TESTS OF HATCHERY FOODS FOR SALMON, 1953 AND 1954

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by

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ABSTRACT

Feeding trials were conducted at the Salmon-Cultural Laboratory (Entiat, Wash.) during 1953 and 1954 using chinook and blueback salmon as the test animals.

One excellent diet for chinook salmon fingerlings utilizing arrow-toothed halibut (Atheresthes stomias) as a substitute for a portion of the more expensive meat components was developed during the 1953 feeding trials.

The 1954 blueback salmon feeding trials were designed to develop virus-free rations. Several diets devoid of salmon viscera, the suspect carrier, were tested and found satisfactory.

The 1954 chinook experiments were designed to study diets containing 50 percent of dry meals. No satisfactory high-meal diet was produced from these trials.

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INTRODUCTION

The feeding trials conducted at the Salmon-Cultural Laboratory in 1953 and 1954 were a continuation of previous experiments reported by Burrows et al. (1951), Robinson et al. (1951a), Robinson et al. (1951b), Burrows et al. (1952), and Newman et al. (1954). The objective of these trials was the same as that of the previous tests, the development of adequate, economical diets for salmon applicable to production operations.

In 1953, the work was directed toward the development of the most efficient combinations of pretested products. Although the experimental program included tests with both chinook (Oncorhynchus tshawytscha) and blueback (O. nerka) salmon fingerlings an outbreak of a virus disease in the blueback salmon forced the abandonment of this series of trials. As a result, only the chinook experiments were carried to completion. One excellent production diet was developed from these trials.

In 1954, both the chinook and blueback trials were carried through to completion. The blueback trials were directed toward the development of diets which would be virus free. The work of Watson et al. (1954) indicated that the virus infection of blueback salmon was carried in the food with salmon viscera as the suspect carrier. Two methods of approach were used: first, the evaluation of sterilized salmon viscera, and, second, the development of diets devoid of salmon viscera which were equal in growth potential and nutritional adequacy. The results of these experiments indicate that the sterilization of salmon viscera alters the feeding consistency and possibly the biological value of the protein. The second phase of these trials developed several practical production diets from which salmon viscera was eliminated.

The 1954 chinook experiments were directed toward the development of diets containing 50 percent of dry meals. Using the Cortland No. 6a meal combination as a base the meat components were varied in one part of these tests. In the second part, the meal components were varied. No satisfactory diet was developed from these trials.

CONDITIONS OF EXPERIMENTS

The methods, equipment, and techniques used were essentially the same as those described by Burrows et al. (1951; 1952). No changes were made in the 1953 experiments.

Before 1954, hemoglobin determinations were made with the Tallquist-Adams hemoglobin scale. This method involves matching a sample of raw blood against a graded color chart. Readings correspond closely to those for human blood.

In 1954 a Spencer hemoglobin meter was used to make the determinations. When this method is used the blood is hemolyzed before the color comparison is made. Amounts of hemoglobin of salmon blood proved to be approximately one-half that of human blood when the Spencer meter was used. The readings obtained for salmon blood at this laboratory, however, correspond closely to those found for trout blood using a similar method of hemoglobin determination.

With this exception, the methods, equipment, and techniques were identical and comparable to those of previous experiments.

RESULTS OF THE 1953 EXPERIMENT

Only the results of the chinook salmon experiment will be reported since an outbreak of a virus disease in the blueback salmon forced the discontinuance of those trials.

The chinook diet trials utilized previously tested products in an effort to develop efficient production diets. The feeding trials were conducted for a 24-week period. At the end of the first 12-week period, all of the diets were altered to include 10 percent of a meal mixture consisting of equal parts of seal meal and distillers solubles. Mortalities were similar in all diets and no deficiency symptoms were evident in any at the end of the experiment. The results of the 1953 experiment are summarized in Table 1.

