RESEARCH BRIEFS

FISH COMMISSION OF OREGON
307 State Office Building
PORTLAND, OREGON

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FOREWORD

These short reports are intended to inform the public, fishing industry, sportsmen, and fisheries scientists of research conducted by the Fish Commission. Reports will be published from time to time as studies are sufficiently complete. Most of the reports provide biological evidence upon which measures are based to enhance and conserve the fishery resource. Research Briefs are free and may be obtained upon request from the editor.

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Analysis of Average-Weight Sampling of Commercial Catches of Columbia River Chinook Salmon

EARL F. PULFORD

INTRODUCTION

Statistics on Columbia River commercial salmon landings are reported in pounds, but for many fishery management problems the numbers of fish landed are required. In order to obtain data for converting pounds to numbers landed, a sampling program has been conducted on the gill-net fishery since 1951 by the staffs of the Oregon Fish Commission and Washington Department of Fisheries. The data were obtained by technicians who examined the salmon catches. Sampling was concentrated at major canneries in Astoria and Portland, although in the years 1951–56 additional data were obtained aboard pick-up boats as purchases were made from individual fishermen.

Prior to the late 1930's, it had been customary to assume an average weight of 22 pounds for use in converting pounds of chinook salmon *(Oncorhynchus tshawytscha)* landed to numbers of fish (Calkins, Durand, and Rich, 1939). It is well known, however, that there are seasonal and annual fluctuations in average weight. In order to provide more satisfactory conversion factors, several studies were undertaken. Rich (1940) reported average-weight data obtained from four salmon canneries during the months of June–August 1939 and Chapman (1940) presented similar data from a Columbia River salmon cannery during the years 1918–40.

This report compares more recent data with those from the earlier period, and also examines significant trends in the average weight of salmon taken from the various zones of the Columbia River and during the different fishing seasons in the years 1951–61.

THE FISHERY

The salmon fishery on the Columbia River has been described in several publications (e.g., Craig and Hacker, 1940, and Johnson, Chapman, and Schoning, 1948). The area open to commercial fishing has been divided into six zones, extending from the mouth of the river (Zone 1) upstream to its confluence with the Deschutes (Zone 6), a distance of approximately 200 miles. Zonal boundary lines correspond to the boundaries of the six Washington counties forming the northern shore of the river except that since 1956 the lower boundary of Zone 6 has been at Bonneville Dam (Figure 1).

The year is divided into five open seasons: (1) winter—February; (2) spring—May; (3) summer—last two weeks of June and first two weeks of July; (4) early fall—August; and (5) late fall—September, October, and November. Although there is frequently some overlap, the months corresponding to the above seasons are in general related to individual races of fish. For conservation purposes, the fishery has been severely restricted in recent years: from 272 days in 1936 to 101 days in 1960. Since 1956, when The Dalles Dam was completed, the only gill-net fishing permitted above Bonneville Dam has been conducted by Indians.

During the period 1951–61, commercial landings of chinook salmon were made primarily by gill nets, although important Indian dip-net catches were made in Zone 6 until Celilo Falls was flooded out by the construction of The Dalles Dam.

ANALYSIS OF MEAN WEIGHT VALUES

Chapman (1940) reported that the samples of salmon from which he computed mean weight values were taken entirely from lower river landings. He speculated that these values might not be applicable to catches from farther upriver because fish taken there may be smaller, on the average, than those caught in the lower river. Unfortunately, Chapman had no data to test his theory.

Rich (1940) also recognized that the use of gill nets on the lower river might tend to remove the larger fish. He attempted to obtain data from the middle and upper zones (Zones 3–6) but concluded that his results were not reliable, due to the limited samples.

During the 11-year period 1951–61, 5,149 average-weight samples, involving some 507,000 fish and constituting about 10% of the total chinook landings, were obtained from the Columbia River gill-net fishery. Table 1 presents the number of salmon weighed and seasonal mean weights for each year.

Samples have been obtained generally from all zones in the river where significant chinook landings have been made. Thus data are available to test the hypothesis that, on the average, the size of fish entering the catch decreases significantly from the lower to upper zones. A tabulation of the mean weight values obtained during the period 1951–61 is grouped by season and zone in Table 2. The data can be considered as representing five samples (the five open seasons on the river) with up to 11 replications (the years 1951–61). Regression coefficients were computed for the combined data and for each season. The analysis indicated that, on the average, considering all seasons and years, there is a significant decrease in the weight of chinook entering the catch proceeding upriver. Testing the seasonal regression coefficients revealed no significant slope for winter, spring, and late fall. Significant slopes, however, are associated with summer and early fall seasons. Computations associated with the analyses are presented in Table 3.

Chapman (1940) has tabulated numbers and weights of chinook purchased during the years 1918–40 by a cannery near the mouth of the Columbia River. How representative these values are for chinook landed from the lower river (Zone 1) during this period is difficult to say, since they represent only part of the catch purchased by this cannery. Chapman estimates that they comprise about 3% of all chinook removed from the river during the period. The fish included in the data were taken primarily

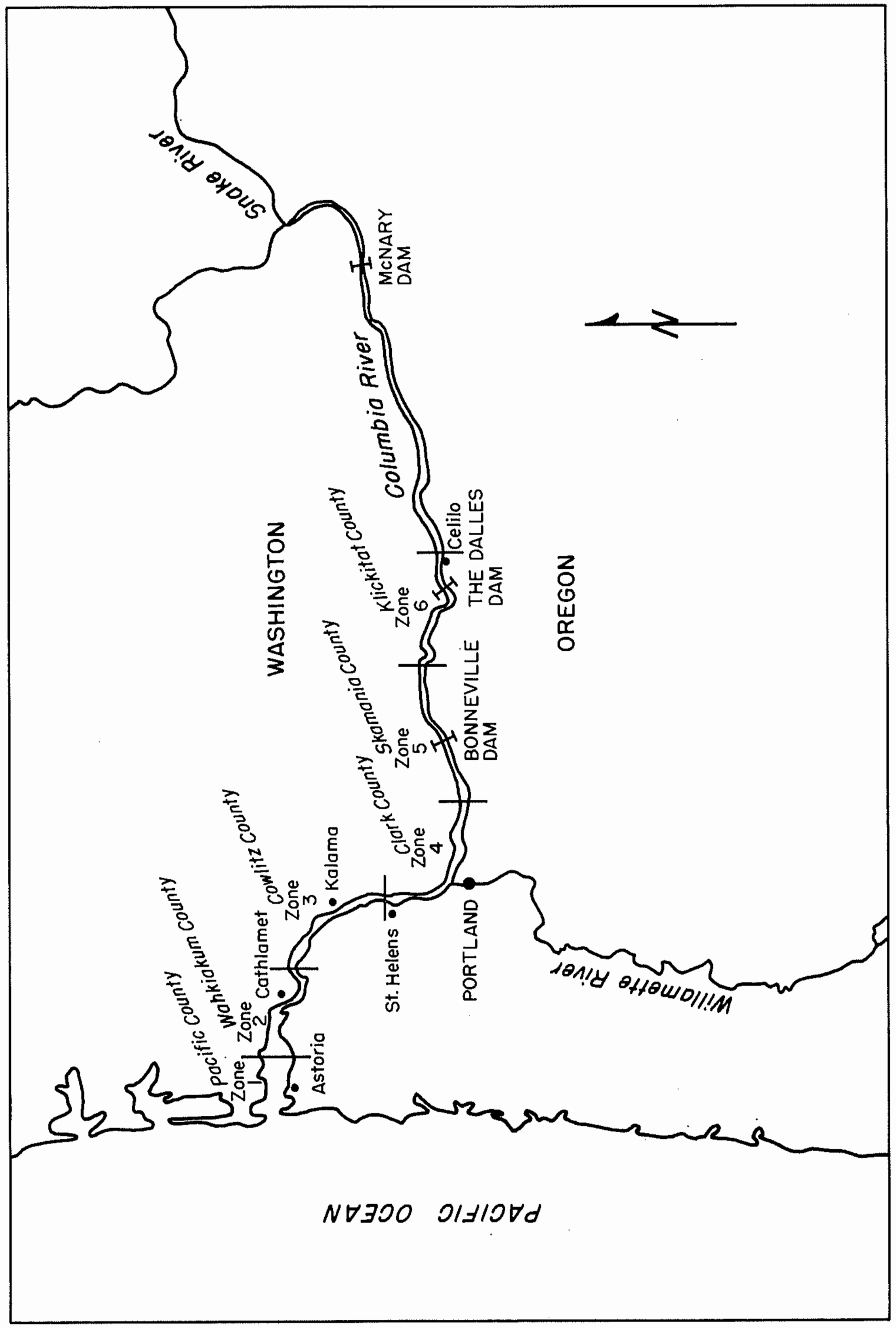

FIGURE 1. COLUMBIA RIVER COMMERCIAL FISHING ZONES.

TABLE 1. **SEASONAL MEAN WEIGHTS OF COMMERCIALLY CAUGHT COLUMBIA RIVER CHINOOK SALMON, 1951–61.**

	Season											
	Winter		*Spring*		*Summer*		*Early Fall*		*Late Fall*		*Total*	
Year	*Number Weighed*	*Mean Weight (lbs.)*	*Number Weighed*	*Mean Weight (lbs.)*	*Number Weighed*	*Mean Weight (lbs.)*	*Number Weighed*	*Mean Weight (lbs.)*	*Number Weighed*	*Mean Weight (lbs.)*	*Number Weighed*	*Mean Weight (lbs.)*
1951	....	.....	....	.....	....	.....	8,675	25.6	11,319	23.3	19,994	24.3
1952	....	.....	17,228	16.5	4,955	19.1	2,320	25.4	9,306	21.2	33,809	18.8
1953	1,049	22.6	15,701	17.4	9,825	16.2	8,761	24.8	8,549	21.4	43,885	19.5
1954	554	21.4	23,647	15.3	6,358	14.5	10,226	24.7	14,753	17.9	55,538	17.7
1955	673	20.8	46,129	14.8	12,916	15.0	14,356	21.1	18,221	18.2	92,295	16.5
1956	643	19.4	63,179	15.2	16,798	14.9	26,000	21.4	5,374	13.8	111,994	16.5
1957	65	20.8	9,594	14.5	730	17.2	174	22.6	1,930	14.1	12,493	14.7
1958	2,277	19.5	9,750	16.0	6,495	15.2	5,698	19.6	2,569	17.4	26,789	17.0
1959	2,475	20.2	8,288	15.5	15,106	13.7	10,004	20.2	1,471	17.7	37,344	16.5
1960	406	17.5	11,926	12.7	14,541	13.5	15,793	15.5	9	19.2	42,675	14.0
1961	1,632	18.9	10,409	15.3	11,944	14.7	5,691	18.9	101	13.8	29,777	15.9
Total	9,774	20.0	215,851	15.3	99,668	14.9	107,698	21.2	73,602	19.2	506,593	17.1

TABLE 2. **MEAN WEIGHTS, IN POUNDS, OF COLUMBIA RIVER CHINOOK SALMON BY ZONE AND SEASON, 1951–61.**

Season and Zone	*Year*										
	1951	*1952*	*1953*	*1954*	*1955*	*1956*	*1957*	*1958*	*1959*	*1960*	*1961*
Winter											
Zone											
1	......	......	23.2	22.6	21.6	19.6	20.8	19.4	21.0	17.4	18.7
2	......	......	21.3	20.6	20.0	19.5	......	19.3	19.7	18.1	19.0
3	......	......	......	......	22.7	17.5	......	21.2	20.5	14.7	20.0
4	......	......	22.3	......	......	......	......	20.6	20.6	......	......
5	......	......	......	......	......	......	......	......	......	......	......
6	......	......	......	......	......	......	......	......	......	......	......
Spring											
Zone											
1	......	......	19.0	16.8	16.0	16.0	17.8	16.9	15.9	13.7	17.1
2	......	15.9	18.4	15.4	14.9	14.6	14.8	14.5	15.1	13.1	15.3
3	......	16.8	16.1	15.1	15.3	15.4	14.5	15.9	14.4	12.8	15.2
4	......	16.6	16.7	15.1	15.0	14.8	14.0	16.3	16.4	12.1	14.0
5	......	16.4	17.1	17.0	16.1	16.8	13.2	16.2	15.8	11.7	......
6	......	17.9	......	12.8	14.1	13.3	......	14.7	......	......	......
Summer											
Zone											
1	......	24.8	18.8	16.4	16.1	17.7	18.3	16.1	13.8	12.9	14.1
2	......	18.0	12.2	14.0	14.2	15.5	17.3	15.5	14.4	13.3	13.6
3	......	19.3	17.0	15.6	17.8	15.1	16.3	16.8	13.6	13.3	15.3
4	......	20.3	14.9	13.0	13.8	14.5	17.3	15.0	12.7	13.8	15.4
5	......	19.4	15.6	11.3	12.5	14.0	17.5	11.6	11.2	13.8	15.6
6	......	18.2	......	12.2	......	10.9	......	......	......	......	......
Early Fall											
Zone											
1	25.6	26.7	25.5	26.7	22.5	22.4	22.6	19.9	20.9	20.6	21.2
2	......	22.1	27.1	22.5	20.1	21.6	......	17.3	20.1	14.2	15.1
3	......	23.9	22.8	17.9	20.0	20.7	......	19.9	18.5	9.8	12.6
4	......	24.3	23.6	21.2	18.9	16.6	......	16.9	17.9	10.3	12.4
5	......	......	26.1	......	16.0	15.7	......	......	18.9	......	9.5
6	......	......	......	......	12.8	9.1	......	......	......	......	......
Late Fall											
Zone											
1	21.5	21.9	21.4	18.7	18.9	12.7	16.2	18.5	20.6	19.2	13.8
2	22.4	18.8	18.3	18.0	18.1	13.5	14.0	17.3	17.3	......	......
3	22.6	21.8	22.5	19.1	18.6	15.5	13.8	18.8	18.0	......	......
4	22.9	22.2	19.8	16.1	20.0	16.7	13.4	16.3	16.8	......	......
5	25.0	......	22.9	22.3	22.6	17.2	15.1	16.1	......	......	......
6	......	19.9	21.0	12.1	15.4	12.6	......	......	......	......	......

TABLE 3. **ANALYSIS OF ZONAL MEAN WEIGHTS OF COLUMBIA RIVER CHINOOK SALMON FOR ALL SEASONS COMBINED AND EACH SEASON SEPARATELY.**

					Regression		*Residual*			
Season	*Sample Size (n)*	*SSx*	*SP*	*SSy*	*SS*	*DF*	*SS*	*DF*	*F*	*Conclusion*
Winter	25	22.960	—1.952	86.563	0.165	1	86.398	23	0.04	Not Significant
Spring	53	132.755	—31.569	125.974	7.507	1	118.467	51	3.32	Not Significant
Summer	53	125.472	—64.218	360.121	32.867	1	327.254	51	5.12	Significant
Early Fall ..	45	99.200	—172.966	1,037.032	301.585		735.447	43	17.6	Significant
Late Fall	50	134.020	—3.448	518.736	0.088	1	518.648	48	0.09	Not Significant
Combined	226	514.407	—274.153	2,128.426	146.109	1	1,786.214	216	17.7	Significant

$F_{.05}$ = 4.28 with 1 and 23 d.f.; 4.03 with 1 and 51 d.f.; 4.06 with 1 and 43 d.f.; 4.04 with 1 and 48 d.f.; 3.89 with 1 and 216 d.f.

by two types of gear—80% from gill nets and 20% from traps. When the mean weights were compared by analysis of variance no statistical significance was found in the difference in mean weight of the trap and gill-net catches in May, June, and July. The difference in August was statistically significant: the trap-caught chinook were smaller than the gill-net fish. When analysis of variance was applied to the combined data it was found that the trap-caught salmon were, on the average, significantly smaller than those taken in gill nets. Thus the inclusion of trap-caught salmon in the data tends to reduce the average-weight values over what they would have been if only gill-net landings were reported. Table 4 shows comparisons of the data presented by Chapman for the years 1918–40 and our data for 1951–61. For the latter period only data from Zone 1 have been included and all these salmon were captured by gill nets. In some cases, Chapman's data have been combined so that they correspond more closely to the seasons of recent years. Data for the winter season have been omitted since no comparable values were reported for the 1918–40 period. The May values of earlier years are compared with the spring season values of recent years. Chapman's data for June and July have been combined for comparison with data from the current summer season. August data given by Chapman are compared with the current early fall season, and September-November data of the earlier period are combined with the current late fall season. It is important to note that the data apply only to chinook salmon entering the commercial catch, and not to the run as a whole.

A comparison of the mean weight values obtained for the 1918–40 period with those for 1951–61 indicates that, on the average, significantly larger fish were landed during the earlier years. Summer, early fall, and late fall chinook landed during the period 1918–40 were significantly larger than those examined during the years 1951–61. No significant difference in mean weights existed during the spring season. Details of the analyses are provided in Table 5.

TABLE 4. **SEASONAL MEAN WEIGHTS OF CHINOOK SALMON, IN POUNDS, FROM ZONE 1 OBTAINED DURING THE TWO SAMPLING PERIODS 1918–40 AND 1951–61.**①

	1918–40		1951–61			1918–40		1951–61	
Season	*Year*	*Mean Weigh*	*Year*	*Mean Weight*	*Season*	*Year*	*Mean Weight*	*Year*	*Mean Weight*
Spring	1918	12.9	1951	......	Summer	1918	21.8	1951	......
(May)	1919	15.1	1952	......	(June-	1919	20.5	1952	24.8
	1920	20.5	1953	19.0	July)	1920	24.4	1953	18.8
	1921	20.2	1954	16.8		1921	26.4	1954	16.4
	1922	16.0	1955	16.0		1922	22.1	1955	16.1
	1923	15.5	1956	16.0		1923	24.8	1956	17.7
	1924	17.0	1957	17.8		1924	26.4	1957	18.3
	1925	20.3	1958	16.9		1925	27.8	1958	16.1
	1926	17.5	1959	15.9		1926	23.2	1959	13.8
	1927	16.2	1960	13.7		1927	24.6	1960	12.9
	1928	16.7	1961	17.1		1928	25.4	1961	14.1
	1929	20.9				1929	28.6		
	1930	21.1				1930	24.6		
	1931	17.4				1931	21.2		
	1932	17.1				1932	24.2		
	1933	17.6				1933	29.2		
	1934	27.2				1934	29.3		
	1935	27.6				1935	32.6		
	1936	21.3				1936	30.0		
	1937	16.6				1937	29.2		
	1938	17.2				1938	27.5		
	1939	18.5				1939	30.2		
	1940	15.2				1940	27.4		
Early Fall	1918	25.1	1951	25.6	Late Fall	1918	25.0	1951	21.5
(August)	1919	23.6	1952	26.7	(Sept.-	1919	20.3	1952	21.9
	1920	26.3	1953	25.5	Nov.)	1920	28.1	1953	21.4
	1921	28.2	1954	26.7		1921	......	1954	18.7
	1922	27.6	1955	22.5		1922	23.4	1955	18.9
	1923	27.2	1956	22.4		1923	......	1956	12.7
	1924	24.0	1957	22.6		1924	23.4	1957	16.2
	1925	27.9	1958	19.9		1925	22.3	1958	18.5
	1926	25.8	1959	20.9		1926	22.3	1959	20.6
	1927	24.4	1960	20.6		1927	21.8	1960	19.2
	1928	24.3	1961	21.2		1928	......	1961	13.8
	1929	23.5				1929	25.5		
	1930	25.9				1930	......		
	1931	26.8				1931	......		
	1932	25.6				1932	......		
	1933	26.4				1933	......		
	1934	26.0				1934	......		
	1935	29.6				1935	......		
	1936	26.5				1936	......		
	1937	28.2				1937	22.6		
	1938	25.5				1938	......		
	1939	28.0				1939	......		
	1940	......				1940	......		

① Data for the 1918–40 sampling period from Chapman (1940).

TABLE 5. **COMPARISON OF SEASONAL MEAN WEIGHTS OF CHINOOK SALMON FROM ZONE 1 OBTAINED DURING THE TWO SAMPLING PERIODS 1918–40 AND 1951–61.**

Season	*Variation Due to Sampling Period*	*DF*	*Variation Due to Error*	*DF*	*F*	*Conclusion*
Spring	24.009	1	9.877	30	2.4	Not Significant
Summer	596.063	1	10.700	31	55.7	Significant
Early Fall	68.422	1	3.909	31	17.5	Significant
Late Fall	129.858	1	7.333	19	17.7	Significant
Combined	577.009	1	17.713	117	32.6	Significant

$F_{.05}$ = 4.17 with 1 and 30 d.f.; 4.16 with 1 and 31 d.f.; 4.38 with 1 and 19 d.f.; 3.93 with 1 and 117 d.f.

