TESTS OF HATCHERY FOODS FOR BLUEBACK SALMON 1951

SPECIAL SCIENTIFIC REPORT: FISHERIES No. 63

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

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Washington, D.C.
May, 1951

United States Department of the Interior, Oscar L. Chapman, Secretary
Fish and Wildlife Service, Albert M. Day, Director

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Fishery Biologists

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INTRODUCTION

The 1950 feeding trials with blueback salmon (Oncorhynchus nerka) were conducted at the Leavenworth Laboratory to develop adequate diets for the artificial propagation of salmon. In these experiments various combinations of previously tested products and several untried foods were evaluated on the basis of growth, survival, and the presence or absence of recognizable deficiency symptoms.

The 1950 trials consisted of two experiments: The first was largely an evaluation of previously tested foods in production diets and was conducted for a 24-week period which was divided into 12 weeks when the water was relatively cold (45°) followed by 12 weeks when much warmer (54°). The second, being more exploratory in nature, evaluated less thoroughly the foods and diet combinations tested and was conducted for 12 weeks during a warm-water period.

The first experiment was designed to make the following appraisals: (1) a comparison of the growth and mortality resulting from the experimental diets with the standard beef liver control; (2) an evaluation of the effect of the deletion of spleen from the meat-viscera combination; (3) a comparison of salmon eggs and salmon viscera in several combination diets ; (4) a test of salmon milt and its effect on mortality and growth when used in combination diets; and (5) a determination of the contribution of a salmon waste meal and crab meal to some of the foregoing diets. Trials were conducted also with high-level salmon viscera diets to evaluate yeast and liver supplements as well as diets with decreasing levels of salmon viscera and increasing levels of beef liver and hog liver.

The following comparisons were made in the second experiment: (1) beef liver and the meat-viscera-meal control diets with the experimental diets; (2) mackerel offal meal with salmon viscera meal; (3) four differently preserved lots of salmon eggs with fresh-frozen salmon eggs; (4) hake, whole cod, and halibut sawdust with hog spleen in the meat-viscera-meal control; (5) halibut sawdust with whole cod in single component studies; (6) combination diets utilizing salmon milt, salmon eggs, and salmon viscera meal with comparable diets in the first experiment; (7) tuna liver with beef liver in the meat-viscera-meal control; and (8) diets with and without APF (Animal Protein Factor) concentrates.

The conditions of experiment for the first and second groups of feeding trials are comparable and are presented as one section, but the results and recommendations are developed separately because two distinct sets of trials are involved.

CONDITIONS OF EXPERIMENT

In the first experiment, 500 grams of fingerling blueback were placed in each of the 36 troughs necessary for the 18 diets. By an actual count of 4 troughs, the average number of fish per trough was determined to be 1,308.5 with a coefficient of variation of 2.5 per cent. This number of fish represented an initial average weight per fish of .3821 grams or an initial number per pound of 1,188.

In the second experiment 1000 grams of fingerling blueback were placed in each of the 52 troughs. The average number of fish per trough as determined by an actual count of 6 troughs was 448.5 fish, with a coefficient of variation of 3.6 percent. The number of fish per pound was calculated at 203.6 and the average weight per fish at 1.1148 grams.

In both experiments the diets were treated uniformly when prepared and fed, and the bind resulting from the addition of 2 percent salt, although not entirely uniform from diet to diet, was satisfactory for purposes of experimentation (Burrows et al, 1951). The fish were fed three times a day with a modified potato ricer.

The description of the food products common to most of the diets in both experiments was as follows: all raw products were ground, and mixed while in a frozen condition; the beef liver and hog liver were dyed and flukey; the hog spleen was fit for human consumption and therefore not dyed; the salmon viscera was obtained from Puget Sound pink salmon (O. gorbuscha) and contained only the gonads, livers, air bladders, and digestive tracts; the vacuum-dried salmon viscera meal was prepared from the same salmon viscera used in the experiments. A small Stokes rotary vacuum-dryer operating at 100° F. was used to dry-render the meal.

Blood counts and hemoglobin determinations were made at the end of both the first and second experiments. Two blood counts were taken from a single sample of blood from each of four fish chosen at random from each lot. The hemoglobin determinations were made with the Tallqvist-Adams readings. As the hemoglobin determinations and erythrocyte counts were derived from different samples, an anemic tendency was not indicated unless the means of both determinations were in agreement (with the hemoglobin determination below 9.4 grams per 100 milliliters and the erythrocyte count below 900,000 red cells per cubic millimeter).

The water temperatures for the first experiment averaged 45° F. with little variation during the cold-water period of 12 weeks from April 5 to June 28, 1950. At the end of this period the water temperature rose rapidly. The water temperatures averaged 53.9° F. for the warm-water period of 12 weeks from June 29 to September 20, 1950. In the second experiment (July 5 to September 27) the water temperature averaged 54° F.

RESULTS AND RECOMMENDATIONS

Results of feeding the various diets of the first experiment and second experiment were judged almost entirely by significant differences in mean lot weights using analysis of variance for paired experiments as described by Snedecor (1946). The mortalities, being low and comparable, offered no assistance in judging the diets except in one or two instances. Conversion factors merely served to confirm the weight differences since, with minor exceptions, the greater the mean lot weight the more efficient (or lower) the conversion rate. Blood counts and hemoglobin determinations showed that none of the diets in the first experiment produced a tendency toward anemia, but that two of the diets in the second experiment created an anemic condition. The blood counts and hemoglobin determinations proved almost valueless for the establishment of clear-cut differences by analysis of variance because of variation within lots.

RESULTS OF FIRST EXPERIMENT

Beef Liver Control

In the first experiment the beef liver control, represented by Diet 1 (Table 1), repeated the results attained in previous trials. The relationship of the mean lot weight produced by the beef liver control and the mean lot weights produced by the other diets changed however, during the cold-water period. Previously, beef liver had been one of the better cold-water diets. In this trial the growth produced by beef liver was not only exceeded at the 5 percent confidence level by all but two diets, but also there was, with two exceptions, no significant difference in mean mortalities. These results at the end of the cold-water period indicated that the diets in this first experiment worthy of consideration as production diets during the most difficult time of fingerling rearing: the cold-water period. During the warm-water period, beef liver produced the same relatively low growth rate encountered in previous experiments.

Effect of the Deletion of Hog Spleen from the Meat-Viscera Mixture

This experiment compares the meat-viscera mixture with a similar diet containing no hog spleen. The purpose for this deletion was to form a diet with a higher vitamin and protein content. The higher vitamin and protein level was attained by replacing hog spleen with increased amounts of liver.

The meat-viscera mixture (represented by Diets 2 and 3) consisted of 22.2 percent each of beef liver, hog liver, and hog spleen, and 33.4 percent of salmon viscera during the cold-water period. During the warm-water period, but a salmon waste meal was added to Diet 3 to form a mixture of 20 percent each of beef liver, hog liver, and hog spleen, 30 percent salmon viscera, and 10 percent vacuum-dried salmon viscera meal.

The diet without spleen (represented by Diets 8 and 9) consisted of 33.3 percent beef liver, 33.3 percent hog liver, and 33.4 percent salmon viscera during the cold-water period. During the warm-water period Diet 8 remained the same but salmon waste meal was added to Diet 9 to form a mixture of 30 percent each of beef liver, hog liver, and 10 percent of vacuum-dried salmon viscera meal.