The standard meat-viscera mixture was used as the control diet (Diet 1-C) in these trials. Arrow-toothed halibut (Atheresthes stomias) and salmon viscera were fed in combination with beef lung (Diet 2-C), with hog liver and beef lung (Diet 3-C), and with hog liver alone (Diet 4-C). The combination containing only the hog liver (Diet 4-C) produced excellent growth, equalling that of the control and exceeding significantly that of the other two diets containing arrow-toothed halibut (Diet 2-C and 3-C). Neither beef lung nor beef lung and hog liver provided as much growth stimulus as did hog liver alone in the combination.

Another fish product, hake (Merluccius productus) was fed with beef lung and salmon viscera (Diet 5-C). Significantly less growth was obtained from this diet than for a comparable one containing arrow-toothed halibut (Diet 2-C).

Two meats, hog liver and beef lung, were compared with arrow-toothed halibut when fed in combination diets with 50 percent of salmon viscera as the base. Similar gains resulted from the meat diet (Diet 6-C) and the beef lung - arrow-toothed halibut ration (Diet 2-C). The meat diet produced significantly less growth however than the hog liver - arrow-toothed halibut diet (Diet 4-C). It was concluded from these comparisons that beef lung did not provide as much impetus to the growth rate as did either hog liver or arrow-toothed halibut.

The results of this experiment indicated that the hog liver - arrow-toothed halibut - salmon-viscera mixture was equal to the standard meat-viscera diet in growth potential and could be recommended for production use. The meat-fish-viscera diet was more economical since it contained only 25 percent liver whereas two-thirds of the meat-viscera mixture was composed of relatively high cost meats. Hog liver proved superior to either beef lung or hog liver and beef lung together when these meats were fed in combination with arrow-toothed halibut and salmon viscera. Hake produced less growth response than arrow-toothed halibut in comparable mixed diets.

RESULTS OF THE 1954 EXPERIMENTS

In 1954 the blueback feeding trials were designed to test the growth potential of heat treated salmon viscera and to develop adequate hatchery diets that contained no salmon viscera. The chinook experiment was designed to test the effect of high-meal diets, 50 percent level, in the rations of chinook salmon.

Blueback Salmon

Since raw salmon viscera was suspected to be the carrier of the virus disease, two methods of approach to the problem of developing virus-free diets were explored. The first involved sterilization of the salmon viscera with heat and the second the development of efficient diets devoid of salmon viscera. Both methods were tried in the 1954 experiment. At the end of the first 12-week period all diets except Diets 4 and 12 were altered to include 10 percent of salmon offal meal. The results of the blueback trials are summarized in Table 2.

Two types of heat treatment were used in this experiment. The frozen salmon viscera was thawed and canned in No. 1 tall tins. One lot was pasteurized for 15 minutes at 50° C., the other lot cooked for 90 minutes at 100° C. It was necessary to keep the pasteurized lot in frozen storage while the cooked viscera was stored at room temperatures. The diets containing the heat-treated viscera were prepared and fed in the usual manner.

A basic mixture of 25 percent hog liver and 25 percent arrow-toothed halibut was fed with 50 percent raw viscera (Diet 1), with 50 percent pasteurized viscera (Diet 2), and with 50 percent cooked viscera (Diet 3).

The growth response from the raw viscera and the cooked product was quite similar for the first 12 weeks of the experiment. The pasteurized viscera produced significantly less growth than the other two viscera diets. Results at the end of the 24-week period, however, showed the raw viscera definitely superior to the two heat-treated products. The final weight of the cooked viscera diet (Diet 3) was significantly less than that of the diet containing raw viscera (Diet 1). Even less growth resulted from the pasteurized viscera (Diet 2).

Two factors may be responsible for the lowered growth potential of the heat-treated salmon viscera. The most obvious was the poorer feeding consistency of these products. The heat treatment apparently destroyed the binding quality of the salmon milt and therefore allowed the feed to leach. The canned viscera was more nearly comparable to the raw viscera in this respect than was the pasteurized product. Alteration of the biological value of the protein and/or destruction of essential vitamins due to heat treatment may also have been factors responsible for the poorer growth of the sterilized viscera diets. Regardless of the cause, the heat treatment resulted in an inferior product.

