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Preface

Enclosed is the Report of the Nutritional Conference held at Wenatchee, Washington on November 13 and 14, 1951. The members of the Entiat Salmon-Cultural Laboratory staff kept the notes on the discussions following each report. Summaries of the reports were forwarded by the individual speakers and included without editing.

Roger E. Burrows

NUTRITIONAL CONFERENCE - 1951 (WENATCHEE)

Meeting called to order by Chairman Burrows at 9:00 a.m. on Tuesday November 13.

ROSTER OF ATTENDANCE

Duncan K. Law	Seafoods Laboratory	Astoria, Oregon
Donald L. McKernan	Oregon Fish Commission	Portland, Oregon
Russell O. Sinnhuber	Seafoods Laboratory	Astoria, Oregon
Thomas B. McKee	Oregon Fish Commission	Bonneville, Oregon
Ernie R. Jeffries	Oregon Fish Commission	Bonneville, Oregon
Wallace F. Hublou	Oregon Fish Commission	Marion Forks, Oregon
Lewis R. Garlick	U.S. Fish & Wildlife Service	Portland, Oregon
John R. Parvin	U.S. Fish & Wildlife Service	Leavenworth, Washington
H.W. Newman	U.S. Fish & Wildlife Service	Entiat, Washington
Robert J. McElrath	U.S. Fish & Wildlife Service	Underwood, Washington
Bruce B. Cannady	U.S. Fish & Wildlife Service	Carson, Washington
Robert L. Azevedo	U.S. Fish & Wildlife Service	Entiat, Washington
David D. Palmer	U.S. Fish & Wildlife Service	Entiat, Washington
Forest S. Keller	Dept. of Fish and Game	Big Timber, Montana
R.R.H. MacLeod	Int. Pac. Sal. Fish. Comm.	British Columbia
R. R. Rucker	U.S. Fish & Wildlife Service	Seattle, Washington
J. A. Coates	U.S. Fish & Wildlife Service	Seattle, Washington
John E. Halver	U.S. Fish & Wildlife Service	Seattle, Washington
Donald R. Johnson	Wash. State Dept. of Fisheries	Seattle, Washington
Marshall Thayer	Wash. State Dept. of Fisheries	Seattle, Washington
Brian J. Earp	Wash. State Dept. of Fisheries	Seattle, Washington

C. H. Ellis	Wash. State Dept. of Fisheries	Seattle, Washington
Cliff Millenbach	Wash. State Game Department	Seattle, Washington
David Miyauchi	U.S. Fish & Wildlife Service	Seattle, Washington
William N. Sumerwell	U.S. Fish & Wildlife Service	Seattle, Washington
William L. Peck	U.S. Fish & Wildlife Service	Portland, Oregon
Marvin Hull	Wash. State Dept. of Game	Ford, Washington
Fred E. Keffel	Wash. State Dept. of Game	Vancouver, Washington
D. C. Lavier	Wash. State Dept. of Game	Vancouver, Washington
H. E. Johnson	U.S. Fish & Wildlife Service	Cottage Grove, Oregon
L. E. Perry	U.S. Fish & Wildlife Service	Portland, Oregon
H. B. Cox	U.S. Fish & Wildlife Service	Cook, Washington
Alfred C. Gastineau	U.S. Fish & Wildlife Service	Leavenworth, Washington
Edward M. Tuttle	U.S. Fish & Wildlife Service	Portland, Oregon
Fred [illegible]. Ritle	U.S. Fish & Wildlife Service	Leavenworth, Washington
Zell E. Parkhurst	U.S. Fish & Wildlife Service	Tracy, California
Roger E. Burrows	U.S. Fish & Wildlife Service	Entiat, Washington

McKernan presented a tentative agenda for the meeting as follows:

1. Agenda discussion (30 min) 9:30 a.m. - 10:00 a.m.
2. Participation (30 min) 10:00 a.m. - 10:30 a.m.
3. Diet Experiments
   - Washington State Depts. (90 min) 10:30 a.m. - 12:00 noon
   - Oregon Fish Commission (120 min) 1:30 p.m. - 3:30 p.m.
   - Fish & Wildlife Service (150 min) 3:30 p.m. - 6:00 p.m.

4. Nutritional and Disease Problems

Washington State Depts.	(60 min)	8:00 a.m. - 9:00 a.m.
Oregon Fish Commission	(60 min)	9:00 a.m. - 10:00 a.m.
Fish & Wildlife Service	(60 min)	10:00 a.m. - 11:00 a.m.

Participation by various agencies in future conferences discussed. No conclusions reached other than the sponsoring agency next year would have responsibility for extending invitations to interested agencies.

Suggested that notification of meeting dates be made earlier than this year so that time would be allowed to make travel arrangements.

NUTRITIONAL PROBLEMS

Washington Department of Game

Speaker: Cliff Millenbach

Because of the nature of our hatchery operations we are unable to contribute much to the technical aspect of the meeting. As it is very unsatisfactory to attempt to carry out any research under actual production conditions, we will undoubtedly confine our work to the mechanical problems present in our current feeding practices. Use of pellet type feeds offers considerable promise. I personally do not anticipate going into wide use of a dried pellet, such as advocated by certain commercial people, but look forward to the use of semi-wet pellets as described. So far, our tests have demonstrated that a mixture of 50% salmon carcasses or other fish flesh with 50% meal mixed in a mechanical mixer, then re-processed thru a power grinder, provides a very satisfactory pellet.

During the ensuing year I hope to be able to experiment with different types of machinery for breaking up frozen blocks of materials now used for feed.

Discussion

Burrows: Did you alternately feed meat with the pellets?

Lavier: Yes.

Burrows: Did you have trouble with the pellets oxidizing during storage?

Lavier: Yes, we did. We had some heating of the material but were able to overcome the trouble by stirring the material periodically, however, we have made no rancidity tests.

Rucker: Would a cement mixer help in preparing the pellets?

Burrows: I believe that a dough mixer is better.

Cannady: A concrete mixer is used at Cortland, N.Y. in preparing a semi-dry food mix.

Sinnhuber: Are you able to get any bind in this mixture?

Lavier: Yes, with 2% salt in some mixes, but comparison between mixes is difficult because of the variation in moisture content between various types of fish products. The availability of the food in this form is fine.

Ellis: I have noticed that addition of red coloring makes the food more attractive and results in better food consumption by the fish.

Keller: Is there an Idaho representative here? I visited the state hatchery at Hagerman recently and found that they are making and distributing pellets there. The superintendent, Elwood Grimes, feels that they are very successful although some hatchery men do not feed them correctly. The only disadvantage is that they sink rapidly. The ingredients are purchased in carload lots and turned over to a local packing company to make the pellets, which are then distributed to the various hatcheries. The pellets are stored either at room temperature or in cold storage. I do not know if gelatin is one of the ingredients.

Pellets are not fed continuously, meat must be used sometimes.

In Montana we have known of pellets for some time but have not been successful with them. The fault may lie in our method of feeding.

Red Johnson: Do you have a statewide production diet?

Millenbach: No, we have no set production diet. We feed the materials which are available at the time.

Washington State Department of Fisheries

Speaker: Bud Ellis

PROGRESS BRIEFS ON EXPERIMENTAL DIETS WITH SALMON OF THE 1950 BROOD

Diet experiments were carried on at two locations: At the Kalama Hatchery, located on the Kalama River, and the Minter Creek Hatchery, located on Minter Creek.

KALAMA HATCHERY (FALL CHINOOK SALMON)

Feeding experiments were carried on at the Kalama Hatchery on the 1950 brood fall chinook salmon. Experimental fish were placed in 8 wooden tanks 6' in diameter, each tank equipped with individual inlets and outlets. Each tank was loaded with 2,500 fish which averaged 996 per pound at the beginning of the experiment. The fish were in the fry stage, just beginning to feed, and were put on the experimental diets at the first of their feeding and carried through a 20-week period.

Only four diets were used for the 8 tanks, i.e., duplicate diets being fed four batteries of two tanks each. Experiments began on January 26, 1951, and ended June 15, 1951.

Populations within the experimental tanks were reduced 25% each four weeks, until May 12, when populations were reduced 50%. This resulted in populations which started with 2,500 fish per tank being reduced to 527 per tank on May 12. The population reductions as listed were in keeping with procedures followed in the large production rearing ponds, and the resulting populations were proportionate throughout.

Diets used were as follows:

Diet #1:	Salmon and halibut sawdust	3%
	Salmon viscera	40%
	Salmon carcasses	18%
	Salmon heads	15%
	Beef liver	20%
	Yeast	2%
	Salt	2%
Diet #2:	Beef liver	40%
	Meal mix (Donaldson's)	60%
Diet #3:	(Leavenworth Diet)	
	Beef liver	20%
	Hog liver	20%
	Hog spleen	20%
	Salmon viscera	30%
	Meal mix (Donaldson's)	10%

(Meal mix being deleted when temperatures were below 50°F.)

Diet #4:	Salmon viscera	81%
	Beef liver	15%
	Yeast	2%
	Salt	2%

Results obtained for the period of the experiment are as follows:

Diet	Starting Weight of Fish (Fish per lb.)	Ending Weight of Fish (Fish per lb.)	Total Mortality for Experiment (Two Tanks)
Diet #1	996	130	175
Diet #2	996	292	556
Diet #3	996	133	247
Diet #4	996	123	125

Temperatures for the period of the experiment ranged from an average daily mean of 36° F. minimum to 60° F. maximum.

Total populations of fish in each tank were weighed weekly for computing weights, and measurements of the weights made within an accuracy of 1/100 of a pound.

MINTER CREEK

Feeding experiments were conducted on 1950 Brood salmon at Minter Creek, to determine any apparent effect of supplementing diets with synthetic vitamins at approximately the same levels that Wolf used for a complete synthetic diet on trout.

Listed on the following page are the comparative levels of Wolf and the State diets, as supplemented with Lederle's "Fortafeed" 249-C, and Lederle's "Aurofac".

Five diets were used at Minter Creek as follows:

Diet #1: 83% Viscera
15% Beef liver
2% Yeast

Diet #2: 83% Salmon carcasses
15% Beef liver
2% Yeast

COMPARATIVE VITAMIN CONTENTS OF DIETS USED AT MINTER CREEK IN 1951 FEEDING EXPERIMENTS AND COMPARED TO WOLF'S NEW YORK EXPERIMENT AS DESCRIBED IN THE JANUARY, 1951 PROGRESSIVE FISH CULTURIST

	WOLF'S FEEDING LEVELS	STATE'S DIETS SUPPLEMENTED BY: LEDERLE'S "AUROFAC" AND LEDERLE'S "FORTAFEED" - 2-49C @ 20 lbs. each per ton of feed	
Riboflavin	20 mgs. in 400 grams	20 mgs. in 453.6 grams	(1 lb.)
Calcium Pantothenate	28 mgs. in 400 grams	40 mgs. in 453.6 grams	"
Niacin	80 mgs. in 400 grams	90 mgs. in 453.6 grams	"
Choline	80 mgs. in 400 grams	100 mgs. in 453.6 grams	"
Folic Acid	1.5 mgs. in 400 grams	.6 mgs. in 453.6 grams	"
B_{12}	9 mcg. in 400 grams	15.8 mcg. in 400 grams	"

Diet #3: 100% Salmon viscera
Plus the supplement 4.54 grams "Fortafeed" per pound of feed fed, and 4.54 grams "Aurofac" per pound of feed fed.

Diet #4: 100% Carcasses
Plus the supplement of 4.54 grams "Fortafeed" per pound of feed fed, and 4.54 grams of "Aurofac" per pound of feed fed.

Diet #5: 40% Beef liver
Plus 60% Donaldson's meal mix

MINTER CREEK FALL CHINOOK SALMON

Feeding experiments began on these fish on March 12, 1951, when they weighed 970 to the pound. They received the experimental diets from the beginning of their feeding. Experiments are still in progress.

Ten raceways of chinook received the diets, two raceways receiving duplicate diets of the five, as listed above.

Results to date are that the supplementation of the vitamins, as used, has no apparent effect on the well-being of the fish, and that the highest remaining populations (that is, those with the lowest total mortality) are on Diets #1 and #2, respectively, these fish also being the largest - now weighing 20 to the pound.

The poorest diets are Diets #4 and #5, respectively, such fish having the lowest residual population, fish on #4 Diet weighing 45 to the pound; those on #5, however, weighing 24 to the pound.

Fish on Diet #3 showed poor survival in one of the two populations receiving this diet, and good survival in the other population. (Fish on this diet weigh 27 to the pound).

All fall chinook on these diets have become infected with kidney disease, and much of the differentiations because of diets have been obscured because of the disease complication.

MINTER CREEK SILVER SALMON

Five raceways of silver salmon, one raceway on each of the experimental diets, as listed above, were utilized for feeding experiments. Fish weighed 1,100 per pound at the beginning of the experiment, and received the diets as listed from the beginning of feeding, to date. Feeding experiments are still under way.

General results to this point of the experiment, after fish have been fed over 327 days, show the following:

Diet	Remaining Population	Number Fish Per Pound
#1	10,496	33
#2	10,953	27
#3	10,122	35
#4	1,811	42
#5	7,039	40

To date, therefore, it may be noted that the best diet is the carcasses, with liver and yeast (Diet #2), whereas the poorest diet is the carcasses with the vitamin supplement (Diet #4). There were reductions of populations in these experimental fish after the beginning of the experiment.

The residual populations, as listed above, is that remaining from the last reduction, which occurred in June of 1951 when the population of each pond was reduced to 11,600 fish.

Discussion

Red Johnson: Are you successful in binding the viscera diet?

Ellis: Yes, with frost in the diet, the bind is good.

Burrows: Milt gives an excellent bind. The bind obtained with the viscera varies with the amount of milt in the viscera.

Sinnhuber: Was there any anemia in the fish fed these diets?

Ellis: Yes, in those fed salmon carcass.

Burrows: What did the sick fish look like?

Ellis: There was lot of serous fluid, bloating, and popeye in the fish. No pathogenic organisms were seen.

Sumerwell: How many ponds are required to be run on a single diet for proper statistical analysis?

McKernan: One pond is all that is necessary if the experiment is carried over a long period of time. We run a single trough on each diet. Periodically and at random we move these fish to a different location in the hatchery. We also stabilize the water flow through the troughs.

Halver: Your method is not statistically sound. You can't run a statistical analysis where only a single trough is fed on a diet. You must have two troughs, at least.

Hull: These diets need to be duplicated at different hatcheries because of the varied conditions. Results that are obtained at one station don't necessarily apply at all hatcheries.

McKernan: In the laboratory, we take into consideration the fact that these variations exist between hatcheries.

Sumerwell: In diet experiments using rats or guinea pigs, a minimum of six test animals are needed for statistical analysis of the results.

Burrows:	In diet experiments using fish, many test animals of varied sizes are used to test a diet. At Entiat, using paired troughs, we have a coefficient of variability of only $2\frac{1}{2}$%.
Sumerwell:	I'd like to have someone explain to me the use of statistics in fish nutrition.
Burrows:	I would suggest that each one giving a report write up his report and send it in for use in preparing the main report of the meeting.
Halver:	I would also like a list of the literature cited with the report.

Oregon Fish Commission

1950 Feeding Experiments
Speaker: Ernie Jeffries

Statement of Accomplishments:

The feeding experiment was conducted at the Bonneville Fisheries Station, Bonneville, Oregon. The water supply used was Tanner Creek, a cold water creek and source of the hatchery water supply. The experiment was carried on over a 30-week period. The fish were weighed bi-weekly and the food intake adjusted to the new weight of the lot. The fish were fed seven days a week and from two to four times daily during the feeding period, depending on how well they consumed their food. The foods fed and the results obtained will be found in the context of the discussion.

There were 12 starting diets in the feeding experiment. All food intakes were based on dry weight of the food fed. Water content analyses were made at the Seafoods Laboratory at Astoria. The lots were first fed two percent of their body weight (dry weight of food) daily. As the water temperatures cooled down the amount of food fed was decreased to 1.5 percent and finally to one percent during the cold water months of December, January, and February.

Other than Lots 5, 6, 7, and 11, which were shown to be inadequate during the experiment, all lots were fed the full 30-week feeding period. None of the lots fed the 30-week period broke i.e. exhibited weight loss and high mortalities on the diets fed.

A discussion of the diet components and the reactions of the individual lots of fish to their respective diets follows:

Diet 1 - Lot 1

Control diet: beef liver - 98 percent; salt - 2 percent.

The liver control lot finished the feeding experiment in seventh place in weight gain. The fish appeared quite jittery for most of the feeding experiment, and for the most part it was difficult to get the fish to eat all their daily ration. The losses were low but the weight gain was not too good. This experiment corroborates earlier findings that a diet of beef liver is satisfactory for a time but in combination with other food components does much better. The high cost and scarcity of this food item makes its use prohibitive in large scale feeding operations.