TABLE 1.—Summary of 1950 feeding trials with blueback salmon—First Experiment

Initial number per trough: 1,308.5 fish
Initial weight per trough: 500 gr.

Initial average weight per fish: .3821 gr.
Initial number per pound: 1,188 fish

Period: 4/5/50 to 9/20/50

Temperature: Average for 1st 12 wks., 45.0° F; average for 2nd 12 wks., 53.9° F; average for 24 wks., 49.3° F.

Diet No.	Components	Percentage Composition	Mean diet weight at the end of 12 and 24 weeks in grams		Per cent mortality		Mean mortality		Conversions		Hemoglobin g/100 ml. blood	Red Blood cells/c.mm.	Deficiency Symptoms
			12 wks.	24 wks.	12 wks.	24 wks.	12 wks.	24 wks.	12 wks.	24 wks.			
1	Beef liver	100.0	1,947.5	6,405	1.49	2.75	19.5	36.0	3.75	4.52	10.3	1,000,000	None
2	Beef liver S 2/ Hog liver Hog spleen Salmon viscera	22.2 22.2 22.2 33.4	2,306	8,475.5	87	3.29	24.5	43.0	3.25	3.84	10.6	1,260,000	None
1/ 3	Beef liver S Hog liver Hog spleen Salmon viscera	22.2 22.2 22.2 33.4	2,320	11,619	1.83	2.87	24.0	37.5	3.25	2.99	10.9	1,180,000	None
4	Beef liver S Hog liver Hog spleen Salmon viscera Crab meal	21.0 21.0 21.0 32.0 5.0	2,297.5	9,005.5	2.71	4.24	35.5	55.5	3.27	3.67	10.3	1,090,000	None
1/ 5	Beef liver S Hog liver Hog spleen Salmon viscera Crab meal	21.0 21.0 21.0 32.0 5.0	2,327	10,813.5	2.25	3.36	29.5	44.0	3.21	3.18	9.4	1,080,000	None
6	Beef liver S Hog liver Hog spleen Salmon eggs	22.2 22.2 22.2 33.4	2,612.5	10,262	3.97	5.81	52.0	76.0	3.00	3.42	10.3	1,000,000	None
1/ 7	Beef liver S Hog liver Hog spleen Salmon eggs	22.2 22.2 22.2 33.4	2,647	13,917	2.87	3.93	37.5	51.5	2.95	2.70	10.3	3/	None
8	Beef liver S Hog liver Salmon viscera	33.3 33.3 33.4	2,396	8,338	.65	1.60	8.5	21.0	3.18	4.00	10.3	1,140,000	None
1/ 9	Beef liver S Hog liver Salmon viscera	33.3 33.3 33.4	2,340	11,243.5	1.53	2.45	20.0	32.0	3.31	3.11	11.9	1,250,000	None
10	Beef liver S Hog liver Salmon viscera Salmon milt	30.0 30.0 30.0 10.0	2,304.5	8,443	1.45	3.48	19.0	45.5	3.26	3.87	9.7	3/	None
1/ 11	Beef liver S Hog liver Salmon viscera Salmon milt	30.0 30.0 30.0 10.0	2,257.5	11,064.5	2.14	3.36	28.0	44.0	3.36	3.09	9.7	3/	None
12	Beef liver S Hog liver Salmon eggs Salmon milt	30.0 30.0 30.0 10.0	2,428.5	10,840	5.85	7.60	70.5	99.5	3.16	3.13	10.6	1,220,000	None
1/ 13	Beef liver S Hog liver Salmon eggs Salmon milt	30.0 30.0 30.0 10.0	2,463	13,654.5	4.97	6.84	65.0	89.5	3.11	2.65	12.2	1,160,000	None
14	Beef liver S Salmon viscera	15.0 85.0	2,145.5	7,063	2.06	2.75	27.0	36.0	3.37	4.37	10.6	1,110,000	None
15	Beef liver S Salmon viscera Yeast	15.0 83.0 2.0	1,972	6,553.5	2.87	4.51	37.5	59.0	3.54	4.45	12.5	1,080,000	None
16	Hog liver S Salmon viscera	15.0 85.0	2,124.5	6,934.5	2.94	3.67	38.5	48.0	3.45	4.47	11.2	3/	None
17	Beef liver S Hog liver Salmon viscera	7.5 7.5 85.0	2,100	6,618	2.71	4.93	35.5	64.5	3.45	4.51	10.3	1,240,000	None
18	Beef liver S Hog liver Salmon viscera	15.0 15.0 70.0	2,196.5	7,188	1.91	3.44	25.0	45.0	3.36	4.33	12.5	1,160,000	None
	Least difference at the 5% confidence level:		162 grs. 12 weeks	399 grs. 24 weeks	2.83	3.59	37	47					

1/ 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.
2/ Salt added at the rate of 2 grams per 100 grams of ration.
3/ No data.

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exceeded the control diets, Diets 2 and 8, by about 50 percent if the difference between weight gains of comparable diets during the warm-water period is used as the basis of calculation.

From the lack of differences between the meat-viscera mixture and the diet without hog spleen it was concluded that an increase in the vitamin content and a slight increase in the protein content made no measurable contribution over and above the meat-viscera combination when fed to blueback salmon.

Crab Meal Supplement

Crab meal was used to supplement the meat-viscera mixture to determine the effect of crab meal on growth and survival when added at the 5 percent level. The crab meal was derived from the total crab scrap of the blue crab (*Callinectes sapidus*) and reduced to a dry powder in a conventional, rotary, flame-drier.

Diets 4 and 5, used in this test during the cold-water period, consisted of 21 percent each of beef liver, hog liver, and hog spleen, 32 percent of salmon viscera and 5 percent of crab meal. During the warm-water period, Diet 4 remained the same and Diet 5 was changed to 19 percent each of beef liver, hog liver, and hog spleen, 28.5 percent salmon viscera, 4.5 percent of crab meal, and 10 percent of vacuum-dried salmon viscera meal.

Results at the end of the first 12 weeks (the cold-water period) showed that crab meal caused no differences in growth, but at the end of the warm-water period, the diet supplemented with crab meal (Table 1, Diet 4), produced a significantly higher final mean lot weight than did Diet 2, a comparable diet which had no crab meal. There were no significant differences in mortalities. The addition of vacuum-dried salmon viscera meal to Diet 5 during the 12 weeks of warm water provided a 26 percent gain in weight which was the smallest percent gain yielded by vacuum-dried salmon viscera meal in this expdriment.

The slightly increased growth brought about by crab meal alone in the meat-viscera mixture during the warm-water period showed that crab meal exerted its greatest effect on growth during the warm-water period. The small increase has no special significance in blueback salmon culture, however, since an equal amount of salmon viscera meal during the warm-water period assuredly would have made a greater contribution. Of some importance was the fact that crab meal could be used during the cold-water period at the 5 percent level without a resulant mortality or diminution in mean low weight.