A diet consisting of 100 percent beef liver (Diet 4) was included merely as a comparison with the work of other investigators who use this product as a standard. The growth of fish fed this diet was exceeded significantly by all diets in the experiment except Diets 2 and 12.

Salmon viscera was eliminated from the remaining diets in the experiment (Diets 5 through 12). These diets utilized instead other fish products and meat or meat and meal combinations. Squawfish (Ptychocheilus oregonensis) and arrow-toothed halibut were compared in Diets 5 through 8. Squawfish are fairly abundant in the lower Columbia River and are known to prey on young salmon. Sufficient demand for squawfish for hatchery diets might stimulate commercial fishing for this species and thereby relieve the predator situation as well as provide a source of fish food. Arrow-toothed halibut is being used in hatchery production diets. Sufficient quantity is available to meet the demands of Pacific slope hatcheries.

Squawfish and arrow-toothed halibut were compared at the 25-percent level in combination diets containing beef liver, hog liver, and beef lung (Diets 5 and 6) and at the 50-percent level in diets containing hog liver and beef lung (Diets 7 and 8). At the 25-percent level squawfish compared favorably with arrow-toothed halibut. No significant differences in final weights of the two diets occurred. Mortalities and conversions were similar for both. The halibut diet (Diet 8) proved superior in growth production to squawfish (Diet 7) when these products were fed at the 50 percent level. At the end of 24 weeks the final weight of the Diet 8 fish was significantly higher than those of Diet 7. The amount of hemoglobin was low in the fish fed the halibut diet (Diet 8). Apparently this diet was deficient in the antianemic factor. No such deficiency was present in the squawfish diet (Diet 7).

Dry meal supplements were included in Diets 9 through 12. The hog liver - beef lung - arrow-toothed halibut mixture (Diet 8) was used as the base for three diets (Diets 9, 10, and 11), and proportional reductions in these components were made when dry meals were added. The last diet (Diet 12) contained only hog liver and beef lung with 50 percent of dry meal. This meal mix consisted of the 50 percent distillers solubles and 25 percent each of wheat middlings and cottonseed meal.

Partial reconstitution of the dry meal was accomplished by adding 30 percent water to the diet during mixing. No water was added to the other three diets, (Diets 9, 10 and 11).

Salmon offal meal at the 5 percent level (Diet 9) contributed significantly more growth stimulus during the first 12-week period than did a like amount of distillers solubles (Diet 10). The control for this group (Diet 8) which contained no meal produced gains comparable to Diet 9. The addition of 10 percent of salmon offal meal to these diets during the second 12-week period did not produce any significant differences in final weights among the three diets.

Distillers solubles at the 5 percent level proved to be an excellent vitamin supplement. This product, while not contributing measurably to growth production, prevented an anemic tendency in the fish of Diet 10. The fish of both Diets 8 and 9 which did not contain distillers solubles had low amounts of hemoglobin.

The inclusion of comparatively high levels of meals, again, proved to be detrimental during the cold-water period. The addition of 15 percent of distillers solubles (Diet 11) caused a reduction in growth and an increase in mortality. The diet containing 50 percent of dry meal (Diet 12) made the poorest growth of any in the experiment. Mortalities were significantly higher than any other with the exception of Diet 11, however no deficiency symptoms were evident at the end of the 24-week period.

It may be concluded from the results of this experiment that heat treated salmon viscera was inferior to raw viscera in growth potential. Arrow-toothed halibut proved superior to squawfish in diets containing 50 percent fish products and may be considered an adequate substitute for salmon viscera in blueback salmon diets. Dry meals in excess of 5 percent did not prove satisfactory at water temperatures below 50° F. Five percent distillers solubles added to a diet was effective in preventing an anemic tendency which was found in similar diets not containing this proportion of distillers solubles.