Because it appears from the preceding discussion that the chinook salmon of the 1951–61 period were, on the average, significantly smaller than the 1918–40 fish, it was decided to examine the data to see if a significant trend could be detected in the mean weights of the 1951–61 fish. A significant decrease was found in the mean weights (Table 1) in the winter, summer, early fall, and late fall fish taken during the 11 years. Only the data from the spring season revealed no significant decrease. Details of the analysis are presented in Table 6.

SUMMARY

During the 11-year period 1951–61, 5,149 average-weight samples, involving some 507,000 chinook salmon, were obtained from the Columbia River gill-net fishery, constituting about 10% of the total chinook landings. These fish were collected from all six zones of the river and during the five fishing seasons—winter, spring, summer, early fall, and late fall.

The hypothesis that the average weight of fish entering the catch decreases from the lower to upper zones was tested. Regression coefficients obtained for each season revealed no significant slope for winter, spring, and late fall. However, significant slopes were associated with the summer and early fall seasons. For the combined data, there was a significant decrease in the weight of chinook entering the catch proceeding upriver.

Comparisons were made between the mean weight values obtained from Zone 1 during the period 1951–61 and those reported in the literature for the period 1918–40. Samples from the earlier period were significantly larger for all seasons except spring.

Examination of average weights of chinook salmon landed in the 1951–61 period for all seasons revealed a significant downward trend. It was found that a significant decrease was associated with the mean weights of winter, summer, early fall, and late fall fish. Only the data from the spring season revealed no significant decrease during the period.

TABLE 6. **ANALYSIS OF TRENDS ASSOCIATED WITH SEASONAL MEAN WEIGHTS OF CHINOOK SALMON LANDED DURING THE PERIOD 1951–61.**

Season	*Sample Size (n)*	*SSx*	*SP*	*SSy*	*Regression*		*Residual*		*F*	*Conclusion*
					SS	*DF*	*SS*	*DF*		
Winter	9	60.000	—27.600	17.976	12.696	1	5.280	7	16.8	Significant
Spring	10	82.500	—19.900	14.036	4.800	1	9.236	8	4.2	Not Significant
Summer	10	82.500	—29.800	25.820	10.764	1	15.056	8	5.7	Significant
Early Fall ..	11	110.000	—95.600	101.600	83.085	1	18.515	9	40.4	Significant
Late Fall	11	110.000	—71.700	102.320	46.735	1	55.585	9	7.6	Significant
Combined	51	451.922	—254.462	599.264	143.278	1	455.986	49	15.4	Significant

$F_{.05}$ = 5.59 with 1 and 7 d.f.; 5.32 with 1 and 8 d.f.; 5.12 with 1 and 9 d.f.; 4.04 with 1 and 49 d.f.

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Fecundity of Columbia River Chinook Salmon

JAMES L. GALBREATH
and
RICHARD L. RIDENHOUR①

INTRODUCTION

In 1959 the Oregon Fish Commission studied the fecundity of chinook salmon *(Oncorhynchus tshawytscha)* of the Columbia River. This information was collected to obtain a measure of potential productivity in order to relate escapement to future runs. It was also postulated that these data might be used to separate races of chinook by differences in fecundity, both within the Columbia and between this and other river systems. Samples were collected from Columbia River commercial catches throughout the main fishing seasons—spring, summer, and fall—to include the various runs or races of chinook in the river.

METHODS

Samples of ovaries were obtained from various fish processing plants in Astoria and Portland, Oregon. They were selected from two fish at every odd-inch fork-length interval (measured to the nearest lower inch) if available. The possibility of change in fecundity with time of migration through the river was monitored by obtaining samples from spring, summer, and fall runs. A total of 62 fish was sampled (Table 1). Scales were also taken from each fish for age determination.

The egg skeins were preserved in 10% formalin and subsequently transferred to 50% isopropyl alcohol in three gradual steps. Egg counts were recorded on a Veeder hand counter. Separate counts were made of "normal" and "abnormal" (noticeably small or off-colored) eggs, but only counts of normal eggs were used in the statistical analyses.

One skein of eggs from each of 7 fish was counted a second time and all were within 1% of the first counts. This was merely a check on the accuracy of the count; hence the first counts were used in the analyses.

TABLE 1. **EGG COUNTS OF OVARIES FROM 62 FEMALE CHINOOK SALMON TAKEN BY SAMPLING OF COLUMBIA RIVER GILL-NET FISHERY, MAY-AUGUST, 1959.**

Date	*Fork Length (Inches)*	*Age*	*Normal Eggs*	*Abnormal Eggs*
5/1	23	4_2	2,148	170
5/5	23	4_2	3,214	209
5/1	25	4_2	2,839	307
5/1	25	4_2	3,069	70
8/24	25	....	2,600	3
5/1	27	....	3,429	294
5/1	27	4_2	2,959	....
5/1	27	5_2	4,022	....
6/24	27	4_2	3,017	124
8/24	27	4_2	4,339	73

① Formerly Biologist, Oregon Fish Commission; now Assistant Professor of Fisheries, Humboldt State College, Arcata, California.

TABLE 1—Continued

Date	*Fork Length (Inches)*	*Age*	*Normal Eggs*	*Abnormal Eggs*
5/1	29	4_2	4,445	330
5/1	29	4_2	4,183	286
6/23	29	4_2	2,925	35
6/23	29	4_3	4,034	72
7/16	29	4_2	4,142	39
8/19	29	3_1	5,107	8
8/19	29	3_1	4,375	1
5/1	31	4_2	3,907	303
5/1	31	4_2	5,434	....
6/23	31	4_2	3,794	140
6/23	31	4_2	4,857	101
7/16	31	4_1	5,516	144
7/15	31	4_3	4,930	35
8/19	31	3_1	3,961	497
8/19	31	4_2	5,120	3
5/1	33	5_2	4,690	127
5/1	33	5_2	4,935	....
6/23	33	5_2	5,074	91
6/23	33	4_2	5,419	92
7/9	33	4_1	5,054	194
7/9	33	4_2	6,531	21
8/19	33	4_1	4,589	14
8/19	33	4_1	5,366	3
5/1	35	5_2	6,838	....
5/1	35	5_2	6,126	155
6/23	35	5_1	3,874	10
6/23	35	5_1	4,455	98
7/14	35	4_2	6,531	21
7/9	35	5_1	5,256	43
8/19	35	....	6,035	2
8/19	35	....	5,374	11
5/1	37	5_2	6,227	....
5/1	37	5_2	5,230	....
6/23	37	5_1	5,674	61
6/23	37	5_1	5,905	21
7/9	37	5_2	5,125	137
7/14	37	5_1	5,926	127
8/19	37	4_1	5,584	27
8/19	37	4_1	5,401	51
5/5	39	5_2	6,238	....
5/5	39	....	7,705	....
6/23	39	5_1	6,428	56
6/23	39	5_1	7,195	425
7/15	39	5_1	6,482	28
7/15	39	5_1	6,812	57
8/19	39	4_1	6,098	33
8/25	39	....	7,402	39
6/23	41	5_1	6,162	267
7/16	41	5_1	5,439	39
8/25	41	....	7,280	26
8/26	41	....	7,571	5
8/25	41	....	6,048	30

The length-fecundity relationships were determined by computing the regressions using fork length as the independent variable, *X*, and numbers of eggs as the dependent variable, *Y*, according to the techniques outlined by Snedecor (1959, p. 122). The general equation of the regression for these analyses was as follows:

$$\hat{Y} = a + bX$$

where $\hat{Y}$ = estimated number of eggs for a given fork length,

a = value of $\hat{Y}$ when $X = 0$,

b = increase in the numbers of eggs per inch increase in fork length, and

X = fork length.

The correlation coefficients, r, expressing the degree of relationship between length and fecundity were determined according to the procedures outlined by Snedecor (1959, p. 160). Also, r^2, the proportion of the variation in fecundity which can be attributed to changes in fork length, was computed. Various regressions and correlations were computed by season and age for the entire Columbia River sample, and then for the subsamples, as well as for the other river systems (Table 2). The length-fecundity regressions were then analysed for possible significant differences between age, season, and river system following the analysis of covariance procedures outlined by Snedecor (1959, p. 394).

RESULTS

Relation Between Size of Fish and Fecundity

Ricker (1932) stated that the relationship between the numbers of eggs and length of fish is curvilinear for the eastern char or brook trout *(Salvelinus fontinalis)*. However, Rounsefell (1957) and others have indicated that a straight line adequately describes this relationship in *Oncorhynchus*. Linear regression is much more frequently used than curvilinear regression, because it is much easier to calculate and use. The Columbia River data were tested for linearity following the procedures outlined by Li (1957, p. 295) prior to the analysis of covariance tests, and were found not to deviate significantly from linearity.

Fish taken over the entire period from May through August had a fork length range of 23 to 41 inches (odd intervals only) and a range in fecundity from 2,148 to 7,705 eggs. The mean was 33.3 inches and 5,090 eggs. It is noted that this mean is not from a random sample, but is from one where two fish were taken for each odd-inch interval. The length-fecundity relationship was computed as $\hat{Y} = -2{,}733 + 235X$ (Figure 1). The significant correlation coefficient, $r = 0.87$, indicated that 76% of the variation in egg count could be accounted for by the differences in length.

TABLE 2. **SUMMARY OF BASIC DATA FOR LENGTH-FECUNDITY RELATIONSHIPS OF CHINOOK SALMON.**

Sample Identification	*Sample Size*	*Length (Inches)*		*Egg Count*		*Linear Regression Equation (Y = a+bX)*	*Correlation Coefficient*	*Y Variation due to X Variation (%)*	*Significant Correlation Coefficients*	
		Mean	*Range*	*Mean*	*Range*				*5%*	*1%*
Columbia River										
Season										
April–May	19	30.8	23–29	4,613	2,148– 7,705	Y = —3,634+268X	0.92	85	0.46	0.58
June	14	34.0	27–41	4,915	3,017– 7,195	Y = —3,936+260X	0.86	74	0.53	0.66
July	12	35.0	29–41	5,588	4,142– 6,926	Y = 179+155X	0.65	42	0.58	0.71
August	17	34.3	25–41	5,424	2,600– 7,571	Y = —2,207+222X	0.88	77	0.48	0.61
Total	62	33.3	23–41	5,090	2,148– 7,705	Y = —2,733+235X	0.87	76	0.25	0.32
Age										
3_1	3	29.7	29–31	4,481	3,961– 5,107	Y = 15,597—374X	0.78	61	1.00	1.00
4_2	20	28.8	23–25	4,065	2,148– 6,531	Y = —4,504+297X	0.86	74	0.44	0.56
4_1	8	34.5	31–39	5,302	4,589– 6,098	Y = 1,747+103X	0.62	38	0.71	0.83
5_2	10	34.6	27–39	5,451	4,022– 6,838	Y = —694+177X	0.69	48	0.63	0.77
5_1	12	37.8	35–41	5,884	3,874– 7,195	Y = 4,248+268X	0.59	35	0.58	0.71
Total	53	32.8	23–41	4,940	2,148– 7,195	Y = —2,290+220X	0.84	71	0.27	0.35
Klamath River①	106	31.6	21–42	3,760	1,718– 8,406	Y = —1,860+178X	0.67	45	0.19	0.25
Sacramento River①	50	36.0	23–44	7,422	4,795–11,012	Y = 2,708+131X	0.39	15	0.28	0.36
Total all Rivers	218	33.1	21–44	4,980	2,148–11,012	Y = —4,490+286X				

① Data from McGregor (1922, 1923a and b).

Variation by Season

Length-fecundity regressions were computed and plotted by month and compared with the over-all regression (Table 2 and Figure 2). The summer season was separated into June and July as there is a progressive change in the nuclear scale patterns. These regressions had highly significant correlations with the exception of July which was still significant at less than $P = 0.05$. Comparison of the seasonal length-fecundity regressions was made by an analysis of covariance (Table 3). If we assume that the data represented random samples from normal populations with equal variance, the variation among the regression coefficients or the slopes was not significant ($F_{.05} = 1.34$ with 3 and 54 degrees of freedom). Since we must adjust for varying values of length, the seasonal differences were also examined by using the test of adjusted means, but the differences were again not significant ($F_{.05} = 1.65$ with 3 and 57 degrees of freedom). We may conclude that there was no significant difference in the length-fecundity relationships between the different seasons.

TABLE 3. **SUMMARY OF ANALYSES OF COVARIANCE OF LENGTH-FECUNDITY RELATIONSHIPS FOR CHINOOK SALMON.**

Analysis	*Computed F*	*Degrees of Freedom*	*Significant F Values 5%*	*1%*
Variation between seasons (Columbia River)				
Difference between regression coefficients	1.34	3 & 54	2.78	4.17
Difference between adjusted means	1.65	3 & 57	2.77	4.15
Variation between ages (Columbia River)				
Difference between regression coefficients	1.66	3 & 42	2.83	4.29
Difference between adjusted means	0.35	3 & 45	2.81	4.25
Variation between rivers (Columbia, Klamath, & Sacramento)				
Difference between regression coefficients	3.86①	2 & 212	3.04	4.71
Difference between adjusted means	147.20①	2 & 214	3.04	4.71

① Significant

Relation Between Age and Fecundity

Age of the samples was determined by examination of the scales under a microscope. Ages were designated according to the nomenclature established by Gilbert and Rich (1927). This consists of two figures with the second written as a subscript. The first figure indicates the year of life in which the fish was captured and the subscript the year it migrated from fresh water to the sea. Thus a 4_1 (sub one) migrated to the ocean in its first year and was captured in its fourth year. A 4_2 (sub two) left fresh water in its second year and returned in its fourth.

Ages could be assigned to 53 of the 62 fish. Of these, 3 were designated as being in their third year of life, 28 in their 4th year, and 22 in their 5th year. Because of the paucity of data on the 3-year fish, they were deleted from the statistical analysis of aged fish.

The length-fecundity regressions for age groups 4_2, 4_1, 5_2, and 5_1 were computed and plotted so that they might be compared with the over-all regression (Table 2 and Figure 3). The analysis of covariance test indicated no significant differences between slopes ($F_{.05} = 1.66$ with 3 and 42 degrees of freedom) or adjusted means ($F_{.05} = 0.35$ with 3 and 45 degrees of freedom) of the regressions for the different ages (Table 3).

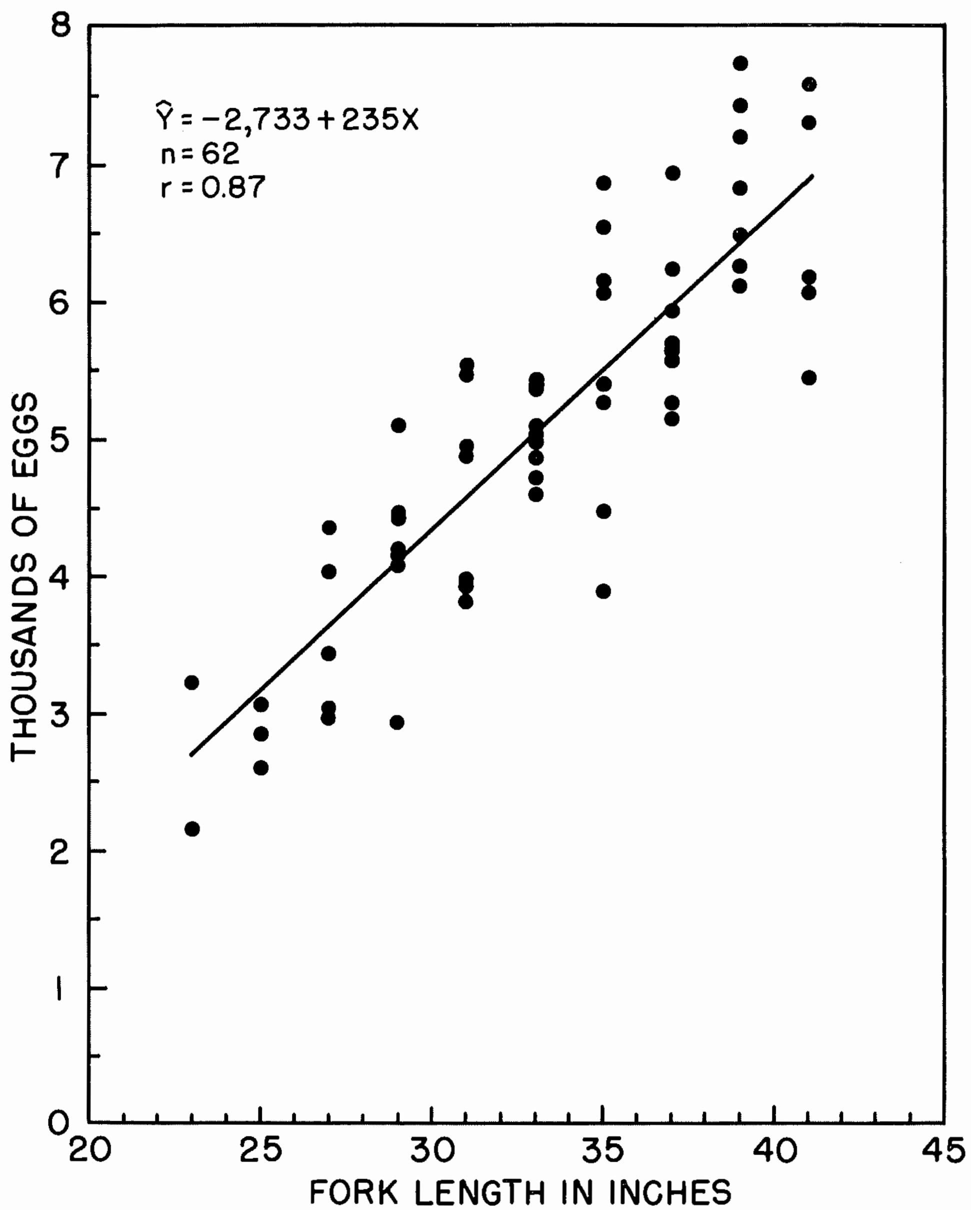

FIGURE 1. RELATION OF NUMBER OF EGGS TO BODY LENGTH FOR COLUMBIA RIVER CHINOOK SALMON.

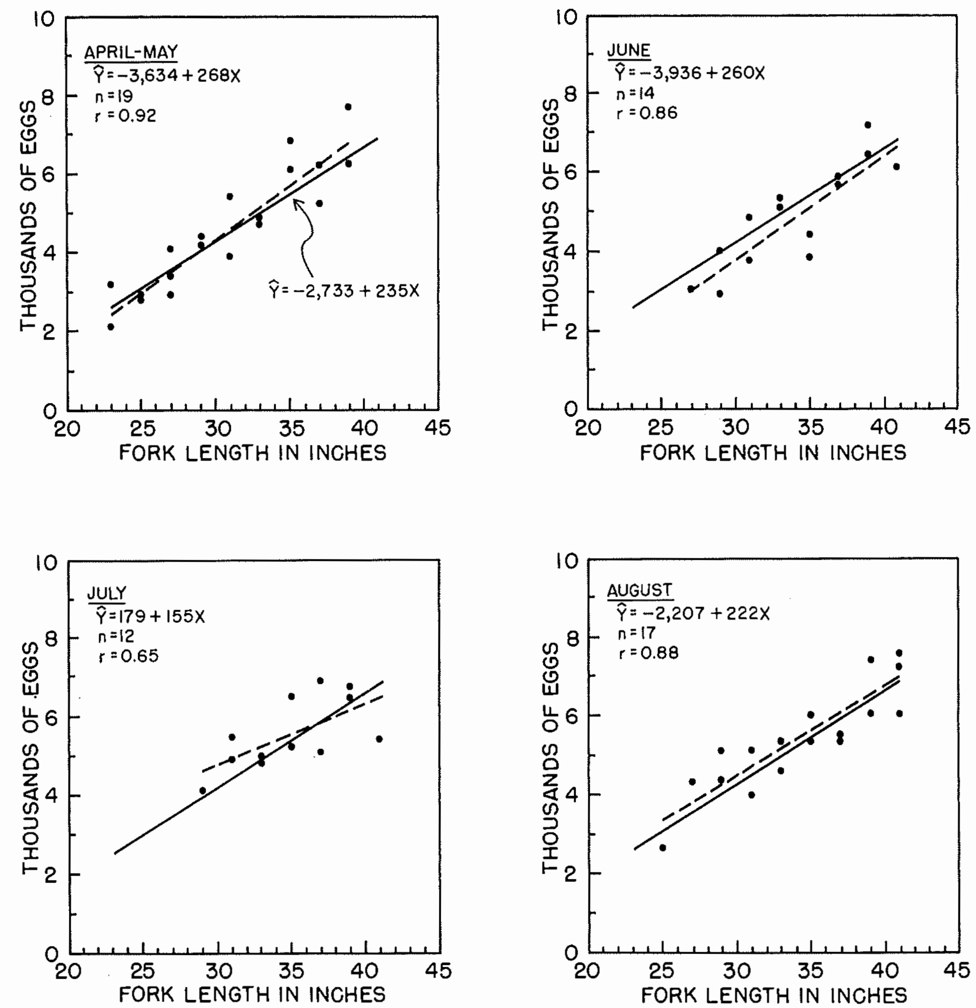

FIGURE 2. RELATION OF NUMBER OF EGGS TO BODY LENGTH FOR COLUMBIA RIVER CHINOOK SALMON BY SEASON. (SOLID LINE REPRESENTS COMBINED REGRESSION FOR ALL SEASONS AND DOTTED LINES THE INDIVIDUAL SEASONAL REGRESSIONS.)

