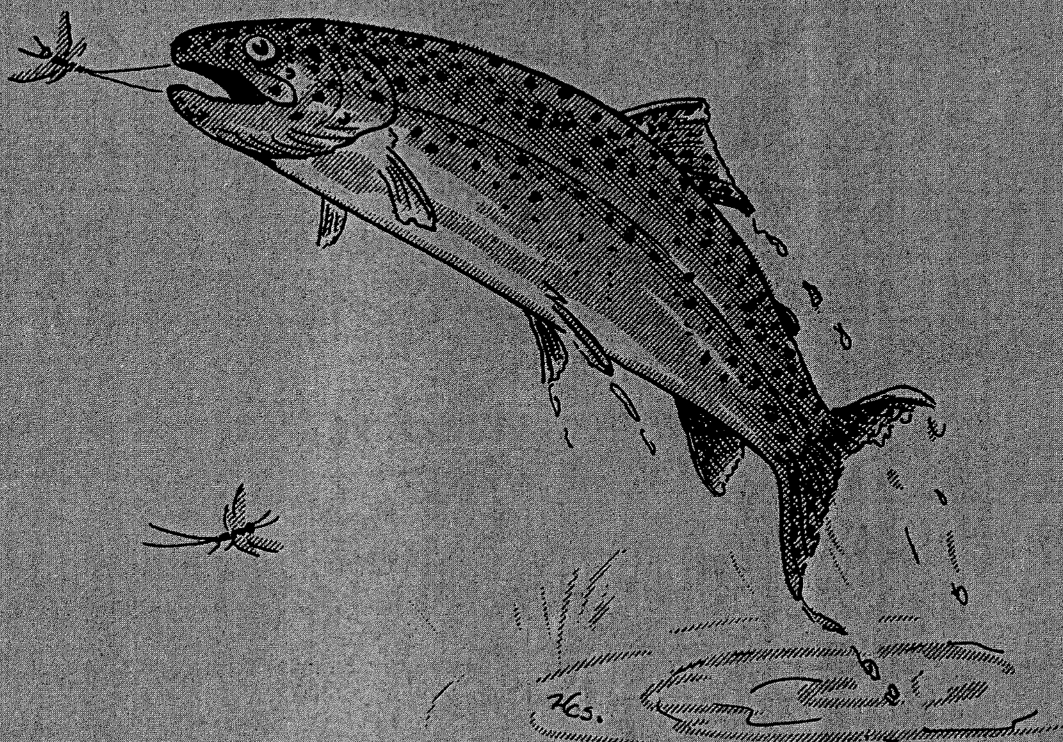
NORTHWEST FISH CULTURE CONFERENCE



portland, oregon
december 3, 4, 1970

THE NORTHWEST FISH CULTURE CONFERENCE

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

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

PROCEEDINGS OF THE TWENTY-FIRST NORTHWEST FISH CULTURE CONFERENCE

Included herein are the summaries of 49 presentations made at the Twenty-first Northwest Fish Culture Conference held in downtown Portland at the Pacific Power and Light Building auditorium on December 3 and 4, 1970.

In behalf of the 275 persons who registered at the conference and as chairman, I wish to thank the participants for their most interesting and learned presentations.

Summaries herein have undergone minor editing. Permission to reproduce any of the enclosed abstracts or parts thereof must be obtained from the respective authors.

To Chuck Campbell and Dick Pressey, I wish to extend my appreciation for their assistance as Session Chairmen. My special thanks and appreciation are extended to Miss Joan Stremich who worked so diligently in preparing for the conference and typing the summaries in preparation for the printer.

Finally, I wish to thank Pacific Power and Light Company for allowing us the use of their fine auditorium.

The 1971 conference will be under the chairmanship of Mr. Marvin Smith, Bureau of Sport Fisheries and Wildlife. Richard Noble, Washington Department of Fisheries, was selected as chairman for 1972.

Chris C. Jensen - 1970 Chairman
Oregon State Game Commission
P. O. Box 3503
Portland, Oregon 97208

TWENTY-FIRST ANNUAL NORTHWEST FISH CULTURE CONFERENCE

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ADULT RETURNS OF SALMON REARED IN REUSE AND SINGLE-PASS WATER SYSTEMS

Roger E. Burrows
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The Salmon-Cultural Laboratory has developed an environmental control system for hatchery propagation whereby we can manipulate growth rates by means of controlled water temperatures. This system involves the reconditioning and reuse of water by means of bacterial filters and the introduction of supplemental water at the rate of 5 or 10 percent of the amount recirculated in the system. In addition, our system is equipped with a heat exchanger and heat pump whereby we can maintain optimum rearing temperatures throughout the rearing period.

In this manner we have manipulated temperatures to produce salmon fingerlings much larger than those normally produced in the natural hatchery water supplies. Fall chinook adults from the 1966 and 1967 brood years have returned as 3 and 4 year-olds. In addition, we have the results of a 1968 brood-year release of coho fingerlings which were reared for six months and released at 17 per pound.

These data are presented in the table. We are not attempting to compare survivals between years but rather the relative survivals within years as indicated by the return ratios. It will be noted that there is a marked difference between the ratios of return between the 1966 and 1967 brood years. The 1966 brood-year fingerlings had a vitamin C deficiency at time of release which was much more pronounced in the large, reuse-reared fingerlings. We assume that this difference in degree of debility accounts for the difference in ratio of survival between the 1966 and 1967 groups.

Even a ratio of 7.5:1, however, will justify environmental control. To rear a comparable number of fish to three times the normal size requires 2.3 times the amount of rearing space. In the same facilities, therefore, you would expect more than three times the return from the larger fish. In the 1967 brood year, a return ten times that of normal hatchery stock is indicated from equal facilities.

The contribution of the larger fingerlings from the 1967 brood year to the fishery is also considerable. Returns to the Washington troll and sport fishery in 1970 amounted to an estimated 2,580 and to the Columbia River gill net fishery in 1970 of 7,940 fish. Other catch data are not available yet, but the maximum escapement could not be more than 16.5 percent.

The average size of the returning adults from the 1967 brood was 15.0 pounds for the small fingerlings and 15.3 for the large fingerlings.

The 1970 adult return of 1966 brood coho consisted of 762 males and 206 females. The fish averaged 4.5 pounds and ranged from 2 to 10 pounds. These fish were of comparable size to the parent stock. The indications are that the early release of large fingerlings has shifted the return from 3 year-olds to 2 year-olds.

The returns of both chinook and coho which have been reared in environmental control systems indicate that such systems are entirely practical. There is every reason to believe that such systems offer an economically feasible tool for the enhancement of salmon runs.

ADULT SURVIVAL EXPERIMENTS

SALMON-CULTURAL LABORATORY

FALL CHINOOK SALMON

Brood Year	Experimental Variable	Release				Returns					
		Time	Number	Size	Mark	2's	3's	4's	Total	Percent	Ratio
1966	Reuse system	5/03/67	199,997	33/lb.	LM-½ An	1968 (29) 29	1969 (138) 142	1970 (9) 9	180	0.090	7.5:1
1966	Creek water	5/03/67	197,387	96/lb.	RM-½ An	1968 (6) 6	1969 (13) 14	1970 (3) 4	24	0.012	
1967	Reuse system	5/14/68	200,404	26/lb.	LM-½ D	1969 (445) 448	1970 (720) 893		1,341	0.669	26.5:1
1967	Creek water	5/14/68	200,297	80/lb.	RM-½ D	1969 (6) 6	1970 (35) 45		51	0.025	

( ) Return to holding pond.

COHO SALMON

Brood Year	Experimental Variable	Time	Number	Size	Mark	2's	3's	4's	Total	Percent	Ratio
1968	6 mo. rearing	5/27/69	78,376	17/lb.	Ad / T	1970 448	242 M - 206 F		448	0.571	

USE OF HYBRIDIZATION AS A MEANS OF ENHANCING SALMON PRODUCTION

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Olympia, Washington

The definition of a hybrid is the offspring of two animals or plants of different races, breeds, varieties, species or genera. Give a salmon hatchery manager a choice between native and non-native stocks, and invariably his choice will be native spawners. On the other hand, if no local eggs are available then he will accept other stocks. Just how important is the concept of selectivity in salmon propagation? Does the continued use of a specialized stock result in a population that responds to fish cultural procedures better than "wild stocks"? Stories are circulating that hatcheries have created a salmon that cannot spawn in a normal fashion.

The state of Washington has initiated a great number of studies that have provided generalized information on the comparison of indigenous and non-indigenous stocks of salmon.

Individual experiments were far from ideal and left many questions relative to the interpretation of recovery data; however, trends are evident and reoccurrences of certain results firm-up several hypotheses.

Generalized summaries of the various chinook and coho marking studies involving only recoveries to the point of release and with no attempt to correct for differential mark mortality, provide some interesting data for conjecture.

Fall Chinook Studies

1. Puget Sound fall chinook stock released in Puget Sound was compared with an imported Columbia River stock.

   Soo's Creek stock (Puget Sound) returned 20:1 over the Little White River stock of the Columbia River.

2. Soo's Creek stock fall chinook compared to second generation Little White River stock gave a 7:1 return, favoring the indigenous group.

3. Soo's Creek fall chinook compared with fall chinook at Nooksack and Minter Creek hatcheries with the releases made at Nooksack and Minter gave returns favoring the Soo's Creek stock 2.8:1 at Minter and 1.2:1 at Nooksack, despite both stations having orginially been started with Soo's Creek fall chinook.

4. Nemah fall chinook (a coastal station) was compared with a hybrid group (Soo's Creek females x Willapa males) released at Nemah and the return was 43:1 favoring the local stock.

5. Nemah stock fall chinook compared with three imported groups: (a) Klickitat stock of Columbia River (which was started from Spring Creek); (b) Soo's Creek stock and (c) a hybrid group (Soo's Creek females x with Willapa males).

   The Nemah stock returns were 10:1 over Soo's Creek stock, 3:1 over the hybrid group and there were no returns of the Klickitat group.

6. Nemah stock fall chinook compared with Elokomin fall chinook and hybrids of Elokomin and Nemah stock. The hybrids involved both Elokomin males crossed with Nemah females and the reciprocal. The local Nemah stock returned 36:1 over the straight Elokomin stock and 12:1 over the hybrids.

7. Nemah fall chinook compared with Nemah males crossed with Deschutes River females of Puget Sound (orginally Soo's Creek stock). No significant difference in returns between the two stocks with a return rate of 0.23 percent for the Nemah stock and 0.25 percent for the hybrids.

8. Local stocks of fall chinook at the two coastal stations compared with the hybridization of Deschutes females with local males two successive years. No significant difference in the returns between the two stocks.

Coho Studies

The coho studies gave generally the same pattern of returns as did the fall chinook.

9. Coastal stocks of coho released into a coastal stream and compared with Soo's Creek stock (Puget Sound).

   Returns favored the indigenous group 6½:1.

10. Elokomin River, tributary of the Columbia River, coho study. Elokomin stock compared with Lewis River stock (a tributary of the lower Columbia River) and Soo's Creek stock (Puget Sound). No recoveries for either Lewis River or Puget Sound stock. Local stock returns were also very poor.

11. A coastal stock of coho (Nemah River) transferred to Elokomin as eggs and with full rearing at Elokomin gave no returns out of 97,000 liberated.

12. A northern coastal stock of coho moved to Simpson Hatchery and compared with the local fish resulted in a return ratio of 12:1 favoring the indigenous group.

These various experiments leave many unanswered questions. Second and third generation follow-up of non-indigenous groups, which would have provided more information on selectivity, was not done. The data do indicate, however, that the probability of failure is high when stocks are moved from one major watershed to another. Hybridization generally appears to provide an advantage over direct imports and some hybridized lots may actually equal indigenous stocks.

These experiments and others have resulted in a generalized policy by the Washington Department of Fisheries. Indigenous stocks are used even within a watershed, unless experimental marking information indicates other stocks are just as suitable. When local eggs are not available, hybridization is recommended. The final choice would be non-indigenous stocks, but only after receiving clearance from the pathologist.

The concept of hybridization to change the characteristics of local stocks is currently in progress. Spring chinook have been crossed with fall chinook and a special race of Rivers Inlet, British Columbia, fall chinook have been hybridized with Hood Canal fall chinook to test for greater catchability by sports gear.

These groups will be identified and in event survival is sufficient to provide a suitable egg potential, these groups will be carried through second and third generation studies.

It is obvious that selectivity is an important principal in salmon culture and hatcheries can develop populations of fish for specific purposes. The selectivity can be such that the resultant salmon progeny from hatcheries would be incompatible with nature's environmental constraints under natural conditions. It is equally true that salmon survivals can be enhanced by selective forces working within a hatchery complex.

The potential within the hatchery system is virtually untapped and selection of stocks for specific management purposes will expand dramatically in the near future.

Hybridization may provide the initial key to success when attempting to implement important and valuable fish cultural programs.

MANIPULATION OF COLUMBIA RIVER HATCHERY COHO STOCKS TO MEET THE NEEDS OF FISHERY MANAGEMENT

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Historically, coho entered the Columbia River gill-net catch in the greatest number during late September, October, and November. The general timing picture of coho is presently significantly different as a result of the successful production of early running coho at nearly all the Columbia River salmon hatcheries. The bulk of the hatchery coho now enter the river in August and peak in the fishery during September in a manner similar to that of fall chinook. It is this aspect that provides the fishery managers with a difficult task, since chinook escapements are usually low and can only afford a minimal net fishery harvest, while the hatchery coho can generally withstand the opposite in terms of fishing pressure and harvest. The managers presently provide the chinook the needed protection and most hatcheries realize an over escapement of coho as the direct result. The use of a later running stock having a comparable rate of survival would facilitate the net fishery management and reduce the problems associated with the early running surpluses. This, in turn, would result in an increase in the benefit-cost relationship and add to the justification for continuation and, perhaps, expansion of the salmon cultural program within the Columbia River system.

The early running hatchery production has been extensively evaluated during the past few years. The patterns of coastal distribution, contribution, and of timing into the river net fishery have generally been determined. Conversely, little is known of the performance of the later running coho stocks. The implementation of the hatchery program on the Cowlitz River provided the Department with the opportunity to study these fish prior to making hatchery production decisions simply to enhance the river fishery management.

The Cowlitz coho study began with the production of the 1967 brood. The program outline is presented in Figure 1. It is a three-year study comprised of comparisons of the progeny of early and late (in terms of net fishery) segments of the native coho escapement to the hatchery fish facilities. The groups are identified by unduplicated double fin clips. The basic data for analysis are scheduled to come from the sampling of the coastal troll and sport fisheries, the river net fishery, and from hatchery returns. The use of large marked groups serves to offset the reduction in the sampling rate of the coastal landings.

The precise catch estimates of the 1967 brood marked coho are unavailable at this time, however, the results are sufficiently complete for the purpose of this presentation. Comparisons of the actual mark recoveries by general sampling area are interesting and stimulate a number of thoughts pertaining to the impact of hatchery production on the fisheries.

The actual mark recoveries (Table 1) indicate a marked difference between the groups in terms of coastal distribution. The early (Toutle stock) performed in its usual fashion and moved primarily to the south of the Columbia.

The later running native Cowlitz coho, on the other hand, demonstrated a more northerly distribution and appeared to be harvested in greatest numbers off the Washington coast.

Periodic sampling of the Columbia River net fishery indicated a marked timing difference between the two groups. A weekly breakdown of mark recoveries is not presented here but timing curves of marked fish returning to Cowlitz hatchery (Figure 2) graphically indicate this difference.

The total number of marks recovered is of little significance for comparison purposes at this time, since the fish demonstrated distributional differences and sampling levels varied widely from area to area. The large number of actual mark recoveries does, however, indicate that the native later running Cowlitz River coho adapted well to the hatchery rearing program.

Table 1. Summary of the 1967 brood early-late Cowlitz coho marks recovered in the fisheries during 1970.

Fishery Sampled	Summarized Through	Ad-LV (Toutle Stock-Early)	Ad-RV (Cowlitz Stock-Late)
California - Troll & Sport	July 31	196	20
Oregon Troll	September 12	327	155
Washington - Troll & Sport	October 31	390	941
Columbia River Gill Net		274	372

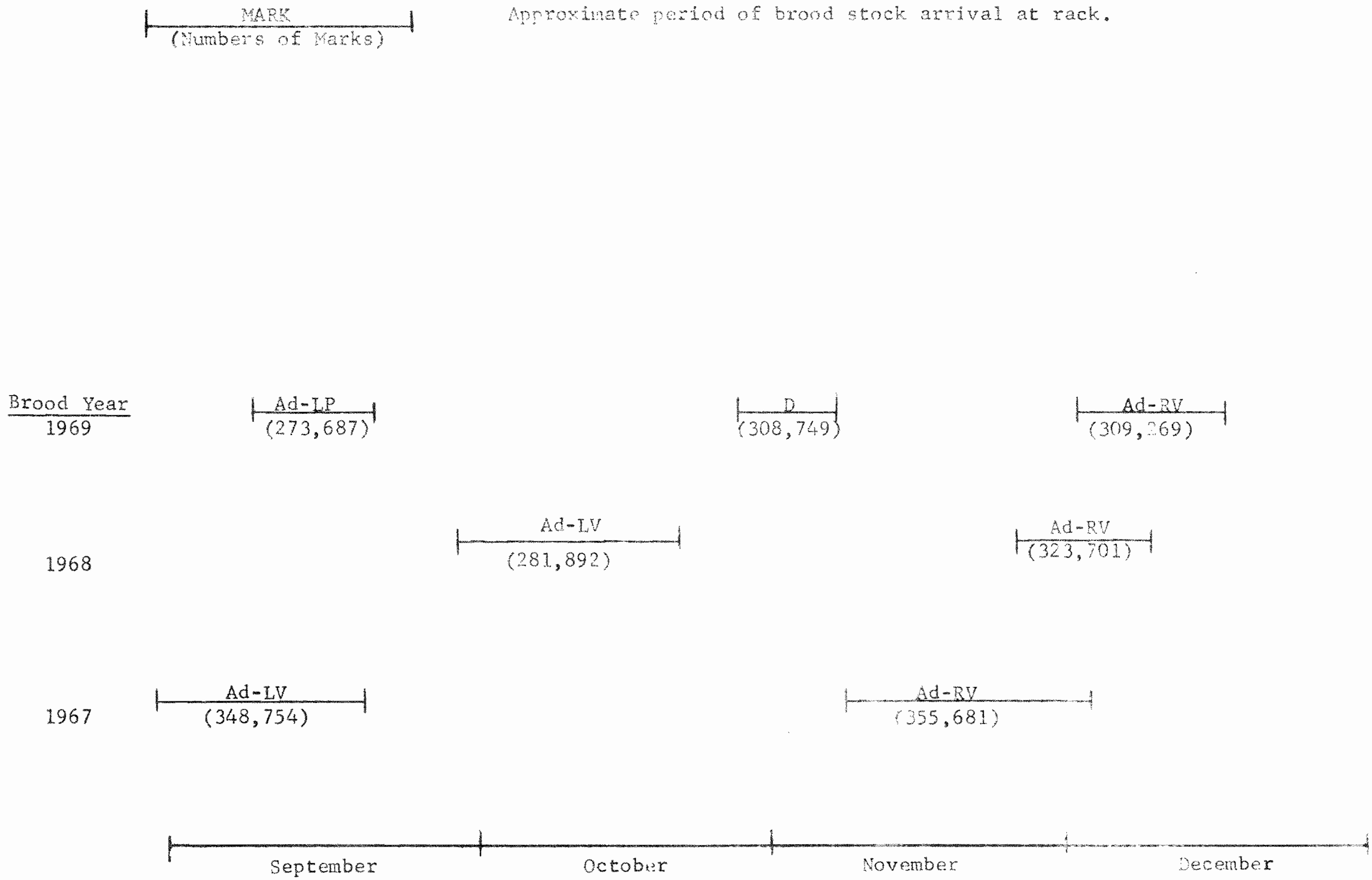

Figure 1. Cowlitz Coho Study Design

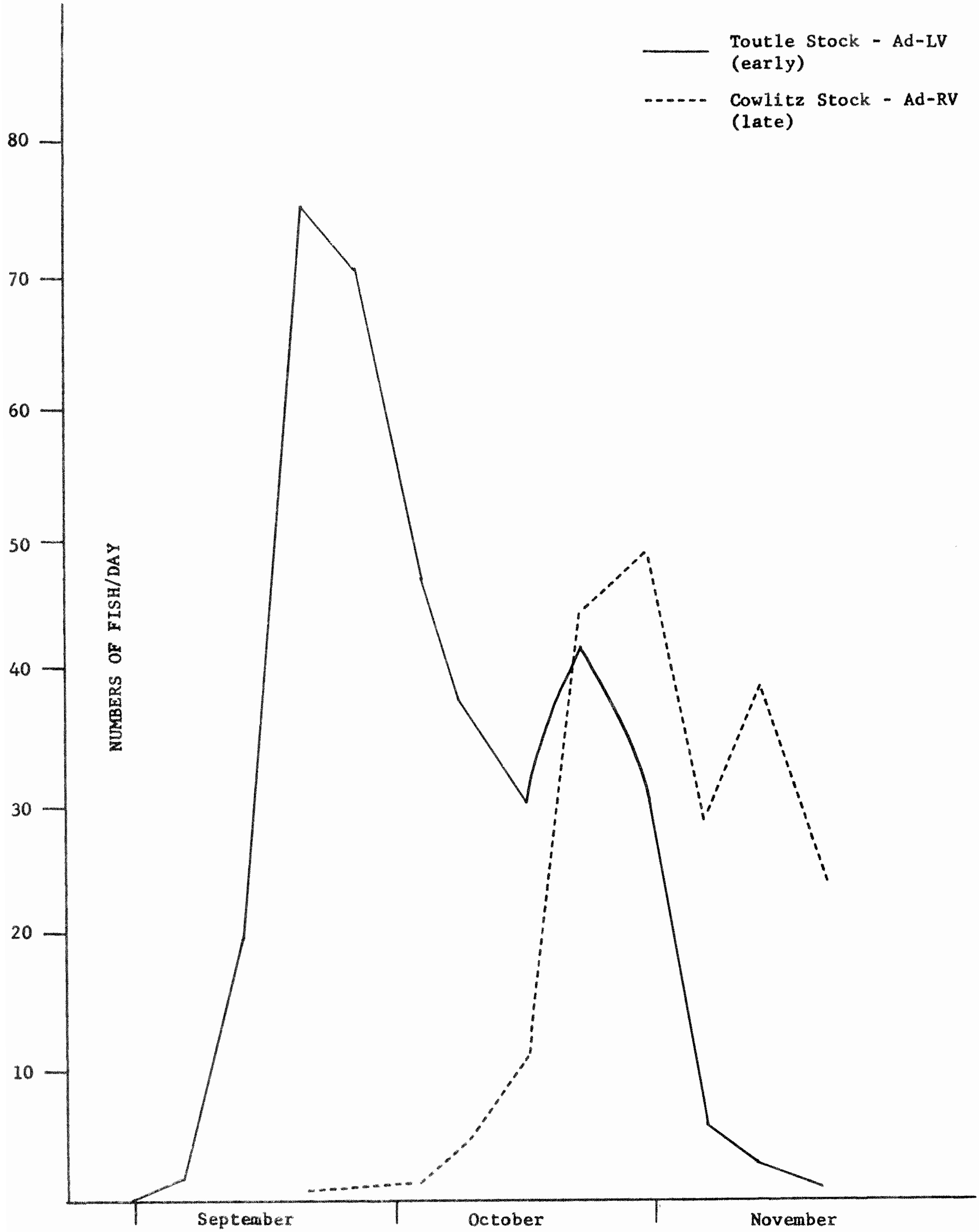

Figure 2. 1967 brood marked adult coho rack return timing curves, through November 21, 1970 - Cowlitz Hatchery.

SUCCESSFUL PROPAGATION OF COHO SALMON IN AN UPPER COLUMBIA RIVER HATCHERY

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National Marine Fisheries Service
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Leavenworth National Fish Hatchery is located east of the Cascade Mountain Range almost in the center of the State of Washington (Figure 1). It was built to propagate sockeye salmon, but the sockeye were phased out and today it is successfully rearing coho salmon.

The coho success story at Leavenworth was the result of a combination of events. Lower Columbia River hatcheries were making some impressive gains in rearing coho salmon at the time that the sockeye program was phased out at Leavenworth. Adult coho were returning to the lower river hatcheries in such numbers at spawning time that there wasn't room to take care of all the eggs that were available. Space was available at Leavenworth, but there were good reasons to doubt that it would be feasible to rear coho at this hatchery. These reasons included a water problem at Leavenworth, dams in the Columbia River, and genetic limitations of salmon.

The main source of water at Leavenworth hatchery is Icicle Creek. Water temperatures in the stream are near the freezing point during most of the winter, and this is too cold for coho salmon.

Coho salmon should be reared for one year and released the following spring for maximum survival and contribution to the fisheries. This requires holding them at the hatchery over winter, but because of the cold water this would have been difficult at Leavenworth prior to 1964.

A limited supply of warm well water is available for indoor use in the hatchery, but not enough to operate the outdoor ponds, too. This difficulty was eased with construction of a water re-use system, in 1964. The system doubled the supply of warm water simply by using it twice.

There are seven dams on the river between the hatchery and the ocean. A certain number of young salmon are killed at each of these dams as the fish migrate downstream. There was a strong possibility that most of the fish would die before they reached the ocean.

Leavenworth is located about 500 miles upstream from the ocean, which is about 350 miles farther than most of the lower river hatcheries. Young coho salmon would have to migrate much farther than their ancestors to reach the ocean, and they would have to find their way through seven impoundments on the way. But coho had proved to be so hardy and adaptable at the lower river hatcheries that it seemed worthwhile to try them at Leavenworth, too.

Surplus coho eggs were transferred to Leavenworth from lower Columbia River hatcheries. These included Eagle Creek, Little White Salmon, and Cascade.

Adult coho returned to Leavenworth hatchery from the very first brood that was reared there, and some have returned each year since then. Remember that these fish had to pass those same seven dams again that they passed on their way downstream. A new sport fishery for salmon was established as a result of this new run. Sport fishing for salmon was allowed above Rock Island Dam for the first time in many years. This fishery is in Icicle Creek, below the hatchery.

Catch distribution of the 1965 brood of Leavenworth coho is shown in Figure 2. Marine and freshwater fisheries, both commercial and sport, are combined in the data used in this figure. A major portion of the total catch was taken off the coasts of Washington and Oregon. Columbia River gillnetters took 9 percent of the fish.

