Development of Rations for the Enhanced Survival of Salmon

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by

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Abstract

The nutritional quality of feed plays an important role in determining the health and "fitness" of smolts. Commercial fish meal, the major source of protein in salmon rations, is subject to heat damage during drying and chemical interaction of fat oxidation products with proteins. Protein bioavailability is reduced and dietary stress may be introduced into hatchery feeds. This investigation tests the hypothesis that ration protein quality can influence the survival of smolts and the ultimate return of adults. Improved survival production would be better able to reestablish natural runs of salmon in the Columbia River system and maintain and improve the genetic integrity of specific stocks.

The general approach being used involves a comparison of coho and chinook salmon reared on rations containing very high quality protein derived from vacuum dried meals and commercial rations relying on commercial fish meal as a source of protein. Survival and return of replicate brood-years of coded wire tagged test and control fish are being used to determine the influence of ration on survival.

Project rearing and release of tagged fish to date include 1982, 1983, 1984 and 1985-broods of coho salmon; the 1983 and 1984-broods of fall chinook (tule stock) salmon; and the 1985 and 1986-broods of fall chinook (up-river-bright stock) salmon. This report covers the rearing and release of the 1985-brood coho and the 1986-brood fall chinook (up-river-bright stock) salmon.

Duplicate lots of coho salmon were reared on two test rations containing vacuum dried salmon or hake meals and a control ration composed of the hatchery supply of Oregon pellet ration from 13 June 1986 to release on 30 April 1987. Fall chinook (up-river-bright stock) salmon were reared on a test ration containing vacuum dried salmon meal and a control ration composed of the hatchery supply of Oregon pellet ration from 14 April 1987 to 8 September 1987 when fish were released early under emergency low water conditions. Test rations generally produced growth equal to the control ration with less feed for both coho and chinook salmon. The ration containing salmon meal was more efficient than the test ration containing hake meal. Fish reared on test rations were released at a size equal to those supplied the control ration.

Plasma cortisol and thyroxine (T_4) level, gill Na^+/K^+-ATPase, osmoregulatory performance and total hepatic lipid content were monitored from early June through early September 1987 to assess the physiological condition of fall chinook salmon. Results indicated that on several sampling dates in the 1987 rearing period fish supplied the control ration were physiologically different than fish receiving the salmon meal ration. Differences in thyroxine pattern and total hepatic lipid content were observed. Gill Na^+/K^+-ATPase patterns, while not ration dependent, differed from those observed of the 1985-brood of fall chinook.

Recovered coded wire tags (as of September 1987) from 1982, 1983 and 1984-broods of coho salmon (Sandy stock) revealed an improved ($P \geq .001$) survival for fish supplied test rations. Improved survival due to ration was only observed for the 1983-brood which survived better ($P \geq .001$) than either the 1982 or 1984-broods; a significant ($P \geq .001$) interaction of ration x brood year was observed. Recovered coded wire tags (as of September 1987) from the 1983 and 1984-brood years of fall chinook (tule stock) shows a somewhat (NS $P=.05$) improved survival for 1983-brood fish supplied the test ration, but the control ration is producing better survival for the 1984-brood. This latter result clearly reflects the exposure of fish to an inpalatable test ration for three months prior to release. The fish oil supplement used was highly susceptable to autooxidation, could not be stabilized with antioxidants, and was very rancid.

Introduction

The natural habitat for the spawning and rearing of salmon in the Columbia River system has been reduced by hydroelectric development and other encroachments. Artificial production of salmon in hatcheries has become a critical link in the restoration of natural stocks.

Time of release, natural abundance of food, fish size and the health or “fitness” of smolts play important roles in determining survival and the ultimate return of adult fish. It is believed that nutrition quality plays a major role in determining the effectiveness of hatchery production and the health and/or “fitness” of smolts. Ration regimes containing high quality components in uniform and fine-free pellet forms produce efficient growth response and minimize loss of nutrients. Quality feeds produce fish less susceptible to disease and of *a* more uniform and desirable size at release. High quality smolts would help to optimize out-migration and successful adaptation to salt water.

The success of a ration in rearing high quality salmon smolts is dependent upon the quality and quantity of their protein complement. Although adequate levels of quality energy, essential fatty acids, vitamins and minerals are needed for optimum growth and “fitness” , protein is the major food component in rations. The most successful fish rations rely on large quantities of fish protein in the form of fish meal. Plant sources of protein (soybean and cottonseed meal) are tolerated to a certain extent based upon growth response, but an excessive replacement of fish protein results in a reduction in feed consumption and growth response parameters (conversion and/or weight gain). Their presence in rations represent a dietary stress factor affecting smolt “fitness”.

Commercial fish meal supplies needed for formulating successful rations are declining in availability and quality. Industrial round (whole) fish that in the past formed the raw material base for high quality meal production is disappearing because of cost and/or regulation dictating its use for human food, Carcass waste is replacing round fish as a raw material. Resulting reals have a poorer quality and lower protein content and an elevated mineral level because of the removal of muscle tissue for human food. *The* majority of meals are produced by high-temperature efficient direct flame dryers to meet the specifications of the poultry industry. Variability in raw materials and the need to meet protein content requirements for marketability have encouraged excessive heating during drying. Excessive heating damages proteins directly and initiates lipid-protein interactions, Both of these effects reduce the biological value of fish proteins. The basic hypothesis of this investigation is that ration protein quality can also influence the survival of smolts and ultimate return of adult salmon to the Columbia River system. it is believed poor quality fish meals based upon composition dictated by raw materials or processing damage introduces a dietary stress into fish ration formulations that can affect survival of smolts and the ultimate return of adult fish.

Meals and fish protein concentrates produced from round fish and/or upgraded fish processing waste using processes employing low temperature and reduced pressure yield protein of optimum quality. These gentle drying and concentration procedures coupled with the use of fat antioxidants limit heat damage to proteins and markedly reduce lipid-protein interactions. Ration regimes incorporating these sources of protein would be more costly, but additional feed costs could be offset by more favorable survival of smolts and return of adult hatchery fish. Hatchery production efficiency would be improved and more hardy smolts would be less susceptible to disease and mortality.

The general approach being used to test this hypothesis involves the rearing of coho and chinook salmon on nutrient dense rations containing a high quality fish protein complement. Fish reared on the hatchery supply of commercial ration relying on commercial fish meals as a source of protein serve as a control. Coded wire tagging experiments are being conducted on replicate brood years of test and control fish to determine the influence of ration protein on survival. beginning with the 1985-brood, fall chinook (up-river-bright stock) salmon are being assessed for physiological changes associated with smoltification and correlated with ration type and smolt “fitness”.

Project rearing and release of tagged fish to date include 1982, 1983,1984 and 1985-brood replicates of coho salmon, the 1983 and 1984-brood replicates of fall chinook (tule stock) salmon and the the 1985 and 1986-brood replicates of fall chinook (up-river-bright stock) salmon. This report covers the rearing and release of the 1985-brood coho and the 1986-brood fall chinook (up-river-bright stock) salmon replicates.

Methods and Materials

General Project Operation

This project combines the facilities and expertise of the Oregon Department of Fish and Wildlife and Oregon State University through their Seafoods Laboratory of the Department of Food Science and Technology and the Department of Fisheries and Wildlife. The Oregon Department of Fish and Wildlife carried out required fish husbandry tasks involved in survival feeding trials at their Sandy and Bonneville Hatcheries and conducted coded wire tagging survival experiments. The task of ration component acquisition and/or production and test ration production and characterization were carried out at the Seafoods Laboratory. The Department of Fisheries and Wildlife at Oregon State University carried out a determination of the physiological changes associated with smoltification of fall chinook salmon to assess smolt "fitness" and its relationship to the type of ration supplied fish.

Husbandry Protocol

Coho Salmon; Oregon Department of Fish and Wildlife Sandy Hatchery: Coho salmon (*Oncorhynchus kisutch*) (Sandy stock) were reared in 20 x 80 x 4 ft. (variable depth) raceways with an actual volume of 4,290 cu. ft. (32,089 gal.) at a maximum water depth of 3.5 ft. Raceways were supplied with 228 to 396 gpm/pond of Cedar **Creek water at 38 to 59 °F (three year monthly mean range)** (Appendix I). The lowest flow rates occurred during the summer, and the highest during the spring before release of smolts. The hatchery had north and south facing banks of ten ponds each with a separate head box for each bank. The north head box was constructed so that only a single pass of water will go into each pond. The south head box was equipped with a pipe and pump system that was used to recirculate water into the head box (along with the normal creek water). This system was used only during the summer and early fall when the water flow in the creek was too low to meet the needs of the hatchery. Under normal circumstances, the pump is used only three months during the year.

Unfed fry were ponded on March 27 (pond 7) (620,885 fish/pond) and 28 (pond 17) (633,427 fish/pond), 1986, at 1100 fish/lb (0.412 g/fish). Fish were supplied starter ration and progressed through the pellet size guide for salmon recommended by the Oregon Department of Fish and Wildlife for moist pelletized feeds:

Pellet size (in.)	Fish size	
	fish/lb	g/fish
Starter	1000-700	0.4-0.6
1/32	700-500	0.6-0.9
3/64	500-250	0.9-1.8
1/16	250-150	1.8-3.0
3/32	150-50	3.0-9.1
1/8	50-13	9.1-34.9

Fish (194.758 fish/lb; 2.329 g/fish) were randomly distributed (in 10 lb lots) into six ponds at a rate of 53,633 to 59,520 fish/pond on June 11, 1986. Control and two test rations were randomly assigned to duplicate ponds/ration; one pond located in the south bank and the other in the north bank of raceways.

Control and two test rations were supplied to fish from June 13, 1986 to release on April 30, 1987. Each ration in recommended pellet sizes was fed by hand to replicate ponds of fish at the feeding frequencies listed as follows:

Fish size (fish/lb)	Feeding frequency (times/day)
1200-800	8-10
800-500	6
500-250	4
250-150	3
150-15	1-2

Control fish were supplied feed according to a feeding guide which schedules fish to be 15 fish/lb (30.24 g) at liberation. Fish supplied test rations were fed at a rate less than the feeding rate guide to achieve equal size at liberation.

Fall Chinook Salmon; Oregon Departrent of Fish and Wildlife Bonneville Hatchery: Fall chinook salmon (up-river-bright stock) (*Oncorhynchus tshawytscha*) were reared in 17.5 x 75 x 3 ft. raceways (3,938 cu ft.; 29,456 gal.). Ponds were supplied with **well water (49-51 °F) at a rate of 300 to 550 gpm/pond.** Water flow rate was gradually increased from 306 gpm/pond for swim-up fry to 550 gpm/pond and/or to a maximum of 6 lbs of fish/gpm at liberation.