Substitution of Salmon Eggs for Salmon Viscera

In the 1949 feeding trials (Robinson *et al*. 1951) salmon eggs in single component rations produced more growth during the warm-water period than did whole salmon viscera, and that during the cold-water period the differences were difficult to judge by mean lot weights because of the very serious mortalities (up to 50 percent) caused by both the salmon viscera and salmon egg diets. The diet used in the previous experiment, 90 percent salmon eggs or salmon viscera and 10 percent salmon waste meal, was not particularly adapted to production uses because of its unbound character. For this reason and because it was thought that salmon eggs would not produce any undue mortality if properly supplemented with beef liver and hog liver, salmon eggs were tested in various combination diets.

Salmon eggs, derived from pink salmon (O. gorbuscha) were substituted for salmon viscera in the meat-viscera combination to make up Diets 6 and 7. The components of these two diets during the first 12 weeks were 22.2 percent each of beef liver, hog liver, and hog spleen, and 33.4 percent of salmon eggs. During the second 12 weeks, meal was added to change the components of Diet 7 to 20 percent each of beef liver, [illegible] liver, and hog spleen, 30 percent salmon eggs, and 10 percent of vacuum-dried salmon viscera meal. Salmon eggs were also substituted for salmon viscera in a previously untried combination to make up Diets 12 and 13. The components of these last two diets during cold water were 30 percent each of beef liver, hog liver, and salmon eggs, and 10 percent salmon milt. During warm water, Diet 13 was changed to 27 percent each of beef liver, hog liver, and salmon eggs, 9 percent of salmon milt, and 10 percent of vacuum-dried salmon viscera meal.

The mean lot weight produced by salmon viscera in the meat-viscera mixture of Diet 2 was significantly less than the mean lot weight produced by salmon eggs in the meat-egg mixture of Diet 6 at the end of the cold-water period and the warm-water period (Table 1, Diets 2 and 3, 6 and 7). The addition of 10 percent of vacuum-dried salmon viscera meal to Diet 7 during the 12 weeks of the warm-water period resulted in a 47 percent increase over the gain of the diet without meal, (Diet 6).

Contrary to the differences achieved by eggs over viscera in the preceding diets, the combination of salmon eggs, salmon milt, beef liver, and hog liver did not produce any consistent weight differences over the salmon viscera control during the cold-water period (Table 1, Diets 10, 11, 12 and 13). The mortalities during the cold-water period in this salmon egg diet were significantly greater than those of the comparable diet containing viscera (Table 1, Diets 10, 11, 12, and 13). Despite the mediocre growth and high mortality rates during the cold-water period, Diets 12 and 13 proved to be satisfactroy diets during the period of warm water. At the conclusion of the experiment Diets 12 and 13 had exceeded their viscera controls with a significant difference in mean lot weights (Table 1, Diets 10, 11, 12, and 13). In addition, the total gains in these salmon egg combinations were equal to or better than those of other diets which included salmon eggs -- the meat-egg and meat-egg-meal combinations (Table 1, Diets 6, 7, 12, and 13).

The addition of meal to Diet 13 during the warm-water period provided only a 33 percent gain over the comparable control, Diet 12. This relatively low increase is explained, in part, by the rapid growth rate of the diet without meal, Diet 12, which was used as the basis for comparison.

It may be concluded from these and previous experiments that during warm-water periods salmon eggs produced more growth than salmon viscera, and, if salmon eggs were used in the proper combination of foods such as Diets 6 and 7, they produced more growth than salmon viscera during cold-water periods. From the results of these experiments, salmon eggs as a component of a composite diet have a place in practical production diets.

Salmon Milt in Composite Diets

Incidental to the 1949 experiments it was found that of the various components of salmon viscera only salmon milt would bind in the presence of an added two percent of salt. Moreover, the bind of salmon milt was found to be stronger and more elastic than the binds of either hog spleen or hog liver. It was determined that no more than 10 percent of milt in a diet was the equivalent of 20 percent of hog spleen.

To put this information to practical use, it was first necessary to determine if salmon milt at the 10 percent level had an adverse effect on growth and survival such as occurred in the 1949 trials with milt at the 90 percent level. No attempt was made to evaluate the effect of the bind on the utilization of food since this would have been beyond the scope of this experiment.

The diets used in the study of milt were: Diets 8 and 9, the controls, which consisted of 33.3 percent each of beef liver and hog liver, and 33.4 percent of salmon viscera; Diets 10 and 11 which consisted of 30 percent each of beef liver, hog liver, and salmon viscera, and 10 percent of salmon milt; and Diets 12 and 13 which consisted of 30 percent each of beef liver, hog liver, and salmon eggs, and 10 percent of salmon milt. During the warm-water period, vacuum-dried salmon viscera meal at the 10 percent level was added to Diets 9, 11, and 13 with a commensurate reduction in the other components. Diets 8, 10, and 12 remained unchanged.

The inclusion of salmon milt with viscera, as in Diets 10 and 11, produced no significant difference in either growth or mortality rates during either cold water or warm water (Table 1, Diets 8, 9, 10, and 11).

The addition of 10 percent of vacuum-dried salmon viscera meal to Diet 11 during the 12 weeks of the warm-water period served to increase the gain produced by Diet 11 over Diet 10 by 43 percent.

As was mentioned in the previous section on salmon eggs, the combination of salmon milt and salmon eggs in Diets 12 and 13 produced no more growth and significantly lower survivals than the combination of salmon milt and salmon viscera in Diets 10 and 11 during the cold-water period. During the warm-water period, however, Diets 12 and 13 had low mortalities and produced growth rates that were among the best in the entire experiment.

From the trials with salmon milt it may be concluded that salmon milt in combination with salmon viscera did not reduce the growth rate nor effect the mortality. Salmon eggs in combination with salmon milt caused a significant increase in mortality during the cold-water period, but losses were normal and gains were exceptional in this combination when fed during the during the period of warm water.

Contribution of a Salmon Waste Meal to Various Diets

Supplementation with 10 percent of salmon waste meal during warm-water periods increased the growth potential of the various diets tested in previous feeding trials at this station. Information was desired, however, to determine if a salmon waste meal would give more growth stimulus to some diets than to others.

From the results already mentioned in previous sections, vacuum-dried salmon viscera meal did have a variable effect ranging from a 26 percent increase to a 50 percent increase. If we consider 50 percent a normal increase under the conditions of the experiment since most of the increments were close to 50 percent, then the gain of the diet supplemented with crab meal, Diet 5, over the control without meal, Diet 4, may be considered well below normal. Also the 33 percent gain of the diet containing salmon eggs and salmon milt, Diet 13, may be considered below normal.

High-Level Salmon Viscera Diets

This series of feeding trials was designed to test a high level of salmon viscera with either beef liver, hog liver, or a combination of beef liver and hog liver. The effect of yeast was measured also with a high-level salmon viscera combination. In addition, this series evlauated salmon viscera at progressively lower levels with a corresponding increase in the beef liver-hog liver supplement.

Included in these experiments were Diet 14, with 15 percent beef liver and 85 percent salmon viscera; Diet 15, with 15 percent beef liver, 83 percent salmon viscera and 2 percent dried brewer's yeast (Olympic Brewers); Diet 16, with 15 percent hog liver and 85 percent salmon viscera; Diet 17, with 7.5 percent beef liver, 7.5 percent hog liver, and 85 percent salmon viscera; Diet 18, with 15 percent beef liver, 15 percent hog liver, and 70 percent salmon viscera; and Diet 8, with 33.3 percent beef liver, and 33.3 percent hog liver, and 33.4 percent salmon viscera. Meal was not added to any of these diets.