There is a facet of the Columbia River catch that is interesting from a public relations viewpoint. There have been complaints that fishermen above Bonneville Dam are not getting a fair share of the salmon reared in Columbia River hatcheries. Leavenworth hatchery is one of several hatcheries that do contribute to the coho salmon fishery above Bonneville Dam.

When the data for one year of production had been compiled, we made an analysis and found that the benefit/cost ratio for that year was $3 gained for each $1 spent. The benefit/cost ratio for the sockeye salmon that had previously been reared at Leavenworth averaged 2¢ return for each $1 spent.

Originally there was no thought of starting a new run at Leavenworth. There was no need to start one, because surplus eggs were available at other hatcheries. These could be used to stock Leavenworth if rearing coho at this hatchery proved to be feasible. But adult coho did return to the hatchery starting with the first brood that was reared there, and they have continued to return every year since then.

It has been generally assumed that progeny from a race of short-run salmon could not be used to establish a long run, but Leavenworth coho seem to contradict this assumption. Leavenworth is 500 miles from the ocean, Little White Salmon is 170 miles, and Eagle Creek 160 miles. That means that Leavenworth fish had to migrate three times as far as their ancestors and they had to do it in the first generation. There was no chance for a gradual increase over a period of years.

The feasibility of rearing coho at Leavenworth hatchery has been demonstrated, and we are pleased with the results. But this is only the beginning. Coho production has been started and it can be increased.

For instance, the rearing capacity at Leavenworth exceeds the winter holdover capacity; so some of the fingerlings have to be released in the fall. Do these fish contribute to the fisheries, too? An experiment is underway now to evaluate the fall release. If it proves to be profitable, production can be increased by rearing more fish for the fall release. If it turns out to be unprofitable, there are other things that can be investigated, such as genetic improvement or an enlarged water re-use system.

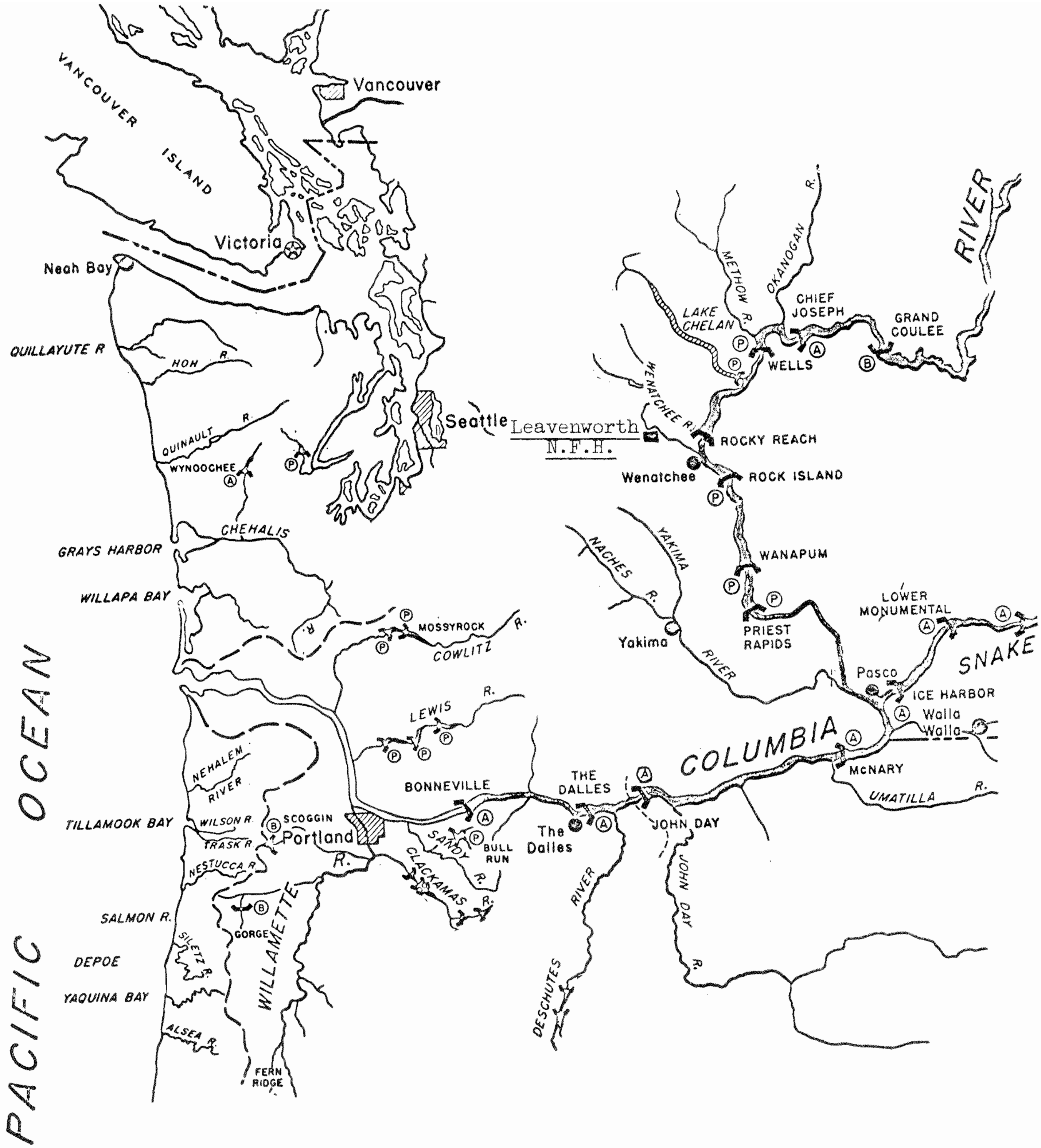

Figure 1.--Location of Leavenworth National Fish Hatchery in the Columbia River system

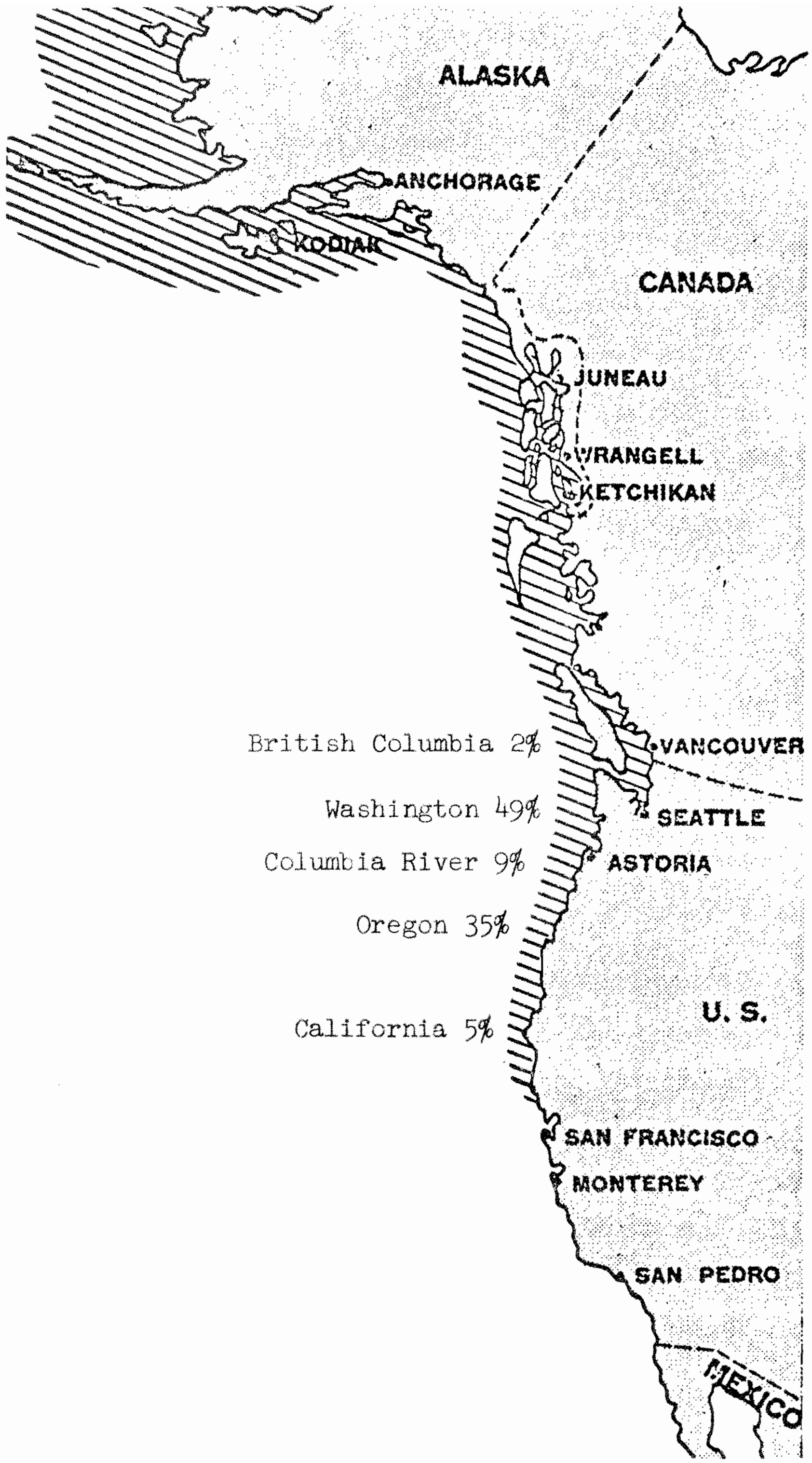

Figure 2.--Catch distribution of coho salmon originating at Leavenworth National Fish Hatchery

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

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Hatchery-produced spring chinook salmon and summer steelhead again provided the majority of each run in the North Umpqua in 1970. Runs for each species have increased between 500 and 600 percent while sports fisheries have increased between 300 and 1,600 percent since the hatchery programs were initiated.

The 1970 run of 12,970 spring chinook over Winchester Dam on the North Umpqua has been exceeded only by the record run of 20,777 fish in 1969 since the counting station was constructed in 1946. Table I illustrates the continued improvement for the spring chinook run and the increasing contribution by hatchery fish.

Table I

Spring Chinook Counts at Winchester Dam
1946-1970

Period	Average Run	Average No. Smolts Released	Averages for Hatchery Contribution: Number of Fish	Averages for Hatchery Contribution: Percent of Run
1946-50	2,745			
1951-55	5,908	43,375	929	15.7
1956-60	5,355	52,000	822	15.3
1961-65	8,671	81,300	1,911	22.0
1966-70	11,863	100,500	4,498	37.9

Spring chinook of hatchery origin made up 53.3 percent of the 1970 run. Fish from the 1966 brood contributed the greater part of the return; however, fish from the 1965 brood produced a substantial portion of the run. The additional 1965 brood fish recovered brings the total known adult recovery figure to 9.4 percent of the number stocked. The return figure for the 1966 brood is 5.6 percent. The normal return pattern would have the 1966 brood about 73 percent complete; thus it appears the return for the 1966 brood will fall short of the 1965 brood figure. Return figures are considered minimal in that they do not include figures for hatchery fish taken in the sports and commercial fisheries.

Hatchery programs for the North Umpqua are geared to produce a spring chinook smolt in March averaging 7.0 to 7.5 inches fork length (5-6 fish per pound) in visible smolt condition with a condition factor of 1.10.

Hatchery-produced spring chinook have not only assisted in producing record runs for the North Umpqua but have brought about an increased sports fishery as well. Table II shows figures for the salmon harvest taken from the punch card reports and projected angler trips. Table II illustrates an increase from 296 fish harvested by 3,700 angler trips in 1960 to 5,714 fish for 12,986 angler trips in 1969.

Table II

Harvest and Angler Use Statistics for North Umpqua
Salmon and Steelhead, 1960-69

Year	Salmon Harvest	Angler Trips	Steelhead Harvest	Angler Trips
1960	296	3,700	478	2,515
1961	508	5,080	688	3,621
1962	306	1,700	945	4,974
1963	759	3,994	1,799	9,468
1964	575	3,594	1,140	6,000
1965	699	4,112	2,235	22,350
1966	745	4,382	4,069	29,064
1967	802	4,717	3,297	23,550
1968	1,083	3,495	4,335	30,964
1969	5,714	12,986	6,986	42,113

The 1970 run of 15,580 summer steelhead established a new record high for the North Umpqua. The rate of increase for summer steelhead passing Winchester Dam and the contribution by hatchery fish is presented in Table III.

Table III

Summer Steelhead Counts at Winchester Dam
1946-70

Period	Average Run	Average No. Smolts Released	Averages for Hatchery Contribution: Number of Fish	Percent of Run
1946-50	3,149			
1951-55	3,439			
1956-60	2,395	34,000	833	34.3
1961-65	3,874	69,760	1,339	34.6
1966-70	9,338	124,900	6,631	71.0

Hatchery-produced fish made up 82.5 percent of the 1970 run of summer steelhead. Brood-year contribution was 0.1 percent from 1965, 2.0 percent 1966, 28.6 percent 1967, and 69.3 percent from 1968. The rate of returns of hatchery fish are ranging between four and eight percent of the number stocked.

Hatchery programs are geared to produce a summer smolt for release into the North Umpqua in March averaging 7.0 to 8.0 inches fork length (5-7 fish per pound) in visible smolt condition, with a 1.00 condition factor.

Recent experiments have indicated little difference between releases made at Winchester (River Mile 114) and Steamboat (River Mile 167) in two of the past three years. Releases in 1968, however, favored the Winchester site. Returns from the first plants were 5.4 percent from the number stocked in the Winchester area, 5.5 percent return of those stocked in the Steamboat area, and 3.5 percent of the number stocked in Canton Creek, a tributary to Steamboat Creek. At present an attempt is being made to release smolts and bring back the adults into a particular tributary which has undergone habitat improvement.

Hatchery-produced summer steelhead, like spring chinook, have greatly increased angler effort, harvest, and have also produced record runs in the North Umpqua. Table II illustrates an increase from 478 steelhead harvested by 2,515 angler trips in 1960 to 6,986 steelhead harvested by 42,113 angler trips in 1969.

In summary, the 1970 run of 12,970 spring chinook containing 53.3 percent hatchery fish and the 15,580 summer steelhead run containing 82.5 percent hatchery fish continue to present a picture of improved runs into the North Umpqua. Figures from the catch card report indicate sport fishery harvest increases ranged from 300 to 1,600 percent. Both facts stress the apparent success of the hatchery program for these two species in the North Umpqua.

SOME CHARACTERISTICS OF ANTIBODIES FROM JUVENILE SALMON[1]

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As a means of better understanding both the immune state and immunological capabilities of salmon, our laboratory has been studying salmon antibodies against the fish pathogen *Aeromonas salmonicida*.

Juvenile coho salmon were immunized parenterally with *A. salmonicida* cells in Freund's complete adjuvant. The susceptibility of antibody activity to combinations of various chemical treatments (reduction, alkylation, and exposure to urea) was determined on antisera collected at various times after immunization. The results of this analysis suggested that juvenile coho produce a single, macroglobulin class of antibody. Reduction and alkylation markedly lowered titers and also gave rise to prozones. Urea exposure had no effect on antibody activity in untreated samples; however, it did abolish the activity which remained after reduction and alkylation.

Separation of coho antiserum on G-200 Sephadex revealed a single peak of antibody activity associated with the macroglobulin fraction of the serum.

To obtain purified coho antibodies against *A. salmonicida*, immunoadsorption procedures were employed. Satisfactory results have been obtained from a method which uses purified *A. salmonicida* cell walls as the immunoadsorbent and 15% NaCl as the antibody releasing agent. The product of this method possesses antibody activity and migrates as a single, sharp, slow moving band on polyacrylamide gel electrophoresis.

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

CURRENT RESEARCH CONCERNING ORAL IMMUNIZATION OF SALMONIDS AGAINST BACTERIAL DISEASES

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The study of oral immunization designed to develop techniques for the prevention and control of bacterial diseases in fish has been under investigation in our laboratory for some time. The bacteria receiving our primary attention are *Aeromonas salmonicida*, *Chondrococcus columnaris* and *Vibrio anguillarum*, the causative agents of furunculosis, columnaris, and vibriosis, respectively. The vaccines have consisted of lyophilized sonicates of bacterial cells which are then incorporated into a semi-synthetic diet and administered to fish under controlled conditions and at known concentrations. Thus far the experimental work with *A. salmonicida* and *C. columnaris* have been inconclusive and new methods of vaccine preparation are presently being considered.

Results with vaccines prepared from *V. anguillarum* have been most encouraging. When the vaccine is offered at a level of 300 micrograms per fish over a fourteen day period, it has been possible to reduce the loss from approximately 95 percent of the controls to approximately 18 percent in the experimental group receiving the vaccine. The most successful experiment employed 1,000 micrograms per fish administered over a thirty day period. The losses were virtually reduced to zero.

It has been interesting to note that fish exhibiting this high degree of protection have no circulating antibody. It is presently our assumption that the vaccine causes the formation of secretory antibody in the gut and thus affords protection to the animals against this bacterial disease. Presently we are attempting to detect this type of antibody in fish which have received the lyophilized sonicate (vaccine) prepared from these bacteria.

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*This work supported by the Fish Commission of Oregon and the Oregon State Game Commission.

**Experimental work described in this report are a result of the activities of W. D. Patterson, J. S. Nelson, and J. E. Sanders, Oregon State University, and R. L. Garrison, Oregon State Game Commission.

OBSERVATIONS ON PSEUDO-KIDNEY DISEASE AND THE REDMOUTH DISEASE BACTERIUM IN OREGON SALMONIDS/1

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The pseudo-kidney and redmouth disease bacterium (enteric) are probably normal inhabitants of the water environment of most fish populations. These two microorganisms have been isolated from diseased fish at various fish hatcheries in Oregon. The pseudo-kidney disease bacterium is a Gram positive, non-sporeforming, non-motile diplobacillus, possibly belonging to the genus *lactobacillus*. This organism is distinctly different from the agent of bacterial kidney disease. These bacteria are frequently isolated from fish which at the same time are infected with bacterial kidney disease, furunculosis, or various Gram negative bacteria (*Pseudomonas*, *Aeromonas*). This organism appears to be very low in virulence requiring that the fish be stressed sufficiently before the infection will proceed. The pseudo-kidney disease bacterium is most frequently isolated from the kidney, liver, and spleen of rainbow and cutthroat brood trout.

The redmouth disease bacterium is a Gram negative peritrichously flagellated rod of the Enterbacteriaceae family. This organism was found to produce a bacterial hemorrhagic septicemia in fall chinook and winter steelhead at four sites in Oregon during the spring of 1970. Two outbreaks of this disease were probably initiated when the fish were stressed during transportation to new locations.

/1 This work was supported by the Fish Commission of Oregon and the Oregon State Game Commission

GAS-BUBBLE DISEASE STUDIES OF FISH

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Gas-bubble disease of fish is characterized by the accumulation of gas as blebs in the skin and fins; and in the vascular system where it is easily seen in the gills, kidney and heart. Death is due to circulatory interference. A bubble may develop in yolk-sac fry causing them to float upside down in the water. Surviving fry frequently show a white spot (coagulated yolk) which may be confused with the gas bubble.

Gas-bubble disease has been attributed to excess free carbon dioxide, oxygen and nitrogen gas in the water. In my experience carbon dioxide is not a factor: it can cause anaesthesia and death, but not gas-bubble disease. Oxygen has been shown to cause gas-bubble disease but only under artificial conditions. Nitrogen gas at supersaturated levels in water causes the problem. The excess nitrogen gas leaves the ambient water and enters the atmosphere. The excess gas in the fluids of fish similarly equilibrates to atmospheric pressure but is trapped within the fish as bubbles. Nitrogen is not assimilated by the fish as is carbon dioxide and oxygen but remains as free gas.

Excess nitrogen gas is sometimes found in water from springs and wells. It can be developed by allowing air to be sucked into a pumped or gravity-flow water system. Merely warming water can cause a supersaturated condition. Water falling into deep water will carry air bubbles to a depth where the gases are absorbed to an amount greater than normally present at atmospheric pressure -- in other words, dams can cause supersaturated water conditions.

We know that some waters supersaturated with air are toxic to fish. We do not know exactly what minimum levels can be tolerated by eggs, fry, and fingerlings. To obtain this information I developed two tanks: one with saturated water (100 percent) with a temperature control system; the other with a circulating pump that sucks in air to give cooled water of 110 percent saturation. These two waters are combined to supply six fish troughs with 100, 102, 104, 106, 108, and 110 percent air-saturated water. To date, only eggs have been subjected to these conditions.

VIRULENT AND ATTENUATED FORMS OF FURUNCULOSIS

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Through the last ten years the Western Fish Disease Laboratory has collected and stored Aeromonas salmonicida isolates from all over the world. Some of the older isolates showed marked attenuation or loss of virulence when compared with bacteria from recent epizootics. The bacterial colonies resulting from the different isolates were closely examined, and it was observed that the majority of the colonies from the old isolates were transluscent, dull, and often minutely pitted or rough-looking. In contrast, the recent isolates formed colonies which were predominatly smooth, creamy, and glistening. The rough (R) and smooth (S) colonies were separated, harvested, titered, and inoculated subcutaneously into yearling coho. LD-50's were plotted and the results demonstrate that the S form is much more pathogenic than the R form of the same isolate (Figure 1).

Fish were inoculated with standard doses of the R and S forms to study the bacteria in vivo. A. salmonicida was isolated from the site of inoculation, where a small lesion occurred in most cases, and also from the kidney at post-inoculation time intervals, as shown in Table 1. After 72 hours, the smooth-inoculated fish had all died. However, the rough-inoculated fish returned to an apparently healthy state, eliminating or greatly reducing the inoculated bacteria.

It is hoped that these studies will lead to a better understanding of the antigenic structure of A. salmonicida and help to further develop immunization techniques.

Figure 1. Mortality in coho salmon after a subcutaneous inoculation of ten-fold dilutions of the No. 2 and No. 95 rough and smooth dissociate forms. The results are 5-day accumulative deaths.

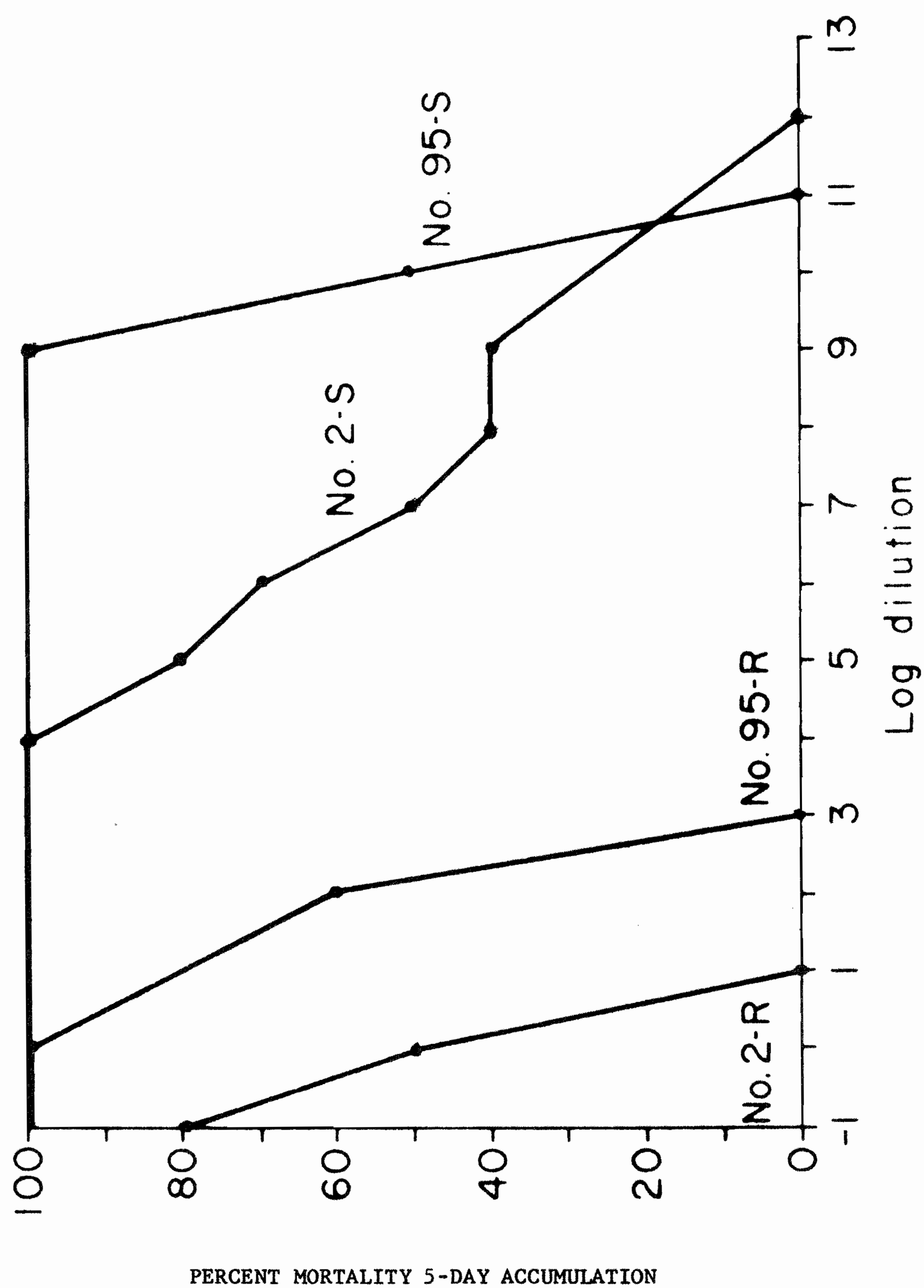

TABLE 1: FISH SHOWING CULTURES AFTER INOCULATION WITH ROUGH AND SMOOTH DISSOCIATE FORMS OF A. SALMONICIDA. NO BACTERIA WERE RECOVERED FROM THE SALINE-INOCULATED CONTROLS.

	ROUGH		SMOOTH	
	LESION	KIDNEY	LESION	KIDNEY
PRE-INOCULATION	0/10	0/10	0/10	0/10
2 HOURS POST-INOCULATION	9/10	10/10	10/10	10/10
24	9/10	10/10	9/10	9/10
48	9/10	9/10	10/10	10/10
72	6/10	5/10	5/5	5/5
96	1/10	1/10	-	-
120	0/10	1/10	-	-

WHAT'S NEW IN EGG DISINFECTANTS?

