RESEARCH BRIEFS

FISH COMMISSION OF 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.

FISH COMMISSION OF OREGON

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Siletz Bay Surf Perch Tagging

ALFRED R. MORGAN

INTRODUCTION

During a Siletz Bay salmon tagging program in 1954, the fyke nets used to obtain salmon for tagging incidentally took numbers of viviparous perch. The most abundant species was the pile or dusky perch, *Rhacochilus vacca.* The blue or striped sea perch, *Embiotoca lateralis,* and the wall-eye surf perch, *Hyperprosopon argenteum,* occurred in lesser numbers. Little is known about these species in Oregon, and a number were tagged in order to obtain information on their movements and abundance in the Siletz Bay area.

Like other species of the family Embiotocidae, the above species have minor commercial importance in Oregon (Cleaver, 1951). The average annual commercial catch of all species of surf perch in Oregon from 1928 through 1949 was 24,800 pounds, ranging from 94,300 pounds in 1929 to 600 pounds in 1937. Perch are utilized as a food fish as well as bait for other species of fish and crabs. They support an important recreational fishery in Oregon bays and the surf area along the coast. Numerous anglers were observed fishing in Siletz Bay for these fish in July and August before the sport fishery for salmon began in September. The surf perch are found in brackish and marine environments.

Siletz Bay is located on the central Oregon coast, 90 miles south of the Columbia River and 20 miles north of the city of Newport, and is typical of a number of other small bays along the Oregon coast.

GEAR AND METHODS

The fyke nets used in the Siletz experiment were the same as those employed in the Tenmile Lakes salmon tagging experiment (Morgan and Henry, 1959). The 3 fyke nets used were 18 feet in length (2 were 10 feet in diameter and one 8 feet in diameter), cylindrical in shape, covered with 2-inch wire mesh, and equipped with 2 fykes or funnels leading to a pot at the back of the net. Access to the pot by the tagging crews was possible by 3 doors equally spaced around the pot.

By this arrangement the fish could be removed from the net while it was resting at nearly any position in shallow water. The nets were anchored to the bank by 2 cables, one attached by a swivel apparatus at the pot end and used as a safety line in case the other fouled or broke, and the other attached to the center of the net and used to pull it from the water by means of a small, hand-operated winch.

The nets were pulled each day as near low-water slack tide as possible, at which time algae attached to the nets were removed as completely as possible.

The perch were tagged with a pair of Petersen disc tags, one numbered and one blank, held to the back of the fish by a soft stainless steel pin which pierced the fish near the junction of the spinous and soft dorsal fins. The type of tag used was not entirely satisfactory because many recovered perch had rather large sores caused by the tag and pin, and considerable tag loss probably took place. The injuries did not appear serious enough to cause tagging mortality, however. The tag number, location of the fyke net, species, and fork length in centimeters were recorded when the fish were tagged. All recaptured tagged fish were recorded by tag number, date of recapture, and area taken. Fish which had lost tags were recorded as having tag scars and retagged.

LOCATION AND NUMBERS TAGGED

The fyke nets were first fished on August 8, 1954, when 2 nets were located downstream from the Highway 101 bridge at Kernville. One net was placed about 200 yards below the bridge and the other approximately ¼ mile below the first net. Both nets were on the south side of the bay. On August 9, a third net was placed on the north bank

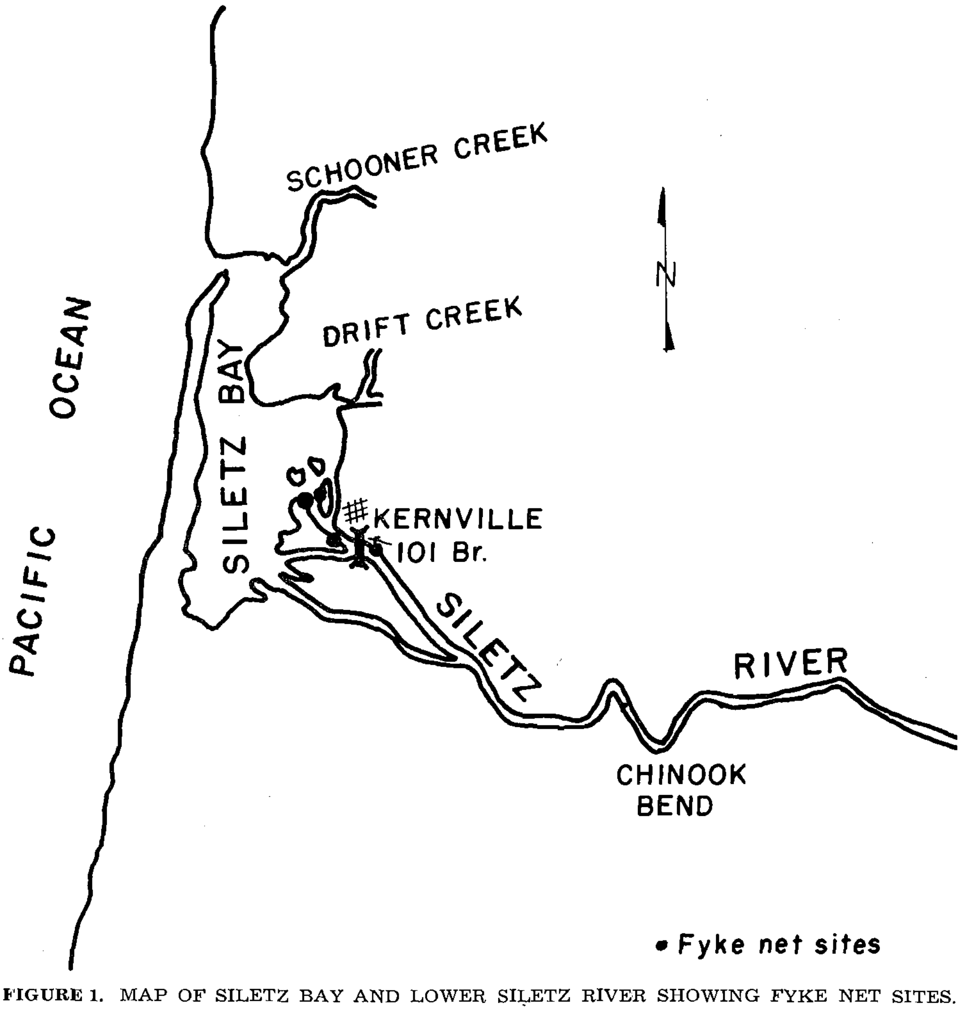

FIGURE 1. MAP OF SILETZ BAY AND LOWER SILETZ RIVER SHOWING FYKE NET SITES.

immediately above the bridge. The nets were fished in these positions until September 2 when the net above the bridge was moved downstream approximately one-half mile but kept on the north bank. These locations are shown in Figure 1.

Good catches of surf perch were made as soon as the nets began fishing, but none were tagged until August 20. During the period August 8-19, 1954, 1,526 perch were captured and released but not identified as to species. This number undoubtedly included fish captured several times. During the period August 20–October 23, 1,887 surf perch were tagged, all species combined, including 20 fish which had lost their tags and were retagged. The numbers tagged according to species were: 1,409 dusky perch, 397 blue perch, and 81 walleye perch.

TAG RECOVERIES

Of the 1,409 dusky perch tagged, 229 or 16.2 per cent were recovered in the fyke nets, including 23 recaptured more than once. A single recovery was made in the salmon gill-net fishery near the tagging area. During the tagging period, anglers recovered 2 tagged fish while surf casting in the ocean 2 or 3 miles north of the entrance to Siletz Bay. During the summer of 1955, anglers fishing in the bay near Kernville recovered 3 more tagged fish which had been tagged about a year previously.

Of the 397 blue perch tagged, 262 or 65.9 per cent were recovered in the fyke nets, including multiple recoveries of some fish. Several fish were recaptured 4 times. None of the blue perch were recovered in the salmon gill-net fishery, and only 1 tag was returned by anglers in 1954. This single recovery was made within the tagging area. No tags were returned in 1954 by anglers surf fishing in the ocean. During the 1955 season, 2 tags from blue perch were returned by anglers. One recovery, made from Siletz Bay near Kernville, had been at liberty approximately 9 months. The other, at liberty 361 days, was recovered by an angler surf casting in the ocean about 3 miles north of the Siletz Bay entrance.

Walleye perch were captured in much smaller numbers than dusky or blue perch. Only 81 were tagged, and none were recovered in the fyke nets. Two were taken in the salmon gill-net fishery near Chinook Bend, approximately 3 miles upstream from the tagging area. No tagged walleye perch were known to have been recovered by anglers in Siletz Bay or the ocean.

The few tag recoveries suggest that either fishing intensity on these species is very light, or tag loss and/or tagging mortality is high.

MOVEMENTS AND MIGRATIONS

The majority of the dusky perch taken in the early part of August were ripe but unspawned females. The actual sex ratio was not determined. By late August very few unspawned females were observed, and the numbers of fish caught each day had decreased from peak catches made earlier in the month. The data from this study were not sufficient to determine whether the mature dusky perch were in Siletz Bay on a spawning migration or for some other reason, or came there by chance. Some movement to the ocean is shown by the few recoveries made by surf casters. The few recoveries made by anglers in 1955 indicate a similar distribution as in 1954. Tagged dusky perch were taken in the ocean a few miles north of the entrance and in Siletz Bay near the tagging area approximately 1 year after tagging.

Although fewer blue perch were tagged, a greater percentage of recaptures was made and numbers sampled did not fluctuate as much as with dusky perch. It would appear that blue perch migrated less than dusky perch. Also, unlike the dusky perch, very few blue perch taken at any time during the tagging period appeared to be unspawned females. Ripe blue perch females have been observed in other bays in Oregon in early summer, and may also enter Siletz Bay to spawn at that time. A single recovery made by an angler fishing in the tagging area in the early summer of 1955 indicates that some blue perch present in Siletz Bay in the fall of 1954 were in the bay during the expected spawning period the next spring. No blue perch were recovered by anglers fishing in the ocean in 1954, but a single recovery was made in the fall of 1955 by a surf caster about 3 miles north of the Siletz Bay entrance, indicating that the known distribution of this species is similar to dusky perch tagged in the same area.

The movements of both dusky and blue perch, as indicated by tag recoveries, are in and out of Siletz Bay and along the beach adjacent to the entrance of the bay for a few miles. No tag recoveries were made farther than 3 miles from the bay entrance. The lack of recoveries in other bays, or along the ocean beaches farther than 3 miles from the mouth of Siletz Bay, indicates that the dusky and blue perch tagged in the bay did not move extensively away from the area. The apparent northward-only movement is probably caused by greater accessibility of the ocean beach on the north side of the entrance to Siletz Bay and its more common use by anglers. It should also be noted that all tag returns not made in the fyke nets were voluntary, and some tags recovered were possibly not returned.

The 2 recoveries of walleye perch are interesting in that both were taken farther upstream from the tagging area than any dusky or blue perch.