The results of the experiment showed that beef liver alone with salmon viscera produced a significantly greater mean lot weight at the end of 24 weeks than did a combination of beef liver, hog liver and salmon viscera (Table 1, Diets 14 and 17). The comparison of the beef liver supplement and the hog liver supplement showed no significant differences in mean lot weights (Table 1, Diets 14 and 16). The mortalities were significant throughout.

Yeast proved to be of no value when added to the diet of beef liver and salmon viscera. The final mean lot weight of the fish being fed the diet containing yeast was significantly lower than the weight of the fish being fed almost the same diet without yeast (Table 1, Diets 14 and 15). There were no differences in mortalities.

Progressively lower levels of salmon viscera with a corresponding increase in the amount of equal parts beef liver and hog liver proved to be decidedly beneficial. The highest level of beef and hog liver, 66.6 percent in Diet 8, produced gains that were significantly greater than either the 30 percent level or the 15 percent of beef and hog liver (Table 1, Diets 8, 17, and 18). The 30 percent level of meats, in turn, although producing no significant difference at the end of the cold-water period, yielded a significantly greater mean lot weight at the end of the experiment than did the 15 percent level of meats. The mortalities also seemed to indicate that the higher the level of meats the less the mortality rate. There were no significant differences to substantiate this statement, but there was a trend toward higher mortalities with the higher levels of salmon viscera.

As practical diets during cold-water, the relative value of these high-level salmon viscera rations was demonstrated by a comparison of these diets with the beef liver control, Diet 1. At the end of the first 12 weeks, all of the high-level salmon viscera fed lots made gains that were as good or better than the lot on straight beef liver, and there were no statistically significant differences in mortalities (Table 1, Diets 1, 14, 16, and 17).

The production diets used at this station during the cold-water period, Diets 2 and 8, if compared with the high-level salmon viscera rations, produced superior weight gains that were significant in most cases at the end of 12 weeks and significant in all cases at the end of 24 weeks.

During warm-water periods, the feeding of high-level salmon viscera diets without a salmon waste meal resulted in comparatively low growth rates. What these high-level salmon viscera diets could have produced in the way of growth if meal had been added is a matter of conjecture. A reasonable estimate, based on comparison of Diet 14 with Diet 2, which had the same meat-viscera base as Diet 3 but no added salmon waste meal, would be that the final mean lot weight of Diet 14 with meal would have been less than the final mean weight of the meat-viscera-meal mixture, (Diet 3).

SUGGESTED PRODUCTION DIETS DERIVED FROM THE FIRST EXPERIMENT

The following suggestions for practical hatchery diets were designed, not only for immediate use, but also to stimulate interest in products such as salmon eggs and vacuum-dried salmon viscera meal that are not commercially available but could be if sufficient demand were created. Primary emphasis was given to rapid growth and high survival.

The dollar value of the various diets was left to the reader to decide on the basis of current market prices, conversions, and on the rate of growth and survival desired.

The diets for cold water rearing had low, comparable mortalities, except the identical pair of diets, Diets 12 and 13. This ration on the basis of higher than average mortalities and the relatively small stimulus resulting from the addition of salmon eggs in this combination may be considered an unsatisfactory cold water diet. The other diets were all adequate during the cold-water period on the basis of growth except Diet 15, where the added expense of the yeast was not justified by the resultant growth rate.

Of the satisfactory diets, the most rapid growth during the cold-water period was made by Diets 6 and 7, each consisting of 22.2 percent beef liver, 22.2 percent hog liver, 22.2 percent hog spleen, and 33.4 percent salmon eggs.

The next most rapid growth rate was achieved, not by one diet, but by several. The diets in this group were: the meat-viscera mixture of 22.2 percent each of beef liver, hog liver, and hog spleen, and 33.4 percent of salmon viscera (Diets 2 and 3); the meat-viscera mixture supplemented with crab meal (Diets 4 and 5); the diet of equal parts beef liver, hog liver, and salmon viscera (Diets 8 and 9); and a similar diet supplemented with 10 percent salmon milt, (Diets 10 and 11). Of special interest is the meat-viscera mixture supplemented with 5 percent crab meal since this diet had a growth rate comparable to its control, Diets 2 and 3, and would by reason of the cost of crab meal be a less expensive diet.

The lowest group of growth rates in the experiment, and again the rates were quite comparable, was produced by the high-level salmon viscera diets supplemented variously with either beef liver, or hog liver, or a combination of beef liver and hog liver. The diet supplemented with hog liver in this group has an advantage over the diet supplemented with beef liver since hog liver is usually cheaper and more readily obtainable than beef liver. The beneficial effect on growth, of increasing levels of beef liver and hog liver and decreasing levels of salmon viscera, should be noted in Diets 17, 18, and 8.

The diets suitable for warm water may be limited at once by discarding all diets without vacuum-dried salmon viscera meal since this meal or a similar salmon waste meal reduces the cost and increases the growth rate so markedly. Unfortunately this eliminates a factual discussion of the high-level salmon viscera diets because space was not available to test the effect of meal on them. A supposition as to the effect of salmon waste meals on these diets was advanced, however, in the high-level salmon viscera section. The supposition, based on existing evidence, was that the addition of a salmon waste meal probably would have increased the growth rates but not enough to compare favorably with the diets with lower levels of salmon mixture supplemented with crab meal, Diet 5, since the control with no crab meal, Diet 3, made much better gains.

This elimination leaves the following diets, Diets 3, 7, 9, 11, and 13, all of which had satisfactory growth rates and low mortalities during the warm-water period. Of these diets, Diets 7 and 13 produced the highest rate of growth. Diet 7 consisted of 20 percent each of beef liver, hog liver, and hog spleen, 30 percent salmon eggs, and 10 percent of vacuum-dried salmon viscera meal. Diet 13 consisted of 27 percent each of beef liver, hog liver, and salmon eggs, 9 percent of salmon milt, and 10 percent of vacuum-dried salmon viscera meal. The next highest rate of growth was produced by Diets 3 and 9. Diet 3 consisted of beef liver, hog liver, hog spleen at 20 percent each, salmon viscera at 30 percent, and vacuum-dried salmon viscera meal at 10 percent. Diet 9 consisted of 30 percent each of beef liver, hog liver, and salmon viscera, and 10 percent vacuum-dried salmon viscera meal. Following Diets 3 and 9 was Diet 11, which consisted of 27 percent each of beef liver, hog liver, and salmon viscera, and 10 percent salmon milt.

In summary of these recommended diets, the greatest gains were attained with the meat-egg mixtures, the next greatest gains with the meat-viscera mixtures, and least gain with high-level salmon viscera diets.

RESULTS OF SECOND EXPERIMENT

The results of the second experiment are summarized in Table 2.

Beef Liver Control

As in the first experiment, the beef liver control was included in order to make comparisons with results of other investigations in which a beef liver control was included and to make comparisons with the diets in this experiment.