Diet 2 - Lot 2

Beef liver - 96 percent; supplemental salts - 4 percent.

Since this diet had proved superior in an earlier feeding program, it was decided to try it again. It was believed that the biological salts IV (supplemental salts) added some unknown factor to the growth of the fish. It was found, however, that Lot 1 did equally as well as this lot and that the added chemical components in the biological salts IV were not needed. The lot finished the experiment just a few grams heavier than the control lot. The losses were low but the growth was only fair. The fish were not jittery, however, and ate better than the control lot for the feeding period.

Diet 3 - Lot 3

Beef liver - 76 percent; corn oil - 10 percent; salmon meal - 10 percent; supplemental salts - 4 percent.

This lot finished in third place in weight gains and was declared a superior diet. The lot did very well on the diet, and the losses were the lowest for any lot. It was apparent from the results that corn oil and salmon meal added something to the growth factor in the diet even when fed at low water temperatures. The fish were in very good condition at the end of the experiment. Further work in addition of salmon meals to diets is contemplated in order to study the efficiency of salmon meal at varying water temperatures.

Diet 4 - Lot 4

Beef liver - 32.6 percent; hog liver - 32.7 percent; salmon viscera - 32.7 percent; salt - 2 percent.

This lot was heaviest for most of the 30-week feeding program. This diet is a slight modification of one of the production diets used at the U. S. Fish and Wildlife Leavenworth Fisheries Station. It was definitely a superior diet but costly to feed; it is an all meat diet and the scarcity of supply as well as rising costs makes it prohibitive on large scale feeding programs.

Diet 5 - Lot 5

Tuna liver - 10 percent; synthetic meals - 90 percent.

On October 24, 1950, after 12 weeks on this experimental diet, Lot 5 was declared "broken" because of unusually high mortalities and general debility of the fish. After this lot was declared broken they were placed on a rehabilitation diet of 98 percent beef liver and two percent salt for a two-week period and then placed on a diet of 10 percent beef liver and 90 percent synthetic meals as a check diet for Diet 10. They were held on this diet for eight weeks.

During this time the fish appeared in better shape and increased in weight, and the losses dropped. This lot was then placed on a diet of 10 percent salmon liver and 90 percent synthetic meals for the final eight weeks of the experiment. The fish did quite well on this diet and were in quite good shape at the end of the feeding experiment on February 27, 1951. It was found that tuna liver fed at 10 percent in combination with 90 percent synthetic meals was an unsatisfactory diet.

Diet 6 - Lot 6

Salmon liver - 10 percent; synthetic meals - 90 percent.

On October 24, 1950, after 12 weeks on this experimental diet, Lot 6, like Lot 5, was declared broken because of unusually heavy mortalities and general debility of the fish. This lot was also given a build-up diet of 98 percent beef liver and two percent salt after being broken on the above diet. This lot was then placed on a diet of 10 percent Argentina beef liver meal and 90 percent synthetic meals for an eight-week period. The fish looked in fairly good shape at this time. The final eight weeks this lot was fed a diet of 10 percent tuna liver and 90 percent synthetic meals, and at the end of the feeding experiment the fish were in poor shape and near the breaking point. It was found from the above results that salmon liver as well as tuna liver at the 10 percent level fed in combination with 90 percent synthetic diet proved unsatisfactory as a diet component.

Diet 7 - Lot 7

Sardine stickwater - 5 percent; synthetic meals - 95 percent.

Lot 7 also was discontinued as broken on October 24, 1950 because of unusually heavy losses and generally poor condition of the fish. This lot after being broken was not given the customary two-week build-up diet of beef liver but was placed directly on a diet of 19 percent Argentina beef liver meal, 79 percent hake, and 2 percent salt. The lot did not do too well on this diet but was held on for a 10-week period. It was decided then to rehabilitate the lot with a diet composed of 49 percent beef liver; 49 percent hog liver; and 2 percent salt. The final eight weeks Lot 7 was fed the beef liver-hog liver combination and were in fair shape and increasing in weight gain at the end of the experiment. From the results of this feeding test it was found that the sardine stickwater at five percent level in synthetic diet was an unsatisfactory diet component. Later analysis of the stickwater used in this diet showed it to be much too high in ash content. Further studies on the use of another sardine stickwater are underway in the 1951 feeding program.

Diet 8 - Lot 8

Hog liver - 32.7 percent; salmon viscera - 32.7 percent; Argentina beef liver meal - 32.6 percent; salt - 2 percent. (The Argentina liver meal calculated on wet weight basis)

This lot started slowly but made extremely good growth during the cold water months and ended as the top lot in weight gains. The results indicate that the liver meal does contain the anti-anemic factors found in fresh beef liver and should be further studied as a source of food. The meal sells for about 15 cents a pound and is 92 percent dry. Calculated on the wet weight of fresh beef liver this meal cost approximately five cents per pound. The use of Argentina liver meal is encouraged. Further work is being done with the Argentina liver meal. The commodity is plentiful and the price is reasonable.

Diet 9 - Lot 9

Salmon eggs - 10 percent; synthetic meals - 90 percent.

At first the lot did well, but the growth pattern was not consistent. The mortalities were greater than average. The lot ate only fairly well during the feeding experiment. At the end of the experiment this lot was in eighth place in weight gain and was on the verge of breaking. Salmon eggs at the 10 percent level in a synthetic mix were found to be unsatisfactory as a diet component.

Diet 10-Lot 10

Beef liver - 10 percent; synthetic meals - 90 percent.

This was found to be a superior diet. The fish did well, and were in fine shape at the end of the experiment. The lot ended up in fourth place in weight gain. At the 10 percent level, beef liver in synthetic meals was found to be a satisfactory diet. Further work is being done with this diet in the current feeding program.

Diet 11 - Lot 11

Beef liver - 60 percent; meal mixture - 40 percent.

This lot was fed on a diet which is used at the University of Washington School of Fisheries. The fish did poorly from the first few days of feeding. They refused to eat the food. The food was first blended in a shallow pan and then run through a blower to break up the particles. After two weeks of feeding, the lot was declared broken because of the unusually heavy mortality and emaciated condition of the fish. It is not known why the fish refused to eat this diet. After being broken, the lot was given a two-week build-up of 98 percent beef liver and two percent salt. They responded well and showed a good growth increase for the two-week period. They were then placed on a vegetable protein diet compounded at the Astoria Seafoods Laboratory. The consistency of the vegetable protein was similar in some respects to the dry diet originally used. The fish also refused to eat this diet and were again declared broken after feeding two weeks. This lot was then fed beef liver 98 percent and salt two percent for an eight-week period. The growth was good and the losses decreased. A diet of 19 percent beef liver, 79 percent shad and two percent salt was fed for a 12-week period. The fish did extremely well for about 10 weeks and then broke with a heavy mortality and generally poor condition of the fish. The lot was then placed on a diet of 98 percent beef liver and two percent salt for the final four weeks of the feeding program. It was found that the dry diet was unsatisfactory; the fish refused to eat this diet. Likewise, the vegetable protein diet was found to be unsatisfactory. They also refused to eat this diet. It was found that shad fed at 79 percent of the diet did well for a time but broke in 10 weeks with a heavy loss of especially the larger fish. The gill color was bad, denoting anemia. Several of the sick fish were preserved in Bouin's solution for later cytological work on the livers. A complete breakdown of the liver is suspected.

Diet 12 - Lot 12

Beef liver - 19 percent; hake (in the round) - 79 percent; salt - 2 percent.

Although the growth pattern was not phenomenal in this lot, the pattern was steady and the losses low. The lot ended in fifth place in weight gain for the feeding experiment. It was found difficult to bind the resultant liver-hake mixture and much of the food materials were leached out and down the drain. It is felt that if a good binder agent could have been used that this lot would have done better. The fish ate well during the feeding experiment and were in very good shape at the end of the experiment. The diet was one of the most inexpensive used. Hake can be purchased for about five cents a pound. Burrows, et.al., of the U.S. Fish and Wildlife Service Leavenworth Hatchery have experimented with hake and found it to be an acceptable dietary component. Further work on hake in the diet of fish is being undertaken.

Final Results Obtained

Salmon and tuna livers at the 10 percent level, fed on dry weight basis, are not satisfactory diet components when mixed with 90 percent synthetic meals. (See Diets 5 and 6) Beef liver at the 10 percent level mixed with 90 percent synthetic meals produced a superior diet. Hake (in the round) has proven very satisfactory as a diet component and further work with hake as a diet component is urged. Salmon eggs, while containing a good growth factor, have proven unsatisfactory when added at the rate of 10 percent in combination with 90 percent synthetic meals. The salmon eggs have caused an abnormally heavy mortality. The Argentina beef liver meal shows great possibilities as a substitute for fresh liver, and its further use and experimentation is urged.

The diet using salmon meal and corn oil in addition to beef liver is a superior diet and indicates that at water temperatures of between 35 and 57 degrees F. the meal and oil have been valuable supplements, even at low water temperatures. Further work on the use of salmon meal as a diet component is being conducted. Shad in the round minus the roe at 79 percent level fed lot 11 after it had been broken and rehabilitated proved unsatisfactory. High mortalities and general poor condition of the fish forced the abandonment of feeding shad at 79 percent level. Shad is a cheap food source and further experimentation using from 5 to 15 percent in combination with other foods is urged. An experimental diet using shad at 10 percent in combination with other food components is being tested now at the Marion Forks Laboratory.

Since the dietary requirements of spring chinook salmon have not been properly assessed and since many food items previously considered desirable are becoming difficult to obtain in adequate amounts and at reasonable cost,

TABLE 1.

Lot	Initial Weight	Final Weight	Weight Increase	Percent Increase	Cumulative Mortality	Percent Mortality	Conversion Factor
1	3500	8,552	5052	144%	65	5.9%	3.76
2	3500	8,597	5097	145%	73	6.1%	3.68
3	3500	10,893	7393	211%	30	2.7%	2.84
4	3500	11,239	7739	221%	40	3.4%	2.65
8	3500	11,269	7769	222%	48	3.9%	2.11
9	3500	7,550	4050	116%	260	23.0%	4.51
10	3500	10,354	6857	196%	66	5.7%	3.05
12	3500	9,135	5635	161%	54	4.5%	3.14

Note* Lots 5, 6, 7, and 11 were discontinued and not included in this table.

it is felt that these studies are very significant. The findings are already proving useful.

Discussion

Palmer: Did the fish fed on the shad diet show a dark color?

Jeffries: Yes, also a good deal of "popeye".

Palmer: Did the fish in any of these diets become anemic?

Jeffries: Yes, the last two diets, except the 11th.

Composition of Diets
Speaker: R.O. Sinnhuber

All remarks are confined to the summer 1951 series experiments run at Bonneville Dam.

Since the previous experiment 1950-51 series had shown that a modified purified dry diet very similar to that of the Wisconsin workers would support fair growth of chinook salmon, it was decided to continue use of this tool in the present studies. A purified dry diet offers certain advantages in that it can be prepared so as to give certain definite values for protein, ash, fat, and carbohydrates; and this diet may be duplicated or varied to give a food of any desired concentration of nutrients. Vitamins and growth factors may also be incorporated, and by either addition, subtraction or substitution possible food components may be compared and assayed. Another difficulty encountered in many diets is the problem of binding the diet. In previous work it was found that several food components, notably hake and some fish livers, leached so easily that it is impossible to assay its value as a food for raising fish. It was found that many of these foods if dried and then incorporated in a test diet with gelatin and Kraystay T, a bound diet resulted with very little leaching. In the past the Seafoods Laboratory has studied many methods of drying fish waste, and the drum dryer was finally used to give a meal that is only briefly heated, approximately 3 seconds, and at a fairly low temperature--approximately 160°F. Meals prepared by this method and using Kraystay T would produce diets that were free from leaching and enabled a comparison of several food components.

All 12 diets fed were adjusted to contain the same protein, ash, carbohydrate, fat, and moisture content with the exception of diet #12--a modified Wolf's diet. This particular diet, because of the difficulty of feeding thru a ricer, was made higher in water content. The Wisconsin diet was modified so as to contain at least the same vitamin content as the Leavenworth Production diet which was found previously to be a superior diet. All diets were fed at the same level, only the particular component that was added to the basal modified Wisconsin diet was tested.

The following observations were made: Wolf's diet in which the diet was modified to contain vitamin-free casein instead of crude casein supported fair growth for approximately 20 weeks contrary to Wolf's report, which stated that trout refused to eat vitamin-free casein; however, at the conclusion this lot was heavily infected with kidney disease and mortalities were increasing.

The modified Wisconsin diet apparently is a fully adequate diet under the conditions of the experiment.

Argentine beef liver offered no additional beneficial effects when added to the Wisconsin basal diet.

When drum dried beef liver was added to the basal diet at the same level as the Argentine liver meal, a definite increase in growth was noted.

Approximately the same growth response was given by the addition of 5% condensed fish solubles or stickwater to the dry diet as was obtained by the drum dried beef liver.

An additional jump in growth was obtained when fresh frozen beef liver was added to the basal diet in the same amount as the Argentine or drum dried beef liver. These experiments indicate that there is a substance present in beef liver that stimulates growth which is effected adversely by heat since a maximum response was obtained by fresh frozen liver, a lesser effect with drum dried liver meal, and no effect over the basal diet with dried Argentine liver meal, which was old meal of doubtful quality.

Grasshoppers which had been dried in air when incorporated in the basal diet at a 10% level (dry basis) were superior to drum dried beef liver, but was not equal to fresh beef liver supplement.

Commercial fish meal did not quite equal vitamin-free casein as a source of protein for fish under the conditions of the experiment, and on the basis of only this one experiment one might question the value of commercial fish meal, however, this lot will be repeated in the future.

Salmon viscera meal, drum dried, was slightly superior to vitamin-free casein as a source of protein for raising chinook salmon.

The Leavenworth diet was a superior diet and good growth was obtained with this combination of wet foods.

The hake diet in which hake is substituted for the vitamin-free casein showed that drum dried hake meal was superior to vitamin-free casein and that growth was better than in Leavenworth diet.

Drum dried turbot meal again substituted for vitamin-free casein in the basal diet gave the best growth of all diets tested.

This experiment indicates that there is a substance present in fresh beef liver that assists and promotes growth in chinook salmon. This substance is adversely affected by heat. Condensed fish solubles and air dried grasshoppers also have a substance which promotes growth. Turbot and hake serve as excellent food for chinook salmon and are superior to the commercial meal tested, and when combined with 10% frozen beef liver apparently provide fish with all the essential material needed for rapid growth. It is a possibility that there is a substance or factor responsible for growth in chinook salmon that is present in beef liver, fish, grasshoppers, and condensed fish solubles that is affected by heat, but which is different from any of the commonly described vitamins or factors including B_{12} or antibiotics.

Discussion

Palmer: Has there been any attempt to evaluate the Argentine beef liver meal for the anti-anemic factor?

Sinnhuber: There are apparently two Argentine beef liver meals--one good, the other no good as our experiments will bear out.

Palmer: Were the tuna livers, used in the experiment, frozen, thawed and refrozen?

Sinnhuber: Yes, two freezings.

Halver: What percent ash was there in the condensed herring solubles?

Sinnhuber: There was about 12% ash.

Ellis: Why did you add the corn oil?

Sinnhuber: Because of the high growth--the increase in calories. Corn oil has $2\frac{1}{2}$ times the calories.

Burrows: What about glycogen in the livers?

Sinnhuber: We made no analysis for glycogen. The liver had uniform, firm rounded lobes as contrasted with the other diets in which the fish had irregularly shaped livers.

Sumerwell: You got some good growth on your diets. Did you make any attempt to fractionate the livers?

Sinnhuber: Yes, we did in the 1951 diet experiments.

1951 Feeding Experiments
Speaker: Tom McKee

Statement of Accomplishments:

The feeding program was conducted at the Bonneville Fisheries Station, Bonneville, Oregon. The water supply used was Tanner Creek, a cold water creek and source of the hatchery water supply. The experiment was carried on over a 22-week period, May 22 through October 24, 1951. The fish were weighed bi-weekly and the food intake adjusted to the new weight of the lot. The fish were fed six days a week and from two to four times daily during the feeding period, depending on how well they consumed their food. The foods fed and the results obtained will be found in the context of the discussion.