Unfed fry were ponded on February 6, 1987 into one pond of 475,077 fish at 1,060 fish/lb (0.428 g/fish). Fish were supplied rations composing the Oregon pellet feed system between February 6 and April 13, 1987 prior to initiation of test rations evaluation. On April 13, 1987, the lot of fish was split into two ponds of approximately 270,000 fish each. One was supplied the control ration and the other the test ration until June 26, 1987, when each ration/pond treatment was split into duplicate ponds of approximately 134,000 fish each. Control and test rations were supplied these duplicate ponds from June 26, 1987 until August 18, 1987 when control and test rations fish split to meet projected pond water flow/fish weight requirements. Fish were reared until September 8, 1987 and released under an emergency situation predicated by a low water supply. Fish were scheduled for release in late October of 1987. Scheduled target release size of 13 fish/lb was not achieved.

Control and test fish were initially supplied starter ration and then progressed through the pellet size guide recommended by the Oregon Department of Fish and Wildlife for moist pelletized feeds listed above. Test ration feeding began with the l/16-inch pellet size. Rations were supplied with Garon automatic feeders at a rate designed to achieve a target release size.

Pathological Assessment

Oregon Department of Fish and Wildlife pathologists responded to any increase in mortality rates that occurred. At the pathologists discretion, appropriate diagnostic tools were employed to determine the causative agent and remedial treatments were prescribed. Examinations were summarized and reports became a permanent record of the lot of fish involved. During their experimental rearing period coho salmon at Sandy Hatchery were inspected twice including a preliberation exam (Appendix III). Fall chinook (up-river-bright stock) at Bonneville Hatchery had no disease problems warranting examination. The emergency release of fish precluded a preliberation exam.

Physiological Assessment

Physiological changes associated with smoltification were determined and correlated with ration type and smolt "fitness". Growth, plasma cortisol, thyroxine (T_4) levels, gill Na+/K+-ATPase activity, osmoregulatory performance, irmunocompetency, and total and specific hepatic/lipid content were monitored from early June to early September 1987.

Growth was monitored by measuring fork length and wet weights. Plasma cortisol and thyroxine levels were measured by radioimmunoassay; gill Na^+/K^+-ATPase activity was measured spectophotometrically. Osmoregulatory performance was assessed using the plasma sodium regulatory approach with fish placed for 24 hours into 26 ppt artificial seawater. Plasma sodium and potassium concentrations were determined using ion-specific electrodes. Total hepatic and gill microsomal lipid content was determined spectrophotometrically following chloroform/methanol extraction. Specific hepatic fatty acids were identified using reversed-phase high pressure liquid chromatogaphy.

Fish samples were obtained with a dip net in a manner that provided as representative as possible sampling of the fish in each raceway. Fifteen fish were collected from each pond, in duplicate (yielding 30 fish/ration) for each treatment. The last sample was obtained one week prior to release. Fish were weighed and measured and then blood, gills, livers and head kidneys were collected and prepared for later assay. Data from replicate ponds were pooled, since no differences (except where noted) were observed.

Growth Response Parameters

Fish weight, feed consumption, feed conversion and mortality information were determined at monthly intervals and reported at two to three month intervals for coho and fall chinook salmon. At liberation, fork length, weight and blood hematocrits were measured and samples of fish from each pond collected for the determination of body composition.

Mean fish weight and length were based on the measurement of three to six randomly selected samples (varying in weight depending on fish size) of the pond populations, Peed consumption and mortality were recorded daily. Feed conversion (feed/gain) was computed wet weight on a cumulative and period basis for interim reporting purposes and on both a wet and dry weight basis for the entire rearing period at liberation. The blood hematocrit level for each pond replicate was the mean of twelve to fourteen fish. Body composition determinations were based upon the mean of duplicate analyses of three randomly selected samples of ten fish/pond replicate.

The emergency release of fall chinook (up-river-bright stock) from Bonneville hatchery precluded the above outlined sampling schedule. One sample from each replicate pond (293-329 fish each) was obtained at release and immediately frozen. Fish were thawed, weighed, measured and pooled samples used to determine body composition. Blood hematocrit levels were not determined.

Coded Wire Tagging Experiments

Coho salmon were injected with a distinctive coded wire tag between 7 and 21 October 86 at a rate approximating 30,000 fish/pond replicate of control and test fish and marked with an adipose fin clip. Coho were randomly selected for tagging by passing the entire pond of fish over a sampling table which was adjusted to select the desired percentage of fish. Pall chinook salmon were similarly tagged and marked between 21 and 26 August 87 at a rate approximating 32,000 fish/pond replicate of control and test fish. Fish were randomly selected using a procedure similar to that used for coho salmon. Tag retention numbers from each pond replicate were determined prior to the release of coho salmon. Emergency release of fall chinook salmon did not allow for this procedure. Tag retention numbers were determined from frozen samples used to determine weight and length measurements.

Protein Evaluation Design

The hatchery supply of rations composing the Oregon pellet feed system served as a control ration for both coho and fall chinook salmon. This included, when applicable, Biomoist Starter Ration and the OP-4 and OF-2 formulations of the Oregon pellet feed. Coho salmon were supplied with two test rations deriving their major protein complement from vacuum dried salmon hatchery carcasses and round Pacific hake. A single test ration containing vacuum dried salmon meal as the major protein source was supplied fall chinook. The major protein complements provided by both vacuum dried salmon and hake were supplemented by hydrolyzed and vacuum concentrated bone-free fish derived from round hatchery salmon carcasses.

Ration Component Product ion and Acquisition

Advanced Hydrolyzing Systems, Inc. of Astoria, OR, in direct cooperation with the Seafoods Laboratory, produced high quality vacuum dried meal with their equipment using Seafood Laboratory facilities, power and steam. Concentrated hydrolysates were produced in company facilities. Hatchery carcasses were provided by the Oregon Department of Fish and Wildlife. Hake and groundfish carcass waste were purchased on the open market.

Fish meals were prepared by subjecting coarse ground fish, in a steam jacketed chamber equipped with a stirring-scraping device, to a vacuum equivalent to 25-27 inches of Hg. Product temperature **was maintained at 101-105 ^{o}F except for a time period of** approximately 5.0 minutes while the product was still moist when **the product temperature was allowed to rise to 180 ^{o}F to achieve** pasteurization. Product temperatures upon completion of drying **were $\leq$110 ^{o}F.** All vacuum dried meals, if not used immediately for ration preparation, **were sacked and held frozen $\leq$0 ^{o}F.**

Concentrated fish hydrolysates were prepared by exposing coarse **ground fish to a temperature approximating 140 ^{o}F with mechanical** agitation until sufficient liquefaction was achieved to allow screen removal of bones. The temperature of the liquefied **material was raised to 180 ^{o}F to achieve pasteurization and then** concentrated in vacuum with scraped surface heat transfer equipment to approximately 50% solids. Concentrates were sacked or boxed, cooled and then frozen and held at $\leq 0\ ^{o}F$.

Remaining components required for ration preparation were purchased from commercial firms that either produce moist pelletized fish rations or provide components to the fish feed industry. All purchased components met specifications for the Oregon pellet feed.

Test Ration Formulation and Production Protocol

Test rations were formulated to contain 28 lb of protein derived from meal and 7.7 lb from concentrated hydrolyzed fish/100 lb of ration. Water and wheat germ meal were balanced to yield rations with 76% solids (24% moisture). Herring oil was added in amounts needed to yield a total ration fat content that provided a ration fat:protein caloric ration of 0.95 (protein = 4.0, fat = 9.0 kcal/g). Computer controlled formulation using the above criteria relied upon the determined compositions of vacuum dried meal and concentrated hydrolyzed fish used for each batch of ration and the general and accepted composition of remaining components. The formulation of test and control rations is listed in Appendix II. Ration dry components (vacuum dried fish meal, wheat germ meal, dried whey product, spray dried blood, mineral and vitamin premixes and sodium bentonite) were mixed in 600-1000 lb batches and hammer milled to achieve a fine particle size. Milled dry mix was sacked in 50 lb units and held frozen at 0 to -30 ^{o}F if not immediately used to prepare ration.

Milled dry mix was mechanically mixed with remaining "moist" components (antioxidant stabilized herring oil, choline chloride, concentrated hydrolyzed fish and water) in 150-250 lb batches. The thoroughly mixed components were then mechanically extruded into desired length-diameter pellet forms, screened to remove fines, sacked into 40 lb (l/32-inch pellets only) or 50 lb units and immediately frozen at -30 ^{o}F.

Ration Composition Control

The proximate analysis (moisture, ash, protein and fat content) of test and control rations was determined to assure composition and for computation of dry weight and protein consumption and conversion. The entire hatchery supply of control ration was sampled by pellet size and if possible, by production date. Test rations were sampled during production at a rate of at least two samples from each MO-250 lb mixer batch. The mean for all samples derived from each production day lot, which was prepared from the same dry mix formulation, was used as the composition of a particular lot of pelletized ration. The composition of control rations was related to feed consumption at the hatchery only by pellet size. The mean composition of each pellet size derived by sampling was used to compute dry weight and protein consumption and conversion. The composition of test rations was directly related to the actual feed consumed.

Analysis of Growth Response Data

Growth response data were analyzed using analysis of variance (one-way classification) procedures. Tag recovery information was analyzed using a factorial design for analysis of variance. The significance of differences between treatment means was determined using “least significant difference” (LSD) procedures.

Results and Discussion

Rearing Results: 1985-Brood Coho Salmon

Duplicate lots of coho salmon (2.329 g initial average weight) were reared on two test rations containing vacuum dried salmon and hake meals and a control ration composed of the Sandy Hatchery supply of Oregon pellet feed system rations from 13 June 1986 to release on 30 April 1987. The number of fish initially supplied test rations, the number released and the numbers released with recognizable coded wire tags are listed below.

Ration	Pond No.	Initial No. fish	No. fish released	No. recognizable tags released
Salmon	6	59,520	58,984	30,839
	12	58,633	58,219	30,927
Hake	7	53,633	51,683	29,410
	13	57,340	55,594	28,560
OMP	4	54,554	54,147	32,011
	14	59,100	58,721	31,475

Coho salmon, from which experimental lots were derived, often experience a cold water disease epizootic prior to the ponding at Sandy Hatchery. Fish were supplied furanace at 1 ppm and 2 ppm prior to ponding (March, 22 and 25-26, 1986). After ponding (March 27 and 28, 1986), fish were supplied with feed medicated with 3% TM-100 until May 1, 1986. Medication was recommenced on May 15, 1986 due to increased mortality and cold water disease symptoms. At final splitting and initiation of feeding experimental rations, cold water disease was not evident (Appendix III). Preliberation exam showed fish to be free of VEN.