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Egg disinfection can reduce egg losses due to fungus, fry losses due to diseases passed onto the eggs from the parent fish, and can prevent introduction of undesirable diseases into new areas. Hatchery disinfectants in common use are not broad spectrum germicides and in some cases do not adequately destroy target microorganisms. In addition, the Food and Drug Administration (FDA) will soon restrict the use of these disinfectants because all (except for formalin) cannot be cleared at this time. Consequently, the need for new egg disinfectants is urgent.

Iodophores (organic iodine compounds) are used widely as broad spectrum disinfectants in medicine and industry and are FDA approved. Recent data indicate that the iodophores will work satisfactorily for disinfecting eggs and we are gathering data for FDA approval for fish eggs. I have tested Wescodyne for its virucidal effect on the infectious hematopoietic necrosis (IHN) virus and have determined its toxicity to rainbow trout eggs. A 5-minute dip in a 1:600 (27 ppm I_2) Wescodyne solution will completely inactivate the IHN virus and will not kill eyed rainbow trout eggs. When the pH is maintained above 6.0, eyed eggs can tolerate concentration of Wescodyne over 300 ppm I_2 for 15 minutes or longer. In soft water with low buffering capacity, a 1:600 dilution can give a pH value of about 3.0. In order to keep the pH of the dip solution above 6.0, it can be buffered by adding sodium bicarbonate to give a final concentration of 0.05 percent.

The possibility of using iodophores for eliminating other egg born diseases is being examined, and the overall value of egg disinfection was discussed.

THE STRESS OF FORMALIN TREATMENTS IN TWO SALMONID FISHES

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Formalin is a very useful chemical for controlling external fish parasites, but at the 200 ppm treatment level commonly needed, it can be unexpectedly toxic, especially to rainbow trout. To evaluate the physiological stress caused by formalin treatments and the length of time needed for recovery, a formalin resistant (coho salmon) and a susceptible (rainbow trout) salmonid were compared.

In general, gill function-related blood chemistry tests showed that rainbow trout were less able to maintain a normal metabolism during formalin exposure than were coho salmon. Specifically, sharp declines in plasma Cl^- and arterial CO_2 levels occur in rainbows but not in coho given the same 200 ppm treatment. The oxygen consumption of trout declines about 50 percent during a 1-hour, 200 ppm treatment implying that formalin markedly reduces the ability of trout to extract oxygen from water. Again, coho salmon are not comprised nearly as much at the same exposure.

Further tests showed that significant disturbances in acid-base balance can occur during formalin treatments. As before, the two species differed considerably in their metabolic response. Rainbow trout suffered a progressive acidosis during formalin exposure, with the blood pH continuously declining until shortly before death at which time a mild alkaline shift occurred. In coho salmon, the alkaline rebound occurred much earlier and they were able to maintain a more constant blood pH.

For the usual hour treatment at 200 ppm, the alkaline reserve level was a more sensitive indication than blood pH of early changes in acid-base balance. Plasma bicarbonate levels in both species dropped sharply during the hour treatment but, when fresh water was introduced, rapidly returned to initial values and by 24 hours were essentially normal.

Adrenal hyperplasia has been noted in trout exposed to formalin implying that "stress hormones" are released during treatments. To evaluate the extent of pituitary-interrenal activation, interrenal vitamin C and plasma cortisol levels were determined prior to, during, and after formalin treatments. The results showed that severe vitamin C depletion occurs in the trout but not the salmon with ACTH production beginning immediately after formalin is introduced. Thus, although behavioral changes may not indicate it, treating with formalin apparently does impose a considerably greater metabolic load on trout, aside from inflicting gill pathology, and it is this which is reflected in the disrupted Cl^-, CO_2, HCO_3^-, and vitamin C levels.

As expected from the sequela of methanol poisoning in the higher vertebrates, folic acid metabolism was also involved in formalin toxicity. In trout, the severity of the acidosis which develops due to formalin exposure is inversely proportional to the size of the metabolic folate pool.

Using plasma bicarbonate as a measure of the alkaline reserve, the resulting depletion was less pronounced than without folic acid pretreatments but the total recovery time was about the same. Pretreatment with the usual dosages of folic acid inhibitors did not precipitate the severe formate-induced metabolic acidosis which has been seen in methanol intoxication. However, it did markedly change the shape of the alkaline reserve deplection curve.

In summary, juvenile rainbow trout are apparently less able than juvenile coho salmon to maintain normal levels of vitamin C, Cl^-, CO_2, and HCO_3^- during formalin treatments. In additon, their oxygen consumption decreases more and they do not replenish their alkaline reserve as rapidly as do the salmon following formalin treatments. Further work is planned to devise treatment conditions which will minimize these metabolic disturbances and hopefully reduce the sensitivity of rainbows and other salmonids to formalin treatments.

CADMIUM TOXICITY

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Summary

Investigations into the relationship of water temperature to natural salmon population of the Columbia River included effects of temperature on the toxicity of heavy metal pollutants. Initial studies indicated that combinations of 10 heavy metals at 100 percent of Oregon guidelines concentrations were lethal to juvenile steelhead. Cadmium was chosen as being potentially highly toxic and was investigated singly. Flowing water and acute tests indicated extreme cadmium toxicity above 1.5 ppb and variable toxicity at 1 ppb using juvenile steelhead trout. Oregon water quality criteria for the Columbia River, however, gives 10 ppb as a theoretically safe level. These data demonstrate a necessity for revising Oregon guideline criteria for cadmium.

A PRELIMINARY REPORT OF THE EFFECTS OF METABOLIC PRODUCTS ON THE QUALITY OF RAINBOW TROUT

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Abstract

An experiment was designed to determine the effect of ammonia nitrogen on the quality of rainbow trout. Fish were subjected in duplicate to three levels (0.5, 1.0, and 1.5) of metabolic ammonia nitrogen at a pH of 7.65 and temperature of 50° F. Preliminary data indicate that the growth rate of trout was reduced when ammonia nitrogen levels exceeded 1.0 ppm.

Pathological changes consisting mainly of hypertrophied (swollen) epithelial cells were present at all three levels, but more severe at the 1.5 ppm level. Hematocrits and morphology of blood cells were not adversely affected. However, stamina was reduced up to 40 percent when compared with controls, at an ammonia nitrogen level of 1.5 ppm.

COMPARATIVE LIPID AND FATTY ACID FEATURES OF PELLET DIETS CURRENTLY USED IN FISHERIES

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Pacific salmon are capable of storing large amounts of lipid. The total lipid content and individual fatty acid percentages will reflect the quality and quantity of food ingested. Therefore tne diet of salmon will have a direct effect on the total lipid content and the component fatty acids.

The major commercial pellet diets used in salmon culture in the Northwest list their lipid source as cottonseed oil and soybean oil. These two oils contain large percentages of linoleic acid (18 carbons with 2 double bonds). Juvenile chinook salmon may retain up to 30 percent of linoleic acid when fed a pellet diet. Native salmon residing in the streams contain between 2-3 percent of linoleic acid. The increased percentage of linoleic acid found in fish fed a pellet diet is in contrast to a decreased percentage of the long chain essential polyunsaturated acids typical of marine organisms. Eicosapentaenoic acid (20 carbons, 5 double bonds) and docosahexaenoic acid (22 carbons and 6 double bonds) will account for 35 percent of the total fatty acids present in native fish, but when the fish are fed diets containing large percentages of linoleic acid these two fatty acids will account for only approximately 12 percent of the total. In fish, linoleic acid is not a precursor for eicosapentaenoic and docosahexaenoic acid.

It is not known what the overall effect of increased levels of linoleic acid may have on the growth and development of salmon. It is possible that large accumulations of total lipid and large accumulations of certain fatty acids with the reduction of other major essential fatty acids could be a disadvantage to developing fish. An oil source derived from marine organisms (i.e., fish, shrimp, crab) with a reduction in the amount of soybean and cottonseed oils would improve the diets. This would also provide a fatty acid composition more closely related to the fatty acid composition of native young salmonids.

UTILIZATION OF SHRIMP PROCESSING WASTE AS A DIETARY SUPPLEMENT FOR RAINBOW TROUT (*Salmo gairdneri*) /1

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Up to the month of August for the 1970 season, 7.9 million pounds of shrimp were landed in Oregon ports ready for processing (1). The increased mechanization of the shrimp processing industry and the fact that 75 percent of the shrimp consists of unused waste material presents a timely problem in our age of environmental pollution and ecological awareness.

The shrimp processing waste, which consists mainly of shell and visceral material, can be compounded into a colorful pink meal if suitable grinding and drying techniques are employed. Shrimp meal is not a new by-product. It has been used in the past as a dietary supplement for ducks, pigs, poultry, and cattle. One of the best ways to evaluate the use of shrimp or its by-products is through the observation of its consumption in the natural environment, and most noteworthy is its consumption by fish.

Even though trout feeds are reportedly producing top quality fish, there is one aspect which deserves attention and that is the trout's coloration. The trout which spends its lifetime in the natural environment is often more colorful and asthetically appealing than the hatchery or farm-raised trout that is available on the fresh market. Numerous workers agree that certain species of fish derive their pigmentation from dietary sources.

In 1967, investigations indicated that the incorporation of shrimp meal into purified diets at 2.5 percent and 5.0 percent levels produced

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/1 This study was supported by the National Science Foundation's Sea Grant Program.

very little quantitative muscular pigmentation when fed to rainbow trout over a ten-month feeding period. However, there was an observable red coloration along the lateral line, operculum and fins.

Further studies, in 1968, illustrated that shrimp meal incorporated into a purified diet at a level of 15 percent would impart a quantitative pigmentation to the muscular tissue. At the end of a six-month feeding period, fish receiving shrimp meal at this level exhibited a twelvefold pigmentation intensity in the muscular tissue when compared to control fish.

Investigations were then conducted to determine the most effective mode of pigment transfer from the diet to the tissue of the fish. Five groups of rainbow trout were fed separate pigment-rich diets and pigment deposition in the fish tissue was quantitated at specific intervals during an eight-month period. Comparisons were made to fish receiving a control diet. All six diets were formulated on an isocaloric basis.

Figure I illustrates the pigment uptake by the tissue of the rainbow trout. Diet 1 was the control diet; diet 2 contained shrimp meal at a 15 percent level (dry weight); diet 3 contained whole ground shrimp at a level of 15 percent (dry weight); diet 4 contained a pigmented lipid-extract of shrimp meal equivalent in pigment intensity to diet 2; diet 5 also contained a pigmented lipid-extract of shrimp meal yet it was twice the pigment intensity of diet 2 or diet 4; and diet 6 contained a commercially produced carotenoid known as canthaxanthin which was fed as a pure crystalline powder dispersed in oil, then fed later as a water-dispersible beadlet at the twenty-third week in the feeding period. The canthaxanthin crystals were fed at a level of 190mg/kg food (dry weight). The canthaxanthin beadlet, which was 10 percent of the pigment in a dry water-soluble form dispersed in a carrier of gelatin, sugar, and starch, was fed at a level of 1,680 mg/kg food (dry weight).

Growth data was also collected during the eight-month feeding period in order to evaluate any nutritional advantages of each diet. Figure 2 indicates the growth produced by each diet. Food conversion values were also calculated in order to make these curves more meaningful. When food conversion values were calculated as weight food/weight fish, the averages over the entire feeding period were: diet 1 - 1.06; diet 2 - 0.82; diet 3 - 1.62; diet 4 - 0.79; diet 5 - 0.86; and diet 6 - 0.97. It should be noted that poor conversions and growth produced by diet 3 were probably due to the physical characteristics of the diet. The hydrolytic activity of the enzymes present in the whole ground shrimp prevented the gelatin binder from setting up the diet into an intact soft cube. Consequently, diet 3 was fed as small frozen chunks which easily dissipated when dropped into the water.

At the termination of this phase of the research, extensive flavor analyses were conducted on specific groups of fish using the Department of Food Science and Technology flavorium. Two hundred panel judges, consisting of students and members of the department's staff, were used for this study. In essence, these results indicated that the supplementation of a trout diet with shrimp meal or its pigmented lipid-extract produced fish which were firmer in texture, more desirable in flavor and color, and higher in overall desirability than control fish. The supplementation of a trout diet with water-dispersible canthaxanthin produced fish which were more desirable in color than control fish.

All the data concerning pigment uptake, growth, and flavor evaluations was statistically analyzed using Oregon State University's CDC 3300 computer. Linear regression analyses were conducted on the pigment uptake and growth curves with further statistical tests to establish the significance of the aforementioned results. Flavor panel scores were evaluated using an analysis of variance with additional statistical tests to establish these results at specific significance levels. Statistical computations were also used to illustrate correlations between growth and pigment uptake. The fish which received diets 2, 4, and 5 exhibited significant correlation coefficients. When calculated as ρ these were equal to 0.89, 0.88, and 0.90 respectively. The remaining diets showed correlations which were not significant.

The next phase of the research involved the characterization of the pigments from the diets and the tissue of the fish. These qualitative studies were conducted using column chromatography, spectrophotometry, polarity, thin-layer chromatography, and infrared-spectroscopy. These results indicated that the dietary pigment from the shrimp derivatives was primarily the carotenoid astaxanthin in the esterified form. However, the primary pigment from the tissue of fish receiving these diets was astaxanthin in the unesterified form. The canthaxathin remained unaltered after ingestion by the fish.

Currently, studies are being conducted to elucidate the functional importance of carotenoid pigments in newly-hatched fish. Specifically, the viability of the orange-pigmented eggs obtained from the shrimp meal or canthaxanthin fed fish are being compared to the yellow eggs from control fish.

Literature Cited

1. "Oregon's Shrimp Fishery Remains Strong." Commercial Fisheries Review 32(8-9), p. 6, Aug.-Sept., 1970.

FIGURE 1

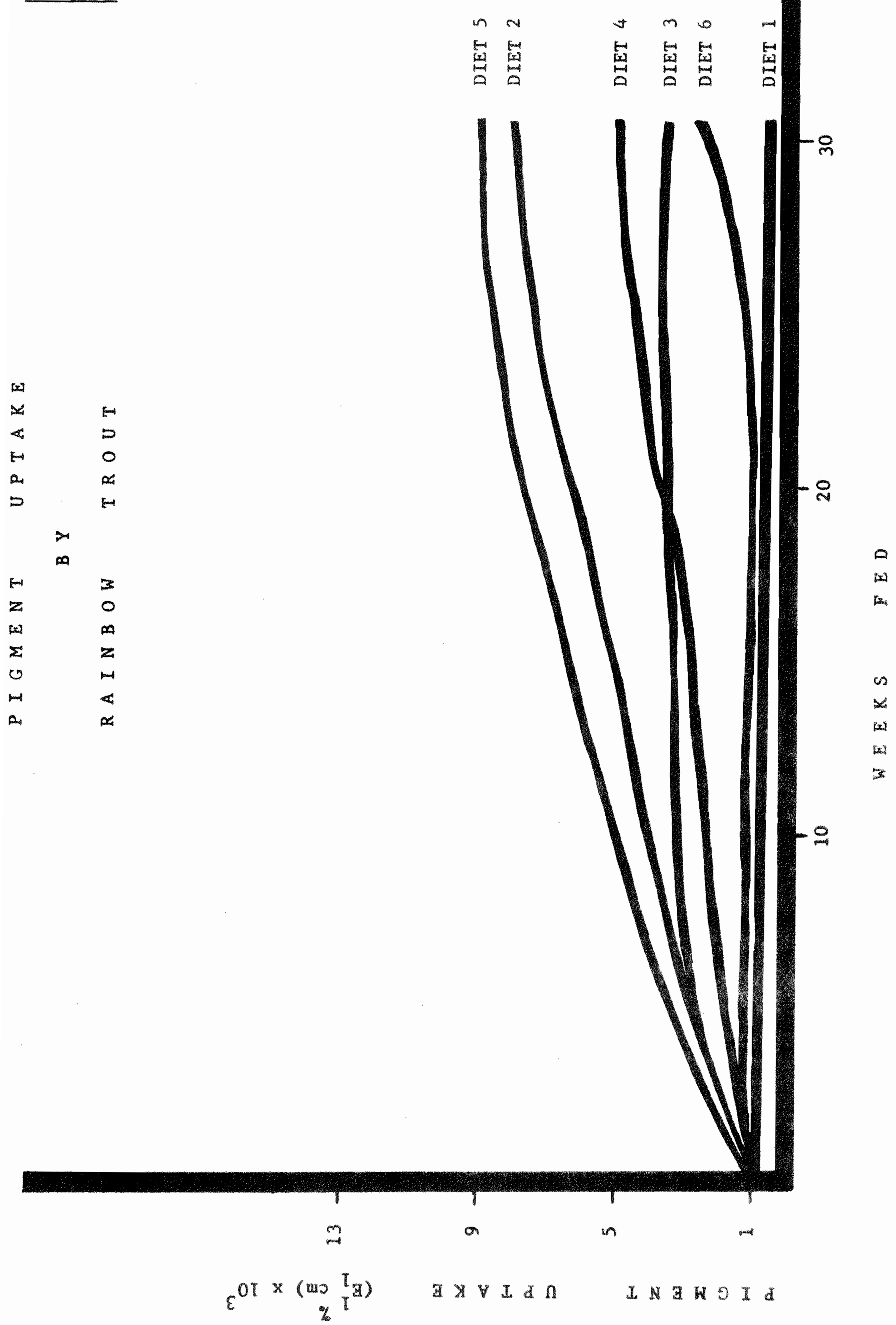
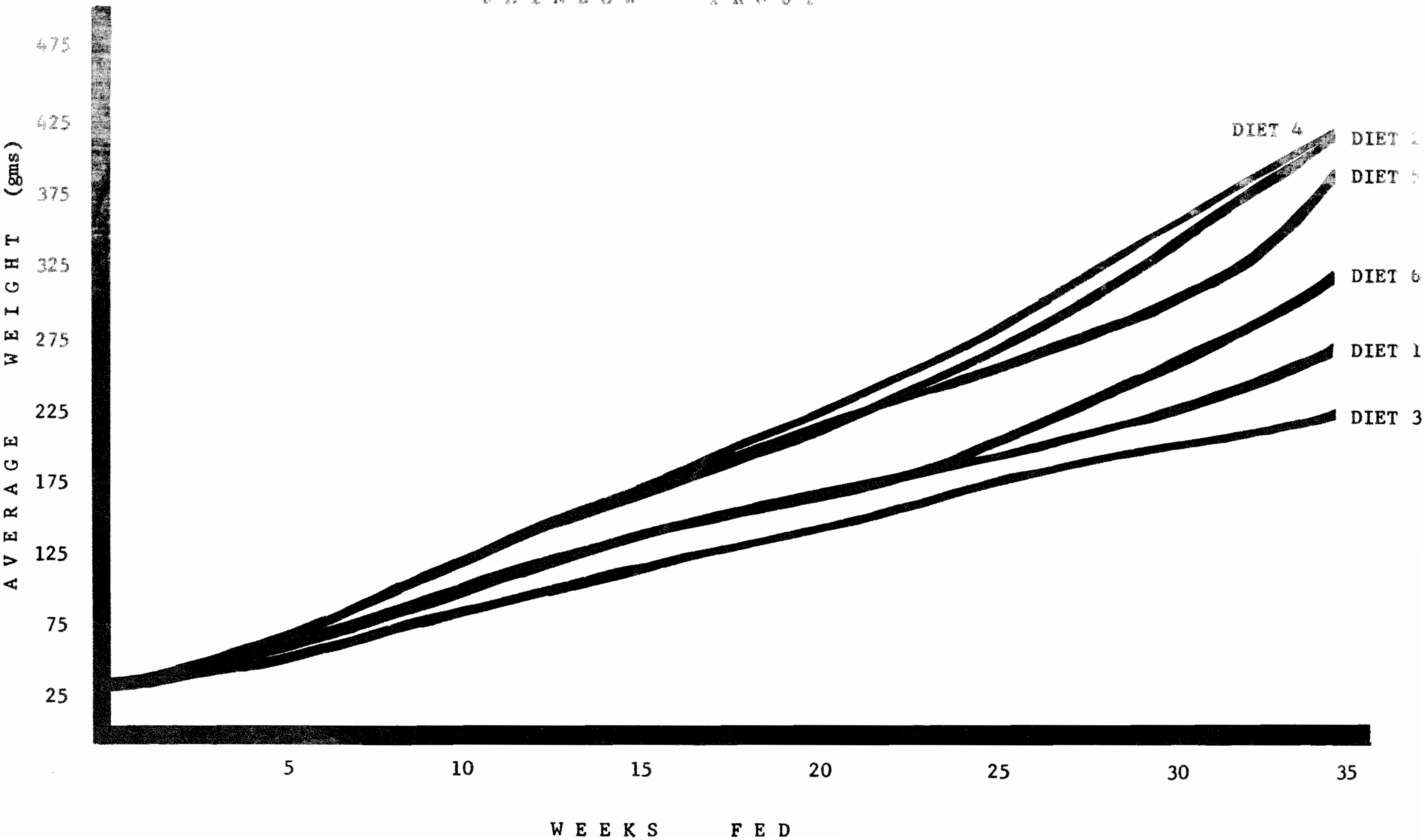

PIGMENT UPTAKE BY RAINBOW TROUT
DIET 5
DIET 2
DIET 4
DIET 3
DIET 6
DIET 1
10
20
30
WEEKS FED
1
5
9
13
PIGMENT UPTAKE
($E_{1}^{1\%}$ cm) x 10^3

FIGURE 2

G R O W T H   C U R V E S

F O R

R A I N B O W   T R O U T



UTILIZATION OF SHRIMP SCRAP IN THE PREPARATION OF MOIST PELLETED FOODS

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During the immediate past shrimp fishing season over 13,000,000 pounds of shrimp were landed in Oregon. Yields of 18-25 percent shrimp meats can generally be expected from the green catch. The 75-82 percent remaining represents a sizeable volume of waste. This waste constitutes a disposal and pollution problem of considerable magnitude, especially in areas that do not have reduction plants. Shrimp meal is presently allowed as one of the ingredients in the Oregon Moist Pellet but production of the meal is contingent on a reduction plant. It is the purpose of this experiment to determine the potential of unprocessed shrimp scrap in the formulation of a moist pelletized fish food. Successful useage of unprocessed shrimp scrap would help in relieving the waste disposal and pollution problem, provide additional revenue for processing plants, and provide a low-cost ingredient for the manufacture of moist pellets.

It is the concept of this experiment to utilize as much shrimp scrap as possible. The analyses of a typical batch of shrimp scrap may be found in Table I. Levels of 40 percent appear to be the maximum that we could attain from a physical as well as nutritional basis. The diet formulation was also kept as simple as possible. Other than herring meal and oil, the only other major ingredient was oat groats. This grain component possesses excellent water holding and binding properties. Varying levels of oat groats were used. These are described in Table II. Proximate analyses of the diets may be found in Table III.

Three species of fish, chinook, coho, and rainbow trout were selected for this experiment. The chinook were subjected to only the 10 percent level of oat groats. The diets were fed to each species for 22 weeks with a standard 40 percent Oregon Moist Pellet diet as control. All the moist diets were frozen. The fish were fed on a percentage body weight basis based on demand for the control diet of each species. The number of feedings were not allowed to exceed four per day. There were two lots per treatment.

At the termination of the experiment after 22 weeks, the chinook and the rainbow control fish showed substantial percent weight gains over the treatments, although statistically at the 10 percent oat groat level this was not significant. With the coho, however, all treatment levels were better than the control though not significantly so. With the coho and chinook, feeding enthusiasm was increased. This experiment indicates that unprocessed shrimp does have potential for the manufacture of a moist pellet. With the chinook and rainbow the economic advantage may well outweigh its apparent growth disadvantage, while with the coho its apparent growth advantage and taste appeal could be of considerable value.

