	"	5.0	"	4.2	"	4.0	"	2.9	"	2.8	"	3.2	"
8	8.3	"	6.6	"	5.3	"	4.4	"	4.2	"	3.0	"	2.9	"	3.4	"
9	8.7	"	6.9	"	5.6	"	4.6	"	4.4	"	3.2	"	3.1	"	3.6	"
60	9.1	"	7.2	"	5.9	"	4.8	"	4.7	"	3.3	"	3.2	"	3.8	"
1	9.5	"	7.6	"	6.2	"	5.0	"	4.9	"	3.5	"	3.4	"	4.0	"
2	10.0	"	8.0	"	6.5	"	5.3	"	5.1	"	3.7	"	3.5	"	4.2	"
3	10.5	"	8.4	"	6.8	"	5.6	"	5.4	"	4.0	"	3.6	"	4.4	"
4	11.0	"	8.8	"	7.1	"	5.9	"	5.6	"	4.2	"	3.8	"	4.6	"
65	11.5	"	9.2	"	7.5	"	6.2	"	5.8	"	4.4	"	3.9	"	4.8	"

/1 Per cent body weight to be fed each feeding day.
/2 F - refers to number of days to feed per week and number feedings per day. (7/4: 7 days/wk. & 4 times/day)
/3 E/1 means feed every other day, one feeding per day.

Table III

1960 Brood Chinook Salmon Pellet Production as of October 31, 1961

Fall Chinook

	Number of Fish	Pellets Fed	Estimated Lbs. Fish Produced	Pellet Conversion	Per Cent Mortality	Fish per Pound
Cascade	3,321,948 1/	16,214	9,835	1.6	1.2	147
Sandy	61,348 2/	558	371	1.5	2.6	88

1/ The fish averaged 247 per pound at start of pellet feeding.
2/ The fish averaged 199 per pound at start of pellet feeding.

Table IV

1960 Brood Chinook Salmon Pellet Production as of October 31, 1961

Spring Chinook

Marion Forks	1,449,943	57,768	30,700	1.9	.9	39
McKenzie	150,620	10,735	5,385	2.0	1.2	23
Metolius	194,781	4,805	2,559	1.9	.7	58
South Santiam	147,669	6,425	3,877	1.7	.2	31
Trask	119,047	8,845	4,699	1.9	3.7	21
Willamette	1,047,375	72,952	41,574	1.8	1.1	23
Total	3,109,435	161,530	88,794	1.8	1.3	30.3

Table V

1960 Brood Silver Salmon Pellet Production as of October 31, 1961

Hatchery	Number of Fish 1/	Pellets Fed	Estimated Pounds Fish Produced	Pellet Conversion	Per Cent Mortality	Fish per Pound
Alsea	668,819	55,100	28,234	2.0	.7	21
Big Creek	1,225,621	98,944	55,967	1.8	2.3 2/	20
Bonneville	947,681	73,294	37,076	2.0	.7	23
Cascade	962,421	75,467	43,963	1.7	.6	20
Coos	582,700	31,950	14,972	2.1	8.8 3/	29
Klaskanine	1,217,510	114,950	56,095	2.0	.5	19
Nehalem	307,279	25,948	13,179	2.0	.2	21
Ox Bow	289,241	15,777	8,679	1.8	1.4	28
Sandy	611,523	41,766	20,675	2.0	.7	26
Siletz	615,594	47,203	25,830	1.8	8.6 2/	20
Trask	610,215	31,743	17,732	1.8	2.2	30
Willamette	43,247	3,596	1,980	1.8	1.6	20
Total	8,081,851	615,738	324,382	1.9	2.2	21.8

1/ Average size at start of pellet feeding - 256 fish per pound.

2/ Infection of furunculosis encountered.

3/ Infection of columnaris.

OREGON PELLETS AS A STARTING DIET - FEEDING OF DEHYDRATED OREGON PELLETS

Wallace F. Hublou
Oregon Fish Commission

INTRODUCTION

At the present time, moist Oregon pellets are not being fed until the fish reach a size of about 300 per pound. This is because the smallest pellets being made are 1/16 inch in diameter and about the same length. Our experience has been that most fish smaller than 300 per pound have difficulty in eating the 1/16-inch size of pellet.

In 1961, approximately 30 per cent of the fish food used by the Oregon Fish Commission was fed to the fish in a meat and fish diet before they were large enough to receive Oregon pellets. If smaller pellet sizes were manufactured, it would lengthen the time Oregon pellets could be fed.

It is not practical to extrude Oregon pellets smaller than 1/16 inch in diameter, because extra fine grinding of ingredients would be required and rate of production would be very slow. It was recently found that the pellets could be cut into extremely short lengths to produce "flakes," or if handled in the freezer while they were frozen and hard, the pellets could be cracked and made into "crumbles." The flakes, or crumbles, are then screened to provide the desired granulation.

When fed to larger fish, Oregon pellets, which are soft and moist, possess most of the advantages one would find when feeding a successful dry pellet diet. However, feeding smaller fish crumbled Oregon pellets may not prove to be very practical. The product will be very fragile as it will tend to ball up and become unmanageable if not handled with extreme care. Also, moist particles do not float well. A floating product is desirable when salmon first start feeding and for a short time thereafter. Crumbles made from dry pellets may be more satisfactory for small fish as they are free flowing, easy to handle, and float quite well. Oregon pellets can be dried and crumbled into the desired sizes, and resemble the common, hard, non-expanded commercial varieties. However, dried Oregon pellets may be inferior to the moist product because of destruction of nutrients or oxidation occurring during the drying process. It is difficult to determine chemical changes in the food brought about by drying or to predict what effect these changes will have on the fish. An alternative to chemical analysis is the biological test; i.e., feed some fish the food in question and observe the results.

In 1961, two feeding experiments were conducted to test Oregon pellets as a starting diet and to test dried Oregon pellets, both as a starting diet and over a longer period of time.

MATERIALS AND METHODS

The experiments were conducted at the Clackamas research laboratory using 6-foot circular tanks supplied with spring water which provided temperatures ranging from 50° to 58° F. Each tank was stocked with 2,000 fish at the start; after 6 weeks of feeding, the number per tank was reduced to 500. Each diet was fed to two tanks of fish on an appetite basis; i.e., all the fish would consume readily during a predetermined number of feedings per day. Feeding frequency was kept the same for all diets. Observations to be made included fish growth, mortality, food conversion, hematocrit and hemoglobin determination, general appearance and behavior, and microscopic internal examinations.

One experiment was conducted with fall chinook salmon for a period of 90 days, which corresponds to our normal rearing period. Unfed fry averaging 1,086 per pound and from the same day's egg-take were used as experimental animals. The original experiment was composed of two diets--a control composed of equal parts beef liver, hog liver, and pasteurized salmon viscera plus 2 per cent salt, and Oregon pellets. When the number of fish per tank was reduced, a third diet, dried Oregon pellets, was initiated. The fish utilized were those discarded from the lots fed Oregon pellets. Oregon pellets, moist or dried, were fed in three sizes of crumbles during the course of the study. By the end of the experiment, those fish receiving the moist pellets were receiving the 1/16-inch size. Feeding frequency ranged from 8 times per day at first to as little as 2 times per day by the end of the test.

The second experiment was conducted with silver salmon and it is still in progress at the time of writing. For this report, the data is summarized as of the end of October after 26 weeks of feeding. Unfed fry averaging 830 fish per pound, from eggs taken over a 9-day period, were used as experimental animals. Three diets were fed at the start of the experiment--a control of the same meat and fish composition as fed the fall chinook, Oregon pellets, and dried Oregon pellets. After the fish fed the control diet reached a size of 300 per pound, the diet was changed to Oregon pellets. This was done to have the control duplicate the normal production feeding procedure. Feeding frequency ranged from 8 times per day at the start to as little as once every other day when the fish reached a size of about 40 per pound.

RESULTS

A summary of the results produced by the control and Oregon pellet diets in the fall chinook experiment are given in Table 1. Table 2 contains a summary of the results for Oregon pellets and dried Oregon pellets during the period dried pellets were fed the fall chinook.

Results of the silver salmon experiment are summarized in Table 3.

DISCUSSION

Fall Chinook Salmon Experiment

At first, the fish ate the control diet much better than crumbled moist pellets, but after a few days the crumbles were eaten with vigor. The fish fed the dried crumbles were already used to eating moist crumbles and did not seem to hesitate eating the dried product.

It became obvious during the experiment that more frequent pellet feeding, moist or dried, would have been desirable than with the meat diet. However, feeding frequency was kept the same for all diets. Towards the end of the experiment, it was felt that the dried crumbles should have been fed more frequently than the moist ones. As frequency of feeding was reduced, the fish did not seem to be able to eat as much of the dried crumbles per feeding as they could of the moist crumbles.

Table 1

Summary of Results, Control and Oregon Pellet Diets, Fall Chinook Diet Experiment, April 13 to July 11, 1961.

Diet	Growth (Fish/lb) Start	Growth (Fish/lb) End	Mortality (Per Cent)	Food Efficiency Dry Wt. Conv.	Food Efficiency Cal/100GMS Lot Gain /1	Hematology (7/11/61) Hematocrit (Per Cent)	Hematology (7/11/61) Hemoglobin (GMS/100ML)
Control	1,106	89	0.8	0.96	368	38	10.9
Oregon Pellets	1,068	113	7.4	1.01	335	33	11.0

/1 Digestible calories calculated according to the values suggested by Phillips and Brockway (1959).