Feeding schedules supplied varying ($P>.001$) quantities of ration on a wet and dry weight basis to control and test fish (Table 1). The quantity of feed on a wet and dry weight basis was ranked salmon < hake < OMP ($P=.05$). The varying feed rate supplied unequal quantities of protein to control and test fish ($P>.01$). Protein supplied by the salmon ration was less ($P=.05$) than that supplied by the OMP and hake rations; hake and OMP ration provided an equal amount of protein ($P=.05$). The lower feed consumption by test fish ($P=.05$) was a function of the programed feed schedule based upon ration composition (Table 2) and conversion which was designed to achieve an equal size to control fish at release. Conversion of test and control rations did not vary ($P<.05$) on a wet and dry weight basis or on the basis of the ratio of feed protein to body protein gain (Table 1).

Table 1. Feed consumption and conversion. 1985-Brood coho salmon; Sandy Hatchery.

Ration	Pond No.	Feed consumption (kg) Wet wt.	Dry wt.	Protein	Feed/gain Wet wt	Dry wt.	Feed protein/protein gain
Salmon	6	1950.9	1403,5	800.1	1.235	.889	2.965
	12	1952.3	1404.4	800.7	1.252	.901	3.028
Hake	7	2120.5	1531.6	854.9	1.509	1.090	3.594
	13	2098.3	1515.4	843.8	1.393	1.006	3.594
OMP	4	2267.5	1645.1	841.3	1.535	1.114	3.321
	14	2302.0	1670.1	854.0	1.392	1.010	3.054
Salmon	Mean	1951.6[a]	1404.0[a]	800.4[a]	1.244	.895	2.997
Hake	Mean	2109.4[b]	1523.5[b]	848.4[b]	1.451	1.048	3.483
OMP	Mean	2284.7[c]	1657.6[c]	847.7[b]	1.464	1.062	3.188

Significant relationships: feed (wet wt.), P≥.001; feed (dry wt.), P≥.001; feed protein, P≥.01

Mean values in a column with same exponent letter did not vary significantly (P=.05).

Table 2. Ration composition. 1985-Brood coho salmon; Sandy Hatchery

Ration		Composition (% wet wt.) Moisture	Ash	Fat	Protein
Salmon	Mean	28.19	6.69	17.00	40.81
n = 11	S.D.	.918	.707	1.024	.847
Hake	Mean	27.81	9.00	17.17	40.18
n = 10	S.D.	.874	.767	.563	1.092
OMP	Mean	27.42	7.65	13.98	37.08
n = 8	S.D.	.599	.304	1.281	1.200

n = Number of lots of experimental ration; number of' samples of hatchery feed supply taken through rearing period for OMP.

Although conversion rates did not vary statistically (P<.05), test rations produced equal (P<.05) size and length fish with less

(P=.05) feed on a wet or dry weight basis. Feeding schedules produced equal (P<.05) weight gain and produced fish of comparable (P<.05) size, length, condition and blood hematocrit at release (Table 3).

The mortality rate for fish supplied control and test rations differed (P>.005). Mortality for fish supplied the hake meal test ration was higher (P=.05) than the rate observed for the salmon meal ration or the control OMP ration. Mortality rates for salmon meal and control OMP rations were equal (P=.05). Increased mortality was observed for both replicate ponds of fish supplied the hake meal ration in early April of 1987 and was restricted to only these two ponds in the entire hatchery. An examination on April 4, 1987 identified no causative disease (Appendix III). Pathologists offered handling during a pond inventory as a possible cause for mortality.

The body composition of fish supplied control and test rations varied in fat content wet (P>.025) and dry (P>.025) weight and in protein content dry weight (P>.025) (Table 4). The fat content (wet and dry wt.) of fish supplied test rations was greater (P=.05) than the fat content for fish supplied the control ration. Hake and salmon rations did not vary (P=.05).

Table 3. Fish release size, gain, length, condition factor, hematocrit and mortality. 1985-Brood coho; Sandy Hatchery.

Ration	Pond No.	Fish Release wt. (g)	Weight gain (g/fish)	Length (mm)	Condition factor[1]	Hematocrit (%)	Mortality (%)
Salmon	6	29.12	26.79	141.0	1.038	37.8	.907
	12	29.12	26.79	139.8	1.065	41.0	.715
Hake	7	29.60	27.27	142.2	1.028	35.3	3.634
	13	29.50	27.17	140.3	1.068	42.6	3.054
OMP	4	29.63	27.30	140.2	1.074	35.2	.757
	14	30.50	28.17	141.5	1.075	35.8	.640
Salmon	Mean	29.12	26.79	140.4	1.051	39.4	.811[a]
Hake	Mean	29.55	27.22	141.3	1.048	39.0	3.344[b]
OMP	Mean	30.06	27.74	140.9	1.075	35.5	.698[a]

[1] $[100000 \times wt. (g)]/[length (mm)^3]$.

Significant relationships: mortality (%), $P \geq .005$;

Mean values for rations in a column with same exponent letter did not vary significantly (P=.05).

The higher fat content of fish supplied the test rations produced somewhat lower body protein contents dry weight than fish supplied the control ration, but the difference was only significantly (P=.05) for fish supplied the hake meal ration. Hake and salmon meal rations did not vary (P=.05). Variations in body composition reflected ration fat composition differences (Table 2).

Table 4. Body composition. 1984-Brood coho; Sandy Hatchery.

Pond No. /Ration	Composition (% wet wt.) Moisture	Ash	Fat	Protein	Composition (% dry wt.) Ash	Fat	Protein
6/ Salmon	74.13	2.40	7.26	17.09	9.29	28.05	66.05
	.116	.034	.196	.411	.141	.834	1.636
12/ Salmon	74.68	2.43	6.74	16.96	9.60	26.60	67.01
	.404	.014	.347	.090	.146	.963	.741
7/ Hake	74.04	2.42	7.26	16.89	9.31	27.96	65.09
	.335	.012	.298	.047	.167	.888	.688
13/ Hake	74.35	2.42	7.34	16.61	9.42	28.63	64.76
	.127	.026	.063	.110	.061	.180	.112
4/ OMP	75.09	2.47	6.03	17.15	9.92	24.18	68.91
	.618	.008	.416	.070	.229	1.103	1.434
14/ OMP	75.07	2.45	6.07	16.91	9.84	24.35	67.85
	.130	.031	.070	.126	.175	.308	.149
Salmon	74.40	2.42	7.00[a]	17.02	9.45	27.33[a]	66.53[ab]
Hake	74.19	2.42	7.30[a]	16.75	9.37	28.30[a]	64.93[b]
OMP	75.08	2.46	6.05[b]	17.03	9.88	24.27[b]	68.38[a]

n = 3 replicate samples/pond.

Significant relationships: fat (% wet wt.), P≥.025; fat (% dry wt.), P≥.025; protein (% dry wt.), P≥.025

Mean values in columns with same exponent letter did not vary significantly (P≤.05).

Rearing Results: 1986-Brood Fal 1 Chinook Salmon

Fall chinook salmon (up-river-bright stock) were reared on a test ration containing vacuum dried salmon meal and a control ration composed of the Bonneville Hatchery supply of Oregon feed system rations from 14 April to 8 September 1987. Experimental lots of control and test ration fish were split during this time period to meet projected pond water flow/fish weight requirements according to the following schedule:

Split date	Ration:	OMP		Salmon meal	
	Pond:	C-1		C-2	
4/14/87	No. fish:	273,319		274,836	
	G/fish:	2.040		2.040	
	Pond:	C-1	C-4	C-2	C-3
6/26/87	No. fish:	133,331	135,989	131,256	137,364
	G/fish:	7.428	7.428	8.620	8.620
	Pond:	C-5	C-6	C-7	C-8
8/18/87	No. fish:	49,929	50,257	50,168	50,150
	G/fish:	17.569	16.732	18.337	17.576

Fish were coded wire tagged during the period 21 to 26 August, 1987; the total number of fish released and number with recognizable coded wire tags are listed below. Fish were released under emergency low water conditions at Bonneville Hatchery about two months prior to schedule.

Release date	Ration:	OMP		Salmon meal	
	Pond:	C-5	C-6	C-7	C-8
9/8/87	Released	49,929	50,257	50,168	50,150
	Tagged	31,944	32,823	32,283	31,823

Fish health during the rearing period warranted no examinations. Emergency release did not allow for a preliberation examination of fish.

Fish were supplied significantly smaller quantities of salmon meal ration during the rearing period (wet wt., $P>.025$; dry wt., $P>.025$) than control ration (Table 5). The salmon ration was converted more efficiently on a wet ($P>.05$) and dry ($P>.05$) weight basis than the control ration. The conversion of ration protein to body protein (feed protein/protein gain) did not vary ($P<.05$).

The more efficient conversion of less test ration yielded weight gain equal ($P<.05$) to that of the control and produced fish of equal ($P<.05$) weight and length at release (Table 6). Although fish weight and length did not vary statistically ($P<.05$), fish supplied the salmon meal ration were sufficiently longer to yield a lower (P>.025) condition factor. Mortality was lower (P>.05) for fish reared on the salmon meal test ration.

Table 5. Feed consumption and conversion. 1986-Brood fall chinook; Bonneville Hatchery.

Ration	Pond No.	Feed consumption (kg)			Feed/gain		Feed protein/ protein gain
		Wet wt.	Dry wt.	Protein	Wet wt.	Dry wt.	
OMP	C-5	2429.0	1764.5	913.8	1.060	.770	2.425
	C-6	2483.4	1804.1	933.9	1.116	.810	2.539
Salmon	C-7	2148.0	1559.7	886.0	.923	.671	2.311
	C-8	2193.0	1592.1	904.6	.926	.673	2.354
OMP	Mean	2456.2[a]	1784.3[a]	923.8	1.088[a]	.790[a]	2.482
Salmon	Mean	2170.4[b]	1575.9[b]	895.3	.925[b]	.672[b]	2.333

Significant relationships: feed (wet wt.), $P \geq .025$; feed (dry wt.), $P \geq .025$; feed (wet wt.)/gain, $P \geq .05$; feed (dry wt.) /gain, $P \geq .05$.

Mean values for rations in a column with same exponent letter did not vary significantly (P=.05).

Table 6. Fish size, gain, length, condition factor and mortality. 1986-Brood fall chinook; Bonneville Hatchery.

Ration	Pond No.	Fish release wt. (g)	Weight gain (g/fish)	Length (mm)	Condition factor[1]	Mortality (%)
OMP	C-5	21.87	19.83	118.6	1.309	.974
	C-6	21.39	19.35	117.8	1.309	.823
Salmon	C-7	21.38	19.34	119.2	1.262	.432
	C-8	22.34	20.31	120.6	1.275	.461
OMP	Mean	21.63	19.59	118.2	1.309[a]	.898[a]
Salmon	Mean	21.86	19.82	119.9	1.268[b]	.446[b]

[1] [100000 x wt. (g)]/[length (mm)^3].