No tagged fish were recovered after 1955, but a tag from a dusky perch was found on the beach at Nelscott (½-mile north of Siletz Bay) in 1960.

Comparison of the general decline in daily catches and the low tag recovery for dusky perch with the more or less steady catches and higher recovery rate for blue perch (Tables 1 and 2), suggests that the dusky perch were emigrating from the bay while the blue perch were more of a resident population during the tagging period. Average daily catches during the periods August 20-29, August 30-September 8, and September 9-20 were as follows: dusky perch, 84, 59, and 18; blue perch 22, 20, and 20.

POPULATION ENUMERATION

Estimates of the dusky and blue perch populations were made from tagged and untagged individuals taken in the fyke nets during the period August 20–September 20. Tagged and recovered fish after this period were not included. The formula used was $N = \frac{\Sigma nt}{\Sigma s + 1}$ (Chapman, 1952) which is a slight modification of the formula suggested by Schnabel (1938). Each day the fish tagged previously that were recaptured (s) were counted and released. The untagged fish were counted, tagged, and released. Total recoveries and untagged fish observed each day formed the sample (n). All fish tagged previously (t) were assumed to be available. An estimate of the population was obtained by adding the daily values of nt and dividing by the sum of all the tags recovered $(s + 1)$ for the period August 20–September 20. These data are shown in Tables 1 and 2.

Substituting the values from Tables 1 and 2 in the formula, the population estimate for dusky perch is found to be 5,086 fish, and for blue perch 537 fish. Because of the apparent emigration of both tagged and untagged dusky perch from the tagging area, the population estimate for this species appears to be too low.

Assuming that the tagged fish were recovered from samples with a Poisson distribution, upper and lower 95 per cent confidence limits for the number of tags in the sample were calculated by Ricker's formula (1937, p. 352). For the dusky perch the upper and lower limits were found to be 256 and 197 tags, respectively, and for blue perch 287 and 225 tags, respectively. Substituting the above values for s in the equation $N = \frac{\Sigma nt}{\Sigma s + 1}$, the upper and lower 95 per cent confidence limits for the dusky perch populations were calculated to be 5,805 and 4,473 fish, respectively, and for the blue perch 606 and 476 fish, respectively.

DISCUSSION

Useful information was obtained from the surf perch tagging experiment. For example, it is apparent that the spawning season for dusky perch in Siletz Bay extends into late August, while the blue and walleye perch have completed spawning before the first week in August. During the late summer and early fall the dusky perch are considerably more abundant than blue or walleye perch. This type of information would be useful in evaluating the effect on the fish and fisheries of Siletz Bay of certain potential industrial uses of the water, or of any future sport fishing regulations. Information that could be used as a guide in future surf perch studies was also obtained. The type of tags used did not appear satisfactory for long-term studies because of their tendency to snag on objects and cause sores on the fish with subsequent tag loss. The fyke nets were satisfactory for catching surf perch in good condition. In fact, they took almost no other species of fish. More nets should have been fished at different locations in order to trace fish movement within the bay. The nets required considerable attention because of the algae which collected on them. Any future enumeration study should coincide with, or come before, the peak abundance of the various species to be studied; the peak abundance of dusky, blue, and walleye perch in Siletz Bay probably occurs in June and July. Any future study should also incorporate catch-per-unit-of-effort data along with tag recoveries in order to obtain better estimates of the populations.

TABLE 1. **DATA USED IN OBTAINING AN ESTIMATE OF THE POPULATION OF DUSKY PERCH IN SILETZ BAY, 1954.**

Date	*Number Tagged*	*Number Recovered*		*Number Sampled*	*Number Tagged Previously*		*Cumulative*	
		s	*Σs*	*n*	*t*	*nt*	*nt*	*N*
August								
20	163	....	....	163	....	....	....	....
21	105	....	....	105	163	17,115	17,115	17,115
22	77	1	1	78	268	20,904	38,019	19,010
23	63	....	....	63	345	21,735	59,754	29,877
24	96	2	3	98	408	39,984	99,738	24,935
25	53	4	7	57	504	28,728	128,466	16,058
26	138	12	19	150	557	83,550	212,016	10,609
27	54	5	24	59	695	41,005	253,021	10,120
28	10	8	32	18	749	13,482	266,503	8,076
29	31	17	49	48	759	36,432	302,935	6,059
30	16	12	61	28	790	22,120	325,055	5,243
31	27	19	80	46	806	37,076	362,131	4,471
September								
1	32	16	96	48	833	39,984	402,115	4,146
2	39	12	108	51	865	44,115	446,230	4,094
3	50	9	117	59	904	53,336	499,566	4,234
4	89	4	121	93	954	88,722	588,288	4,822
5	32	6	127	38	1,043	39,634	627,922	4,906
6	48	5	132	53	1,075	56,975	684,897	5,150
7	75	9	141	84	1,123	94,332	779,229	5,486
8	73	14	155	87	1,198	104,226	883,455	5,663
9	4	1	156	5	1,271	6,355	889,810	5,668
10	52	10	166	62	1,275	79,050	968,860	5,802
11	4	6	172	10	1,327	13,270	982,130	5,677
12	20	14	186	34	1,331	45,254	1,027,384	5,494
13	13	15	201	28	1,351	37,828	1,065,212	5,273
14	17	6	207	23	1,364	31,372	1,096,584	5,272
15	3	1	208	4	1,381	5,524	1,102,108	5,273
16	9	3	211	12	1,384	16,608	1,118,716	5,278
17	3	3	214	6	1,393	8,358	1,127,074	5,242
18	4	3	217	7	1,396	9,772	1,136,846	5,215
19	....	....	....	....	....	....	....	....
20	1	8	225	9	1,400	12,600	1,149,446	5,086
Total	1,401	225	....	1,626	....	1,149,446	....	....

TABLE 2. **DATA USED IN OBTAINING AN ESTIMATE OF THE POPULATION OF BLUE PERCH IN SILETZ BAY, 1954.**

	Number Tagged	Number Recovered		Number Sampled	Number Tagged Previously		Cumulative	
Date		*s*	*∑s*	*n*	*t*	*nt*	*nt*	*N*
August								
20	26	....	....	26	....	....	....	....
21	40	....	....	40	26	1,040	1,040	....
22	21	6	....	27	66	1,782	2,822	403
23	10	7	13	17	87	2,349	5,171	369
24	8	8	21	16	97	1,552	6,723	306
25	2	3	24	5	105	525	7,248	290
26	14	8	32	22	107	2,354	9,602	291
27	24	13	45	37	121	4,477	14,079	306
28	8	2	47	10	145	2,450	15,529	324
29	16	5	52	21	153	3,213	18,742	354
30	8	5	57	13	169	2,197	20,939	361
31	13	9	66	22	177	2,301	23,240	347
September								
1	47	14	80	61	190	11,590	34,830	430
2	10	4	84	14	237	3,318	38,148	454
3	1	3	87	4	247	988	39,136	445
4	17	4	91	21	248	5,208	44,344	482
5	15	5	96	20	265	5,300	49,644	512
6	10	9	105	19	280	5,320	54,964	519
7	4	13	118	17	290	4,930	59,894	503
8	5	6	124	11	294	3,324	63,218	506
9	1	4	128	5	299	1,495	64,713	502
10	8	11	139	19	300	5,700	70,413	503
11	3	12	151	15	308	4,620	75,033	497
12	25	22	173	47	311	14,617	89,650	515
13	20	27	200	47	336	15,792	105,442	527
14	18	17	217	35	356	12,460	117,902	541
15	3	6	223	9	374	3,366	121,268	541
16	2	5	228	7	377	2,639	123,907	541
17	5	4	232	9	379	2,653	126,560	543
18	2	10	242	12	384	4,608	131,168	540
19	....	....	....	....	....	....	....	....
20	3	12	254	15	386	5,790	137,958	537
Total ..	389	254	....	643	....	137,958	....	....

SUMMARY

During a 1954 Siletz River salmon tagging program, numbers of viviparous surf perch were captured in fyke nets and tagged. The most abundant species was the pile or dusky perch, *Rhacochilus vacca*; the blue or striped sea perch, *Embiotoca lateralis,* and the walleye surf perch, *Hyperprosopon argenteum,* were taken in lesser numbers.

Of the 1,409 dusky perch tagged, 229 or 16.2 per cent were recovered in the fyke nets; one recovery was made from the salmon gill-net fishery near the tagging area and 2 by anglers fishing in the surf 2 or 3 miles north of the entrance to Siletz Bay. In 1955, anglers returned 3 tags from dusky perch taken near the tagging area approximately one year after tagging. Only one tag recovery was made after 1955; a tag was found on the beach near the bay in 1960.

Fewer numbers of blue perch were tagged, but the recovery rate was higher. Of a total of 397 blue perch tagged, 262 or 65.9 per cent were recovered in the fyke nets, and 1 tag was returned by an angler fishing in the tagging area in 1954. No ocean recoveries of tagged blue perch were made by anglers in 1954. In 1955, anglers returned 2 tags from blue perch: 1 from the tagging area and the other by a surf caster 3 miles north of the entrance to Siletz Bay.

Of 81 walleye perch tagged, 2 recoveries were made upstream from the tagging area in the salmon gill-net fishery, and none were taken in the fyke nets or by anglers.

The few tag recoveries suggest that the fishing intensity on these species is light. During the tagging period the dusky perch appeared to be emigrating from the bay while the blue perch were more of a resident population.

Recoveries of tagged surf perch were confined to Siletz Bay itself and to an area 3 miles north of the bay. This suggests a local population in the area with no extensive coastwise migration or mixing between bays.

An estimate of the dusky perch population present during the period August 20-September 20, 1954 was slightly more than 5,000 fish, with upper and lower 95 per cent confidence limits of 5,800 and 4,500 fish, respectively. An estimate of the blue perch population was slightly more than 500 fish, with upper and lower 95 per cent confidence limits of about 600 and 470, respectively. The population of dusky perch present prior to the tagging period was probably considerably larger than 5,000 due to emigration from the bay during the tagging period.

ACKNOWLEDGMENTS

The tagging program was carried out under the direction of Kenneth A. Henry, then in charge of the Coastal Rivers Investigations for the Oregon Fish Commission. Thanks are due to Alvin E. Berg, Eldon E. Korpela, Richard G. Rowland, and Walter D. Weidlein who assisted in the tagging and collection of data.

The cooperation of commercial fishermen, fish dealers, moorage operators, and sportsmen of the Siletz area is greatly appreciated.

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The Oregon Trawl Fishery for Mink Food—1948-1957

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INTRODUCTION

Mink ranching in Oregon has developed into an important industry, particularly since World War II. With the increase in mink farming, an ocean fishery for bottom fish for mink food has evolved. In the 10-year period 1948-57 the following important questions arose concerning the otter-trawl fishery for mink food: (1) What is the total annual catch of whole fish by species landed for mink food? (2) What are the size composition and numbers of the three principal fillet soles (Dover sole, *Microstomus pacificus;* English sole, *Parophrys vetulus;* and Petrale sole, *Eopsetta jordani*) delivered for mink food markets? and (3) What are the effects of the mink food fishery on the production and economics of the Oregon trawl fishery?