Table I. PROXIMATE ANALYSIS OF SHRIMP SCRAP

	Moisture	Ash	Fat	Total N Protein	Less Chitin N Protein
Wet	79.90	5.52	0.56	9.66	7.97
Dry		27.46	2.79	48.06	39.65

Table II. DIET DESCRIPTION

Diet	Components
C	Control - Standard 40% Fish
D	Shrimp 40% - Meal mix - 10.0% Oat Groats
E	Shrimp 40% - Meal mix - 17.5% Oat Groats
F	Shrimp 40% - Meal mix - 25.0% Oat Groats

Formulation

Herring meal	42.45
Vitamin mix	1.50
Shrimp scrap	40.00
Choline chloride	0.50
Herring oil	5.50
Tenox IV	.05
Oat groats	10.00

Table III. PROXIMATE ANALYSES OF DIETS

Diet	Ash	Fat	Protein	Carbohydrate
C	10.65	12.39	57.73	19.23
D	11.77	18.05	55.72	14.46
E	11.46	18.06	49.35	21.13
F	9.87	18.19	42.02	29.92

COMPARATIVE RESPONSE OF CHINOOK AND STEELHEAD TO VARIATIONS IN THE ABERNATHY DRY DIET

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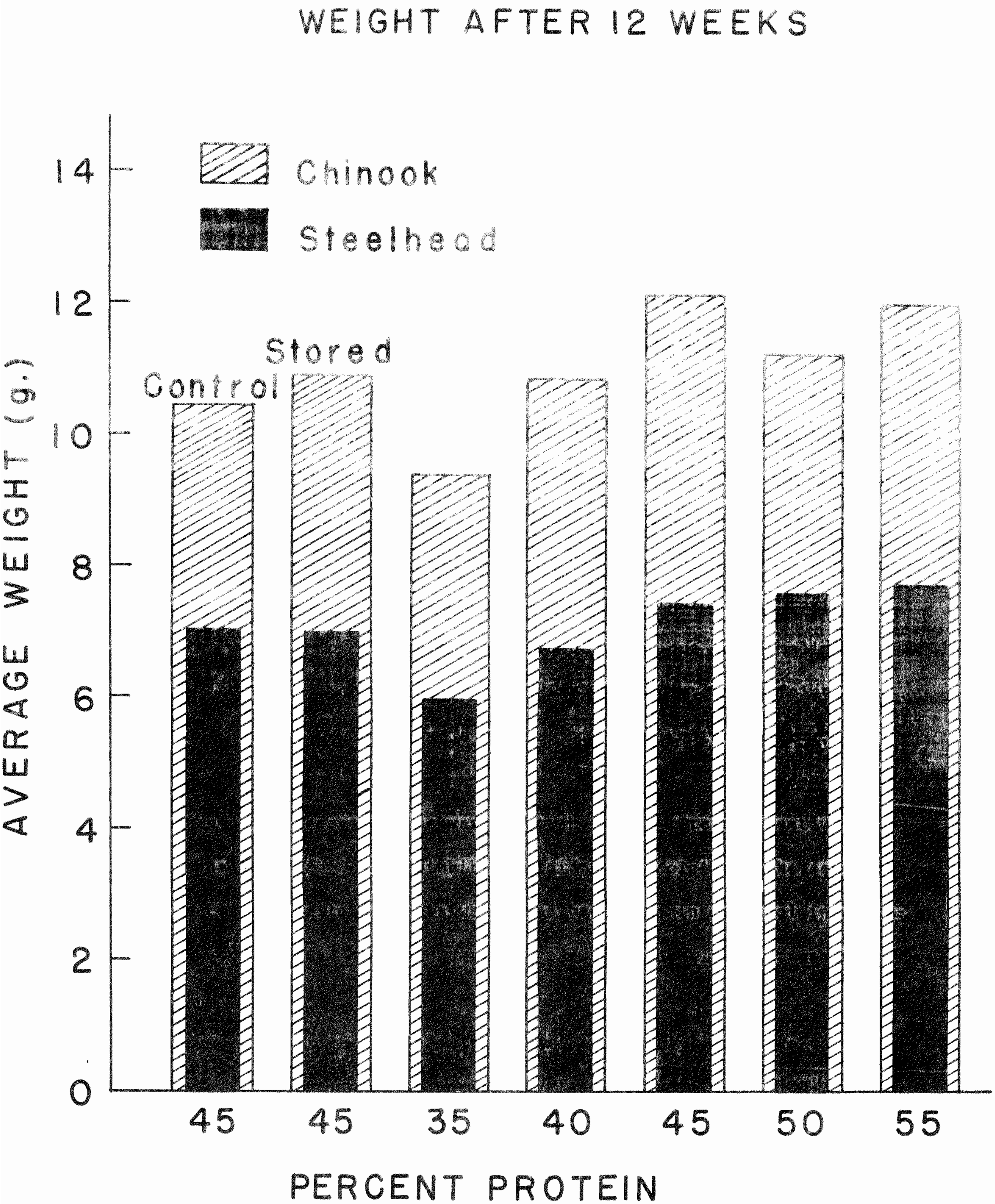
In diet experiments during 1970, fall chinook and steelhead fingerlings were fed the Abernathy dry diet and several variations in this formulation. After 12 weeks of rearing, the response of steelhead to all experimental diets was found to closely parallel that of chinook fingerlings (Figure 1). Pellet storage at room temperature did not adversely effect either species. In the chinook experiment, better growth on an altered diet, isoprotein (45 percent) and isocaloric (3230 kcal./kilo.) with the control, indicated that protein quality had been improved by removal of the cottonseed meal and adjustment of the whey and wheat germ to a 1:1 ratio. A 45 percent protein level appeared close to the optimum for feeding the Abernathy dry pellet to both chinook and steelhead fingerlings in production operations as increased growth was not obtained by feeding at 50 or 55 percent levels.

FIGURE 1


WEIGHT AFTER 12 WEEKS
Chinook
Steelhead
Stored
Control
AVERAGE WEIGHT (g.)
14
12
10
8
6
4
2
0
45
45
35
40
45
50
55
PERCENT PROTEIN

PRODUCTION RESULTS WITH IMPROVED OREGON STARTER MASH AND PELLETS

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At last year's Fish Culture Conference John Westgate reported on some developments in the Oregon Starter Mash and Oregon Pellet formulations.

In 1970 we conducted a production diet trial comparing the old and new mash at all hatcheries that started fish. Approximately half of the chinook and coho started at each hatchery were fed the old (OM-1) and half the new (OM-2) mash.

Table 1. Oregon Starter Mash Formulae, 1970

Ingredient	OM-1 (%)	OM-2 (%)
MEAL MIX		
Herring meal	33.0	46.0
Dried skim milk	10.0	-
Dried whey product (MNC)	-	10.0
Cottonseed meal	7.0	-
Shrimp or crab meal	5.0	-
Wheat germ meal	3.5	10.0
Corn distillers dried solubles	3.5	4.0
VITAMIN MIX	1.5	1.5
WET MIX		
Fish	24.0	16.0
Soybean oil, antioxidant	10.0	12.0
Kelp meal (Algit)	2.0	-
Choline chloride	0.5	0.5
TOTAL	100.0	100.0

Table 2. Results of Production Evaluation of Oregon Starter Mashes, 1970

Species	Conversion		Ingredient Cost to Grow a Pound of Fish (¢)		Mortality (%)	
	OM-1	OM-2	OM-1	OM-2	OM-1	OM-2
Fall chinook	2.49	2.21	26.6	22.0	0.82	0.68
Coho	2.26	2.03	24.2	20.2	0.66	0.87
Spring chinook	2.45	2.21	26.2	22.0	1.55	1.44
All species	2.44	2.18	26.1	21.7	0.89	0.81

The overall conversion was significantly better with the new mash.

Our estimate of ingredient cost for OM-1 is 10.7 cents per pound and 9.96 cents per pound for OM-2. In this evaluation, based on our estimate of ingredient costs, the new mash produced a pound of fish for 4.4 cents less than the old mash.

Mortalities were comparable for both starter mashes.

This yéar we are also conducting a production diet comparison with our new Oregon Pellet.

Table 3. Oregon Pellet Formulae, 1970

Ingredient	OP-1 (%)	OP-2 (%)
MEAL MIX		
Herring meal	22.0	28.0
Cottonseed meal	22.0	15.0
Dried whey product (MNC)	-	5.0
Shrimp or crab meal	4.0	4.0
Wheat germ meal	3.0	4.0
Corn distillers dried solubles	3.0	4.0
VITAMIN MIX	1.5	1.7
WET MIX		
Fish	40.0	30.0
Soybean oil, antioxidant	2.0	5.8
Kelp meal (Algit)	2.0	2.0
Choline chloride	0.5	0.5
TOTAL	100.0	100.0

For the production comparison of the pellets we paired hatcheries by species reared. This was accomplished by matching hatcheries that had fed approximately the same amount of food the previous year and had attained similar conversions.

Table 4. Results of Production Comparison of Oregon Pellets Through October 1970

Species	Conversion		Ingredient Cost to Grow a Pound of Fish (¢)		Mortality (%)	
	OP-1	OP-2	OP-1	OP-2	OP-1	OP-2
Fall chinook	[illegible]	1.23	[illegible]	10.8	0.8	1.2
Coho	1.86	1.51	14.9	13.3	5.4	1.4
Spring chinook	1.69	1.67	13.5	14.7	2.9	3.4
All species	1.72	1.52	[illegible]	13.4	2.2	1.7

Table 4 shows the results through the end of October for the pellet comparison. For fall chinook these are the final results. Liberation size for fall chinook was about 100 per pound for OP-1 and 80 per pound for OP-2. For coho and spring chinook we will not have the final results until next spring when the fish are liberated.

The conversions for fall chinook and coho are considerably better with the new pellet. With spring chinook the conversion rate for the two pellets is about the same. The overall conversions for all species are better with the new pellet.

Our estimate of ingredient cost is 8.0 cents per pound for the OP-1 pellet and 8.8 cents per pound for OP-2. The ingredient costs to grow a pound of fish is less with fall chinook and coho fed the new pellet than for those fed the old pellet. The ingredient cost to grow spring chinook through the end of October is higher for the new pellet. Based on our ingredient cost estimate, considering all three species, it has cost less to grow fish with the new pellet.

Mortality rates are about the same for both pellets except for coho where one hatchery on the old pellet experienced higher than normal mortality this year.

We are specifying the new mash and new pellet for the feed contract this coming year.

PANTOTHENIC ACID REQUIREMENTS OF HENRYS LAKE CUTTHROAT TROUT FRY

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A test diet (Table I) and vitamin concentrate (Table II) with three levels of calcium pantothenate was tested in 60-day feeding tests during 1968 and 1969 rearing seasons and used during the 1970 production season.

Calcium pantotenate levels were 2.5, 5.75, and 8.75 grams per 100 pounds of fry feed. The level of 5.75 grams of calcium pantothenate per one hundred pounds of fish feed gave excellent results with a food conversion of 1.5 pounds of feed per pound of fish produced and no gill clubbing. The low level of calcium pantotenate resulted in clubbed, swollen, gills; the high level of 8.75 grams acted as a growth-inhibiting mechanism resulting in very poor feed conversion as high as 2.5 pounds of feed per pound of fish produced.

Table I

Cutthroat Trout Diet

Herring Meal	42 %
Blood Flour Meal	20
Fish Solubles	10
Dried Brewers Grain	8
Herring Oil	5
Lecithin	5
Whey	4
Salt	2.5
Vitamin Premix	.5
Yeast	3

Table II

Vitamin concentrate one-half pound used to mix with one hundred pounds of fish feed.

A	1000	USP Units
D_3	180	ICU
Ascorbic Acid	10	gms
B_{12}	1	mg
Choline Chloride	12.5	gms
D Biotin	30	mg
E	3	IU
Folic Acid	150	mg
Niacin	5	gms
Pyridoxine Hydrochloride	1	gm
Riboflavin	4.5	gms
Thiamine Hydrochloride	4.5	gms

Plus carrier to total one-half pound

LINEAR PROGRAMMED IDAHO OPEN FORMULA DIETS

Paul Cuplin
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Boise, Idaho

Diets were selected by a 494 Univac on the basis of the ten essential amino acids and ingredient prices. Levels used were calculated amino acid levels for a successful IOF trout diet and Halvers minimum amino acid requirements for rainbow trout plus 10 percent and 25 percent.

Diets are presented in Table I.

The computer was instructed to select high portions of soybean meal. Other items believed to be necessary to promote good diet palatability were left in the diet.

Feed tests are in progress.

Table I

Computer Selected Least Cost Diets

	A/1	B/1	C/1
Alfalfa Meal			
Blood Meal	3		3
Canadian Herring Meal	9	19	6
Fish Solubles, Condensed	5	5	5
Meat Scrap Meal	2	1	
Whey	.9	5	
Wheat Middlings	7		42
Yeast	5	5	5
Soybean Meal	50	55	29
Lignin Sulfonate	2	2	2
Vitamin Concentrate	.5	.5	.5
Kelp Meal	3	3	3
Salt Iodized	2.5	2.5	2.5
Feeding Oil	2	2	2

/1 Add one-third pound Methionine per ton to each of these test diets A, B, and C.

SELECTION OF WATER TREATMENT TECHNIQUES FOR FISH HATCHERY WATER SUPPLIES

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Baker Filtration Company
Huntington Beach, California

Abstract

Few hatcheries have ideal water sources for optimum efficiency.

Control of temperature, suspended solids and infections are difficult to maintain using natural waters.

The author sees the provision of re-cycle water systems in many new facilities and conversion of some existing hatcheries to re-use type operation.

High quality make-up water for re-use systems is critical and economically possible. Also some areas of single-pass hatcheries can benefit from improvement of water quality.

Techniques for hatchery water disinfection must vary from usual chlorine disinfection of domestic water treatment. Ultraviolet irradiation seems the method of choice; however, pre-treatment of water for effective penetration by ultraviolet is generally required.

Use of filters and filtration theory is discussed as well as other pre-treatment methods.

Ultraviolet equipment and detectors are described.

The value of using equipment in series for progressive removal or destruction of undesirable organisms is noted.

Conclusions:

Equipment now available has been shown to be effective and reliable.

Make-up water treatment is indicated for re-cycle hatcheries. It is possible and economically feasible.

Reliable disinfection of supply water can be assured.

TESTING EXTENDED DAYLIGHT HOURS WITH TUNGSTEN LIGHT FOR EARLIER SPAWNING OF SUMMER-RUN STEELHEAD

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Washington Department of Game
Olympia, Washington

PURPOSE:

To extend the biological year for growing summer-run steelhead.

To reduce mortalities from prolonged spawning period.

LIMITATIONS:

1. No control of hatchery river water temperatures.
2. Rising mortalities when spawning delayed by frigid weather.
3. A biological deadline on release of summer-run smolts.
4. Lower percent of adult returns with smaller size smolts planted.

NEW MATERIALS:

1. Used car lot or brewery-twisted electrical cord.
2. Clamp on light sockets and standard plug-ins.
3. Regular outside flood projection lamps of 150 watts.
4. Galvenized wire and cement anchors.

PROCEDURE:

Not knowing what degree of light intensity was required for a possible tangible affect on spawning, the most convenient arrangement was set up and adjusted visually for uniformity.

Wire fastened to the top edge of the brood raceways (12 feet wide) cleared the surface of the six-foot deep water by three feet. A single lamp hung in the middle of each ten-foot section of raceway gave a reasonably even illumination to the section.

Each lamp illuminated about a six-foot diameter cone when hung three feet from the water surface.

Starting about five weeks prior to anticipated spawning operations, lights were automatically turned on daily at 3:30 p.m. and turned off at 9:00 p.m. for a period of two weeks -- December 15 to January 1. After that, supplemental light period was extended daily to 11:00 p.m. through the spawning period.

RESULTS:

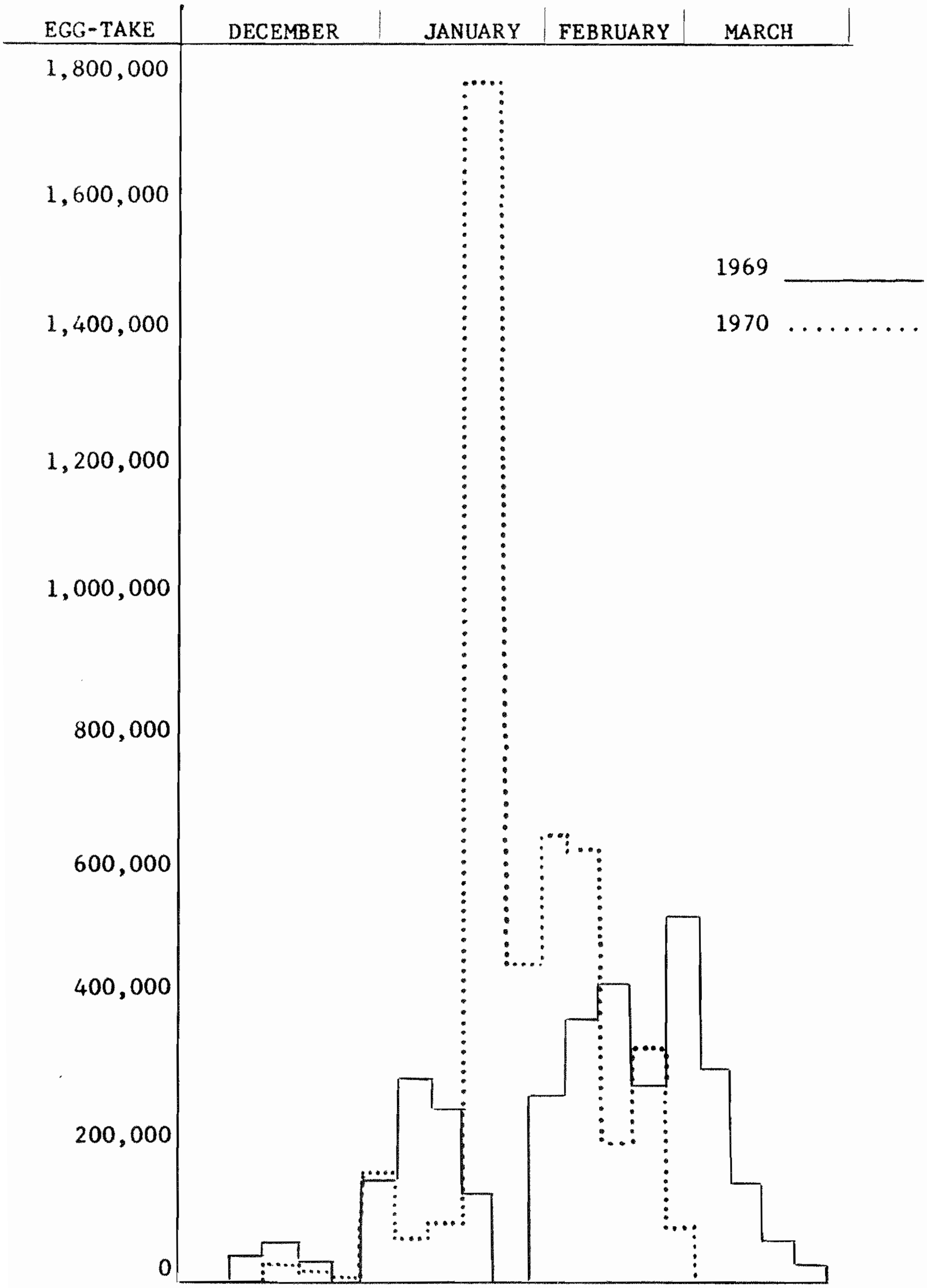
1. The normal egg-take volume peak build-up was definitely altered.
2. The entire spawning operation was apparently accelerated.
3. The results were similar to the previous spawning year and/or for all previous spawnings.
4. The fish responding the least had physically damaged eyes.

CONCLUSION:

This exploratory technique proved to be a big step toward station goals. The nominal operating costs make it practicable for hatchery operations.

SPAWNING OPERATIONS

Skamania Hatchery



"DROP-BACK" METHOD FOR SORTING FALL CHINOOK

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Fish Commission of Oregon
Bonneville, Oregon

Archie Anderson, Fish Commission of Oregon hatchery manager, initiated the "drop-back" method for sorting adult fall chinook at Bonneville Hatchery. This method works on the principle that salmon coming upstream to spawn will lay in a pool until such time as they become sexually mature. They will then move either up or down stream seeking a spawning bed. The adult ponds at Bonneville are set up using this theory. In 1969 and 1970, records were kept to calculate the effectiveness of the method.

Bonneville's holding area is made up of four ponds in series. The upper pond is 124 feet by 39 feet by 8½ feet deep. Water depth is usually kept at 7 feet during the holding period but is lowered as the numbers of fish decrease during spawning. The lower three ponds are 83 feet by 39 feet by 3½ feet deep. An alleyway runs along one side of the ponds and a jack trap is located in the second pond. The upper pond, alleway, and jack trap have concrete bottoms. The lower three ponds are gravel bottomed. Water, having been used at the hatchery rearing ponds, is piped to a 10-foot by 6-foot upwell grid located at the head of the upper pond. Flows average 23 cfs.

All fish entering the lower holding pond are sorted by means of a manually operated gate located at the entrance V. Those fall chinook to be used for spawning are placed in the alleyway while excess males, all jacks, and any coho are sent elsewhere. Once in the alleyway, spawners are able to swim up into the large holding pond.

During the holding period, the fish develop a clock-wise swimming pattern. Originating in the upper half of the pond, the rotating mass moves further down the pond each day to a point where the downstream swing of movement comes close to the pond outlet. At this time the pond V is removed and fish are allowed to drop down the ladder and into the alleyway. A grill is placed in the lower alleyway to stop the "drop-back" fish at the spawning area.

Prior to killing, all females are tested for degree of ripeness. Those that are found to be green are returned to the alleyway. Males are killed as needed for spawning or thinning. Sufficient males are always available.

In 1969, the first fall chinook entered the holding area on September 8. Spawning operations began on September 22 and continued daily until October 10. During 1970, fall chinook were sorted into the holding pond beginning September 6. Spawning began September 21 and continued daily, terminating on October 6.

Table 1 shows the water temperatures, total numbers of fish held, and total percent mortalities for 1969 and 1970. Percent mortality is computed using total accumulated fish placed in the pond and the total mortality that occurred during the holding period. High male mortalities, which occur late in the spawning season, are found to be scarred up, "linebacker" bucks that are unable to maintain themselves in the current of the alleyway. They eventually drift down against the stop grill.

Disposition of females for each year is shown in Table 2. In 1969, 86.3 percent of the females that dropped back were ripe. The sorting method was not as effective in 1970 and can be attributed to an attempt to clean the rearing ponds during the sorting period. The effluent disrupted the normal fish pattern in the holding pond. Even so, in 1970, of the 1,845 females that sorted themselves down to the spawning area, 1,514 or 82.0 percent were ripe. During the entire spawning season only 319 green females or 17.3 percent were turned back to be handled again. In both 1969 and 1970, sorting and spawning operations were terminated when egg quotas were reached. The percent of residual females to total females held is a reflection of the arbitrary termination dates of the system and would be lower if the system had continued.

The lack of handling which is inherent in this system reduces the man-hours spent in obtaining fall chinook eggs. A maximum comparison of this method would be one where all females held are sorted daily. Under such circumstances, the equivalent of the 1,845 females handled in 1970 would have been 12,529 females; 12,529 being the sum of the daily numbers of females held in the pond during the sorting period. If the males that were held are also used in the comparison, the total number of fish handled in the holding pond at Bonneville during 1970 would have run 19,676 rather than the actual 2,967 fish handled. As stated, this is a maximum comparison. However, many stations have operated under such a daily, total, hand-sorted system.

The lack of handling also contributes to the good condition of the adults at the time of spawning. No fungus problems have been experienced, therefore malachite green treatments have not been initiated.

Perhaps to fish culturists, the quality of the eggs taken from females obtained through "drop-back" sorting is the most important criterion of the method. Resulting egg mortalities through the eyed stage of 2.6 percent in 1969 and 2.9 percent in 1970 are considered minimal.

TABLE 1. Water temperature, stocking rate, and percent mortality during holding of fall chinook at Bonneville Hatchery, 1969 and 1970.

Year	Temperature in °F.		Total Number Fish Held			Percent Mortality		
	Range	Average	Males	Females	Total	Males	Females	Total
1969	45-53	49.4	1,251	2,425	3,676	7.5	0.6	2.9
1970	44-52	46.8	736	1,679	2,415	4.8	0.9	2.1

TABLE 2. Female disposition, fall chinook "drop-back" sorting method, Bonneville Hatchery, 1969 and 1970.

Year	"Drop-back" Females			Residual Females /1			
				Percent of Females Held	Composition of Residuals		
	Ripe (%)	Green (%)	Other /2 (%)	(%)	Ripe (%)	Green (%)	Other /2 (%)
1969	86.3	12.5	1.2	2.7	68.1	28.9	3.0
1970	82.0	17.3	0.7	8.2	63.8	33.3	2.9

/1 Caused by termination of sorting and spawning operations.

/2 Includes females found spawned out or containing "bad" or over-ripe eggs.

VARIANCES IN SURVIVAL OF SALMON EGGS AS EXPERIENCED BY VARIOUS FIELD PERSONNEL WHEN USING DELAYED FERTILIZATION TECHNIQUES

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Washington Department of Fisheries
Olympia, Washington

Various reports concerning delayed fertilization techniques on salmon eggs have been presented during the past several years. In the 1961 Northwest Fish Culture Conference, Noble, Fallert, and Damron reported on the delayed fertilization procedures wherein the carcasses of the salmon were used for storing both the eggs and the sperm. In general, they reported achieving 90 percent fertilization where the sperm had not been stored in the dead male more than two hours.

Poon and Johnson (Progressive Fish Culturist, April 1970) described procedures for hauling eggs and sperm in separate containers and they achieved 90 percent fertilization after 18-20 hours of storage where both sperm and eggs were chilled to 43° F.

During the past two years the Washington Department of Fisheries has transported many millions of eggs utilizing the delayed fertilization technique, but the results have not been marked with a great degree of consistency.

Several of the cases, including methods and results, are detailed here. The mortality reported in each case was measured following the shocking of well-eyed eggs.

CASE I

Fall chinook eggs transported from Hood Canal to Skokomish Hatchery (1970 brood) - Two lots

LOT I (Stored eggs and sperm)

A total of 250,000 eggs were spawned dry and stored in 5 gallon cans, which were held partially submerged in running water to control egg temperature. Sperm was collected separately and stored in plastic bags leaving approximately two-thirds air space. All plastic bags were then placed on crushed ice in a styrofoam chest.

Elapsed time from egg-take to egg fertilization approximated one hour. Elapsed time from sperm take until fertilization approximated one-half hour. To achieve fertilization, sperm was mixed with water and then immediately with the eggs.

Mortality through shocking was 17.5 percent.

LOT II (Normal spawning procedures - delayed washing)

Using normal dry spawning egg-taking procedures, 1 million eggs were spawned and mixed with sperm immediately. The mix was placed in 5-gallon cans and cooled in the manner previously mentioned and then transported to the Skokomish Hatchery where they were washed and put down for incubation. The elapsed time of this operation was approximately one hour.

This procedure resulted in 2 percent loss.

For both Lots I and II of Case I, egg-taking and transportation was conducted where air temperatures approximated 70° F. and water temperatures varied from 47° F. to 50° F.

CASE II

Fall chinook eggs from Hood Canal to Soleduck (1970 brood) - Two lots

LOT I (Stored eggs and sperm)

This case involved 2 million eggs which were transported from Hood Canal Hatchery to Soleduck Hatchery near Forks, Washington.

In this haul, large plastic garbage cans were utilized as the hauling containers. A layer of crushed ice was placed in the bottom of the can, and a damp burlap sack was placed over the layer of crushed ice. The eggs were then dry spawned and placed in plastic bags with approximately 20 pounds of eggs per bag. Four such 20-pound lots were then placed in the cans and covered with damp burlap which was covered with crushed ice.

The milt was transported in plastic bags (with two-thirds air space) which were stored for transfer on burlap covered crushed ice in a styrofoam box. Upon arrival at Soleduck Hatchery, sperm was added with water and eggs fertilized in the usual procedures. Elapsed time from egg-taking to fertilization and washing was five hours.

This procedure resulted in a 45 percent loss.

LOT II (Stored eggs and sperm)

A total of 250,000 eggs from Issaquah fall chinook females was transported to Soleduck and fertilized with sperm obtained from Cook Creek (tributary to Quinault River) fall chinook. This procedure was followed to effect a cross fertilization from different stocks of fish from widely separated watersheds.

Five lots of eggs of approximately 50,000 each were dry spawned and placed in plastic bags inside five 20-gallon garbage cans. A lid was fit over each 20-gallon garbage can and each unit was then placed inside a 30-gallon garbage can, the bottom of which had been covered with crushed ice. Crushed ice was then placed in the circumference space between the side of the 20-gallon and the 30-gallon garbage can. This ice was replaced as needed during the haul. Hauling time for this lot was seven hours. Temperature of eggs on arrival was 42° F.

Sperm from Cook Creek males was transported in a large plastic container which was nestled in crushed ice within a styrofoam box. Storage time for the sperm approximated 2 hours. Temperature of sperm at arrival at Soleduck was 38° F.