Significant relationships: condition factor, P>.025; mortality, P>.05.

Mean values for rations in a column with same exponent letter did not vary significantly (P=.05).

Despite a higher fat content in salmon meal test ration (Table 7), the moisture, fat and protein (wet and dry wt. basis) of fish supplied salmon meal and control ration did not vary (P<.05) (Table 8). The body ash content of fish supplied the salmon meal ration was higher (P>.01) than observed for the control ration, but only on a wet weight basis.

Table 7. Ration composition. 1986-Brood fall chinook; Bonneville Hatchery.

Ration		Composition (% wet wt.) Moisture	Ash	Fat	Protein
Salmon n = 10	Mean	27.18	6.77	16.85	41.31
	S.D.	.82	.17	.52	.71
OMP n = 9	Mean	27.27	8.04	12.45	39.08
	S.D.	1.55	.71	2.90	1.87

n = Number of lots of experimental ration; number of samples of hatchery feed supply taken through rearing period for OMP.

Table 8. Body composition. 1986-Brood fall chinook; Bonneville Hatchery.

Ration /Pond	Composition (% wet wt)				Composition (% dry wt.)		
	Moisture	Ash	Fat	Protein	Ash	Fat	Protein
OMP/C-5	75.80	2.06	6.53	16.44	8.55	27.08	68.13
OMP/C-6	76.37	2.06	6.13	16.52	8.70	25.94	69.91
SAL/C-7	75.94	2.13	6.62	16.48	8.83	27.51	68.49
SAL/C-8	75.02	2.12	7.64	16.24	8.83	30.57	68.49
OMP	76.12	2.06[a]	6.33	16.48	8.63	26.51	69.02
SAL	75.48	2.12[b]	7.13	16.36	8.65	29.04	66.75

Significant relationships: ash (% wet wt.), $P \geq .01$

Mean values for rations in a column did not vary significantly ($P \leq .05$).

Assessment of Physiological Condition: 1986-Brood Fall Chinook Salmon

The pattern of plasma cortisol levels observed for the 1986-brood of fall chinook was identical to that observed for the 1985-brood. Plasma cortisol from fish reared on both the control OMP and salmon meal test ration decreased during July, followed by a sharp increase during August (Fig. 1).

Plasma thyroxine (Fig. 2) and triiodothyronine (Fig. 3) patterns differed between the two ration groups, suggesting differences in developmental dynamics. At the beginning of August, fish reared on the control ration experienced a major increase in plasma thyroxine, while a decrease was observed for fish supplied the test ration. The concentration of plasma triiodothyronine, while showing less alteration with respect to time, reflected similar ration differences.

Gill Na+/K+-ATPase activity appeared to peak in mid-August. This pattern was apparently not influenced by ration. However, the trend in ATP-ase activity was clearly different from that observed for the 1985-brood when a depression was noted in August (Fig. 4).

No temporal or dietary effect on the ability of salmon to regulate plasma sodium following a 24-hour saltwater challenge was observed (Fig. 5). Interestingly, the plasma potassium levels were higher in the fish receiving the test ration than in those supplied the control ration following the seawater challenge. This effect was evident at all test dates and suggests a clear dietary affect on the ability of the fish to maintain electrolyte equilibrium.

Total hepatic lipids decreased through time (Fig. 6); a pattern similar to that observed for the 1985-brood of fall chinook. In contrast to the 1985-brood, however, the total hepatic lipid level in fish fed the control ration was always higher than that of fish supplied the test ration. It is difficult to determine what this means, but one can speculate that fat levels in the liver must somehow be correlated with the fitness of the fish following release.

A high-pressure liquid chromatographic (HPLC) technique for fatty acids was developed. The ability of this technique to resolve fatty acids is illustrated by the data on Figure 7. Although we demonstrated that total hepatic lipid levels decreased through time and that the levels were consistently higher in the fish fed the control ration, there was no difference in specific hepatic fatty acids between the rations (Fig. 8). Fatty acids present are identified in Table 9. This was evident for fish from the 1985-brood; samples from the 1986-brood are presently being evaluated.

The main point of interest for the immunocompetency assessments were the comparisons between the dietary groups at the time of release. This could not be accomplished because of the emergency release of fish on 8 September 1987. Although evaluations were conducted at each of the sampling dates, meaningful results were not obtained.

In summary, it is believed that the physiological parameters monitored in the present study are sensitive and reliable indicators of early salmonid development and fitness. As observed for the 1985-brood, results indicate that on several sampling dates in the sampling period, the fish supplied the control and test rations were physiologically different. Physiological indices have clearly shown sensitivity in detecting developmental differences attributable to hatchery practices (i.e., in this case ration composition).

Table 9. Fatty acids identified by reversed phase HPLC in liver samples from juvenile fall chinook reared on OMP and salmon meal rations. Fatty acids are ranked in order of relative abundance. 1985-Brood; Bonneville Hatchery.

Rank	Fatty acid	Common name
1	14:0	Myristic acid
2	16:0	Palmitic acid
3	$18:1_c$	Oleic acid
4	16:1	Palmitoleic acid
5	18:2	Linoleic acid
6	18:0	Stearic acid
7	20:1	Eicosaenoic acid
8	18:3	Linolenic acid
9	22:1	Erucic acid
10	22:0	Behenic acid

c = cis isomer

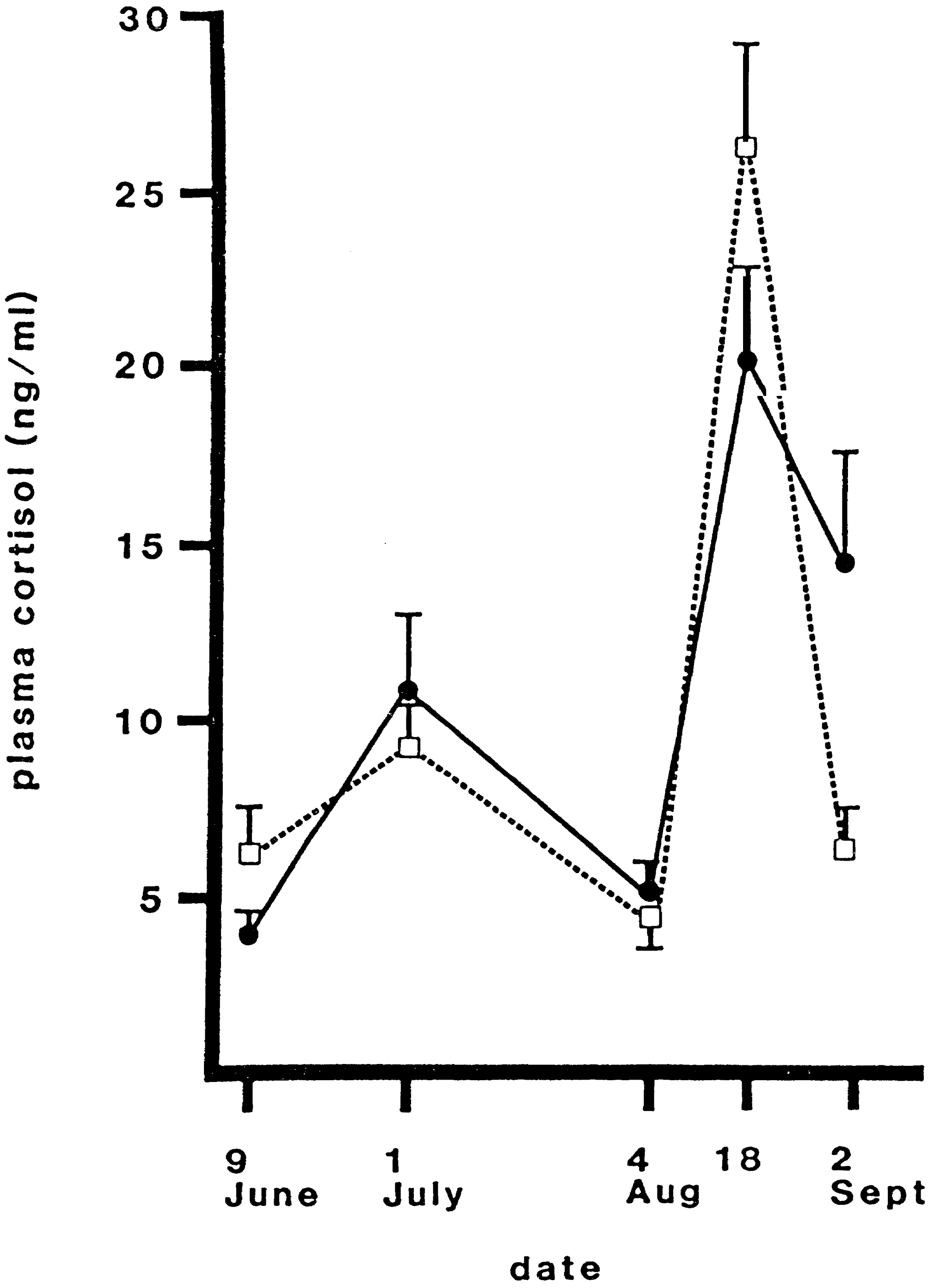

Figure 1. Mean plasma cortisol concentrations in juvenile fall chinook salmon reared on Oregon pellet (solid line) and salmon meal (dotted line) rations. 1986-Brood; Bonneville Hatchery. Vertical lines indicate S.E.; n = 7-20.