HISTORY OF THE MINK FOOD FISHERY

The first Oregon mink ranch was established about 1925. During the early years of the industry there was no otter-trawl fishery for marine bottom fish in Oregon waters. Ranchers relied on sources of red meat such as horse meat and young dairy calves for the main protein constituent of the mink diets. Gradually certain species of fish such as starry flounder (*Platichthys stellatus*), caught incidentally by salmon gill netters, Columbia River smelt (*Thaleichthys pacificus*), and carp (*Cyprinus carpio*) were included in mink rations. It was not until there was a shortage of red meat during World War II that ocean fish came into general use by most mink ranchers.

After a decline in the numbers of mink raised by Oregon ranchers during World War II (approximately 56,000 animals in 1945), production increased to a total of about 250,000 mink in 1957. The value of pelts produced in 1957 was over $4,000,000.

Development of the Oregon trawl fishery during World War II made an inexpensive source of protein available to mink ranchers in the form of fish carcasses from fillet processors. Mink ranchers west of the Cascade Mountains used fillet scrap, supplemented with some whole fish, for as much as 80 per cent of the mink rations.

A sharp decline in the fillet market fishery in 1953, with little recovery in the following years, caused the demand for fillet scrap to exceed the supply. As result, an extensive fishery developed for whole fish for mink food. In 1953 several trawlers fished occasionally for mink food, and a few which had lost their fillet markets fished exclusively

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for mink food. In 1955 and 1956 mink ranchers purchased trawl boats and plants for catching and processing fish.

When an active otter-trawl research program began in January 1948, it became evident that information was needed on the relationship of the mink food fishery to the human food (fillet fish) fishery. Some fishermen declared that fillet fish stocks were being depleted because of their use as mink food. On the other hand, most mink ranchers and some fishermen insisted that no damage was being done since the mink food fish either had no value on the fillet market or would have been discarded at sea as too small and therefore wasted. This controversy has prevailed to the present time, although the entire trawl fleet now participates to some extent in the mink food fishery.

MINK FOOD PRODUCTION

Both whole fish and fillet scrap from the trawl fishery are sold for mink food in Oregon. Poundages of whole fish landed for mink food from 1953 through 1957 were obtained from reports filed with the Oregon Fish Commission by fish receivers. These data were compiled monthly for each vessel at each port. Before 1953 the total annual production was estimated from data received from mink ranchers on the amount of fish fed to their animals. Estimates of the total landings from 1948 to 1952 were computed from these data (Harry, 1956).

The fillet market fishery in Oregon showed a general downward trend from approximately 20 million pounds in 1948 to lows of 10 million pounds in 1953 and 1955 (Figure 1) but rose to about 16 million pounds in 1957. During this period the numbers of mink on Oregon ranches increased. Landings of whole fish for mink food rose sharply from about 2 million pounds in 1952 to 14 million pounds in 1956, when mink food exceeded fillet market landings by slightly over 2 million pounds.

Distribution of bottom fish landings of mink food among major Oregon trawl ports is given in Table 1 for 1953 through 1957. Astoria landings were 2.1 million pounds in 1953, rose to a high of 6.9 million pounds in 1956, and then declined to 3.9 million pounds in 1957. At Newport, the major portion of trawl fish received was mink food, since fillet processing was at a minimum between 1952 and 1957. Landings of whole fish for mink food at Newport ranged between 2.8 and 4.3 million pounds annually.

The establishment of processing plants by Oregon fur producers at Astoria in 1951 and at Newport in 1953 to receive only mink food was a major factor in increased landings at those ports. After 1955, most Astoria fillet plants also began receiving substantial quantities of whole fish for mink food. A similar situation developed at two fish-processing plants in Newport in 1955 and 1956.

The other Oregon trawl ports (Tillamook Bay, Winchester Bay, and Coos Bay) received only minor quantities of mink food until ranchers organized a company at Winchester Bay in 1955 to process mink food.

Combined landings at these three ports increased from about 0.2 million pounds in 1954 to almost 1.5 million pounds in 1955; in 1957 total landings (principally at Winchester Bay) approached those at Astoria and Newport (Table 1).

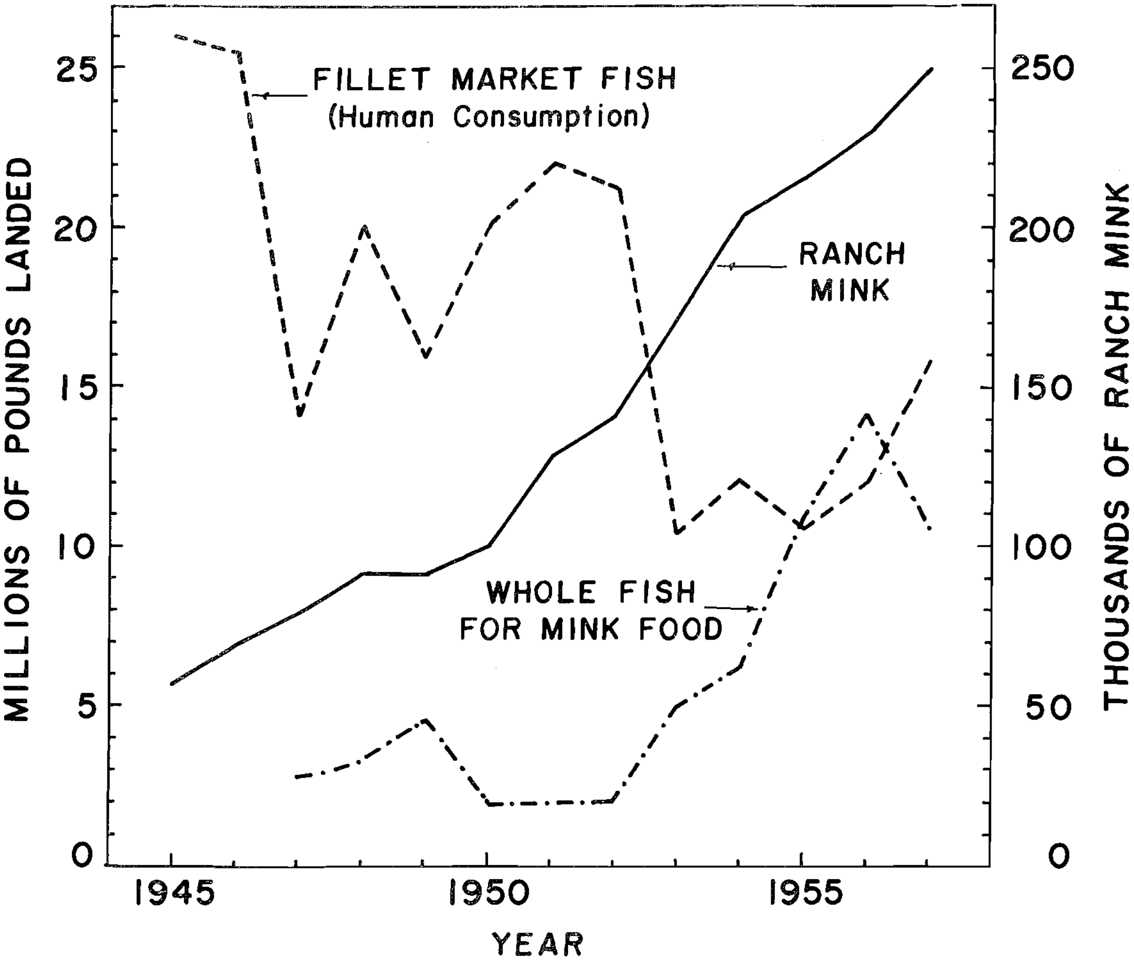

FIGURE 1. ANNUAL OREGON LANDINGS OF FILLET-MARKET FISH, WHOLE FISH FOR MINK FOOD, AND NUMBERS OF OREGON RANCH MINK, 1945-57.

TABLE 1. **WHOLE BOTTOM FISH LANDED IN OREGON PORTS FOR MINK FOOD, 1953–57.**

	LANDINGS IN POUNDS				
Port	*1953*	*1954*	*1955*	*1956*	*1957*
Astoria	2,088,000	2,400,000	5,940,000	6,855,000	3,896,000
Newport	2,813,000	3,542,000	3,558,000	4,303,000	3,469,000
Other①	76,000	197,000	1,457,000	2,963,000	3,214,000
Total	4,977,000	6,139,000	10,955,000	14,121,000	10,579,000

① Tillamook Bay, Winchester Bay, and Coos Bay Areas.

SPECIES COMPOSITION OF MINK FOOD LANDINGS

The catch of fish by otter-trawl nets usually consists of many species that are not retained for human consumption and are discarded at sea or saved for mink food. The species saved for mink food are generally not sorted and weighed separately when landed. To determine the numbers and weight of the species in the catch, it was therefore necessary to sample the landings. At the fish plant, the mink food was loaded into a box in the hold of the vessel and then hoisted to the dock. The sampling unit was a box of fish of known weight, usually about 600 pounds. One box usually was sampled from each load, although occasionally two were sampled. An attempt was made to choose each box in a non-selective manner.

The fish of each species were counted and average weights taken periodically. In most samples all Dover, English, and petrale soles were measured. Sex of these three species was determined from 1948 to 1952. After 1952, only occasional sex determinations for English sole were made.

Because mink food landings increased from 1953 through 1956, it was necessary to expand the sampling program. In each of the peak years, 1955 and 1956, approximately 90,000 fish were counted in a total of 130 samples, thus tending to give better distribution of samples by area fished. At each port, samples were combined and the percentage weight composition by species determined. These percentages were used in conjunction with total production figures to determine landings by species. The calculated landings by species at each port were combined to give the total for the state (Table 2).

TABLE 2. **SPECIES COMPOSITION OF OTTER-TRAWL LANDINGS DELIVERED FOR MINK FOOD IN OREGON, 1953–1956.**

	1953		*1954*		*1955*		*1956*	
Species	*Pounds*	*Per Cent*	*Pounds*	*Per Cent*	*Pounds*	*Per Cent*	*Pounds*	*Per Cent*
Dover Sole	547,000	11	677,000	11	759,000	7	1,700,000	12
English Sole	647,000	13	308,000	5	759,000	7	552,000	4
Petrale Sole	99,000	2	62,000	1	109,000	1	228,000	2
Bellingham Sole	348,000	7	184,000	3	217,000	2	82,000	1
Rex Sole	846,000	17	492,000	8	1,844,000	17	1,944,000	14
Turbot	1,045,000	21	1,907,000	31	4,448,000	41	4,239,000	30
Rockfishes	647,000	13	1,415,000	23	1,627,000	15	4,298,000	30
Miscellaneous Fishes	796,000	16	1,107,000	18	1,085,000	10	1,078,000	7
Total	4,975,000	100	6,152,000	100	10,848,000	100	14,121,000	100

In 1957 the sampling program was reduced and the principal objective was to determine the size composition of Dover, English, and petrale soles. The species composition of the mink food landings for the state was not calculated for this year.