Following transportation the eggs and sperm were tempered to 44-45° F., at which time water was added to the sperm and fertilization was completed.

Mortality through shocking for this lot was 8.5 percent.

CASE III

<u>Deschutes fall chinook transported to Willapa Hatchery (1969 brood) - Three lots</u>

This case involved three lots of one-half million eggs each of 1969 fall chinook salmon hauled from the Deschutes ponds at Olympia to Willapa Hatchery. Variations of procedures in this case dealt only with ovarian fluid. The eggs were hauled in styrofoam boxes covered with damp burlap. No ice was used, as air temperatures approximated water temperatures from which spawning females were obtained.

All lots were fertilized with freshly taken sperm from Willapa males at time of arrival at the hatchery. The fertilized eggs were then washed and placed in trays in the usual manner. Practically no change in temperature took place in the eggs during the four hours of transportation.

<u>LOT I (Stored eggs - ovarian fluid removed)</u>

All ovarian fluid was removed from the eggs before storing for transportation.

This procedure resulted in a 13 percent non-fertilization loss.

LOT II (Stored eggs - ovarian fluid removed, re-added at spawning time)

The ovarian fluid was drained and saved in a separate container. On arrival at the hatchery, the ovarian fluid was re-added to the eggs. Milt was added and the eggs were immediately washed and put down in trays in the usual manner.

This procedure resulted in an 8 percent nonfertilization loss.

LOT III (Stored eggs hauled in ovarian fluid)

The eggs in this group were hauled within the ovarian fluid. Upon arrival at Willapa all eggs were fertilized with fresh sperm from Willapa males, washed, and put down in trays in the usual manner. This procedure resulted in a 3 percent nonfertilization loss.

CASE IV

Fall chinook eggs transferred from Hood Canal to Willapa (1970 brood-Two lots

LOT I (Stored eggs - hauled on ice)

This lot consisted of 1 million fall chinook eggs which were stored and transported in 100-pound lots in a plastic bag within garbage cans cooled with ice, such as was described under Case II, Lot I. Each can held one plastic bag containing 100 pounds of eggs.

Hauling time was 3½-4 hours. Temperature of eggs on arrival was 48° F. On arrival at Willapa the eggs were combined with fresh sperm and handled in the routine manner.

This procedure resulted in a 22 percent loss through shocking.

LOT II (Stored eggs - hauled without ice)

This lot consisted of 600,000 chinook eggs taken at Hood Canal, placed in plastic bags inside a styrofoam box. No ice was utilized. Hauling time was 3½-4 hours. On arrival egg temperature was 50° F.

Fresh sperm from Willapa males was added and normal procedures were followed.

This procedure resulted in a 19 percent loss through shocking.

CASE V

Big Creek fall chinook eggs transported to Klickitat and Washougal (1970 brood) - Two lots

LOT I (Stored eggs and sperm) - Klickitat

A total of 600,000 eggs was dry spawned, placed in plastic bags and folded in a damp burlap bag placed within a wire hatching basket. The baskets were then set on crushed ice and crushed ice was heaped over the burlap sacks converning the plastic-bagged eggs.

The milt taken at Big Creek was placed in 1-quart freezer cartons which had been nestled in crushed ice within a styrofoam box. The cartons were three-fourths filled and were sealed. Transportation time for this lot was eight hours. Air temperature during this haul varied from 74° F. to 92° F. Arrival temperatures of the milt and eggs were respectively, 42° F. and 45° F.

Both eggs and milt, while remaining within their separate containers, were placed in hatchery water for tempering. After tempering, water was added to the milt, (1 part water to 4 parts milt), then added to the eggs. Normal hatchery procedures were then followed for placing in hatchery trays.

The loss on this lot through shocking stage amounted to 19.6 percent. Considering the fact that the average loss of chinook eggs at the Big Creek Hatchery through the shocking stage amounts to approximately 20 percent; it can be judged that the above procedure produced a fertilization rate free from any effects from storing and hauling.

LOT II (Stored eggs and sperm) - Washougal

Two million eggs were hauled in the same manner as those of the above lot. The sperm, however, was handled somewhat differently, as described above in Lot I. The sperm in the Washougal haul was placed in two 1-gallon plastic jugs. One of the jugs was filled to within one inch of the top while the other jug was only half filled. These plastic jugs of sperm were nestled in crushed ice inside a styrofoam chest.

The air temperature during the hauling time approximated 90° F. and the hauling time approximated three hours. The time from take until eggs were fertilized was approximately eight hours.

On arrival, one-fourth cup of sperm was added to one-half cup of water and this was poured into a bag of approximately 40,000 eggs and throughly stirred.

A wire strainer was then used to dip the eggs from the bag into the hatching trays. Water was then turned on for washing, fertilizing, and hardening of the eggs.

This procedure resulted in loss of 51 percent through the eyeing and shocking stages. Comparing these results with the Klickitat haul (Lot I) it indicates a 31 percent greater loss than Klickitat's, even though procedures were almost identical except for the sperm handling. Whether or not this handling difference was the cause for the large loss difference is open to question.

CASE VI

Green River fall chinook to Prairie Creek California (1970 brood)

This case involved the transportation of 1½ million chinook eggs from Green River Hatchery near Auburn to the Prairie Creek Hatchery near Eureka, California. Transportation was via a pick-up truck with its bed modified for hauling. The truck bed was fitted out with styrofoam insulation, sides, bottom, and top. The eggs were placed in plastic bags which were in turn placed in wooden boxes. The wooden boxes were loaded, set on ice, then covered with a layer of crushed ice. The entire load was then covered with a sytrofoam-lined cover. Temperature of the eggs at time of take was 48° F.

The sperm for this lot was taken and placed in plastic bags. No attempt was made to leave air space above the sperm. The bags of sperm were placed in boxes the same as for the eggs described above.

The elapsed time for the taking and hauling of eggs and sperm was 30 hours.

Temperature of the eggs and sperm on arrival was 39° F.

To effect fertilization, the bags of eggs were poured into a plastic container and sperm and water were mixed 50-50 and poured over the eggs. This was mixed thoroughly with eggs which were then poured into hatchery trays surrounded by 46° F. water. Eggs and milt in these trays were then allowed to temper for approximately 20 minutes when water was then turned through the trays for completion of the washing and hardening of the eggs. It required approximately another 7 hours to fertilize, temper, and place all eggs in incubators. Total elapsed time from egg-take to placement in incubators was 37 hours.

This procedure resulted in a loss of 40 percent through shocking.

<u>Some added notes in relation to delayed fertilization procedures:</u>

In conjuction with the haul of 2 million eggs as described above from Green River to Prairie Creek Hatchery; several male chinook salmon were killed and the carcasses placed in the crushed ice in the truck and hauled in that fashion to the Prairie Creek Hatchery. On arrival (30 hours later) the sperm from these male carcasses was utilized to fertilize a sample lot of eggs that had been hauled. This procedure resulted in a 100 percent fertilization loss.

In 1969, 20,000 coho salmon eggs were transported from the University of Washington in a sytrofoam chest to the Prairie Creek Hatchery. Egg transportation time was 24 hours from spawning. On arrival these transported eggs were fertilized with fresh coho males taken at the Prairie Creek Hatchery. This procedure resulted in a fertilization loss of only 5 percent.

In summary, the cases presented here indicate that slight variations in procedure can produce wide ranges in the fertilization levels. Under some instances it is very difficult to determine just what differences in procedure caused the difference in the loss.

It is this writer's impression that there are critical procedure routines in the proper handling and storage of sperm and unless this is followed very carefully and very specifically then little consistent success can be anticipated. It is surmized that proper chilling of the sperm in relatively small lots, leaving air space above and collected without any invasion of foreign matter such as water or slime, is the most probable approach to consistent success.

Poor procedures with the eggs cannot of course be ignored as such a routine can affect survivals. Following the presentation of these data, J. W. Wood of the Washington Department of Fisheries determined that with coho eggs and sperm there was no significant difference in fertilization rate of eggs, whether or not slime was combined with the eggs at the time of fertilization, providing fresh eggs and sperm were used. However, when slime was added to the eggs and they were stored for four hours and then fertilized with fresh sperm, then nonfertilization losses amounted to

11.6 percent; this was in contrast to 3.7 percent loss when the slime was added to the eggs which were immediately fertilized with fresh sperm.

POND TRAYS FOR INCUBATING SALMON EGGS

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Olympia, Washington

Incubating and hatching of mass numbers of salmon eggs in large screen trays submerged in standard concrete rearing ponds has been successfully conducted.

Over a 5-year period and at seven hatcheries with varying water types, green and eyed eggs have been incubated in standard rearing ponds.

The mortality on the eggs is comparable with those eggs incubated in standard hatchery methods and the quality of the fry is comparable with the highest quality fry obtained using standard hatchery methods.

The procedure is adaptable to nearly all hatcheries without interference with the normal fish production. During the fall of 1970, 30,000,000 eggs were programmed by the Washington Department of Fisheries to be hatched with this method.

While many variations of tray types and water flows have been successfully tested, the most practical method is described in brevity as follows:

Window-frame like trays are constructed with fir or cedar lumber from 2-inch by 2-inch stock. Ten-mesh fiberglas screen cloth is used to face one side (bottom).

To incubate eggs in a 10-foot wide raceway, it is desirable to construct trays 3 feet wide by 4 feet 10 inches long (trays 3 feet wide by 9 feet 10 inches long can be used). A total of 40,000 eggs can be placed on each 3-foot by 5-foot tray for hatching. As the trays are placed in the ponds, the bottom tray should be elevated off the bottom by two inches. Each succeeding tray with eggs should be placed upon one another separated by a one-half inch spacer. The space between each tray allows the horizontal movement of water and allows the fry to escape once the yolk material is nearly absorbed.

Using 3-foot by 5-foot trays, two stacks can be placed across a 10-foot pond one tray upon another, until within two inches of the normal pond depth. For hatching, it is preferable to place the stacks near the upper end of the pond.

A 10-foot by 20-foot sheet of black plastic is placed over the two stacks and allowed to trail downstream on the surface of the water.

Four inches upstream from the two stacks of incubating trays, tongue and groove 2-inch by 6-inch cardecking should be placed vertically across the pond, one upon another, to a height of one board above normal pond water level. Each board should be drilled (perforated) with two horizontal rows of 3/8-inch holes spaced 4 inches apart.

This procedure disperses an even flow of water across each tray. With a 1- or 2-inch head differential on the upstream side, approximately 7 gallons of water per minute will pass through every square foot of drilled cardecking.

During the incubation period, malachite green should be used to control fungus. Siltation can be removed from the eggs as in normal hatchery practices. It can be to ones advantage, however, to utilize the rearing pond "upstream" from the eggs for a "settling basin."

Once the eggs are eyed, they can easily be removed, shocked, and replaced for hatching and final yolk absorption. During the yolk absorption period it is common to observe up to 5 percent of the fry escape "immediately" from the trays through the half-inch spacing.

When about 25 percent of the yolk material has been absorbed and the fry are free swimming, exodus from the trays begins and continues over a 10-day period.

The initial feeding by the fry is nearly "immediate."

Labor and materials for constructing trays to hatch 1,000,000 eggs will approximate $150. An additional $150 per 1,000,000 fry should be allowed for miscellaneous material and labor.

A more detailed report is being prepared by the Washington Department of Fisheries and will be available upon request.

OPTIMUM TEMPERATURE FOR INCUBATING STEELHEAD EGGS

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U.S. Bureau of Sport Fisheries and Wildlife

The water supply at Dworshak National Fish Hatchery can be maintained at any desired temperature by a system of heat exchangers connected to oil fired boilers and chillers. With temperature controls available, it became desirable to determine the optimum temperature for the normal development of steelhead eggs.

Six self-contained fiberglas tanks and a vertical incubator were used in the test. The tanks, equipped with refrigeration units and individual temperature controls, and the incubator, which served as a control, were supplied with normal hatchery incubation water. Water used for incubation flows through an electric grid, sand filter, and ultraviolet radiation to control fish pathogens. Two groups of steelhead eggs were obtained for the experiment during the hatchery spawning operation. Group one consisted of pooled eggs from three females and group two was made up of eggs from two females. The eggs in each group were fertilized with two males. The adult steelhead were examined and found to be negative for kidney disease, furunculosis, *Ceratomyxa* and infectious pancreatic necrosis. After fertilization the eggs were water hardened for one hour and then divided equally into seven lots for incubation. The seven lots included eggs for incubation in water temperatures of 38° F, 43° F, 48° F, 53° F, 58° F, and 63° F. in the tanks and in 48° F. water in the vertical incubator. All eggs were hand counted after development into the eyed stage.

Daily water temperatures and weekly ammonia and oxygen determinations were recorded throughout the trial. Ammonia levels in the self-contained tanks were maintained under 0.2 p.p.m. until hatching when the level increased to approximately 1.0 p.p.m. At the time of hatching, when the ammonia levels increased, part of the water was withdrawn from the tanks and replaced with fresh water to reduce the ammonia levels to below 0.2 p.p.m. The dissolved oxygen levels remained about 8.5 p.p.m. during the entire test. Disease examinations were conducted throughout the trial and no pathogens were found. Since the oxygen and ammonia levels were similar in all tanks and no disease organisms were present, the rate of survival was directly related to the only variable -- the temperature of the water.

Results:

The water temperature, number of eggs to start, number of eyed eggs, and number of eggs to hatch are listed for both groups in table one. The low survival (58 percent in control) in group one was probably due to poor eggs from one of the females rather than overall deficiencies in all three females. The survival in group two was 93.9 percent. The lower temperature threshold for normal development did occur at 38° F. although the percentage of eggs developing was lower at 38° F. than at 43° F. or 48° F. The upper temperature threshold was determined to be 55° F. as fry with coagulated yolk and abnormal morphology such as double heads, double bodies, and/or extra fins developed when incubated in 58° F. and 63° F. water. The percentage of freaks in 58° F. water was 0.59 and in 63° F. water 2.52. All of the fry developed coagulated yolk in the

63^{o} F. water while about 25 percent had coagulated yolk in the 58^{o} F. water. The highest survival of eyed eggs and fry occurred in the tank with 48^{o} F. water and it is concluded that the optimum temperature for incubating steelhead eggs at Dworshak National Fish Hatchery is 48^{o} F.

TABLE 1. Survival of Steelhead Eggs Incubated in Six Temperatures at Dworshak National Fish Hatchery

Water Temperature	Actual Average Temperature	Group	Number Eggs to Start	Eyed Eggs	Percent Eyed	Number Eggs Hatched	Percent Hatched
Tank - 38°	38.04	1	2,179	1,265	58.1	1,009	46.3
Tank - 43°	42.71	1	2,243	1,500	66.9	1,495	66.7
Tank - 48°	48.03	1	2,107	1,489	70.7	1,467	69.6
Tank - 53°	52.52	1	1,838	1,202	65.4	1,199	65.2
Tank - 58°	57.94	1	1,987	1,128	56.8	1,053	53.0
Tank - 63°	61.67	1	2,279	756	33.2	362	15.9
Incubator-48°	47.60	1	8,491	5,179	60.1	4,972	58.6
Tank - 38°	38.04	2	1,296	1,165	89.9	1,123	86.7
Tank - 43°	42.71	2	1,705	1,600	93.8	1,594	93.5
Tank - 48°	48.03	2	1,166	1,104	94.7	1,097	94.1
Tank - 53°	52.52	2	1,235	1,125	91.1	1,121	90.8
Tank - 58°	57.94	2	1,468	1,357	92.4	1,154	78.6
Tank - 63°	61.67	2	1,771	480	27.1	272	15.4
Incubator-48°	47.60	2	8,102	7,642	94.3	7,608	93.9

MALACHITE TREATMENT FOR HEATH INCUBATORS

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We found that the plexiglass dispenser was too time consuming and messy. I was sure that there could be something built that would work more efficiently for the Heath incubators. I came up with the present system that we use at North Nehalem hatchery and it has worked well for two years. The supply box is built with two tanks; the top and larger tank for mixing and a lower tank to hold a constant head pressure. The head pressure is controlled by a Ball cock valve. We have three rows of incubators. There is a shut-off valve on the bottom of the tank and a valve at the start of each row of incubators. This way we can shut off the whole system or just isolate any one of the three. There is a metal pinch shut-off clamp on each of the latex tubes to each incubator so we can shut off any one of them in the row. We used one-half inch black plastic pipe to carry the Malachite with a stab joint T above each incubator. You have to cut the two ends off the T that stays in the main line. To the lower part of the T, we put a piece of 3/16-inch latex tubing 7-1/4 inches long and then inserted a piece of 1-millimeter glass capillary tubing 2 inches long. The size and length of the glass capillary tubing will determine the cubic centimeter flow. Our tank will hold 20 gallons in the mixing tank and 2.5 gallons in the lower tank. It takes 119.4 grams of Malachite in 20 gallons of water to give us 1:400,000 treatment at 30 cc. per minute. Ours is set up for a one-hour treatment. It will take one man about 15 minutes to weigh out the Malachite and mix it into the tank and get the system started.

The approximate cost for materials only was about $54.

In summary, this procedure was tested over a two-year period and was found to be an efficient and effective method for treatment that conserved time, money, and manpower. The procedure is adaptable for use with hatching troughs with minor technical adjustments. Since time and proper utilization of personnel are always considerations, let's examine the treatment procedure from that point of view. It used to take one man five hours a day to complete one treatment. Depending on species and water conditions, the number of treatments a week would vary from hatchery to hatchery; some treating as much as three times a week. Taking that figure, 3 five-hour man days equal 15 man hours a week for perhaps seven weeks or a total of 105 man hours devoted to Malachite treatment. Couple this with several hatcheries treating on an extensive schedule, and the man hours rise even higher. The new system I have suggested for the same treatment schedule would compare as follows: Total treatment time, 1 hour. Three treatments a week, 3 hours actual work. A seven-week schedule would bring the total to 21 hours of man time, as opposed to the present method that requires 105 man hours. In brief, this method utilizes one-fifth the normal time now devoted to Malachite operations during incubation.

This system of treatment then is based on technical simplicity and conservation of hatchery personnel time. I suggest it as an effective method of Malachite treatment for Heath incubators.

A HEATED WATER SUPPLY

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The Wells Game Fish Hatchery is located at the Wells Dam site on the Columbia River between Chelan and Pateros, Washington. The hatchery was constructed by the Douglas County P.U.D. and is operated by the Washington Department of Game to provide steelhead and rainbow to replace losses sustained by construction of the dam. An adjacent facility and spawning channel is operated by Washington Department of Fisheries.

The well water supply for the hatchery is 46° F. average, although in summer the temperature does rise to a more favorable 50° F.

The summer steelhead adults for the program are trapped in September and October and ripen in January, February, and March. Because of the demand to rear migrant steelhead in one year, with the low water temperatures it was apparent that some method of heating the water for incubation and fry would be beneficial, if not essential.

Since Wizard Falls trout hatchery, operated by the Oregon Game Commission, had installed a heating system which worked to their satisfaction, I was able to obtain all pertinent information regarding necessary equipment.

We obtained a heating unit, a 45,000 Watt 480 Volt 3 Phase hot water booster and the necessary electrical equipment, which was installed in time for the second season. A 3-Phase line was connected to the trough room electrical panel to the booster located in the incubation room. The hatchery crew was able to do most of the installation, including piping, alarm system and electrical work.

We did make some changes. We found the black flexible plastic pipe, which was recommended to withstand 100° F., would split at the joints after several months use. Replacement was done with rigid PVC 3/4-inch plastic with cemented joints. The original installation utilized hose bibs to disperse the hot water at each point; these we replaced with a plastic valve, since the hose bib would not remain in the same position to insure a constant flow. We heated only a small percent of the water for the incubator, or trough, and increased the temperature to, but not to exceed 100° F.

Each incubator stack and trough has a separate hot water supply with valve plumbed in (plastic 3/4-inch PVC). The water is added or mixed at the head of the trough, or top of the incubator, and the necessary amount of heated water is added to reach the desired temperature. This method of heating water decreases the cost of installation of piping and heating equipment.

An inexpensive central alarm system was installed. Three alarm jack outlets, one for main water supply float, one for thermo switch adjusted to close at 58° F., and the third jack outlet for a spare. Upon activation of any one alarm jack, the hot water booster is shut off, an adjacent trough room warning light is turned on, and the master alarm system is activated. We have found this alarm system to be foolproof.

We have found the heating system to be very effective and beneficial, and, because of this, added a second booster of 54 KW units, providing a total of 99 KW of heating equipment. The 99 KW will raise the temperature of 32 gallons per minute 5° F., or 16 gallons 10° F. Although this water volume doesn't seem to be a large quantity, it is very helpful. With a simple reuse system and fresh-water addition, one can have a total of 320 gallons per minute with a 5° F. temperature increase. We have found that by carefully using the heated water we make a marked improvement in a 40-trough hatchery without adapting to a reuse system using a 10 percent fresh-water addition.

In assessing the costs of installing the system, the first black plastic pipe and plastic valves were not included.

First 45 KW Booster (heater) approximately	$	450.00
Second 54 KW Booster		550.00
PVC plastic pipe cement, fittings, etc.		50.00
Plastic valves for dispersing heating water to incubator or troughs	$	30.00
Cost of complete alarm control system including water supply float and temperature thermo switch	$	50.00
TOTAL	$	1,130.00

I have not included labor since we at the station did all the work. Although we do not have a direct electricity cost assessment, the average hot water heating rate would range from $17.90 to $23.80 per 24-hour day. An average cost of $20.85 per 99 KW, or 32 gallons per minute raised 5° F. for one month (30 x $20.85) would amount to $265.50.

We found this water heating system to be very effective without being excessive in cost.

TERRITORIAL AND FEEDING BEHAVIOR OF STEELHEAD AND COHO WITHIN A STREAM'S MICROHABITATS

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Coho salmon occupy more diverse ecological habitats than steelhead trout in Worthy Creek, a Western Washington coastal stream. The macro-habitats of coho ranged from deep runs behind beaver dams to the margins of shallow riffles. The steelhead were associated primarily with areas of higher stream velocities and coarse gravel substrate.

Coho and steelhead select different microhabitats within macro-habitats during periods of low flow depending upon the physical character-istics of the macrohabitats (depth, gradient, and bottom composition). The microhabitats of steelhead varied little in vertical distribution and the species were observed to be always associated with the stream substrate. The horizontal distribution of these trout varied from area to area and appeared to be dependent on bottom contour and stream velocity. In one macrohabitat the steelhead distributed themselves across the flat stream channel in the riffles. In an adjacent macrohabitat the trout remained in pools, apparently because they could not hold position in the short, turbulent riffles between these pools. The microhabitats of coho were more closely associated with the stream surface than steelhead, but the depth of coho distribution varied with stream velocity. They were positioned near the surface in areas of low velocity and midway between surface and substrate in areas of higher velocity. During the high flows of winter, both coho and steelhead occupied the stream margins near the substrate.

A statistical analysis of variance of the diets of coho in four distinctly different macrohabitats indicated that the diets were not significantly different from area to area. The same analysis applied to the diets of steelhead within two of these macrohabitats indicated no significant difference exists in the diets of steelhead in different macrohabitats within Worthy Creek.

A comparison of the coho and steelhead diets in two macrohabitats which they jointly occupied indicated that coho fed more on surface foods (terrestrial and aerial aquatic adults) and steelhead fed more on foods associated with the substrate (immature aquatic invertebrates). A similar ration of surface to subsurface diet existed for coho in macrohabitats they occupied alone, indicating that coho food selection was not significantly influenced by the presence of steelhead.

OCEAN CATCH DISTRIBUTION OF FALL CHINOOK AND COHO SALMON PRODUCED IN COLUMBIA RIVER HATCHERIES

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Of the total catch of fall chinook salmon of Columbia River hatchery origin, including ocean and freshwater, about 75 percent are taken in the ocean fishery.

The main purpose of this talk is to discuss the ocean catch distribution of fall chinook and coho salmon from Columbia River hatcheries included in the evaluation study being conducted by the Columbia Fisheries Program Office. Some of the hatcheries are operated by the Federal government and some by the States of Washington and Oregon.

Hatcheries producing salmon have been in operation on the Columbia River for many years. The magnitude of their contribution to the various fisheries and the distribution of the fish from these hatcheries had been somewhat of a mystery until the middle 1960's. The present study has provided some answers to these questions.

The hatchery evaluation study was implemented by fishery agencies of Alaska, British Columbia, Washington, Oregon, California, U.S. Bureau of Sport Fisheries and Wildlife, and U.S. Bureau of Commercial Fisheries (now National Marine Fisheries Service, NOAA). The task of evaluation was assigned to the Columbia Fisheries Program Office, and limited to fall chinook and coho salmon.

I will talk first about fall chinook.

FALL CHINOOK

Marking

A marking experiment was begun at 12 study hatcheries on the Columbia River in 1962 to estimate the contribution of hatchery-reared fall chinook salmon to commercial and sport fisheries of the Pacific Coast. Beginning with the 1961 brood (which was marked and released in 1962), the marking continued through four consecutive years, ending in 1965 with the 1964 brood. Over the 4-year period about 10 percent (over 21 million) of the hatchery production of over 200 million fish was marked by fin-clipping with an adipose-maxillary mark. The success of the marking experiment required the efforts of many people and the cooperation of the fishery agencies on the Pacific Coast.

Sampling

The seven years of sampling for marks in the various fisheries started in 1963 and ended in 1969. The experiment was designed to include sampling in the major ocean fisheries including southeast Alaska to and including southern California. Sampling for marks consisted of recording numbers of fish examined and the numbers recovered with each type mark.

During the first year (1963), when 2-year-old fish entered the fishery, sampling in the ocean fishery was limited to Washington and Oregon. Beginning in 1964, sampling was expanded to include most chinook salmon fisheries from southeast Alaska to southern California.

During the seven years of mark sampling about 20 percent of the chinook salmon catch was examined for marked fish. Although marked fish were recovered in the ocean over the entire range of sampling, most were recovered north of the Columbia River.

Catch

Based on the number of marks recovered in the catch, and adjusting for fin-clip mortality, an estimated 1,050,000 fish from Columbia River study hatcheries were taken in the ocean fishery during the seven years.

In looking at the total mark recoveries, our data show the following distribution, in percent, of fall chinook of Columbia River hatchery origin taken in the ocean fishery:

Southeast Alaska	0.5%
British Columbia	42.0%
Washington	50.5%
Oregon	6.0%
California	1.0%

A point of interest which our data have shown is that fall chinook from Kalama hatchery have consistently ranged farther north than fish from any other hatchery in the study. Mark recoveries also indicate that fall chinook from Kalama hatchery mature later than the main body of hatchery fish.