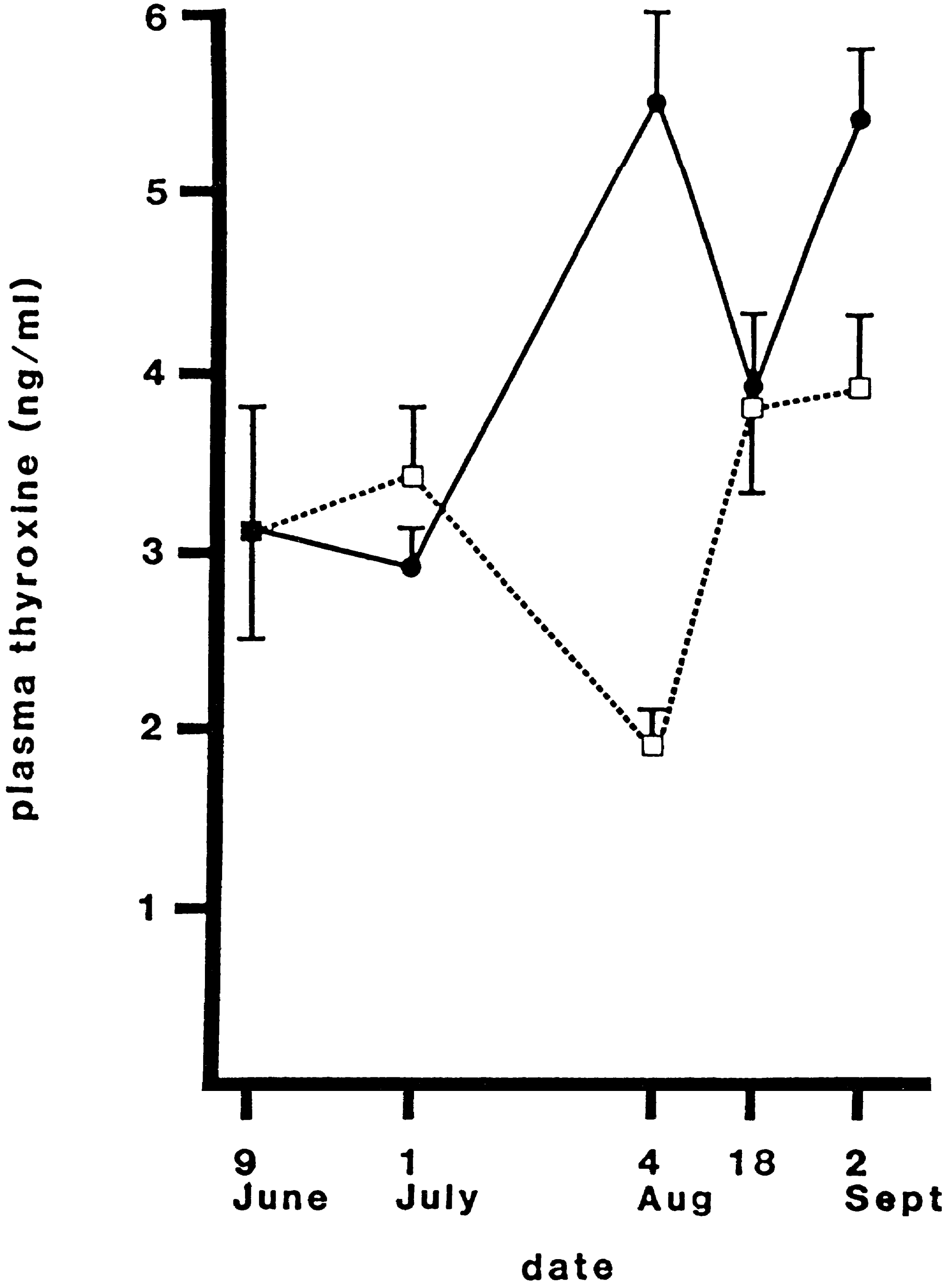

Figure 2. Mean plasma thyroxine concentrations in juvenile fall chinook salmon reared on Oregon pellet (solid line) and salmon meal (dotted line) rations. 1986-Brood; Bonneville Hatchery. Vertical lines indicate S.E.; n = 7-20.

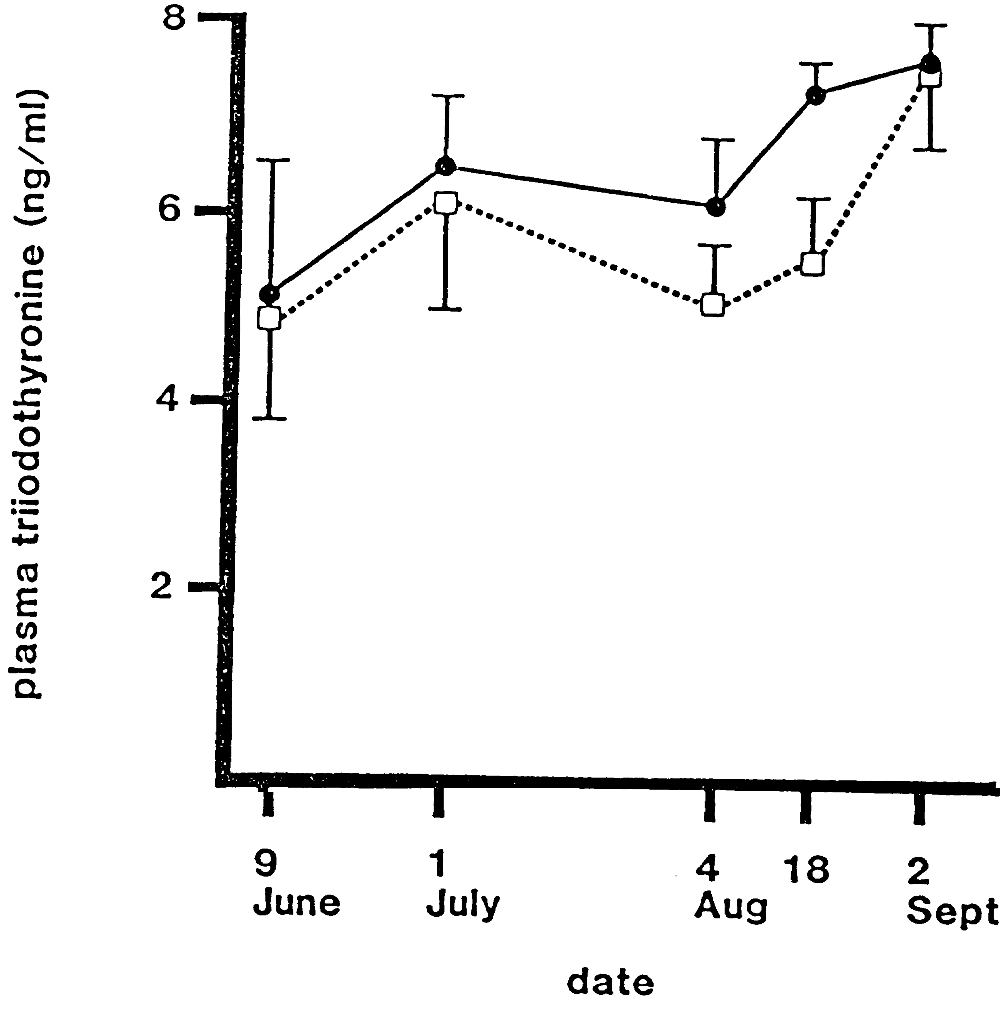

Figure 3. Mean plasma triiodothyronine concentrations in juvenile fall chinook salmon reared on Oregon pellet (solid line) and salmon meal (dotted line) rations. 1986-Brood; Bonneville hatchery. Vertical lines indicate S.E.; n = 6-14.

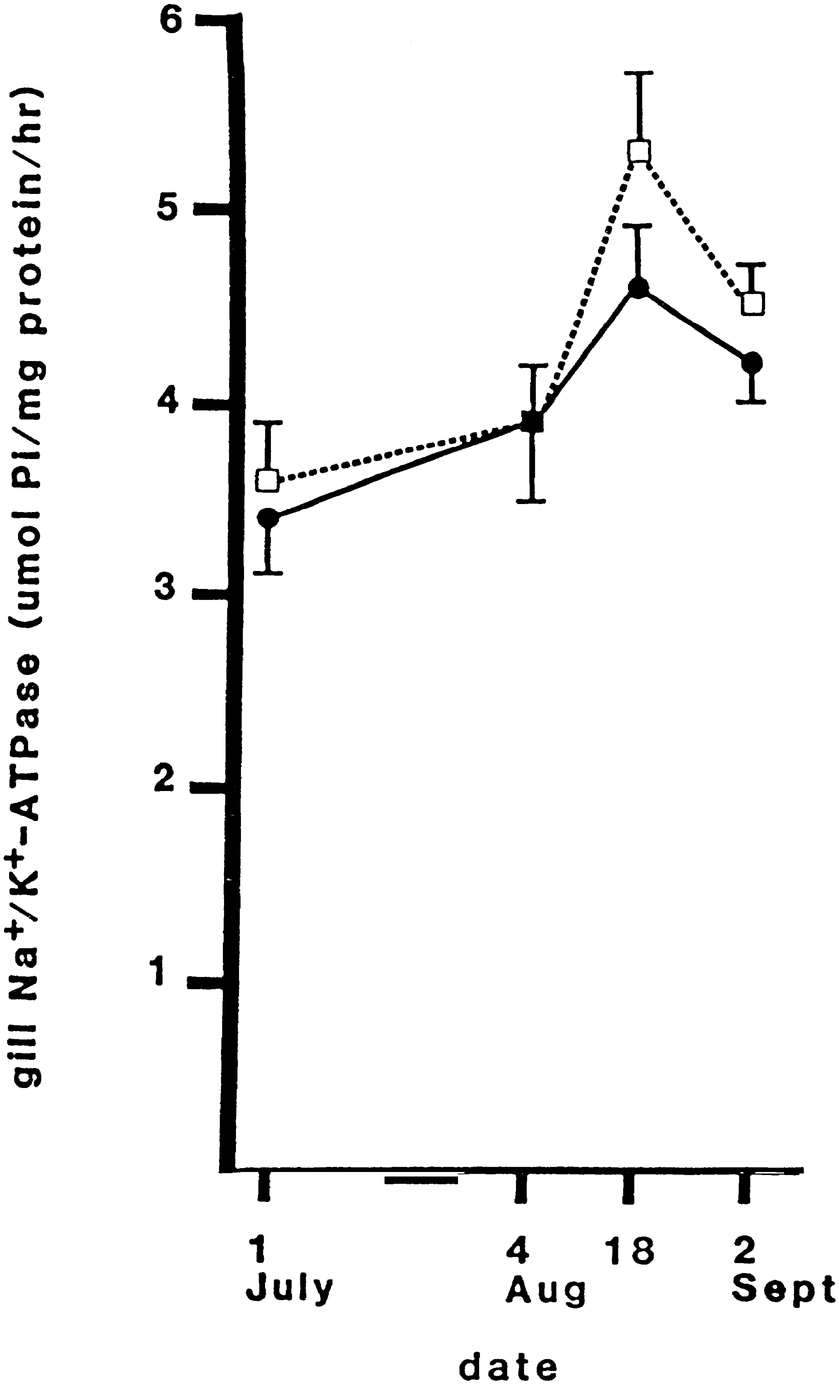

Figure 4. Mean gill Na^+/K^+-ATPase levels in juvenile fall chinook salmon reared on Oregon pellet (solid line) and salmon meal (dotted line) rations. 1986-Brood; Bonneville Hatchery. Vertical lines indicate S.E.; n = 20.