Chinook Salmon

The emphasis in the 1954 chinook feeding trials was placed on 50 percent meal diets using previously tested rations containing 10 percent meal as controls. The Cortland No. 6 diet was used as the base and variations were made in the meal mix in one phase and in the meat components in the other phase. These diets were partially reconstituted by the addition of 30 percent water.

A coccidia-like intestinal infection caused an increase in the mortality during the first 12 weeks of the trials but was successfully controlled by sulfa therapy. Higher than normal mortalities, however, resulted and tended to obscure the results of the experiment.

The standard meat-viscera mixture with 5 percent each of seal meal and distillers solubles (Table 3, Diet 1-C) was used as one of the control diets. This diet again produced excellent growth with no deficiency symptoms. The second control (Diet 2-C) was a previously tested combination of 22.5 percent each of hog liver and arrow-toothed halibut, 45 percent of salmon viscera and 10 percent of the seal meal - distillers solubles mix. Similar results were obtained with this diet as with Diet 1-C.

The high meal diets may be divided into two groups. In the first group (Diets 3-C through 6-C) the meal components remained the same and the meats were varied. The meal mixture was essentially the Cortland No. 6a mix: equal parts of wheat middlings, cottonseed meal, distillers solubles and salmon offal meal. The Cortland No. 6 diet with 15 percent beef liver and 35 percent hog spleen (Diet 3-C) acted as the control for this group. Salmon viscera was the only meat component in Diet 4-C. Equal parts of hog liver and beef lung (Diet 5-C) and hog liver and salmon viscera (Diet 6-C) completed this group of diets.

None of the diets in the meat-variable group produced good growth but of the four, the Cortland diet (Diet 3-C) and the hog liver - salmon viscera variable (Diet 6-C) showed the best gains at the end of 12 weeks. The other two diets produced very poor growth with Diet 4-C actually losing weight. This loss of weight was due to a mortality in excess of 50 percent at the end of 12 weeks. During the sixth week, moribund fish from this diet (Diet 4-C) were examined and the presence of clubbed gills indicated a pantothenic acid deficiency.

The results at the end of the 24-week period were very similar to those at the end of 12 weeks. One diet (Diet 3-C) was discontinued during the sixteenth week when silt-clogged water inflow pipes caused a heavy mortality. The other three diets, however, maintained the same positions in amount of growth with the final weight of fish in Diet 6-C exceeding significantly those of Diets 4-C and 5-C. During the gross examination of the fish at the end of the experiment, both Diets 4-C and 6-C contained some fish with clubbed and fused gills - evidence of a previous pantothenic acid deficiency.

The hog liver - salmon viscera components remained the same in the second group of diets (Diets 6-C through 9-C) and the meal mix was varied. The Cortland meal mixture (Diet 6-C) acted as the control for this group. Seal meal was substituted for salmon offal meal in Diet 7-C. In the last two diets (Diets 8-C and 9-C) both the salmon offal meal and seal meal were deleted and the distillers solubles increased.

In the meal variable group of diets, seal meal (Diet 7-C) provided as much or more growth response than did salmon offal meal (Diet 6-C). The increased amounts of distillers solubles in Diets 8-C and 9-C however showed a downward trend in growth production when compared with the control for this group (Diet 6-C). At the end of the 24-week period the average weight of the fish in Diet 6-C was 13.6 grams while those in Diets 8C- and 9-C averaged 11.2 grams and 8.8 grams respectively. No deficiency symptoms were observed in the fish in Diets 7-C, 8-C, or 9-C.

The fish receiving the 50 percent meal diets were reluctant to consume the feed at temperatures below 50° F. Some of the fish from each group actually starved to death rather than eat the sinking feed. During the second 12-week period when water temperatures were above 50° F. the fish fed normally. Those of Diet 7-C were especially vigorous in their feeding habits.