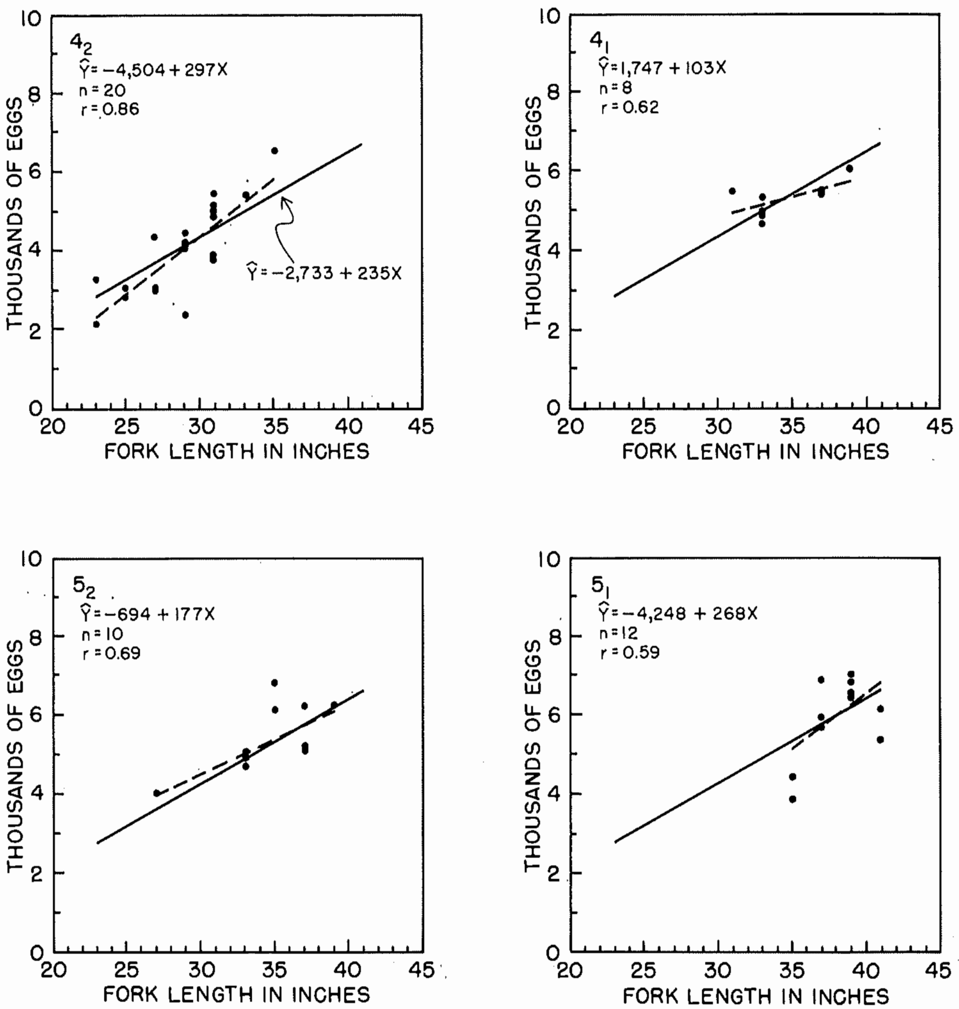

FIGURE 3. RELATION OF NUMBER OF EGGS TO BODY LENGTH FOR COLUMBIA RIVER CHINOOK SALMON BY AGE. (SOLID LINE REPRESENTS COMBINED REGRESSION FOR ALL AGES AND DOTTED LINES THE INDIVIDUAL AGE REGRESSIONS.)

For the convenience of those who might have occasion to use these data to compute potential egg deposition, etc., Table 4 is given. This table shows the calculated average number of eggs for each inch interval of length.

TABLE 4. **CALCULATED FECUNDITY OF COLUMBIA RIVER CHINOOK SALMON BY LENGTH AND SEASON.**

Fork Length (Inches)	*Season*				*Combined Seasons*
	April-May	*June*	*July*	*August*	
24	2,800	2,300	3,875	3,125	2,850
25	3,050	2,575	4,050	3,350	3,100
26	3,325	2,825	4,200	3,575	3,350
27	3,600	3,100	4,325	3,800	3,550
28	3,850	3,350	4,500	4,025	3,800
29	4,125	3,600	4,650	4,250	4,050
30	4,400	3,875	4,800	4,475	4,300
31	4,650	4,125	4,950	4,700	4,500
32	4,925	4,375	5,125	4,925	4,750
33	5,200	4,650	5,275	5,150	5,000
34	5,475	4,900	5,425	5,350	5,250
35	5,750	5,175	5,575	5,575	5,450
36	6,000	5,425	5,725	5,800	5,700
37	6,275	5,700	5,900	6,025	5,950
38	6,550	5,950	6,050	6,250	6,150
39	6,825	6,200	6,200	6,475	6,400
40	7,025	6,475	6,350	6,700	6,650
41	7,350	6,725	6,500	6,925	6,900
42	7,625	7,000	6,650	7,125	7,100

SEPARATION OF POPULATIONS

McGregor (1922 and 1923a) assigned ocean-caught salmon to the Klamath and Sacramento rivers by use of egg counts irrespective of length. Galbreath (1961) further substantiated this method in a study of the egg content of troll-caught chinook off San Francisco, California. Of 100 sample ovaries taken, only 4 contained less than the egg range for the Sacramento River established by McGregor (4,795–11,012).

Data collected in our study of the Columbia River was compared with published data from the Klamath and Sacramento rivers (Figure 4). Columbia River samples had a fecundity range of 2,148 to 7,705 eggs and a mean egg content of 5,090. Egg counts for the Klamath River ranged from 1,718 to 8,406 with a mean of 3,760 and for the Sacramento River, 4,795 to 11,012 with a mean of 7,422. An analysis of covariance test indicated a significant difference between the slopes ($F_{.05} = 3.86$ with 2 and 212 degrees of freedom) and a highly significant difference between the adjusted means ($F_{.05} = 147.20$ with 2 and 214 degrees of freedom) of the length-fecundity regressions for the three streams (Tables 2 and 3). Differences in sampling techniques could account for some of the differences between the relationships and also reduce their significance somewhat. Egg count techniques differed in that actual egg counts were made in the Columbia River study, whereas McGregor calculated number of eggs by weighing the ovaries, determining the number of ova per 10 grams, and calculating total number of eggs. Calculated numbers, however, are considered accurate enough for all practical purposes. Hartman and Conkle (1960) and Galbreath (1961) showed deviation of about 2% from actual egg counts.

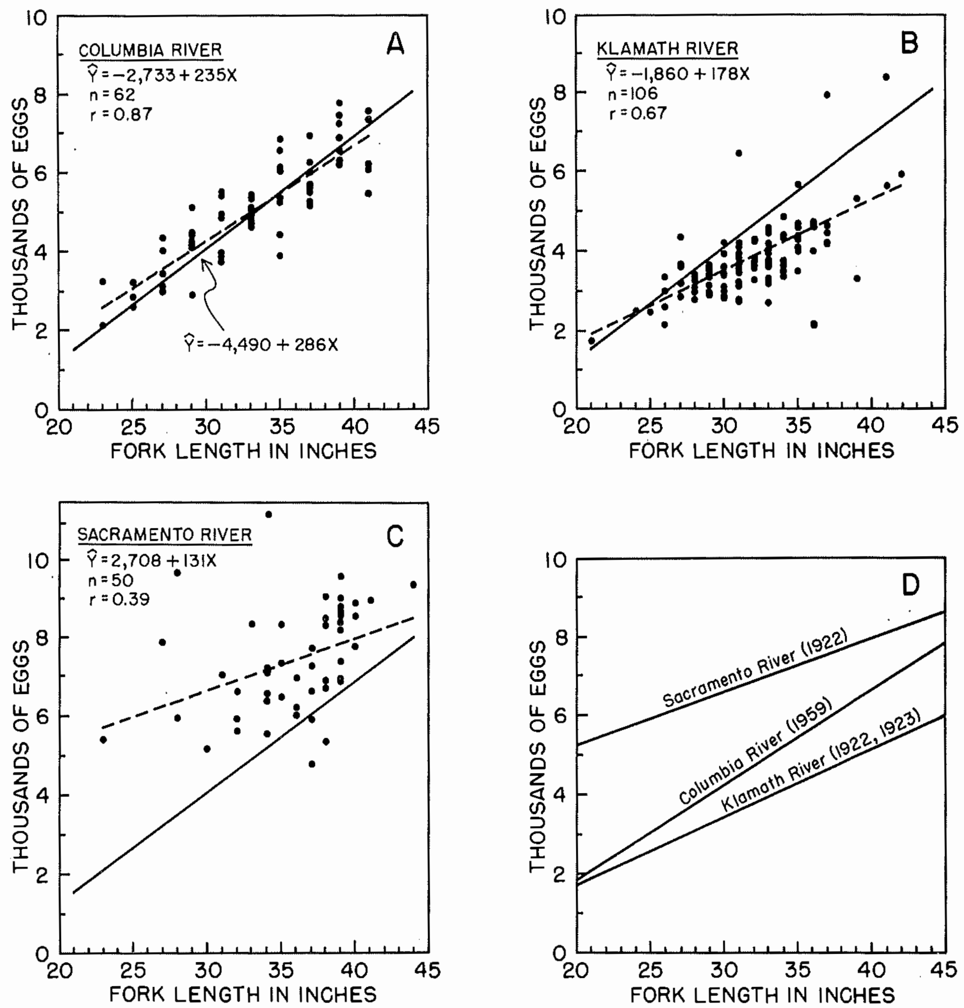

FIGURE 4. RELATION OF NUMBER OF EGGS TO BODY LENGTH FOR COLUMBIA, SACRAMENTO, AND KLAMATH RIVER CHINOOK SALMON. (SOLID LINE REPRESENTS THE COMBINED REGRESSION FOR THE THREE RIVERS AND DOTTED LINES THE INDIVIDUAL STREAM REGRESSIONS. GRAPH D SHOWS THE COMPARATIVE POSITIONS OF THE FECUNDITY REGRESSION LINES.)

It would appear that the significance of the differences between the length-fecundity regressions for these three rivers might permit assignment of some salmon in ocean catches south of the Columbia River to the proper stream of origin. However, because certain portions of the plotted data tend to overlap—smaller Columbia and Klamath river fish and larger Columbia and Sacramento river fish—assignment of the fish to the different rivers would be problematical. Also, the length-fecundity relationship of salmon from other streams is unknown and would confound the problem of separating salmon populations on this basis.

SUMMARY

Ovaries were collected from 62 female chinook salmon taken by commercial gill-net fishermen in the Columbia River including spring, summer, and fall runs. After preservation, the egg content of each ovary was determined by actual count. Analysis of the data involved the computation of an over-all length-fecundity regression line based on all samples, and investigation by analysis of covariance of the variability between seasons, age groups, and other river systems.

The number of eggs ranged from 2,148 for a 23-inch fish to 7,705 for a 41-inch fish with a mean of 5,090. The formula for the length-fecundity regression line was $\hat{Y} = -2{,}733 + 235X$, with a significant correlation coefficient of 0.87. This relationship did not deviate significantly from linearity, therefore it could be described as a straight-line relationship. Length-fecundity regressions from individual seasonal samples were computed as well as corresponding correlation coefficients, the values of which were all associated with significant probability levels. No significant differences were found between seasons.

Length-fecundity regressions were also computed for the four principal age groups in the sample. Tests indicated no significant differences between age groups. Since length is greatly influenced by time in the ocean, and fecundity is a function of length, fish of the same total age but with different periods of ocean life had different levels of fecundity.

A comparison was made between data collected in this study and data for the Klamath and Sacramento rivers. Klamath and Sacramento River samples had a fecundity range of 1,718–8,406 and 4,795–11,012, respectively, with means of 3,760 and 7,422. Analysis of covariance indicated a significant difference between the length-fecundity regressions for the three streams.

The length-fecundity relationship of Columbia River chinook was demonstrated to lie between that of the Klamath and Sacramento rivers. This suggested that some chinook races in the ocean catches could be separated in this manner. However, this method of racial identification cannot be considered reliable since overlapping in the length-fecundity relationship occurs, and does not consider other streams which have chinook populations.

ACKNOWLEDGMENTS

Thanks are due to George Hirschhorn, Wayne A. Burck, Robert B. Herrmann, Donald Amend, Bernie Carter, and Paul Knaupp, members of the research staff of the Oregon Fish Commission in 1959, who were involved in the collection of ovaries, compilation of data, and the tedium of egg counting.

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The Effect of Confinement on Blood Lactate Levels in Chinook and Coho Salmon

ROBERT J. ELLIS[1]

INTRODUCTION

Present regulations in Oregon require that commercial trollers release chinook salmon *(Oncorhynchus tshawytscha)* less than 26 inches in total length and all coho salmon *(O. kisutch)* caught before June 15. Other areas have the same or similar regulations. Many thousands of small salmon are caught and released by the Pacific Coast troll fleet each season. In addition, the ocean sport fisheries are subject to various minimum size limits, and numbers of small salmon are released by this fishery. The rate of survival of released fish is unknown. They are thought to be subject to two types of mortality due to being hooked: the first, observable when the fish is landed, is due to drowning or severe tissue damage and bleeding; the second, not observable when the fish is landed, is due to fatigue and accumulation of lactic acid in the body while struggling on the hook—a delayed mortality.

The results of several field experiments indicate that a significant percent of troll-caught salmon released in apparently good condition will die, presumably from fatigue products accumulated while struggling on the hook (Milne and Ball, 1956; Parker and Black, 1959; and Parker, Black, and Larkin, 1959). There is also evidence from laboratory work (Black, Fry, and Scott, 1939; Black and Barrett, 1957; and McFarland, 1959) that experimental conditions, i.e. unnatural handling and confinement, contribute additional stress which may be a factor in the high mortalities observed in the field experiments.

The two major objectives of this study were: (1) to obtain additional data on fatigue mortality in troll-caught salmon held in live tanks; and (2) to measure the effects of holding salmon in live tanks—an attempt to separate the mortalities from holding from those of hooking. The first objective was to be accomplished by holding the salmon in live tanks and measuring the blood levels of fatigue products (lactic acid) after various time intervals. The second was to be accomplished by comparing the mortalities and blood levels of fatigue products in salmon held in normal sea water with those held in sea water with tranquilizer added to reduce the psychological stress of holding.

METHODS

Experimental fish were caught by a commercial troller at sea off the Oregon coast during the summers of 1958 and 1959 and held in live tanks aboard the boat. Sub-legal chinook and small coho salmon, boated in good condition, were placed immediately in a strong anesthetic solution to aid in removing them from the hook and reduce handling stress. The anes-

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thetic used, MS 222 (tricaine methanesulfonate) at a concentration of 1:5,000 in sea water, generally inactivated the fish in about 60 seconds.

Mature male coho salmon in fresh water also were used as experimental subjects because of insufficient numbers of troll-caught salmon. They were mostly "jacks" or precocious males that matured at 2 years of age instead of the usual 3. These fish had been intercepted in their spawning migration and had been confined in running water in holding pens for periods of several hours to several days at the Oregon Fish Commission Klaskanine and Nehalem hatcheries. All were subjected to stress when hatchery personnel removed other fish for spawning and again when netted for use in these experiments. All fish struggled strenuously when netted, during the minute or so of transport to the area of the holding tanks, and briefly in the anesthetic.

The holding tanks were a 110-gallon wooden barrel and a rectangular plywood box of 85-gallon capacity. One tank contained water only and the other water with tranquilizer. Troll-caught fish were held in sea water, either with or without tranquilizer, and the fish used at the hatcheries were held in fresh water, either with or without tranquilizer. Consecutive fish were alternated in the two tanks, and the tanks were alternated between days as to whether they contained water with or without tranquilizing solution. Water was not circulated or changed during a holding period.

A concentration of MS 222 of 1:150,000 was used as a tranquilizer in both salt and fresh water. This dosage was selected after trying higher and lower concentrations and observing the reaction of the fish. The tranquilized state attained in this study is comparable to Stage I, plane 1 to 2, level of anesthesia delineated by McFarland (1959): the fish retain their equilibrium but do not react strongly to external stimuli. As McFarland observed, there was considerable variation in susceptibility.

Blood samples were taken from some fish prior to holding in live tanks, from others after they had been held, and from others both before and after holding. The blood was removed with a syringe and needle either from the dorsal aorta in the mouth if the anesthetized fish was to be blood sampled again, or from the heart through the ventral body wall.

The blood sample was expelled from the syringe into a small glass vial. A 1-milliliter aliquot was removed from the vial with a pipet and placed in a polyethylene bottle to be deproteinized with 10% trichloroacetic acid. The further processing of the sample and the analysis followed the procedures outlined by Hawk, Oser, and Summerson (1954).

Possible harmful effects of blood sampling before the fish are placed in holding tanks must be considered. The volume of blood removed was never more than 2 milliliters and usually about 1.2 milliliters. In trout the blood volume is about 3% of body weight (Schiffman and Fromm, 1959). Schiffman (1959) suggests that reductions in blood volume should not exceed 25% of the total. A 2-milliliter sample of blood represents about 5.0% of the estimated total blood volume (about 40 milliliters) of a 17- to 20-inch coho salmon. The loss of effective hemoglobin was usually increased slightly by an internal hemorrhage and blood clot in the vicinity of the needle puncture. Occasionally there was a slight external loss of blood from the puncture.

RESULTS

Due to poor troll-fishing conditions and the pressure of other duties, only 9 blood samples were obtained from troll-caught salmon in 1958 and 4 in 1959. Of these, 2 were from chinook and 1 from coho salmon when boated, 3 from chinook and 1 from a coho held in plain sea water, and 6 from chinook held in sea water with tranquilizer.

By October 1958, insufficient numbers of troll-caught fish had been obtained for comparison of the effects of holding tranquilized and non-tranquilized fish and the experiments were continued on sexually mature male coho salmon entering Oregon Fish Commission hatcheries. Use of mature fish at the hatcheries was repeated in 1959.