There were twelve starting diets in the feeding experiment. All food intakes were based on the dry weight of food fed. Water content analysis were made at the Seafoods Laboratory at Astoria. The lots were first fed three percent of the body weight (dry weight of food) daily. As the water temperatures cooled down the amount of food fed was decreased finally to one and one half percent in October. All diets were found to be adequate for the twenty two week feeding period. A discussion of the diet components and the reactions of the individual lots of fish to their respective diets follows:

Diet 1 - Lot 1

100% (Oregon modification of the Wisconsin synthetic (purified) diet)

This lot ended the experiment in eleventh place in weight gain. The fish were in fair shape upon termination of the experiment. They readily ate the daily ration of food. The losses in this lot were low but the weight gains were also low. The materials used in the Oregon modification of the Wisconsin synthetic diet material were altered somewhat from the materials used in the 1949-

1950 feeding experiments. The average red blood cell count of ten fish sacrificed at the end of the experiment was 1,350,000 per cubic millimeter.

Diet 2 - Lot 2

(32.6% beef liver, 32.7% hog liver, 32.7% salmon viscera and 2% salt) (control diet)

This is one of the diets used at the Leavenworth hatchery in production feeding to chinook salmon. This was a superior diet, producing fine growth and very low mortality. The average red blood cell count of ten fish was 1,475,000 per cubic mm.

Diet 3 - Lot 3

(90% Oregon modification of the Wisconsin synthetic diet, 10% Argentina beef liver meal)

This lot finished in tenth place, not significantly different from lot #1. Argentina beef liver meal was used to determine its efficiency as compared to or as a substitute for fresh beef liver. It was found at the level used, that the liver meal was not a suitable substitute for fresh beef liver when used in combination with a synthetic diet. The average red blood cell count of ten fish was 900,000 per cubic mm.

Diet 4 - Lot 4

(90% Oregon modification of the Wisconsin synthetic diet, 10% fresh frozen beef liver)

This diet was used as a second control diet. It had produced superior growth in previous work so was used again as a check for lots 3 and 5, which also contain liver. The lot ended in fifth place in weight gain amd were in fine shape at the termination of the experiment. The average red blood cell count of ten fish was 1,020,000 per cubic mm.

Diet 5 - Lot 5

(90% Oregon modification of the Wisconsin synthetic diet, 10% drum dried beef liver meal)

The drum dried beef liver meal was prepared from fresh condemned livers, at the Seafoods Laboratory at Astoria. The drum drying was at low temperatures. This diet was used to compare drum dried liver product with the Argentina prepared beef liver meals and to also determine if the drum dried liver meal could be used as a substitute for fresh beef liver. The lot ended in ninth place in weight gain. It is indicated that some heat labile components are lost during drum drying and even more are lost when the material is cooked and pressed as is the Argentina beef liver meal. Beef liver meal (drum dried) is not a satisfactory substitute for fresh beef liver when fed at the prescribed levels. The average red blood cell count of ten fish was 1,140,000 per cubic mm.

Diet 6 - Lot 6

(90% Oregon modification of the Wisconsin synthetic diet in which most of the more expensive vitamin test casein was replaced by drum dried hake meal, plus 10% beef liver)

The hake meal was prepared from fresh hake in the round obtained in Astoria, disintegrated and drum dried at the Seafoods Laboratory. This is the first in a series of synthetic diets in which the more expensive components are being replaced by cheaper products. The hake meal replaced most of the casein as the protein component of the synthetic diet. This lot ended the experiment in second place and was in fine shape. The average red blood cell count of ten fish was 1,170,000 per cubic mm.

Diet 7 - Lot 7

(90% Oregon modification of the Wisconsin synthetic diet in which most of the vitamin test casein was replaced with turbot meal, 10% beef liver)

The turbot was obtained fresh at Astoria, disintegrated, and then drum dried at the Seafoods Laboratory. As in the diet #6 above, the fish product replacement for the casein was studied to determine if fish proteins could replace the more expensive casein in the synthetic diet. This lot was the heaviest of all lots. The fish were in excellent shape. The average red blood count of ten fish was 1,180,000 per cubic mm.

Diet 8 - Lot 8

(90% Oregon modification of the Wisconsin synthetic diet in which most of the vitamin test casein was replaced with salmon viscera meal, 10% beef liver)

The salmon viscera was collected fresh in Astoria and disintegrated and drum dried at the Seafoods Laboratory. Here, a waste fish meal was used to replace casein in the synthetic diet. The lot ended in fourth place and was in good shape at termination of the experiment. No evidence of anemia was noted, however the average red blood count of ten fish was 880,000 per cubic mm.

Diet 9 - Lot 9

(90% Oregon modification of the Wisconsin synthetic diet in which most of the vitamin test casein was replaced by commercial salmon meal, plus 10% beef liver.)

The salmon was commercially prepared from fall chinook salmon carcasses of the Bonneville spawning operations. The meal was prepared by Bio-Products Inc. of Warrenton, Oregon and the product was steam jacket dried at high temperatures. Average red blood cell count of ten fish was 1,020,000 per cubic mm.

Diet 10 - Lot 10

(95% Oregon modification of the Wisconsin synthetic diet plus 5% sardine stickwater.)

This diet was composed to determine the efficiency of sardine stickwater as compared to beef liver and to find if stickwater could be used as a substitute for beef liver. This experiment was tried in the 1950 work but the fish lot developed severe anemia. The sardine stickwater used in this experiment was from a different batch which analyzed less in minerals (ash) than the material used in 1950.

This lot ended in 8th place just a bit higher than the drum dried liver meal supplement of diet #5. The average of ten fish gave a red blood cell reading of 1,250,000 per cu. mm.

Diet 11 - Lot 11

(90% Oregon modification of the Wisconsin synthetic diet plus 10% air dried grasshopper meal.)

The grasshoppers were received in the dried condition courtesy of the Florida State Agricultural Experiment Station. They were made into a meal at the Seafoods Laboratory at Astoria. Although the growth gains were not as good as that for the fresh beef liver, the dried grasshopper meal bears further experimental work. The lot ended in 7th place and an average of 1,250,000 red blood cells per cu. mm. were reported on ten fish checked.

Diet 12 - Lot 12

(Wolf's synthetic diet 100%) (described in Prog. Fish. Cult. 13 #1 pp 17-24 Jan. 1951.)

This lot ended in 12th place in weight gain. The losses were heaviest and the growth poorest of any lot. The lot was anemic at the end of the experiment. Wolf's diet was inadequate to maintain growth and vigor of spring chinook salmon under Tanner creek water conditions. This diet was used as a comparison with Lot #1, which was the Oregon modification of the Wisconsin synthetic diet, both being synthetically prepared diets. These diets are valuable in that once a diet has proved to be adequate, the different components can be deleted one by one and in this way the elusive "H" factor or factors will be isolated. An average of 750,000 red blood cells per cu. mm. of blood were checked from ten fish.

Final Results Obtained:

The Oregon modification of the Wisconsin synthetic diet at the 100% level was found to be an adequate diet, however the growth response of the fish on this diet was not too great. Argentina beef liver meal at the 10% level in a synthetic mix was not a satisfactory substitute for beef liver. Likewise the drum dried beef liver meal was found inferior to fresh beef liver. Diets 6, 7, and 8 using fish product meals to replace casein, all showed a greater weight increase than Lot #4, which used the synthetic mix and the casein. Commercial salmon meal in the synthetic meal replacing the casein produced growth approximating that of the ration containing casein. Sardine stickwater at the 5% level was not an equal substitute for beef liver but proved to be an average diet. More work will be done on stickwater. A grasshopper meal supplement to the synthetic mix proved out quite successful and almost as good as the fresh beef liver supplement when fed at the 10% level. Wolf's synthetic diet was found to be inadequate. The fish were going anemic at the end of the experiment and the losses were increasing at that time. Further work will be carried on using fish supplements in a synthetic diet to replace casein. Since the dietary requirements of spring chinook have not been properly assessed and since many food items previously considered desirable are becoming difficult to obtain in adequate amounts and at a reasonable cost, it is felt that these studies are very significant. The findings are already proving useful.

Discussion

Burrows: Were hemoglobin content and erythrocyte counts taken from the same fish?

McKernan: Yes, but there was no correlation.

Burrows: When we ran them at the termination of the 1950 diet experiments, we got a correlation.

Your synthetic diet did not contain 10% beef liver when figured on a wet basis--only approximately 3.6%.

Sinnhuber: Then the diet showed up better than average since only 3.6% beef liver was used, instead of 10%.

TABLE 1

Lot	Initial Weight	Final Weight	Weight Increase	Percent Increase	Cumulative Mortality	Percent Mortality	Conversion Factor
1	2000	10,263	8,263	413%	32	2.4%	2.49
2	2000	16,658	14,658	739%	11	.82%	1.55
3	2000	10,408	8,408	420%	41	3.2%	2.42
4	2000	14,527	12,527	621%	18	1.3%	1.93
5	2000	12,390	10,390	519%	20	1.5%	2.16
6	2000	18,019	16,019	800%	12	.92%	1.68
7	2000	20,437	18,437	921%	6	.5%	1.44
8	2000	15,003	13,003	650%	5	.4%	1.78
9	2000	13,964	11,964	598%	7	.5%	1.77
10	2000	12,469	10,469	523%	18	1.4%	2.02
11	2000	13,797	11,797	589%	20	1.5%	2.07
12	2000	8,852	6,852	342%	141	10.4%	2.15

Weights in grams

Burrows: Then the fish receiving the synthetic meal showed no anemia?

Sinnhuber: That's right.

Palmer: It appears to me that if grasshoppers can be dried without loss of the anti-anemic factor while the drying of beef liver destroys the anti-anemic factor, the grasshoppers might be a much more valuable dry meal supplement.

Sinnhuber: We obtained the grasshoppers from Georgia. They were collected there by 4-H club members.

Burrows: We had an offer from Wyoming for dried grasshoppers but the price quoted was 40¢ per lb. and it seemed too high to consider.

Our experiments confirm your results with hake and turbot.

Rucker: Was the visceral fat analysed visually or chemically?

Sinnhuber: Chemical analysis of the fat was made.

Palmer: The turbot meal looks good. How large is the supply available and at what cost?

McKernan: There is an excellent, almost inexhaustible supply since it is not used commercially, at present, and is therefore thrown overboard. It could be obtained very reasonably.

Marion Forks First Feeding Experiment
Speaker: Wally Hublou

Statement of Accomplishments:

The experiment was conducted at the Marion Forks Hatchery for a period of 18 weeks (December 7, 1950 through April 10, 1951). Six diets were used in this experiment, a cold water experiment to determine the percentage of beef liver, required to keep spring chinook in health and vigor. The fish were fed 3 to 4 times a day, depending on how well they took their food. They were fed six days a week.

The amount of food fed was based on a dry weight basis and totalled 1% of the body weight of the fish.

Six circular concrete rearing tanks 25' in diameter and with an 18" water depth were used. Each tank was stocked with 52,210 grams of fish averaging 7.38

grams each or approximately 7,073 fish per pond. The stock used was spring Chinook of the North Santiam river strain. The average weight per fish was determined by four random samples of 908 grams per sample. Two samples from each pond were taken biweekly to calculate the weight gain. It was found impractical to weigh all fish in each pond on weigh day. Methods of sampling were kept as constant as possible to get a good random group for the sampling.

Six diets were used:

Diet 1 98% beef liver, 2% salt (control lot)

The control diet did not do as well as expected. The fish did not feed too well and were very scary. It was noted that this lot did the poorest in water temperatures less than 38°. Losses were about average or slightly above.

Diet 2 44% salmon flesh, 44% salmon viscera, 10% beef liver, 2% salt.

This lot made fair growth on the diet. They ate well during the experiment and the losses were average.

Diet 3 49% salmon flesh, 39% salmon viscera, 20% beef liver, 2% salt.

This lot made fair growth on the diet. They ate well during the experiment and the losses were average.

Diet 4 Salmon flesh 34%, salmon viscera 34%, beef liver 30%, salt 2%.

This lot made fair growth on the diet. They ate well during the experiment and the losses were average.

Diet 5 Shad 30%, salmon viscera 48%, Argentina liver meal 20%, salt 2%.

This diet showed all indications of being the inferior diet of the experiment. The growth was inferior to all other lots and the mortality was considerably greater. The fish did not eat well and were quite sluggish. Since there are two variables in this diet (Argentina beef liver meal, shad), it can only be said that the inferior quality of the diet was probably the result of one or two causes, or a combination of both:

a. No red meats in the diet.
b. Possible action of the anti-thiamine factor in the shad.

Diet 6 Salmon flesh 31%, salmon viscera 31%, beef liver 20%, salmon meal 12% wheat germ 4%, salt 2%.

This was the superior diet of the experiment. Mortalities were about average. The fish in this lot did not feed as actively as lots 2,3, and 4 but the total weight gained was much more consistant than some of the other diets. The good growth in this lot can be attributed to the two inclusions: salmon meal for added proteins, and the wheat germ for the added B vitamins.

Conclusions:

100% liver does not appear to be a successful diet during the winter months at the Marion Forks hatchery. This has been borne out by other experiments.

No significant growth difference or mortality when the liver content of the diet was between 10, 20, and 30%. This was essentially a short term cold water experiment, and indicates that the requirements are lower during lower water temperatures. This seems to bear out well in light of the anemic condition of fish fed 10% beef liver during the summer months at Marion Forks in experiment 2.

The shad, Argentina liver meal, salmon viscera, salt diet was inferior, as heretofore explained.

A diet containing salmon meal and wheat germ supplements to a salmon viscera, salmon flesh, beef liver, salt proved superior due to increased protein content of the diet and the added vitamin B series from the wheat germ.

Lot	Initial Weight	Final Weight	Weight Increase	Pct. Increase	Cum. Mort.	Pct. Mort.
1	52,210	63,129	10,919	20.6%	108	1.5%
2	52,210	69,800	17,590	33.0%	93	1.3%
3	52,210	68,443	16,233	31.0%	77	1.1%
4	52,210	71,049	18,839	36.0%	80	1.1%
5	52,210	56,479	4,269	8.1%	160	2.3%
6	52,210	72,007	19,797	37.9%	82	1.2%

Weekly mean average water temperatures:

For week ending	December	13	39.5°
		20	40.0°
		27	40.0°
	Jan	3	39.4°
		10	38.9°
		17	38.1°
		24	37.3°
		31	36.8°
	Feb	7	37.0°
		14	37.9°
		21	38.3°
		28	38.0°
	March	7	37.2°
		14	37.5°
		21	38.3°
		28	39.3°
	April	4	39.6°
		10	40.1°

Discussion

Palmer: Was the 12% liver calculated on a dry weight basis?

Hublou: Yes.

Palmer: Were all of the fish in each pond weighed at the end of the experiment?

Hublou: Yes, they were.

McKernan: The final weights shown on the chart are based only on the same sampling technique used throughout the experiment. However, the final weights, indicated by the samples, varied only slightly from the actual weights.

Burrows: Did the fish in No. 6 lose weight?

Garlick: No. 6 shows a loss of weight on your chart. This might indicate that the fish were breaking.

Hublou: Yes, they did lose weight during the last weigh period.

Don Johnson: Such a break should be indicated in the mortality of the fish in that diet.

Burrows: That isn't necessarily true. You could very easily experience a loss of weight without a build-up in the mortality.

McKernan: We had only between 1 and 2% mortality in the group.

Ellis: How was the salmon meal prepared?

Sinnhuber: It was prepared commercially by high temperature drying.

Marion Forks Second Feeding Experiment
Speaker: Wally Hublou

Statement of Accomplishments:

The second nutritional experiment at the Marion Forks Salmon Hatchery laboratory was conducted for a period of 22 weeks. The experiment started on June 6, 1951 and terminated on November 7, 1951. This experiment was conducted along in the same manner as the first experiment.

Ten diets, not paired, were used for the experiment. Ten circular concrete rearing ponds 25 feet in diameter with an 18 inch water depth were used. The water intake was calibrated at 35 gallons per minute. Marion creek water was used for most of the experiment because it was the warmer of the two hatchery water supplys.

The fish were fed six days a week and from 2 to 4 times daily depending upon how well the fish took the diet. The food intake was based on the dry weight of food fed basis. For the first 4 weeks of the experiment the food intake was 3% of the body weight (dry weight of food fed). The intake was jumped to 4% as the water warmed further. A decreasing water temperature made it necessary to drop back to 3% and finally 2%. The fish were weighed bi-weekly and the food intake adjusted accordingly.

Daily water temperatures were checked and all mortalities examined for cause of death wherever possible to denote. Each tank was stocked with 6,000 fish (2,778.5 grams of fish). A discussion of the diet components and the reactions of the individual lots of fish to their respective diets follows:

Diet 1 - Lot 1

(Control Lot 32.6% beef liver, 32.7% hog liver, 32.7% salmon viscera, 2% salt)

(This is one of the Leavenworth production diets for chinook salmon). This lot experienced the best growth of any of the 10 lots. The loss was very low. The fish did well from the first on this diet. The fish were quite uniform at the termination of the experiment. They ate their daily ration of food eagerly, for the most part during the feeding experiment.