From the results of these feeding trials it may be concluded that meat-viscera diets with 10 percent meals were superior to 50 percent meal diets if both growth and mortality are used as the criteria. Variations of the meat components in 50 percent meal diets indicated that equal parts of hog liver and salmon viscera produced as much growth as did the Cortland combination of beef liver and hog spleen. During the cold water period the diets containing either salmon viscera as the sole raw product or hog liver and salmon viscera combined were inadequate. The substitution of seal meal for salmon offal meal in the Cortland No. 6 mixture resulted in as good or better gains. Greater amounts of distillers solubles substituted for salmon offal meal, however, apparently had a depressing effect on the growth rate.

SUMMARY OF RESULTS - 1953 EXPERIMENT

The results of the 1953 feeding trials with chinook salmon fingerlings are summarized as follows:

1. A diet consisting of 25 percent each of hog liver and arrow-toothed halibut and 50 percent salmon viscera produced excellent growth, equalling that of a more expensive diet, the standard meat-viscera production diet. This economical diet can be recommended for production use.

2. Beef lung did not provide as great a growth stimulus as did hog liver when fed in combination with arrow-toothed halibut and salmon viscera.

3. Hake proved inferior to arrow-toothed halibut when these products were fed with beef lung and salmon viscera.

SUMMARY OF RESULTS - 1954 EXPERIMENTS

The results of the 1954 feeding trials utilizing both fingerling blueback and chinook salmon may be summarized as follows:

Blueback Salmon

The following conclusions were reached for the blueback feeding trials:

1. Both pasteurized and canned viscera produced less growth than raw salmon viscera when these products were fed in comparable mixed diets. Poorer feeding consistency and possibly alteration of the protein may be factors responsible for the lowered growth potential of the sterilized products.

2. Squawfish compared favorably with arrow-toothed halibut when these products were fed at the 25 percent level in conjunction with meats, but was inferior in growth response when fed at the 50 percent level.

3. Distillers solubles at the 5 percent level proved to be an excellent vitamin supplement. Diets containing high amounts of arrow-toothed halibut and supplemented with distillers solubles at the 5 percent level can be recommended for production purposes. Similar diets not containing this vitamin supplement showed an anemic tendency at the end of 24 weeks.

4. Neither distillers solubles at the 15 percent level nor 50 percent dry meals in a diet proved satisfactory at water temperatures below 50° F.

Chinook Salmon

Despite an increased mortality due to an intestinal protozoan infection and the loss of one diet during the experiment, the following conclusions were drawn from the chinook feeding trials:

1. Diets containing 10 percent of dry meals with meats and viscera were superior to 50 percent meal diets.

2. Equal parts of hog liver and salmon viscera produced gains comparable to the Cortland combination of 15 percent beef liver and 35 percent hog spleen when fed in conjunction with 50 percent meals.

3. Seal meal sustituted for salmon offal meal in the Cortland mix provided a comparable growth response to its counterpart containing salmon offal meal.

4. Neither salmon viscera nor hog liver and salmon viscera in combination with the Cortland No. 6 meal mix was adequate during the cold water period. Fish from these diet combinations showed clubbing of the gills indicating a pantothenic acid deficiency.

5. Increased amounts of distillers solubles substituted for salmon offal meal in the Cortland No. 6 meal mixture did not result in an increase in growth rate or a reduction in mortality.

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TABLE 1.—Summary of 1953 feeding trials with chinook salmon - 24-week period

Initial number per trough: 670 fish
Initial weight per trough: 1,000 gr.

Initial average weight per fish: 1.49 gr.
Initial number per pound: 304 fish

Period 4/15/53 to 9/29/53

Average temperature: 1st 12 wks., 46.4°F; 2nd 12 wks., 54.2°F; 24 wks., 50.3°F.