Some forty species of fish were found in the mink food samples (Table 3). Six species of flatfish plus rockfishes comprised 90 per cent of the total mink food landed in most years studied.

Prior to 1953, only the percentage composition by number and weight of each species in the mink food samples was determined. Totals for the state were not computed. For these years Rex sole was dominant in the samples both by weight and numbers, except in 1948 when English sole was dominant. Second in importance, by numbers, varied by year and port among starry flounder, Dover sole, petrale sole, and Bellingham sole. Third in importance varied among Rex sole, rockfish, sand dab, starry flounder, Bellingham sole, and English sole (scientific names are given in Table 3).

Dover sole landed for mink food ranged from 0.5 million pounds in 1953 to 1.7 million pounds in 1956, or 11 per cent of the annual mink food landings. Dover sole is one of the principal flatfishes filleted in Oregon for human consumption; from 1952 through 1957, landings for human consumption ranged from 2.5 to 5.8 million pounds. Because it is in demand for both human and animal food, Dover sole has been the subject of considerable research by Oregon Fish Commission biologists and the source of controversy among fillet-market fishermen, mink-food fishermen, and mink ranchers.

TABLE 3. **FISH COUNTED IN MINK FOOD SAMPLES, ASTORIA AND NEWPORT, 1953 AND 1954.**

Common Name	*Scientific Name*
Flatfish	
Arrowtooth flounder, turbot	*Atheresthes stomias*
Flathead sole	*Hippoglossoides elassodon*
English sole	*Parophrys vetulus*
Rex sole	*Glyptocephalus zachirus*
Sand dab	*Citharichthys sordidus*
Rock sole	*Lepidopsetta bilineata*
Petrale sole	*Eopsetta jordani*
Sand sole	*Psettichthys melanostictus*
Bellingham sole	*Isopsetta isolepis*
Slender sole	*Lyopsetta exilis*
Dover sole	*Microstomus pacificus*
Starry flounder	*Platichthys stellatus*
Rockfish	
Pacific Ocean perch	*Sebastodes alutus*
Silvergray rockfish	*S. brevispinis*
Blackmouth rockfish	*S. crameri*
Splitnose rockfish	*S. diploproa*
Greenstriped rockfish	*S. elongatus*
Yellowtail rockfish	*S. flavidus*
Chilipepper	*S. goodei*
Black rockfish	*S. melanops*
Blue rockfish	*S. mystinus*
Bocaccio	*S. paucispinis*
Canary rockfish	*S. pinniger*
Flag rockfish	*S. rubrivinctus*
Stripetail rockfish	*S. saxicola*
Shortspine channel rockfish	*Sebastolobus alascanus*

TABLE 3—Continued.

Miscellaneous Fish

Common Name	*Scientific Name*
Shad	*Alosa sapidissima*
Eel pout	Family Zoarcidae
Jack mackerel	*Trachurus symmetricus*
Lingcod	*Ophiodon elongatus*
True cod	*Gadus macrocephalus*
Hake	*Merluccius productus*
Dogfish	*Squalus acanthias*
Tom cod	*Microgadus proximus*
Sea poachers	Family Agonidae
Ratfish	*Hydrolagus colliei*
Blackcod	*Anoplopoma fimbria*
Sculpins	Family Cottidae
Skates	Family Rajidae

English sole in the mink food landings ranged from 308,000 to 759,000 pounds in the 4-year period 1953-1956 and the proportion of the total annual landings decreased from 13 per cent in 1953 to 4 per cent in 1956. English sole is the second most valuable flatfish processed for fillets in Oregon. Since 1953, landings for the fillet markets have ranged from 800,000 to 900,000 pounds annually.

Of the three most important flatfish in the otter trawl fishery, petrale sole was in greatest demand by fillet markets. Landings for fillet processing have ranged from 0.8 to 1.1 million pounds annually since 1953. This species, however, has constituted only 1 or 2 per cent of the total animal food landings, although the poundage increased steadily from 62,000 in 1954 to 228,000 in 1956.

Arrowtooth flounder has been utilized for mink food more than any other species, primarily on the basis of diet studies conducted since 1952 with ranch mink at the Experimental Fur Farm at Oregon State University (Watt, 1951). Oregon landings increased from none in 1950 to over 4 million pounds in 1955. Arrowtooth flounder is not now landed for fillet markets, although attempts were made in 1943 and 1949 to use this species for human consumption. Large quantities are still discarded at sea from the fillet market and shrimp fisheries. This species is underutilized and production for mink food should be encouraged.

Bellingham sole is not processed for human consumption in Oregon. Although considered a desirable fish for mink, it has not been actively sought by the mink food fishery. Landings declined from 348,000 pounds in 1953 to 82,000 pounds in 1956. Generally, this fish is seasonal in appearance on the trawl grounds fished by mink-food boats.

Rex sole is first in numbers, but not in pounds, landed for mink food markets. Landings increased from 492,000 pounds in 1954 to 1,944,000 pounds in 1956, constituting between 8 and 17 per cent of the mink food total. The species appears to have a wide distribution both in depth and range along the Oregon and Washington coasts and has become increasingly important to Oregon fillet processors in recent years.

Rockfishes include about 20 species important in mink diets. Landings increased from 0.6 million pounds in 1953 to 4.3 million pounds in 1956. Most of the landings are at Newport and Winchester Bay, where fillet processing is conducted on a small scale. Five species comprise 85 percent of the rockfish landings. In order of importance, by weight, they are: *Sebastodes pinniger*, S. *alutus*, S. *paucispinis*, S. *rubrivinctus*, and *Sebastolobus alascanus*. The relative annual landings of rockfish for mink food, by species, from 1953 to 1956 are shown in Figure 2. All species listed above except *Sebastolobus alascanus* are also processed for fillets. Of these, the Pacific Ocean perch, *Sebastodes alutus,* and the canary rockfish, *S. pinniger,* are the most important. Rockfish landings for fillet markets in Oregon, exclusive of Pacific Ocean perch, ranged from 1.0 to 2.6 million pounds annually during the period 1953-56. Annual Pacific Ocean perch landings ranged from 1.6 to 3.6 million pounds during the same period.

The miscellaneous category of fishes landed for the mink food market includes 12 to 15 species, each of which generally comprised less than 1 per cent of the total annual landings, or a total of about 1 million pounds in each of the 4 years. Landings of this group decreased from 16 per cent of the total in 1953 to 7 per cent in 1956.

SIZE COMPOSITION

To understand the effect on the stocks of fish of catches of Dover, English, and petrale soles for mink food, it was necessary to know the size distribution and numbers of these species landed for both mink food and fillet markets. Measurements were taken to the nearest lower centimeter (to eliminate bias by the sampler) for most of the three species.

The following steps were taken to calculate numbers at each size-interval landed by the mink food and fillet market fisheries:

1. Numbers of fish measured at each size-interval were combined to form a length-frequency distribution.
2. Total weight landed at each port was computed.
3. Total weight was converted to total numbers by use of average weights.
4. Sample length-frequency distributions were expanded to the calculated total numbers to compute the size composition of the total landed for mink food at each port.
5. Length-frequency distributions from each port were combined to form a length-frequency distribution of the total landed in the state.

The relative length-frequency distributions of Dover sole landed for mink food during the years 1953 through 1957 and comparison of the numbers of fish landed for the mink food and fillet markets are shown in Figure 3. The minimum size of Dover sole generally accepted by Oregon fillet processors is about 14 inches.

Dover sole landed for mink food ranged from 4 to 24 inches with the

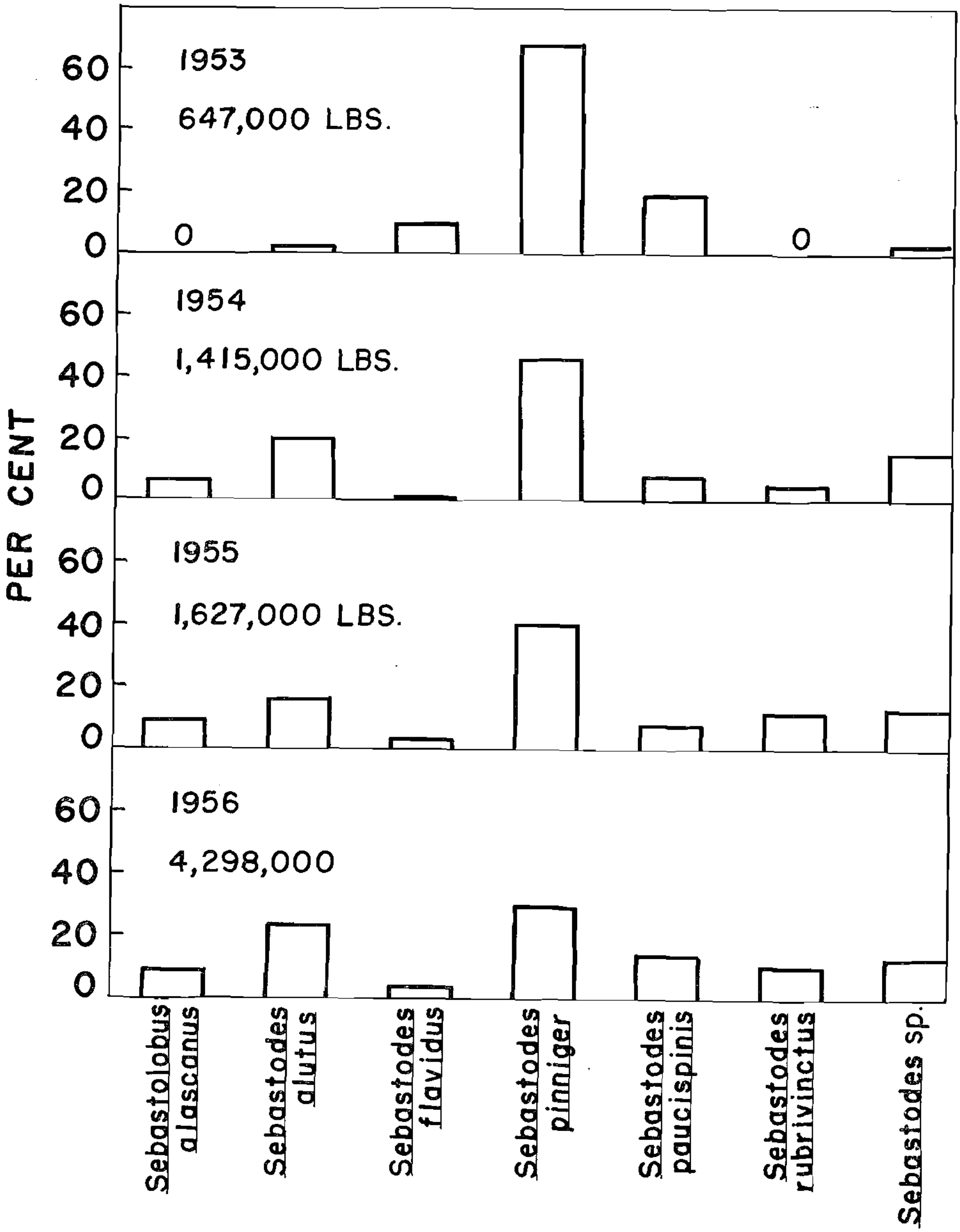

FIGURE 2. RELATIVE POUNDAGES AND PERCENTAGES OF THE MAJOR SPECIES OF ROCKFISH LANDED FOR MINK FOOD IN OREGON, 1953-56.

mode at 14. The ratio of estimated numbers of this species landed for mink food to estimated numbers landed for the fillet market varied from 1:4 in 1954 to 1:0.8 in 1956. The numbers of fish smaller than the 14-inch discard length landed for mink food increased from approximately 0.25 million in 1953 and 1954 (over 40 per cent of the total) to around 1 million in 1956 and 1957, 63 and 84 per cent, respectively.