Diet 2 - Lot 2

(Beef liver 32.6%, hog liver 32.7%, tuna viscera (without livers) 32.7%, salt 2%.)

This was similar to the control diet, but the salmon viscera was replaced with tuna viscera in which the livers had been removed. This lot appeared in fine shape and the gill color good, the mortalities were low. However a growth stimulant in salmon viscera was not evident in the tuna viscera. The fish in this lot appeared always hungry and eagerly cleaned up their food. The diet did not bind too well and much leaching was noted.

Diet 3 - Lot 3

(32.6% beef liver, 32.7% hog liver, 32.7% salmon viscera, 2% salt plus Bi-Con-TM-5)

Terramycin antibiotic (Pfizer Co.) at the rate of one gram per 1,000 grams of food fed mixed in food and fed. The effects of Terramycin as a good supplement were checked in this diet, which was the same as the control diet with only the addition of minute amounts of Terramycin TM-5. For all intents and purposes, lots 1 and 3 were identical, the weight of lot 1 being somewhat higher but the losses also higher than lot 3. Both numbers were not significant.

Diet 4 - Lot 4

(10% beef liver, 44% salmon viscera, 44% rockfish scrap, 2% salt)

This lot made good growth up until August 29th. At that time the mortality began increasing until September 22, when about 180 fish were dying a week. The lot was discontinued on September 22nd. After being discontinued, the lot was rehabilitated on the control diet and made remarkable come back growth.

Diet 5 - Lot 5

(10% beef liver, 44% salmon viscera, 44% turbot (in the round), 2% salt)

This lot made very good growth up to September 26th. At this time the mortality began to increase and by October 1st, 200 a week were dying. The lot was discontinued on October 6th. As in diet 4 above, the lot was rehabilitated quickly with the control diet.

Diet 6 - Lot 6

(10% beef liver, 39% salmon viscera, 39% rockfish scrap, 10% shad, 2% salt)

This lot growth was average for the first twelve weeks of the experiment. The mortality however was higher than any lot even from the beginning. The diet was discontinued on August 31st. The fish were rehabilitated on the control diet.

Diet 7 - Lot 7

(10% beef liver, 34% salmon viscera, 34% turbot, 20% meal mixture, 2% salt)

This lot was definitely the poorest lot of fish on the experimental diets. Growth was not uniform and variation in size within the lot became more pronounced every weigh day. The mortality for the first 6 weeks was low, but increased as the smaller pinheaded fish began to die. By the 19th week, the weekly mortality was 241 fish. The diet was discontinued on October 10th. The food was ricer and spoon fed but the fish never did eat too well possibly due to mechanics of feeding plus the diet offered. The lot was rehabilitated on the control diet.

Diet 8 - Lot 8

(10% beef liver, 39% salmon viscera, 39% turbot, 10% meals, 2% salt)

This lot made average growth for the first twelve weeks of the experiment. After this time mortalities began to increase sharply. Size variation in the lot was great. The fish did not eat at all well. This lot held through until the final weigh day November 7th. Again the mechanics of feeding plus the diet used produced a poor diet.

Diet 9 - Lot 9

10% beef liver, 39% salmon viscera, 39% turbot, 10% salmon meal, 2% salt)

The growth of this lot was third of the ten lots. Size variance in the fish was much less than in lot #8. Mortalities were quite high for this lot.

Diet 10 - Lot 10

(10% beef liver, 44% salmon viscera, 44% hake, 2% salt)

The fish did very poorly on this diet and for the entire experiment. All were small fish with little size variation. The mortality was not unusually high. The fish ate quite well for most of the experiment. This diet was difficult to bind and leaching was heavy. This may account for the low growth response to the diet.

The salmon meal used was commercially prepared at Bio-Products Inc. of Warrenton, Oregon from carcasses of spawned out chinook salmon from Bonneville hatchery.

The meal composition used in diets 7 and 8 was:

salmon meal 55%	crab meal 10%	wheat germ 5%
alfalfa meal 10%	tomato pulp 10%	Argentina liver meal 10%

Results and Conclusions:

The Leavenworth chinook production diet as the control diet in this experiment was a very adequate diet.

The tuna viscera substitute for salmon viscera in diet #2 indicated that there is a growth factor or factors present in salmon viscera but not in tuna viscera. Tuna viscera is not equal to salmon viscera in growth factors. The fact that this viscera had no livers may be an important fact to consider. Future experiments will be along the line of tuna viscera with livers.

Terramycin TM-5 (Bi-Con) when added to the Leavenworth control diet at the rate of 1 gram per 1,000 grams of food (the standard prescribed level to feed livestock) added nothing to the diet. The losses were less than the control and the weight some less but these figures are not statistically significant.

Based on the success obtained in a 10% beef liver level fed at Marion Forks in the 1st feeding experiment (under very cold water conditions) the 2nd experiment diets 4, 5, 6, 7, 8, 9, 10 were all based on 10% beef liver. It was found that 10% is inadequate during warm water and higher metabolic rates of the fish.

In diet #4, the fish became very anemic and then the lot broke. Much fat accumulated along the intestinal tract. Livers were of a light tan color. Gall bladders large with much bile in the intestinal cavity. This diet composition was definitely inadequate.

In diet #5, the fish were quite anemic at the time the lot was discontinued. Livers tan, much fat along and between the pyloric caecae and intestinal tract. Much bile in the intestine. This diet composition was definitely inadequate.

In diet #6, the fish were also anemic. Near mortalities revolved in corkscrew motions, much muscle spasms, loss of appetite, sluggish fish, much yellowish fat along intestinal tract, intestine with bile, gall bladders large. This diet was definitely inadequate. The shad at 10% level may have destroyed the thiamin in the diet, causing a B avitaminosis.

Diet #7, a combination of possibly poor diet and difficulty of feeding the pasty like mixture noted. Much variation in fish sizes. Fish were very anemic at time of discontinuation of the lot. Many pinheaded fish ended as mortalities. This diet composition was definitely inadequate.

In lot #8, it was noted at the termination of the experiment that the fish were anemic. (gill checks, blood counts, and hemoglobin levels made on all lots.) The fish were not as variable in size as of lot #7. Mortality was quite heavy. Fish not of uniform size. This was definitely an inadequate diet, however the lot was never discontinued but would have been if the experiment would have been lengthened 2 more weeks.

The fish in lot #9 were the third heaviest of the ten lots. There was some evidence of anemia at the termination of the experiment. Fish were of fairly uniform size. This lot lasted the entire feeding experiment but were starting to go bad at the end of the period. Lot #10 had a very low growth response. Mortalities were not excessive. Leaching of the unbindable foods probably is the answer for the lowered growth response. It was noted in the 1950 feeding program at Bonneville that the hake bound poorly and was readily leached into the drains. It is felt that hake in a diet composition which can be bound, is a must for future diet work. This lot did not appear to be anemic. This diet as well as diet #9 were definitely inadequate diets.

TOTAL WEIGHTS

Week No.	1	2	3	4	5	6	7	8	9	10
2	4,405	3,970	4,222	4,063	4,191	3,478	3,684	3,975	4,185	4,070
4	6,258	5,432	6,593	6,335	6,454	5,902	5,078	5,627	6,053	5,056
6	9,085	7,056	9,270	8,251	8,616	7,972	6,430	7,734	7,945	5,816
8	12,563	9,462	12,932	11,846	12,730	11,368	8,075	10,512	11,650	7,521
10	15,798	12,164	17,013	15,006	17,414	14,555	9,755	14,222	15,669	9,039
12	21,280	15,485	22,752	20,314	23,430	17,344	13,472	20,255	21,756	12,398
14	29,535	18,751	28,530	18,265	27,140	----	16,529	22,264	27,725	15,094
16	33,529	20,652	32,764	----	31,629	----	16,825	25,134	31,540	18,435
18	38,285	21,583	37,695	----	29,176	----	16,754	26,847	33,844	20,182
20	41,774	25,687	39,385	----	----	----	----	27,351	38,514	20,451
22	43,799	26,942	42,474	23,007	31,623	26,229	19,051	26,418	37,131	22,821
Cumulative Mortality										
	103	167	92	1,124	1,152	848	1,490	1,046	531	257
Percent Cumulative Mortality										
	1.7%	2.8%	1.5%	18.7%	19.2%	14.1%	24.8%	17.4%	8.9%	4.3%
Wet weight of food conversion Factors										
	5.29	6.43	5.47	--	--	--	--	6.24	5.01	7.73

Discussion

Ellis: Was the tuna viscera used here fresh or cooked?

Hublou: It was fresh, not cooked.

Don Johnson: Did the terramycin supplemented diet show any anemia?

Hublou: No.

Palmer:	Did you find any plugging up of the intestines or other mechanical injury to the fish which received the rockfish in the diet?
Hublou:	No, there was no apparent plugging.
Hull:	How soon was the food which contained these fresh fish products fed after preparation?
Hublou:	It was prepared and fed the same day.
Red Johnson:	We experienced similar results when we fed shad at Coleman.
Ellis:	Was the turbot in that diet in the form of a meal or fresh?
Hublou:	It was fresh.
Burrows:	We had the same results with tuna viscera five years ago when we fed it to bluebacks.

Fish and Wildlife Service
Speaker: Bruce Cannady

DIET TRIALS - FALL CHINOOK SALMON - 1951
Carson, Washington

The diet trials conducted at the Carson Hatchery in 1951 were divided into two sections. The first experiment, consisting of 18 diets, was planned for a 24 week period, but Diets 7 to 18 failed in 4 to 8 weeks. The other diets in this section completed the 24 week period. Thus, the results of the diets are listed in the accompanying table (See Table No. 2 - Diet Trials 1951 - Fall Chinook Salmon - Carson Hatchery): Diets 1 to 6 for 24 weeks, Diets 7 to 18 for 4 weeks, and Diets 19 to 25 for 22 weeks.

All diets were considered to be potential production diets with most of the ingredients available at reasonable cost. However, some of the ingredients, such as liver and spleen, are becoming more difficult to procure. The results of these experiments may be summarized as follows:

First Experiment

1. Diet 6 of this experiment had better conversion and gain than any other diet, but was not the cheapest nor the best from the standpoint of mortality.

2. There was virtually no difference in the results of diets whether fed Chum salmon carcass (stored whole) or Chinook salmon carcass (stored ground), (Diets 2 and 3).

3. Better results were obtained with salmon viscera than with salmon carcass, (Diets 1 and 2).

4. A lower conversion, better growth, and lower mortality were the results of replacing salmon viscera with salmon eggs, although the salmon eggs in the diet raised the cost per pound fish raised, (Diets 4 and 6).

5. Replacement of salmon viscera with a salmon carcass-salmon eggs combination brought better results (Diets 4 and 5).

6. While the salmon carcass-salmon eggs combination had a higher conversion and lower growth rate than salmon eggs, both the mortality and cost per pound fish raised were better (Diets 5 and 6).

7. All diets containing 50 percent meals failed in four to eight weeks. All the fish were debilitated and losses were rising when the diets were terminated. All the diets containing yeast, except Diet 10 which also contained 25 percent salmon eggs, lost weight during the first four weeks. While those diets which contained no yeast did gain a little and were not terminated until later, they showed little promise when fed to fish of this size (Diets 7 to 18).

Second Experiment

1. While there are slight differences in the percentages of components, of Diets 21 and 25, the similarity of Diet 21 to Diet 5 induces a comparison between the salmon-carcass-salmon eggs combination and salmon eggs. Comparable results were obtained in the second experiment as in the first (Diets 5, 6, 21, and 25).

2. When beef liver is replaced by salmon carcass in a diet containing 50 percent salmon eggs, the mortality rises sharply, although the growth rate remains the same. Cost per pound fish raised was lower with salmon carcass in the diet rather than beef liver (Diets 22 and 25).

3. When salmon eggs were replaced by beef liver, the growth response declined. However, the mortality decreased as the beef liver level was increased. Conversions and costs per pound fish raised remained the same (Diets 22, 23, and 24).

4. The addition of 10% salmon meal to a beef liver-salmon carcass-salmon eggs combination did not affect growth, but did result in some greater mortality (Diets 19 and 20).

5. The addition of 10 percent salmon meal and 10 percent wheat middlings to a beef liver-salmon carcass-salmon eggs combination lowered cost per pound fish raised somewhat and gave a better growth response. However, mortalities were somewhat higher when these meals are added (Diets 19 and 21).

6. Better growth response, comparable mortalities, and a somewhat lower cost per pound fish raised resulted when 10 percent wheat middlings were added to the diet (Diets 20 and 21).

7. When diets containing no meals, 10 per cent salmon meal, and 10 percent salmon meal-10 percent wheat middlings combination are compared in periods governed by fish size (See Table No. 3), it becomes apparent that fish size may affect the results obtained by the addition of meals to the diet rather than water temperature. At the Carson station the water temperature is seldom higher than 45 degrees, therefore this probably had little effect on these results. Diet 19 containing no meals consistently had greater gains than Diets 20 and 21 during the first ten weeks of the experiment, or until the fish reached a size of about 250 per pound. At that time the trend reversed and Diet 19 lagged behind the diets containing meals for the remaining 12 weeks of the experiment. Although, the mortalities continued to be lower in Diet 19, throughout the last 12 weeks, most of the losses that occurred in Diets 20 and 21 were small fish that apparently had been starved during the early part of the experiment.

8. The rates of gains of the various diets closely follow the amounts of protein in the various diets (See Table 1).

TABLE NO. 1.

PERCENTAGE PROTEIN OF INGREDIENTS USED IN CARSON DIET TRIALS - 1951*

INGREDIENT	% PROTEIN
Beef liver	20.2
Beef Spleen	17.0
Salmon Carcass (Spawned)	20.0
Salmon Viscera	22.7
Salmon Eggs (Pink)	29.4
Salmon Offal Meal-Flame Dried	64.4
Wheat Middlings	17.8

Diet No.		% Gain	% Protein
		First Section	
1.	6	797	29.0
2.	5	667	26.7
3.	4	481	25.7
4.	1	361	24.3
5.	3	279	23.5
6.	2	274	23.5
		Second Section	
1.	25	644	29.0
2.	22	643	28.9
3.	23	593	28.0
4.	21	583	26.7
5.	24	573	27.0
6.	20	521	27.3
7.	19	499	23.2

*Percentages protein derived from table contained in notes by Stansby and Phillips, U. S. Fish and Wildlife Service.

TABLE NO. 2.

DIET TRIALS - FALL CHINOOK SALMON - 1951
Fish and Wildlife Service
Carson, Washington

Water Temperature 42 - 45
No. Fish Per Pound at Start
Diets 1 to 18 --- 890
Diets 19 to 25 --- 617
Weight Per Trough at Start --- 10,000 grams

Length of Feeding Periods
Diets 1 to 6 ---- 24 weeks
Diets 7 to 18 ---- 4 weeks
Diets 19 to 25 ---- 22 weeks

Diet No.	Components	Per Cent	Food Conversion	% Gain A.W.	% Mortality 2 Wk. Ave.	Cost Per lb. Fish Raised
1.	Beef liver	38.0	5.0	361	.51	$0.48
	Beef spleen	20.0				
	Salmon viscera	30.0				
	Salmon meal	10.0				
	Salt	2.0				
2.	Beef liver	38.0	6.3	274	.81	0.54
	Beef spleen	20.0				
	Whole salmon flesh	30.0				
	Salmon meal	10.0				
	Salt	2.0				
3.	Beef liver	38.0	6.3	279	.89	0.53
	Beef spleen	20.0				
	Ground salmon flesh	30.0				
	Salmon meal	10.0				
	Salt	2.0				
4.	Beef liver	30.0	4.6	481	1.30	0.35
	Salmon viscera	50.0				
	Fish Meal (salmon)	10.0				
	Wheat middlings	10.0				
5.	Beef liver	30.0	3.7	667	.59	0.32
	Whole salmon flesh	25.0				
	Salmon eggs	25.0				
	Salmon meal	10.0				
	Wheat middlings	10.0				
6.	Beef liver	30.0	3.4	797	.68	0.39
	Salmon eggs	50.0				
	Salmon meal	10.0				
	Wheat middlings	10.0				
7.	Beef liver	25.0	---	---	.34	---
	Beef spleen	25.0				
	Salmon meal	10.0				
	Wheat middlings	10.0				
	Cottonseed meal	10.0				
	Distillers solubles	10.0				
	Dried Brewers yeast	8.0				
	Salt	2.0				

TABLE NO. 2.