Over the period of sampling, fish from the 12 study hatcheries contributed an average of about 12 percent to the total chinook fisheries sampled. This ranged from a low of 6 percent for the 1962 brood to a high of 20 percent for the 1963 brood. The catch contribution to the ocean fishery alone averaged 10 percent for the four broods. This is quite revealing when we take into consideration the fact that there are other areas of contribution, such as the Sacramento River, Puget Sound, British Columbia streams, and southeast Alaska mainland streams.

Value

In looking at the final analysis of hatchery contribution we have estimated the benefit-to-cost ratio for three of the four brood years from the 12 study hatcheries. The 1961 brood showed $2.30 return for each $1.00 spent; 1962 brood showed $1.30 to $1.00, and the 1963 brood showed the highest at $4.20 return for each $1.00 spent.

COHO

Now we will look briefly at the distribution and contribution to the ocean fishery of coho salmon from Columbia River study hatcheries.

Marking

The marking of coho started in 1966 with the 1965 brood at 20 hatcheries on the Columbia River. The program continued with the marking of the 1966 brood in 1967. About 4 million fish were marked with an adipose and/or adipose maxillary mark. This represented about 10 percent of the total release of over 39 million yearlings reared at lower Columbia River hatcheries.

Sampling

The three years of sampling for marked fish started in 1967 and ended in 1969. Sampling was tied in with the fall chinook study and, therefore, included the major ocean fisheries from and including British Columbia to and including southern California.

Catch

During the first year of sampling, in 1967, no 2-year-old fish were taken in the ocean fishery. The 1965-brood coho entered the ocean fishery in 1968 as 3-year-old fish.

Preliminary analysis, based on estimated number of fish in the catch for 1965 brood only, indicates the ocean catch distribution looks something like this, in percent:

British Columbia	5%
Washington	37%
Oregon	37%
California	21%
	100%

Data indicate that over 11 percent of the ocean catch of coho in the fisheries sampled was fish from the Columbia River study hatcheries.

SPRING CHINOOK

As I mentioned near the beginning, this talk has been limited to a discussion on fall chinook and coho. Looking at other species such as spring chinook and steelhead, we would like to find answers to some of the same questions. Where do they go in the ocean? What is the contribution to the fishery of these species?

The Columbia Fisheries Program Office hopes to embark on studies soon, especially on spring chinook, similar to the study on fall chinook and coho.

SOME COMPARISONS OF NATURAL AND ARTIFICIALLY REARED JUVENILE SPRING CHINOOK SALMON

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and
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The Fish Commission of Oregon has a research program in progress, the objective of which is to establish criteria or standards that may be applied to the production of high quality salmon and steelhead with increased potential for survival from juvenile to adult. We are looking for desirable criteria on which to base working hypotheses for testing with hatchery fish.

Researchers working on population dynamics have observed that hatchery chinook have eight times higher egg-to-outmigrant survival than wild stocks -- hatchery 80 percent (Hublou 1970) vs. wild 10 percent (Burck 1970). However, the wild juvenile-to-adult salmon returns are usually in the magnitude of ten times the hatchery returns. Bjornn (1969) reports a wild juvenile-to-adult spring chinook salmon return of 1.2 percent on the Lemhi River in Idaho. Burck (1970) observed a juvenile-to-adult spring chinook return of about 0.9 to 1.3 percent on the wild fish from Lookingglass Creek. Hatchery juvenile-to-adult returns of spring chinook are usually in the magnitude of 0.1 to 0.3 percent (Swartz 1970).

Investigators conducting studies on salmon and trout quality have observed that by and large, wild salmon fry are superior to hatchery fry in stamina, color, and avoidance of predators. Bams (1966) discovered that wild sockeye salmon fry had higher stamina and lower incidence of predation than hatchery fry. Senn (1966) noted that gravel-hatched coho fry in a natural environment had a 52 percent survival compared to 31 percent survival of incubator-hatched fry for a time period of 85 and 99 days respectively. Peterson, et. al., (1966) working on rainbow trout, reveals that hatchery-reared trout do not have natural coloration and are always drab in color. Mead and Woodall (1968) noted that hatchery-produced sockeye fry weighed less at time of emergence than spawning channel or natural fry of the same race, and that hatchery fry were less photonegative than natural fry.

Since wild fish are a self-sustained product of natural selection and may well be of superior quality to hatchery fish, we decided to begin an investigation on a natural run of spring chinook salmon in Lookingglass Creek, a tributary of the Grande Ronde River in Northeastern Oregon. The operation was coordinated with Art Oakley and Wayne Burck of the Oregon Fish Commission's Columbia River Investigation-Ecology Study.

As our proposed investigation of wild fish quality was a "look-and-see" type operation; time, manpower, and existing work load demands and conflicts prevented having a simultaneous hatchery control environment. However, the previous year we had conducted an experiment on the 1968-brood spring chinook salmon at the Fish Commission's Marion Forks Hatchery in the Cascade Mountains on Oregon Highway 22, and possessed limited but comparable data on most of the qualities we intended to investigate in the wild fish. Information from ponds of spring chinook receiving the current formulated Oregon Pellet in the routine hatchery manner was used for hatchery fish data. Hatchery and wild juvenile spring chinook were examined at four-week intervals for:

1. Size (length and weight)
2. Hematology (hematocrit and hemoglobin)
3. Liver histology

4. Energy stores
    a. Total body lipid
    b. Body lipid fatty acid composition
    c. Liver glycogen
5. Swimming ability (stamina)
6. Subjective observations
    a. Visceral appearance
    b. Coloration
    c. General shape and configuration

Our observations thus far are listed in Table 1 and Figure 1. Some of the recorded measurements have no direct comparison at this time, but continuation of the study is anticipated to complete the data. Table 1 depicts the physical and chemical measurements while Figure 1 illustrates the general timing of downstream wild juvenile spring chinook outmigrants (Burck 1970) and their relative energy stores.

Our observations to date are:

1. The outmigration time of the wild chinook varies with climatic and stream conditions (Burck 1970), whereas the hatchery releases of spring chinook are intoto and traditionally in late winter or early spring.

2. Hatchery fish for the same ages sampled are larger than wild fish.

3. Hematocrit and hemoglobin values were comparable in fish from both environments (hematocrit, 35 to 39 percent and hemoglobin, 14 to 15 percent).

4. Liver histology with light microscopy in process indicates generally that wild fish have a more solid intercellular structure during the summer and exhibit a more vaculated appearance by fall. Hatchery fish livers revealed no difference as to time of year but had varying degrees of cell vacuolation.

5. Body lipid was lower in the wild fish during summer but achieved a higher, more comparable level by fall.

6. Gas chromatography of the body lipid fatty acid content is still in process.

7. No direct comparisons are available for liver glycogen, but analysis of livers from other hatchery fish revealed glycogen percentages from 0.5 to 2.0 during the rearing cycle or at liberation time. The highest fish liver glycogen levels we have observed to date (5 to 12 percent) were in laboratory experiments with chinook-fed diets high in carbohydrate.

8. Only one stamina index of hatchery control fish is available for lateral comparison, but information from stamina tests at other hatcheries indicate that wild fish for the same size, perform much better and have a higher degree of rhetactic response than hatchery fish.

9. There were no gross differences in internal organ structure or appearance except that the wild fish had little or no visceral fat throughout the summer and fall while the hatchery fish had light to moderate fat during the same period.

10. The wild fish were brighter colored and seemed better able to adapt to backgrounds of varying shades of light and dark quicker and more completely than the hatchery fish.

11. The wild chinook were very streamlined and not rotund in the anterior belly region like the hatchery fish. The wild fish had fins proportionately larger and of different shape than the hatchery stocks with no frayed margins as was sometimes observed in hatchery broods.

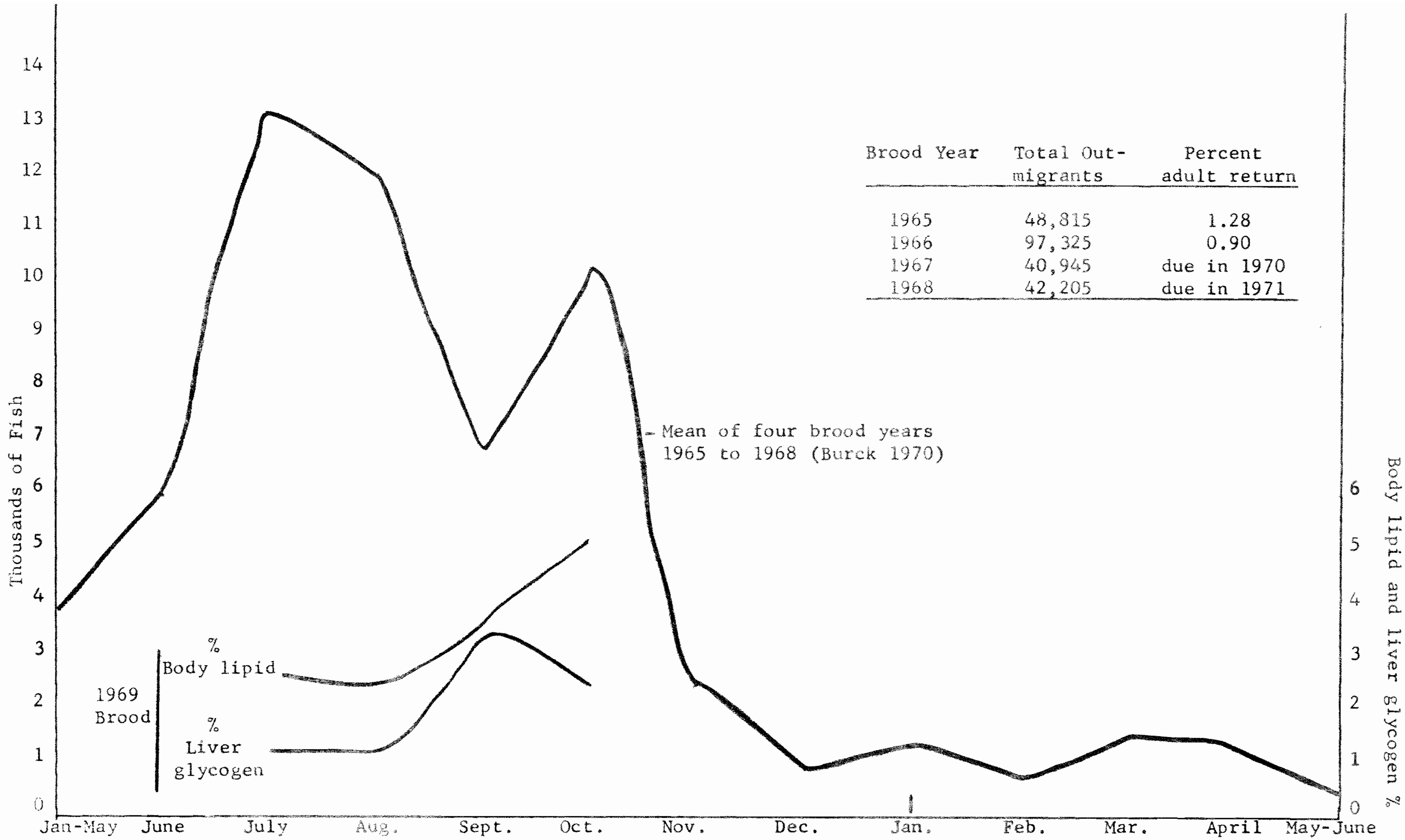
This is not a definitive report but only a "thumbnail sketch" of some differences and similarities we have observed to date in a population of wild spring chinook and their hatchery counterparts.

Table 1 Comparison of Physical and Chemical Characteristics of Artificially vs. Naturally Reared Juvenile Spring Chinook Salmon /1

	Avg. Fish Wt. (gms)		Avg. Fish Length (mm)		Avg. Fish Wt. Gain (%)		Stamina Index		Body Lipid (%)		Liver Glycogen (%)	
Sample Date	Hatch	Wild	Hatch	Wild	Hatch	Wild	Hatch	Wild	Hatch	Wild	Hatch	Wild
July	3.60	2.48	66.5	59.8	---	---	---	55.3	3.83	2.56	---	1.55
August	6.58	3.54	82.4	69.2	82.6	42.8	---	69.0	5.35	2.34	---	1.12
September	10.32	5.15	95.0	78.1	56.8	32.8	---	77.0	7.03	3.54	---	3.31
October	13.76	6.35	101.9	82.3	33.4	23.3	66.0	73.0 /2	7.35	5.10	---	2.33

/1 Marion Forks 1968-brood spring chinook; Lookingglass Creek 1969-brood spring chinook.

/2 Only one stamina run of only 80 fish instead of the usual mean of three runs of 105 fish each.



Brood Year	Total Out-migrants	Percent adult return
1965	48,815	1.28
1966	97,325	0.90
1967	40,945	due in 1970
1968	42,205	due in 1971

Figure 1 Numbers of fish and percent body lipid and liver glycogen of Lookingglss Creek juvenile spring chinook downstream outmigrants.

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EFFECTS OF TEMPERATURE DURING A SIMULATED MIGRATION OF ADULT SOCKEYE SALMON (Oncorhynchus nerka)

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ABSTRACT

This experiment was designed to estimate the water temperature requirements of adult sockeye salmon (Oncorhynchus nerka) during their freshwater spawning migration. Selected migration temperatures were: 10° C (50° F); 16.5° C (62° F); 20° C (68° F); 22° C (72° F). Tests were conducted out-of-doors in large tanks at Bonneville Dam. Water current was supplied by recycling a portion of the water and fresh water was added at 38 liters per minute. Adult sockeye salmon were introduced into tanks and gradually brought to the desired temperatures. Water chemistry analyses indicated that water quality in the tanks generally equalled or exceeded Columbia River water quality. Total mortality occurred within 7 days at 72° F and within four weeks at 68° F. Average survival times at these temperatures were 3.2 and 11.7 days respectively.

Physiological parameters indicated significant differences between sockeye held at various temperatures. Body wet weight loss per 100 degree (C) days was 1.7, 2.2, 2.6, and 3.0 percent at 60, 62, 68, and 72° F respectively. Data on survivors at 62 and 50° F showed that greater weight loss resulted in smaller eggs. Average weight of male gonads was less in 62° F fish than in 50° F fish. Livers in fish at 62° F were larger and had more connective tissue than 50° F fish. Visceral fat was more depleted in 62° F fish. Columnaris invasion (as indicated by antibody development) had occurred in 91 percent at 62° F while at 50° F only 8

percent had antibodies against columnaris.

The water temperature requirements of adult sockeye salmon on their spawning migration are more restrictive than for juveniles, but less restrictive than for embryos. Both egg and sperm development, as based on gonad weight, were diminished at 62° F as compared to 50° F. Additionally, various other physiological data indicate that the adult were in better physiological condition when maintained at 50° F, as compared to 62° F. As temperatures rise above 62° F, fish diseases can become a clear and present danger, at least in the lower Columbia River. Finally, adult sockeye that are exposed to temperatures of 72° F for more than a few days will probably die from heat death.

PEN REARING OF DR. DONALDSON'S RAINBOW-STEELHEAD CROSSES AT BIG BEEF CREEK

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Last year (1969), some 20,000 of Dr. Donaldson's crosses (1968-69 brood) were reared in a brackish water pond in conjunction with Abbott's research on underwater acoustics. These fish were then released into the estuary of Big Beef Creek. A number have been caught by fishermen, and some precocious males returned in the fall and winter of 1969-70, and we expect a considerable number this winter. A weir has been constructed so that an accurate count can be obtained.

At the present time, Dr. Donaldson's fish are being used to determine if there is a difference in the growth rate of a common genetic strain of trout when raised in similar rearing pens in saline waters under different loading densities.

On August 14 and 17, 1970, 3,988 hybrid trout were transported to Big Beef Creek and placed in two holding pens in a brackish water pond. On the 25th of October, 1970, these fish were then divided into four pens, each having a 1,920 cubic foot capacity. The fish will be reared in these pens until the average fish from each pen is one-half pound in weight. At that time, the pens will contain the following pounds per cubic foot:

Pen No. 1 - .75	Pen No. 3 - .38
Pen No. 2 - .14	Pen No. 4 - .50

The fish have been fed three times per day at 1.5 to 3.0 percent of their body weight, depending upon water temperature.

Results

Placed in Pen No. 1 was 1,444 fish; in Pen No. 2, 364 fish; in Pen No. 3, 730 fish; and Pen No. 4, 960 fish.

Table 1

Biomass Changes and Food Conversion Rates in the Four Experimental Pens

Pen Number	Original Biomass	Biomass After 36 Days	Total Food Fed	Conversion in Pounds Fed to Pounds Gained
1	104,904 g.	139,979 g.	62,730 g.	1.8 to 1
2	26,517	35,596	15,480	2.3 to 1
3	53,180	70,039	23,460	2.9 to 1
4	69,936	93,799	31,310	3.0 to 1

Table 1 indicates that 55 percent of the food that goes into Pen No. 1 is turned into fish biomass, 43 percent in Pen No. 2, 34 percent in Pen No. 3, and 33 percent in Pen No. 4. After 36 days, the average weight of the fish in Pen No. 1 was 97 g.; Pen No. 2, 98 g.; Pen No. 3, 96 g.; and Pen No. 4, 97 g.

REARING OF CHINOOK SALMON AT MANCHESTER
(National Marine Fisheries Service Facilities)

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University of Washington
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On July 17, 1970, 4,147 chinook salmon fingerlings were transferred from the Washington State Department of Fisheries' hatchery at Hoodsport, Washington to saltwater rearing pens at the National Marine Fisheries Service installations at Manchester, Washington. Here, one-half of the number were trained to respond to a feeding signal and the other half were retained as a control. The initial weight was 10.5 grams per fish (43.1 fish/lb.), and their growth is summarized below:

At transfer 7/17/70	10.5 grams/fish	43.1 fish/lb.
After 4 weeks	17.9	25.4
6 weeks	25.1	18.1
8 weeks	33.5	13.5
20 weeks (November 30)	approx. 160.0	approx. 2.8

These fish will be marketable size by the first of the year...or upon release can be expected to have a high survival in nature. Mortalities have been negligible and approximately 1,000 will be tagged with a Carlin-type tag and released during early spring of 1971.

PHOTOPERIOD AND THE PARR-SMOLT METAMORPHOSIS IN STEELHEAD TROUT

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The role of photoperiod and temperature in parr-smolt metamorphosis was studied at the behavioral, morphological, and physiological levels in steelhead trout (Salmo gairdneri).

In Experiment I (July 1965 to September 1966), the effects of constant photoperiods on metamorphosis were examined in relation to one constant temperature (12-3° C). Groups of fish reared in the absence of light and in continuous light were also included. Fish were introduced into the controlled regimes as fry in July 1965 and as fingerlings in December 1965. In Experiment II (June 1967 to June 1968), the effects of rate of change in photoperiod and temperature cycles on metamorphosis were emphasized. In addition, the effects of monochromatic light were studied in several groups. Experimental fish were introduced as fry into controlled environments in June 1967. The basic measurements made in the study were changes in migratory behavior, growth, and coefficient of condition, sea-water adaptation, and thyroid activity.

Photoperiod was the main environmental factor controlling the onset of metamorphosis, but did not determine whether or not the event occurred. The primary measure of metamorphosis was taken to be migratory behavior and changes in coefficient of condition. Constant photoperiods of long duration (≥ 16 hours in duration) appeared to inhibit migratory behavior whereas shorter photoperiods (≤ 12 hours in duration)of continuous darkness did not. Fish reared under an accelerated annual photoperiod were migratory earlier than control fish regardless of the temperature cycle. Those receiving a decelerated annual photoperiod had a delayed and extended migratory period. Fish reared under the reverse photoperiod (decreasing day length in the spring) were not migratory during the spring and lacked smolt characteristics. Metamorphic response was greatest in groups of fish reared under a natural photoperiod and temperature regime.

The data suggest that the rate at which the length of the daily photoperiod increases is the information most utilized by the fish for syncuronizing the metamorphic response, rather than the length of the daily light or dark period per se or the accumulated number of hours of exposure. Migratory behavior and smolt characteristics were observed in some of the fish under constant photoperiod and temperature. Therefore, metamorphosis appears to have an endogenous mechanism or possibly be synchronized through rhythmic geophysical factors other than light and temperature.

The parr-smolt metamorphosis appeared not to be affected by monochromatic spectra (peak wavelength of 450 mμ, 550 mμ and 662 mμ), intensity (11 to 2195 lux) or total radiant energy (12 to 896μ Wcm^{-2}) of the light sources used.

Temperature had two measureable effects on metamorphosis. Fish reared in a variable temperature cycle moved downstream in greater numbers and in fewer days than fish reared at constant temperature, regardless of photoperiod. Temperature also influenced the duration of the migratory period. For example, when the temperature cycle was out of phase but behind the photoperiod, the migratory period was extended.

There was no apparent difference in thyroid activity. Thyroid follicle cell heights among groups of fish reared under constant photoperiod and temperature were similar. Thyroid cell heights were not substantially different for fish reared under natural, accelerated, and decelerated photoperiod and temperature regimes. The development and control of the hypo-osmoregulatory mechanism was independent of the photoperiods tested. The development appears to be largely size and perhaps growth rate dependent. The regression and reactiviation of the hypo-osmoregulatory mechanism might be controlled by an innate hormonal rhythm which is reinforced by the smolting process.

The possibilities appear to be good for shortening the time that steelhead must be reared in the hatchery through photoperiod manipulation to attain early smolting and migration. The effect that early migration into the sea will have on survival, growth, and life history remains to be seen.

THE USE OF TETRACYCLINES TO DETERMINE SMOLT SIZE

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Observations made during examination of oxytetracycline (OTC) marks on vertebra from large numbers of adult salmon led to the conclusion that there is a relationship between the OTC mark size and the size of the fish when it was marked. The OTC mark in a fish vertebra corresponds to the size and shape of that bone at the time the mark was produced much the same as a growth ring in a tree indicates the dimension of the trunk at a particular age. Thus, if smolts are OTC marked immediately prior to release the resultant adults will provide positive information as to the size at release of smolts that survived.

An experiment was carried out to determine if fish of similar size (fork length) acquire OTC marks of similar size in vertebra from the caudal peduncle and further to establish the relationship between OTC mark size and fork length. From the production stocks at two Willamette River hatcheries, 133 yearling spring chinook were selected at the conclusion of OTC marking treatments in March 1970. Fork lengths ranged from 10 to 24 cm at 1 cm intervals, giving 15 length groups. With a fin clip and freeze brand employed to identify length groups, the selected fish were reared an additional 10 weeks in a common 6-foot circular tank. The additional growth was considered necessary to provide clear definition of the OTC mark in the vertebra.

A vertebra from the caudal peduncle of each fish was examined under ultraviolet illumination with a binocular microscope at 20x. The diameter of the OTC mark on the vertical axis of the vertebra was measured by use of an optic micrometer located in the eyepiece of the microscope. Little variation in OTC mark diameter was noted within a given length group. When OTC mark diameters were compared with fork length at time of marking, a straight line relationship was established (Figure 1). The relationship was significant at the 1% level.

The established relationship provides a means of accurately estimating fork length at the time of the OTC treatment throughout the life of the fish. The Fish Commission of Oregon (FCO) will employ this method to determine the smolt size of those fish which are contributing most heavily to our adult returns.

The 1967-brood spring chinook at the FCO Trask River Hatchery received an OTC marking treatment just prior to release into that river in October 1968 and February 1969. In 1970, 37 male 3-year returnees bearing OTC marks were recovered at the hatchery. Comparing OTC mark diameters with adult fork length a significant relationship was found to exist between smolt size and adult size (Figure 2). Small returnees tended to have smaller OTC mark diameters than larger returnees. Further investigation of this relationship will be made when 4- and 5-year fish return to the hatchery.