Table 2

Summary of Results, Oregon Pellet and Dried Oregon Pellet Diets, Fall Chinook Diet Experiment, May 24 to July 11, 1961.

Diet	Growth (Fish/lb) Start	Growth (Fish/lb) End	Mortality (Per Cent)	Food Efficiency Dry Wt. Conv.	Food Efficiency Cal/100GMS Lot Gain	Hematology (7/11/61) Hematocrit (Per Cent)	Hematology (7/11/61) Hemoglobin (GMS/100ML)
Oregon Pellets	368	113	3.0	0.99	329	33	11.0
Dried Oregon Pellets	363	126	3.3	0.91	304	38	11.3

The moist crumbles did not float well and were difficult to feed as a starting diet. As a result, pinheaded fish were produced in the groups fed moist pellets, whereas they were not present among the fish fed the control diet. When the number of fish per tank was reduced, all pinheaded fish were removed and arbitrarily called mortality. This accounts for the high mortality in the groups fed moist pellets (Table 1). Dried crumbles did not produce any more pinheaded fish than moist crumbles, although they were not fed as a starting diet and the experimental period was much shorter.

Oregon pellets produced less growth than the control diet and dried Oregon pellets produced less growth than the moist product (Tables 1 and 2). In either case, this was not because the diet producing less growth was utilized less efficiently. It appeared that feeding frequency influenced the growth rate.

Table 3

Summary of Results, Silver Salmon Diet Experiment,
April 26 to October 25, 1961, Clackamas Laboratory.

Diet	Growth (Fish/lb) Start	Growth (Fish/lb) End	Mortality (Per Cent)	Food Efficiency Dry Wt. Conv.	Food Efficiency Cal/100GMS Lot Gain	Hematology /4 Hematocrit (Per Cent)	Hematology /4 Hemoglobin (GMS/100ML)
Control/1	818	26.2	1.8	/2	/3	35	10.7
Oregon Pellets	841	26.4	2.5	1.10	366	37	11.0
Dried Oregon Pellets	833	35.3	1.7	1.08	358	36	11.3

/1 Fed meat-fish diet from 4/26-6/6; Oregon pellets from 6/7-10/25.
/2 Meat-fish diet - 0.90; Oregon pellets - 1.15.
/3 Meat-fish diet - 339; Oregon pellets - 383.
/4 Hematocrits taken 10/25/61; hemoglobins taken 9/26/61.

The major difference in the growth rates between fish fed the control diet and moist Oregon pellets was realized in the first 4 weeks of the experiment. After that time, the pellet diet produced gains comparable to those of the control diet.

Blood condition, as represented by hematocrit and hemoglobin determinations taken at the conclusion of the experiment (Tables 1 and 2), was about the same for fish fed all three diets.

In general, it was concluded that the use of Oregon pellets as a starting diet is not very practical because of the physical consistency and the fact that they do not float well. The dried pellets seemed to be more practical in this regard; it is felt that if fed as a starting diet they would be more available to the fish and thus might reduce the production of pinheaded fish encountered in feeding the moist pellets. It is also felt that both moist and dried pellet diets might have produced better growth if feeding frequency had been increased.

Silver Salmon Experiment

The silvers started eating both moist and dried pellets with little hesitation; however, there was an obvious lag in growth during the first two weeks when compared with the control diet. Other observations on practicality of the pellet diets were about the same as mentioned for the fall chinook. Production of pinheaded fish was not a problem with the silvers; this is reflected in the low rate of mortality for all three diets (Table 3).

As a starting diet for silvers, the pelleted diets did not produce as much growth as the control diet. However, with the moist pellets, this difference was overcome later on in the experiment. The difference in growth rate between fish fed moist and dry pellets became more pronounced as the study progressed. As for the fall chinook, the differences in growth rates are not attributable to differences in food conversions.

No conclusions can be made for the silver salmon experiment as it is still in progress.

LITERATURE CITED

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1959. Dietary Calories and the production of trout in hatcheries. Prg. Fish Cult., Vol. 21, No. 1, pp. 3-16.

A PROGRESS REPORT ON THE 1961 DIET TRIALS

Richard G. Bigej
Bureau of Sport Fisheries and Wildlife

Feeding trials, testing the Oregon moist pellet, are in progress at three national fish hatcheries.

These tests are being conducted by the hatchery managers and personnel of the respective hatcheries and were set up on a single or duplicate raceway scale as space permitted. The pellets are being fed in accordance with the Oregon feeding chart while the wet control diets are being fed in accordance with a modified Cortland feeding chart. The control diets are the standard wet production diets for each respective hatchery.

The Sandy laboratory of the Oregon Fish Commission has offered many suggestions pertaining to the feeding of pellets and has cooperated in the monthly sampling of blood from each lot of fish included in the feeding trials.

At the Willard hatchery, Mr. Cairns started feeding the Oregon moist pellet to 34,000 silver salmon in a single raceway on May 11, 1961. An adjoining raceway containing the same number of fish, but receiving the Willard production diet, serves as the control. The control diet components, a comparison of fish growth, and the total percentage mortality are given in the table. The water temperature at Willard averaged 44.8° F. for the period from May through October.

The Oregon moist pellet fish, at the end of October, averaged 11.18 grams as compared to the control fish which averaged 10.05 grams per fish. Monthly blood samplings indicate normal hematocrits and red blood cell counts on fish from both diets, but a sustained low hemaglobin level in the fish on the Oregon moist pellet was noted.

At the Carson hatchery, Mr. McElrath has been feeding the Oregon moist pellet to 60,000 spring chinook in a single raceway since June 1, 1961. An adjoining raceway, stocked with the same number of fish but receiving the Carson production diet, serves as the control. A comparison of growth, the components of the control diet, and the percentage mortality to date are given in the table. The water temperature at Carson averaged 50.5° F. for the period from June through October.

The Oregon moist pellet fish at the end of October averaged 8.69 grams as compared to 8.23 grams per fish on the control diet. The blood levels of the fish receiving the Oregon moist pellet have remained above the minimal level, but the fish receiving the control diet are suffering from a slight anemia, with both the hemaglobin level and hematocrits below normal.

At the Eagle Creek hatchery, Mr. Parvin has duplicate raceways of spring chinook, silvers, and steelhead receiving the Oregon moist pellet and in addition is testing Stockton's Rainbrook and McNenny #13 dry feeds on duplicate raceways of silvers.

The spring chinook trials were started June 1, 1961 with 53,000 fish in each of four raceways. Two raceways receive the Oregon moist pellet and the remaining two receive the Eagle Creek production diet. The control diet components, growth data, and percentage mortality to date are given in the table. The average water temperature at Eagle Creek from June through October was 54.8° F.

At the end of October, the Oregon moist pellet fish averaged 16.05 grams per fish as compared to 11.86 grams per fish on the control diet. The blood levels of the fish have remained comparable and well above the minimal levels on both diets.

The silver salmon trials were started June 1, 1961 and consist of eight raceways stocked with 56,000 fish in each. The Oregon moist pellet, Stockton's Rainbrook, McNenny #13, and the Eagle Creek production diet are each being fed to a pair of the eight raceways. Growth, percentage mortality, and the control diet components are given in the table.

At the end of October the average gram weight of the fish on each diet was as follows: 21.70 on the Oregon moist pellet, 18.18 on Stockton's, 15.65 on McNenny #13, and 14.09 on the control diet. The blood levels of the four groups are closely comparable and well above the minimal levels.

The steelhead feeding trials were started July 18, 1961 with approximately 107,000 fish in each of four raceways. One pair of raceways is being fed the Oregon moist pellet while the other pair is receiving Stockton's Rainbrook. Stockton's is being used as the control diet since it was found to be equal to the Eagle Creek production diet in previous feeding trials with steelhead.

The steelhead trials were started with fish of unequal sizes--261 and 368 per pound--and after 12 weeks of feeding were graded and cut back to 50,000 fish per raceway. At this time, growth was slightly in favor of Stockton's dry feed with a 440 per cent gain in total weight as compared to 408 per cent gain on the Oregon moist pellet. Growth and percentage mortality figures are given in the table. Both diets maintained satisfactory blood levels in the fish.

All of the above diets will be continued through the winter and until the normal release date for the species and hatchery concerned.

The Oregon moist pellets simplify fish food preparation greatly, but some difficulty was experienced in converting the fish from the floating wet diets to the sinking pellets--especially the spring chinook at both the Carson and Eagle Creek hatcheries. Also, a delay in the changing of pellet sizes from 3/32 inch to 1/8 inch was found necessary with both the silvers at Willard and the spring chinook at Carson and Eagle Creek. These are considered technique difficulties that can be corrected with experience in the handling of the pellets.

The results to date are in favor of the Oregon moist pellet, but no conclusions can be drawn until the winter growth period is completed and the data more carefully analyzed.