DIET TRIALS - FALL CHINOOK SALMON - 1951
Fish and Wildlife Service
Carson, Washington

Diet No.	Components	Per Cent	Food Conversion	% Gain A.W.	% Mortality 2 Wk. Ave.	Cost Per Lb. Fish Raised
8.	Beef liver	25.0	----	----	.37	----
	Salmon viscera	25.0				
	Salmon meal	10.0				
	Wheat middlings	10.0				
	Cottonseed meal	10.0				
	Distillers solubles	10.0				
	Dried brewers yeast	8.0				
	Salt	2.0				
9.	Beef liver	25.0	----	----	.46	----
	Whole salmon flesh	25.0				
	Salmon meal	10.0				
	Wheat middlings	10.0				
	Cottonseed meal	10.0				
	Distillers solubles	10.0				
	Dried brewers yeast	8.0				
	Salt	2.0				
10.	Beef liver	25.0	30.0	5.0	.28	2.97
	Salmon eggs	25.0				
	Salmon meal	10.0				
	Wheat middlings	10.0				
	Cottonseed meal	10.0				
	Distillers solubles	10.0				
	Dried brewers yeast	8.0				
	Salt	2.0				
11.	Beef liver	25.0	12.0	14.0	.23	1.02
	Beef spleen	25.0				
	Salmon meal	12.0				
	Wheat middlings	12.0				
	Cottonseed meal	12.0				
	Distillers solubles	12.0				
	Salt	2.0				
12.	Beef liver	25.0	10.0	16.0	.23	0.73
	Salmon viscera	25.0				
	Salmon meal	12.0				
	Wheat middlings	12.0				
	Cottonseed meal	12.0				
	Distillers solubles	12.0				
	Salt	2.0				

TABLE NO. 2-

DIET TRIALS - FALL CHINOOK SALMON - 1951
Fish and Wildlife Service
Carson, Washington

Diet No.	Components	Per Cent	Food Conversion	% Gain A.W.	% Mortality 2 Wk. Ave.	Cost Per Lb. Fish Raised
13.	Beef liver	25.0	14.0	12.0	.20	0.88
	Salmon flesh	25.0				
	Salmon meal	12.0				
	Wheat middlings	12.0				
	Cottonseed meal	12.0				
	Distillers Solubles	12.0				
	Salt	2.0				
14.	Beef liver	25.0	9.0	19.0	.17	0.82
	Salmon eggs	25.0				
	Salmon meal	12.0				
	Wheat middlings	12.0				
	Cottonseed meal	12.0				
	Distillers solubles	12.0				
	Salt	2.0				
15.	Beef liver	20.0	---	---	.33	---
	Salmon flesh	30.0				
	Salmon meal	10.0				
	Wheat middlings	10.0				
	Cottonseed meal	10.0				
	Distillers solubles	10.0				
	Dried brewers yeast	8.0				
	Salt	2.0				
16.	Beef liver	10.0	---	---	.31	---
	Salmon flesh	40.0				
	Salmon meal	10.0				
	Wheat middlings	10.0				
	Cottonseed meal	10.0				
	Distillers solubles	10.0				
	Dried brewers yeast	8.0				
	Salt	2.0				
17.	Beef liver	20.0	17.0	10.0	.25	0.97
	Salmon flesh	30.0				
	Salmon meal	12.0				
	Wheat middlings	12.0				
	Cottonseed meal	12.0				
	Distillers solubles	12.0				
	Salt	2.0				

TABLE NO. 2.

DIET TRIALS - FALL CHINOOK SALMON - 1951
Fish and Wildlife Service
Carson, Washington

Diet No.	Components	Per Cent	Food Conversion	% Gain A.W.	% Mortality 2 Wk. Ave.	Cost Per Lb. Fish Raised
18.	Beef liver	10.0	15.0	12.0	.40	0.69
	Salmon flesh	40.0				
	Salmon meal	12.0				
	Wheat middlings	12.0				
	Cottonseed meal	12.0				
	Distillers solubles	12.0				
	Salt	2.0				
19.	Beef liver	33.3	3.1	508	.09	0.28
	Salmon flesh	33.3				
	Salmon eggs	33.4				
20.	Beef liver	30.0	3.1	521	.19	0.28
	Salmon flesh	30.0				
	Salmon eggs	30.0				
	Salmon meal	10.0				
21.	Beef liver	26.6	3.0	583	.21	0.26
	Salmon flesh	26.7				
	Salmon eggs	26.7				
	Salmon meal	10.0				
	Wheat middlings	10.0				
22.	Salmon flesh	30.0	3.0	643	1.27	0.23
	Salmon eggs	50.0				
	Salmon meal	10.0				
	Wheat middlings	10.0				
23.	Beef liver	10.0	3.0	593	.33	0.24
	Salmon flesh	30.0				
	Salmon eggs	40.0				
	Salmon meal	10.0				
	Wheat middlings	10.0				
24.	Beef liver	20.0	3.0	573	.21	0.24
	Salmon flesh	30.0				
	Salmon eggs	30.0				
	Salmon meal	10.0				
	Wheat middlings	10.0				
25.	Beef liver	30.0	2.8	644	.23	0.32
	Salmon eggs	50.0				
	Salmon meal	10.0				
	Wheat middlings	10.0				

TABLE NO. 3.

DIET TRIALS - FALL CHINOOK SALMON - 1951
COMPARISON OF MEAL AND NON-MEAL DIETS
Fish and Wildlife Service
Carson, Washington

Diet No.	Differences	Food Conversion	% Gain A.W.	% Mortality 2 Wk. Ave.	Cost Per Lb. Fish Raised
	First Ten Weeks - Until Fish Reached CA 250 per lb.				
19.	No Meal	3.0	173	.12	$0.27
20.	10% Salmon Meal	3.4	148	.17	0.31
21.	10% Salmon) 10% Wheat Middlings) - -	3.1	167	.17	0.26
	Next Twelve Weeks - After Fish Reach CA 250 per lb.				
19.	No Meal	3.3	123	.02	0.30
20.	10% Salmon Meal	2.9	151	.20	0.26
21.	10% Salmon Meal) 10% Wheat Middlings) - -	2.9	156	.25	0.25

Discussion

McKernan: How did you cut back your fish periodically? What was your sampling technique?

Cannady: We set the scales at the new reduced weight and dipped out fish until the scales balanced.

Burrows: With such a procedure, you were removing primarily the smaller fish in the tub.

Red Johnson: Don't give him a bad time. Let him give his report. That was Phillip's method of sampling.

Cannady: The method was recommended to me by Phillips and I followed it blindly.

McKernan: What percent body weight did you feed?

Cannady: About 5.5% at the start and gradually reduced to 3.8% at the end.

McKernan: Is 50% salmon eggs practical when the price is so high?

Garlick: Yes, it is at 10¢ per lb.

McKernan: Why did the No. 4 diet have such a high mortality?

Cannady: I don't know.

Palmer: What kind of bind did you get on No. 4?

Cannady: A fairly good bind.

Halver: What kind of salmon viscera did you have?

Cannady: We got Columbia River salmon viscera, collected at the Dalles. However, the proportions of eggs to viscera varied somewhat.

Sinnhuber: When figuring on a dry weight basis, Diets 5 and 6 are comparable.

Burrows: How did you figure your conversions?

Cannady: By the total weight gained and the amount of food fed.

Red Johnson: What are you going to feed next year?

Cannady: You'll have to ask Mr. Garlick that.

Garlick: We'll feed 50% eggs, 25% liver and 25% salmon carcass.

Red Johnson: How large were the fish at the end?

Cannady: 85 to 100 per pound.

Comments on McElrath's report of the Spring Creek Diet Experiments. (No summary forwarded)

Burrows: Salmon eggs produce very rapid growth. Apparently they contain more protein than the fish need, because the fast growth continues even when there is considerable food wastage.

McKernan: The viscera did better in these experiments than it did in the Carson experiments.

Garlick: The fish in the pond which were fed on the salmon egg diet ran 90 per pound at planting time as compared with 150 per pound in the troughs.

Burrows: That may have been due to the space factor. The fish grew better in the ponds.

Palmer: Perhaps the lack of growth stimulus of salmon eggs over salmon viscera was due to the fact that the water temperature was low-below 50°F.

Ellis: At 53° water temperature we found no difference in growth rate between fish fed salmon viscera and salmon carcass.

Fishery Technological Laboratory
Summary of the Salmon Waste Collection Report
Speaker: Dave Miyauchi

During the summer of 1951 a large-scale collection of approximately 100,000 pounds of frozen salmon viscera and 3,000 pounds of frozen salmon eggs was made at Petersburg, Alaska. The purpose of this collection was:

1. To test out on a commercial scale the feasibility of bagging the salmon waste in an inner plastic (poly-ethylene) bag with an outer burlap bag, which would keep the cost of shipping empty containers to Alaska at a minimum.

2. To keep careful records of all costs involved in the collection so that in the future some basis would be available for estimating such costs for even larger-scale operations.

The soft visceral portions were diverted separately from the heads, tails, and fins at the iron chink onto a draining table. The drained viscera were bagged, frozen and shipped to Seattle, Washington, aboard a commercial vessel. Inspection of the shipment upon arrival in Seattle failed to show a single bag which had lost any of its contents or needed re-bagging for any reason whatever.

The cost of the raw material at the cannery was ½¢ per pound; the cost of labor was $2.00 per hour; the freezing and storage charges were $7.00 per 1,000 pounds; and the cost of the burlap bag was 30¢ each and of the polyethylene liner 16¢ each.

The summary of the costs for collection of the salmon viscera and eggs follows:

	Viscera	Eggs
Price per pound, f.o.b. steamship dock, Petersburg, Alaska	3.06¢	5.90¢
Shipping costs from Petersburg, Alaska, to Seattle, Washington	2.15¢	1.85¢
Price per pound, f.o.b. steamship dock, Seattle, Washington	5.21¢	7.75¢

The cost of miscellaneous supplies and of construction work required for the entire project ($413.19) was not included in the prices given above.

Discussion

Burrows: The viscera in the polyethylene bags came through beautifully preserved. There was no evidence of oxidation.

Gastineau: It is quite difficult to salvage the burlap and plastic bags.

Ellis: What was the cost of the polyethylene bags?

Miyauchi: The polyethylene bags cost 16¢ apiece and the burlap bags 40¢ apiece.

McKernan: Why was the cost per pound so different between the salmon viscera and salmon eggs?

Miyauchi: Because of the different containers used in shipping and the extra handling cost of the eggs.

Burrows: It is necessary to use cans for shipping the salmon eggs?

Miyauchi: No, they could be handled in the bags.

Entiat Salmon Cultural Laboratory
Summary of Diet Experiments
Speaker: Roger E. Burrows

The feeding trials at the Salmon Cultural Laboratory were divided into four main groups: a 12-week cold-water experiment, a continuation of certain diets of the cold-water trials through the warm-water period, and a 12-week warm-water experiment, all conducted on blueback salmon, plus a combination, 24-week, cold- and warm-water experiment conducted on chinook salmon.

The techniques and methods of evaluation did not differ from those of previous feeding trials.

First Experiment, Cold-Water Phase

The cold-water phase of the first experiment using blueback salmon as the test animals, was conducted for a 12-week period at an average water temperature of 44.5°F.

The results of both the cold and warm-water phases of these trials are shown in Table 1. The cold-water trials may be divided into three main groups. In the first group, Diets 1 through 7 and Diet 12, evaluations were made of individual components and limited combinations, usually two, of the components. In the

TABLE 1.--Feeding Trials with Blueback Salmon - 1951 First Experiment

Initial number per trough: 2,314 fish
Initial weight per trough: 1,000 gr.

Initial average weight per fish: .43 gr.
Initial number per pound: 1,052 fish
Period: 4/4/51 to 9/18/51

Temperature: Average 1st. 12 wks., 44.5°F.; Average 2nd 12 wks. 54.7°F.; Average for 24 wks., 49.6°F.

Lot	Diet Components		Percentage Composition	Mean Weight in grams 12 wks	Mean Weight in grams 24 wks	Percent mortality 12 wks	Percent mortality 24 wks	Conversion 12 wks	Conversion 24 wks	Hemoglobin g/100 ml. blood 12 wks	Hemoglobin g/100 ml. blood 24 wks	Deficiency Symptoms
1	Beef liver		100.0	2,176	6,086	1.08	2.12	3.19	4.44	13.8	11.8	None
2	Beef lungs	S[1]	100.0	2,402	6,002	1.90	3.33	2.99	4.94	10.7	11.6	None
3	Beef liver Hog liver	S	50.0 50.0	2,420		.91		2.87		15.6		None
4 (52)	Beef liver Beef lungs	S	50.0 50.0	2,406		.82		3.04		13.0		None
5	Hog liver Beef lungs	S	50.0 50.0	2,498		1.30		2.89		14.1		None
6	Hog liver Salmon viscera	S	50.0 50.0	2,740	8,920	.99	1.90	2.75	3.66	13.0	9.2	Possible anemic tendency after 24 wks. of feeding
7	Hog liver Hog spleen Salmon viscera	S	40.0 10.0 50.0	2,744	9,072	1.38	2.07	2.76	3.65	12.5	10.9	None
8[2]	Beef liver Hog liver Hog spleen Salmon viscera	S	22.2 22.2 22.2 33.4	2,668	12,612	.95	1.43	2.79	2.79	14.1	11.7	None

Lot	Diet Components	Percentage Composition	Mean Weight in grams 12 wks	Mean Weight in grams 24 wks	Percent mortality 12 wks	Percent mortality 24 wks	Conversion 12 wks	Conversion 24 wks	Hemoglobin g/100 ml. blood 12 wks	Hemoglobin g/100 ml. blood 24 wks	Deficiency Symptoms
9[2]	Beef liver S	22.2									
	Hog liver	22.2									
	Hog spleen	22.2									
	Salmon eggs (frozen)	33.4	2,854	14,194	1.38	2.42	2.66	2.65	13.8	12.2	None
10[2]	Beef liver S	22.2									
	Hog liver	22.2									
	Hog spleen	22.2									
	Salmon eggs (pres.)	33.4	2,606	12,526	1.25	2.03	2.79	2.89	12.0	11.2	None
11[2]	Tuna liver S	22.2									
	Hog liver	22.2									
	Hog spleen	22.2									
	Salmon viscera	33.4	2,584	10,406	1.21	2.03	2.87	3.25	12.8	12.7	None
12	Tuna liver	50.0									
	Salmon viscera	50.0	2,010		.95		3.68		13.3		None
13	Beef liver S	20.0									
	Hog liver	20.0									
	Hog spleen	20.0									
	Salmon viscera	30.0									
	V.D.S.V. Meal	10.0	2,959		2.20		2.58		13.0		None
14	Beef liver S	20.0									
	Hog liver	20.0									
	Hog spleen	20.0									
	Salmon viscera	30.0									
	V.D.S.V.M.(pre.dig.)	10.0	2,894		3.46		2.65		13.0		None

Lot	Diet Components	Percentage Composition	Mean Weight in grams 12 wks-24 wks	Percent mortality 12 wks-24 wks	Conversion 12 wks-24 wks	Hemoglobin g/100 ml. blood 12 wks-24 wks	Deficiency Symptoms
15	Beef liver S	18.1					
	Hog liver	18.1					
	Hog spleen	18.1					
	Salmon viscera	25.7					
	V.D.S.V.M.(pre.dig.)	20.0	2,922	9.72	2.67	12.0	None
16	Beef liver S	21.1					
	Hog liver	21.1					
	Hog spleen	21.1					
	Salmon viscera	31.7					
	V.D.S.V. meal	5.0	2,887	.86	2.61	13.0	None
17	Beef liver S	20.0					
	Hog liver	20.0					
	Hog spleen	20.0					
	Salmon viscera	30.0					
	V.D.S.V.M. (Vit.)	10.0	2,934	1.68	2.57	14.3	None
18	Beef liver S	20.0					
	Hog liver	20.0					
	Hog spleen	20.0					
	Salmon viscera	30.0					
	V.D.S.V.M. (AA)	10.0	2,817	1.99	2.64	13.0	None
Least difference at 5% level			143 254	.50 1.64			

1/ Salt added at the rate of 2 grams per 100 grams of ration.

2/ At the end of the first 12-week period 10% of vacuum-dried salmon viscera meal was added to these diets with a corresponding proportional reduction in each of the original components.

second group, Diets 8 through 11, variations in the standard meat-viscera mixture were tested. In the third group, Diets 13 through 18, an unsuccessful attempt was made to determine the cause for high mortalities when feeding salmon meals during periods of cold water.