Diet No.	Components	Percentage Composition	Mean diet weight in grams 12 wks.	24 wks.	Per cent mortality 12 wks.	24 wks.	Conversion 12 wks.	24 wks.	Hemoglobin g/100 ml. blood 24 weeks	Deficiency Symptoms
1-C[2]	Beef liver S[1] Hog liver Hog spleen Salmon viscera	22.2 22.2 22.2 33.4	4,069	11,058	.45	.45	2.45	2.99	13.3	None
2-C[2]	Beef lung S Arrow-toothed halibut Salmon viscera	25.0 25.0 50.0	3,965	9,799	.45	1.04	2.53	3.37	13.6	None
3-C[2]	Hog liver S Beef lung Arrow-toothed halibut Salmon viscera	12.5 12.5 25.0 50.0	3,943	9,507	.90	2.39	2.52	3.45	14.2	None
4-C[2]	Hog liver S Arrow-toothed halibut Salmon viscera	25.0 25.0 50.0	4,042	11,195	.75	1.72	2.45	2.93	14.2	None
5-C[2]	Beef lung S Hake Salmon viscera	25.0 25.0 50.0	3,568	8,026	.60	1.57	2.87	3.96	13.5	None
6-C[2]	Hog liver S Beef lung Salmon viscera	25.0 25.0 50.0	3,878	9,034	.75	1.94	2.71	3.63	13.1	None
	Least difference at the 5% confidence level:		281 grs. 12 weeks	1,035 grs. 24 wks.	1.1%	2.4%				

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

2/ At the end of the first 12-week period 5% seal meal and 5% distillers solubles was added to these diets with a corresponding proportional reduction in each of the original components.

TABLE 2.—Summary of 1954 feeding trials with blueback salmon - 24-week period

Initial number per trough: 1,225 fish
Initial weight per trough: 500 gr.
Initial average weight per fish: .41 gr.
Initial number per pound: 1,111 fish
Period 4/14/54 to 9/29/54
Average temperature: 1st 12 wks., 46.0°F.; 2nd 12 wks., 52.0°F; 24 wks., 49.0°F.

Diet No.	Components	Percentage Composition	Lean diet weight in grams 12 wks.	Lean diet weight in grams 24 wks.	Per cent mortality 12 wks.	Per cent mortality 24 wks.	Conversion 12 wks.	Conversion 24 wks.	Hemoglobin g/100 ml blood 24 weeks	Deficiency Symptoms
1[2]	Hog liver S[1] Arrow-toothed halibut Salmon viscera (raw)	25.00 25.00 50.00	3,306	13,310	3.22	3.76	2.7	2.8	7.4	None
2[2]	Hog liver S Arrow-toothed halibut 50°C. heat treated Salmon viscera	25.00 25.00 50.00	3,000	7,618	2.73	4.00	2.9	4.0	6.9	None
3[2]	Hog liver S Arrow-toothed halibut 100°C heat treated Salmon viscera	25.00 25.00 50.00	3,390	10,668	2.90	4.24	2.6	3.4	7.5	None
4	Beef liver	100.00	2,740	7,305	2.53	4.37	3.1	4.0	7.2	None
5[2]	Beef liver S Hog liver Beef lung Squawfish	25.00 25.00 25.00 25.00	3,066	9,940	2.86	3.76	2.8	3.4	6.4	None
6[2]	Beef liver S Hog liver Beef lung Arrow-toothed halibut	25.00 25.00 25.00 25.00	3,238	10,350	2.49	3.51	2.5	3.4	6.7	None
7[2]	Hog liver S Beef lung Squawfish	25.00 25.00 50.00	2,975	8,783	2.41	3.71	2.8	3.6	7.1	None
8[2]	Hog liver S Beef lung Arrow-toothed halibut	25.00 25.00 50.00	3,269	11,007	2.20	3.31	2.6	3.3	5.8	Anemic tendency
9[2]	Hog liver S Beef lung Arrow-toothed halibut Salmon offal meal	23.75 23.75 47.50 5.00	3,273	11,365	3.22	5.10	2.6	3.2	4.9	Anemic tendency
10[2]	Hog liver S Beef lung Arrow-toothed halibut Distillers solubles	23.75 23.75 47.50 5.00	3,107	10,659	3.27	4.16	2.7	3.3	7.6	None
11[2]	Hog liver S Beef lung Arrow-toothed halibut Distillers solubles	21.25 21.25 42.50 15.00	2,873	9,848	5.96	7.51	2.8	3.3	7.3	None
12	Hog liver S Beef lung Distillers solubles Wheat middlings Cottonseed meal	25.00 25.00 25.00 12.50 12.50	2,176	5,589	5.88	7.91	3.4	4.5	6.7	None
	Least difference at the 5% confidence level:		166 grs. 12 wks	859 grs. 24 wks.	1.5%	2.4%				