The muscular effort involved in struggling on the hook is assumed to be the primary cause of the original build-up of blood lactate in troll-caught fish. Therefore, blood lactate concentrations should be similar in both tranquilized and non-tranquilized troll-caught salmon during at least the early phases of confinement. If the stress of confining exercised salmon in live tanks contributes significant quantities of lactic acid to the blood and the tranquilizer decreases the stress of confinement, it follows that: (1) the blood lactate concentrations will decline in the tranquilized fish after the original high concentrations of fatigue products in the muscle have been removed and dissipated; and (2) the blood lactate concentrations in the non-tranquilized fish will not decline as fast as in the tranquilized fish and may even increase due to the additional psychological stress of confinement. This high level of blood lactate will continue until readily available stores of energy are exhausted or the rate of disposal of lactic acid exceeds the rate of production long enough to eliminate the lactic acid resulting from the pre-holding exercise. This is one explanation for the differences in blood lactate concentrations recorded in Table 1 for troll-caught chinook salmon held in tranquilizer (from the present study) and in

TABLE 1. **CONCENTRATIONS OF BLOOD LACTIC ACID IN TROLL-CAUGHT CHINOOK SALMON AFTER HOLDING IN SEA WATER WITH AND WITHOUT TRANQUILIZER.**

	*Held With Tranquilizer*①			*Held Without Tranquilizer*②		
Time Held (Hours)	*Number of Fish*	*Blood Lactic Acid Milligrams %*		*Number of Fish*	*Blood Lactic Acid Milligrams %*	
		Range	*Mean*		*Range*	*Mean*
0	2	54.8–55.5	55.2	6	38.8–101.0	64.6
0.6–1.0	1	....	116.5	6	9.6–240.0	120.1
1.1–1.5	1	....	143.5	8	108.0–202.0	150.1
1.6–2.0	2	63.1–73.2	68.2	10	83.2–220.0	163.1
2.1–2.5	....	....	......	7	125.0–216.0	177.9
2.6–3.0	1	....	59.8	5	134.0–226.0	185.6
3.1–3.5	....	....	......	5	87.3–216.0	171.5
3.6–4.0	....	....	......	2	182.0–209.0	195.5
4.1–4.5	1	....	100.2	3	136.0–186.0	157.7
4.6–5.0	....	....	......	1	....	160.0

① MS 222 at 1:150,000.
② From Parker and Black (1959), page 99, fish held in circulating sea water.

normal sea water (from Parker and Black, 1959). Blood lactate levels were essentially the same in the two groups of fish through the first 1.5 hours of holding. From that time on, fish held in a tranquilizing solution had blood lactate levels well below non-tranquilized fish. Parker *et al.* (1959) indicated that the development of blood lactate is similar in troll-caught chinook and coho salmon.

Levels of lactic acid in the blood of sexually mature, male coho salmon, held in fresh water in live tanks, with and without tranquilizer, are summarized in Table 2 (1958 and 1959 data combined). These data show the commonly observed wide range in blood lactate levels among fish which have received the same treatment. The average lactate levels for the two groups—those held with and without tranquilizer—were initially nearly equal (blood samples taken before holding). Subsequent blood lactate concentrations, however, were quite different. The concentrations in untranquilized fish increased during the first holding period (up to 1.5 hours) then slowly declined until the 3.6- to 4.5-hour period when they were slightly below the pre-holding level. Fish held in water with tranquilizer did not show an increase in blood lactate during the first holding period, but rather a general decline from pre-confinement to 4.5 hours of holding.

TABLE 2. **CONCENTRATIONS OF BLOOD LACTIC ACID IN COHO SALMON HELD WITH AND WITHOUT TRANQUILIZER AT KLASKANINE AND NEHALEM HATCHERIES.**

	Held With Tranquilizer			*Held Without Tranquilizer*		
Time Held (Hours)	*Number of Fish*	*Blood Lactic Acid Milligrams %*		*Number of Fish*	*Blood Lactic Acid Milligrams %*	
		Range	*Mean*		*Range*	*Mean*
0	11	20.6–71.0	37.4	9	23.0–71.5	36.5
0.6–1.5	3	11.6–58.1	34.0	4	40.7–62.1	51.2
1.6–2.5	6	20.0–60.1	36.5	8	15.7–71.5	40.1
2.6–3.5	10	13.0–48.2	24.0	8	19.3–71.8	41.8
3.6–4.5	3	3.9–26.7	17.9	3	13.5–54.5	31.0

The mean lactate concentrations present in the mature coho salmon after holding were compared statistically with a "t" test (Dixon and Massey, 1951) for: (1) all tranquilized versus all non-tranquilized fish; and (2) all fish in each time period held with tranquilizer versus those held without tranquilizer. The results of these tests indicated that the mean blood lactate level of all tranquilized fish, as a group, was significantly lower than for the non-tranquilized group. However, except for the fish held 2.6–3.5 hours no difference could be demonstrated between mean blood lactate levels of the 2 groups of fish in each time period. The salmon held for 2.6–3.5 hours in tranquilizer had a mean blood lactate level significantly lower than the comparable non-tranquilized group. The tranquilized group had blood lactate levels that were 102% of the non-tranquilized fish before holding, but in subsequent periods of holding they dropped to 66.4 (1 hour), 91.0 (2 hours), 57.4 (3 hours), and 57.7% (4 hours) of the levels of comparable non-tranquilized groups. However, the fact that the tranquilized fish had a significantly lower lactate level as a group and consistently (though not always statistically significant) lower levels within each holding period indicates that the tranquilizer was effective.

This pattern of blood lactate development in mature coho salmon held in tanks in fresh water in the present study is very similar to that found by Parker *et al.* (1959) for comparable fish and holding conditions. However, the concentrations in the present study were 34 to 80% higher than they found. The work of Miller, Sinclair, and Hochachka (1959) and Black and Barrett (1957) indicates that the necessary fuel for muscular activity and lactic acid production (blood, muscle, and liver glycogen) may be exhausted by prolonged exercise, and that from several hours to a week may be required to recover from vigorous activity. The consistently lower levels reported by Parker *et al.* (1959) probably occurred because their fish were generally used within 2 or 3 minutes of the time they were captured with a fish wheel. In contrast to these actively migrating fish, the subjects of the present experiment were confined to hatchery ponds for periods ranging from several hours to several days before use.

DISCUSSION

Parker *et al.* (1959) found a large difference in magnitude, but a similar pattern of development, of blood lactate levels between immature ocean-caught and mature river-caught coho salmon during holding without sedation. They suggest that this difference may be due to two factors: (1) the actively feeding, immature troll-caught fish may normally be close to oxygen distress because of low oxygen solubility in the sea water and high oxygen requirements associated with the assimilation of food; (2) the immature feeding fish in the ocean have comparatively more readily available glycogen reserves for muscular effort than the mature salmon in freshwater.

The theories of Parker *et al.* (1959) would serve to explain the difference observed here in the pattern of blood lactate development in tranquilized ocean-caught chinook salmon and mature coho salmon in fresh water. The mature coho salmon held in tranquilizer did not show an increase in mean blood lactate over pre-holding levels while a two- to three-fold increase did occur in the troll-caught chinook held in tranquilizer. The greater quantities of blood lactate in the ocean-caught fish might be due to a combination of the factors suggested by Parker *et al.* (1959). The stress of confinement was apparently reduced by the use of a tranquilizer in both groups but the mature fish held in tranquilizer were able to dispose of the relatively small amounts of lactic acid resulting from the pre-holding stress at about the same rate as it moved into the blood while in the ocean-dwelling fish this was not the case.

Parker *et al.* (1959) suggest that actively migrating mature salmon use the stored energy of fat and protein as fast as it becomes available. Comparison of their data on blood lactate concentrations with data from comparable fish in the present report (mature coho salmon held in fresh water without tranquilizer) indicates, however, that migrating fish may be able to accumulate some of this energy in readily available form if given an opportunity to rest. They exercised mature salmon almost immediately after they were captured in a fish wheel while comparable fish of the present study had been confined to holding pens for at least several hours before experimental use. The average blood lactate concentrations found in the mature coho salmon in this study were about 80% higher than comparable fish of Parker's work immediately following exercise and 38, 34, 60, and 55% higher after holding for 1, 2, 3, and 4 hours. These higher blood lactate levels could be the result of larger quantities of immediately available energy during the experimental period. Thus it appears that mature salmon in fresh water may be able to accumulate some readily available energy if given an opportunity to rest.

A quantitative study of the liver and muscle glycogen in actively feeding ocean-dwelling salmon and sexually mature salmon when migrating and after periods of rest could supply answers to many of the questions regarding fatigue and energy stores in these fish.

CONCLUSIONS

The holding of fish in live tanks may contribute materially to high blood lactate concentrations. Use of unnatural confinement in the assessment of fatigue as a cause of mortality in troll-caught salmon should take into account the possible additional stress of such confinement. It is probable that although actively migrating salmon in fresh water may use the carbohydrate from transformation of body fat and protein as fast as it becomes available they are able to accumulate some stores if given an opportunity to rest.

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Ranking of Wet Ingredients for Oregon Pellets[1]

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INTRODUCTION

Oregon pellets have been fed at Oregon Fish Commission hatcheries since 1959 and their use has spread to other agencies rearing Pacific salmon (Hublou, 1963). The diet is presently composed of 60% dry meals and 40% wet-fish products. Albacore tuna viscera *(Thunnus alalunga)* together with either arrowtooth flounder (turbot, *Atheresthes stomias)* or salmon viscera *(Oncorhynchus* sp.), each comprising 20% of the complete diet, have been successful as the wet component. Past formulations have included tuna liver and beef liver, which were nutritionally successful but expensive (Hublou *et al.*, 1959). Drum-dried dogfish *(Squalus acanthias)* meal was tried and produced good growth in laboratory tests (Hublou *et al.*, 1963); however, the presence of high levels of urea and vitamin A has been responsible for a cautious approach toward use of dogfish as a wet ingredient in the Oregon pellet.

A study was conducted at the Clackamas Laboratory of the Oregon Fish Commission to evaluate and compare the nutritional quality of tuna viscera, turbot, dogfish, and salmon viscera when fed to fingerling chinook salmon *(O. tshawytscha)* as the wet-fish portion of Oregon pellets.

MATERIALS AND METHODS

The experiment lasted for 24 weeks, August 7, 1962 to January 23, 1963, using replicate lots of 400 spring chinook salmon averaging 2 grams (224 per pound) initially. Lots were kept in 6-foot circular tanks supplied with 50–58° F. spring water at about 4 gallons per minute.

Test diets (Tables 1 and 2) were compounded at the Astoria Seafoods Laboratory. Formulation of the control diet was identical to the 1962 production Oregon pellet and contained equal parts tuna viscera and turbot as wet-fish ingredients. In the test diets, wet-fish ingredients were tested individually as 40% of the total diet. Dogfish was tested both whole and without livers because of concern about hypervitaminosis A. Salmon viscera was pasteurized according to the standard practice of the Oregon Fish Commission in order to minimize the transmission of disease. Fish were fed on a timed appetite basis; that is, all the food they would readily consume in a certain time period. Frequency of feeding and size of pellets closely approximated the recommendations of the 1962 Oregon pellet feeding chart.

RESULTS AND DISCUSSION

We evaluated the results (Table 3) statistically by analysis of variance

[1] Technical Paper No. 1872, Oregon Agricultural Experiment Station.

and ranking with Duncan's New Multiple Range Test at the 5% level of significance, combining replicate lots for tabulation.

Average fish weight gains from tuna viscera, whole dogfish, or dogfish without livers were not significantly different. Each of these diets produced greater gains in weight than turbot or salmon viscera. Position of the control diet was not clearly defined; however, it appeared to lie between the two groups. Average fish weights during the course of experimentation are presented in Figure 1. Tuna viscera produced the heaviest fish during much of the period, while dogfish lagged behind in weight gain until the fish averaged about 9 grams in November.

Tuna viscera and dogfish produced fish of significantly greater length than did diets of turbot or salmon viscera (Table 3). Position of dogfish without livers and the control was not clearly defined, although these groups were somewhat shorter than those fed the tuna viscera diet.

TABLE 1. **OREGON PELLET FORMULAS.**

Ingredient	*Per Cent of Total*
Dry Mix	
Cottonseed oil meal	23.0
Herring meal	21.0
Shrimp solubles①	6.0
Wheat germ meal	3.6
Distillers dried corn solubles	2.4
Vitamin premix (Hublou, 1963)	1.5
Wet Mix	
Corn oil	1.8
Choline chloride (liquid, 70% product)	0.65
Antioxidant (Tenox IV)	0.05
Diet 1 Control: Turbot	20.0
Tuna viscera	20.0
Diet 2 Tuna viscera	40.0
Diet 3 Turbot	40.0
Diet 4 Dogfish, whole	40.0
Diet 5 Dogfish, without livers	40.0
Diet 6 Salmon viscera, pasteurized	40.0

① Made from equal parts shrimp meal and condensed fish solubles, dried together.

Hemoglobin and hematocrit differences among test groups were not significant and the values do not indicate anemia.

Mortality during the test was negligible. The losses are not considered excessive and may have been caused by handling during weighing and tank cleaning operations.

Whole dogfish was converted to fish weight (food conversion) more efficiently than were the other diets. When diet efficiency expressed as calories needed to produce 100 grams of fish weight was compared, salmon viscera and dogfish without livers were superior to tuna viscera and the control. Whole dogfish and turbot ranked between those two groups.

TABLE 2. **AVERAGE PROXIMATE ANALYSIS (PER CENT) OF EXPERIMENTAL DIETS.**

Diet Description	*Moisture*	*Fat*	*Protein*	*Carbo-hydrate*	*Ash*	*Calories per 100 Grams of Diet*①
Control	34.2	6.8	37.6	14.3	7.1	224
Tuna viscera	33.8	7.1	38.1	14.6	6.4	229
Turbot	35.8	7.1	36.4	13.8	6.9	221
Dogfish, whole	32.3	11.1	37.1	12.9	6.6	254
Dogfish, without livers	34.4	7.8	37.9	13.1	6.8	231
Salmon viscera, pasteurized	35.8	6.2	37.1	14.2	6.7	217

① Digestible calories per 100 grams wet diet were estimated by using 8.0 calories per gram of fat, 3.9 for protein, and 1.6 for carbohydrate (Phillips and Brockway, 1959).

TABLE 3. **SUMMARY OF RESULTS.**

Diet Description	*Average Weight Gain (Grams)*	*Fork Length (Milli-meters)*	*Hemoglobin (Gms/100 ml)*	*Hematocrit (%)*	*Mortality (%)*	*Food Conversion (Dry Weight)*	*Calories per 100 Grams Weight Gain*
Control	13.6	111	10.5	42	1.0	1.19	406
Tuna viscera	14.8	113	11.4	43	1.5	1.16	402
Turbot	13.3	109	10.3	40	1.5	1.14	392
Dogfish, whole	14.2	112	10.6	42	0.8	1.04	391
Dogfish, without livers	14.2	110	10.1	38	1.0	1.09	384
Salmon viscera, pasteurized	13.4	109	9.8	41	0.5	1.12	376

Proximate analyses of test fish are summarized in Table 4. Fish fed the whole dogfish diet contained less moisture and more fat than those fed the other diets, while those fed dogfish without livers, salmon viscera, and turbot were intermediate in fat content. There were no significant differences in protein or ash content among groups.

TABLE 4. **AVERAGE PROXIMATE ANALYSIS (PER CENT) OF FISH CARCASSES.**①

Diet Description	*Moisture*	*Fat*	*Protein*	*Carbohydrate*	*Ash*
Control	75.3	5.8	16.4	0.3	2.2
Tuna viscera	75.0	4.6	16.8	1.4	2.2
Turbot	74.8	5.4	16.6	0.9	2.3
Dogfish, whole	73.6	7.2	16.5	0.5	2.2
Dogfish, without livers	74.2	6.4	16.7	0.5	2.2
Salmon viscera, pasteurized	75.0	4.6	16.8	1.3	2.3

① From samples of 10 fish per diet taken at termination of experiment.

A comparative summary of ranking analyses is presented in Table 5. Criteria were limited to weight gain, length, conversion, and caloric efficiency—measurements that had significant differences. A plus signifies that the diet at the top of the table produced a significantly better result than the diet on the left; a minus indicates a significantly inferior result; a zero means the difference was not significant. One point was given for each superior result and subtracted for an inferior, producing a numerical total for each criterion and final score for comparison of diets.

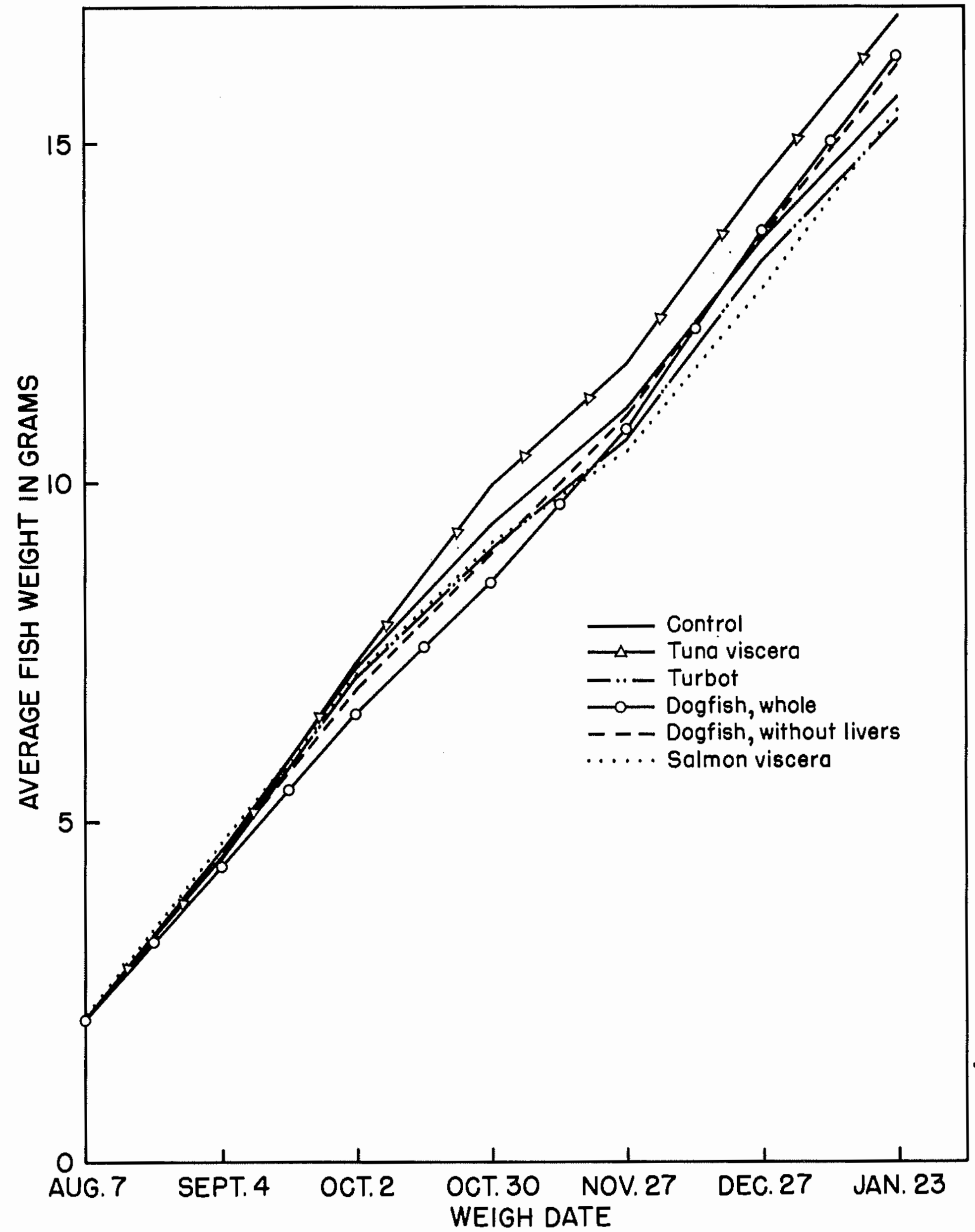

FIGURE 1. AVERAGE FISH WEIGHT.

TABLE 5. **COMPARATIVE SUMMARY OF RANKING.**

Diet Description	*Dogfish, whole* ① W.	② L.	③ Fc.	④ C.	*Dogfish, without livers* W.	L.	Fc.	C.	*Tuna viscera* W.	L.	Fc.	C.	*Salmon viscera* W.	L.	Fc.	C.	*Turbot* W.	L.	Fc.	C.	*Control* W.	L.	Fc.	C.
Control	0	0	+	0	0	0	+	+	+	+	0	0	0	0	+	+	0	0	+	+	----	----	----	----
Tuna viscera	0	0	+	0	0	—	+	+	----	----	----	----	—	—	0	+	—	—	0	0	—	—	0	0
Turbot	+	+	+	0	+	0	+	0	+	+	0	0	0	0	0	—	----	----	----	----	0	0	—	—
Dogfish, whole	----	----	----	----	0	0	+	0	0	0	—	0	—	—	—	+	—	—	—	0	0	0	—	0
Dogfish, without livers	0	0	+	0	----	----	----	----	0	+	—	—	—	0	0	0	—	0	—	0	0	0	—	—
Salmon viscera	+	+	+	—	+	0	0	0	+	+	—	—	----	----	----	----	0	0	0	+	0	0	—	—
Total	2	2	5	—1	2	—1	4	2	3	4	—3	—2	—3	—2	0	2	—3	—2	—1	2	—1	—1	—4	—3
Score		8				7				2				—3				—4				—9		

① Average weight gain (grams).
② Average fork length (millimeters).
③ Food conversion (dry weight).
④ Calories per 100 gram weight gain.