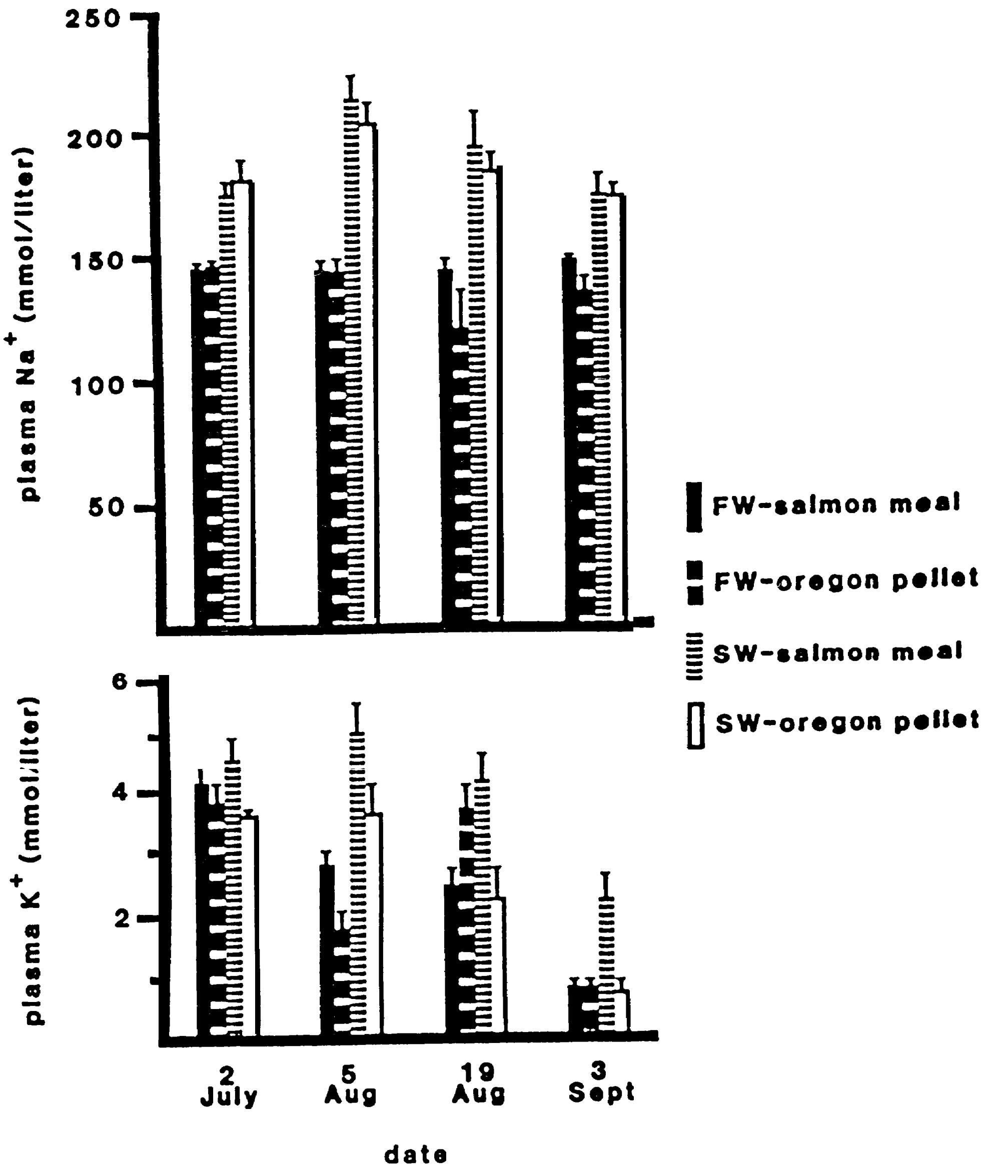

Figure 5. Mean plasma sodium and potassium concentrations in juvenile fall chinook salmon 24 hours after transfer to either fresh water (FW) or 25 ppt artificial seawater (SW). 1986-Brood; Bonneville Hatchery. Vertical lines indicate S.E.; n = 5-10.

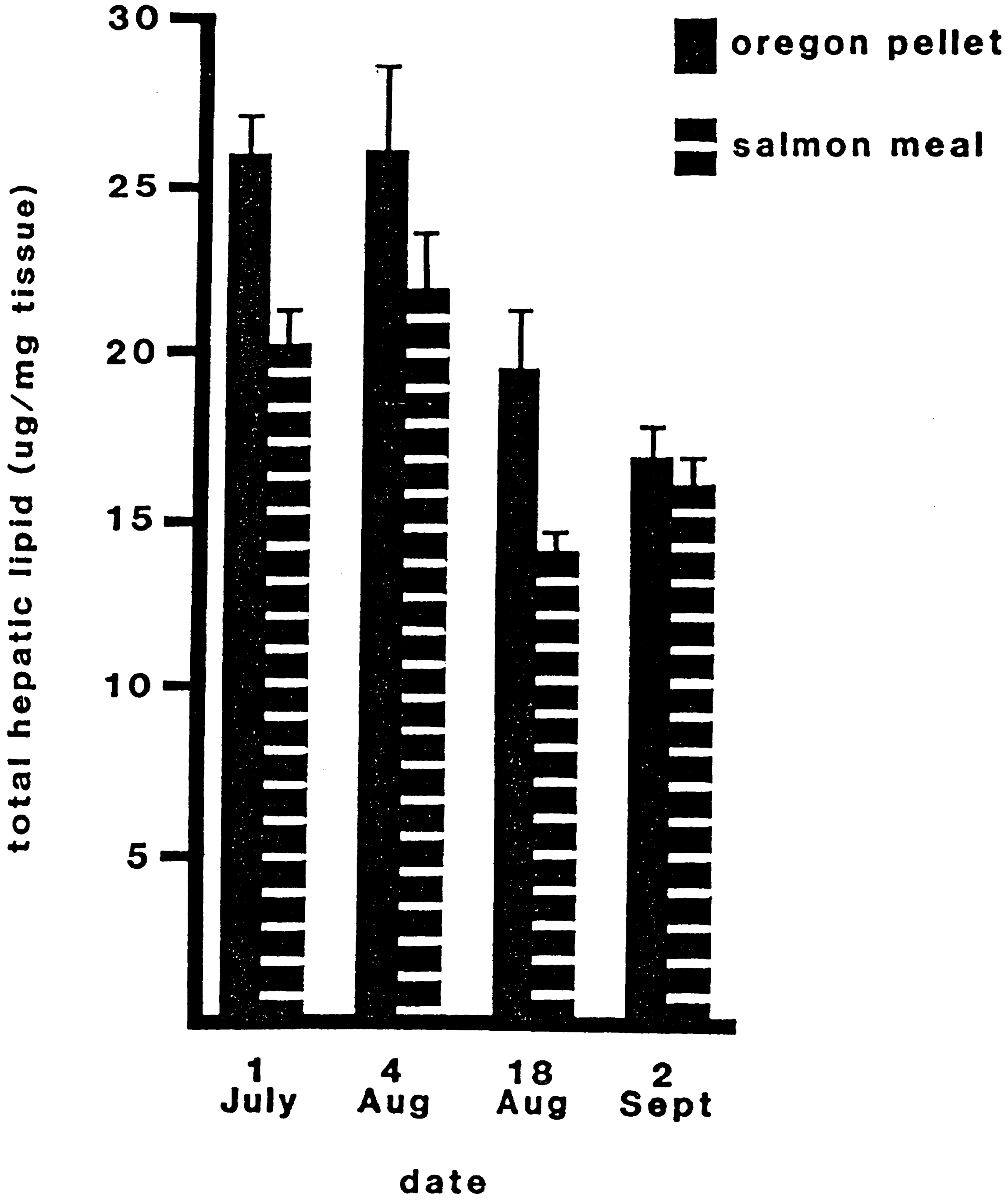

Figure 6. Mean liver lipid content in juvenile fall chinook salmon reared on Oregon pellet and salmon meal rations. 1986-Brood; Bonneville Hatchery. Vertical lines indicate S.E.; n = 20.