AVERAGE GRAM WEIGHT OF FISH REARED IN THE 1961 FEEDING TRIALS AT WILLARD, CARSON AND EAGLE CREEK NATIONAL FISH HATCHERIES

Willard Silver Salmon Date	Control	OMP
5/11	1.64	1.64
5/31	2.36	2.18
6/15	3.01	2.86
6/30	3.76	3.76
7/15	4.57	4.48
7/31	5.45	5.27
8/15	6.07	6.20
8/31	7.22	7.47
9/15	8.24	8.79
9/29	8.74	9.32
10/16	9.47	10.41
10/31	10.05	11.18
Mortality to date(%)	3.77	3.19

Carson Spring Chinook Date	Control	OMP
6/1	1.60	1.65
6/15	2.06	1.64
6/30	2.60	2.07
7/16	3.33	2.85
7/30	4.06	3.50
8/15	4.78	4.55
8/31	5.72	5.65
9/14	6.45	6.77
9/29	7.12	7.33
10/16	7.80	8.15
10/31	8.23	8.69
Mortality to date(%)	1.27	1.49

Eagle Creek Spring Chinook Date	Spring Chinook Control	Spring Chinook OMP	Silver Salmon Control	Silver Salmon OMP	Silver Salmon Mc#13	Silver Salmon Stock	Steelhead Stock	Steelhead OMP
6/1	1.48	1.48	1.71	1.70	1.41	1.51		
6/15	1.95	1.83	2.40	2.55	1.82	2.31		
6/29	2.74	2.94	3.72	4.31	3.01	3.71		
7/13	3.40	3.60	5.20	5.98	4.11	5.17	1.23	1.74
7/30	4.80	5.49	7.18	8.69	5.74	7.63	1.71	2.49
8/14	5.85	6.31	8.57	10.69	7.10	9.52	2.43	3.41
8/28	7.35	8.62	10.25	12.69	8.98	11.29	3.33	4.54
9/13	8.59	10.73	11.47	15.03	10.69	13.31	4.40	5.89
9/27	10.12	12.85	12.68	17.90	12.63	15.36	5.53	7.56
10/16	11.09	14.84	13.60	20.12	14.72	17.66	6.67	8.89
10/29	11.86	16.05	14.09	21.70	15.64	18.18		
Mortality to date(%)	1.68	2.23	0.79	0.94	2.41	1.05	0.79	0.72

Willard — Control Died Composition

Turbot	28%
Beef liver	10%
Pork liver	10%
Beef spleen	15%
Sal. viscera	30%
Sal. eggs	5%
T.M. Salt	2%
Total	100%

Carson — Control Died Composition

Turbot	35%
Beef liver	14%
Pork liver	13%
Beef spleen	20%
Sal. eggs	10%
Dist. solubles	5%
Brewer's yeast	1%
Salt	2%
Total	100%

Eagle Creek Spring Chinook — Control Diet Composition

Turbot	35%
Beef liver	20%
Pork liver	20%
Beef spleen	25%
Total	100%

+ 2% salt added

Eagle Creek Silver Salmon — Control Diet Composition

Turbot	35%
Beef liver	20%
Pork liver	20%
Beef spleen	25%
Total	100%

+ 2% salt added

Steelhead: No wet diet control

FEEDING OF SPRING CHINOOK SALMON AND ASSOCIATED PROBLEMS

Panel: Mr. R. E. Noble, State of Washington Dept. of Fisheries
Mr. Ernest R. Jeffries, Fish Commission of Oregon
Mr. John R. Parvin, BSF&W - Branch of Fish Hatcheries
Mr. Roger Burrows, BSF&W - Branch of Fishery Research
Mr. Marvin A. Smith, BSF&W - Discussion Leader

The spring chinook salmon is considered to be one of the more endangered species of anadromous fishes in the Columbia Basin. It is felt that a discussion of the diet requirements and the problems associated with the rearing and time of release of this species would be timely and useful to management and research personnel faced with the preservation of this fish.

It was decided to approach this topic by having four speakers from different state and federal agencies discuss the subject. The four speakers and their respective agencies are listed above.

R. E. Noble

The role of spring chinook in the hatchery program of the Washington State Fisheries Department has been a very minor one for two reasons.

1. Only three department stations have access to spring chinook - Dungeness, Skagit, and Klickitat.

2. The rearing of spring chinook has been a real problem and because spring chinook play a minor role in hatchery production, effort to solve the diet problem has not been extensive.

Based upon the theory that the larger the outgoing migrant--other factors being equal--the higher the survival, spring chinook are reared from 10 to 15 months prior to release. Marking experiments designed to test success of 5 to 10 and 15-month rearing of spring chinook were undertaken at Klickitat involving the 1955 brood (Figure 1), but returns were not of sufficient numbers to evaluate the experiment. Hatchery returns included two BV marks, no Ad-BV marks, and five Ad-LM marks. (5 to 10 and 15-month liberations respectively.)

An attempt to determine information on natural migration was undertaken at Klickitat by counting the numbers of spring salmon fingerlings moving out of a large dirt pond. The pond had a spring-water supply of 50 gallons per minute and a temperature of 45-48° F.

On January 23, 1961, a total of 20,000 hand counted spring chinook was transferred to the spring-fed pond. The fish weighed 650 per pound at the time of the transfer. The overflow from the pond went into a screen box which served as a trap for fish that moved out of the pond. The pond was screened off for one week after the initial planting of the pond to allow the fish to stabilize. The screen was removed on January 30, 1961 and by 10:00 a.m. of the 31st, a total of 161 springs had moved into the trap. Through the first two weeks of February, 23 per cent of the number placed into the pond moved out on their own accord. At the end of February, the percentage was up to 23.9. There was no attempt by the fish to leave the pond during the month of March.

The fish started moving out again the first part of April and continued through the first week of July.

At the end of May, 50 per cent of the number placed into the pond had been counted out. A slight peak occurred during the second week of April and another in the third week of May. After the first week of July, there was virtually no movement of fish out of the pond until the first two weeks of September when a few fish migrated from the pond. The fish remaining in the pond will be observed through the spring of 1962 and the remaining fish will be drained from the pond in July of 1962 to determine the number of survivors. This representative of natural movement is still rather questionable, but it is theorized that the experiment does serve as an indication of natural migration time of spring chinook from the upper Klickitat.

The availability of feed, crowding, competition, and time, as they effect migration, are as yet not fully understood and the variation of any of these factors may effect migration rate and time.

Ernest Jeffries

The Oregon Fish Commission has been in the spring chinook raising business since the turn of the century. I believe our oldest spring chinook hatchery was on the McKenzie River where we still operate a hatchery. The early days' spring chinook hatchery operations consisted of large egg-takes, with many of the resulting eggs being shipped out and the remaining fish being released as early feeding fingerlings. A look at the egg shipment records of the McKenzie Hatchery in the late 1920s, when they had egg-takes varying between 20,000,000 and 27,000,000, reminds one of a world scenic tour. The eggs went from the McKenzie to the Alsea on the coast, Bonneville on the Columbia, Klaskanine on the Columbia, Wallowa Lakes, Willamette River, Rogue River, Clackamas River, Salmon River in Idaho, Siuslaw River, South Santiam River, Hornbrook, California, and Finland.

The Commission rears spring chinook on one coastal stream, the Trask, on four Willamette streams, the North and South Santiam, the McKenzie and the Middle Willamette Rivers, and on the Metolius River, a tributary of the Deschutes River. Last year we released 4.25 million; this year we have 3 million yearlings.

It was not until the mid-1940s, when it was determined that spring chinook normally spend the first year in fresh water, that the numbers of eggs taken were reduced, and the fingerlings released were of a larger size.

The ponds in the early-day hatcheries were usually dirt ponds in series, with limited rearing capacities. As soon as the length of rearing increased with the spring chinook, it was readily evident that the diets then in use were not producing satisfactory fish and that disease was a serious problem.

Shortly after this change came about in the rearing program, two large dams were built on Willamette River tributaries--the Lookout Point Dam on the Middle Willamette and the Detroit Dam on the North Santiam. These dams were not equipped with fishways; instead two large modern hatcheries were built to replace two smaller hatcheries which the dams made inoperative. All of the spawning area for spring chinook salmon in the Middle Willamette River and a large percentage of it in the North Santiam River was taken out of production. With these new, large units, we now have modern facilities where yearlings numbering into the millions can be reared. With so much spawning area gone and facilities for rearing several million yearlings, it became more important that a satisfactory diet be developed, disease control methods be found, and that we should know more about the time and size to release these fish if the Willamette runs of spring chinook were to be maintained.

Much of the success which we believe we now are having, at least with the rearing of spring chinook fingerlings, is due to the development of the Oregon moist pellet cooperatively with the Oregon State University technicians.

The wet pellets are not fed until the fish reach about 300 per pound; therefore, it is necessary that we have a good wet diet to feed the fish until they are ready for the pellet. This year, as a starting diet, we are feeding one of the better known diets--1/3 each of hog liver, beef liver, and pasteurized salmon viscera. After about a month we will change the diet to 15 per cent beef liver, 15 per cent hog liver, 20 per cent beef spleen, 40 per cent pasteurized salmon viscera, and 10 per cent tuna viscera. We have followed this basic feeding plan since the 1958 brood springs. The wet diets in 1959 and 1960 included many other ingredients which were on hand. We now only purchase hog and beef liver or spleen, pasteurized salmon viscera and tuna viscera.

I am sure you are all familiar with the advantages of pellets over wet diet in that the food leaching is gone, as is the grinding and mixing operation. All that is required is that they go to the freezer, take out a sack of pellets, allow them to thaw for a short time, and feed them. The fish get a homogenous mixture in each pellet.