This method of ranking indicated that dogfish was superior to the other ingredients in spite of an apparent growth lag early in the experiment associated with less feeding enthusiasm. Food conversion of the dogfish diet was particularly good throughout the experiment, including the period of growth lag. High caloric content of this diet may have influenced appetite response, or the quality of dogfish may have varied. No problem appeared from vitamin A, and therefore no advantage was realized by removing the dogfish livers.

Tuna viscera produced excellent growth, perhaps because of its apparent taste appeal and relatively large quantity consumed, but was weak in diet efficiency. Salmon viscera, turbot, and control diets gave satisfactory results but did not equal dogfish or tuna viscera in the overall comparison.

SUMMARY AND CONCLUSIONS

Tuna viscera, arrowtooth flounder (turbot), whole dogfish, dogfish without livers, and pasteurized salmon viscera were fed for 24 weeks to fingerling chinook salmon as wet components of the Oregon pellet. Good results were produced by all five ingredients. Dogfish and tuna viscera rated especially well. No advantage was realized by removing the livers from dogfish.

An early growth lag was noted in fish fed dogfish. This lag, which continued until the fish approximated 9 grams (50 per pound) in size, did not seem to be due to a diet deficiency because the fish converted their food exceptionally well but may have been caused by unpalatability to the very young salmon.

ACKNOWLEDGMENTS

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Experiments With Repeated Spawning Ground Counts of Coho Salmon in Three Oregon Streams[1]

RAYMOND A. WILLIS

INTRODUCTION

Surveys of spawning coho salmon *(Oncorhynchus kisutch)* have been conducted for many years to obtain indices of the abundance of mature fish returning from the ocean. Unit (standard) areas, established 10 years ago in certain Oregon tributaries of the lower Columbia River, have been surveyed each year, some several times a year. Prior to 1959, the total lineal distance of the unit surveys was 42 miles. Since 1959, the surveys have been reduced to 6.1 miles. Coho salmon usually mature at 3 years of age when they are approximately 21–36 inches in length and are often accompanied by 2-year-old jacks (16–20 inches in length).

To secure information on the validity of spawning ground counts under ideal conditions, the Milton, Sierkes, and Trestle Creek units (Figure 1)

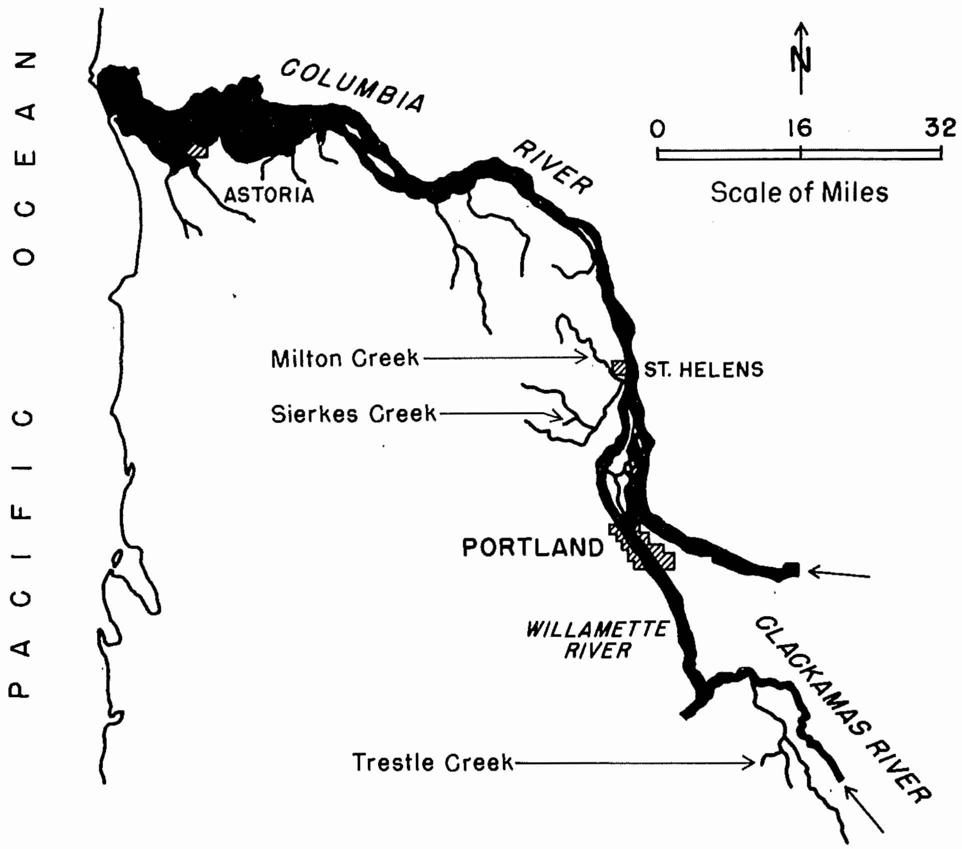

FIGURE 1. LOCATION OF THE STREAMS USED FOR COMPARING SURVEY COUNTS OF SPAWNING COHO SALMON.

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were independently surveyed by three biologists. Milton Creek flows into Scappoose Bay at St. Helens, Sierkes Creek is a tributary of North Scappoose Creek, and Trestle Creek is a small stream in the Clackamas River system. The survey units were 0.3, 0.5, and 0.4 mile long, respectively. Coho salmon adults are relatively easy to count when they spawn in such clear, shallow streams with flows of from 2 to 15 cubic feet per second. Difficulty is often encountered, however, during freshets and in larger streams where visibility is reduced. At times, turbidity and turbulence make it impractical to attempt a survey. The ability of a stream surveyor to see into the water was subjectively standardized in this experiment and this problem was minimized by the very short interval of time between different surveyors on the same stream.

METHODS

Variable weather conditions after the standard surveys were completed did not permit the experiment to start until December 21, 1959 or about two weeks later than desirable for these low-altitude areas. Separate vehicles and survey forms were provided each of the three surveyors. Each was supplied the following written directions prior to the first survey: (1) survey on foot in an upstream direction; (2) do not reveal your count to anyone until the experiment is completed; (3) use polaroid glasses if they improve visibility; (4) survey the standard areas on Milton, Trestle, and Sierkes creeks (which were described in detail); (5) write the report immediately after completing the count; and (6) survey at the same speed and in the same manner that other standard surveys are made. The stream survey report forms listed live fish as either adults or jacks and dead fish as males, females, jacks, or unknown. The total of all coho salmon observed on each survey was subsequently used in the analysis.

EXPERIMENTAL DESIGN

The scope of this experiment was limited to 3 man-days. Three separate Latin-squares were used for each of the three consecutive survey dates; this design was chosen to minimize or eliminate certain sources of uncontrolled variation (Cox, 1958, Chapter 10). With such a small array of observations it is possible to draw odd and undesirable assignments in a randomized manner (Wilson, 1952, Section 4.13), while in a Latin-square the variables are assigned in a restricted but balanced manner.

It was necessary to choose three survey areas that: (1) had runs of coho; (2) could be surveyed in the same day; and (3) could be surveyed during moderately stormy weather. Since the streams were small, the results should only be applicable to similar small streams.

The experimental design and resulting counts are presented in Table 1 where the capital letters A, B, and C designate the three surveyors and the numerical sub-scripts the order in which the surveys were made. In setting up the design, each biologist was assigned a letter randomly.

ANALYSIS AND RESULTS

Tables 2, 3, and 4 contain the analyses of variances among the counts of coho salmon grouped by the following variables: order; streams; surveyors; and an error term. Statistical methods and reference tables are given in Li (1957).

Under the hypotheses that the mean counts are equal at the 5% significance level, the differences among the average counts of the morning, noon, and afternoon time periods were not significant. The differences among the three surveyors also were not significant but the mean counts of the streams were significantly different.

DISCUSSION

Although substantial effort was made to eliminate bias of any kind, it is possible that an observer could have remembered his previous counts and thus introduced some subjectiveness into the data. Since each person surveyed alone it was not possible to conceal the final count from the surveyor himself. The fact that all surveyors recorded decreasing numbers with each subsequent date suggests this type of bias, if present, may not have been of any consequence.

TABLE 1. **EXPERIMENTAL DESIGN AND COUNTS OF COHO SALMON BY ORDER, STREAM, DATE, AND SURVEYOR.**

		a.m.		*noon*		*p.m.*		
		Surveyor	*Number of Fish*	*Surveyor*	*Number of Fish*	*Surveyor*	*Number of Fish*	*Total Fish*
Exp. 1.	December 21							
	Milton Cr.	A_1	6	B_2	1	C_3	5	12
	Trestle Cr.	B_1	20	C_2	21	A_3	19	60
	Sierkes Cr.	C_1	11	A_2	10	B_3	13	34
	Total		37		32		37	106
Exp. 2.	December 22							
	Milton Cr.	B_1	2	C_2	6	A_3	1	9
	Trestle Cr.	C_1	18	A_2	15	B_3	13	46
	Sierkes Cr.	A_1	13	B_2	14	C_3	10	37
	Total		33		35		24	92
Exp. 3.	December 23							
	Milton Cr.	C_1	2	A_2	2	B_3	4	8
	Trestle Cr.	A_1	14	B_2	12	C_3	12	38
	Sierkes Cr.	B_1	11	C_2	10	A_3	11	32
	Total		27		24		27	78

TABLE 2. **ANALYSIS OF VARIANCE, DECEMBER 21 DATA.**

Source of Variation	*Sum of Squares*	*Degrees of Freedom*	*Mean Square*	*F*
Order	5.556	2	2.778	.41
Streams	384.889	2	192.444	28.39
Surveyors	1.556	2	.778	.11
Error	13.555	2	6.778	
Total	405.556	8		

($F_{.05}$ 2,2 = 19.00)

TABLE 3. **ANALYSIS OF VARIANCE, DECEMBER 22 DATA.**

Source of Variation	*Sum of Squares*	*Degrees of Freedom*	*Mean Square*	*F*
Order	22.889	2	11.445	3.32
Streams	248.223	2	124.112	36.04
Surveyors	5.556	2	2.778	.81
Error	6.888	2	3.444	
Total	283.556	8		

($F_{.05}$ 2,2 = 19.00)

TABLE 4. **ANALYSIS OF VARIANCE, DECEMBER 23 DATA.**

Source of Variation	*Sum of Squares*	*Degrees of Freedom*	*Mean Square*	*F*
Order	2.000	2	1.000	1.00
Streams	168.000	2	84.000	84.00
Surveyors	2.000	2	1.000	1.00
Error	2.000	2	1.000	
Total	174.000	8		

($F_{.05}$ 2,2 = 19.00)

A Latin-square design is a type of fractional factorial where interaction reduces to zero. If the counts were much larger and differed by a much greater factor, a more extensive and detailed design and analysis might have been justified. In a comprehensive analysis of large pink and chum salmon aerial survey counts, Bevan (1961) presented certain two- and three-way interactions that were significant. A recent paper by Sheridan (1962) showed that variability in pink salmon spawning ground survey counts was low when riffle areas alone were used for index counts.

SUMMARY AND CONCLUSIONS

Three biologists each surveyed 3 tributaries for spawning coho salmon on 3 consecutive dates during December 1959. The variances of the resulting fish counts were examined. The 3 experiments utilized a Latin-square design, one for each date because better balance and less bias would be obtained for the small number of observations. Effects of 3 variables were examined by analysis of variance for each experiment separately. The 95% level of significance was used for testing the hypothesis of equal means in each case. Results of each experiment were consistent in that the mean counts grouped by time of day (order) were not significantly different, nor were the differences among surveyors. The means of the stream counts, however, were significantly different.

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A Modified Method of Analyzing Stomach Contents With Notes on the Food Habits of Coho Salmon in the Coastal Waters of Oregon and Southern Washington

PAUL E. REIMERS①

INTRODUCTION

In the summer of 1962, stomachs from troll-caught coho salmon *(Oncorhynchus kisutch)* were collected off the Oregon and southern Washington coast during an Oregon Fish Commission research project evaluating the use of barbless hooks in the ocean troll salmon fishery. The stomach study was begun to provide additional information on the food habits of coho salmon, but subsequent to the field season, need for improvement in the analysis technique became equally important.

The method of analysis selected for this study followed the point allotment system based on visual volumetric estimation of the relative fullness of each stomach. The system was selected because it has previously received little attention and may be valuable in describing the composite food habits of a species. The system was developed by Hynes (1950) for sticklebacks *(Gasterosteus aculeatus* and *Pygosteus pungitius)* and modified by Thompson (1959) for squawfish *(Ptychocheilus oregonensis)*. However, due to the subjectiveness of the method, a further modification was developed in this study that gave a more accurate measure of the relative importance of each food item to fish of different sizes.

Since stomachs could not be collected simultaneously in all coastal areas throughout the summer, strict comparisons of the change in feeding habits with time and area could not be made. The 107 stomachs collected were, however, representative of the fish caught on days sampled in the four collection areas. Month and area of sampling as well as number of stomachs collected are shown in Figure 1.

COLLECTION METHODS

A program for collecting a systematic sample of 10% of the catch was devised, but priority of the hooking study prevented strict adherence to the procedure. The size of the sample taken depended on the catch and work schedule.

The 107 stomachs collected comprised 13% of those available on days stomachs were sampled. Despite variation in sampling intensity, length-frequency distributions of the fish from which stomachs were taken closely fit those of the fish in the catch sampled. The stomach samples therefore appear to be representative of the fish catches sampled.

The stomachs were removed shortly after the fish were caught, and further digestion was prevented by injecting a few cubic centimeters of 10% formalin through the stomach wall. Stomachs and their identification

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labels were placed in perforated plastic bags and stored in a wooden keg containing 10% formalin.

ANALYSIS METHODS

The point allotment system as developed by Hynes (1950) and modified by Thompson (1959) has the advantage of providing a measure of the importance of each food item in terms of fish size and potential stomach volume. The system, therefore, takes into account that a full stomach is just as important to a small fish as to a large one. Hynes lists other advantages of the system as being rapid and comparatively easy, requiring no special apparatus, and not giving a false sense of detailed accuracy as other methods do. He also pointed out that the major shortcoming was subjectivity in that accuracy depended on experience in analyzing stomachs of varying size and degree of fullness.

The system, as Hynes (1950) developed it, was based on visual allotment of 1, 2, 4, 8, and 16 points to a stomach, depending upon its relative fullness. A full stomach was valued at 20 points, but only the above values were allotted, since he felt the technique was only approximate. Thompson (1959) modified the technique so that 20 points could be allotted to a full stomach. He also used a refined point breakdown. If a stomach was considered full when first opened, it received 20 points; half full, 10 points; etc. After the initial points were allotted, the food items were separated and the initial points divided among the various food items, depending on their volumetric percentage of the entire contents. For example, if a stomach was estimated as full and observed to contain half euphausids and half herring, an initial 20 points were allotted, and each food item then received 10 points. The points for each food item were summed for all stomachs and taken as a percentage of the total potential points, that is, 20 points multiplied by the number of stomachs analyzed. Emptiness, the unfilled portion of the stomach, was measured indirectly by subtracting the total actual points allotted from the total potential points and expressing the difference as a percentage of potential.

Shortly after the analysis began, the system was seen to be inaccurate, because the investigator had no previous experience estimating fullness of stomachs from fish of varying size. Since only limited experience could be gained with 107 stomachs, a further modification of the system was developed. The modification was to measure by water displacement the total stomach volume and the volume of the individual groups of food items for each fish, and to establish a criterion for determining the potential volume or maximum fullness of the stomach for fish of each length. The points could then be allotted objectively by comparing the measured volume of the contents with the potential stomach volume for that length fish.

The potential stomach volume from fish of each length was estimated indirectly by the following procedure. When volume of stomach contents was plotted against length of fish, a line depicting the relationship of the upper points (full or nearly full stomachs) to the length was observed to approximate the length-weight curve for the species. A search of the literature revealed two papers supporting the assumption that the amount of food a fish consumes is directly proportional to the fish's weight and therefore proportional to the cube of its length (Allen, 1935; Langford and Martin, 1940).

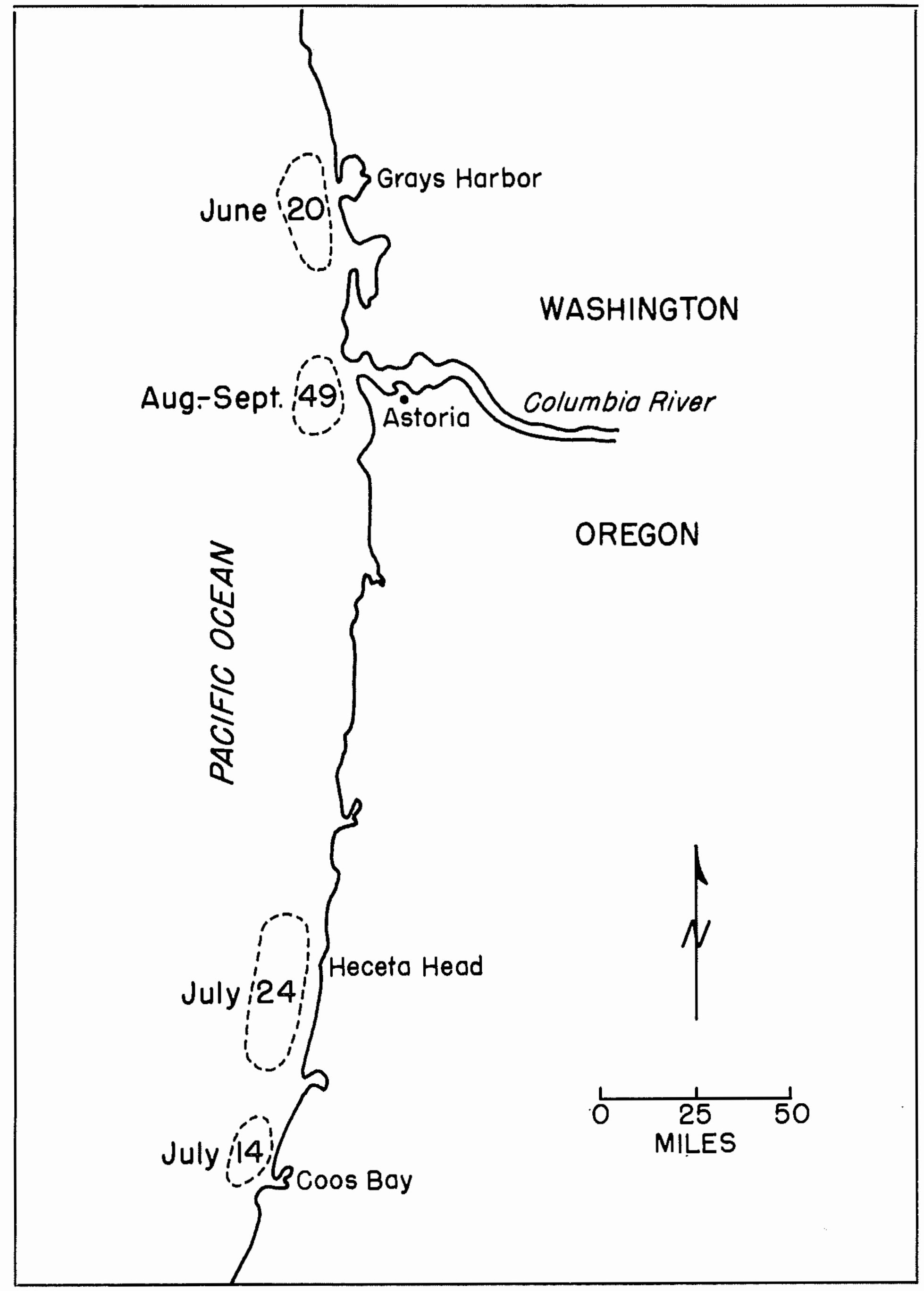

FIGURE 1. AREAS SAMPLED AND NUMBERS OF STOMACHS COLLECTED DURING THE SUMMER OF 1962.

Based on the above assumption, the length-weight curve for coho salmon (Van Hyning, 1951) was then proportionally transposed to the data on volume of stomach contents and length so that the line transected the largest volume. The potential stomach volume for fish of each length was then read directly from the curve. The relationship between volume of stomach contents and length of fish is plotted in Figure 2, with the stomach volumes on a logarithmic scale. That some points fall above the curve was considered reasonable, since the length-weight curve was an average line, and the 165 ml reference stomach may have been "average full" instead of "maximum full".