The final mean weight of the beef liver control of the second experiment (Table 2, Diet 19) was relatively low in comparison with most of the composite diets. This relative standing was, of course, to be expected since this was a warm water experiment. The comparisons of the beef liver diet with single raw component diets showed that beef liver was a superior diet to whole cod, equal to halibut sawdust, and inferior to fresh-frozen salmon eggs. This last comparison confirmed the results of the warm-water section of the 1949 trials.

Meat-Viscera-Meal Control

The meat-viscera-meal control (Table 2, Diet 46) served as a measure of the composite diets. The components of this control diet were: 20 percent each of beef liver, hog liver, and hog spleen, 30 percent salmon viscera, and because the experiment was conducted during a warm-water period, 10 percent of vacuum-dried salmon viscera meal.

Comparisons of final mean weights demonstrated that the meat-viscera-meal control usually produced significantly smaller gains than the comparable diets which included salmon eggs. Similar results were attained with the meat-viscera-meal mixture when halibut sawdust was substituted for hog spleen and when tuna liver was substituted for beef liver. This diet resulted in significantly greater gains than the diets testing hake or whole cod as a substitute for hog spleen, or the diet testing air-lift dried mackerel offal meal as a substitute for vacuum-dried salmon viscera meal.

TABLE 2.--Summary of 1950 feeding trials with blueback salmon--Second Experiment

Initial number per trough: 448.5 fish Initial weight per trough: 1,000 gr. Initial average weight per fish: 1.1148 gr. Initial number per pound: 204 fish Period: 7/5/50 to 9/27/50 Temperature: average for 12 weeks, 54.0° F.

Diet No.	Components	Percentage Composition	Mean diet weight at the end of 12 weeks in grams	Per cent mortality 12 weeks	Mean mortality 12 weeks	Conversion 12 weeks	Hemoglobin g/100 ml. blood	Red Blood cells/c.mm.	Deficiency Symptoms
19	Beef liver	100.0	3,417.5	.67	3.0	4.27	10.9	1,140,000	None
20	Salmon eggs (frozen) Salmon viscera meal 1/	90.0 10.0	7,381	1.11	5.0	1.99	10.9	1,220,000	None
21	Preserved salmon eggs 2/ Salmon viscera meal	90.0 10.0	3,409	1.89	8.5	4.20	11.3	1,050,000	Nervousness, loss of equilibrium, retracted heads.
22	Preserved salmon eggs 3/ Salmon viscera meal	90.0 10.0	3,668.5	.89	4.0	3.88	11.2	1,060,000	Nervousness, loss of equilibrium, retracted heads.
23	Preserved salmon eggs 4/ Salmon viscera meal	90.0 10.0	6,445.5	.56	2.5	2.22	12.5	1,030,000	Nervousness, loss of equilibrium, retracted heads.
24	Preserved salmon eggs 5/ Salmon viscera meal	90.0 10.0	4,943	1.11	5.0	2.85	11.5	1,110,000	Nervousness, loss of equilibrium, retracted heads.
25	Beef liver S6/ Hog liver Hog spleen Salmon eggs (frozen) Salmon viscera meal	20.0 20.0 20.0 30.0 10.0	5,557.5	.45	2.0	2.02	12.5	1,190,000	None
26	Beef liver S Hog liver Hog spleen Preserved salmon eggs 2/ Salmon viscera meal	20.0 20.0 20.0 30.0 10.0	4,934	.33	1.5	2.85	10.9	1,320,000	None
27	Beef liver S Hog liver Hog spleen Preserved salmon eggs 3/ Salmon viscera meal	20.0 20.0 20.0 30.0 10.0	5,296	.89	4.0	2.70	11.9	1,160,000	None
28	Beef liver S Hog liver Hog spleen Preserved salmon eggs 4/ Salmon viscera meal	20.0 20.0 20.0 30.0 10.0	5,588.5	1.11	5.0	2.55	12.5	1,230,000	None
29	Beef liver S Hog liver Hog spleen Preserved salmon eggs 5/ Salmon viscera meal	20.0 20.0 20.0 30.0 10.0	5,502.5	.89	4.0	2.57	11.5	1,110,000	None
30	Salmon viscera S Hake Salmon viscera meal	50.0 40.0 10.0	4,004.5	.45	2.0	3.52	9.7	980,000	None
31	Salmon viscera S Hake Salmon viscera meal APF supplement (without aureomycin)	50.0 40.0 10.0	2,895	.56	2.5	5.05	8.4	800,000	Anemic tendency 7/
32	Beef liver S Hog spleen Canned salmon Salmon viscera meal	25.0 25.0 45.0 5.0	4,390	.33	1.5	3.22	8.8	890,000	Anemic tendency 7/
33	Beef liver S Hog spleen Canned salmon Salmon viscera meal APF supplement (with aureomycin)	25.0 25.0 45.0 5.0	4,214.5	.33	1.5	3.41	10.6	990,000	None
	Least difference at the 5% confidence level: 288 gr.			1.34%	6 fish				

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TABLE 2. (Concluded) — Summary of 1950 feeding trials with blueback salmon—Second Experiment

Initial number per trough: 448.5 fish
Initial weight per trough: 1,000 gr.
Initial average weight per fish: 1.1148 gr.
Initial number per pound: 204 fish
Period: 7/5/50 to 9/27/50
Temperature: average for 12 weeks, 54.0° F.

Diet No.	Components	Percentage Composition	Mean diet weight at the end of 12 weeks in grams	Per cent mortality 12 weeks	Mean mortality 12 weeks	Conversion 12 weeks	Hemoglobin g/100 ml. blood	Red Blood cells/c.mm.	Deficiency Symptoms
34	Beef liver S Hog liver Hake Salmon viscera	22.2 22.2 22.2 33.4	3,305	.56	2.5	4.34	10.3	1,220,000	None
35	Beef liver S Hog liver Hake Salmon viscera Salmon viscera meal	20.0 20.0 20.0 30.0 10.0	4,401	.78	3.5	3.23	11.6	1,160,000	None
36	Beef liver S Hog liver Hake Salmon viscera Salmon milt	20.0 20.0 20.0 30.0 10.0	3,424	.78	3.5	4.04	10.6	1,060,000	None
37	Beef liver S Hog liver Hake Salmon viscera Salmon milt Salmon viscera meal	18.0 18.0 18.0 27.0 9.0 10.0	4,651.5	0	0	3.07	10.3	1,220,000	None
38	Beef liver S Hog liver Hake Salmon eggs Salmon milt	20.0 20.0 20.0 30.0 10.0	4,024	.78	3.5	3.52	10.3	1,110,000	None
39	Beef liver S Hog liver Hake Salmon eggs Salmon milt Salmon viscera meal	18.0 18.0 18.0 27.0 9.0 10.0	5,277.5	.67	3.0	2.70	9.7	1,130,000	None
40	Tuna liver S Hog liver Hog spleen Salmon viscera Salmon viscera meal	20.0 20.0 20.0 30.0 10.0	5,029.5	.22	1.0	2.80	10.9	1,240,000	None
41	Whole Cod	100.0	2,685.5	1.00	4.5	5.58	10.6	1,150,000	None
42	Beef liver S Hog liver Whole Cod Salmon viscera Salmon viscera meal	20.0 20.0 20.0 30.0 10.0	4,325	.33	1.5	3.27	9.4	1,160,000	None
43	Halibut Sawdust	100.0	3,258.5	2.34	10.5	4.29	9.1	950,000	None
44	Beef liver S Hog liver Halibut Sawdust Salmon viscera Salmon viscera meal	20.0 20.0 20.0 30.0 10.0	4,790	.33	1.5	2.97	10.9	1,220,000	None
45	Beef liver S Hog liver Hog spleen Salmon viscera Air-lift mackerel offal meal	20.0 20.0 20.0 30.0 10.0	4,293.5	.56	2.5	3.27	10.0	1,080,000	None
46	Beef liver S Hog liver Hog spleen Salmon viscera Salmon viscera meal	20.0 20.0 20.0 30.0 10.0	4,963.5	.56	2.5	2.86	9.4	1,090,000	None
	Least difference at the 5% confidence level: 288 gr.			1.34%	6 fish				