Many of the disease problems that we had before have vanished. Gill disease is practically gone and kidney disease, which was a limiting factor, has completely disappeared this year and was practically nonexistent last year. John Fryer reported on the disappearance of tuberculosis. We occasionally have some ectoparasites, generally trichodina, which can easily be controlled with a formalin treatment. We have had a myxosporidian called myxobolus which appeared at McKenzie and South Santiam Hatcheries. However, we are not familiar with ways to treat for this parasite and fortunately it has been a very minor problem this year.

It has been found that spring chinook normally go to sea after one year in fresh water, comparable to silvers, but different than fall chinook. Our rearing and release is accomplished with this as a guide, but many other factors influence the specific time of release. Size, of course, is intimately interwound in this release time.

Generally, we attempt to get our springs as large as we can by time for release. The water supplies at the hatchery control the size which we are able to get. At Marion Forks, which is a cold water station, our 1959 brood year fish averaged from 25 to 60 per pound when liberations were started in January. We hope to beat that this year. At the other hatcheries, with approximately the same time of release, the fish ran 20 to 34 per pound. In the Willamette, there are several other factors influencing the liberation of spring chinook other than biological ones. First, all the hatcheries raising spring chinook on the Willamette are above Willamette Falls. The water-flow pattern down over Willamette Falls in the spring has changed because many of the upper tributaries in the Willamette are now dammed. The winter and spring freshets are reduced with a more stable flow resulting in the spring. Flash boards, which are put on the falls earlier in the spring, divert most of the river through the industrial plants. The Game Commission has conducted some tests with downstream migrants at Willamette Falls. These tests show that there are high mortalities among fish going through the industrial plants. Therefore, hoping that the migrants head downstream immediately after release, we liberate in the early spring or late winter at a time when there is a better chance for a lot of water to be going over the falls. If we release the fish too early, there is a chance that the high winter flows will allow them to end up in pot holes along the side of the river and become stranded when the river drops. If we allow the fish to go out too late and they do not move down over Willamette Falls soon enough, they may be caught in the pollution block which occurs nearly every year in the lower Willamette River. And then, there is the problem at hatcheries like Willamette where we have approximately 70,000 pounds of fish to be released and each load has to be hauled some 40 miles to the release point. This operation extends over a period of several months. In addition, the Willamette Hatchery has a water supply which is subject to extreme flooding, depending on the flows in the stream. One year it was necessary to liberate salmon prematurely, into the forebay of the reservoir, to save them. Therefore, for insurance against this type of thing, we liberate some of our fish in late November in order to get them out ahead of any possible floods.

In an experiment with the 1955 brood spring chinook at Willamette Hatchery, approximately 120,000 fish in each of five groups were double-fin marked and released below Dexter Dam at different times during the year. The first group was released on June 1, the next about August 31, the third group around the 1st of October, the fourth on the 1st of December, and the last group about the middle of February. Unfortunately, the fish being liberated were infected to some unknown degree with kidney disease. We are sure that this factor contributed to the rate of survival. However, from the returns of this group of fish to the hatchery, it appeared that the fish going out the 1st of December came back a little stronger than those going out in either October or the following February. We have not done any marking with recent broods of fish to attempt to better determine these findings.

The numbers of adult spring chinook coming into the Willamette have been low the last two years. We hope that our changed hatchery procedures, which include feeding pasteurized salmon viscera and pellets, reducing incidence of disease, growing the fish larger and apparently more healthy, will influence the numbers of adults returning as 4-year olds in 1962 and subsequent broods.

John R. Parvin

I first became acquainted with spring chinook in 1942. I was stationed at the old Delph Creek Station of this service. During that period, I had four years experience. From 1956 through this time, we have reared spring chinook at the Eagle Creek National Fish Hatchery. In addition, I had some limited experience with the long-run spring chinook salmon at the Leavenworth National Fish Hatchery.

We have started our spring chinook salmon on a combination of 50 per cent beef liver and 50 per cent hog liver. This was fed for about two weeks to a month and then the fish were switched to a production-type diet. In early years, many combinations of foods were used as they became available. During that period, nutritional information was not as readily available to the hatcheryman as it is today.

In the past few years, we have fed, with some variation, a production diet consisting of the following formula: 20 per cent beef liver, 20 per cent hog liver, 20 per cent spleen, 30 per cent turbot, and 10 per cent meal. When the meal was unavailable or not used because of cold water conditions, the turbot and spleen were increased.

In the past years, tests have been made with Oregon moist pellets with very good results. The production-type diet is fed until release time. During 1959 we ran tests on dry feed with no favorable results.

The time of release has been determined, for this station, to be in the early spring after one full year of feeding. We arrived at this release time from work done by the Oregon Fish Commission. This work consisted of the sampling of downstream migrants which showed that the bulk of these were of yearling size. Extensive scale readings were made of returning migrants, and these showed that almost 100 per cent were of yearling size at time of migration.

On the whole, dietary problems and disease have not been of great concern. The mortalities for the years of rearing of this species at Eagle Creek have not been excessive. During the year 1958, kidney disease was diagnosed. The source of this infection is unknown.

Roger Burrows (Summarized by discussion leader)

Mr. Burrows pointed out that he has been confronted with dietary and other associated problems involving the rearing and release of spring chinook salmon since early Grand Coulee Project days. Mr. Burrows also wanted it to be known that in his opinion we were discussing two different strains of fish. He had no previous experience with the lower Columbia River strain of spring chinook salmon, and his remarks applied only to chinooks that migrate above Rock Island Dam.

Diet of Spring Chinook. Modifications of the Leavenworth production diet proved to be the best of all diets tested at the up-river federal hatcheries for the feeding of spring chinook salmon. Experimentations were made with dry diets but with little success.

Time of Release. Early in the hatchery rearing program of this species it was noted that in the fall of the year, there was a tendency for the fish to "tail" the outlet screen. Upon removal of the restraining screen, the fish moved downstream out of the holding ponds. Since this time of release fitted in smoothly with hatchery and ponding operations, the months of September and October have been established as the times of release of spring chinook salmon from up-river federal hatcheries.

Summary of Discussion

Diets. The percentages of liver and spleen to be used in the wet diet were discussed and it appears that the best rearing success is obtained by keeping high percentages, 50 to 60 per cent, wet weight in the diet. The 15 per cent liver and spleen used at the Klickitat Hatchery was questioned as being too low.

Time of Release. Management and fish cultural personnel on the lower Columbia River drainages were more or less in agreement that, where possible to do so, spring chinook should be reared to yearling size and released in the spring of the year. This procedure has been successful in establishing an artificial run from up-river fish in Wind River, Washington.

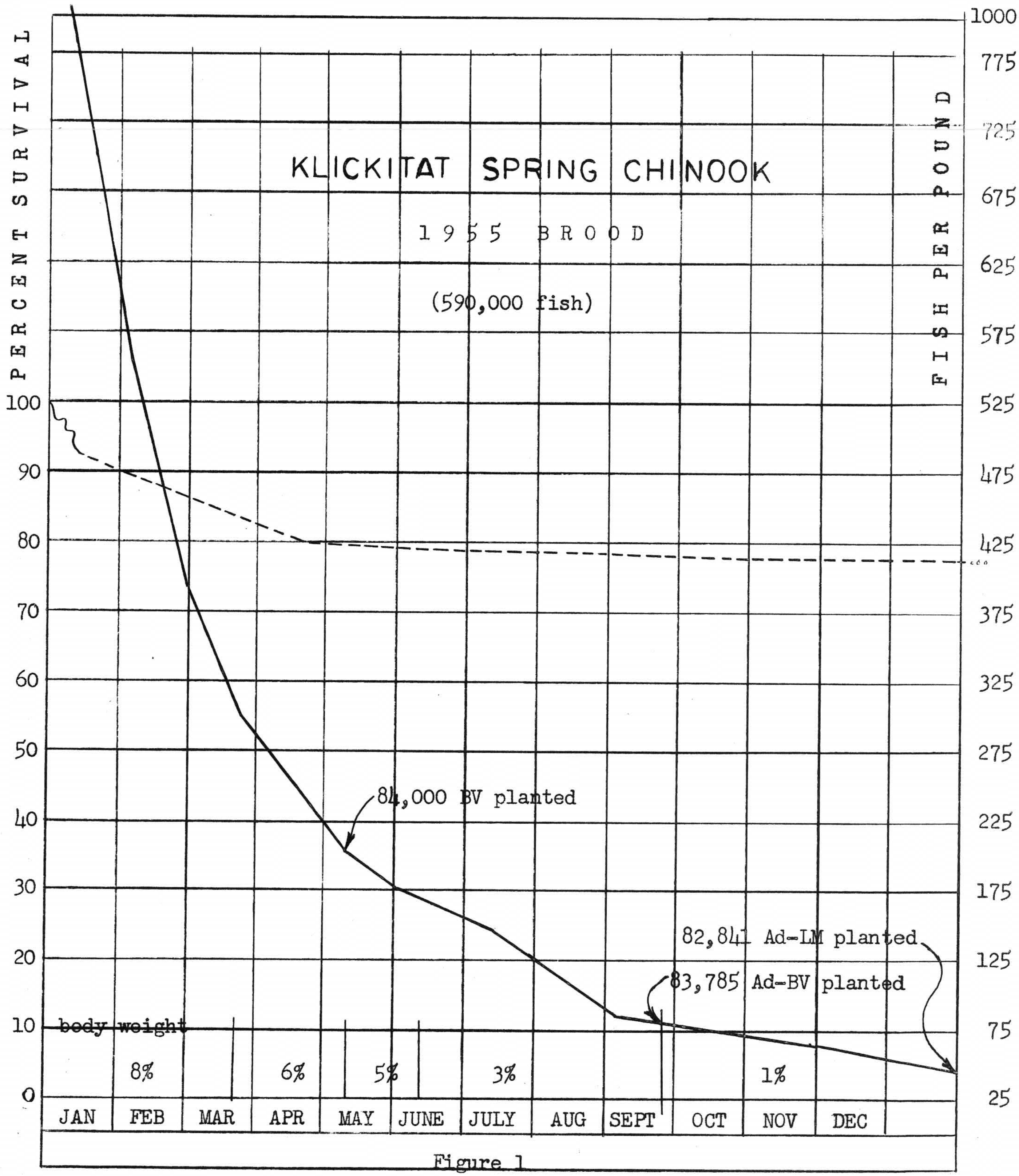

Figure 1

DIET

83% viscera, 12% beef liver, 3% spleen, 2% salt.
2 grams sulmet per 100 pounds fish.