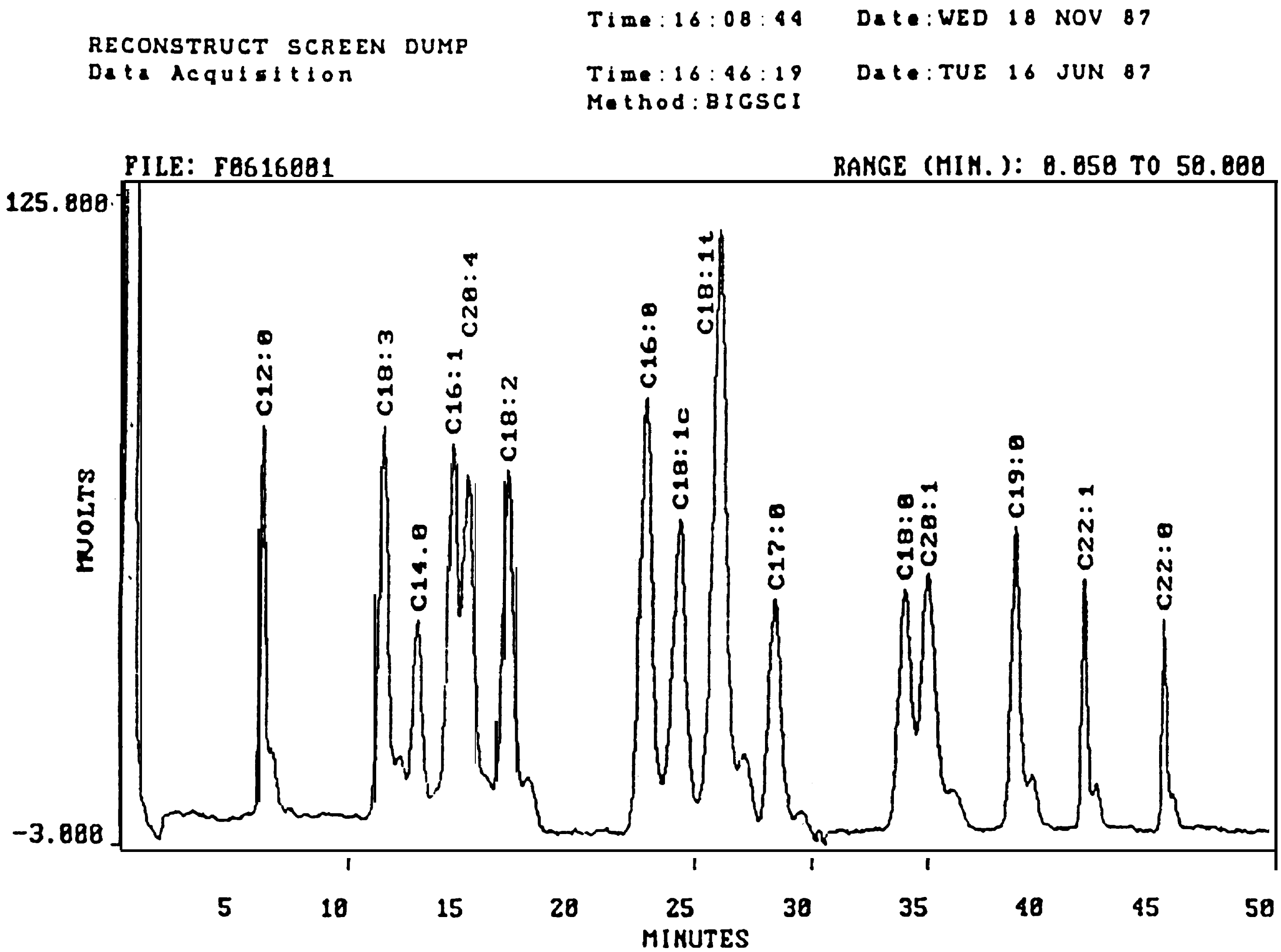

Figure 7. Chromatogram showing typical separation of phenacyl esters of fatty acids by reversed phase HPLC. Fatty acids were purchased from Sigma Chemical Company. Analysis was made on a 10.0 x 2.1 mm octadecyl column at a solvent flow rate of 1.0 ml/minute. The initial solvent system was acetonitrile-water (65:35) programed to 80:20 in 30 minutes and then to 98:2 in 9 minutes. Elution was controlled by an IBM LC/9533 ternary gradient liquid chromatograph equipped with a UV detector to monitor absorbance at 254 nm.

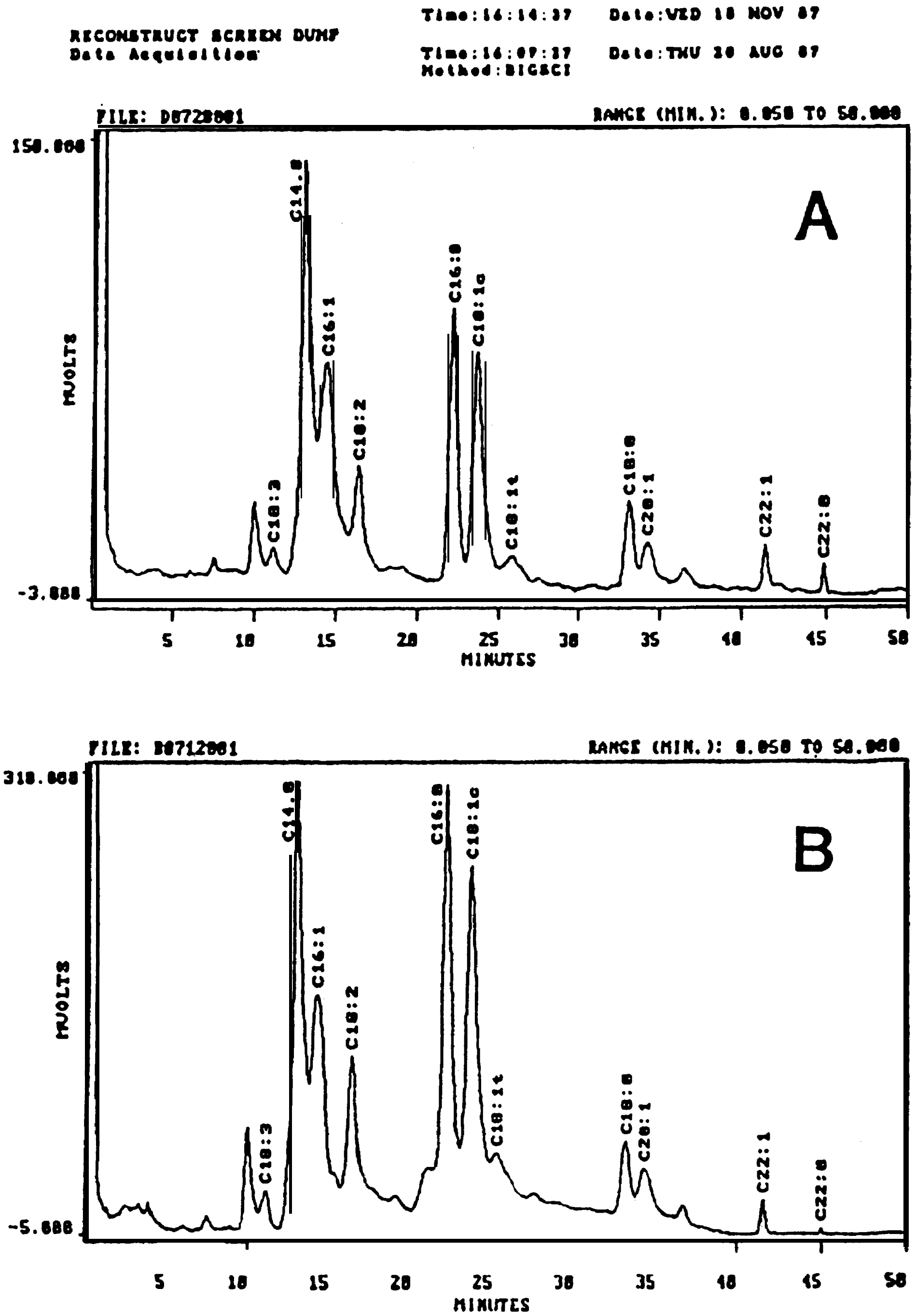

Figure 8. HPLC analysis of phenacyl esters of hepatic fatty acids from juvenile fall chinook salmon reared on Oregon pellet (A) and salmon meal (B) rations. 1985-Brood; Bonneville Hatchery. Chromatography conditions as described in Figure 7.

Preliminary Coded Wire Tag Recovery for Coho Salmon (Sandy Stock), Sandy Hatchery; Fall Chinook Salmon (Tule Stock), Bonneville Hatchery

Project releases of coded wire tagged fish to date include the 1982, 1983, 1984 and 1985-broods of Sandy stock coho salmon (Sandy Hatchery), the 1983 and 1984-broods of tule stock fall chinook salmon (Bonneville Hatchery) and the 1985 and 1986-brood of up-river-bright stock fall chinook salmon (Bonneville Hatchery). Preliminary recovery coded wire tags from the 1982, 1983 and 1984-broods of coho salmon (Sandy stock) and 1983 and 1984-broods of fall chinook (tule stock) through September of 1987 have been reported. Recoveries include those from the hatchery and from the fishery. The recoveries from the fishery may or may not have been expanded depending upon the fishery and the brood year.

Test rations, those containing vacuum dried salmon and hake meal, appear to be favorably altering the survival of coho salmon, but not in a uniform manner (Table 10). Analysis of variance of the percent of the tags recovered to date (September 87) from the 1982, 1983 and 1984-brood releases in a 3 x 3 factorial design revealed that fish supplied either the salmon or hake ration produced superior (P>.001) survival to fish receiving the control OMP ration. The hake ration produced somewhat poorer survival than fish supplied the salmon ration, but the magnitude of the difference was not significant (P<.05). However, analysis revealed the recovery of tags to vary (P>.001) by brood year and ration and brood year interaction in a significant (P>.001) manner.

Inspection of individual recovery means revealed the significant interaction to reflect the fact that recovery of tags from test ration fish, based upon the level of data collected to date, did not vary from the control for the 1982 and 1984-brood, but did for the 1983-brood. For the l983-brood, recoveries from fish supplied the salmon and hake meal rations were greater (P=.O5) than the control OMP ration; recoveries from fish supplied salmon and hake real rations were equal (P=.O5). All of the individual recovery means by brood year (1982, 1983 and 1984-brood) differed (P=.O5). The significant interaction of brood year and ration was related to the superior (P=.O5) recovery of test ration fish over control for the 1983-brood and no ration differences (P=.05) for the 1982 and 1984-brood years. Although recovery of coded wire tags to date from the 1983-broods of coho indicated that test ration did significantly improve survival, the incomplete recovery data to date suggests that the effectiveness of superior quality rations may be dependent upon the general survival success of a particular brood-year.

Results from the recovery of coded wire tags from the 1983 and 1984-broods of fall chinook (tule stock) are preliminary and represent data available as of September 1987 (Table 11). Analysis of variance (2 x 2 factorial design) of tag recovery data to date shows a significant variation with respect to ration (P>001) (OMP > salmon meal), brood year (P>.005) (1984-brood year > 1983-brood year). Ration and brood year interacted in a significant (P>.005) manner and was directly related to a difference in ration performance by brood year.

Recovery of tagged fish from the 1983-brood shows some improvement in survival by fish supplied the salmon meal ration, however, the observed difference is not significant (P=.O5) based upon the data to date. For the 1984-brood, the control ration has shown superior survival (P=.O5) to that of the test ration. This is not a surprising result. The growth response of fish between mid February of 1985 to release in May was compromised in an intermittent manner by poor test ration palatability resulting in reduced feed consumption and conversion. Poor ration palatibility was traced to the herring oil component of the ration derived from one lot of two lots of oil being used to prepare rations. The lot of herring oil that produced problem was not oxidized, based upon chemical analysis, but contained only traces of antioxidant. It possessed an unusual potential for oxidation when incorporated into the ration. This was the case even when antioxidant protection against autooxidation was strengthened to four times that normally incorporated into the ration.

Table 10. Summary of preliminary tag recovery. Coho salmon; Sandy Hatchery

Brood Year	Ration	Tag Code	Tagged Fish Release	No. Recovered[1] 2-Year	3-Year	Total	Percent Release: Release	Mean
1982	OMP	7-29-13	25,763	4	492	496	1.93	
		7-29-06	26,983	3	475	478	1.77	1.85[a]
	Salmon meal	7-29-12	25,250	4	444	448	1.77	
		7-29-09	26,573	6	511	517	1.95	1.86[a]
	Hake meal	7-29-10	26,654	5	514	519	1.95	
		7-29-07	26,095	3	447	450	1.72	1.84[a]
1983	OMP	7-30-45	25,683	20	1,912	1,932	7.52	
		7-31-05	26,459	53	2,046	2,046	7.93	7.73[b]
	Salmon meal	7-30-48	26,673	66	2,397	2,463	9.23	
		7-31-06	25,743	68	2,233	2,301	8.94	9.09[c]
	Hake meal	7-30-47	25,493	48	2,211	2,259	8.86	
		7-31-07	25,827	55	2,305	2,360	9.14	9.00[c]
1984	OMP	7-37-46	27,623	11	181	192	.695	
		7-36-20	27,974	6	173	179	.640	.668[d]
	Salmon meal	7-37-45	28,079	9	215	224	.798	
		7-36-19	27,115	10	199	209	.771	.785[d]
	Hake meal	7-36-18	27,489	6	173	179	.651	
		7-36-23	27,542	7	181	188	.683	.667[d]

[1]Includes catch and escapement data available through September 1987.