The steady increase during the 5-year period in Dover sole landed for mink food makes it apparent that this species was actively sought for animal food. This becomes more obvious when it is considered that data from sampling catches at sea indicate that an average of about 20

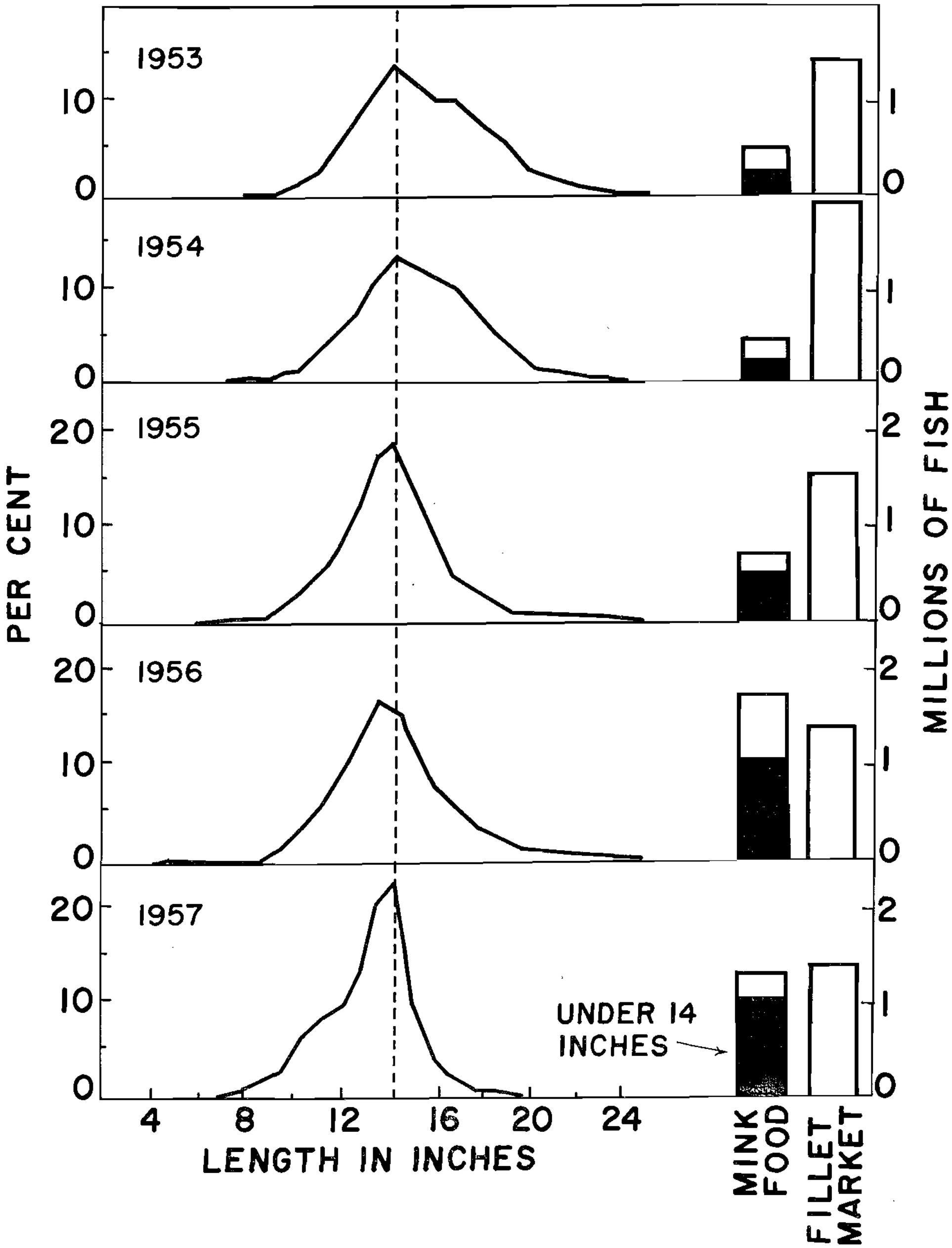

FIGURE 3. LENGTH-FREQUENCY DISTRIBUTIONS OF DOVER SOLE IN MINK FOOD LANDINGS AND NUMBERS LANDED FOR MINK FOOD AND FILLET MARKET, 1953-57.

per cent of the Dover sole caught while fishing for the fillet markets was discarded as too small. The percentage discarded, of course, varies considerably, depending on the mesh size of the net and grounds fished.

The size distribution of mink food English sole from 1953 through 1955 ranged between 6 and 22 inches with the mode at about 13, which is close to the minimum generally required by fillet plants (Figure 4). In 1956 the English sole in the mink food landings were generally larger and the mode occurred at about 15 inches. The fish were not sorted by size for use in fillet markets, but were landed exclusively for mink food, which accounts for the larger size distribution in 1956. In 1957 the mode was only about 11 inches. The decrease could have been due to sample bias, but it was more likely due to the use of the three-inch-mesh net (smaller than previously used) and the discovery by mink food fishermen that it was profitable to sort out fillet fish.

In each of the 5 years, except 1954, numbers of English sole landed for mink food equalled or exceeded those landed for fillet markets. The numbers of mink food fish smaller than the discard length of 13 inches varied between 64 and 91 per cent of the total, except in 1956 when only 20 per cent were smaller than the minimum fillet size. The generally large proportion of undersized English sole is not as important as may first appear. Male fish, which are usually smaller than minimum fillet size even when mature, outnumbered females by about 2 to 1 in the mink food samples.

Petrale sole are not as abundant as other species in the mink food landings. However, because they are intensely fished for the fillet market, adding fishing pressure may be detrimental. Therefore, close observation of the landings of petrale sole for mink food should be continued.

The size of petrale sole in mink food landings ranged between 5 and 21 inches (Figure 5). A minimum of 13 inches is imposed by fillet plants but is not rigidly observed. The modes in the mink food length-frequency distributions occurred between 12 and 13 inches, except in 1957 when the mode was about 9 inches. Between 55 and 87 per cent of the fish were less than the discard length. There was a steady increase in numbers of petrale sole landed for mink food, from 93,000 in 1953 to 342,000 in 1957. The latter figure approaches the fillet market landings.

INTENSITY OF THE MINK FOOD FISHERY

All but a few of the trawl vessels in the Oregon fleet participated to some extent in the mink food fishery during the period 1953-57. Most of the trawl boats at Newport and Winchester Bay had no markets other than for mink food during this period.

Early in the history of the fishery at Astoria, mink food was generally landed incidentally to fillet market deliveries. By 1953, some trawlers had only limited markets for fillet fish because of adverse market conditions, and by 1954 some vessels in the Astoria area were fishing exclusively for mink food at least part of the year. Others were actively seeking animal food in conjunction with fillet market fishing. A mink rancher in the Astoria area purchased a trawl boat in 1955 to fish for mink

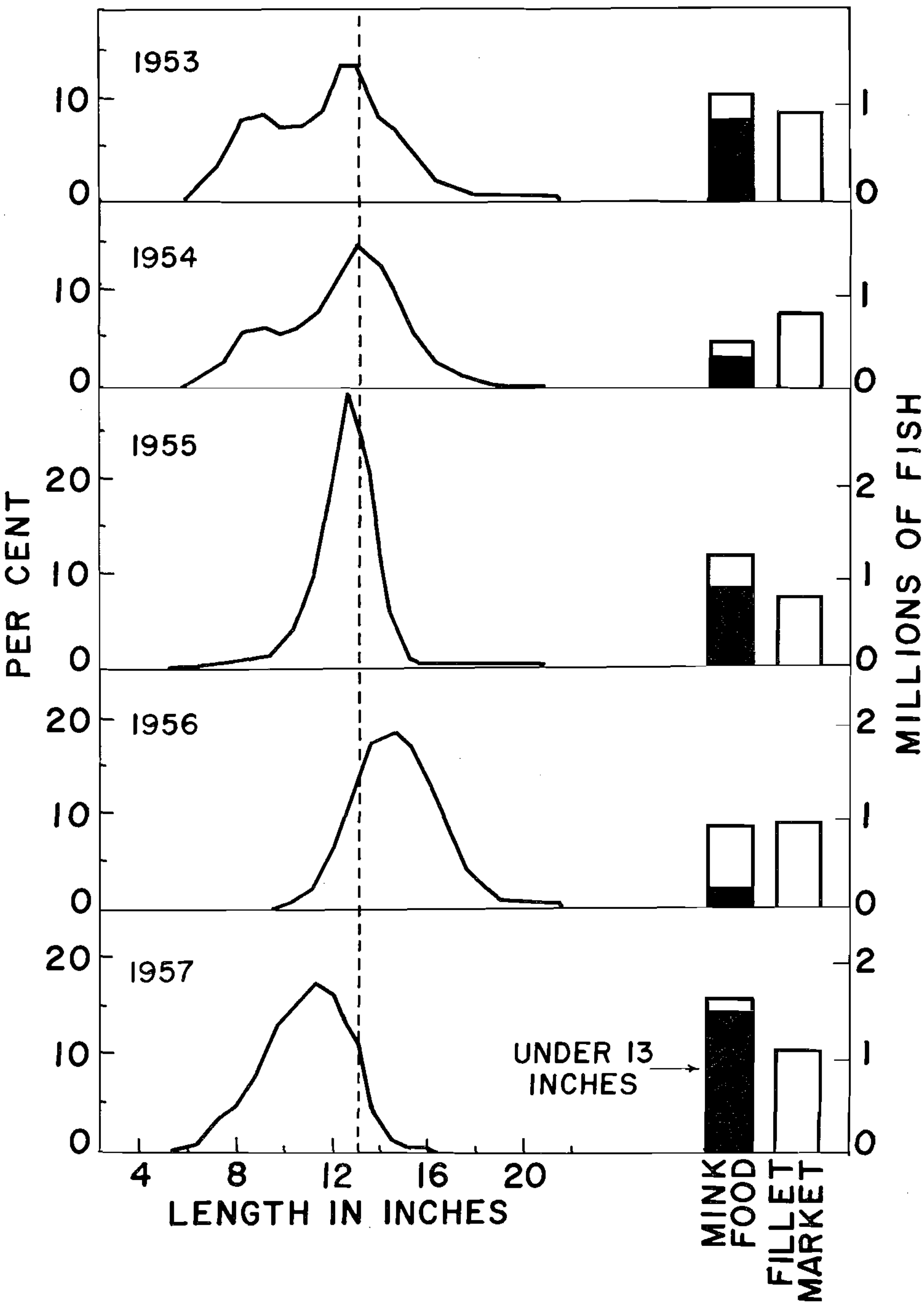

FIGURE 4. LENGTH-FREQUENCY DISTRIBUTIONS OF ENGLISH SOLE IN MINK FOOD LANDINGS AND NUMBERS LANDED FOR MINK FOOD AND FILLET MARKET, 1953-57.

food and by 1957 three other trawlers were controlled by mink ranchers, although not always used exclusively for this purpose.