In the first group, 100 per cent beef liver (Diet 1) was fed as the accepted control. Beef lung at the 100 per cent level (Diet 2) and in equal parts with beef liver (Diet 4) and hog liver (Diet 5) was compared with beef liver (Diet 1) and equal parts of beef and hog liver (Diet 3). Beef lung excelled beef liver in its growth potential and was equal to beef liver and hog liver in the various combinations tested. Mortalities were significantly higher in the 100 per cent beef lung fish but were still not excessive. Although the hemoglobin content of the blood was lower in Diet 2 than in the other diets in this group no acute anemia was indicated. From these experiments beef lung appeared to offer excellent possibilities as a diet component in view of its growth potential, low cost, and availability.

Salmon viscera at the 50 per cent level in combination with hog liver (Diet 6), hog liver and hog spleen (Diet 7), and tuna liver (Diet 12) was evaluated for comparison with the liver and lung combinations. In Diets 6 and 7 viscera provided an impetus to the growth rate significantly greater than any of the other comparable similar combinations (Diets 3 and 5). The hog spleen was introduced into Diet 7 to produce a more tightly bound combination. A diet of a better feeding consistency resulted and the growth rate was comparable to Diet 6. Tuna liver when combined with salmon viscera was inferior to hog liver (Diets 6 and 12) in its growth potential. Previous trials indicated that tuna liver alone had an extremely low growth potential but the anti-anemic factor appeared to be present.

Blueback salmon fed combinations of hog liver and salmon viscera (Diet 6) and hog liver, hog spleen and salmon viscera (Diet 7) had growth rates comparable to those fed the standard meat-viscera combination (Diet 8) during the 12 weeks of feeding at cold water temperatures. No symptoms of anemia or other dietary deficiencies were present during this period.

The second group of diets were variations of the standard meat-viscera combination. Salmon eggs, both preserved and frozen, were substituted for salmon viscera (Diets 9 and 10) and tuna liver for beef liver (Diet 11). The salmon eggs preserved with 0.5 per cent sodium bisulfite, had been allowed to stand for three months at room temperatures before being frozen. These eggs differed from those used in previous trials in this respect. In the 1950 trials only the toxicity of the preservative was tested in that the eggs were not allowed to stand more than two or three days after the preservative was added before being refrozen. A comparison of the growth produced by Diets 9 and 10 indicates that an alteration in the growth potential of salmon eggs occurs when preserved with 0.5 per cent sodium bisulfite. Partial decomposition of the eggs was indicated by the disintegration of the eggs, heavy mold formation on the surface, and rather putrid odor. The growth response of the fish fed the preserved eggs was equal to that of those fed frozen salmon viscera but inferior to that of those fed frozen salmon eggs.

Tuna liver substituted for beef liver in the meat-viscera combination (Diets 8 and 11) proved adequate during the first 12 weeks of feeding. The growth rates were comparable and no anemia was indicated.

The third group in this experiment was designed to determine the cause of the mortality when meals were included in the diet during prolonged periods of cold-water temperatures. Two hypotheses were advanced as to the cause for this mortality. In the first, it was assumed that a reduction in enzymatic action due to colder temperatures reduced the rate of digestion of the protein. As a result some of the more slowly liberated amino acids were not made available to the fish. To test this hypothesis predigested salmon viscera meal was fed at the 10 and 20 per cent levels in Diets 14 and 15 for comparison with Diet 13 which contained 10 per cent of vacuum-dried salmon viscera meal. In addition 4 per cent methionine and 4 per cent of lysine were substituted for an equal portion of the vacuum-dried meal on the basis of 100 per cent meal content (Diet 18). The substitution of 10 per cent predigested meal resulted in a significant increase in mortality over the vacuum-dried meal. When 20 per cent of predigested meal was used the mortality was tremendously increased. The amino acid supplemented meal showed no reduction in mortality when compared with the vacuum-dried meal.

The second hypothesis was based on the assumption that the addition of meal inhibited the absorption of or increased the requirement for the vitamins of the B complex during the cold-water period. In Diet 17 the vacuum-dried meal was fortified with thiamin, riboflavin, niacin, biotin, folic acid, pantothenic acid, and pyridoxine at levels required for maximum storage as established by either Phillips or McLaren for trout. Although the resulting mortality was significantly lower than the unfortified diet (Diet 13), it was still significantly higher than the meat-viscera mixture without meal (Diet 8). It is possible that a more complete vitamin supplement might correct the mortality resulting from feeding meals but the results of this experiment are inconclusive.

In Diet 16 the meal content was reduced from 10 to 5 per cent. The mortality was significantly reduced below that of the fish fed 10 per cent meal (Diet 13) and was comparable to the loss incurred in Diet 8, the meat-viscera control. The total gain in weight of the fish fed 5 per cent meal was not significantly different from those fed the 10 per cent meal supplements, all of which showed significantly greater total gains than the meat-viscera control (Diet 8).

It will be noted that the mortalities from the inclusion of meal, with the exception of the predigested meals, approximated 2 per cent for the 12-week period. The mortalities while significantly different from the control group do not compare to previous results at Leavenworth in which losses ranged from 18 to 30 per cent for a similar 12-week period. The differences in mortality may be attributed to differences in water temperature patterns throughout the period of the experiments. The average water temperatures per biweekly period for 1950 and 1951 are as follows:

1950	45.4,	45.1,	44.8,	44.9,	44.5,	47.8,	mean 45.4
1951	43.0,	43.1,	43.9,	44.9,	45.5,	46.8,	mean 44.5

The 1950 temperature pattern does not differ significantly from those of 1948 and 1949. In every instance the temperature either dropped slightly or remained constant during the first 10 weeks of the experimental period. The 1951 pattern differs sharply from those of the previous trials in that the temperature was on a slight and consistent upswing. It is believed that the difference in temperature pattern and the resultant increase in food intake is responsible for the reduction in the mortality during the 1951 trials.

First Experiment, Warm-Water Phase

Certain diets of the cold-water experiment were continued an additional 12 weeks through the warm-water period during which the water temperature averaged 54.7°F. Diet 1 (beef liver), was retained as a control for Diets 2 (beef lung), 6 (hog liver, salmon viscera), and 7 (hog liver, hog spleen, and salmon viscera). All of the group testing variations of the meat-viscera combination (Diets 8 through 12) were retained but altered to include 10 per cent of vacuum-dried salmon viscera meal during the second 12 weeks. The remaining diets were discontinued as being of no further interest.

At the end of 24 weeks the beef lung (Diet 2) showed a marked decline in growth rate when compared with beef liver (Diet 1) although the final weights of the fish were comparable. Hemoglobin determinations indicated no anemic condition in the beef lung lot. The hog liver-salmon viscera (Diet 6 and hog liver-hog spleen-salmon viscera (Diet 7) combinations showed comparable gains which were much greater than those of the beef liver control. The hemoglobin content of the blood of samples from Diet 6 indicates a possible anemic tendency in these fish after 24 weeks of feeding. This result was not confirmed in the 12-week warm-water experiment in which a duplicate diet (Diet 29) altered only by the addition of 10 per cent meal showed no anemic tendency.

The meat-viscera combinations were altered after 12 weeks by the addition of 10 per cent vacuum-dried salmon viscera meal and a proportionate reduction in the other diet components. Frozen salmon eggs (Diet 9) were superior to viscera when substituted for viscera in the meat-viscera-meal mixture. Preserved salmon eggs (Diet 10) were inferior to frozen eggs and when the stored eggs were used the preserved eggs were inferior to salmon viscera. The supply of stored eggs was exhausted after 16 weeks of feeding and preserved eggs from the 1950 trials were substituted. A marked impetus was noted in the growth rate when this substitution was made sufficient to close the gap between the viscera and egg-fed fish at the conclusion of the experiment. Tuna liver proved inferior to beef liver when substituted in the meat-viscera-meal mixture (Diets 8 and 11). The growth response was significantly below that of beef liver but no anemia was present at the end of 24 weeks of feeding.

Second Experiment - Warm Water

These feeding trials were more exploratory in nature and consisted of evaluations of single components, substitution of these components for spleen or beef liver in the meat-viscera-meal mixture, an evaluation of whale meal, a further exploration of salmon viscera and salmon viscera meal in combination with various meat and fish products, and a comparison of a liver-supplemented, purified ration, developed by the Oregon Fish Commission Laboratory, with potential production diets. All fed at an average water temperature of 55.5°F. These diets are summarized in Table 2.

TABLE 2.--Feeding Trials with Blueback Salmon - 1951 Second Experiment

Initial number per trough: 726 fish
Initial weight per trough: 2,000 gr.

Initial average weight per fish: 2.75 gr.
Initial number per pound: 165 fish

Temperature: Average 12 wks., 55.5°F.
Period 7/4/51 to 9/25/51

Lot	Diet Components	Percentage Composition	Mean Weight in grams 12 weeks	Percent Gain	Percent Mortality 12 weeks	Hemoglobin g/100 ml. blood	Conversion 12 weeks	Deficiency Symptoms
19	Beef liver	100	2,731	173.0	.41	10.3	4.54	None
20	Whale liver	100	1,038	3.8	3.72	11.5	48.47	Fish thin, almost emaciated usually one operculum hemorrhagic; one or more gill arch bearing fungus; gill lamellae malformed-some swollen, some curled, some proliferated; some entirely eroded away; livers pale; intestinal fat slight or lacking.
				Diet discontinued 7/31/51				
21	Arrow-Tooth Halibut	100	3,301	230.1	.55	10.2	3.58	None
22	Herring	100	3,801	280.1	1.65	8.9	3.37	Fish fat in appearance; dark in color; head usually retracted; weak & listless; some exhibiting loss of equilibrium; some suffering violent nervous convulsions when startled; livers pale yellow to yellowish brown in color; intestinal fat heavy.
23	Beef liver S1/	20						
	Hog liver	20						
	Hog spleen	20						
	Salmon viscera	30						
	V.D.S.V. Meal	10	4,164	316.5	.14	12.5	2.99	None

Lot	Diet Components	Percentage Composition	Mean weight in grams 12 weeks	Percent Gain	Percent Mortality 12 weeks	Hemoglobin g/100 ml. blood	Conversion 12 weeks	Deficiency Symptoms
24	Beef liver S	20						
	Hog liver	20						
	Hog spleen	20						
	Salmon viscera	30						
	Whale meal	10	4,331	333.0	.14	13.0	2.89	None
25	Whale liver S	20						
	Hog liver	20						
	Hog spleen	20						
	Salmon viscera	30						
	V.D.S.V. Meal	10	3,873	287.3	.83	11.7	3.37	None
26	Beef liver S	20						
	Hog liver	20						
	Beef lung	20						
	Salmon viscera	30						
	V.D.S.V. Meal	10	4,156	315.5	.41	12.8	2.96	None
27	Beef liver S	20						
	Hog liver	20						
	Arrow-tooth halibut	20						
	Salmon viscera	30						
	V.D.S.V. Meal	10	4,558	355.8	.96	13.3	2.74	None
28	Beef liver S	20						
	Hog liver	20						
	Herring	20						
	Salmon viscera	30						
	V.D.S.V. Meal	10	4,739	373.9	.69	13.3	2.35	None

Lot	Diet Components	Percentage Composition	Mean weight in grams 12 weeks	Percent Gain	Percent Mortality 12 weeks	Hemoglobin g/100 ml. blood	Conversion 12 weeks	Deficiency Symptoms
29	Hog liver S Salmon viscera V.D.S.V. Meal	45.00 45.00 10.00	4,583	358.3	.55	12.5	2.79	None
30	Beef lung S Salmon viscera V.D.S.V. Meal	45.00 45.00 10.00	3,994	299.4	1.65	12.2	3.06	None
31	Tuna liver S Salmon viscera V.D.S.V. Meal	45.00 45.00 10.00	2,428	142.8	12.40	13.6	3.64	Fish fat in appearance; on or more gill arch bearing fungus; gill lamellae mal-formed-some swollen, some severely proliferated, som entirely eroded away; live pale, swollen; intestinal fat heavy.
				Diet discontinued 8/28/51				
32	Hog liver S Beef lung Salmon viscera V.D.S.V.Meal	22.50 22.50 45.00 10.00	4,418	341.8	.69	12.7	2.84	None
33	Meal mixture Water Beef liver	33.01 63.32 3.67	3,274	227.4	0.00	12.8	3.67	None
Least difference at 5% level:			365.6		1.07			

1/ Salt added at the rate of 2 grams per 100 grams of ration.

In the first group, beef liver (Diet 19) was compared with whale liver (Diet 20), arrow-tooth halibut (Diet 21) and herring (Diet 22). Whale liver was discontinued after four weeks of feeding due to an apparent over-abundance of vitamin A in the diet which created a toxic effect in the fish. Both arrow-tooth halibut and herring proved to have a higher growth potential than beef liver with herring significantly higher than the halibut. A deficiency, believed to be thiamin, was present in the herring fed fish. The symptoms of a thiamin deficiency as shown in Table 2 were very prominent in these fish after 10 weeks of feeding and were discernible after but six weeks.

The differences in growth potential in the single component studies were confirmed when the herring and arrow-tooth halibut were substituted for spleen in the meat-viscera-meal combination. Although the halibut (Diet 27) did not produce as great a growth response as the herring (Diet 28) both were significantly higher than the control (Diet 23). When whale liver was substituted for beef liver in the meat-viscera-meal mixture (Diets 23 and 25) no anemia developed in the fish and the growth rate although slightly lower was not significantly different. No symptoms of a hypervitaminosis A developed on this diet. Beef lung (Diet 26) was equal to hog spleen when substituted for spleen in the meat-viscera-meal mixture.

A low-temperature-dried whale meal proved to have a growth potential equal to vacuum-dried salmon viscera meal when incorporated at the 10 per cent level in the meat-viscera mixture (Diets 23 and 24). This meal was especially prepared for fish food and is not available commercially. It is hoped to test a commercial whale meal in the near future.

Hog liver (Diet 29), beef lung (Diet 30), tuna liver (Diet 31), and equal parts of hog liver and beef lung (Diet 32) were fed in combination with 45 per cent of salmon viscera and 10 per cent of vacuum-dried salmon viscera meal. The hog liver-salmon viscera-meal combination (Diet 29) produced a significantly greater growth response than did the standard meat-viscera-meal control (Diet 23).

The beef lung-viscera-meal diet (Diet 30) displayed a growth potential equal to the control but below that of the hog liver variable. The tuna liver-viscera-meal ration had to be discontinued after 8 weeks of feeding because of a high mortality believed to be due to a hypervitaminosis A. The hog liver-beef lung combination (Diet 32) was equal to the meat-viscera-meal control in its growth potential.

The liver-supplemented, purified ration (Diet 33) of the Oregon Fish Commission Laboratory successfully maintained salmon for a 12-week period. The growth rate of these fish was significantly greater than those fed beef liver (Diet 19) but was significantly less than those fed the meat-viscera-meal combination (Diet 23). No deficiency symptoms were noted on this diet and no anemia was indicated.

Analysis of the vitamin A content of the standard meat-viscera-meal control diet (Diet 23), the whale liver diet (Diet 20), and tuna liver-salmon viscera-meal diet (Diet 31) indicates the possibility of a hypervitaminosis A being responsible for the high mortality encountered in the whale liver and tuna liver diets. Results of analysis made by the Seattle Technological Laboratory of the Fish and Wildlife Service are as follows:

Diet No.	Oil content	Spectrophotometric units per gram of oil	per 100 grams diet
20	3.37%	94,200	317,454
31	2.94%	19,965	58,697
23	6.15%	4,400	27,060

The vitamin A content of Diets 20 and 31 was much higher than that encountered in Diet 23 the standard control. A high mortality, sufficient to force a discontinuation of the experiments, occurred in Diet 20 after 4 weeks of feeding and in Diet 31 after 8 weeks of feeding. The occurrence of the mortality in these diets is closely correlated with the vitamin A content. All the evidence strongly supports the hypothesis that a hypervitaminosis A was present in the fish fed diets containing high levels of either whale or tuna liver.

Third Experiment - Chinook Salmon

In production feeding a difference appeared to exist between the nutritional requirements of blueback and chinook salmon. Chinook when fed the standard meat-viscera mixture (Diet 8) developed an anemia in at least a portion of the fish in each pond. This condition did not develop in blueback salmon fed an identical diet or one including 10 per cent meal (Diet 23). It was assumed that the anemia was caused by a difference in the nutritional requirements of chinook salmon. To increase the vitamin content of the diet the hog spleen was eliminated from the meat-viscera mixture and a diet consisting of one third each of beef liver, hog liver and salmon viscera was fed to the production chinook. On this diet chinook salmon did not develop an anemia. As this ration was fed during different years and to different stocks of fish without control groups numerous variables were introduced which obscured results. The chinook experiments conducted this season were designed to determine if nutritional differences existed between chinook and blueback salmon.