Table 1

SPRING CHINOOK SALMON - EAGLE CREEK NATIONAL FISH HATCHERY

Brood Year	Source	Number Starting to Feed	Number Released	Feeding Data		Number per Pound	Conversion	Diseases	Per Cent Survival to Release
				Dates Fed	Components				
1956	Willamette R. Oreg. Fish Comm.	240,000	200,000	3/4/57 - 4/11/57	50% B.L. 50% H.L.	1228 to		None	83.4
				4/12 - 6/15/57	35% B.L., 35% H.L., 30% T.	900 to			
				6/16/57 - 4/1/58	20% B.L., 20% H.L., 25% S., 30% T., 5% D.S. 10% F.M., w/ variations	26	5.6		
1957	Willamette R. Oreg. Fish Comm.	761,450	611,300	3/1/58 - 3/31/58	100% B.L.	1279 to		kidney disease	80.3
				4/1/58 - 2/17/59	20% B.L., 20% H.L., 20% S., 25% T., 5% D.S. 10% F.M., w/ variations	921 to 38	5.0		
1958	Marion Forks, N. Santiam R. Oreg. Fish Comm.	980,000	740,955	2/11/59 - 2/23/60	15% B.L., 25% H.L., 20% S., 30% T., 5% D.S. 5% F.M. 1 pond dry pellets	1338 to 33	4.3	None	75.6
1959	McKenzie River Oreg. Fish Comm.	521,000	400,000	2/25/60 - 4/15/60	50% B.L. 50% H.L.	1214 to			95.9
				4/15/60 - 2/5/61	20% B.L., 25% H.L. 25% S., 30% T.	790 to 29	4.0	None	

Note: B.L. (beef liver), H.L. (hog liver), T. (turbot), S. (spleen), D.S. (distillers solubles), F.M. (fish meal).

RECOVERIES OF MARKED ADULT SALMON RELEASED FROM SPRING CREEK AND LITTLE WHITE SALMON NATIONAL FISH HATCHERIES

Harlan E. Johnson
Bureau of Sport Fisheries and Wildlife

This is the third year that I have reported on recoveries of marked fall chinook salmon at Spring Creek and Little White Salmon National Fish Hatcheries. This year I will also report on recoveries of marked silver salmon.

Spring Creek

Fall chinook salmon of the 1956, 1957, and 1958 brood years were marked and released at Spring Creek to compare survival from releases of unfed fry and 90-day reared fingerlings. Both groups of fish were marked just before they were ready to feed when they were about 1,100 fish per pound. Each year the fish marked adipose-left pectoral were released February 5 immediately after marking. The second group was marked adipose-right pectoral and then reared for about 90 days before release on May 7. Approximately 240,000 fish of each mark were released each year.

Marked adults from this experiment were recovered in 1959, 1960, and 1961. Data on recoveries at Spring Creek only are given in the following table:

	Ad-LP	Ad-RP
Date released	February 5	May 7
Days reared	0	90
Fish per pound	1,077 to 1,178	121 to 143
Adults recovered 1959	3	107
Adults recovered 1960	10	84
Adults recovered 1961	None	82
Total recovered	13	273

I believe that all agencies that recover marked salmon report the marks to the Mark Analysis Section of the Oregon Fish Commission. The following data on total recoveries of Spring Creek marks in 1960 are taken from their report.

	Ad-LP	Ad-RP
Total at Spring Creek	10	84
Total reported	28	202
Per cent at Spring Creek	36	42

All data available indicates a much greater survival from releases of fingerling than of unfed fry. Releases of unfed fry at Spring Creek have been discontinued.

Little White Salmon

Fall chinook salmon of the 1956, 1957, and 1958 brood years were marked and released at Little White Salmon to determine survival after several periods of rearing. The fish were marked in May and June when they were 500-200 fish per pound. Releases were made in May, July, September, October, and as yearlings in February, with about 200,000 marked fish in each group. Two marks were released in October to compare returns from dorsal and anal marks.

Marked fish from this experiment were recovered in 1958, 1959, 1960, and 1961. Recoveries at only Little White Salmon are given below.

Mark	LP	RP	D-LP	D-RP	An-RP	An-LP
Date released	May	July	Sept.	Oct.	Oct.	Feb.
Days reared	70	125	190	230	230	350
Fish per pound	272-387	134-155	87-96	76-88	72-88	59-70
Adults recovered 1958	1	2	0	0	0	0
Adults recovered 1959	12	32	4	7	20	53
Adults recovered 1960	18	46	6	4	31	72
Adults recovered 1961	24	55	8	8	74	64
Total recovered	55	135	18	19	125	189

Recoveries of Little White Salmon marks in 1960 as reported by Oregon Fish Commission were as follows:

	LP	RP	D-LP	D-RP	An-RP	An-LP
Total at Little White	18	46	6	4	31	72
Total reported	60	92	9	8	58	132
Per cent at Little White	30	50	67	50	53	55

The results at Little White Salmon are not as clear-cut as those at Spring Creek, but it appears that the fingerlings should not be released before July. The fish marked dorsal-right pectoral were recovered in much smaller numbers than those marked anal-right pectoral released at the same time. We have had similar results with other groups of dorsal-marked fish in the past, and I do not feel that the data from dorsal marks are of any value.

Silver salmon

Silver salmon of the 1958, 1959, and 1960 brood years were marked and released at Little White Salmon. Each year a group of about 250,000 fish marked left ventral was released in November and another group marked right ventral was released in February as yearlings, as shown below.

	LV	RV
Date released	November 3	February 12
Days reared	250	350
Fish per pound	70-46	46-37
Recovered 1960	22 Jacks	27
Recovered 1961	27 Jacks	55
	70 Adults	141

In 1960, jacks from the 1958 brood were recovered in almost equal numbers (22-27), but adults from this brood recovered in 1961 (70-141) indicate greater survival of fish released in February. The recovery of jacks of the 1959 brood in the fall of 1961 is also greater from the group released in February (27-55). These data indicate that it is advantageous to rear silver salmon until February, but final decision cannot be made until 1963 when all of the returns will be in.

It is my opinion that, for both fall chinook and silver salmon, the size of the fish at the time of hatchery release has a considerable effect on survival, with the greatest returns being from the largest fish. There are certainly many other factors that also affect survival, but size of the fish at the time of planting is one over which we have some control.

NOTES ON WIZARD FALLS HATCHERY OPERATIONS, 1961

K. E. Morton
Oregon State Game Commission

The changes brought about through the use of pelleted foods have so greatly revolutionized our production procedures that it seems appropriate to make a brief comparison between the "before" and "after" eras.

A production of 45,000 pounds of fish per year, at a cost of approximately 80 cents per pound, was about par for the course a few years ago. This was equal to 11,000 pounds per man employed and a production of 14.3 pounds of fish per gallon per minute flow of water. This latter factor, we feel, is most important in hatchery evaluation criteria.

This year we have liberated 94,447 pounds of fish for an operational cost of 40 cents per pound. This is a production of 23,600 pounds per man employed and a production of 31 pounds of fish per gallon per minute flow of water.

Percentage wise, this is an increase of 110 per cent in poundage produced, 114 per cent increase in labor efficiency, and a 116 per cent increase in production from the same flow of water.

Because of the substantial savings made possible by the use of pelleted foods, we have been able to plant a larger-size legal trout which has increased the return of these fish to the anglers' creels. The jaw-tagging and experimental planting of legal-size trout in the Metolius River demonstrated that 49 per cent more fish were returned to the anglers' creels when planted at three fish per pound than when planted at five fish per pound.

To more accurately determine the lowest possible cost of producing a pound of game fish, it seems to me we should make an all-out effort to mechanize at least a few hatcheries to the highest possible degree. It is thought that the above production figures can be increased to 150,000 pounds, and possibly up to 200,000 pounds, with no increase in manpower, through the development of new ideas and a mechanization program.

A brief summary of operations at Wizard Falls Hatchery is as follows:

In cooperation with the Pam Company of Portland, we developed an improved fry feeder. The new feeder is mounted on styrofoam floats and can be floated in any position which best feeds circular or other types of ponds. The new feeder has a greatly enlarged food hopper and will hold in excess of 50 pounds of fry food. It can be equipped with a heat tape to eliminate moisture. A new cover was designed to prevent rain water from entering the feeder. All sizes of fry foods, from fines to 3/32 pellets, were successfully fed through the feeder. With the new Branom and Leeland timer, the feeder can be energized every five minutes or at any interval desired up to once every hour. The feeders are now built in 8, 10, and 12-foot models.