Significant relationships, 3 x 3 factorial design: percent of release; brood year, $P \geq .001$; ration, $P \geq .001$; brood year x ration interaction, P.001.

Ranking of level means (means with same underline did not vary significantly; P=.05):

Brood year 1984 < Brood year 1982 < Brood Year 1983

OMP < Hake < Salmon

Mean values in a column with same exponent letters did not vary significantly (P=.05).

Table 11. Summary of preliminary tag recovery. Fall chinook salmon (tule stock); Bonneville Hatchery

Brood Year	Ration	Tag Code	Tagged Fish Released	Number Recovered[1] 2-Year	3-Year	4-Year	Total	Percent of Release
1983	OMP	7-31-20	80,348	5	9		14	.017
		7-31-21	80,048	6	39		45	.056
		Mean						.037[a]
	Salmon meal	7-31-22	80,138	9	47		56	.070
		7-31-23	81,282	7	28		35	.043
		Mean						.057[a]
1984	OMP	7-33-22	78,367	246	177		423	.540
		7-33-23	78,962	278	119		397	.530
		Mean						.535[b]
	Salmon meal	7-33-24	80,242	122	112		234	.292
		7-33-25	79,750	84	107		191	.239
		Mean						.265[c]

[1]Includes catch and escapement data available through September 1987.

Significant relationships, 2 x 2 factorial design: percent of release; brood year, $P \geq .001$; ration, $P \geq .005$; brood year x ration interaction, $P \geq .005$.

Ranking of level means (means with same underline did not vary significantly; P=.05):

Brood year 1983 < Brood year 1984

Salmon meal < OMP

Mean values in a column with same exponent letters did not vary significantly (P=.05).

APPENDIX I.

Water Temperatures (^{o}F) by the Month at Sandy Hatchery

	1983			1984			1985		
Month	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.
January	44	42.5	43.3	42	40	41	39	37	38
February	45	44	44.5	45	42.5	44	39	37	38
March	47	45	46	47	44	45.5	43	40	41.5
April	49.5	45	47	47.5	44	45.8	48	44	46
May	54.5	49.8	52.1	51	47	49	52	47	49.5
June	56	52	54	54	50	52	56	51	53.5
July	56.6	53.4	55	61	54	57.5	66	58	62
August	61	56	58.5	62	56	59	61.4	55.2	58.3
September	60	45	54	60	48	54	59	48	53.2
October	51	47	49	49	47	48	49	46	47.5
November	47	46	46.5	45	44	44.5	41	40	46.5
December	41	39	40	41	40	40.5	37	36	36.5

APPENDIX II.
Ration Formulation

Component	Control ration	Test Rations: Hake meal	Test Rations: Salmon meal
Fish meal	28.0 (min)[1]	40.0-48.4[14]	37.7-41.4[14]
Cottonseed meal	15.0[2]	0.0	0.0
Dried whey product[3]	5.0	2.0	2.0
Wheat germ meal[4]	Remainder	Remainder	Remainder
Corn distillers solubles[5]	4.0	0.0	0.0
Trace mineral premix[6]	0.1	0.1	0.1
Vitamin premix[7]	1.5	1.5	1.5
Spray dried blood meal[8]	0.0	2.0	2.0
Sodium bentonite	0.0	2.0	2.0
Concentrated hydrolyzed fish[9]	0.0	19.7-22.3	19.7-22.3
Choline chloride[10]	0.5	0.5	0.5
Pasteurized wet fish[11]	30.0	0.0	0.0
Fish oil	6.0-6.75[12]	1.8-7.5[13]	7.7-10.6[13]
Water	0.0	8.1-12.6	8.1-10.5
Total	100.0	100.0	100.0

[1]Herring meal (min. 67.5% protein) used at no less than 50% of the fish meal in each batch. Anchovy (min. 65% protein), capelin (min. 67% protein), or hake (min. 67% protein) meals may be used as the remainder. Level to supply not less than 21.5% fish meal protein; max. 5% NaCl; 8-12% fat; max 17% ash.

[2]Preprocessed, solvent extracted, min. 48% protein, max 0.055% free gossypol.

[3]Min. 12% protein, max. 6% moisture, max. 10% ash, max. 3% salt

[4]Min. 23% protein and 7% fat

[5]May contain up to 30% "grains" in place of solubles

APPENDIX II (continued)

[6]Gm/lb: Zn ($ZnSO_4$), 34.0; Mn, 34.00 ($MnSO_4$) 9.10; Fe, Cu ($CuSO_4$) 0.70; I (ethylenediamine dihydroiodide), 4.54; diluted to 1.00 lb with cereal product.

[7]Mg/lb: d-biotin, 18.0; vitamin B_6 535.0 (pyridoxine.HCl, 650 mg); B_{12}, 1.8; vitamin C, 27,000.0 (ascorbic acid); vitamin E, 15,200.0 (water dispersible alpha tocopheryl acetate): folacin, 385.0 (folic acid); Myo-inositol, 4000.0 (not phytate); vitamin K, 180.0 (menadione sodium bisulfite complex, 545 mg); niacin, 5700.0; d-pantothenic acid, 3200.0 (d-calcium pantothenate, 3478 mg or d,l-calcium pantothenate, 6957 mg; riboflavin, 1600.0; thiamine, 715.0 (thiamine mononitrate, 778 mg); dilute to 1.0 lb with cereal product

[8]Spray dried whole blood

[9]Concentrated bone-free hydrolysate of salmon carcasses, groundfish carcass waste and whole Pacific hake

[10]Liquid, 70%

[11]Two or more of the following, with none exceeding 50% of the combination; (1) Salmon or tuna viscera (no heads or gills, with livers); (2) whole herring; (3) bottom fish (whole or fillet scrap); (4) dogfish; (5) whole hake; and (6) whole salmon. Approved enzymes used to aid liquefaction.

[12]Herring, salmon, menhaden, dogfish (not more than 3%), or refined tuna oil; stabilized with 0.4% BHA-BHT (1:1); free fatty acids not more than 3%; BHA-BHT must be added at the time of reprocessing if reprocessed oil is used. Special condition when using hake as a wet fish: add 0.5% oil for every 10% hake in total ration.

[13]Herring oil; stabilized with 0.02% BHA-BHT (1:1); free fatty acids not more than 3%.

[14]Vacuum dried

Ethoxyquine antioxidant protection: control ratio, 0.009% in the ration; test rations, 0.015% of the ration excluding concentrated hydrolysed fish, choline chloride, fish oil, and water components.

APPENDIX III. OREGON DEPARTMENT OF FISH AND WILDLIFE

FISH EXAMINATION 1985 - Brood Coho
Sandy Hatchery

SOURCE Sandy

EXAM DATE(S) 5/20/86

ADDRESS

COMPLETION DATE 5/20/86

SAMPLE 11.85 CoFry
Lot No. - Species - Fish Size

REASON FOR EXAM: ☐ Certification ☐ Increased Loss ☐ Preliberation ☐ Routine

☒ Other assessment of current cwd situation

SIGNS OF DISEASE:

3/22 & 25-26 furanace at 1 ppm, 1 ppm and 2 ppm just before ponding--results nebulous. Ponded 3/27 & 28. Fed TM-100 at 1.2 lbs/40 lb bag starter diet and 2.4 lbs/40 bag at 1/32 OMP. Fed until 5/1. Stopped on 5/1, recommenced on 5/15 due to mortality increasing and cwd symptoms. Feeding at 3 lbs/40 lb bag currently. Loss throughout period was normal with no major cwd epizootic occurring.

RESULTS:

RECOMMENDATIONS:
Furanace not justified due to cwd symptoms and slight increased loss right after ponding. The furanace did seem to work last year but it would appear that furanace is best used for an active acute cwd epizootic in the stacks before ponding. After ponding TM or furox therapy seems to be the necessary key to preventing a cwd epizootic.

See Reverse

C: Source
Pathology - Clackamas
Pathology - Corvallis
Fish Culture - Portland
Regional Office
Other

5/22/86
Date

Terry Kreps
Pathologist(s)

Previous Diseases, Treatments, **Stress Conditions of** This Fish Stock:

Diet ____________ **Water Temperature** ____________ **Loss** normal

Microscopic Exam:

Gill **structure good, no "bugs" on 4/18/86 exam.**

Culture Exam: ND

Tissues ☐ Kidney ☐ Gill ☐ Other ____________

Media ☐ TSA ☐ BHI ☐ Cytophaga ☐ Other ____________

Additional Comments:

For future coho brood years recommend 6% TM-50 incorporated into fish food from initial feeding until fish at 150/lb **and/or** final split and thin. **Any time TM therapy** stopped during **April and May and cwd epizootic commences** 7-9 **days later so it would appear justifiable to go on a continuous TM-50 regime.**

OREGON Fish & Wildlife

SOURCE Sandy

EXAM DATE(S) 4-7-87

ADDRESS

COMPLETION DATE 5-15-87

SAMPLE 11.85 Coho smolts 15/lb
Lot No. - Species - Fish Size

REASON FOR EXAM: ☐ Certification ☐ Increased Loss ☒ Preliberation ☐ Routine

☐ Other

SIGNS OF DISEASE:

Chronic loss in Pond 7 but no definite disease found. Perhaps aftermath of pond inventory. Other ponds fish look and act normal.

RESULTS:

VEN exam - Ponds 5, 6 & 7. 18 fish each for total of 54. All negative. Exam by OSU fish disease personnel. Ponds 5, 6 & 7 reflect 3 different diets - Hake, Biomoist & Silver Cup.

RECOMMENDATIONS:

Liberate.

See Reverse

c: Source
Pathology - Clackamas
Pathology - Corvallis
Fish Culture - Portland
Regional Office
Other

5-28-87
Date

Terry Kreps
Pathologist(s)

Previous Diseases, Treatments, Stress Conditions of This Fish Stock:

No major disease problems since ponding April of 1986.

Diet ____________ Water Temperature ____________ Loss Pond 7 20/day
other ponds - 1-3/d
runts

Microscopic Exam:

Gill structure good; no costia.

Culture Exam: Pond 7

Tissues [X] Kidney [ ] Gill [ ] Other ____________

Media [X] TSA [ ] BHI [ ] Cytophaga [ ] Other ____________

Some A-p but no definite pathogens.
Gram stain negative: No BKD or gram negative bacteria.

Additional Comments:

Sandy still remains VEN negative.