During 1956, 26 of the 38 boats in the Oregon trawl fleet fished for the animal food market all or part of the time. The remaining 12 generally

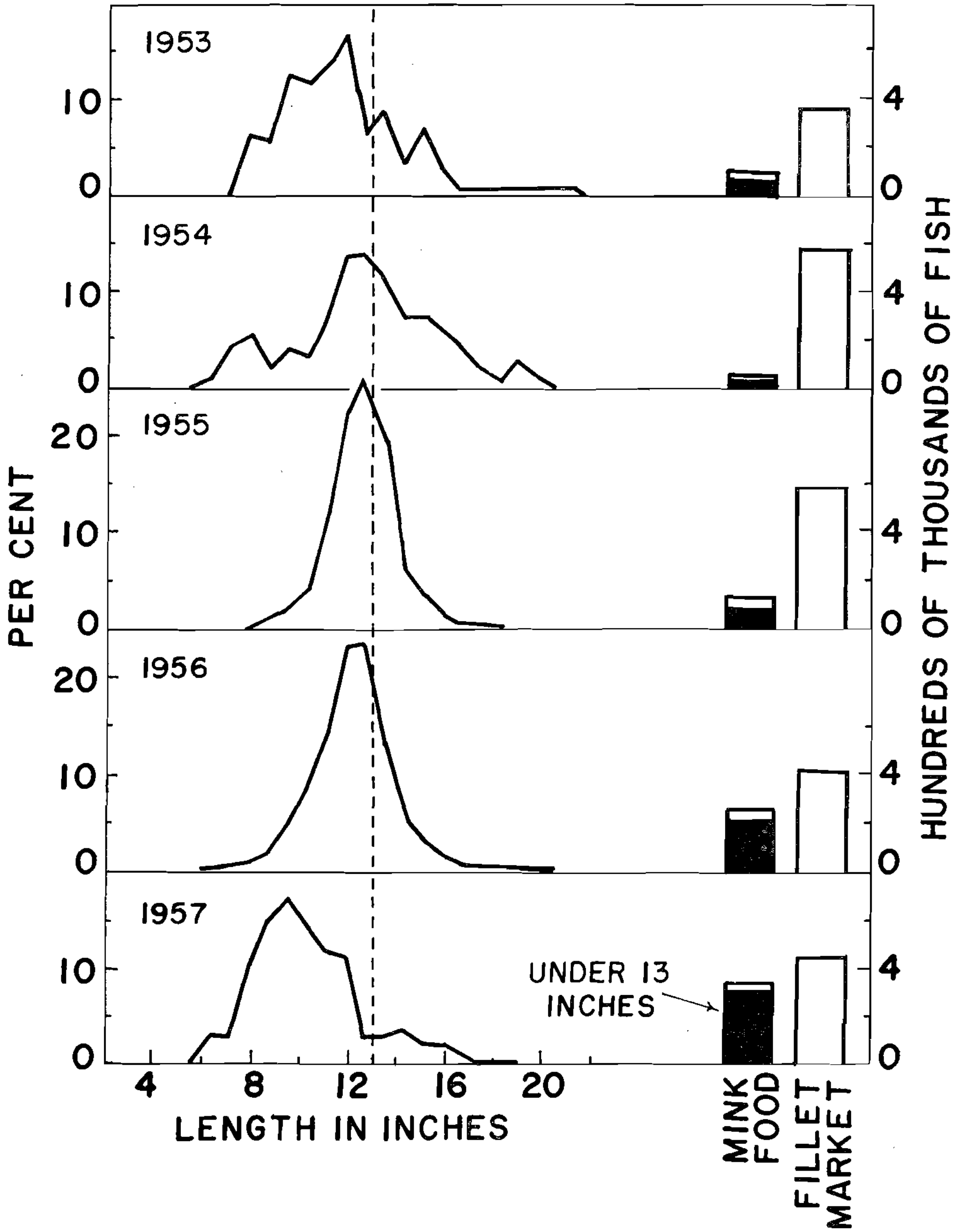

FIGURE 5. LENGTH-FREQUENCY DISTRIBUTIONS OF PETRALE SOLE IN MINK FOOD LANDINGS AND NUMBERS LANDED FOR MINK FOOD AND FILLET MARKET, 1953-57.

made landings of mink food caught incidentally while fishing for fillet markets.

Relative intensity of the mink food fishery on Oregon fishing grounds is depicted in Figure 6. Fishermen usually report the area where most of their catch was made either by sardine block number or loran and depth readings. The sardine block or grid system was adopted from the California method of dividing the fishing waters into approximately

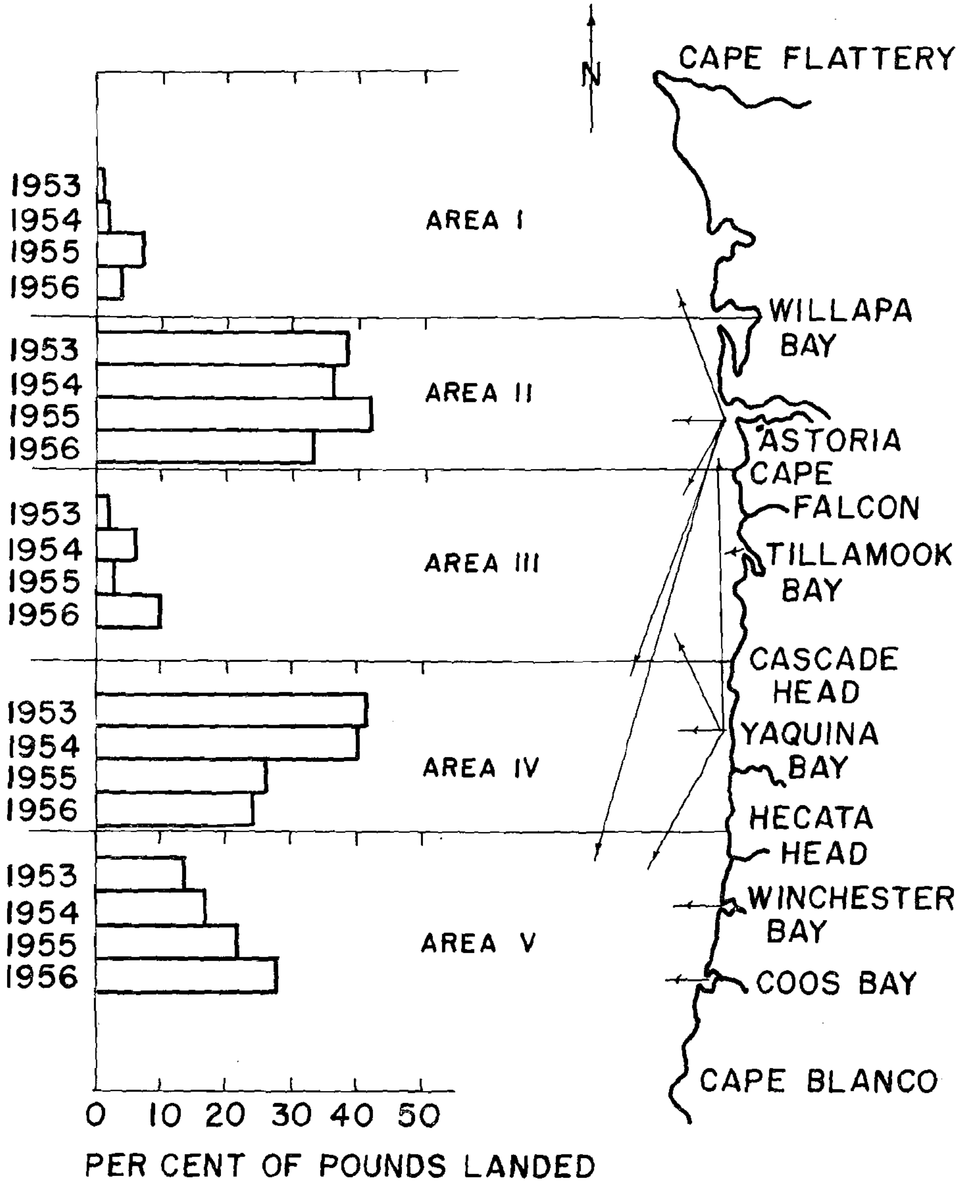

FIGURE 6. RELATIVE DISTRIBUTION, IN PER CENT, OF OREGON TRAWL LANDINGS OF MINK FOOD, BY AREA OF CATCH, 1953-56.

10-mile-square blocks, each identified by number. Several sardine blocks within a general fishing area might be fished in one trip.

For this study, fishing grounds off Oregon and Washington were defined as follows: Area I, Cape Flattery to Willapa Bay; Area II, Willapa Bay to Cape Falcon (this is called the "local" area for the Astoria fleet); Area III, Cape Falcon to Cascade Head; Area IV, Cascade Head to Heceta Head; Area V, Heceta Head to the California border.

Area I was not heavily fished for mink food by Oregon boats in any year under study. Generally, less than 5 per cent of the total pounds landed in Oregon came from this area.

Area II produced 2 million pounds of mink food in 1953 and 1954 and 4.5 million pounds in 1955 and 1956. This was about 80 per cent of the Astoria mink food landings each year and 35 to 40 per cent of the total Oregon landings.

In Area III the narrow continental shelf limits the trawling grounds, and production of mink food varied from 100,000 pounds in 1953 (2 per cent of the total) to 1,440,000 pounds in 1956 (10 per cent).

Area IV contains fishing grounds heavily utilized by Newport trawlers, particularly in 1953 and 1954 when about 40 per cent of the total landings, approximately 2.1 and 2.3 million pounds, respectively, were taken. In 1955 and 1956 landings from this area increased to 2.8 and 3.4 million pounds, respectively, but the proportion dropped to 25 per cent because of heavier fishing by Newport boats in Areas III and V.

Area V was fished by Newport trawlers in 1953 and 1954 and produced about 15 per cent (0.1 and 1.0 million pounds, respectively) of the total pounds of mink food delivered. Development of the mink food fishery out of Winchester Bay in 1955 and 1956 increased production from this area, mainly north of Cape Blanco, to 2.4 and 3.9 million pounds, respectively.