We successfully started 22,857 kokanee fry on a 100 per cent commercial diet with 100 per cent automatic feeding. These fry increased from 5,357 per pound to 365 per pound in 86 days without ever being fed by hand. As this is the most critical phase in the lives of these fish, we demonstrated that automatic fry feeders will work and will save a great many man-hours. At the end of 86 days, these fish had outgrown their trough space and were transferred to an outside raceway. Electric power was not available at this pond, so the fish were hand fed for an additional 74 days. When the fish were liberated on July 31, 1961, they averaged 70.4 per pound. The over-all mortality was 9 per cent and the food conversion was 1.8.

In another group, 1.6 million rainbow fry were started on a commercial diet with the aid of automatic feeders, with some supplemental hand feeding as a precautionary measure. Hand feeding, however, was not really necessary. In total, we produced 40,698 pounds of rainbow fingerlings, with an over-all mortality of 8.3 per cent and a food conversion of 1.45 (22,929 pounds of this production are still on hand as holdover stock). We eventually liberated 204,000 yearling trout weighing 72,278 pounds, at an average size of 2.83 fish per pound. Food conversion was 1.69 for the lot, and the cost of food per pound of fish raised was approximately 14.5 cents. Frequent examination of these fish showed no trace of hepatoma up to 17 months of age.

We developed a new grading system to prove out the feasibility of running fish through irrigation pipe and facilitate the movement of many tons of fish. With this new system, the grader is mounted on the top of the pond wall. The fish pass through the grader into hoppers and are then transferred quickly to their respective size-group ponds by means of "Quick Connect" aluminum irrigation pipe. The fish are raised by wash tubs attached to the end of a 20-foot piece of pipe which is mounted on a tripod. This pipe is attached to the tripod in such a manner as to give the operator leverage in raising the tubs approximately 8½ feet from the bottom of the ponds to the grader. With a little experience, we were able to grade 4,500 pounds of fish in 1 hour's time. Another big advantage of this system is that 2 ponds can be graded without moving the grader to another position. While this method is an improvement over former methods, we do not consider it a substitute for the new "multi-purpose Piscatorial Combine," which we still have hopes of building some day. (Color slides shown of the above apparatus.)

We also made a test this fall of the use of oxygen in one of our medium size tank trucks. In tank unit No. 28, which normally carries 800 pounds of 8-inch fish for 6 hours, we successfully held approximately 1 ton of fish (1,979 pounds) for 7 hours. The fish were released into a holding pond, after the test, for observation of any delayed mortality. Of the 4,290 fish in this test load, only 15 dead fish were found immediately after unloading. Only 1 fish died in the ensuing 7 days. Four hundred fifty pounds of ice were preloaded into the tanker, but no ice was added during the 7 hours that the fish were held in the tanker. The fish were held at a density of 3.2 pounds of fish per gallon of water, or 24 pounds of fish per cubic foot of water. Oxygen was fed at a rate of 4 liters per minute through a 4-inch diameter carborundum stone attached to bottom center and running the length of the tank.. The overhead sprays were operated continuously except for a 7-minute period when the pump was shut off deliberately to see if the oxygen, alone, would carry the load. In 7 minutes' time, the fish were coming to the surface in large numbers and were gasping for air. When the pump was restarted, the fish returned immediately to the bottom and carried very well for the remainder of the test.

It is interesting to note that the fish involved had been used in previous tests and, for many of them, it was the fourth time they had been put through such a test. It speaks well for the stamina of pellet-fed fish.

These fish were the last of our large, legal-size trout on hand. If more pounds of fish had been available, greater loads would have been tested. It does not appear that the saturation point has been found at which fish can be hauled with the combination of overhead sprays and the addition of pure oxygen.

I wish to credit Mr. Lloyd Smith and Mr. Bill Haight, Central Region personnel, for taking the initiative in equipping this truck with the necessary equipment to make this test possible.

THE CONTRIBUTION OF HATCHERY-REARED STEELHEAD TROUT TO THE SPORT FISHERY ON THREE OREGON RIVERS

Harry H. Wagner, Research Division
Oregon State Game Commission

The Oregon Game Commission, for several years, has conducted an intensive sampling program on the Alsea, Sandy, and Wilson Rivers for the purpose of determining the sport catch of adult winter-run steelhead trout of hatchery origin. The assessment of the contribution of hatchery fish to the sport fishery is required if survivals are to be estimated and correlated with the conditions under which the fish were stocked, and if stocking programs are to be designed which are commensurate with the history of returns, the hatchery fish available, and the magnitude of the sport fishery.

The Alsea and Wilson Rivers are coastal streams but differ greatly in the angling effort which they receive. During the 4-month winter migratory season (December through March) the Wilson River receives approximately 32,000 angler-days of use while the Alsea River receives approximately 7,600 days during the same time. The Sandy River is a tributary of the lower Columbia River and is intermediate between the Alsea and Wilson in the number of angler-days of use; it received an average of 20,000 days of effort each season for the last 5 years.

Results of this investigation to date have shown the catch of hatchery-reared steelhead to be quite variable between the three streams under study (Table 1). Hatchery fish have made a substantial return to the creel on the Wilson River where an average of 1,500 hatchery fish appeared in the sport catch the last 2 years. The numbers of fish taken were less on the Alsea River than on the Wilson, but the marked fish per angler figure is comparable because of the lesser angling intensity occurring on the Alsea River. Hatchery fish have been of little importance on the Sandy River where a 5-year total catch of less than 800 fish of hatchery origin was estimated.

On the Alsea River where a measure of the total numbers of hatchery fish returning can be obtained, the angler has taken an estimated 35 per cent of the hatchery fish available.

It remains to be seen how many hatchery fish must be released in order to make a significant contribution to the sport fishery in relation to the fishing intensity, the accessibility of the fish, and maximal survival that can be obtained from the hatchery-reared steelhead.

Table 1

Contribution of Hatchery-reared Steelhead Trout to the Sport Fishery on Three Oregon Rivers

River	Migratory Season /1	Total Catch/2	Catch Hatchery Fish	Per Cent Hatchery Fish	No. of Angler-Days /3	Hatchery Fish per Angler	Number Fish Released	Fish per Pound	Per Cent Returned to Creel
	1956-57	972	231	24	17,027	0.014	82,937	11.2	0.3
Sandy	1957-58	1,893	312	16	24,485	0.013	78,279	8.9	0.4
River	1958-59	1,306	93	7	27,934	0.003	77,361	9.0	0.1
	1959-60	899	68	8	13,374	0.005	57,623	29.0	0.1
	1960-61	665	73	11	15,244	0.005	83,462	10.4	0.1
Total & Means		5,735	777	14	98,064	0.008	379,662	12.8	0.2
Wilson	1959-60	3,472	1,963	56	36,612	0.054	78,459	10.6	2.5
River	1960-61	2,006	1,003	50	27,373	0.037	101,943	8.4	1.0
Totals & Means		5,478	2,966	54	63,985	0.046	180,402	9.4	1.6
	1958-59	945	187	20	7,906	0.024	40,015	11.5	0.5
Alsea	1959-60	1,619	595	37	8,310	0.072	34,279	11.7	1.7
River	1960-61	658	299	46	6,527	0.046	43,861	9.3	0.7
Total Means		3,171	1,081	34	22,743	0.048	118,155	10.7	0.9

/1 All figures are for a 4-month period--December through March.
/2 Catch figures are estimates from probability sampling programs.
/3 The angler-day is approximately four hours in duration.

PROGRESS WITH SUMMER-RUN STEELHEAD
SKAMANIA HATCHERY

Marvin Hull
Washington Department of Game

Many people in fisheries management and fish culture have expressed interest in the summer-run steelhead program. During the past six years, considerable data has been collected on the results of rearing summer-run steelhead at the Skamania hatchery. The program has been patterned after the successful winter steelhead program and results to date have been quite encouraging.

From the beginning, the young fish have been much more difficult to rear, with the result that few fish have reached migrant size in one year, and the bulk have been held for 18 to 24 months. In an attempt to measure the results of releasing fish of migrant size at 18 months of age, several groups were marked at the time of release.

Two self-explanatory tables are attached covering the plantings of summer-run fish, the return of adult fish, and the number of wild and marked hatchery adults trapped at the station. The procedure has been to rear fish to a size larger than 10 per pound, release them in either the spring or fall months, and to check returning adults which enter a holding pond through a fish ladder without being manually handled. The use of the ladder is voluntary as the stream is not racked.

The results to date indicate that returns from the release of migrant-size fish during March and April provide the highest survival and return.

Releases and Returns of Summer-run Steelhead
Skamania Hatchery

Date	Releases: Number	Releases: Size (#/lb)	Releases: Age (Months)	Returns: 1959	Returns: 1960	Returns: 1961	Returns: Total
Oct. 1957	9,500	7	18	2	19		21
March 1958	28,500	8	24	10	131	3	144
Oct. 1958	34,500	6 - 8	18		101	106	207
March 1959	22,500	8	24		92	119	211
Oct. 1959	30,000	6	18			47	47
Apr. 1960	38,250	5 - 9	24			273	273

Note: Returns do not include jacks. Only fish returning to holding pond are recorded.