1/ Vacuum-dried salmon viscera meal.
2/ Preservative: 2% sodium benzoate and 2% salt.
3/ Preservative: 1% sodium benzoate, 0.1% sodium bisulfite, and 2% salt.
4/ Preservative: 0.5% sodium bisulfite.
5/ Preservative: 0.2% sodium bisulfite and 2% salt
6/ Salt added at rate of 2 grams/100 grams diet.
7/ Hemoglobin determination below 9.4 g/100 ml. and erythrocyte count below 900,000 red cells/c.mm.

Air-Lift Dried Mackerel Offal Meal

The test of air-lift dried mackerel offal meal was made to evaluate this comparatively new product as a possible high-protein supplement during warm-water periods. The raw material used in the manufacture of this meal was the offal of the Pacific mackerel (Pneumatophorus diego). The meal from this offal was prepared by the usual wet-reduction method except that the wet press-cake was dried by an air-lift process instead of by the more commonly used driers.

The control diet was Diet 46 with 20 percent each of beef liver, hog liver, and hog spleen, 30 percent salmon viscera, and 10 percent of vacuum-dried salmon viscera meal. The diet testing the mackerel meal was Diet 45 with the same meat-viscera base as Diet 46 but with 10 percent of air-lift mackerel offal meal instead of vacuum-dried salmon viscera meal.

The final mean weights showed that the air-lift dried mackerel offal meal contributed significantly less growth than did the vacuum-dried salmon viscera meal (Table 2, Diets 45 and 46).

This difference does not necessarily mean that air-lift dried mackerel offal meal was an inferior meal to other commercially available meals. It should be mentioned that vacuum-dried salmon viscera meal, although producing far more growth than the other meals tested, is not commercially available as yet, and on the basis of the 1949 feeding trials in which vacuum-dried salmon viscera meal was tested against the commercially available flame-dried salmon offal meal, it may be inferred that the performance of air-lift mackerel offal meal would be similar to that of flame-dried salmon offal meal.

Preserved Salmon Eggs

This series of experiments with preserved-frozen salmon eggs was a continuation of previous research designed to exploit the supply of salmon eggs now going to waste in Alaska. The use of preserved-frozen eggs rather than fresh-frozen eggs was necessary since only limited freezing facilities were abailable at Alaskan canneries. The four preservatives at the concentrations tested in this experiment were sufficient to keep the eggs for three or four months or until the eggs could be shipped to the United States and further preserved by freezing.

The pink salmon eggs selected for the test were held for 9 months in cold storage, thawed, preserved by simply sprinkling the chemicals over each layer of eggs, and then frozen again after several days. Because the preserved eggs were not allowed to incubate for three or four months without refrigeration, this evaluation is, necessarily, only a test of eggs to which preservatives have been added and not a test of the effect of incubation on the nutritive value of the preserved eggs.

Each type of preserved eggs was evaluated in two ways. First, they were tested in a combination of 90 percent preserved eggs and 10 percent of vacuum-dried salmon viscera meal. This trial constituted a rather severe test and should have revealed any toxic effects which the preservatives may have had.

Second, they were tested as a substitute for salmon viscera in the meat-viscera-meal combination. For example; Diets 20 through 24 contained 10 percent of vacuum-dried salmon viscera meal as an absorbing agent and 90 percent of the various kinds of salmon eggs, and Diets 25 through 29 contained, in addition to 30 percent of preserved eggs and 10 percent salmon meal, 20 percent each of beef liver, hog liver, and hog spleen. The type of eggs in each diet was as follows: fresh-frozen eggs in Diets 19 and 25, eggs preserved with 2.0 percent sodium benzoate and 2.0 percent salt in Diets 21 and 26, eggs preserved with 1.0 percent sodium benzoate, 0.1 percent sodum bisulphite, and 2.0 percent salt in Diets 22 and 27, eggs preserved with 0.5 percent sodium bisulphite in Diets 23 and 28, and finally, eggs preserved with 0.2 percent sodium bisulphite and 2.0 percent salt in Diets 24 and 29.

It should be mentioned that of the preserved eggs tested, those containing 0.5 percent sodium bisulphite were the least apt to leach when fed, and approached the fresh-frozen eggs in feeding consistency. Excessive leaching of essential nutrients may have been an important factor affecting the high-level evaluations.

The final mean weights of the high-level tests of salmon eggs showed that fresh-frozen salmon eggs, Diet 20, produced significantly greater mean lot weights than the preserved eggs (Table 2, Diets 20, 21, 22, 23, and 24). Of the preserved eggs, those preserved with 0.5 percent of sodium bisulphite made significantly greater gains in weight than the other diets (Table 2, Diets 21, 22, 23, and 24). The final mean weights of the low-level tests or those in which salmon eggs were substituted for salmon viscera in the meat-viscera-meal combination showed that there were no differences between the weights produced by the control or the preserved eggs except those preserved with 2.0 percent sodium benzoate and 2 percent salt, Diet 26 (Table 2, Diets 25, 26, 27, 28, and 29). Diet 26 produced gains that were inferior to the others at the five percent confidence level. It should be mentioned also that a few fish in each of the lots being fed preserved eggs at the 90 percent level demonstrated the nervousness, loss of equilibrium and the retracted head which are associated with a thiamin deficiency. No such symptoms were observed when eggs were fed at the 30 percent level.

It was evident from these differences that in the meat-egg-meal combination preserved eggs and fresh-frozen eggs made comparable gains in most instances. From these differences, moreover, it may be concluded that 0.5 percent sodium bisulphite was one of the most satisfactory preservatives in the low-level egg test and the most satisfactory in the high-level test. With this in mind and also the fact that the eggs preserved with 0.5 percent sodium bisulphite were the least apt to leach, sodium bisulphite appeared to be the best preservative of the group. Further tests on the effect of incubation before freezing are necessary, however, before practical use may be made of this information.

Hake

Hake (Merluccuis productus) is an abundant and inexpensive source of fish food, but has some shortcomings as shown in the 1947 Leavenworth feeding trials in which this product demonstrated a lack of anti-anemic properties. However, because of the growth rate demonstrated that year, further trials were conducted in 1948 with hake as a substitute for salmon viscera in the meat-viscera diet. Hake appeared quite promising at the end of the cold-water period, but at the end of the warm-water period the salmon viscera variant had exceeded the hake variant in mean lot weight. Further tests were conducted in 1949 with hake as a substitute for hog spleen in the meat-viscera diet. Again the hake variant looked most promising at the end of the cold-water period but failed to hold the advantage during the warm-water period. Repetition of the warm-water trials of 1949 in the present experiment substantiated the former conclusions that hake, although a satisfactory substitute for hog spleen in the meat-viscera-meal diet, did not produce growth comparable to that of hog spleen in warm water.