Fish for mink food brings only about half as much as that for the fillet market, and to compensate for this lower return, mink food fishermen remain close to their home ports. This accounts for the heavy fishing in areas directly off the major trawl ports.

ECONOMIC EFFECTS OF THE MINK FOOD FISHERY

The mink food fishery from 1952 through 1957 contributed substantially to the income of many Oregon trawl fishermen, and for some it was their main income. The calculated income received by trawl fishermen from deliveries of fillet market and mink food fish from 1952 through 1957 is given in Table 4. The value of fillet market fish is based on an average price of 5 cents per pound from 1952 through 1955 and 5.5 cents per pound in 1956 and 1957. Total income for fillet fish ranged from $1,065,000 in 1952 to a low of $520,000 in 1953 and then rose to $895,000 in 1957.

The amount received by fishermen for mink food increased from $156,000 in 1952 to $454,000 in 1956, then declined to $354,000 in 1957. The value of whole fish delivered for mink food was based on a price

TABLE 4. **CALCULATED INCOME RECEIVED BY OREGON TRAWL FISHERMEN FOR FISH DELIVERED, 1952–57.**

	1952	*1953*	*1954*	*1955*	*1956*	*1957*
Total Fillet Market①	$1,065,000	$ 520,000	$ 600,000	$ 525,000	$ 660,000	$ 895,000
Whole Fish Mink Food②	$ 50,000	$ 125,000	$ 155,000	$ 272,000	$ 388,000	$ 265,000
Fillet Scrap Mink Food③	$ 106,000	$ 52,000	$ 60,000	$ 52,000	$ 66,000	$ 89,000
Total Mink Food	$ 156,000	$ 177,000	$ 215,000	$ 324,000	$ 454,000	$ 354,000

① Fillet market fish value based on an average price of 5¢ per pound in 1953-55 and 5.5¢ per pound in 1956-57.

② Whole fish for mink food based on a price of 2.5¢ per pound in all years except 1956, when it was 2.75¢ per pound.

③ Fillet scrap has an indirect value. The fishermen receive approximately 10 per cent more for fillet market fish because most of the fillet scrap can be sold for mink food.

of 2.5 cents per pound in all years except 1956, when it was 2.75 cents per pound. Fillet carcasses sold for mink food add approximately 0.5 cent per pound or 10 per cent of the total value of the fillet market fish. In 1952 the value to the fishermen of whole fish delivered for mink food amounted to only 5 per cent of the value of the fillet market fish; in 1953 and 1954, 24 and 26 per cent, respectively; and in 1955 and 1956, 52 and 59 per cent, respectively. Increased landings of fillet fish in 1957 reduced the proportion of mink food income to 30 per cent.

DISCUSSION

The mink food fishery contributed substantially toward maintaining the Oregon trawl fleet at a level of about 40 vessels during the years 1952-57, stabilized employment for fishermen, and maintained businesses servicing the fleet. By the same token, communities with mink food processing plants benefited from the fishery. In fact, fishing and processing fish for mink food has become an industry in its own right in Oregon. However, as a separate industry, the mink food fishery has come into competition with the fillet market fishery, evidenced by the increasing quantities of Dover and petrale soles landed for mink food. The numbers of these species in mink food landings have closely approached or exceeded those landed for fillet markets. Most of these fish as well as English and rex sole landed for mink food are not large enough to be used by fillet markets.

No management regulations were imposed on the mink food fishery prior to 1955 since the Oregon Fish Commission felt that beneficial effects of the fishery outweighed possible detrimental effects. However, greatly increased production of mink food in 1954 and 1955 resulted in a re-examination of the problem. Studies of the stocks of Dover sole off Astoria indicated that increasing fishing pressure would impose a serious strain on this species. It was also felt that stocks of English and petrale soles could be adversely affected by increased fishing.

Consequently, in 1955, Dover, English, and petrale soles landed for mink food were limited to 20 per cent of the total poundage of each landing of mink food and fillet market fish combined. In 1956 this regulation was amended to 20 per cent of only the mink food landing and a mesh size was imposed on all the trawlers, permitting use of either 4½-inch or larger mesh (stretched measure between the knots) or 3½-inch or smaller. The small-mesh net was permitted for fishing Pacific Ocean perch.

These regulations did not prove effective in reducing the landings of the three fillet market species for animal food. Many mink food fishermen adopted the small-mesh net as an effective gear for making quantity catches of fish.

Because of the large numbers of small (less than fillet market size) Dover, English, and petrale soles landed for mink food in 1957, a regulation limiting the minimum size of these species landed for any purpose to 11 inches was placed in effect in the fall of 1958.

SUMMARY

The Oregon trawl fishery for mink food developed under the impetus of an increase in Oregon mink ranching and general decline of the fillet market fishery. Whole fish landed for mink food rose from 2 million pounds in 1950 to a peak of over 14 million in 1956, which was 2 million in excess of fillet market landings for that year.

A program was developed in 1948 to study the mink food fishery and its relationship to the fillet market fishery. It was determined that mink food landings were composed of the following species in order of importance by weight: (1) arrowtooth flounder; (2) rockfishes, a group of 20 or more species, of which the canary rockfish and Pacific Ocean perch are the most important; (3) rex sole, the species landed in greatest numbers; (4) Dover sole, an important fillet market species; (5) English sole, also valuable in the fillet markets; (6) Bellingham sole; and (7) petrale sole.

It was found that in many years most of the Dover, English, and petrale soles landed for mink food were smaller than the minimum size accepted for fillet processing and that the numbers of Dover and petrale soles delivered for mink food increased steadily until in 1956 and 1957 they approached or exceeded the numbers delivered for the fillet markets.

Almost all vessels in the Oregon trawl fleet participated to some extent in the mink food fishery during the period of this study. Some vessels fished mainly for mink food all or part of the time.

The areas fished most heavily for mink food and the ports from which the boats came were: off the mouth of the Columbia River—Astoria; off the Yaquina River and south on the Heceta Banks—Newport; and off the mouth of the Umpqua and Coos Rivers—Winchester Bay and Coos Bay.

The mink food fishery contributed substantially to the income of Oregon trawl fishermen—up to 50 per cent in some years—and permitted them better to utilize their entire catch. However, the increased intensity of this fishery could have an adverse effect on some species.

Since 1955, management regulations have been in effect to control landings of Dover, English, and petrale soles for animal food.

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Biological Observations and Results of the 1960 John N. Cobb Exploratory Shrimp Cruise Off the Central Oregon Coast

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and
AUSTIN R. MAGILL[2]

INTRODUCTION

The U. S. Bureau of Commercial Fisheries, in cooperation with the Oregon Fish Commission, conducted exploratory cruise 48 with the exploratory vessel *John N. Cobb* from September 26 to November 4, 1960, along the Oregon coast in the area extending from the Coquille River northward to Stonewall Bank, southwest of Newport, at depths from 51 to 105 fathoms.

The primary objectives of the cruise were to locate new shrimp beds which could support expansion of the industry and to collect life history information pertinent to management of ocean shrimp. Because of the limited known trawl fishing grounds in this region, a secondary benefit was to find areas, previously unfished, on which commercial trawlers could operate.

Several previous explorations have been conducted on the Pacific Coast by the Bureau of Commercial Fisheries, the Oregon Fish Commission, and the California Department of Fish and Game. During the 1950's the *John N. Cobb* engaged in shrimp explorations off Alaska, Washington, and northern Oregon. Shrimp explorations were carried out off the Oregon coast by the Oregon Fish Commission in 1951 and 1952. The California Department of Fish and Game has conducted several explorations along the California coast since 1950.

The 1951-52 explorations by the Oregon Fish Commission (Pruter and Harry, 1952) were designed to determine if shrimp were available in commercial quantities and to gather information on the shrimp populations before they were subjected to a commercial fishery. A total of 80 beam-trawl drags was made in the area from Port Orford, Oregon, northward to the mouth of the Columbia River. Results indicated that pink shrimp (*Pandalus jordani*) were present in sufficient numbers to support a commercial fishery. Best catches were taken where the bottom consisted of green mud or green mud and sand.

During 1958 the Bureau of Commercial Fisheries explored for shrimp along the Washington and northern Oregon coast (Alverson, McNeely, and Johnson, 1960). A total of 157 drags was made between the Yaquina River and mouth of the Columbia River at depths of 62 to 275 fathoms. A 43-foot Gulf-of-Mexico-type shrimp trawl or 72-foot Gulf-of-Mexico-type semi-balloon trawl was used during this survey. Of these 157 drags, 31 made at depths from 70 to 110 fathoms produced pink shrimp at a rate of 400 pounds or more per hour of fishing. The best tow, made at a depth of 82-83 fathoms 22 miles west of Tillamook Head, yielded 2,800 pounds per hour.

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HISTORY OF OREGON SHRIMP FISHERY

Prior to these explorations, commercial fishermen reported shrimp inhabiting waters off the Oregon coast, but no attempt was made to delineate the geographical extent of the shrimp beds or assess the magnitude of the populations until the exploratory fishing of 1951 and 1952. Although shrimp were reported available in commercial quantities at that time, it was not until 1957 that serious commercial shrimp fishing was begun along the Oregon coast.

In the late summer of 1957 several California trawlers caught about 200,000 pounds of shrimp in the area off Coos Bay. These catches were landed at the ports of Coos Bay and Winchester Bay, Oregon. Soon after, Astoria boats began fishing for shrimp between the Columbia River and Cascade Head, and over 100,000 pounds were landed in the Astoria area during 1957.

With the installation of peeler machines at two plants in Warrenton, Oregon, the fishery expanded rapidly and the bulk of the 1958, 1959, and 1960 shrimp catches was landed at Warrenton. In 1959 about 400,000 pounds and in 1960 about 500,000 pounds of shrimp caught in the waters off southern Oregon and northern California were landed at the southern Oregon port of Brookings. This shrimp was subsequently transshipped to Eureka, California, where it was handpicked for the markets. Interest in shrimping off Coos Bay was renewed in 1960 when about 80,000 pounds were landed at Charleston.

The number of boats fishing each year has varied with the availability of shrimp, prices, and demand for bottom fish. A total of 7 boats, 3 in the Coos Bay area and 4 in the Astoria area, made shrimp landings in 1957. In 1958, 18 boats landed shrimp in the Astoria area, and in 1959 22 boats, 14 in the Astoria area and 8 in Brookings, made landings. About half of these boats fished shrimp regularly and the others made from one to four trips per year. The number of boats fishing in 1960 decreased to 5 in the Astoria area, 2 in the Coos Bay area, and 7 at Brookings. Of these 14, only 8 made sizeable landings.

Shrimp landed in Oregon supply two different markets. Landings in the Astoria area are processed by machine, canned in 4½-ounce tins or frozen in 5-pound tins, and used in shrimp cocktails and cooked shrimp dishes. This is the product called "tiny (or small) cocktail shrimp". Shrimp landed in Coos Bay and Brookings are processed by handpicking and purchased fresh or frozen by restaurants and hotels for shrimp salads where appearance is of primary concern. The handpicked shrimp are usually intact and have better color and appearance than those peeled by machines.