1/ S: 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 flame dried salmon offal meal was added to these diets with a corresponding proportional reduction in each of the original components.

TABLE 3.--Summary of 1954 feeding trials with chinook salmon - 24-week period

Initial number per trough: 538 fish
Initial weight per trough: 1,000 gr.

Initial average weight per fish: 1.86 gr.
Initial number per pound: 244 fish

Period 4/7/54 to 9/22/54

Average temperature: 1st 12 wks., 45.7°F; 2nd 12 wks., 51.6°F; 24 wks., 48.7°F.

Diet No.	Components	Percentage composition	Mean diet weight in grams 12 wks.	Mean diet weight in grams 24 wks.	Per cent mortality 12 wks.	Per cent mortality 24 wks.	Conversion 12 wks.	Conversion 24 wks.	Hemoglobin g/100 ml. blood 24 weeks	Deficiency Symptoms
1-C	Beef liver S[1] Hog liver Hog spleen Salmon viscera Seal meal Distillers solubles	20.00 20.00 20.00 30.00 5.00 5.00	2,866	7,148	17.66	18.77	3.4	2.5	8.2	None
2-C	Hog liver S Arrow-toothed halibut Salmon viscera Seal meal Distillers solubles	22.50 22.50 45.00 5.00 5.00	2,774	6,267	22.31	24.91	3.5	3.4	7.9	None
3-C	Beef liver S Hog spleen Distillers solubles Wheat middlings Cottonseed meal Salmon offal meal	15.00 35.00 12.50 12.50 12.50 12.50	1,606		26.39 Diet discontinued 8/5/54	.....	8.6	...	...	
4-C	Salmon viscera S Distillers solubles Wheat middlings Cottonseed meal Salmon offal meal	50.00 12.50 12.50 12.50 12.50	870	1,946	59.48	84.01	2/	14.8	6.7	Clubbed and fused gills indicating previous pantothenic acid deficiency.
5-C	Hog liver S Beef lung Distillers solubles Wheat middlings Cottonseed meal Salmon offal meal	25.00 25.00 12.50 12.50 12.50 12.50	1,131	2,208	39.96	61.06	37.2	8.6	6.6	None
6-C	Hog liver S Salmon viscera Distillers solubles Wheat middlings Cottonseed meal Salmon offal meal	25.00 25.00 12.50 12.50 12.50 12.50	1,587	3,995	32.62	45.45	8.9	4.3	6.9	Clubbed and fused gills indicating previous pantothenic acid deficiency.
7-C	Hog liver S Salmon viscera Distillers solubles Wheat middlings Cottonseed meal Seal meal	25.00 25.00 12.50 12.50 12.50 12.50	1,948	5,227	26.95	33.46	5.7	3.5	7.6	None
8-C	Hog liver S Salmon viscera Distillers solubles Wheat middlings Cottonseed meal	25.00 25.00 25.00 12.50 12.50	1,593	3,818	27.14	36.43	8.4	4.8	7.6	None
9-C	Hog liver S Salmon viscera Distillers solubles Wheat middlings Cottonseed meal	25.00 25.00 37.50 6.25 6.25	1,522	3,132	24.54	34.11	9.6	6.2	6.4	None
	Least difference at the 5% confidence level:		406 grs. 12 weeks	1,410 grs. 24 wks.	19.7%	30.5%				

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

2/ Fish lost weight first 12 weeks.

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