In the present experiment, hake was compared with halibut sawdust and whole cod as possible substitutes for hog spleen. In addition, hake was tested in various modifications of the meat-viscera mixture utilizing salmon milt, salmon eggs, and vacuum-dried salmon viscera meal. The hake used in all of these trials was disintegrated whole and then frozen.

The diets and their components used in the hake tests were as follows: Diet 34 consisted of 22.2 percent each of beef liver, hog liver, hake, and 33.4 percent salmon viscera; Diet 35 consisted of 20 percent each of beef liver, hog liver, and hake, 30 percent of salmon viscera and 10 percent of vacuum-dried salmon viscera meal; Diet 36 consisted of 20 percent each of beef liver, hog liver, and hake, 30 percent salmon viscera and 10 percent salmon milt; Diet 37 consisted of 18 percent each of beef liver, hog liver, and hake, 27 percent of salmon viscera; Diet 38 consisted of 20 percent each of beef liver, hog liver, and hake, 30 percent of salmon eggs, and 10 percent of salmon milt; and last, Diet 39 consisted of 18 percent each of beef liver, hog liver, and hake, 27 percent of salmon eggs, 9 percent of salmon milt, and 10 percent of vacuum-dried salmon viscera meal.

The mean lot weights indicated that the hake variant was the equal of the whole cod variant but significantly inferior in growth potential to the halibut sawdust and hog spleen variants (Table 2, Diets 35, 42, 44, and 46).

In the comparison of diets with and without vacuum-dried salmon viscera meal, the diets with salmon viscera meal, Diets 35, 37, and 39, exceeded the controls without meal, Diets 34, 36, and 38, at the five percent confidence level. Moreover, the growth increments by percentages were 47.5 percent for Diet 35. It will be noticed that these percentages are in agreement with similar tests of the effect of meals on growth in the first experiment of the 1950 trials.

The evaluations of salmon eggs and salmon viscera and the comparisons of diets with and without salmon milt confirmed the results secured with these products during the warm-water period of the first experiment in that salmon eggs produced more weight than salmon viscera, and salmon milt had no deleterious effect on growth or mortality (Table 2, Diets 35, 36, 37, 38, and 39).

The results of previous experiments showed that hake could be used as a substitute for hog spleen in the meat-viscera diet during either period of water temperature. The results of this experiment also showed that either hog spleen or halibut sawdust produced greater growth than hake in the meat-viscera-meal diet. The comparisons in this experiment of the different components, such as salmon eggs, salmon milt, and salmon waste meal with a hake, beef liver and hog liver base, indicated that hake was compatible with these components.

Whole Cod

Whole cod (Gadus macrocephalus), ordinarily considered as a food for humans, also may be considered as a possible fish food because of the extremely low market price of cod in the round.

Whole cod was tested in a singly component diet, Diet 41, against the beef liver control, Diet 19, and against halibut sawdust, Diet 43. It was also tested as a component of the meat-viscera-meal combination by substituting whole cod for hog spleen to make Diet 42. Whole cod in this combination may be compared with hog spleen in Diet 46, halibut sawdust in Diet 43, and hake in Diet 35 since all of these diets have the same base.

As a single component, whole cod did not produce as much weight as either beef liver or halibut sawdust (Table 2, Diets 41, 19 and 43). The differences were significant. As a component of the meat-viscera-meal combination in Diet 42, whole cod proved to be inferior to hog spleen or halibut sawdust (Table 2, Diets 42, 44, and 46). Whole cod was the equal of hake, however, as shown by the lack of difference in mean lot weights between Diets 41 and 35.

From these results, whole cod, as a growth producer in the meat-viscera-meal combination, may be rated inferior to halibut sawdust and hog spleen but equal to hake.

Halibut Sawdust

Halibut sawdust is the band saw waste resulting from the preparation of halibut (Hippoglossus stenolepis) for human consumption. The quantity of this by-product is not great, but 50,000 pounds are annually available in this Seattle area at a very nominal cost.

The experiment with halibut sawdust, similar to the previous experiment with whole cod, tested halibut sawdust as a single component, Diet 43, and as a component of the meat-viscera-meal combination, Diet 44.

As a single component, halibut sawdust provided gains that were not significantly different than beef liver (Table 2, Diets 43 and 19), but were significantly greater than those provided by whole cod (Table 2, Diets 43 and 41). As a component of the meat-viscera-meal combination, halibut sawdust supported as much growth as hog spleen and significantly more growth than either whole cod or hake, (Table 2, Diets 44, 43, 42, and 35).

Based on the results of this experiment, halibut sawdust may be recommended as one of the best inexpensive substitutes for hog spleen in the meat-viscera-meal combination when used during the warm-water period. The use of halibut sawdust during a cold-water period should be deferred until such evaluations have been made.

Tuna Liver as a Substitute for Beef Liver

Tuna liver was previously tested as a single component diet in the 1949 trials. The growth produced by tuna liver was very slight, yet, throughout the experimental period, the gills retained a healthy, dark red color. Since tuna liver displayed anti-anemic properties, it was tested in the present experiment as a substitute for beef liver in the meat-viscera-meal combination.

The components of the tuna liver variant, Diet 40, were 20 percent each of tuna liver, hog liver, and hog spleen, 30 percent of salmon viscera, and 10 percent of vacuum-dried salmon viscera meal. The tuna liver was obtained from the yellowfin tuna (Neothunnus macropterus).

A comparison of the tuna liver variant and the beef liver variant disclosed no significant difference in mean lot weights (Table 2, Diets 40 and 46). Also it can be seen that the blood count and hemoglobin level of the tuna liver variant were satisfactory.

Tuna liver in this particular combination had a satisfactory growth potential quite different from its growth potential as a single component diet. Tuna liver, moreover, had enough anti-anemic properties to be a meal combination. Since tuna liver is in abundant supply at a cost lower than beef liver, the possibilities of its use in salmon culture, during the warm-water period, should not be overlooked.

Animal Protein Factor (APF)

Because of the popularity and interest in the animal protein factor (APF), this laboratory tested the effect of certain APF concentrates on anemia and growth.

Two different APF concentrates were selected for test. The first was a Merck product containing 12.5 milligrams of vitamin B_{12} per pound. This concentrate was added at the rate of .73 grams per 100 grams of ration to Diet 31 which contained 50 percent salmon viscera, 40 percent hake, and 10 percent vacuum-dried salmon viscera meal. Diet 30, identical to Diet 31 except for the deletion of the APF supplement, served as the control. The second APF concentrate was largely a protein substrate used by Lederle for the production of aureomycin and contained unknown amounts of vitamin B_{12} and aureomycin. This second concentrate was added at the rate of .73 grams per 100 grams of ration to Diet 33 which contained 25 percent beef liver, 25 percent hog liver, 45 percent canned salmon, and 5 percent vacuum-dried salmon viscera meal. A similar ration, Diet 32, from which the APF supplement was omitted, served as the control.