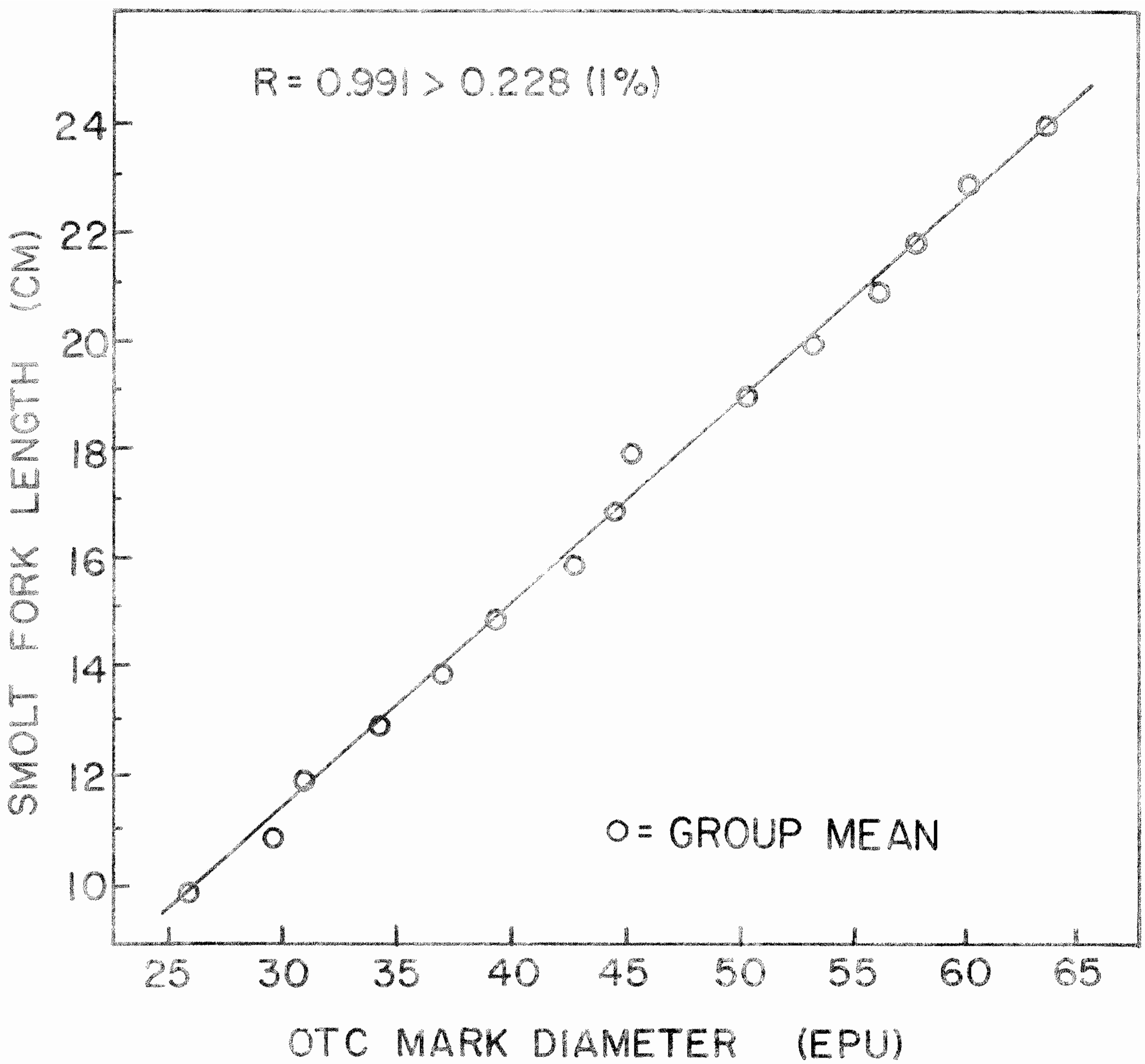

FIGURE 1. RELATIONSHIP BETWEEN OTC MARK DIAMETER AND SMOLT SIZE AT TIME OF OTC TREATMENT, WILLAMETTE RIVER SPRING CHINOOK

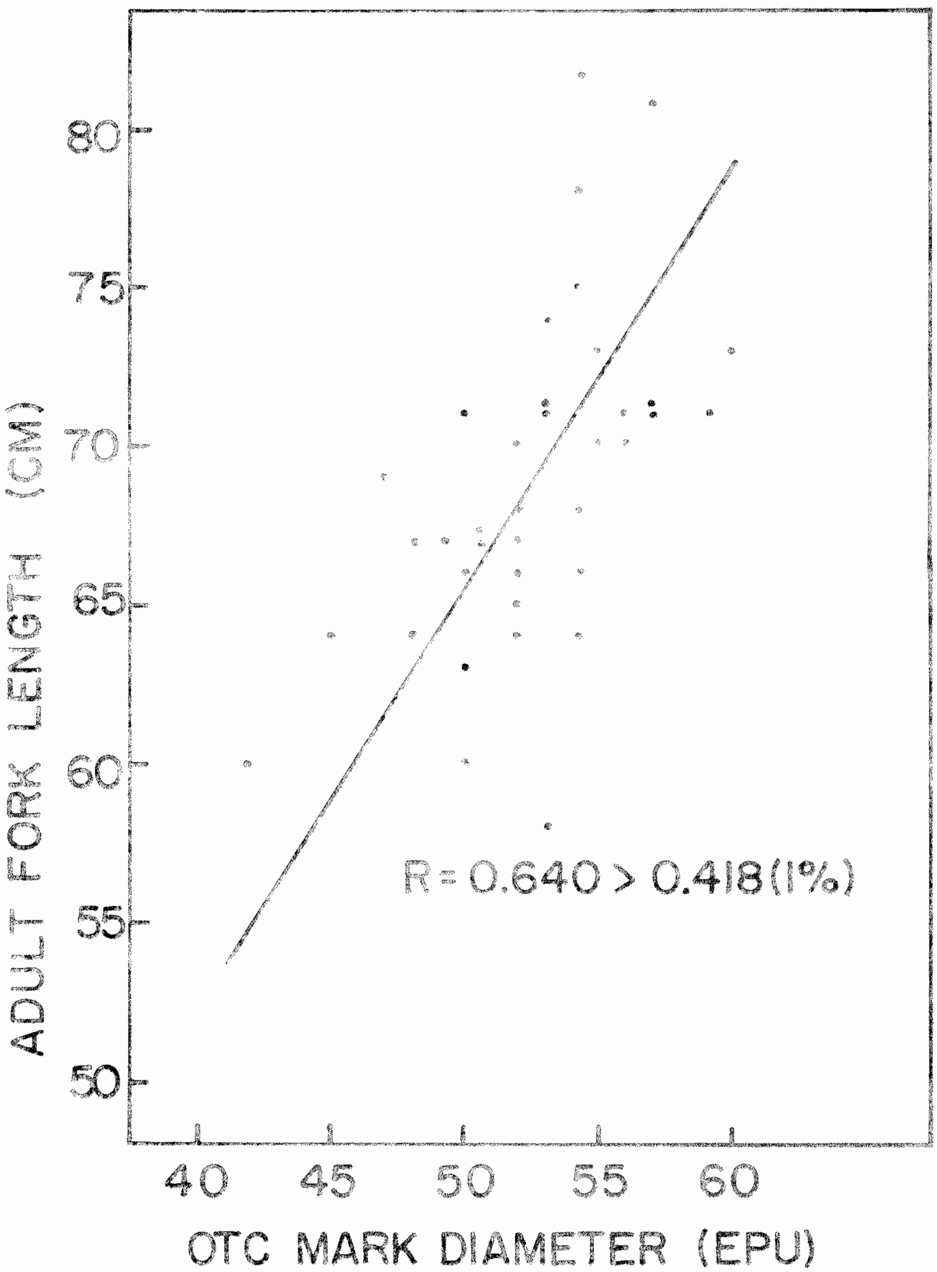

FIGURE 2. RELATIONSHIP BETWEEN OTC MARK DIAMETER AND ADULT FORK LENGTH, 3-YEAR OLD TRASK RIVER SPRING CHINOOK

FREEZE AND LASER MARKING

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and

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Perhaps the most important present requirement of animal field studies is an inexpensive and simple means of identification. The ultimate success of fish migration studies, fisheries management and international fisheries agreements such as the Japanese-Russian treaty agreement requires a completely automated marking system capable of operation at machine gun rates. Such marks should be clearly recognizable by all people making later contact with the fish.

Recent studies on higher animals have resulted in the production of permanent marks by a laser beam which selectively destroys the melanocyte (pigment cell). The technique functions by volatilization of the dark pigment (melanin) which is of higher optical density than surrounding cells. The laser device is capable of producing a mark utilizing a high intensity light flash in 30 billionths of a second. This technique, if successfully adapted to fish, could revolutionize the fisheries industry. Preliminary fish studies with the ruby laser resulted in instantaneous, white marks that slowly darkened with age. It is readily apparent that this procedure could be adapted to automated short-term marking in downstream migration studies. Histologic examination of the marked fish revealed that the iridophore or light reflecting cell, part of the complex dermal chormatophore unit, reflected enough light to spare the deeper pigment producing cells. A study of the anatomy involved, however, suggests alternative methods for producing permanent marks.

Freeze marks have been used successfully on higher animals and fish. Recent experiments have demonstrated the reason that freeze marking techniques resulted in a slow repigmentation of previously white marks. Repigmentation was correlated to severe dermal damage produced by excessive freezing. Studies on freeze-thaw rate have led to methods by which the percentage of visible marks were increased. Current studies on the cellular level should result in successful adaptation of the latter technique to fish. Examination of salmonids trapped on their return migration indicated that many freeze marks applied by current methods resulted in excessive dermal damage.

CAN THE STAMINA TUNNEL BE USED TO PREDICT SURVIVAL OF HATCHERY-REARED RAINBOW TROUT?

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Physical stamina was measured for hatchery-reared rainbow trout by determining the length of time each fish could withstand forced-sustained swimming in a specially constructed stamina tunnel. It was hypothesized that a high-stamina index was indicative of a high-survival potential. Stamina-indexed rainbow trout were stocked into two lentic and two lotic environments in Colorado during the summers of 1966-69.

During field sampling, significant differences were demonstrated only twice between the numerous returns of rainbow trout indexed as high or low stamina. Summarizing the entire project, no conclusive evidence was found that a high-stamina index was indicative of a better survival. Stamina-indexed rainbow trout also exhibited no difference in length, weight, and condition factor after stocking or susceptibility to angling.

Improved swimming ability was demonstrated upon retesting in the stamina tunnel. All but about one-fourth of the low stamina fish improved swimming ability. Additional studies are advised to conclusively determine the merit of stamina tunnel evaluations for predicting survival potential of fish, especially those stocked in fresh-water environments as rainbow trout.

STATUS OF SIMULATED HATCHERIES FOR PINK AND CHUM SALMON

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This report summarizes the status of experiments at the Oregon State University Netarts Fisheries Laboratory, Tillamook County, Oregon to evaluate new hatchery concepts for pink and chum salmon.

The experimental hatchery on Whiskey Creek (Netarts Bay) is designed to simulate conditions in a good quality natural spawning bed in order to produce robust fry which retain natural behavioral traits. In theory, the hatchery offers the promise of using very small coastal streams as a water source, streams which provide insufficient water for spawning channels or conventional hatcheries.

Construction of the prototype hatchery was started in summer 1968 with funds from the Anadromous Fish Act administered by the National Marine Fisheries Service (NMFS -- formerly Bureau of Commercial Fisheries) and the Fish Commission of Oregon (FCO). Subsequent improvements in the hatchery system have been financed by these agencies. The hatchery is operated with Sea Grant funds from the National Oceanic and Atmospheric Administration.

Experimental releases of hatchery fry have been completed for 1968 and 1969 brood years. Eggs have been taken for the 1970 brood year.

1968 brood year: An estimated 250,000 pink salmon eggs from the NMFS, Auke Bay, Alaska, Laboratory were eyed at the FCO Big Creek Hatchery (Clatsop

County). The eyed eggs were transferred to Netarts Bay in October, but a mechanical failure in the hatchery system caused high mortality. Only 7,000 pink salmon fry emigrated from the hatchery to Netarts Bay in winter 1969. No adult pink salmon returned to Whiskey Creek in 1970.

1969 brood year: An estimated 600,000 pink salmon eggs from the Auke Bay Laboratory were eyed at the Big Creek Hatchery and transferred to Netarts Bay in October. An estimated 280,000 chum salmon eggs from the stock native to Whiskey Creek were placed in the hatchery as newly fertilized eggs in November. The migration from the hatchery consisted of 393,000 pink salmon fry (65 percent survival from eyed eggs) and 225,000 chum salmon fry (83 percent survival from newly fertilized eggs).

1970 brood year: We introduced 300,000 eyed pink salmon eggs from Alaska in October and approximately 750,000 newly fertilized chum salmon eggs from the stock native to Whiskey Creek in November. The count on chum salmon may increase slightly if late migrating fish continue to enter Whiskey Creek in December. More than 90 percent of the pink salmon survived to hatch.

The major purpose in introducing pink salmon from Alaska is to test the mechanical operation of the hatchery system in advance of introducing chum salmon. In 1968 we did not take chum salmon eggs into the hatchery because of our failure with pink salmon. In 1969, we felt that approximately 70 percent survival of pink salmon to hatching was justification for introducing chum salmon. Relatively good success with pink salmon this year (over 90 percent survival to hatching) gives us additional confidence in the reliability of the hatchery system for chum salmon. We do no anticipate the introduction of pink salmon eggs to the hatchery in future years unless there should be a return of pink salmon adults to Whiskey Creek from the past releases of fry.

RETURN OF ZERO-AGE COHO SALMON "JACKS" FROM THE SEA

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In the spring of 1968, about 17,000 large coho salmon fingerlings (1967 brood year) that had been used in nutrition experiments were available for use in other programs. Since many of these fish were as large as the wild coho one year older that migrate from the Lake Washington watershed, we decided to mark them with a thermal brand (X on the left side ahead of the dorsal fin) and release them. Most of the fingerlings were transferred to Lake Union on May 29, 1968 to start their migration.

At the time of release the fish averaged 10.8 cm (standard length) and 10.8 grams or 28.7 fish per pound (Table 1).

During the fall months of 1969, a total of 219 coho salmon returned to the campus pond, a survival of 1.25 percent of the fingerlings released. Of this total, 124 were males and 95 were females. The fork length of the males ranged from 30.7 to 79.3 cm, with an average of 55.2 cm. A number of the small males were typical coho "jacks," an indication that they did not migrate to sea immediately at the time of release but stayed in the lake system for an additional year. A number of the males weighing over ten pounds (11.8 pounds maximum) obviously went to sea immediately upon release and found good feeding grounds.

The real surprise in this project was the return of 95 female coho salmon at age two years. The average weight of the females was greater than that of the males, 5.04 to 4.30 pounds.

A portion of the eggs produced by the 1969 brood salmon were retained for rearing, and 37,340 fingerlings produced from the two-year-old parents, after being marked with an adipose-left maxillary (Ad-LM) clip, were released during May 25-27, 1970 (Table 2).

The fingerlings of the 1969 brood year were much smaller at the time of release -- 75 per pound -- than those of the 1968 release. This slow growth was caused by the loss of the warm well-water supply cut off by construction on the campus.

Some of the fingerlings, however, must have migrated to sea, for with the coho run only partially complete we have had eleven zero-age Ad-LM-marked coho males return. These jacks ranged in length from 30.6 to 42.6 cm, average 38.0 cm, or 0.66 to 1.83 pounds, an average of 1.41 pounds.

In addition to the usually expected benefits to salmon culture from accelerated growth, it now seems feasible to rear salmon commercially. The yearling fish in the 1.0-to 1.5-pound range should find a ready market and not be competing directly with the large ocean-run fish.

Table 1.

1967 brood year coho salmon, University of Washington hatchery.

Releases

Date	Mark	Number	Average Weight (g)	Average Length (cm)*	Number per Pound
1968					
May 29	X	17,271	15.8	10.8	28.7
June 6	X	202	11.1	9.6	45.0
		17,473			

Returns

Date	Sex	Mark	Fork Length		Weight (g)		Weight (Lb.)		Number Return	Percent Return
			Mean	Range	Mean	Range	Mean	Range		
1969	F	X	57.5	40.8-74.4	2,289	770-4,450	5.04	1.70-9.80	95	0.5437
	M	X	55.2	30.7-79.3	1,956	320-5,350	4.30	.71-11.78	124	0.7097
								TOTAL	219	1.2534

* Length measured from tip of snout to end of silvery portion of body.

Table 2.

1969 brood year coho salmon, University of Washington hatchery.

Releases

Date	Mark	Number	Average Weight (g)	Average Length (cm)*	Number per Pound
1970					
May 25	Ad-LM	16,155	9.03	9.20	50.3
25	Ad-LM	14,487	4.30	6.92	105.6
27	Ad-LM	6,700	2.71	6.06	167.5
		37,342			

Returns

Date	Sex	Mark	Fork Length Mean	Fork Length Range	Weight (g) Mean	Weight (g) Range	Weight (Lb.) Mean	Weight (Lb.) Range	Number Return	Percent Return
1970										
	F	Ad-LM							0	0.0000
	M	Ad-LM	38.0	30.6-42.6	640	300-830	1.41	0.66-1.83	11	0.0295
								TOTAL	11	0.0295

* Length measured from tip of snout to end of silvery portion of body.

AN INDOOR BURROWS REUSE SYSTEM

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Eagle River, Alaska

An indoor Burrows reuse system was incorporated into the Fire Lake Hatchery to permit warming water used during incubation and early rearing stages, and to overcome a water shortage in late winter.

The system is completely enclosed in a 60-foot by 80-foot building. Bacterial filters are below floor level, and are covered by steel grating to permit use of floor space over the filters. Reconditioned water is pumped into an aeration tank over the office, then it flows by gravity to incubators, troughs, and rearing tanks. Rearing units discharge into a floor drain which leads back into the bacterial filters. A separate drain system permits waste from any individual unit, if desired.

Make-up water passes through sand filters, then ultra-violet sterilizers. Water can be added to the system at prevailing line temperature or it may be heated. Water temperature in the recirculating system increases 5° F. to 10° F. from exposure to building heat. There is an alternate water supply to the incubators which permits use of water colder than that in the recirculating system. There is also an alternate raw water supply in event of power failure or equipment malfunction.

The system is designed for a total flow of 750 GPM, with the capacity to filter and sterilize 75 GPM make-up water. Adjustments in operation are manual, although much of the apparatus is controlled from a central panel through a pneumatic control system.

REARING SALMONIDS IN POWER PLANT COOLING PONDS

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Eagle River, Alaska

Much of the electricity in Alaska is derived from steam-electric generating plants. The plants require cool water to condense steam, and the coolant water is warmed in the process. Rather than discharge hot water directly into the stream, it is tempered in ponds before discharge.

Cold water is a major problem in artificially rearing fish over the winter in Alaska, and these ponds offer some potential for fish cultural use. We have been rearing salmonids in power plant cooling ponds at Fort Richardson since 1959 and at Elmendorf Air Force Base since 1965 in cooperative projects between the military bases and our department.

We have determined that it is feasible and advantageous to utilize these ponds for salmonid rearing. They are an integral part of a current expansion program by our department.

Details of the operation were presented.

RAISING CATFISH IN OREGON FARM PONDS

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ABSTRACT

Research on the feasibility of commercial catfish culture was conducted at the Soap Creek Ponds north of Corvallis, Oregon, in 1969 and 1970 to determine if catfish fed supplemental diets could be grown from fingerlings to a commercially usable size of 3/4 to 1¼ pounds in one season.

In 1964, Young stocked channel catfish fingerlings along with gambusia and bluegills in fertilized ponds at Soap Creek without supplemental feeding. Growth of the channel catfish was slow and production was about 68 pounds per acre at a stocking rate of 500 catfish per acre.

In 1969, Suraswadi stocked channel catfish only in fertilized ponds at Soap Creek and fed them supplemental diets. Production rates averaged about 146 pounds per acre at a stocking rate of 1,200 fish per acre and showed no real correlation to diet or feeding rate. The fish averaged six to the pound at the termination of the study.

At Soap Creek, in 1970, yearling brown bullheads, channel catfish from the 1969 study and yearling channel catfish purchased from a commercial source were reared in floating cages and fed supplemental diets. The bullheads suffered a 95 percent mortality from columnaris outbreaks following handling and temperature fluctuations in the late spring and early summer despite prophylactic dips in 1:15,000 malachite green solutions. Brown bullheads show little promise as a commercial species. Yearling

channel catfish had a 17 percent mortality and produce an average of 171 pounds per acre figured on a stocking rate similar to that of the 1969 study. Conversion ratios averaged five to the pound at the end of the study. There was no difference among diets in either conversion rate or production. The two-year-old channel catfish experienced a 4 percent mortality and produced between 200 and 300 pounds per acre depending on diet. Conversion factors for these older fish averaged 2.7 pounds of food for each pound of fish produced and 20 percent of the fish reached harvestable size in their second season. The chief mortality factors with the channel catfish were handling and tarichatoxin poisoning contracted by biting the rough-skinned newts common in the experimental pond. The main factor limiting the growth of channel catfish in the 1964, 1969, and 1970 experiments was felt to be low water temperature. Successful commercial rearing of channel catfish requires that average water temperatures be above 70° F. for 180 to 210 days. Maximum food conversion efficiency in channel catfish is achieved at temperatures of 84-86° F. At Soap Creek, the average water temperature was above 70° F. only about 100 days in both 1969 and 1970 (June through August) and never exceeded 80° F.

It may be possible to grow channel catfish to commercial size by beginning with larger fish or by feeding the fish for two seasons. However, since the profit margin on catfish production is usually not great, these added manipulations would make it economically infeasible. Other commercial possibilities for the channel catfish may be in the use of heated effluents to elevate water temperatures to desired levels or in supplying fingerlings to producers in regions where the fish can be reared to harvestable size economically.

HISTORY OF MODERN FISH CULTURE

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Slides of the history of fish culture from 1870-1970 were presented. These slides were prepared for a Bureau display at the American Fisheries Society Centennial held in September 1970 in New York City.

Progress in the various facilities and operations was depicted, such as: hatchery buildings, rearing ponds, egg-taking, egg care, fish feeding, fisheries laboratories, fish sampling, fish tagging, fish distribution, fishing pressure, and women's liberation.

HATCHERY WATER REQUIREMENTS BASED ON SALMONID OXYGEN DEMAND

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Kramer, Chin & Mayo
Consulting Engineers
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This brief paper is an abstract of a more detailed study now is preparation by myself and Mr. Paul Liao of our firm. The purpose of this paper is to describe one method we have found useful in predicting water requirements for salmonids. This method is based on oxygen requirements and physical properties of water. While we are quick to admit that there are other limiting factors in the usefulness of a water supply (such as build up of metabolic by-products) we have found this method useful in most design situations.

To the general question, "How much water do you need to raise fish?" one must always start with the answer, "As much as possible." Unfortunately, this answer becomes less satisfactory as sources of good quality of water diminish and as hatcheries become larger. The need for refined answers is further heightened by (1) pumping situations, (2) situations in which standby power facilities are required, and (3) under conditions where water reuse is involved.

As with many attempts at innovation in this field, we took our inspiration from the Abernathy Fish Cultural Laboratory (specifically J. W. Elliot, B. D. Combs, and of course Roger Burrows). They, in several papers in the Progressive Fish Culturist, proposed flow values based on the oxygen requirements of chinook salmon. We used these values in much of our work and found them both consistent and, strangely enough, satisfactory to the engineering mentality. Unfortunately, we were limited in our use of these values by several factors, the first being that the range of size was not broad enough for our work and the second, that these tables were based specifically on the chinook salmon. For these reasons we decided to develop similar but extended water use tables for salmonids up to 10 pounds in size with differentiation between species if such was justified.

As a starting point in the development of these tables, we made a series of "in-raceway" measurements on oxygen uptake rates at the Oregon Game Commission Alsea Steelhead Hatchery on July 23, 1970. These are illustrated in Figure 1. We then added to this data other measurements made in Minnesota, Wisconsin, Colorado, Washington, and Idaho for a total of approximately 300 individual tests. We took these values and plotted them on log scale with fish weight in pounds per individual versus oxygen consumption in pounds of oxygen per 100 pounds of fish per day. In our initial attempt to making curves fit these points we had some trouble due to a lack of data in some areas and due to the variation between points that we couldn't easily explain. We found, however, that the problem became a good deal simpler when we plotted salmon and trout separately. Finally, using variations of the methods proposed in our reference we arrived at the curve indicated in Figure 2.

At this point we should perhaps itemize some of the things that are wrong with Figure 2.

1. No differentiation is made between various levels of activity in the fish, nor the various types of ponds, nor the density of loading, nor the different strains of fish, nor different light levels.

2. Information given to us on raceway loadings was not based on an exact measurement but on the hatchery operator's estimate.

3. The flow values are based on field measurements made by members of our staff but often the situation did not allow precise determinations, thus flow measurements were our "best guess."

4. Finally, no real attempt was made to differentiate between oxygen consumption where oxygen levels were very high as opposed to oxygen consumption where they were low.

However, as engineers we can't fail to act just because our data isn't perfect. When action is required we must find the best information we can and use it. Therefore, we adopted the values indicated in Figure 2 as our basic oxygen consumption values. We hope to refine and improve them.

The next step was to summarize the physical characteristics of water as related to its oxygen carrying capacity. This is illustrated in Figure 3 which shows the 100 percent saturation level of oxygen in water at various temperatures and elevations.

Using Figure 3 and (1) knowing the oxygen requirement of a particular fish of a particular size, (2) the degree of saturation of the water supply and its temperature, (3) the elevation of the site, and (4) the desired minimum oxygen level after the water has been used, one can calculate the water requirement. This has been done in Figure 4 which is an example for a hatchery site in the state of Minnesota. In this figure, required flow volume is based on an elevation of 1,300 feet, a D.O. concentration at the inlet at 95 percent of saturation and a minimum dissolved oxygen level of 5 ppm. Curves are included for both salmon and trout.

In a similar manner we have prepared a chart for the state of Colorado (Figure 5) in which we indicated the variations in carrying capacity, at certain water conditions, at 100 feet and 8,000 feet of elevation. These values are markedly different and suggest several things to the designer relative to the potential for reaeration of water part way through the use cycle.

Under the category of a small bonus we would like to append to this paper some information on another series of tests we ran at the Cowlitz Game Fish Hatchery on a "Cascade" type aeration device. This device is of cast aluminum and made by the Infilco Company. They were installed at Cowlitz to provide aeration and to release excess nitrogen gas. The water coming through these aeration devices is from wells, and tests prior to construction indicated that there probably would be a problem without some means of reducing nitrogen. As we have heard no report of nitrogen diseases, we assume that (1) they have been effective in removing nitrogen gas, or (2) there isn't any problem.

At the time of installation we were unable to get specific data on oxygen input at the higher levels of influent D.O., so several weeks ago we took the opportunity to run D.O. tests on these units. The results are tabulated below.

Aerator * Number	Water Temp.	Air	Flow gpm	D.O. in ppm (% Sat.)	D.O. out ppm (% Sat.)
1	50° F.	70° F.	570	9.8 (86.5%)	10.6 (93.5%)
2	50	70	595	9.5 (84.0%)	10.6 (93.5%)
4	50	70	595	9.6 (85.0%)	10.6 (93.5%)
5	54	70	400	5.4 (50%)	9.2 (85.0%)
1	50	70	433	9.8 (86.5%)	10.9 (96.2%)
2	50	70	433	10.0 (88.0%)	11.0 (97.8%)
3	50	70	461	9.6 (85.0%)	10.8 (95.2%)
5	54	70	400	5.5 (51%)	9.1 (84.2%)
1	50	70	845	10.0 (88.0%)	11.0 (97.1%)
2	50	70	915	9.5 (84.0%)	11.0 (97.1%)

* Aerators No. 1 through No. 4 serve south well field.
Aerator No. 5 serves north well.

These results are plotted in Figure 6 with a drawing of the device.

This unit was installed for 2250 GPM and though flows did not approach this value, evidence indicates that aeration efficiency varies little with flow values. (Note similar values for 400, 600, and 900 GPM flows.)

If we assume an influent D.O. of 68 percent saturation it can be seen that this aerator would produce a 90 percent saturated effluent. However, if we assume a 50 percent saturated influent, it can be seen that two passes would be required to achieve 95 percent saturation. (50% to 84%, 84% to 95%.)

This is the basis on which we have developed aerator designs using this device.

At the end of this paper are the basic references used in the developement of the more detailed study referenced in my opening remarks. We are providing them here for those of you who might find them valuable.