On the assumption that nutritional deficiencies would develop, the standard meat-viscera mixture (Table 3, Diet 1-C) was altered to include 5 per cent of crab meal (Diet 2-C). The chinook ration (Diet 3-C) consisting of one third each of beef liver, hog liver, and salmon viscera was fed for comparison with the control (Diet 1-C). The standard chinook ration was supplemented with 10 per cent of salmon viscera meal (Diet 4-C) during the second 12 weeks of feeding to determine if the addition of meal would be a contributory factor in the development of an anemia. Crab meal was added to the chinook ration at the 5 per cent level (Diet 5-C) for comparison with Diet 2-C. Salmon eggs were substituted for salmon viscera in the chinook ration (Diet 6-C) to measure the contribution of eggs over viscera in this combination.

TABLE 3.--Feeding Trials with Chinook Salmon - 1951 First Experiment

Initial number per trough: 650 fish
Initial weight per trough: 1,000 gr.

Initial average weight per fish: 1.54 gr.
Initial number per pound: 295 fish
Period: 5/5/51 to 9/18/51

Temperature: Average 1st 12 wks., 44.5°F.; Average 2nd 12 wks., 54.7°F. Average for 24 wks., 49.6°F.

Lot	Diet Components	Percentage Composition	Mean weight in grams 12 wks	Mean weight in grams 24 wks	Percent mortality 12 wks	Percent mortality 24 wks	Conversion 12 wks	Conversion 24 wks	Hemoglobin g/100 ml. blood 24 weeks	Deficiency Symptoms
1-C	Beef liver S[1]	22.2								
	Hog liver	22.2								
	Hog spleen	22.2								
	Salmon viscera	33.4	1,893	3,516	.62	1.54	2.56	4.37	14.1	None
2-C	Beef liver S	21.1								
	Hog liver	21.1								
	Hog spleen	21.1								
	Salmon viscera	31.7								
	Crab meal	5.0	1,779	3,461	.62	1.08	2.71	4.40	13.3	None
3-C	Beef liver S	33.3								
	Hog liver	33.3								
	Salmon viscera	33.4	1,814	3,086	.92	3.23	2.66	4.95	11.7	None
4-C[2]	Beef liver S	33.3								
	Hog liver	33.3								
	Salmon viscera	33.4	1,728	3,738	.31	.77	2.75	3.76	12.2	None
5-C	Beef liver S	31.66								
	Hog liver	31.66								
	Salmon viscera	31.68								
	Crab meal	5.00	1,694	3,109	.46	1.54	2.80	4.77	13.4	None

Lot	Diet Components	Percentage Composition	Mean Weight in grams 12 wks	24 wks	Percent mortality 12 wks	24 wks	Conversion 12 wks	24 wks	Hemoglobin g/100 ml. blood 24 weeks	Deficiency Symptoms
6-C	Beef liver S	33.3								
	Hog liver	33.3								
	Salmon eggs (frozen)	33.4	1,854	3,196	.92	1.38	2.55	4.86	13.6	None
Least difference at 5% level:			209	328	.66	3.27				

1/ Salt added at the rate of 2 grams per 100 grams of ration.

2/ At the end of the first 12-week period 10% of vacuum-dried salmon viscera meal was added to these diets with a corresponding proportional reduction in each of the original components.

The results of these feeding trials were not as anticipated. The standard meat-viscera control (Diet 1-C) proved entirely adequate for chinook salmon. The growth response was significantly greater than that of the comparable chinook ration (Diet 3-C) and no anemia was indicated. Crab meal made no discernible contribution to either the meat-viscera mixture (Diet 2-C) or to the chinook ration (Diet 5-C). The addition of vacuum-dried salmon viscera meal to the chinook ration resulted in a significant increase in the growth rate without the development of an anemia. Salmon eggs substituted for salmon viscera in the chinook ration (Diet 6-C) did not result in an additional growth response. The failure of salmon eggs to increase the growth rate is believed to be due to the poor feeding consistency of the diet rather than the inability of chinook to utilize the protein. Apparently the differences in nutritional requirements between chinook and blueback salmon are not as great as was originally anticipated. The failure of the standard meat-viscera mixture to maintain chinook salmon in production feeding may have been due to the inadequate segregation of spring and summer races and the retention of the spring stock past their normal migration time or some unrecognized variation in techniques or environmental conditions. Further experimentation is planned to explore the possibility of differences in nutritional requirements between chinook and blueback salmon.

Summary of Results

Under the conditions of this experiment using blueback and chinook salmon as the test animals the following conclusions were indicated:

1. Beef lung was an adequate substitute for hog spleen in the standard meat-viscera mixture. Its binding qualities were as good or better than spleen and its growth potential appeared to be equal in this combination. When combined with hog liver, salmon viscera, and salmon viscera meal it produced a diet equal in every respect to the standard meat-viscera-meal

combination. In addition to its compatability in combination diets, the low intiial costs of beef lung recommends its use in production diets.

2. Whale liver proved unsatisfactory when fed at the 100 per cent level. The mortality which resulted from feeding this diet was indicated to be caused by a hypervitaminosis A. When substituted for beef liver in the meat-viscera-meal mixture whale liver proved adequate. The growth response was comparable and no anemia developed. Because of the danger of the development of a hypervitaminosis A and the variability in the vitamin A content of different livers, whale liver should be used with caution. Its use in production diets is not recommended.

3. Arrow-tooth halibut proved an adequate substitute for hog spleen in the meat-viscera-meal mixture. The growth rate was comparable but the bound quality of the diet was imparied. At the 100 per cent level its growth potential was inferior to herring. Other combinations including arrow-tooth halibut must be tested before it can be recommended for production use.

4. Herring substituted for spleen in the meat-viscera-meal combination resulted in a significant acceleration in the growth rate of the fish when compared with the standard combination diet. Here, again, the bound quality of the diet was impaired. When used at the 100 per cent level, fish fed herring developed symptoms indicating a thiamin deficiency. In the combination diet this deficiency appeared to be adequately covered. Because of the excellent growth potential of herring further experimentation is indicated to determine proper combinations which would improve the feeding consistency yet retain the growth advantage.

5. A hog liver-salmon viscera and a hog liver-salmon viscera-meal combination were adequate substitutes for the meat-viscera and meat-viscera-meal

control diets. These diets produced growth rates as good or better than their comparable controls. They have excellent possibilities as production diets.

6. Tuna liver substituted for beef liver in the meat-viscera control diet produced comparable gains during the cold water period but resulted in a significantly lower growth rate during the warm water period when 10 per cent meal was added to both diets. No anemia developed during the 24-week feeding period. A tuna liver-salmon viscera-meal combination resulted in an acute hypervitaminosis A after 8 weeks of feeding. Tuna liver because of its low growth potential and high vitamin A content is not recommended for inclusion in production diets.

7. Salmon eggs preserved with 0.5 per cent sodium bisulfite and stored at room temperatures for three months before being frozen lost a portion of their growth potential. This method of preservation still has possibilities in view of the fact that three months is well beyond the maximum storage interval which would be required for Alaskan shipments. A shorter storage interval would, very probably, reduce the amount of decomposition occurring in the preserved eggs.

8. Attempts to reduce mortality due to feeding 10 per cent of salmon meal during prolonged periods of cold water produced, in the main, negative results. Predigested salmon viscera meal and the vacuum-dried product fortified with 4 per cent each of lysine and methionine did not reduce the mortality, rather the predigested meal aggravated it. The addition of vitamins of the B complex to the diet caused a significant reduction in the mortality but the losses were still significantly higher than those of the control lot. A 5 per cent meal content in the diet caused a significant increase in growth rate without an increase in mortality over the control. A more complete vitamin supplementation may prove the

key to mortalities when high-protein diets are fed during periods of prolonged cold water.

9. In experiments with chinook salmon it was impossible to demonstrate a difference between the nutritional requirements of chinook and blueback salmon. The standard meat-viscera mixture used for blueback proved entirely adequate for chinook. The addition of 10 per cent meal to the chinook diet (one third each of beef liver, hog liver, and salmon viscera) resulted in a significant acceleration in growth rate and no anemia when fed during the warm-water period.

Discussion

Ellis: What do you mean by the 90 day unrefrigerated storage period in the case of the preserved salmon eggs?

Burrows: I mean that they were stored at room temperature for 90 days to correspond with the time required to collect and ship the eggs to the States in an unrefrigerated hold.

Sinnhuber: Did you get a high mortality in various sized fish when feeding meals during cold-water periods?

Burrows: Yes, we have experienced it with fish running 2,000 per pound as well as those running 300 per pound.

Sinnhuber: We selected yellow fin tuna livers because we were afraid of the high level of vitamin D not vitamin A in other species of tuna. Are you sure that the hypervitaminosis was that of vitamin A and not D?

Burrows: We did not analyze the livers for vitamin D. Since the literature stressed that the vitamin A content of whale liver exceeded the danger level and the symptoms of the fish fed tuna liver were similar to those fed whale liver, analysis was restricted to vitamin A. When this analysis showed that the vitamin A content was high in the tuna livers, it was naturally assumed that the breakdown was due to hypervitaminosis A.

Ellis: We experienced the same results when feeding anchovies that you did feeding herring.

Red Johnson: How were the mortalities in these diets?

Burrows: The mortalities were all low, with no significant differences.

Ellis: Which do you believe gives the best bind - lungs, spleen or salmon milt?

Burrows: Milt is better than lungs and lungs are better than spleen.

Ellis: Did you run into any trouble mixing the meats and viscera and storing them before feeding?

Burrows: No, we fed our experimental diets on the same day the food was prepared. However, on our production stock we hold this mixture overnight without any harmful effects.

Hull: I have fed a great deal of carp and had trouble mixing them with meats and storing. I found it necessary to feed the mixture promptly.

Red Johnson: We stored the meat-viscera mixture as long as 7 days at Coleman without ill effects.

Hull: Were the hog livers that you used flukey and dyed?

Burrows: Yes, they were all flukey and dyed - not fit for human consumption.

Sinnhuber: The Russians have published on some experiments which they conducted on the destruction of vitamins in beef liver by freezing. They found that the livers suffered severe vitamin losses when frozen-progressing as the freezing period extended.

Halver: A couple of years ago, Phillips found considerable variation between livers obtained from different sources.

Hematopoietic effect of xanthopterins and a 1/100 ratio of Vitamin B_{12} to folic acid when injected into young anemic Chinook salmon.
Speaker: John A. Coates

"Simmon's Xanthopterin", Lederle xanthopterin, and a 1/100 ratio of Vitamin B_{12} to folic acid were injected in one massive dose to young anemic Chinook Salmon (tbc approximately 600,000) and hematopoietic response measured by hemoglobin determinations and total blood cell counts at end of 4, 7, and 14 days respectively.

Of materials tested, Lederle xanthopterin showed no response; Simmon's material gave a slight response but the standard deviation was greater than the measured response; and the Vitamin B_{12} and folic acid in a 1/100 ratio exhibited a definite hematopoietic activity at the termination of the experiment. The response at the 14-day post-injection period exceeded the standard deviation by a factor of three.

A combination of Vitamin B_{12} and folic acid may be an anti-anemic factor in young chinook salmon.

Discussion

McKernan: Will Xanthopterin keep for a long period in storage?

Coates: Yes, under refrigeration.

Halver: It is quite stable. Lederle guarantees their product to keep for 90 days.

Burrows: Do you use standard deviation to determine your differences?

Halver: Yes, at all points.

Burrows: Could the hemoglobins be lagging behind the red cells?

Coates: Yes, they could be.

Palmer: Did you observe any mis-shapen or crumpled red cells?

Halver: Yes, we did, in Lot A they were ragged. In the other lots, many rejuvinated cells were seen.

Palmer: How rapidly is it possible to build up the blood count from say 600,000 to say 1,200,000 per milliliter?

Halver: I don't know. In the case of this experiment, it took 14 days.

McKernan: In the case of a change in temperature, the increase in blood count may be rapid.

Rucker: I believe Dave was referring to a case where the fish have become anemic on a deficient diet and an attempt is made to increase the blood count by fortifying or otherwise changing the diet, weren't you?

Palmer: Yes, that's what I was getting at.

Halver: Recovery from such an anemia depends a great deal on the extent of the anemia. If the condition is permitted to go beyond a certain point, there is no chance of recovery.

Recent work shows that Simmon's material is not actually xanthopterin, but some closely related material.

Vitamin-test Diet for Chinook Salmon
Speaker: John E. Halver

A vitamin-test diet for Chinook Salmon was developed and fry were raised on the test diet for 20 weeks, time measured from initial feeding until release at termination of experiment. Diet consisted of vitamin-free casein supplemented with 2% dl-methionine plus 1% l-tryptophan, C.P. gelatin, purified potato starch, hydrogenated cottonseed oil, C.P. salts and crystalline vitamins. Comparisons with liver control diet showed parallel growth with a -18% differential at end of 20 week feeding period. At time of release no vitamin-deficiency syndromes detected from post-mortem examinations of external and internal organs, microscopic examinations of gill filaments, and hemoglobin and erythrocyte determinations. Representative samples prepared and stored for histological sectioning to determine micro-pathology not apparent from macro observations.

Plans for current year include feeding vitamin-deficient diets and observing and recording specific vitamin-deficiency syndrome for each of vitamins required by Chinook Salmon.

Discussion

Sinnhuber: Have you run any analysis for B_{12} on your diet?

Halver: No, but it will be run.

Sumerwell: Has anyone ever shown that the protein requirements are the same for fish as for other animals?

Halver: No, that has yet to be determined.

Preliminary Report of Dorena Dam Experimental Laboratory
Speaker: Red Johnson

The Dorena Dam Experimental Laboratory was established in the summer of 1950 to determine if it is possible to incubate, hatch and rear salmon and trout in water obtained from Dorena Reservoir.

Water from three levels (765', 785' and 805' elevation) in the reservoir is available in the hatchery during the summer and fall. For the remainder of the year only water from the lower intake (765') is assured. During the summer and fall, fish of all species handled are reared in water from the lower and upper intakes and in an "optimum" supply maintained at about 55-60°F.

Equipment includes 22 deep troughs, 24 six foot circular tanks, cold storage plant and feed preparation equipment, laboratory, office and store rooms all in a building provided by the Corps of Engineers.

The following is a summary of the results of the first year of operation:

Spring Chinook Salmon.

Fingerlings of 1949 brood were reared from September, 1950 to April, 1951, with satisfactory results. A lot of green eggs received in September, 1950, were almost a total loss apparently due to high water temperatures. A third lot received when just ready to start feeding were reared with excellent results throughout the summer in the lower intake and optimum water supplies. Those held in upper intake water had very high mortalities from columnaris. An experiment is now in progress to determine causes of high losses in the egg stage.

Fall Chinook Salmon.

Green eggs received in September, 1950, suffered high mortalities in egg and fry stages apparently from the high water temperatures. The surviving fingerlings made good growth with low losses until released in July. An experiment similar to that with spring chinooks is in progress with eggs of 1951 brood.

Silver Salmon.

Fingerlings of 1949 brood were reared from September, 1950, to May, 1951, with excellent results. Mortalities in egg stages were high in several lots of silver salmon handled. One lot of fingerlings was reared over summer with satisfactory results except for losses from columnaris in fish held in upper intake water. An unidentified bacterial infection caused considerable mortality of fingerlings in two lots during April and May.

Cutthroat Trout.

Egg, fry and early fingerling mortalities were high in a group of cutthroat trout received as eyed eggs in March, 1951. Results with the fingerlings during the summer were satisfactory although losses from columnaris were high in fish held in upper intake water.

Rainbow Trout.

Egg, fry and early fingerling losses were also high in a lot of rainbow trout received in the eyed stage in March, 1951. The fingerling were reared through the summer with satisfactory results with the exception of mortalities from columnaris in the warm upper intake water.

Tentative conclusions.

Lower intake and mixed (55-60 F.) water supplies from Dorena Reservoir are satisfactory for rearing fingerling chinook and silver salmon and cutthroat and rainbow trout.

Water from the upper intake is not suitable because of the development of columnaris in all species reared in this supply.

In the fall of 1950, all water supplies were too warm for satisfactory incubation of chinook salmon eggs.

Results with silver salmon, cutthroat trout and rainbow trout eggs were inconclusive.

Discussion

Burrows: Our experiments at Entiat on the effect of warm water on eggs are confirming yours. We have suffered a total loss of eggs held in 65° water.

Rucker: Don't eggs require tempering for a 3-day period in changing the temperature?

Burrows:)
Ellis:)
Hull:) No, when the temperature change isn't over 10°, no tempering period is required.

Ellis: Did water analysis reveal any hydrogen sulfide?

Red Johnson: No.

Ellis: Dick Smith's report on the Ariel Dam experiments might be of interest on this subject.