The points were allotted for fish of any length by dividing the measured content volume by the potential stomach volume for that length, and then dividing by a constant of 5 to convert to a 0 to 20 point basis. Table 1 shows examples of the allotment of points and computation of potential volume, emptiness, and relative importance of each food item.

TABLE 1. **EXAMPLES OF ALLOTTING POINTS AND COMPUTING RESULTS.**

Stomach Number	*Fish Length (Inches)*	*Potential Volume (ml)*	*Food Items*	*Content Volume (ml)*	*Potential Points*	*Allotted Points*
1	23	89	Euphausids	36	20	8.1
2	28	165	Empty	0	20	0.0
3	15	33	Crab zoea	23	20	13.9
			Anchovies	10		6.1
			Total		60	28.1

Potential points	= 20 points × 3 stomachs	= 60.0
Allotted points		28.1
Empty points	= (60.0 — 28.1)	= 31.9
% empty	= 31.9/60.0 × 100	= 53.1
% euphausids	= 8.1/60.0 × 100	= 13.5
% crab zoea	= 13.9/60.0 × 100	= 23.2
% anchovies	= 6.1/60.0 × 100	= 10.2
	Total	100.0

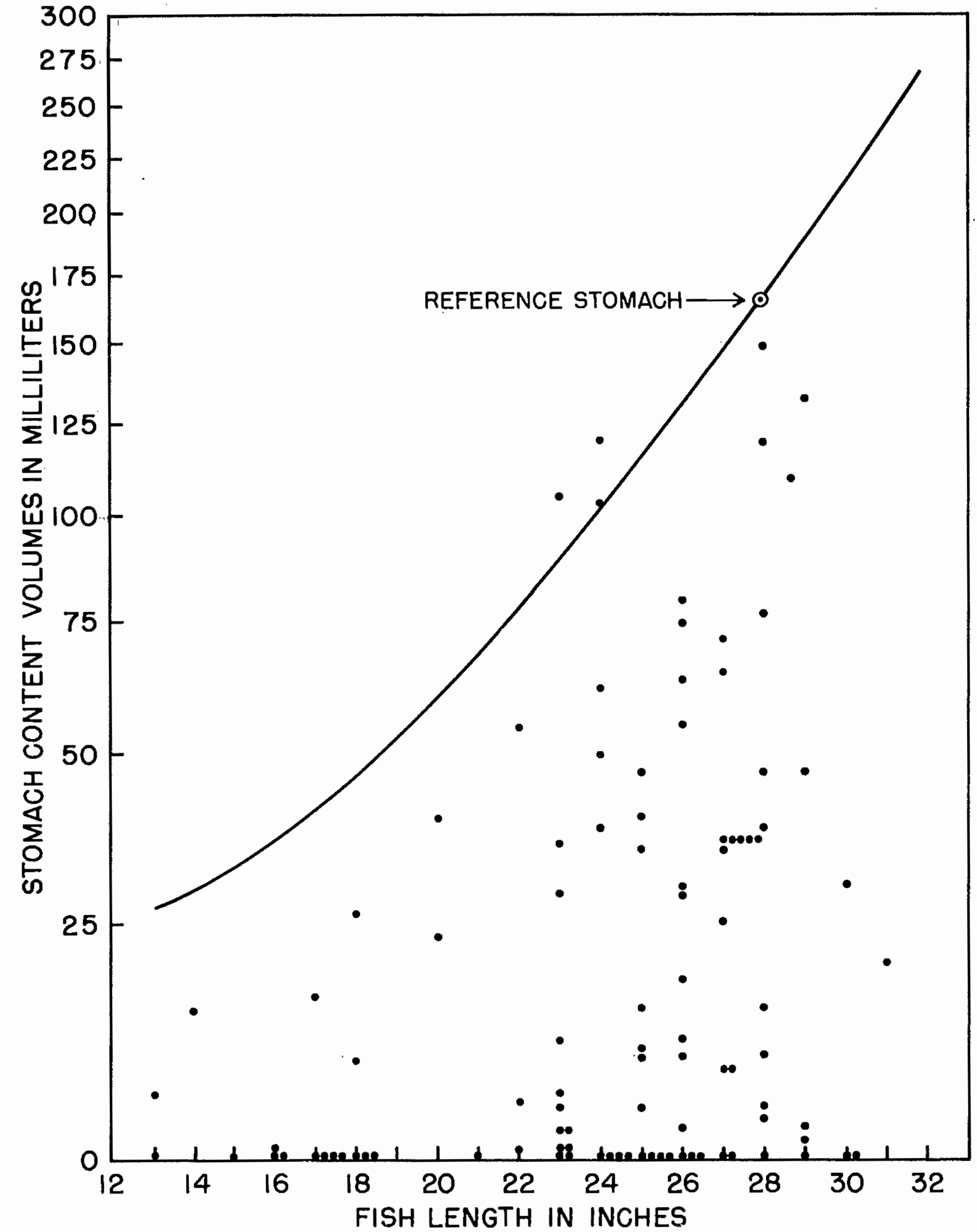

FIGURE 2. OBSERVED STOMACH CONTENT VOLUMES AND FISH LENGTHS (POINTS) AND ASSUMED RELATIONSHIP BETWEEN POTENTIAL STOMACH VOLUME AND FISH LENGTH (CURVE).

RESULTS

Results of the study indicate that herring *(Clupea harengus pallasi)*, unidentified fish remains, anchovies *(Engraulis mordax)*, euphausids (Euphausiacea), and crab megalops larvae (*Cancer* sp.) were the most important items present in the diet of coho salmon in the order listed (Figure 3). The miscellaneous category included surf smelt *(Hypomesus pretiosus)* 2%, sand lance *(Ammodytes hexapterus)* 1%, crab zoea larvae 1%, and a trace of annelids and amphipods. When the number of allotted points for all fish was subtracted from the total potential points, it was seen that only 21% of stomach capacity was used. Because samples were not taken in the same areas throughout the summer, rigid comparisons of food preference could not be made by area or by time.

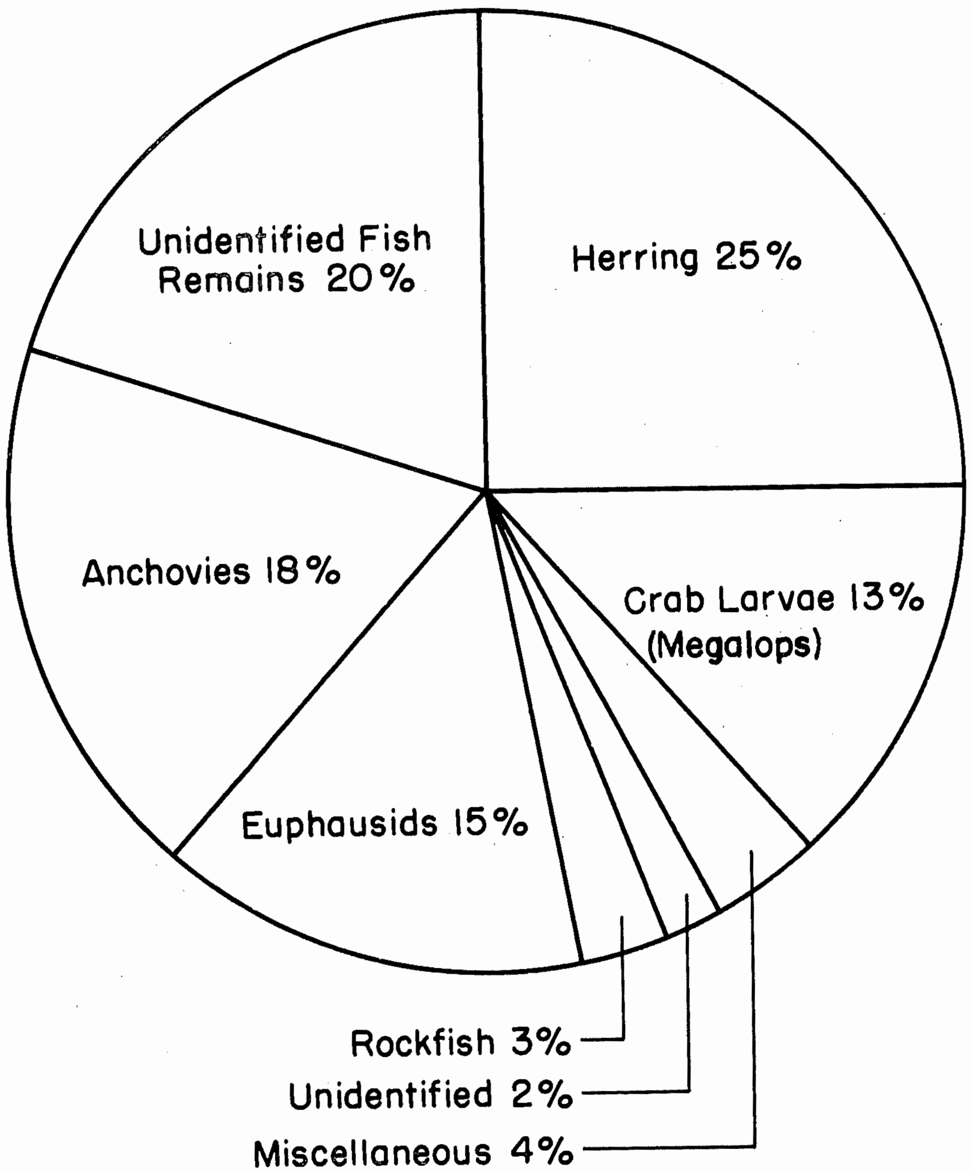

FIGURE 3. COMPOSITE IMPORTANCE OF FOOD ITEMS IN THE DIET OF COHO SALMON CAUGHT OFF THE OREGON AND SOUTHERN WASHINGTON COAST IN 1962.

Considering the offshore area as one large feeding ground, Figure 4 shows generally the following relationships: (1) fish in the diet become more important as the summer progressed; (2) euphausids were the most important food item off Grays Harbor in June, but were not found in the

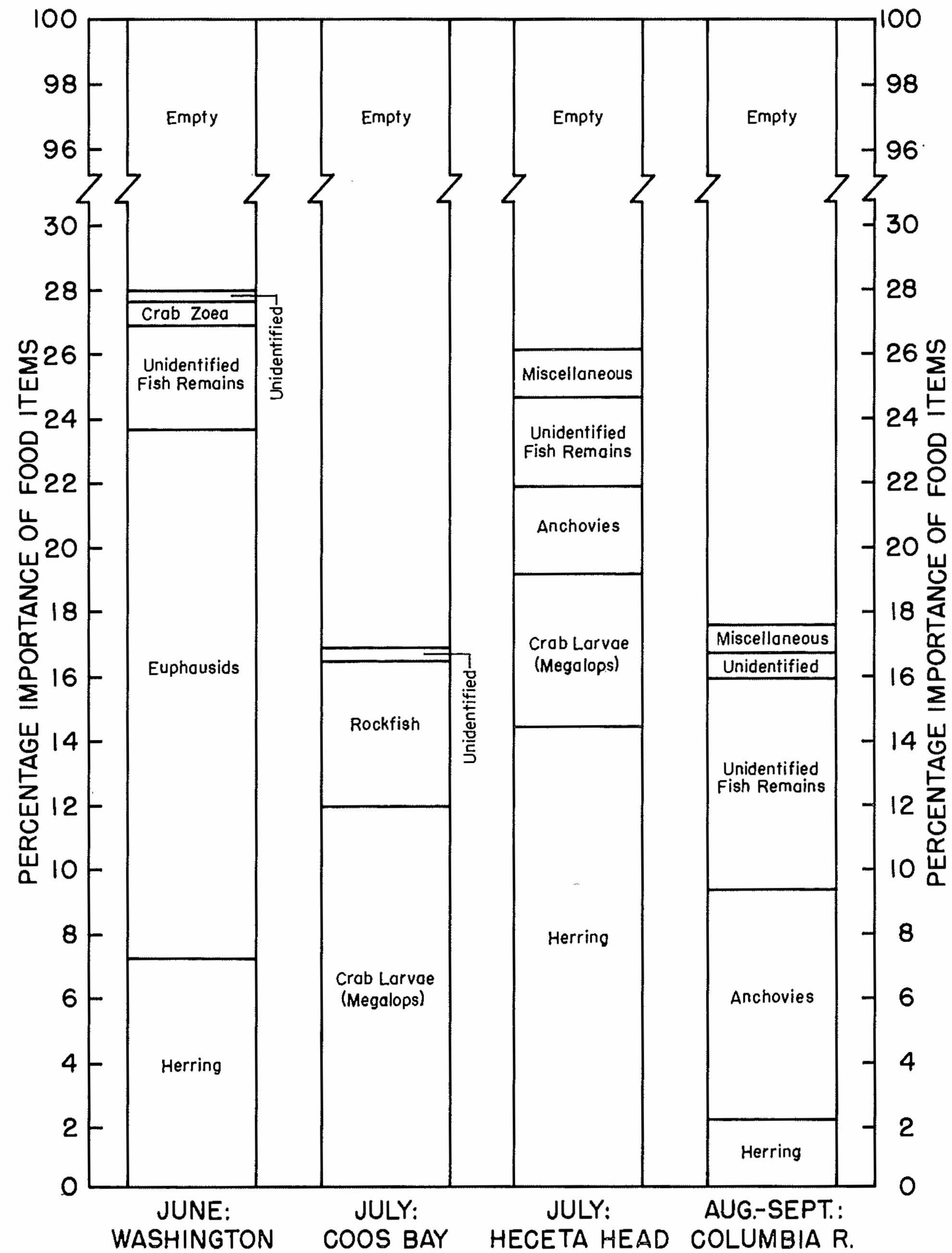

FIGURE 4. IMPORTANCE OF FOOD ITEMS BY SAMPLING AREA AND DATE FOR COHO SALMON CAUGHT OFF OREGON AND SOUTHERN WASHINGTON IN 1962.

other areas later in the summer; (3) crab zoea occurred in June off Grays Harbor, but for the rest of the summer only megalops were found; (4) when juvenile rockfish (*Sebastodes* sp.) were found in the stomachs they generally occurred with crab megalops; and (5) a greater diversity of food items occurred off Heceta Head and the Columbia River. The miscellaneous item in July included surf smelt, rockfish, sand lance, and unidentified and in August-September surf smelt, sand lance, and crab megalops.

Data in Table 2 compare results of the Columbia River sample using the point allotment system with results using the usual unweighted volumetric analysis (Lagler, 1952), where the stomach volume-length relationship is not considered. The merits of the point allotment system are seen by comparing the importance of crab megalops and the annelid worm. With the unweighted volumetric analysis, crab megalops were only slightly more important than the annelid worm. But with the point allotment system the crab megalops were 6 times as important as the annelid worm. The reason for the change in importance was that the annelid worm was in a 29-inch fish, while the crab megalops were in 13- and 23-inch fish, and took up a greater percentage of the potential volume. A similar comparison can be carried to the most important food items, that is, anchovies and unidentified fish remains. The point allotment system decreased the importance of anchovies from 55.6 to 41.4% because they were found in large fish (27.8 inches average length). The importance of unidentified fish remains increased from 22.6 to 36.3% because the average size of fish containing these items was small (21.4 inches average).

From these comparisons it can be seen that the unweighted volumetric analysis minimizes the importance of given food items for fish less than average length and exaggerates it for fish greater than average, if all stomachs contain the same percentage volume of a food item. Although the line of relative importance would not necessarily be linear, Figure 5 shows diagrammatically that when the unweighted volumetric analysis is used, the line of importance is unequal over the length range. By changing to the point allotment system, the line of relative importance is rotated to the horizontal, giving equal importance to a food item for all sizes of fish.

TABLE 2. **COMPARISON OF RESULTS OF COLUMBIA RIVER DATA USING THE UNWEIGHTED VOLUMETRIC AND THE POINT ALLOTMENT SYSTEMS OF ANALYSIS.**

Food Item	*Percentage Importance Using Unweighted Volumetric Analysis*	*Percentage Importance Using Point Allotment Analysis*
Anchovies	55.6%	41.4%
Unidentified fish remains	22.6	36.3
Herring	12.3	10.9
Unidentified	7.1	4.6
Surf Smelt	1.0	2.5
Sand lances	0.7	1.9
Crab megalops	0.4	1.2
Annelid worm	0.3	0.2

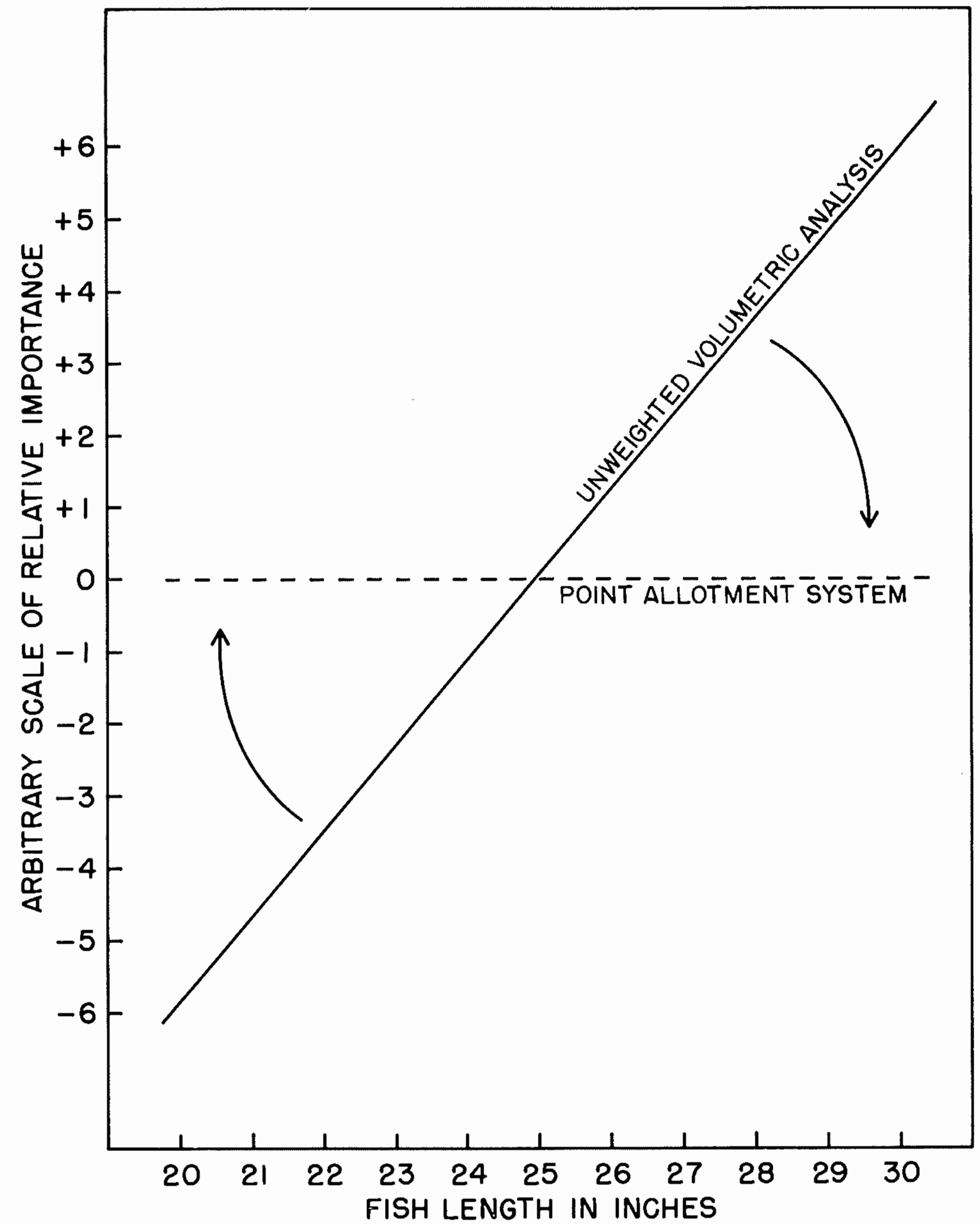

FIGURE 5. RELATIVE IMPORTANCE OF A FOOD ITEM WHICH OCCURS AS THE SAME PERCENTAGE OF POTENTIAL IN ALL SIZES OF FISH, USING THE UNWEIGHTED VOLUMETRIC AND POINT ALLOTMENT SYSTEMS OF ANALYSIS.