Rearing Unit	Test No.	Flow gpm	Species	Fish No/Lb.	Weight/Lbs	Temp of Water	Temp of Air	Dissolved Oxygen mg/l Inlet	Dissolved Oxygen mg/l Outlet	Dissolved Oxygen mg/l Reduction	Oxygen Uptake Rate lbs oz/100 lbs fish/day
Tank #2	1	60	Trout	205	174	63	65	10.3	6.7	3.6	1.50
	2	60	Trout	205	174	62	68	10.1	6.7	3.4	1.41
3	1	60	Trout	205	189	63	65	10.3	6.1	4.2	1.60
	2	60	Trout	205	189	62	68	10.1	6.3	3.7	1.41
4	1	60	Trout	205	120	63	65	10.2	7.5	2.7	1.62
	2	60	Trout	205	120	62	68	10.1	8.4	1.5	0.90
5	1	60	Trout	205	170	63	65	10.2	6.5	3.7	1.56
	2	60	Trout	205	170	62	68	10.1	6.2	3.9	1.65
6	1	60	Trout	205	183	63	65	10.2	6.4	3.8	1.48
	2	60	Trout	205	183	62	68	10.1	6.1	4.0	1.55
7	1	26	Trout	205	165	63	65	10.2	4.0	6.2	1.28
	2	26	Trout	205	165	62	68	10.1	5.3	4.8	0.91
8	1	60	Trout	205	174	63	65	10.2	6.7	3.5	1.45
	2	60	Trout	205	174	62	68	10.4	6.8	3.6	1.44
9	1	55	Trout	205	194	63	65	10.2	5.7	4.5	1.28
	2	55	Trout	205	194	62	68	10.1	5.7	4.4	1.25
10	1	60	Trout	205	186	63	65	10.2	6.0	4.2	1.63
	2	60	Trout	205	186	62	68	10.2	6.5	3.7	1.43
11	1	50	Trout	205	176	63	65	10.2	6.2	4.0	1.37
	2	50	Trout	205	176	62	68	10.2	6.6	3.6	1.23
12	1	60	Trout	205	194	63	65	9.9	5.8	4.1	1.52
	2	60	Trout	205	194	62	68	10.2	5.8	4.4	1.64
13	1	50	Trout	205	176	63	65	10.1	5.7	4.4	2.07
	2	50	Trout	205	176	62	68	10.2	5.7	4.5	2.10
14	1	60	Trout	233	175	63	65	10.1	6.0	4.1	1.69
	2	60	Trout	233	175	62	68	10.2	6.0	4.2	1.73
15	1	38	Trout	233	158	63	65	10.1	4.8	5.3	1.53
	2	38	Trout	233	158	62	68	10.2	4.5	5.7	1.65
16	1	60	Trout	233	164	63	65	10.3	6.5	3.8	1.67
	2	60	Trout	233	164	62	68	10.1	6.4	3.7	1.62
17	1	50	Trout	233	165	63	65	10.3	3.5	6.8	2.47
	2	50	Trout	233	165	62	68	10.1	4.2	5.9	2.15
18	1	60	Trout	233	160	63	65	10.3	6.5	3.8	1.71
	2	60	Trout	233	160	62	68	10.1	6.5	3.6	1.62
19	1	48	Trout	233	162	66	68	9.8	4.7	5.1	1.27
	2	48	Trout	233	162	60	68	10.1	5.7	4.4	1.09
20	1	60	Trout	204	158	66	68	9.7	5.8	3.9	1.78
	2	60	Trout	204	158	60	68	10.1	6.3	3.8	1.74
21	1	50	Trout	204	159	66	68	9.7	6.7	3.0	1.13
	2	50	Trout	204	159	60	68	10.1	7.8	2.3	0.87
22	1	60	Trout	204	160	66	68	9.6	6.0	3.6	1.62
	2	60	Trout	204	160	60	68	10.1	6.2	3.9	1.76
23	1	55	Trout	204	167	66	68	9.6	5.9	3.7	1.46
	2	55	Trout	204	167	60	68	10.1	6.6	3.5	1.38
24	1	60	Trout	204	167	66	68	9.6	5.4	4.2	1.81
	2	60	Trout	204	167	60	68	10.0	6.4	3.6	1.55
25	1	60	Trout	204	169	66	68	9.6	6.2	3.4	1.45
	2	60	Trout	204	169	60	68	10.0	7.2	2.8	1.2
26	1	60	Trout	204	171	66	68	9.7	5.5	4.2	1.77
	2	60	Trout	204	171	60	68	10.2	6.3	3.9	1.64
Pond #14	1	200	Chinook	50	200	66	76	9.9	8.6	1.3	1.56
	2	200	Chinook	50	200	60	79	10.3	9.5	0.8	0.96
16	1	310	Cutthroat	0.62	1016	66	76	9.8	8.5	1.3	0.76
	2	310	Cutthroat	0.62	1016	60	79	10.3	9.0	1.3	0.76
18	1	495	Cutthroat	2.4	1226	66	76	9.7	8.7	1.0	0.49
	2	495	Cutthroat	2.4	1226	60	79	10.2	9.3	0.9	0.44

FIGURE 1. - SUMMARY OF TEST RESULTS (OXYGEN UPTAKE RATES) ALSEA HATCHERY, JULY 23, 1970

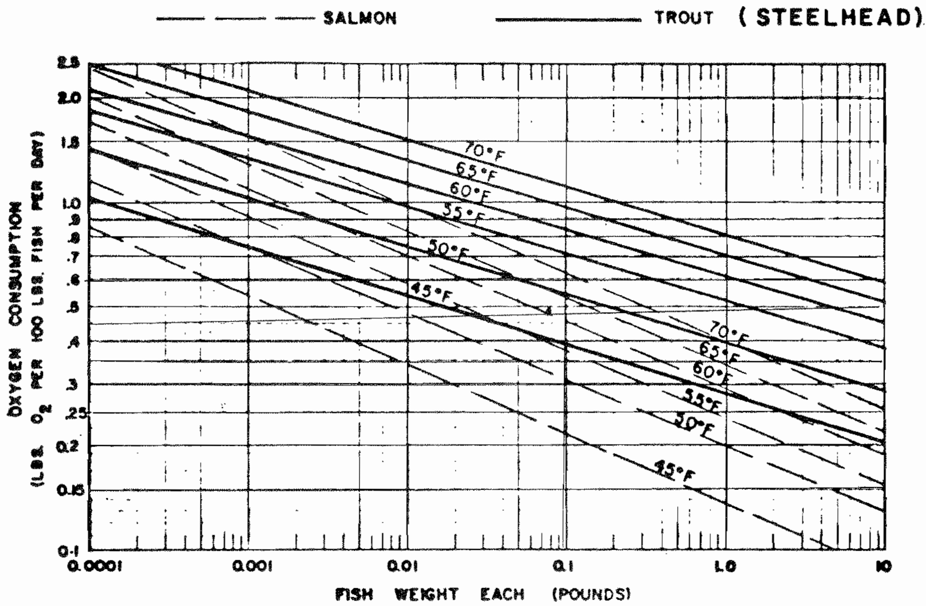
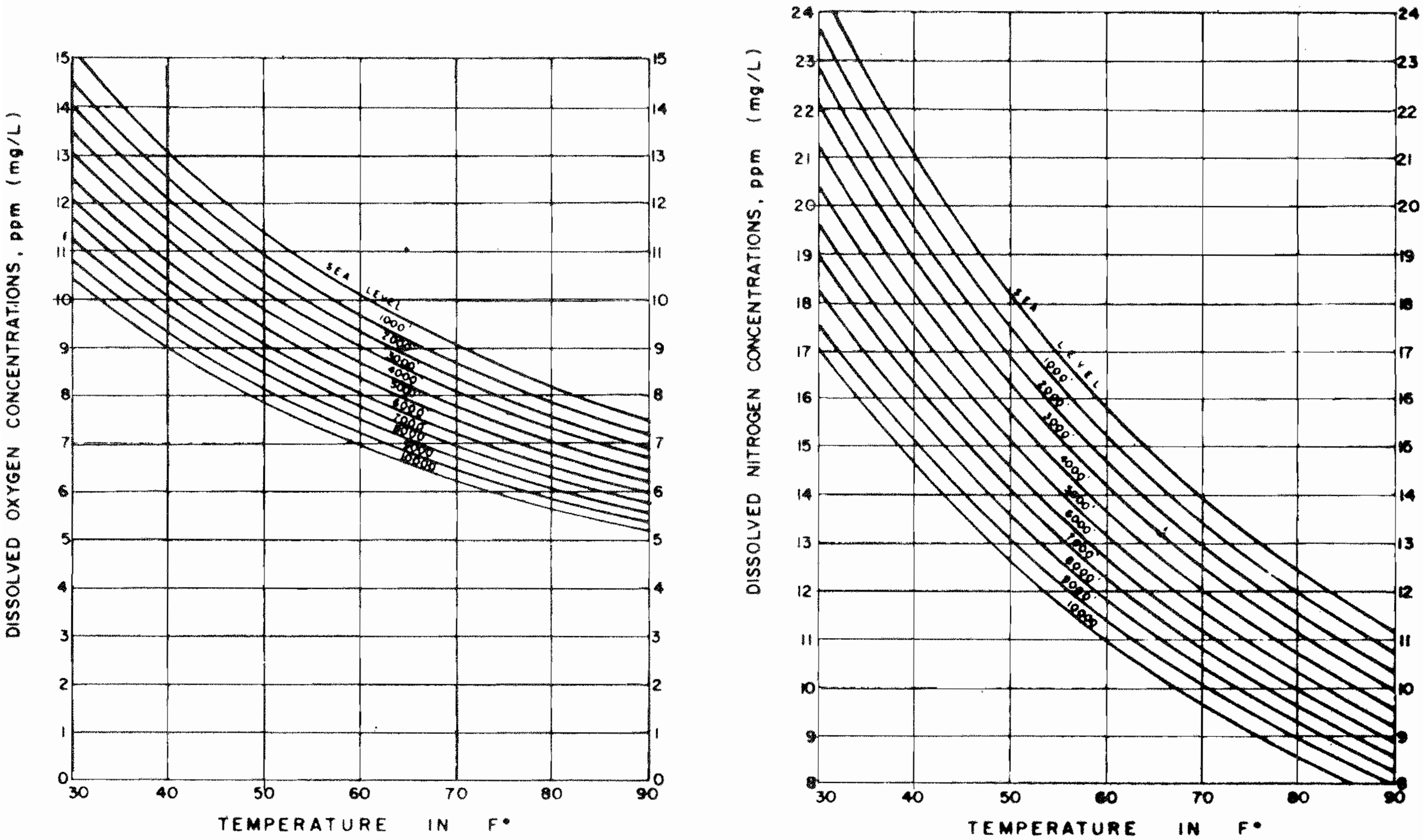


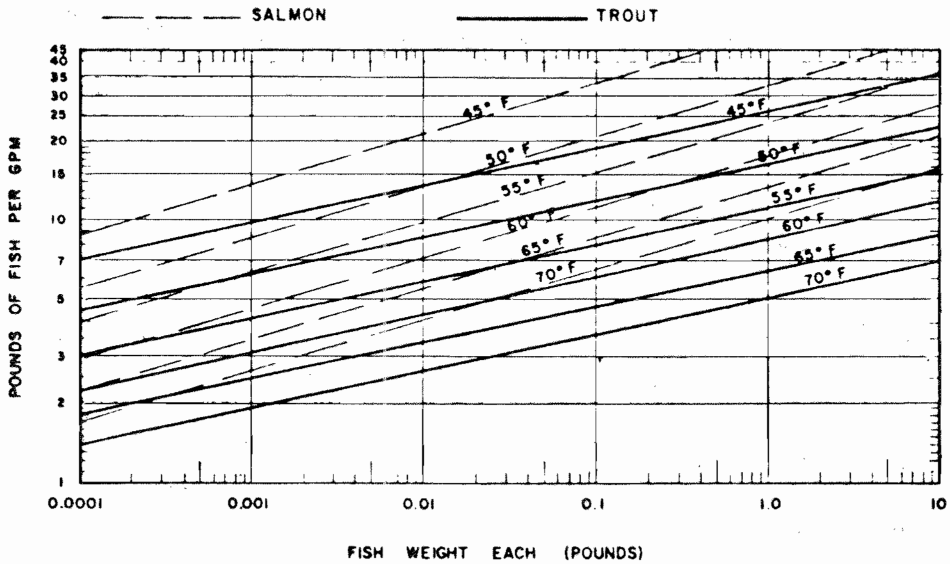
FIGURE 2. - OXYGEN CONSUMPTION AT VARIOUS TEMPERATURES.



100 % OXYGEN SATURATION IN WATER AT VARIOUS ELEVATIONS

100 % NITROGEN SATURATION IN WATER AT VARIOUS ELLEVATIONS

FIGURE 3. - BASIC PHYSICAL CONSTANTS FOR WATER.



REQUIRED FLOW VOLUME

(AT ELEVATION 1,300 FT D O CONC. 95% SATURATION, MIN. D.O. ≥ 5)

FIGURE 4. - DESIGN CRITERIA - RACEWAY FLOWS AND VOLUMES FOR THE STATE OF MINNESOTA.

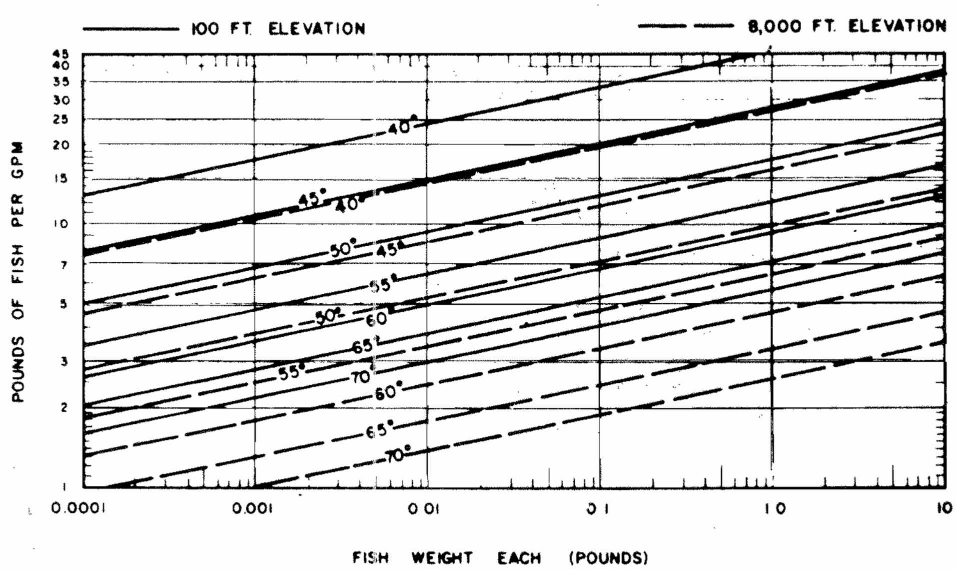
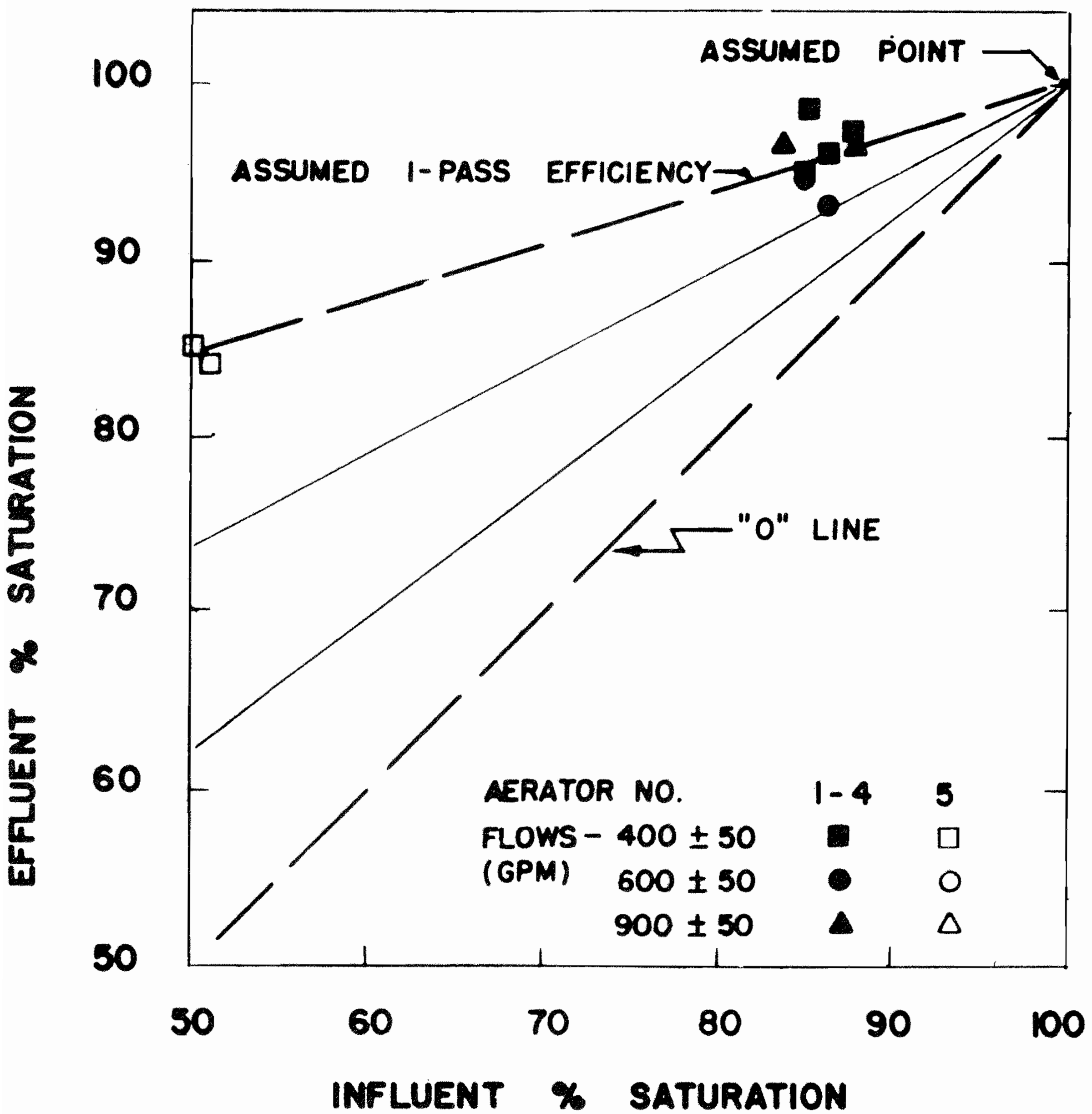
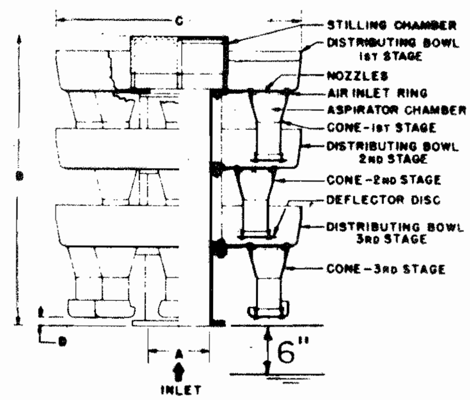


FIGURE 5. - REQUIRED FLOW VOLUME

(D.O. CONC 95% SATURATION, MIN. D.O. 5%)





INSTALLATION DETAIL

Max. Capacities G.P.M.	Size	A	B	C	D	Shipping Wt. lbs.
450	42A	12"	6'-0-1/4"	3'-9-1/2"	2"	1400
600	42B	12"	6'-0-1/4"	3'-9-1/2"	2"	1450
800, 1,000 or 1200	52A	16"	6'-4-3/8"	5'-2-1/2"	2-1/2"	1650
1500 or 1800	52B	16"	6'-4-3/8"	5'-2-1/2"	2-1/2"	1750
2250	62A	20"	6'-4-3/4"	6'-4-1/2"	2-1/2"	2900
2800	62B	20"	6'-4-3/4"	6'-4-1/2"	2-1/2"	3100

FIGURE 6. - AERATION EFFICIENCY OF COWLITZ TYPE AERATORS AT HIGH INLET D.O.

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THE PACO FISH PUMP

Donald Cunningham
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Portland, Oregon

History

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

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

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

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

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

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

Since June, 1969, there have been additional tests with the 5-inch pump and larger units on different species of salmon and larger salmon.

The last test was concluded in September, 1969, pumping 14- to 19-inch long coho or jack salmon. Our short film on fish transfer shows some footage of this test, which is available on a loan basis to any institution.

Our 6-inch pump was used in Northern California in a series of successful tests on transferring channel catfish. Additional tests have been made in Stuttgard, Dumas, Kelso and McGehee, Arkansas, at various governmental agencies experimental farms, and large commercial farms. Transferring of channel catfish up to 19½ inches long was successful without any damage to the fish. A detailed report will be written later.

THE MOVIE - "THE PACO FISH TRANSFER PUMP"

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

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

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

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

The footage shows further testing of the 6-inch fish transfer pump at the Bonneville fish hatchery. Each year salmon called coho or jack salmon return with the mature salmon and have to be separated. These salmon are 14 to 19 inches in length. Tests were made over several weeks, pumping and repumping these larger salmon to determine the mortality rate. The results were excellent, and during September 1969, a demonstration was made to Stage Hatchery and governmental officials showing the capabilities of this pump. After pumping 500 salmon, they were contained in a front loader and dumped to examine them for damage and to see if any of the salmon had been tagged.

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

THE CONTROL OF FISH DISEASES IN THE HATCHERY BY USE OF HIGH RADIATION, MONITORED ULTRAVIOLET AND A NEW FILTER SYSTEM

R. E. Flatow
R. E. Flatow & Company, Inc.
Berkeley, California

Summary

The proven benefits of monitored, fail-safe ultraviolet to control fish diseases were mentioned together with the necessity of controlled filtration to assure the effectiveness of U-V.

Tests to combat *Myxosoma cerebralis* (whirling disease) at Lahontan, Nevada and Leetown, West Virginia, were described and results to date were reported. Control of Saprolegnia through high radiation U-V was discussed, as was increased density of fish raising in U-V purified water and better weight gain possibilities.

Slides of some tests and installations were shown.

RESULTS OF 1970 FALL CHINOOK STORED EGG SHIPMENTS

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Fish Commission of Oregon
Clackamas, Oregon

In 1970 an opportunity to experiment with stored egg shipments, on a production basis, was provided when it became necessary to transfer more than 10 million green fall chinook eggs from Big Creek Hatchery, Knappa, Oregon, to Cascade Hatchery near Bonneville Dam.

Methods and results of our 1968-69 stored gamete experiments were reported at the 1969 Northwest Fish Culture Conference and in the April 1970 issue of the Progressive Fish-Culturist (Vol. 32 (2) p. 81-84).

The following is a review of the spawning, packing, and fertilizing procedures used this year:

Slide No. 1. Females were killed, bled, washed, and wiped with burlap sack to remove as much moisture and mucous as possible. Females were then stripped (incision method) into clean and thoroughly dry 5 gallon plastic buckets.

Slide No. 2. When 400 ounces of eggs and accompanying fluid were collected, the contents were immediately poured into a two dimension, (18" x 35") 0.004 plastic bag and the bag was sealed with masking tape. The volume of eggs and fluid to air was approximately 3:1.

Slide No. 3. Upon sealing with masking tape, the bag was placed in an eyeing basket, covered with a burlap sack, and carried to a nearby insulated van. Shaved ice was then packed around the outer edges of each basket. One-quarter inch plywood was used to separate tiers of stacked baskets. An average shipment of 2 million eggs required 53 baskets with bags and approximately 1 ton of shaved ice.

Slide No. 4. Sperm was collected in clean and thoroughly dry plastic pails from select males which had been slightly prestripped. Approximately six males were stripped into a pail. Sperm was then poured into 4" x 2" x 12" plastic bags at a volume of approximately 10 ounces per bag. Bags were sealed to provide equal volume of air and sperm. Sealed bags were immediately placed in a styrofoam chest with shaved ice. When sufficient sperm was collected, the chest was covered with a styrofoam lid and sealed with masking tape.

Slide No. 5. Upon arrival at Cascade Hatchery, egg baskets were removed from the truck and placed in troughs. Bags were set in an upright position; masking tape was removed and the bags were opened to allow eggs to acclimate to the hatchery water temperature (50 F).

Slide No. 6. Similarly, bags of sperm were removed from the styrofoam chest and placed in a partially submerged egg basket to allow sperm to acclimate to the hatchery water temperature.

Slide No. 7. When eggs and sperm were within 5 F of the water temperature, sperm was poured into a bag of eggs and gametes were immediately mixed by hand. When eggs and sperm were thoroughly mixed, a small beaker of water was added and mixed with the gametes.

Slide No. 8. Immediately after fertilizing, bags were tilted to allow a gentle flow of eggs into the basket.

Slide No. 9. The basket of eggs is gently raised and lowered to wash eggs of excess sperm and to level eggs.

A total of five lots of eggs was shipped from Big Creek to Cascade Hatchery on 4 consecutive days. Time in storage, gamete storage temperatures, and egg mortality data are shown in Table 1. Also shown is the per cent mortality of the total number of eggs retained at Big Creek for incubation.

Table 1. Stored Fall Chinook Egg Shipments From Big Creek to Cascade Hatchery, 1970

Date	Lot	No. Eggs	No. Fish Spawned		Total Time Spawning Packing 1/ (Hrs.)	Total Time Transit 2/ (Hrs.)	Temp. Gametes °F		Total Time Fertilize Set Eggs (Hrs.)	Total Max. Storage Time (Hrs.)	No. Eggs Lost Through Shocking 3/ (Hrs.)	Per Cent Egg Loss Through Shocking
			Females	Males			Eggs	Sperm				
9/23	1	1,951,300	415	69	6.00	2.75	36-42	36	1.25	10.00	255,900	13.1
9/25	2	2,268,100	482	80	6.00	2.25	38-42	38	1.50	9.75	265,300	11.7
9/26	3	2,269,900	483	81	3.75	2.25	38-44	38	1.00	7.00	364,800	16.1
9/27	4	2,155,200	450	75	3.50	2.50	38-42	38	1.25	7.25	277,700	12.9
9/27	5	1,999,400	425	71	3.25	2.25	38-42	38	1.25	6.75	325,500	16.3
Total		10,643,900	--	--	--	--	--	--	--	--	1,489,200	14.0
9/13-28 Control	4/	8,768,300									1,392,100	15.9

1/ Egg containers were 0.004 cellophane bags (18" x 35") @ $0.12 each. Bags were packed at a rate of 400 ounces (eggs + ovarian fluid) per bag.

2/ Distance of shipment was approximately 125 miles (Knappa, Oregon, to Bonneville Dam).

3/ Eggs were shocked at approximately 650TU.

4/ Eggs retained at Big Creek Hatchery for incubation.