Red Johnson: Where is that report? I've been trying for some time to get a copy of it.

Don Johnson: It's in our files. I'll see that you get a copy.

Ellis: Fertility in eggs varies when the pH of the water is varied at the time of fertilizing.

Meeting called to order at 9:00 a.m. Wednesday November 14, 1952

Review of operations of the Horsefly Experimental Station.
International Salmon Commission by R. MacLeod (no summary forwarded)

Discussion

Ellis: Do your intake pipes pull in any sockeye fingerlings?

MacLeod: No, only rough fish.

Jeffries: Do you do any overwinter holding?

MacLeod: We have some we're holding until December or January for the university. There is no reason to hold fish over winter otherwise.

McKee: What returns do you get on eyed egg plants?

MacLeod: I don't know. I do the work. The research work is done by others.

Red Johnson: How large are the fish when you plant them?

MacLeod: Approximately 103 per pound.

Hull: Hasn't the International Salmon Commission done some work with constant temperatures on egg development?

MacLeod: Yes, but the work hasn't been reported yet.

McKernan: Why do you raise Kokanees there?

MacLeod: We're trying to force feed them and make sockeyes out of them because we have a large supply of kokanees. The conditions of the habitat of these kokanees are similar to those of the sockeyes that we're trying to build up.

Ellis: How far down into the planting barrel does the air hose run—to the bottom?

MacLeod: No - only three inches. It gives good aeration when we are flying. It causes a complete churning over of the water.

Millenbach: We use a modification of that barrel, with a small vacuum pump for aeration during loading and unloading or whenever we are not flying.

MacLeod: The trouble with our setup is that we don't have our own aircraft, so we can't install the apparatus we'd like to. We rent a plane from Beaver Aircraft Co. We get around the lack of a vacuum pump by loading and unloading in three minutes or less.

Red Johnson: When using water from the 100 ft. level in the lake, do you have to aerate it?

MacLeod: No, aeration is accomplished at the head trough.

Rucker: What type of aerator do you use in the head trough?

MacLeod: We use a box on the head trough containing two baffles. The water hits the baffles and is aerated.

State of Washington Department of Fisheries

An Interim Report on Fish Disease Investigations
Speaker: Brian John Earp

During the period covered by this report[1/], a considerable incidence of anemia has been noted in most stocks of silver and chinook salmon reared at the various installations of the State of Washington Department of Fisheries. The presence and incidence of this condition was determined by examination of the general gill color and not by blood counting techniques. The cause of this condition is unknown, but incidence and severity was greatly increased in instances where pond populations had been over-estimated and a correspondingly higher percentage of weight of diet to body weight was used. Fish with poor gill color were always found to have an excessive amount of fat along the digestive tract, with a marked serous effusion into the peritoneal cavity. Correlations, if any, between the excessive fat and the anemic condition is unknown. The livers of anemic fish were generally of poor color and texture. No histological studies of such livers have been undertaken to date to determine any possible pathology.

Bacteriological investigations conducted during this period were concerned with a vibrio species isolated from an epidemic in chinook salmon reared in sea water at the Bowman's Bay Marine Biological Station and with the bacterium found associated with "kidney disease" in chinook, silver and blueback salmon. Investigation of other diseases of bacterial etiology was confined to mild outbreaks of furunculosis which responded favorably to treatment with sulfa drugs.

SALT WATER INVESTIGATIONS

Chinook salmon being reared in sea water ponds at the Bowman's Bay Station are frequently affected during the summer months with a disease which closely resembles furunculosis as it appears in fish reared in fresh water. For some time it was believed that this disease was a marine variety of furunculosis, but B. salmonicida was never isolated from the lesions. The disease is characterized by the appearance of hemorrhagic areas around the fins and anus, under the skin, and of the internal organs. In some cases, extensive necrosis with hemorrhaging of the musculature is seen with lesions rupturing to the outside leaving an open bleeding sore. Affected fish often turn dark in color, are subject to spasmodic convulsions, and die very quickly after symptoms are first noticed. Large numbers of a curved gram negative rod, approximately 0.5 by 2.0 microns are found in the lesions. In stained smears from affected areas these bacteria closely resemble Bacterium salmonicida but repeated attempts to isolate this organism on routine media were unsuccessful.

Pure cultures of a vibrio species were readily obtained from the lesions and blood on Tryptone media to which 3% NaCl was added. No growth was obtained in media without the inclusion of NaCl. When dilute suspensions of a pure culture of this organism are injected into healthy fish, the typical symptoms of the disease appear very rapidly and death occurs within 24 hours.

It has been found that the disease responds favorably and very quickly to certain of the sulfa drugs. Sulfamethazine (Lederle) has been successfully employed at the rate of 12 grams of drug per 100 pounds of fish for five consecutive days. A complete description of the disease and organism is being undertaken in a separate paper. A vibrio (Vibrio anguillarum) isolated from an infectious disease of eels has been described.

KIDNEY DISEASE

Kidney disease continues to be an annoying problem at all installations. Cninook salmon are always affected with the disease to some degree toward the end of their first brood year, and recent evidence of the occurrence of the same disease in silver salmon has become more prevalent. An extensive study of the disease has been undertaken.

In all outbreaks of kidney disease the presence of a typical small gram positive rod can always be demonstrated in the organs (principally the kidney). This organism has been maintained on a rich bacterial medium, without the presence of contaminants, for considerable periods of time and there is evidence that slight growth of the organism occurs on such a medium[2/]. Healthy fish will develop the typical syndrome of kidney disease with the development of large numbers of the typical bacterium in the organs when injected inter-peritoneally with washings from culture plates. An incubation period of approximately 21 to 30 days always elapses between the time on injection and the onset of mortalities from the disease.

The effect of poor diet, and the holding of salmon (in this case chinook salmon) past the normal migration age have been suggested as factors inducing or materially advancing the course of kidney disease in hatchery fish. While any adverse condition, dietary or environmental, which does not provide optimum conditions for the health and well-being of hatchery fish undoubtedly contributes to the incidence and severity of many fish diseases, it is believed at this time that the evidence points strongly toward a specific bacterium as the primary etiological agent of kidney disease.

Although the standard production diet currently in use is probably not entirely adequate, it should be noted that kidney disease has been known to occur in stocks of fish fed on a great variety of diets. One lot of blueback salmon at the University of Washington School of Fisheries suffered a considerable mortality from kidney disease after being reared in filtered Seattle city water and fed since hatching on a diet considered to be excellent. This diet included a plentiful percentage of fresh meat by-products currently considered as being a most desirable constituent of fish diet.

The onset of kidney disease in chinook salmon normally occurs in those fish held in fresh water past the normal migration time. However, the disease is known to occur at the same time in other species of salmon, including the silver salmon, and also in various species of trout. There is no substantial evidence at this time that moving chinook salmon into sea water after the disease has been contracted will materially improve the condition of the fish or eliminate the typical bacterium from the organs.

The fact that kidney disease can be transmitted to healthy fish of various species, following a uniform incubation period, by the injection of infected material is strong evidence that the etiological agent of the disease is a bacterium. The same material, subjected to heating or passed through a bacterial filter, fails to transmit the disease in the same manner.

1/ This report covers only that part of the year 1951 during which the writer was affiliated with the State of Washington Department of Fisheries, i.e., August 15, 1951, to the time the report was made, November 14, 1951.

2/ Since the period of this report, the bacterium of kidney disease has been cultivated successfully in vitro. Pure cultures have been employed to reproduce the disease in healthy stocks of fish and the etiological agent reisolated from these test fish. The effects of various antibiotics on the disease after it is introduced into test fish is being investigated.

Discussion

Sinnhuber: How did you recognize fatty degeneration of the livers?

Earp: Purely by visual observation.

Oregon Fish Commission

Nutritional Diseases
Speaker: Don McKernan

Bacterial kidney disease was first discovered in Oregon Fish Commission hatcheries in the fall of 1948, and since that time has been found in at least nine of the thirteen operating Oregon Fish Commission hatcheries. A small experiment set up in 1949 using sulfamethazine, showed some promises for control of the infection. Further studies with the use of sulfamethazine, sulfamerazine, sulfadiazene and terramycin proved unsuccessful. The sulfa powders were mixed with the daily ration of food at the rate of 3 grams per pound of food fed since the weight of the fish in the ponds treated was in most instances not known. This approximates 10 grams per 100 pounds of fish per day, set down by Gutsell et al in earlier work. The terramycin Bi-Con TM-5 was mixed in with the daily food ration and fed at the level of 75 milligrams of TM-5 to each kilogram of fish. This is the level prescribed by veterinarians for treatment of cats and dogs.

It has been noted that this disease usually reaches the endemic stage in September on spring chinook and silver salmon. No kidney disease has been noted on fall run chinook in Oregon. In checking over the diets fed at the OFC hatcheries, it was found that where a good diet had been fed, kidney disease epidemics were lessened. Where inadequate diets were fed the incidence of kidney disease was more evident. All fish with kidney lesions had pale to white gills.

It was noted in the recent feeding experiment at Bonneville that none of the diets considered adequate and showing a good growth potential showed fish with kidney disease. In all, slightly over 100 instances of kidney lesions were found in examining the mortalities of the feeding lots. Of this number one hundred were found in diet #12 (Wolf's synthetic diet). One was found in our diet #1 a straight synthetic diet and a few from diet #3. Both of these diets were low in growth potential. Lot 12 showed the lowest growth and greatest mortality of any of the lots. No kidney disease was found in the better diets. It is the belief of Oregon investigators that nutrition plays a big part in kidney disease, and may be the answer in its control. On this basis experiments will be set up this summer to determine if on an adequate diet, such as the Leavenworth production diet (1/3 beef liver, 1/3 hog liver, and 1/3 salmon viscera, 2% salt) fish can contract this kidney disease. Suitable controls will be set up.

Discussion

Red Johnson: When does the kidney disease show up?

McKernan: Usually in September and October - never in the spring of the first year.

Red Johnson: We have kidney disease in the spring at Dorena but only in silver salmon fingerlings which have been held over winter.

Coates: Do you use prophylactic treatments for diseases other than kidney disease at your hatcheries?

McKernan: No, but we are considering it.

Halver: What are the actual numbers of these marked fish that have returned so far?

McKernan: There have been 141 fish with the adipose and anal marks and 116 with the adipose and dorsal marks.

Burrows: An experiment which we conducted at Leavenworth confirms your results. We reared two lots of fish, one fed on the Leavenworth production diet and the other fed a diet which produced healthy fish but slower growth. At the time of release, the larger fish ran 60 per pound as compared with 110 per pound in the smaller fish. We got a return of 3 to 1 in favor of the larger fish.

Palmer: Have you any information as to the sex ratios of these returned fish which were graded prior to release?

McKernan: No, we don't have that information, yet. We have the raw data but it hasn't been worked up yet.

Ellis: We found that the pond mortalities of large graded fish showed a great preponderance of males.

Garlick: In one instance, with cutthroat trout, selection of large fish for breeders produced a 4 to 1 ratio of males to females.

Burrows: This year, at Entiat, our chinook salmon run contained only 18% females.

Fish and Wildlife Service

Speaker: Robert R. Rucker

Wolf's and McLaren's "synthetic" or test diets were fed to chinook salmon fingerlings: similarly, fingerlings were raised on the same two diets lacking in pantothenic acid. McLaren's diet was a failure but Wolf's diet produced healthy control fish and fish that showed the effects of the deficiency. Material was fixed and put into paraffin blocks for later study. This work is written up in the January, 1952 issue of the Progressive Fish-Culturist.

I am now writing up a contagious disease among the kokanees and blueback salmon fingerlings at the Winthrop and Leavenworth stations. This disease was experimentally transmitted to healthy bluebacks by placing infected fish in the water with them: neither chinook or silver salmon nor cutthroat trout contracted the disease under similar conditions. Therapeutic measures tested on infected stock included pyridylmercuric acetate, sulfamerazine, sulfamethazine, sulfadiazine, sulfaguanidine, aureomycin, terramycin, chloromycetin, streptomycin and penicillin -- all with no effect. It is thought that this disease is caused by a filtrable agent, possibly a virus. A manuscript on this disease was prepared with Whipple, Parvin and Evans as co-authors; it is now being revised.

Discussion

Earp: Identification of the kidney organism is very difficult. We must be careful about calling a disease "kidney disease". A poor diet may weaken the fish to the point of invasion of a multitude of pathogens. Once the capillaries break down, an organism can be found. The kidney disease organism can be cultured in the laboratory, healthy fish injected with the organisms, and the disease thus produced in them. Concerning disease control, there is a great need for someone to review the work that has been done on sulfa therapy and establish the tolerance levels.

Don Johnson: It might be possible that the kidney organism is passed on to the fingerlings by feeding salmon carcass or meals made from salmon carcass.

Halver: We conducted an experiment on chinook salmon fingerlings to attempt to produce blue slime disease. We fed them a biotin deficient diet but no blue slime appeared.

McKernan: In Oregon, we found that wherever kidney disease appeared, the diet was poor.

Rucker: There is a possibility that the organism is present at all times but doesn't appear on the surface until the fish are broken down by a poor diet, or otherwise weakened.

California Fish and Game
Speaker: Harold Wolf (report forwarded, not present)

This past year diet work in California has been limited to field trials involving dry meal meat mixtures and dry pellets. Due to the nature of field trials under hatchery conditions I am not offering any figures as I believe that they are not accurate enough to be of any particular value.

The pellets used were from two sources. One was a commercial pellet made by James N. Ellis of Hagerman, Idaho; the other was a pellet made by our hatchery crew at our Crystal Lake Hatchery, Shasta County. These last pellets were made with a machine manufactured by the California Pellet Machine Company, San Francisco, California. The Ellis Pellets were used by several of our hatcheries throughout the State. Most of the hatchery personnel were not favorably impressed with them. Many of the hatcheries had difficulty in getting the fish to eat the pellets and after the fish once were eating them the fish seemed to grow quite unevenly. The Ellis pellets are supposed to be introduced into the diet gradually, that is when the fish are small they get pellets once every three days with their regular meat diet in between. This is eventually worked down until the fish are about five inches long when they get pellets six out of seven days. From what I have seen of these pellets I would say that they are not the best for raising fish but just for holding fish near the planting season when growth is not particularly desirable.

The pellets which are made at the Crystal Lake Hatchery have varied in composition but the usual ingredients are: beef liver (flukey), sardine meal, cottonseed meal, wheat standard middlings, blood meal, meat scraps and mineralized salt. The liver is well ground, placed in a dough mixer, the dry ingredients are added and allowed to mix for about fifteen minutes--then removed and run through the pellet machine. The pellets are allowed to reach room temperature then stored for twenty-four to forty-eight hours in a refrigerator after which they are placed in a cold, dry room until used. Pellets so processed are free of visible deterioration and mold for at least sixty days which is as long as any have been stored. Fish fed on these pellets are usually started on liver and a gradual shift to pellets takes place not unlike that recommended by the Ellis Company. Fish on these pellets are in better shape than those on the Ellis Pellets and appear to be comparable to our control diet of liver and fish.

Future Programs

Halver: We plan to re-examine holding chinook salmon on vitamin free test diets. We will attempt to improve these test diets with lactalbumin. We will test methods using L amino acids. We plan to continue on with the isolation of tryptic enzymes. We may also undertake some more blood studies.

Garlick: We will be too busy to conduct any diet experiments in 1952.

Burrows: We will continue our feeding trials, testing tried and untried diets. We will explore further such products as beef lungs, various dry meals and so forth. We would be glad to test diets or single diet components developed by other agencies.

Perry: I'd like to suggest the circulating of these proposed diet research programs around to the various groups for reviewing.

Ellis: That would require first a history or foundation of the past work which the organization has done leading up to the proposed program.

McKernan: I'm in favor of such a proposal to review the program. We keep no secrets in Oregon.

Sinnhuber: We are willing to collect any fish product desired by any agency for feeding or testing.

Garlick: There is a need for standardizing data on nutritional experiments for ease in comparison.

Burrows: That's too big a problem to be solved here.

Halver: Diets should be evaluated on nitrogen content not on moisture content.

McKernan: I feel that varied methods in diet evaluations give better coverage.

Burrows: I believe that analyses of the crude protein of diets is a poor indication of their potential growth responses.

Sinnhuber: (read an excerpt from one of McKay's articles concerning evaluation of diets on moisture content)

Perry: I wish you'd give my suggestion on the reviewing of the proposed programs more thought.

Location for Next Year's Meeting

McKernan: I move that we hold our next meeting in Seattle and appoint Washington State Department of Fisheries as Chairman.

Motion carried.

Meeting adjourned for inspection of Entiat Salmon-Cultural Laboratory.