DISCUSSION AND CONCLUSIONS

Coho salmon are probably opportunistic feeders. Generally when herring, anchovies, and euphausids were observed from the boat, they also appeared as dominant food items in the stomachs. Crab megalops were infrequently seen from the boat, possibly occurring mainly in deeper water.

The results of this study were quite similar to those of Heg and Van Hyning (1951) except that in the present work smelt *(Hypomesus pretiosus)* did not show any dominance and squid were not found. In Heg and Van Hyning's work euphausids were important throughout the summer, but here they were important only in June off southern Washington.

Juvenile rockfish may have been ingested incidental to capture of crab megalops. Rockfish occurred in most coho stomachs containing the megalops and were also found to have crab megalops in their own mouths and stomachs.

A basic consideration to keep in mind with most methods of stomach analysis is that the results depict only the volumetric importance of each food item as found in the stomach. The nutritional value or usable energy that can be derived from each food item is more important, but seldom determined. Coho salmon doubling their weight as they do in their ultimate summer (Van Hyning, 1951) must eat large quantities of food and probably have a high conversion of energy in most food consumed.

The technique of transposing the length-weight curve to the stomach volume data and utilizing this curve to estimate potential volume undoubtedly needs refinement. A curve which gives a smaller potential volume for the shorter fish would more closely fit these data. A better estimation of the relationship between stomach potential volume and fish length could possibly be obtained by distending stomachs under a given pressure until maximum volume is attained. Another approach would be to plot the content volumes of a large number of full or nearly full stomachs against fish length and fit a regression line to the points.

Regardless of the initial problems of accurately estimating the potential stomach volume, the point allotment system holds promise in more accurately describing the food habits of a species.

ACKNOWLEDGMENTS

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A Comparison of Spaghetti and Petersen Tags Used on Steelhead Trout at Gnat Creek, Oregon

THOMAS E. KRUSE

INTRODUCTION

The purpose of this study was to compare suitability of spaghetti and Petersen tags for use on large salmonids. The study was conducted in Gnat Creek, a tributary to the Columbia River. Steelhead trout *(Salmo gairdneri)* were trapped at a weir and tagged during three seasons (1955–58) with Petersen disc and plastic spaghetti tags.

Gnat Creek flows into the Columbia River from the Oregon side, 14 miles east of Astoria, Oregon. The lower 4.5 miles are under tidal influence. The first 7 miles of stream above tidewater are available to steelhead trout for spawning. A series of falls limits further ascent. Gnat Creek has a flow pattern typical of Oregon coastal streams, with low summer flows of 7 c.f.s. and high winter flows reaching 830 c.f.s. The stream flow during the period of steelhead trout migration (December-May) is usually more than 100 c.f.s.

The Gnat Creek weir, 200 yards above tidewater, consisted of a dam, 170 feet long, across the stream with a bulkhead divider (60 feet from the south shore) extending 185 feet upstream into the forebay. The water to the south of the divider flowed over inclined screens. Fish moving downstream passed over the screens and dropped into a water-filled trough leading into a large collecting basket. Upstream migrants were blocked by the dam and captured in a trap near the south shore. Water from the forebay was passed through the trap to attract upstream migrants.

MATERIALS AND METHODS

Red Petersen disc tags (Figure 1) were used on adult steelhead trout in all three seasons of the study. These cellulose-acetate tags were 0.55-inch diameter and 0.04-inch thick and attached with stainless steel pins just below the leading edge of the dorsal fin.

A different vinyl-plastic spaghetti tag was used each year. Some of the material used the first season was noticeably brittle by the time the fish moved downstream. Another objection to plastic used the first two seasons was that the vinylite ink used to identify individual tags faded with time and became illegible. During the last season a clear plastic tubing with a black insert bearing an inscription was used. Although this clear tag was more durable than those used previously, moisture tended to make the plastic opaque and to obscure the legend. These tags became clear upon drying, however, and only one had to be removed and dried to identify the number. Tubing used the first two years had an outside diameter of 0.065 inch and that used the last year 0.087 inch. Spaghetti tags were attached below the trailing edge of the dorsal fin. The posterior one-third of the adipose fin of each tagged fish was removed as an aid in recognizing fish

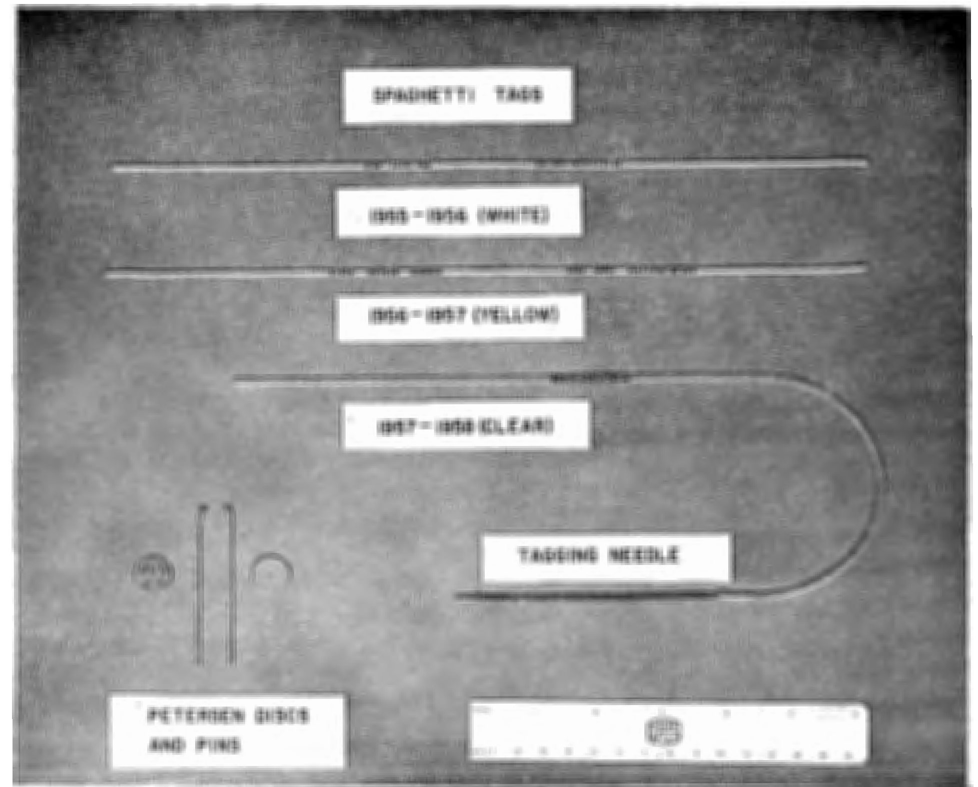

FIGURE 1. TAGS USED AT GNAT CREEK WEIR, 1955–1958.

which lost their tags. This supplementary mark was readily discernible even after a year in the ocean.

Steelhead trout were removed from the upstream-migrant trap each day, measured, sexed, tagged, and released above the weir. The method of selecting the tag to be used on an individual was not consistent for all three seasons. During the first and second years an attempt was made to alternate Petersen discs and plastic tubing. Of the last 20 upstream-migrating steelhead trout captured after April 11 of the first season, 18 received Petersen tags. In the second year, distribution of tags was more equal. During the last season a table of random numbers was used to select the proper tag at the time of application.

Adult steelhead trout returning downstream were dipped from the collecting basket, sexed, measured, and tag condition and number recorded. All but 5 of the 77 untagged trout collected the first two seasons, and all those which had lost their tags, were tagged before release below the weir. New tags (43 in 1956 and 29 in 1957) placed on the downstream migrants were mostly spaghetti-type.

COMPOSITION OF THE SPAWNING POPULATION

The numbers of adult steelhead trout moving upstream past the weir were 259 in 1955–56, 234 in 1956–57, and 60 in 1957–58 (Table 1). There was a good downstream return of adults to the weir after spawning. We recaptured 80% (210) of the 259 upstream migrants as kelts the first season. Recovery dropped to 66% (154) the second season and 50% (30) the third. Female steelhead trout outnumbered the males in all three seasons, but only by a slight margin the last year.

Although some steelhead trout migrating upstream were captured at Gnat Creek weir as early as November, the major movement did not begin until March (Figure 2). Kelts returned downstream to the weir from January through May. Tagging commenced in January the first season and in late February the next two years when the migration was later.

Males remained above the weir longer than females during all three seasons (Figure 3). The average time spent above the weir decreased the second and third seasons, when few upstream migrants passed over the weir before February 1.

TABLE 1. **NUMBERS OF ADULT STEELHEAD TROUT PASSING GNAT CREEK WEIR BY SEASON, 1955–58.**

	Direction of Movement by Season					
	1955–1956		*1956–1957*		*1957–1958*	
Sex	*Up*	*Down*	*Up*	*Down*	*Up*	*Down*
Male	72	80①	91	49	29	13
Female	118	127①	139	102	31	17
Unidentified	69	3	4	3	....	....
Total	259	210	234	154	60	30

① The increase of downstream-migrating males and females resulted from sexual identification at downstream migration of some of the unidentified upstream migrants.

NUMBERS OF FISH TAGGED

To provide an untagged population for comparison with tagged fish and a source of spawn for the stream in case tagging adversely affected the reproductive capacity of the steelhead trout, the first fish to be trapped each season (51 the first, 42 the second, and 13 the third) were placed above the weir without tags. Some fish also escaped upstream during the tag application. Totals of 61 upstream migrants the first season, 48 the second, and 13 the third were placed or escaped above the trap without tags (Table 2).

The number of tag recoveries was expected to decrease with time because of natural and fishing mortalities. Therefore, most of the untagged kelts each year were tagged before they were liberated below the weir.

CONDITION OF TAGS RECOVERED FROM FISH

For all three seasons combined, 162 fish with Petersen discs or Petersen tag scars were recaptured during the downstream migration after spawning. Approximately 6% (9) of these tags were either too tight or too loose (Table 3); only 3% (5) had lost their tags. Condition of the tags on the remainder of the fish (148) was good. None of the 157 Petersen tags recovered after spawning had cracked, and most were in good condition. Calhoun, Fry, and Hughes (1951) tagged migrating salmon in California, mostly in fresh water, with the same type of disc (only 0.01 inch thinner than those used at Gnat Creek). They reported recovering almost as many salmon on the spawning grounds without tags (but with fresh scars) as with tags still in place. The discs recovered were battered or cracked and would soon have been lost. In a later study (Calhoun, *et al.*, 1951), cellulose-acetate tags 0.045 inch thick were used. Of 40 discs recovered from 20 tagged chinook salmon after spawning, 1 tag was missing, 1 was weakened, and 38 were in good condition.

Fifteen fish tagged with Petersen discs during 1955–56 were recovered from the upstream migrants in the 1956–57 season. Tags on 7 of the recoveries were either too tight or too loose, and 2 fish had lost their tags but could still be identified by the adipose clip put on at time of tagging

TABLE 2. **NUMBERS OF TAGGED AND UNTAGGED STEELHEAD TROUT PASSING ABOVE GNAT CREEK WEIR DURING UPSTREAM MIGRATION AND RECOVERED DOWNSTREAM, 1955–58.**[1]

		Tagged					
		Petersen		Spaghetti		Untagged	
Season	*Sex*	*Released Upstream*	*Recovered Downstream*	*Released Upstream*	*Recovered Downstream*	*Released Upstream*	*Recovered Downstream*
	Male	42	36	30	19 (3)	....	22
1955–56	Female	64	56 (3)	54	42 (4)	....	22
	Unknown	1	....	7	2	61	1
	Total	107	92 (3)	91	63 (7)	61	45
	Male	30	18 (2)	29	14 (1)	32	14
1956–57	Female	56	35	70	50 (2)	13[2]	15
	Unknown	....	....	1	....	3	3
	Total	86	53 (2)	100	64 (3)	48	32
	Male	7	4	12	6	10	3
1957–58	Female	14	8	14	9	3	....
	Unknown	....	....	....	....	....	....
	Total	21	12	26	15	13	3

[1] Numbers in parentheses are recaptured individuals which had lost their tags and are excluded from the total for that category.

[2] The sexual identification of upstream-migrating adults was not always correct for extremely "green" fish. Downstream sexual identification was more certain. In cases where a tagged fish was identified as one sex as it was passed above the weir and another when recaptured after spawning, the post-spawning identification was considered correct.

TABLE 3. **CONDITION OF PETERSEN TAGS FROM FISH RECOVERED AT GNAT CREEK WEIR.**

	Tags Recovered from Downstream Migrants[1] (Fresh-Water Residence)		Tags Recovered from Upstream Migrants[2] (Ocean Residence)	
Tag Condition	*Number*	*Per Cent*	*Number*	*Per Cent*
Good	148	91.4	5	33.3
Too Loose	8	4.9	6	40.0
Too Tight	1	0.6	1	6.7
Cracked	....	....	1	6.7
Lost	5	3.1	2	13.3
Total	162	100.0	15	100.0

[1] Three seasons combined.

[2] Recoveries were made only in 1956–57 season.

and a tag scar. One fish returned with a plastic disc which had cracked. Tags on 5 fish were in good condition. No Petersen tags were recovered from upstream migrants in 1957–58.

Recoveries of spaghetti tags were treated separately for each season (Table 4) since a different plastic was used each year. Approximately 10% of the spaghetti-tagged steelhead trout which had been freed above the dam the first season had lost their tags before recapture at the weir on their downstream migration. This tag loss was partially attributed to the stiffening of the plastic, so that it became brittle and was easily broken.

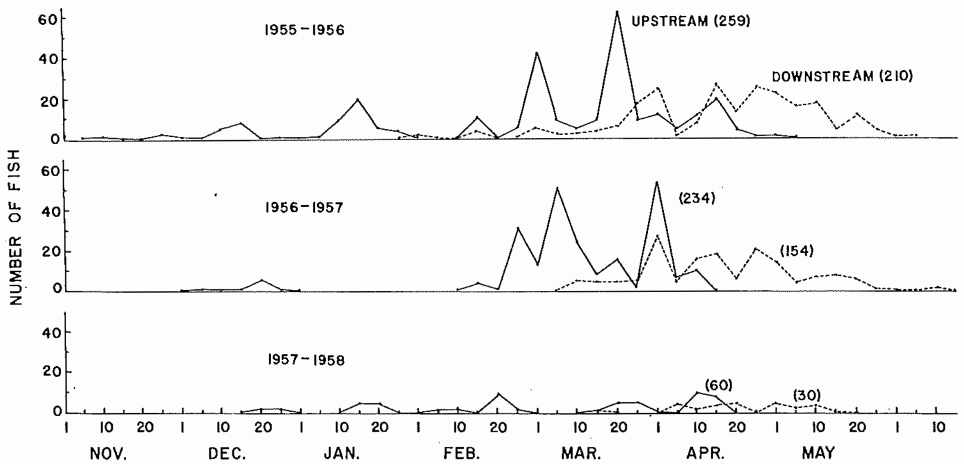

FIGURE 2. NUMBERS OF ADULT STEELHEAD TROUT MIGRATING UPSTREAM AND DOWNSTREAM PAST GNAT CREEK WEIR BY 5-DAY INTERVALS, 1955–1958. NUMBERS TRAPPED IN PARENTHESES.

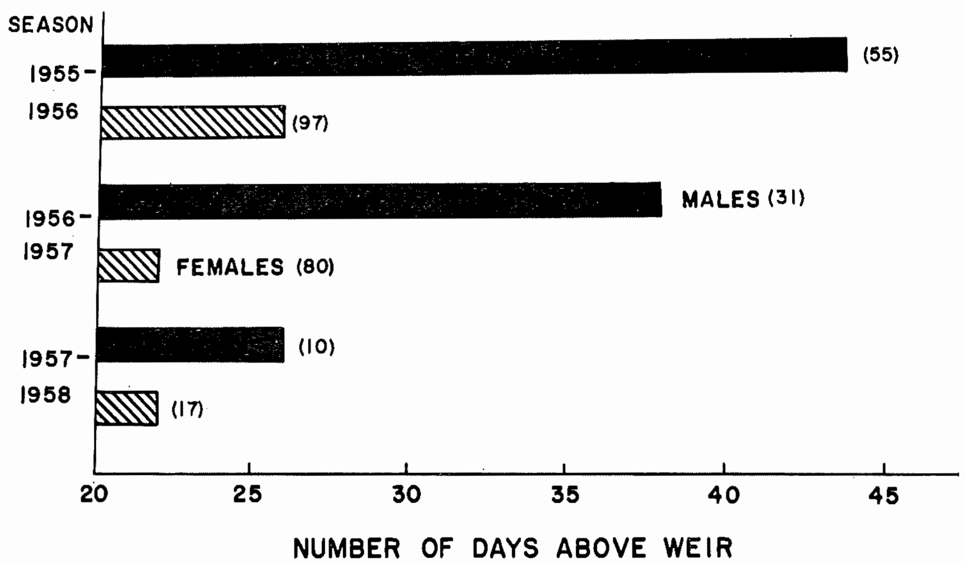

FIGURE 3. MEAN NUMBER OF DAYS SPENT ABOVE GNAT CREEK WEIR BY SPAWNING STEELHEAD TROUT. NUMBERS OF FISH RECOVERED ARE IN PARENTHESES.

Tag loss dropped to 8% when the first change of tubing was made, and no loss occurred the last season. Davis (1959) found a similar hardness developed in plastic spaghetti tags (white vinylite and white ivi-flex tubing) when used on striped bass in the Albemarle Sound-Roanoke River area of North Carolina. There the degree of hardness appeared to be related to the length of time tags were in the water. The shortest time in which tags used by Davis hardened was 123 days, but most of those which changed texture were in the water 300 days.

Only 4 of the 30 spaghetti-tagged fish recaptured after a year's residence in the ocean had lost their tags, and 3 of these were made of poor quality material used the first season. The greatest disadvantage of the plastic tubing used the first year was the illegibility of the printing. The ink had faded on every tag recovered, and 6 tags were unreadable even with infrared photography. Davis (1959) also reported that vinylite ink used on spaghetti tags faded and became illegible where it was in contact with the flesh of striped bass. At Gnat Creek the ink used on spaghetti tags faded regardless of the location of the writing.

Results of the comparison between the physical characteristics of Petersen discs and spaghetti tags, after a satisfactory grade of plastic was found and inserts with stamped legends were used, favored the use of plastic tubing. These tags were easy to attach, readily seen, and did not appear to cause the wear in the flesh around the tag that occurred with Petersen discs.

TABLE 4. **CONDITION OF SPAGHETTI TAGS FROM FISH RECOVERED AT GNAT CREEK WEIR.**

		Tags Recovered from Downstream Migrants (Fresh-Water Residence)		*Tags Recovered from Upstream Migrants (Ocean Residence)*	
Season	*Tag Condition*	*Number*	*Per Cent*	*Number*	*Per Cent*
	Good	63	90.0	....	....
1955–56	Lost	7	10.0	....	....
	Total	70	100.0	....	....
	Good	34①	91.9	15	62.5
1956–57	Unreadable (ink faded)	....	....	6	25.0
	Lost	3①	8.1	3	12.5
	Total	37	100.0	24	100.0
	Good	15②	100.0	5	83.3
1957–58	Lost	....	0.0	1	16.7
	Total	15	100.0	6	100.0

① White spaghetti tags were replaced with yellow ones after March 6, 1957. Downstream recoveries listed are yellow tags placed on fish during upstream migration.
② Yellow spaghetti tags were replaced with translucent plastic tags during upstream migration.

TAG RECOVERIES DURING SEASON OF TAGGING

During the period of steelhead migration from November through June, flows in Gnat Creek often exceed 180 c.f.s., and water passed over the dam to the north of the bulkhead divider. At such times fish could move downstream over the crest of the dam and bypass the trapping facilities. One fish, tagged going upstream the first season and not recorded as a kelt that year, was recaptured during the upstream migration the second year. This was the only evidence that an individual bypassed the weir.