The mean weight produced by Diet 31 which contained the APF concentrate (without aureomycin) was significantly less, than the comparable diet, Diet 30, which contained no APF concentrate. In contrast, the mean weight produced by Diet 33 which contained the APF concentrate (with aureomycin) was not statistically different than the weight produced by the comparable diet, Diet 32, which contained no APF concentrate.

The blood counts and hemoglobin determinations showed that Diets 31 and 32 had a possible anemic tendency.

The conclusions to be drawn from the weights are definite. The APF concentrate (without aureomycin) reduced the growth rate, significantly, in Diet 31 and the APF concentrate (with aureomycin) had no effect on the growth rate in Diet 33. The conclusions from the hemoglobin determinations and the blood counts can not be regarded as nearly so definite. It can be said that the addition of the APF concentrate (without aureomycin) to Diet 31 produced a tendency toward anemia, and that the APF concentrate (with aureomycin) possibly averted a tendency toward anemia in Diet 33. The reason for the anemic tendency in Diet 32 is not clear since previous trials indicated that Diet 32 produced no anemia. Some of the possible reasons for this tendency may have been a difference in meals, a difference in the beef liver, hog spleen, and canned salmon, or a difference in fish size.

From these conclusions it is indicated that more experimental work is needed before APF concentrates may be used to fortify diets for blueback salmon.

POSSIBLE PRODUCTION DIETS DERIVED FROM THE SECOND EXPERIMENT

For immediate practical use, these experiments indicated that mackerel offal meal, hake, whole cod, halibut sawdust, and tuna liver could be substituted for various components of the standard meat-viscera-meal mixture during periods of warm water.

Air-lift dried mackerel offal meal gave less growth than the vacuum-dried salmon viscera meal but should give no less growth than the commercially available flame-dried salmon offal meal. As was previously mentioned, the comparison of mackerel offal meal and flame-dried salmon offal was made on the basis of previous tests. The diet testing mackerel offal meal consisted of 20 percent each of beef liver, hog liver, and hog spleen, 30 percent salmon viscera, and 10 percent of air-lift-dried mackerel offal meal.

Whole hake, whole cod, and halibut sawdust all proved to be satisfactory substitutes for hog spleen in the meat-viscera-meal combination, but of these fish products only halibut sawdust produced as much growth as hog spleen. It should be mentioned that hake in previous experiments proved satisfactory in cold water feeding. The diets testing these products consisted of either 20 percent hake, 20 percent cod, or 20 percent halibut sawdust added to a mixture of 20 percent beef liver, 20 percent hog liver, 30 percent salmon viscera, and 10 percent vacuum-dried salmon viscera meal.

SUMMARY OF FIRST AND SECOND EXPERIMENTS

First Experiment

The results of the first experiment, conducted for 24 weeks during periods of both cold and warm water, may be summarized as follows:

1. The mean lot weight of the beef liver control during the cold-water period was significantly inferior to the weights produced by most of the diets in the first experiment.

2. Hog spleen may be deleted from the meat-viscera mixture of 22.2 percent each of beef liver, hog liver, and hog spleen, and 33.4 percent salmon viscera. The diet without spleen which consisted of equal parts of beef liver, hog liver, and salmon viscera produced results comparable to those of the meat-viscera mixture.

3. Crab meal, at the 5 percent level, had no effect on growth or mortality in the meat-viscera mixture during the cold-water period. During the warm-water period, crab meal in combination with vacuum-dried salmon viscera meal in this same meat-viscera mixture resulted in a growth stimulus inferior to salmon meal alone.

4. Salmon eggs, when substituted for salmon viscera in the meat-viscera mixture produced more growth than salmon viscera during either cold or warm-water periods. Salmon eggs, when substituted for salmon viscera in a diet of 30 percent each of beef liver, hog liver, and salmon viscera, and 10 percent of salmon milt, did not exceed the gain produced by salmon viscera during the cold-water period; but during the warm-water period, salmon eggs again proved superior.

5. Salmon milt at the 10 percent level did not reduce the growth rate produced by a diet of equal parts of beef liver, hog liver, and salmon viscera. However, a diet with both salmon eggs and salmon milt caused an increased mortality and a reduced growth rate during the cold-water period. During the warm-water period, the growth response to this diet was excellent.

6. Vacuum-dried salmon viscera meal when added at the 10 percent level gave growth increases up to 50 percent greater than comparable diets without meal during the warm-water period. Also it was found that the amount of increase varied greatly with the diet used.

7. The experiments with high-level salmon viscera diets showed that these diets produced a growth response inferior to that of diets with higher levels of beef and hog liver. The supplementation with yeast proved valueless in these high-level salmon viscera diets. It also was found that either beef liver or hog liver provided comparable results when used in the high-level salmon viscera diets.

8. Of the diets recommended for production use on the basis of comparative growth rates, the combination diets containing 33 percent or less of salmon eggs

produced the greatest gains. The next greatest gains were produced with the combination diets containing 33 percent or less of salmon viscera. The least gain was produced by high-level salmon viscera diets.

Second Experiment

9. As in past experiments during warm water, the beef liver control produced a final mean weight that was relatively low when compared with those of the composite diets.

10. Air-lift dried mackerel offal meal contributed significantly less growth than did vacuum-dried salmon viscera meal.

11. In the tests of preserved eggs, sodium bisulphite at the 0.5 percent level, produced the greatest growth response.

12. Hake proved to be a satisfactory component of the meat-viscera-meal combination but produced less growth than either halibut sawdust or hog slpeen. The diets in the hake group which tested salmon milt, salmon eggs and vacuum-dried salmon viscera meal not only substantiated the comparisons made in the first experiment with these variables but also demonstrated that hake was compatible with these foods.

13. Both whole cod and halibut sawdust were satisfactory substitutes for hog spleen in the meat-viscera-meal combination, but, of these two products, only halibut sawdust produced as much growth as hog spleen in this diet. In the test of single components, whole cod again produced less growth than halibut sawdust.

14. Tuna liver was a satisfactory substitute for beef liver in the meat-viscera-meal combination under the warm water conditions of this experiment.

15. An APF concentrate (without aureomycin) reduced the growth rate resulting from a diet of salmon viscera, hake, and salmon viscera meal whereas an APF concentrate (with aureomycin) had no effect on the growth rate resulting from a diet of beef liver, hog spleen, canned salmon, and salmon viscera meal.

16. For present use during warm-water periods, tuna liver, halibut sawdust, air-lift dried mackerel offal meal, hake, and whole cod were suggested as possible substitutes for certain components of the standard meat-viscera-meal combination.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the cooperation of personnel of the Branch of Game Fish and Hatcheries for the use of facilities and major food items necessary to conduct the experiments.

Acknowledgement is also extended to Mr. Maurice E. Stansby and Dr. G. Ivor Jones of the Branch of Commercial Fisheries who were in charge of the

project that supplied the preserved and fresh salmon eggs, salmon milt, crab meal, tuna liver, hake, cod, halibut sawdust, brewer's yeast, APF concentrates, air-lift mackerel offal meal, and vacuum-dried salmon viscera meal used in this experiment.

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