Adult Summer-run Steelhead Trapped
at Skamania Hatchery

Year	April	May	June	July	August	September	October	Total	Wild	Marked
1956				100		23	13	136	136	
1957	11	5	28	56	26	7	29	153	153	
1958	2	14	38	38	34	37		114	114	
1959		1	3	16	31	28		95	80	15
1960	3	17	52	156	107	48		451	166	285
1961	18	14	62	203	147	135	44	624	107	517

FISH CULTURAL OPERATIONS AT THE OXBOW-BROWNLEE DAMS ON THE SNAKE RIVER

Ernie Jeffries
Fish Commission of Oregon

There are two newly completed high dams on the upper Snake River--Brownlee Dam, and 12 miles downstream, the Oxbow Dam. The adult fish are trapped below the Oxbow Dam and hauled above the Brownlee Dam. Brownlee Dam creates a reservoir about 55 miles long. When the dams were constructed, it was an exceedingly difficult job to know the best way in which to collect the downstream migrants from the reservoir for hauling below Oxbow Dam. The best solution appeared to be to place a large net across the forebay of the Brownlee Dam. The net is about one-half mile long, 120 feet deep, and is made of 8-mesh seran. There are 3 fingerling trapping systems located on the face of this large net. Pumps withdraw water from the reservoir for attraction to the traps and the downstream migrants are collected and pumped to shore where they are loaded into trucks and hauled downstream. The net has been in operation now for 3 or 4 years, but most fishery people believe it is not working satisfactorily. Listed below are the numbers of upstream chinook put above Brownlee Dam and the number of downstream migrants which were produced by the particular brood year of adults.

Year	Chinook Upstream	Chinook Downstream	Fingerlings Down Per Adult Up
1957	15,013	130,563	8.0
1958	14,839	49,485	3.0
1959	13,097	19,767	1.5
1960	7,801	no count as yet	
1961	8,000+		

Downstream fall chinook fingerling migrants cannot be distinguished from spring chinook migrants, since all chinook downstream migrants appear to be 1-year old. There are no normal 2- to 3-inch fall chinook migrants. It is not known whether there are no fall chinook migrants or whether they now spend an extra year in the reservoir. Fisheries technicians looking at these results recommended that a hatchery be built below the Oxbow Dam to handle part of the run. The hatchery facilities were ready for occupancy about the same time the fall chinook started arriving at Oxbow Dam. The hatchery consists of one Burrows-type adult holding pond some 70 feet wide by 160 feet long with upwells, sloping sides, and upstream and downstream traps. In addition, a hatchery building has been constructed with enough Heath Incubators to handle up to 5,000,000 eggs. The incubators are enclosed in a completely darkened room except for the electric lights which are on only during the time of tending. There is an incubation channel where most of the eggs, when eyed, will be planted, so they can swim out of the gravel at their own free will. In addition, some eggs will be maintained in the incubators to compare survival of those from the incubators and the incubation channel.

The adult chinook are taken in the collection system at the dam and 25 per cent, or up to 2,000, were slated to go to the adult holding facilities.

All fish from the gravel and the incubators will be fed in the large adult holding pond for a length of time before release into the Snake River. Water is supplied to the pond with 2 pumps from the Snake River and 1 pump from Pine Creek which is located immediately downstream from the hatchery facilities. Water for the hatchery building is provided by 1 smaller pump from each Pine Creek and the Snake River.

At the time the first fish were put into the pond, the temperatures in the pond were about 64 to 65° with Pine Creek providing some tempering of the 70° Snake River water. Water to the Snake River pumps is picked up directly from below the powerhouse and since it is taken from the bottom of the Oxbow Dam forebay, it is low in oxygen. Therefore, water to the pond from the Snake was quite low in oxygen. However, the oxygen level was raised by using the Pine Creek pump which had water near saturation. Soon after the adults were put into the pond, it became apparent that the mortality was going to be high. To date there have been between 1,600 and 2,000 adult chinook salmon put into the pond. Of this number, 644 females have died and 177 have been spawned. This is a 78 per cent loss of females. The egg-take is approximately 730,000. We have had a potential egg loss of some 2,700,000. The loss of fish has been diagnosed as either being caused by columnaris or from furunculosis.

The situation in the Oxbow-Brownlee area was explained with the thought that, with most of the experts in fish cultural operations being present, some suggestions might be forthcoming for improving the operation next year. This is an extremely serious situation, where runs in the magnitude of 15,000 to 30,000 a few years ago are in danger of being completely wiped out due to the construction of these dams.

STEELHEAD FARM PONDS

John L. King
Washington State Department of Game

Steelhead farm ponds were first started as a means of raising more migrant steelhead at a lower cost than what our hatcheries could produce. The fish in farm ponds would utilize natural food along with supplemental feedings. Also, we have found these fish to be stronger and "wilder" than hatchery-reared fish, and there appears to be a greater number which survive to return as adults although this point has not been definitely proven, but there are very strong indications of this ability.

At the present time, we have three such projects in progress with varied success for each project. The most successful to date is what we call the Blue Ponds Project. It has been in operation the longest and used as a pilot for other projects.

These ponds are in an old river channel. A railroad fill forms a barrier between the ponds and the present river channel of the North Fork of the Stilliguamish. This channel has been divided into two ponds by a dam and a single flip-plate screen. The lower outlet is through a culvert running under the railroad fill and also has a single flip-plate screen. Water level in both ponds can be controlled by dam boards located at each flip plate.

The upper pond covers 3.5 surface acres, and the lower pond covers 2.5 acres. There is a home by the lower pond, and these people have been hired to keep predators away and also to do supplemental feeding.

The upper pond has been virtually useless, as predators have cleaned out our stock at various times. Different means of predator control have been and are being tried. Success has not yet been known. The lower pond has been highly successful and has been in use since 1958.

The pond was first treated with rotenone and then stocked with fish from the Chambers Creek strain. These fish average 400 per pound at this time.

This treating and restocking is usually done in June. Rearing continues until the last of March when migration begins. As the fish migrate, they are collected in a downstream trap, counted, marked, and then released into the pond's outlet stream which enters the river about 200 feet from the trap.

All fish do not reach migrant size, and these are not marked when released. This may have been a mistake, as we do not know how many of these return as adults and there are indications that a number of them do return. These fish that are not of migrant size when released have typical rainbow markings.

Migrants from this pond, thus far, are as follows:

1959 -- 9,000
1960 -- 22,000
1961 -- 24,000

These figures represent only fish which we consider as migrants.

An intensive river check of fishermen was made during the winter of 1960-61 to check the number of marked fish as compared to unmarked fish. This river also receives a planting of 15,000 migrants from the South Tacoma Hatchery (unmarked) yet almost one-third of the fish checked were from this project; therefore, considering this additional plant as well as natural spawn, the results of this project look very good. Remember, only 9,000 were released from this project for this particular return. This intensive check is again being carried on during the 1961-62 season.

Barnaby is another project now in operation and is on a much larger scale. It is on the Skagit River and covers over 23 surface acres. This is the second year of operation. The first year was not considered too successful, as most of the stock was lost during high water caused by insufficient diking. These fish may or may not return. This year we have over 300,000 fish in this project, and about one-third are now of migrant size.

We have a man working full time at this project feeding and controlling predators.

The third project is a natural lake of over 30 surface acres but is out of regular production at present as a new dam and screening system is needed, to prevent flooding out during heavy run-off and entry of unwanted fish. No supplemental feeding has been used on this project; except that fertilizer has been introduced in the lake. About 2,500 migrants were released from this lake at the end of the first rearing season.

In summary, two most important factors for success of this type of project are good predator control and strict control of supplemental feeding.

INSTURMENTATION FOR HATCHERIES

Jim Sweiberg
Branom and Leeland Instrument Company

Several years ago, the Oregon State Game Commission contacted the office of Branom and Leeland Instrument Company to determine the feasibility of feeding fish automatically. After much discussion concerning the desires of the Game Commission and the needs of the fish, it was concluded that the controller, or timer, must be manufactured as inexpensively as possible and be made up of component parts which could be purchased and repaired locally.

The first experimental controller consisted of a 24-hour time clock which gave an impulse every 30 minutes through an Amperite time-delay tube selected for the proper feeding time. The time-delay tube energized a relay, or magnetic switch, which in turn operated the feeders. After this unit had been in operation for several months, it was found that 30 minutes was sometimes too long between feedings. An adjustable-interval timer, which could be set simply by turning a dial and having a range of from 15 minutes for the fry to once or twice a day for the larger fish, was more desirable.

The second timer, which was built and is displayed on this platform, has a 24-hour clock that can be set to start or stop at any hour of the day or night. On the front cover, a dial-type timer is mounted which has a "plug-in" feature that enables the hatchery operator to replace one timer with another having a different time range, if he so desires. This timer is nationally known and can be purchased under the trade name of Eagle Cycl-Flex in any state. The Cycl-Flex schedules the time between feedings; thus, when it times out, it starts a second timer which adjusts the length of feeding time of the pellet feeders on the pond.

As more feeders were employed in the hatcheries, the load became too heavy for the above described timer and additional modifications and changes were made.

The latest controller on the platform can be set to regulate every feeder in the hatchery house or may be used for all of the pellet feeders on the outside ponds. This unit will draw about 20 to 30 amperes on an average circuit hook-up. As an automatic step switch with as many as 20 steps is utilized in this timer, the operator can operate as many machines at one time in each step as the 35 ampere Mercoid relays will allow.