Recoveries of Petersen and spaghetti tags from recaptured downstream migrants were tested ($P = .05$) against expected numbers of recoveries by using an adjusted chi-square test (Dixon and Massey, 1957). Results indicated that a significantly greater number of Petersen-tagged steelhead trout than spaghetti-tagged individuals were recovered the first season (Table 5). The significant difference in recoveries the initial year may have resulted from two factors. First, tags were not as evenly distributed that season as they were in the following two; of the last 20 upstream migrants arriving at Gnat Creek weir in 1956, 18 were tagged with Petersen discs. We recaptured 16 of these fish during their downstream migration and this high return tended to increase the chi-square value. Second, the plastic tubing available the first season was subject to breakage and 7 fish returned downstream without spaghetti tags, but only 2 lost Petersen discs. Fish with only tag scars were considered as tag mortalities. Results of chi-square tests of tag recoveries from downstream migrants during the following two seasons, when each type of tag was uniformly represented throughout the season (1956–57) or was selected randomly (1957–58), were not significant. These tests indicated that there was not sufficient evidence to state that the survival of a tagged fish on the spawning ground was related to the type of tag attached to it.

TABLE 5. **RESULTS OF CHI-SQUARE TESTS OF DIFFERENCES BETWEEN NUMBERS OF SPAGHETTI AND PETERSEN TAGS RECOVERED FROM DOWNSTREAM-MIGRATING STEELHEAD TROUT, 1955–58.**

Season	*Calculated Chi-Square Value*	*Degrees of Freedom*	X^2 *.05*
1955–56	8.14	1	3.84
1956–57	0.03	1	3.84
1957–58	0.07	1	3.84

It was impossible to conduct a valid test to compare the numbers of tagged and untagged fish recovered. The first group of fish to ascend the stream comprised the untagged population. During the downstream migration, the untagged kelts were predominantly males. Since male steelhead trout were found to suffer a higher mortality rate than females while spawning (Shapovalov and Taft, 1954), this differential mortality might have masked any differences between the tagged and untagged fish.

TAG RECOVERIES FOLLOWING THE SEASON OF TAGGING

Of the 208 tagged kelts freed below the dam the first season, 34 (16%) returned in the next spawning migration (Table 6). An additional 5 fish which had lost their tags were captured at the same time. Because of a smaller spawning migration in 1956–57 than in the previous year, only 148 tagged fish were released below the weir. The following season (1957–58) 5 tagged fish (3.4% of the number tagged) and 1 individual with a spaghetti tag scar were recovered.

TABLE 6. **NUMBERS OF TAGGED AND UNTAGGED STEELHEAD TROUT RELEASED BELOW GNAT CREEK WEIR DURING ONE SEASON AND RECAPTURED THE NEXT SEASON.**

	Disposition of Downstream Migrants					*Recovery of Upstream Migrants*			
		Tagged					*Tagged*①		
Season of Release	*Sex*	*Petersen*	*Spaghetti*	*Untagged*	*Season of Recovery*	*Sex*	*Petersen*	*Spaghetti*	*Untagged*
	Male	41	37	2		Male	1 (1)	3 (2)	84
1955-56	Female	....	66	....	1956-57	Female	12 (1)	17 (1)	108
	Unknown	....	3	....		Unknown	....	1	3
	Total	102	106	2		Total	13 (2)	21 (3)	195
	Male	15	31	....		Male	....	2 (1)	26
1956-57	Female	36	66	....	1957-58	Female	....	3	28
	Unknown	....	....	3		Unknown	....	....	....
	Total	51	97	3		Total	....	5 (1)	54

① Numbers in parentheses are fish which returned without tags but showed tag scars and are excluded from the total for that category.

The 26 (12.8% of total tagged) spaghetti-tag recoveries from fish returning from the ocean was greater than the 13 (8.5% of total tagged) Petersen disc recaptures in all seasons. However, chi-square tests using figures from all seasons combined indicated that there was not sufficient evidence to support the hypothesis that the return of a tagged individual was related to the type of tag affixed to it. A study by Korn (1961) on winter steelhead tagged and recovered in the Columbia River system in 2 seasons (1954–55 and 1955–56) also tested the relation between recoveries of Petersen and spaghetti tags. Korn found that a significantly greater number ($P < .01$) of Petersen discs were recovered from the commercial fishery than spaghetti tags. He could not demonstrate any significant difference between recoveries of these two types of tags by sport fishermen or at dams and hatcheries. He concluded that the commercial fishery was selective to Petersen tags.

SUMMARY

Adult steelhead trout captured in a weir on Gnat Creek, a tributary to the lower Columbia River in Oregon, were tagged with Petersen disc and plastic spaghetti tube tags during 3 seasons (1955–58). The purpose was to obtain information on the relative merits of these two types of tags when used on salmonids.

In 3 seasons 214 steelhead were tagged with Petersen discs as they moved upstream. Of the 167 downstream recaptures, discs on 148 fish were judged to be in good condition, 8 were too loose, 1 was too tight, and 5 tags had been lost. Fifteen steelhead were recovered after 1 year's ocean residence (all seasons combined) with Petersen discs or tag scars. Of the tags on these fish, 5 were in good condition, 6 were too loose, 1 was too tight, 1 had cracked, and 2 had been lost.

Two hundred and seventeen spaghetti tags were placed on steelhead migrating upstream during the 3 seasons. A different type of plastic tubing was used each season. The first and second seasons the plastic became brittle and vinylite ink used on legends faded, making this combination unsuitable. The third season a translucent tubing with an inscribed insert proved satisfactory. Tag loss was 10% the first season, 8% the second, and none the third.

A statistical comparison of Petersen disc and spaghetti tags was made: (1) from fish returning downstream after spawning, and (2) on fish returning to the weir after ocean residence. The first year a significantly greater number of Petersen tags than spaghetti tags was recovered from downstream migrants. No difference could be demonstrated the following two seasons, when a better quality plastic tubing was used. Among tagged fish returning to the weir after ocean residence, no significant difference could be demonstrated between the two types of tags. After experimental problems were resolved, the spaghetti tags were favored over Petersen discs because they were more easily applied, more readily discernible, and caused less visible damage to the flesh of steelhead.

ACKNOWLEDGMENTS

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Occurrence of the Giant Squid (Moroteuthis robusta) Off Oregon

The giant squid (*Moroteuthis robusta* Dall, Verrill) has been reported from California (Phillips, 1933 and 1961, and Smith, 1963) and Alaska (Dall, 1873) but not from points between. This species has been taken occasionally in the trawl fishery off the coasts of Oregon and Washington.

Figure 1 shows a specimen caught by the trawler *Margaret A.* in June 1958 in 90–150 fathoms between the Siletz River and Cape Meares, Oregon (lat. 44° 50′ – 45° 30′, long. 124° 50′). This squid measured 13 feet over-all length. Captain Calvin Johnson mentioned that several other large squid were taken on two consecutive trips in the same area. Berry (1912) states: "This is the largest species of cephalopod, perhaps of any invertebrate, known to inhabit the Pacific coast of North America, and is stated to attain a total length of over 14 feet (Dall's largest specimen minus part of the tentacles measured 427 cm.) or a mantle length of over 7½ feet." The California specimens have ranged up to 11 feet in length including tentacles (Smith, 1963). Thus this Oregon specimen is near the maximum size reported.

During the winter of 1960 the trawler *Trask,* while fishing off the Columbia River, brought in two arms of a large squid. Another giant squid was taken by the *Frank F.* on April 4–7, 1960, in 138–153 fathoms between Yaquina Bay and the Salmon River (lat. 44° 20′ – 45° 45′, long. 124° 50′).

A large *M. robusta* was caught by the trawler *Mel Don* on April 21, 1963 in 190 fathoms in the Willapa deep (46° 40′ N, 124° 50′ W) off the southern Washington coast. Captain Eddie Goodrich recalled catching two more specimens about a week later in the same area which were not brought in. This specimen measured 386 cm (12.7 feet) overall and weighed 54 pounds. Identification was confirmed by Dr. William Pearcy, Department of Oceanography, Oregon State University.

On August 30, 1962 the U. S. Bureau of Commercial Fisheries exploratory fishing vessel *John N. Cobb* caught a specimen of *M. robusta* at a depth of 250 fathoms off the mouth of the Columbia River (personal communication, William Pearcy, 1964). This individual measured 650 mm dorsal mantle length. Heyamoto, Pereyra, and Alton (1963) report another taken between January and June 1963 off the Columbia River.

A newspaper, the *Portland Reporter,* for March 27, 1964 contained an article describing a giant squid landed at Newport, Oregon; a photograph of the "monster" was included. This squid was reported to weigh 33 pounds and have a 4-foot body and 3-foot tentacles.

The observations reported may indicate a fair abundance of these animals in deep water. Although this species is termed "giant", it is dwarfed by the giant squid genus *Architeuthis,* some species of which may attain an over-all length of 55 feet.

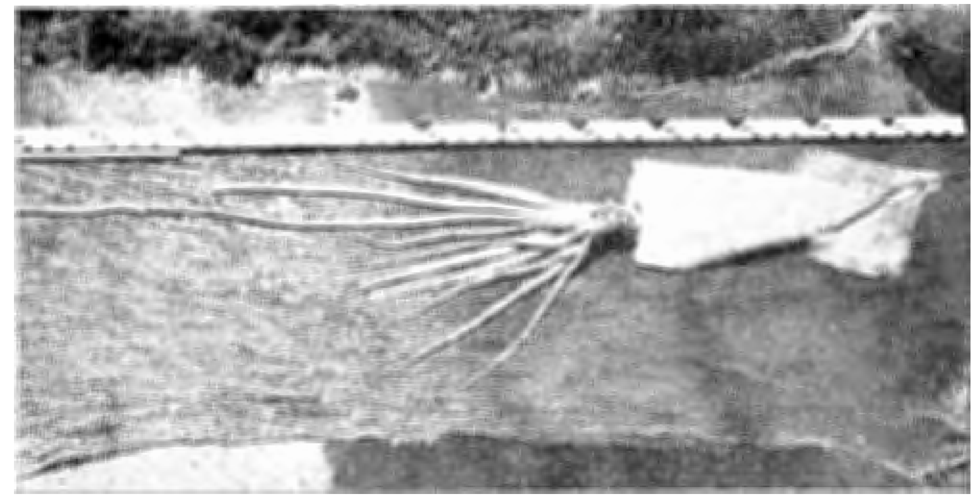

FIGURE 1. A GIANT SQUID, *MOROTEUTHIS ROBUSTA*, TAKEN OFF OREGON IN JUNE 1958.

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Occurrence of Juvenile Salmon in Stomachs of Adult Coho Salmon

In recent years Oregon Fish Commission personnel have received several unverified reports of the occurrence of juvenile salmon in the stomachs of adult coho salmon *(Oncorhynchus kisutch)* taken in the sport fishery off the Columbia River. With the examination of several coho stomachs in 1962 and 1963, we can now verify this occurrence.

On July 12, 1962, Kenneth Olsen caught two 10-pound coho salmon. One stomach contained two juvenile salmon and two smelt and the other one juvenile salmon. Because of the state of digestion, specific identification of the fish could not be made.

On July 28, 1963, a party of sport fishermen caught six adult coho, reportedly all containing juvenile salmonids. Three juveniles from one stomach were brought to the Astoria Laboratory and identified as chinook salmon *(O. tshawytscha)*. They measured 73, 82, and 88 millimeters (approximately 3–3½ inches) fork length. This stomach also contained one 7-inch herring *(Clupea harengus pallasi)*, one 5-inch surfperch (Embiotocidae), and 13 anchovies *(Engraulis mordax)* averaging about 3 inches long.

One of the juvenile salmon had part of the left maxillary bone removed, similar to a hatchery clip. All fins appeared intact, but most of the skin around the adipose fin was missing, due to digestion.

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An Aberrant Green Sturgeon From the Lower Columbia River[1]

An abnormal, small green sturgeon *(Acipenser medirostris)* was caught on August 7, 1957 in a salmon gill net in the lower Columbia River off Megler, Washington by Ed Hillsberry of Ilwaco, Washington.

The frozen sturgeon was 116.7 cm in total length and weighed 18.5 pounds the day after capture. It had 35 dorsal fin rays, 25 anal fin rays, 38 left pectoral fin rays, and 40 right pectoral fin rays. The fish was abnormal in three respects (none of which appeared detrimental to survival): (1) a single median fin on the ventral surface in addition to the normal ventral and anal fins; (2) an incomplete left lateral scute row which arched and became obsolete immediately posterior to the ventral fin bases; and (3) a secondary caudal fin. Location of these anomalies may be seen in Figures 1 and 2, which are tracings from photographs.

The single median fin was located immediately ahead of the anterior ventral scute on the left side; the 5 left ventral scutes were in line between the origin of the left ventral fin and the median fin. The eight ventral scutes on the right side were normal. The length of the median fin base was approximately 60% of that of the ventral fin base. The proximal half of the fin appeared leathery and had no rays, while the distal half was rayed. A small, separate rayed segment was attached to the anterior edge of the fin base.

There were 29 scutes in a normal lateral row on the right side of the fish. On the left side there were 14 normal scutes extending posteriorly from the head, followed by 3 small scutes in a row arching dorsally. Three additional very small scutes formed a separate row ventral to the lateral row and directed posteriorly from a position above the ventral fin base.

The fish had a smaller secondary caudal fin in addition to a normal heterocercal caudal fin. The secondary caudal had a rounded rather than pointed dorsal lobe; it originated on the left side of the caudal peduncle and for more than half its length was joined ventrally to the normal caudal.

Morphometrics are given in Table 1.

The aberrant sturgeon was unfortunately lost in an attempt to dry it and could not be X-rayed to determine if the deviations stemmed from an injury.

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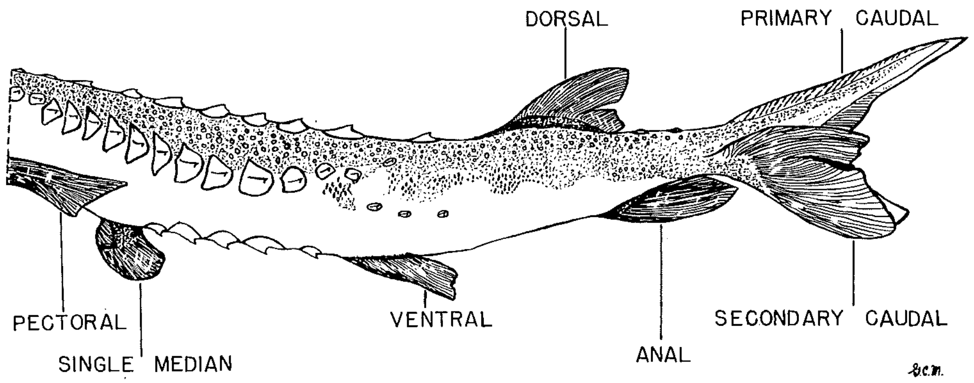

FIGURE 1. LEFT LATERAL VIEW OF THE BODY OF AN ABNORMAL GREEN STURGEON POSTERIOR TO THE PECTORAL FIN.

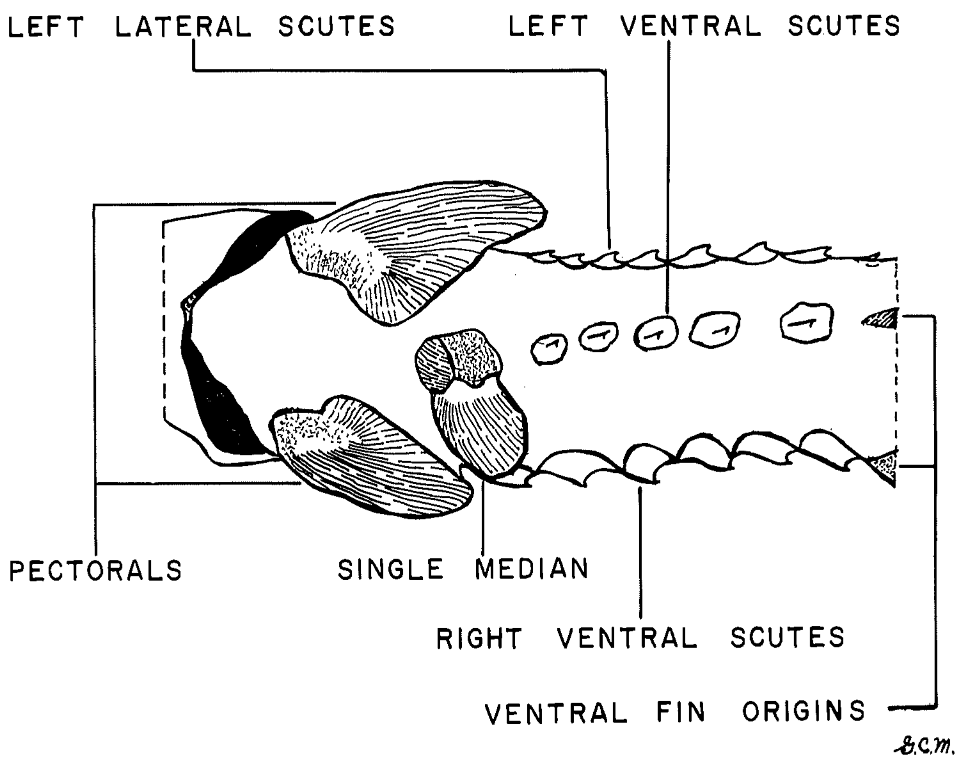

FIGURE 2. VENTRAL VIEW OF A PORTION OF AN ABNORMAL GREEN STURGEON.

TABLE 1. **MORPHOMETRICS FROM AN ABNORMAL GREEN STURGEON.**

Length From Tip of Snout to:	*Millimeters*
Barbel origins	52
Anterior edge of nostrils	63
Anterior edge of mouth	90
Edge of opercle	95
Pectoral fin	233
Median fin	382
Pelvic fin	620
Anterior edge of anus	660
Dorsal fin origin	743
Anal fin origin	830
Primary caudal fin origin	930
Primary caudal fin fork	1,055
Primary caudal fin tip (Total length)	1,167
Secondary caudal fin origin	910
Secondary caudal fin fork	1,063
Secondary caudal fin tip	1,080
Point of separation of caudal fins on ventral surface	1,040

A New Northern Record for the Greenspotted Rockfish

Between August 2 and 4, 1963 a greenspotted rockfish *(Sebastodes chlorostictus)* was captured about 30 miles west of Copalis Head, Washington (47° 11′ N. latitude, 124° 55′ W. longitude). The fish was caught in 90–100 fathoms of water in an otter trawl net by the trawler *Margaret A.*, skippered by Arthur Johnson.

The northern range of this species is listed as off San Francisco, California by Jordan and Evermann (1898), Barnhart (1936), and Phillips (1957). However, Roedel (1953) shows the northern range as northern California. Correspondence from Phillips concerning his current work on this and other species of Scorpaenid fishes mentions the occurrence of *S. chlorostictus* just south of Cape Mendocino, California. The capture of this specimen off Washington extends its known range from Cape Mendocino, California to Copalis Head, Washington, a distance of about 400 miles.

Descriptions given by Phillips (1957) were used for identification. This specimen did not fit properly into either *S. chlorostictus* or *S. cos,* but due to the absence of scales on the mandible and branchiostegals and the general morphology and coloration, it was determined to be *S. chlorostictus*. Identification was verified by Dr. Carl E. Bond of Oregon State University.

Table 1 lists the measurements and meristic counts which agree generally with those given by Phillips. The specimen is preserved at the Oregon Fish Commission Research Laboratory, Astoria, Oregon.

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TABLE 1. **MEASUREMENTS AND MERISTIC COUNTS OF** *SEBASTODES CHLOROSTICTUS.*

Total length	343 mm
Length of head	124 "
Depth of body at origin of ventral fins	117 "
Length of body at origin of ventral fins	84 "
Length of base of anal fin	43 "
Length of snout	33 "
Width of orbit	31 "
Width of interorbital space	19 "
Width of suborbital bone	10 "
Length of upper jaw (mandible)	58 "
Thickness of body	51 "
Width of base of pectoral fin	30 "
Longest pectoral fin ray	80 "
Longest ventral fin ray	68 "
Longest ventral fin spine	41 "
Longest first anal fin spine	20 "
Longest second anal fin spine	49 "
Longest dorsal fin spine	30 "
Longest dorsal fin ray	42 "
Least depth of caudal peduncle	29 "
Ventral length of caudal peduncle	50 "
Dorsal length of caudal peduncle	31 "
Posterior of anus to origin of anal fin	18 "
Longest raker of first gill arch	13 "
Number of rays in caudal fin	17
Number of spines in dorsal fin	13
Number of rays in dorsal fin	13
Number of rays in anal fin	7
Number of rays in each pectoral fin	17
Unbranched rays in each pectoral fin	8
Number of spines in each pelvic fin	1
Number of rays in each pelvic fin	5
Number of rakers on first gill arch	31
Number of pores in lateral line	37
Diagonal rows of scales below lateral line	45–48