All of the feeders which are attached to one controller are on for the same length of time, but the amount of feed spread by each feeder can be varied by adjusting the gate openings on each feeder.

A great deal of progress is being made in the instrumentation field, and many of the presently used timers will probably become obsolete by improved controllers. This is progress toward an ultimate goal, however, and should not be discouraged.

At the writing of this brief, there is now on the drawing board a controller which will operate the entire hatchery feeding system, including both the indoor and outdoor types of feeders. Any group of feeders can have a Master Controller which will control the feeding time and operate independently any feeder or group of feeders so that they will spread the desired amount of feed without having to adjust the feeder itself.

Our main concern for the past two-and-one-half years has been to develop a controller suitable for any hatchery regardless of its feeding problems. We have also endeavored to design a controller that will operate any feeder on the market, such as the ones being manufactured by the Pam Company and the Oregon Master Supply Company, both of Portland, and the large outdoor type as manufactured by the Neilson Manufacturing and Fabricating Company in Salem, Oregon.

It is hoped that the above described controllers will aid in the development of better techniques in the field of fish culture. Through automation, we may help reach the ultimate goal of a better fish product for less money.

AERIAL FISH DROP EXPERIMENTS

Bill Helms
(Presented by Ralph Garbutt)
Wyoming Game and Fish Department

Objectives

1. To determine the effects of aerial planting on various sizes of fish and at different altitudes.

2. To observe the actions of the fish as they were sinking and after they had sunk to the bottom.

3. To determine if there is any delayed mortality within 24 hours.

4. To establish the relative accuracy of aerial planting.

Methods and techniques

1. Fish transportation - Fish were hauled from the Daniel Hatchery in a tank truck to a site where the plane could land. The fish were then transferred to the plane for planting.

2. Control of plants - In the first project, the loss of radio contact with the plane resulted in all the plants being made at lower than desired altitudes and in uncoordinated timing between the divers and the pilot. However, the observations made gave good information as only one drop was not observed.

   In the second project, the altitude of the plane was controlled by helium-filled weather balloons that were anchored to the bottom of the lake. The balloons were held by nylon cord that was marked at 100-foot intervals, and they could be raised or lowered as wanted. The two balloons used were spaced about 200 to 300 feet apart and in the direction the plane was to plant. They were both at the same altitude so the pilot could line up the balloons to establish the altitude of the plant. The plants were made to the side of the balloons where the divers were in the water. The divers were used as the target for the pilot. The speed of the plane was previously established to be 70 mph. air speed, compared to 65 mph. in the first project. Altitudes of the drops were at 100, 200, and 300 feet. Timing was well coordinated in the second project by the pilot and divers following a time schedule that started when the first load of fish was dropped. As each drop was made, the location was marked by a float. Each float was numbered to correspond with the number of the drop for reference purposes.

3. Various sizes of fish were used in the projects. The rainbow was the only species used. The following sizes (number per pound) were used.

1 - 1640
2 - 655
3 - 440
4 - 270
5 - 8

The fish were planted in water that ranged from approximately 5 to 35 feet deep.

The temperatures of the water in the hatchery truck tank ranged from 48° to 52° F. for both projects. The surface temperatures were 64° in the first and 54° in the second. The bottom temperatures were 55° to 60° in the first and 53° in the second. The wide range of temperatures in the first project was due to the fact that some of the fish passed into the thermocline before reaching the bottom. Air temperatures ranged at 61° in the first and 36° in the second project.

<u>Findings</u>--First phase, August 30 (air speed 65 mph.)

Due to the effect of the thunderstorm in the area on the altimeter of the plane, the altitudes of the drops were below what I had planned. This low-level flying was estimated at between 60 and 70 feet for the 100-foot level, 120 to 150 feet for the 200-foot level, and 170 to 200 feet for the 300-foot level.

The casualties resulting from the drops made at between 60 and 70 feet were noticeably fewer in the smallest fish (655/lb. and 270/lb.) where about 50 and 100 casualties were observed, respectively. In the fish going 8/lb., approximately 80 per cent casualties were observed from the low drop (60 to 70 feet). A list of the injuries found in these fish upon dissection and examination was as follows: ruptured air bladder, ruptured kidney, ruptured gill filaments, complete fracture of the vertebrae, complete separation of the ribs from the vertebrae, pectoral girdle torn loose from the body, and contusions on the wall of the body cavity. These fish could be seen bleeding from the gills while they were lying on the bottom. This particular group of fish hit the water extremely hard and with enough forward momentum to cause some to skip and bounce on the surface. The fish (655/lb. and 270/lb.) dropped from the higher level of about 120 to 150 feet had few casualties from the drop. The fish at 8/lb., dropped from 120 to 150 feet, had an estimated 50 per cent casualty rate from the drop. This same size of rainbow dropped at the highest level (170 to 200 feet) had very few casualties. Most of the fish had time to orient themselves and hit the water head first. They continued down in the water approximately 1½ to 2 feet and then abruptly leveled off and swam away.

Second phase, September 22 and 23 (air speed 70 mph.)

Rainbow going 1640/lb. were dropped at 100 feet and no casualties were observed. Some fish remained on the surface and many were found using the underneath of the boat for cover. Those that sank to the bottom were respiring okay. The fish going 440/lb. were dropped at altitudes of 100, 200, and 300 feet. Fish dropped at

100 feet hit the water fairly hard, but there were no casualties observed. Of the fish that were on the bottom from the 200-foot drop, an estimated 50 per cent had recovered enough to swim off after only 20 minutes in the lake. The fish dropped at 300 feet had about the same reaction as those dropped from 200 feet.

A check on each drop was made after a 24-hour period to determine whether there was any delayed mortality. A thorough search of the buoyed areas failed to turn up any dead fish at all.

Discussions and conclusions

The number of fish, pounds of fish, and fish size for each drop was as follows:

6.75#	at	1640/#	=	11,070	fish dropped at 100 feet
7.00#	at	655/#	=	4,585	fish dropped at 100 (60 to 70) feet
7.00#	at	655/#	=	4,585	fish dropped at 200 (120--150) feet
8.00#	at	440/#	=	3,520	fish dropped at 100 feet
8.00#	at	440/#	=	3,520	fish dropped at 200 feet
8.00#	at	440/#	=	3,520	fish dropped at 300 feet
8.00#	at	270/#	=	2,160	fish dropped at 100 (60 to 70) feet
8.00#	at	270/#	=	2,160	fish dropped at 200 (120--150) feet
8.00#	at	8/#	=	64	fish dropped at 100 (60 to 70) feet
8.00#	at	8/#	=	64	fish dropped at 200 (120--150) feet
8.00#	at	8/#	=	64	fish dropped at 300 (170--200) feet
Total 84.75#				35,312	fish

Generally all the fish from 1640/lb. up to 270/lb. reacted in about the same manner; upon entering the water, those that did not swim off immediately either swam about erratically or slowly drifted to the bottom and remained motionless there until they recovered enough to swim away.

The sub-catchables at 8/lb. had such a high casualty rate for the lowest drops that it was considered impractical to plant at such altitudes.

The depth at the bottom (5 to 35 feet) and the temperature differences between the plane tank, air, surface, and bottom had no apparent lethal or delayed affects on the fish up to 24 hours after planting because no dead fish were found after the 24-hour check was made.

It was noted that the fish that were drifting to the bottom and then lying on their sides would be very susceptible to predation, as the divers were able to capture them easily during this period.

Accuracy of the plants made in the projects was satisfactory. It would appear that accuracy depends on the experience of the pilot, weather conditions, and terrain surrounding the lake.

It was noted that the plants made at 100 feet and below had a tendency to string out. This was probably due to their forward momentum having not slowed down enough to allow the fish to drop naturally. This was especially true of the larger fish.

Recommendations

1. Fish planted by plane should be no larger than 500/lb., preferably 1000/lb. and smaller if possible. Although these projects indicated that larger fish can be dropped successfully, the altitude of the drop must be raised accordingly and in instances this will have a definite bearing on the accuracy.

2. Altitude for planting various sizes of fish:

   Fish up to 500/lb. - - - - - - - - - - - - 100 feet
   Fish about 300/lb. - - - - - - - - - - - - 200 feet
   Fish about 20/lb. & larger - - - - - - - - 250 - 300 feet

   It is better to be above rather than below the above stated levels if there is any doubt as to the altitude when planting.

3. Air speed for the above mentioned altitudes should be between 65 and 70 miles per hour.

4. When possible, plants should be made in areas where boulders or vegetation will give the fish some protective cover while they recuperate from the effects of the drop.

RECENT DEVELOPMENTS IN FISH TRANSPORTATION IN OREGON

R. O. Koski
Oregon State Game Commission

Continuing advances have been made in fish transportation techniques in Oregon. Studies by the Research Division have resulted in development of fish tankers which transport high density loads with no "delayed mortality" and with insignificant immediate hauling loss. In 1961, almost one million pounds of fish of all species and sizes were transported with a total loss of only two tenths of one per cent.

Recent improvements in design of the water circulation and refrigeration systems have led to a one hundred per cent increase in load capacity. Current experiments utilizing supplemental oxygen have demonstrated even further gains. New tankers have been designed in which three parts--the truck, tank, and circulation-refrigeration units--are all separate, thus increasing efficiency of operation and maintenance. The addition of oxygen equipment to the present, highly-efficient systems is planned, with a goal of four pounds per gallon density for eight hours transport time.