Shrimp fishermen in Oregon are unrestricted by landing quotas or area or season closures. Gulf shrimp trawls are lawful as long as the mesh is from 1¼ to 2 inches (taut measure between knots). When fishing started in 1957, only beam trawls were lawful, but after considering the possibilities of the fishery, shrimp trawls were considered more suitable for the development of the Oregon shrimp fishery, and were therefore made legal in 1958 by the Oregon Legislature.

OREGON'S SHRIMP RESEARCH PROGRAM

Shrimp research undertaken by the biologists of the Oregon Fish Commission is designed to enlarge our knowledge of pink shrimp life history and areas of concentration, and to compile and analyze catch records to determine population trends. These studies are pursued by collecting shrimp samples during the unloading of commercial boats, at sea aboard commercial vessels, and during exploratory cruises. Samples are measured, sexed, and weighed to determine the size and age composition by sex and heads-on-count per pound. Through interviews with the fishermen, areas, depths, and amounts of catch for each tow are determined. Catch data logged by fishermen provide information on catch, fishing effort, and catch-per-unit effort for the important fishing areas.

REGIONS EXPLORED BY THE *JOHN N. COBB* IN 1960

Explorations in 1960 were conducted off the south central Oregon coast where little exploratory work had previously been done (Figure 1). Although only a small fishery was operating in this area, the landing ports have the necessary processing and storage facilities to support a larger fishery.

The most prominent feature of the continental shelf in this area is Heceta Bank which extends 35 miles offshore and is the widest portion of the shelf along the Oregon coast. The bank ranges in depth from 50 to 75 fathoms and has two prominent shallow areas of about 25 fathoms. South of Heceta Bank the shelf decreases in width until it reaches its narrowest point off the Coquille River.

GEAR AND EQUIPMENT

A Gulf-of-Mexico-type flat shrimp trawl constructed of 1½-inch stretched mesh and measuring 43 feet along the footrope (Schaefers and Johnson, 1957 and Alverson, McNeely, and Johnson, 1960) was used during the explorations. The doors, connected directly to the net, measured 2½ by 5 feet, weighed 160 pounds, and were attached to a single warp line by a 20-fathom bridle. No "dandyline" gear was used.

After every drag a bathythermograph and Dietz-LaFond sampler were used to obtain surface-to-bottom water temperatures and bottom samples, respectively.

METHODS

Exploratory

All drags were of ½-hour duration. The first 10 drags were made on grounds currently fished by shrimp trawlers to establish that the fishing gear was functioning satisfactorily. Since previous exploratory shrimp investigations showed that best catches are generally made in areas where the bottom consists of green mud or green mud and sand, a major effort was made to explore regions indicated by charts as having this bottom type.

To locate soft trawlable grounds free of snags or other obstructions, sounding transects were run, using a high-resolution echo sounder (Hitz,

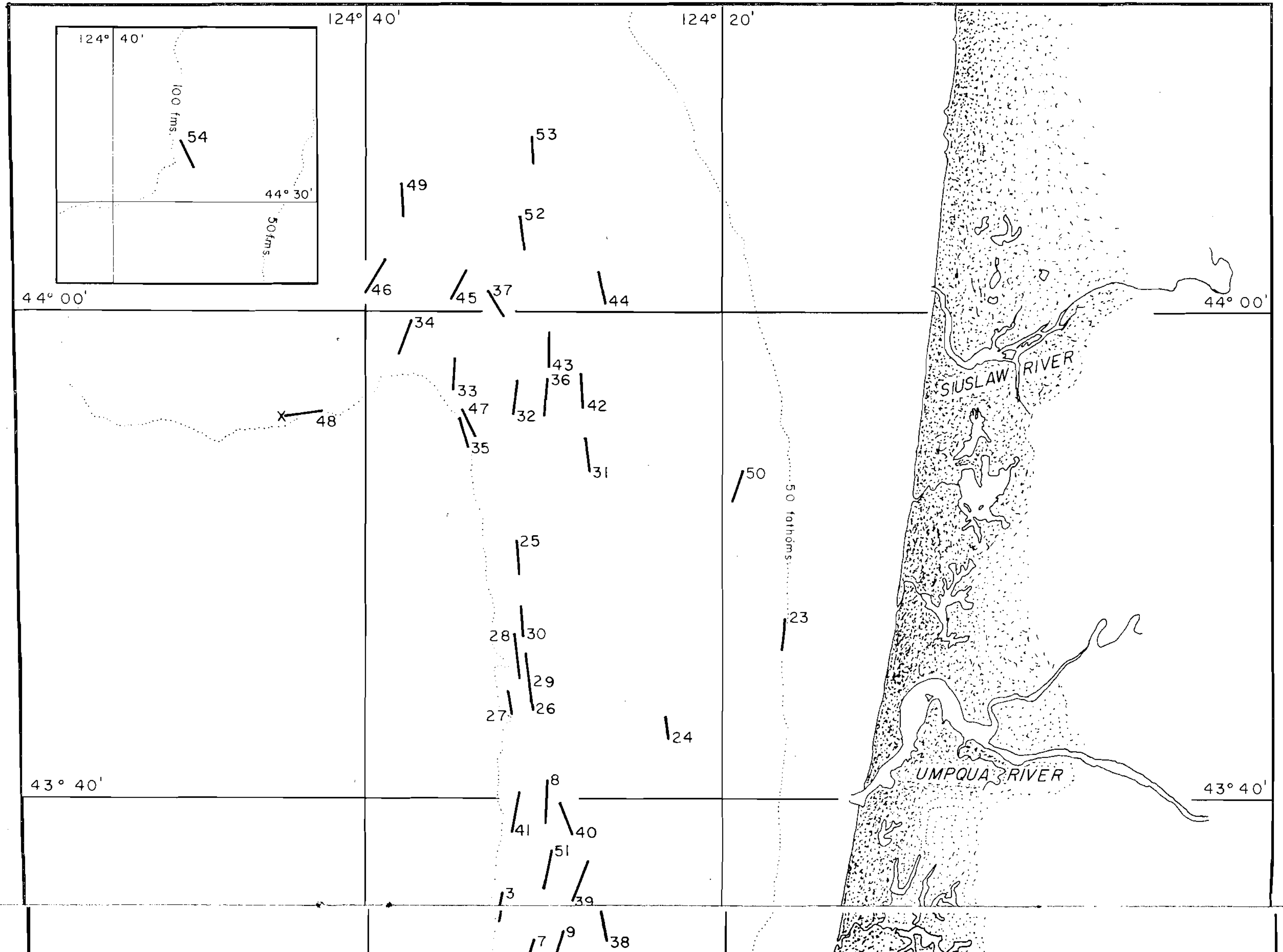
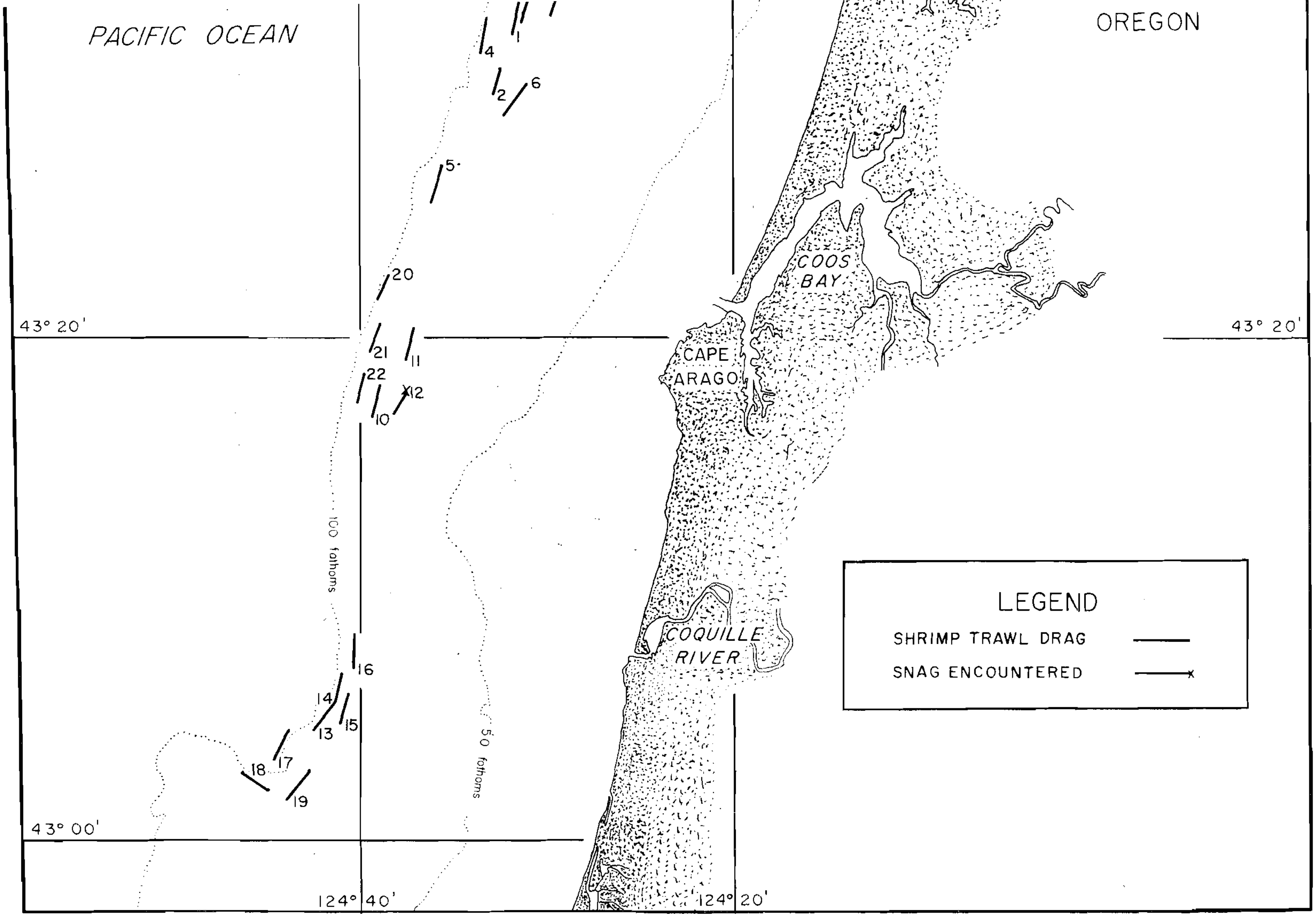


FIGURE 1. LOCATION OF SHRIMP TRAWL DRAGS OFF THE OREGON COAST.


PACIFIC OCEAN
OREGON
COOS BAY
CAPE ARAGO
COQUILLE RIVER
100 fathoms
50 fathoms
43° 20'
43° 20'
43° 00'
124° 40'
124° 20'
1
2
4
5
6
10
11
12
13
14
15
16
17
18
19
20
21
22
LEGEND
SHRIMP TRAWL DRAG
SNAG ENCOUNTERED

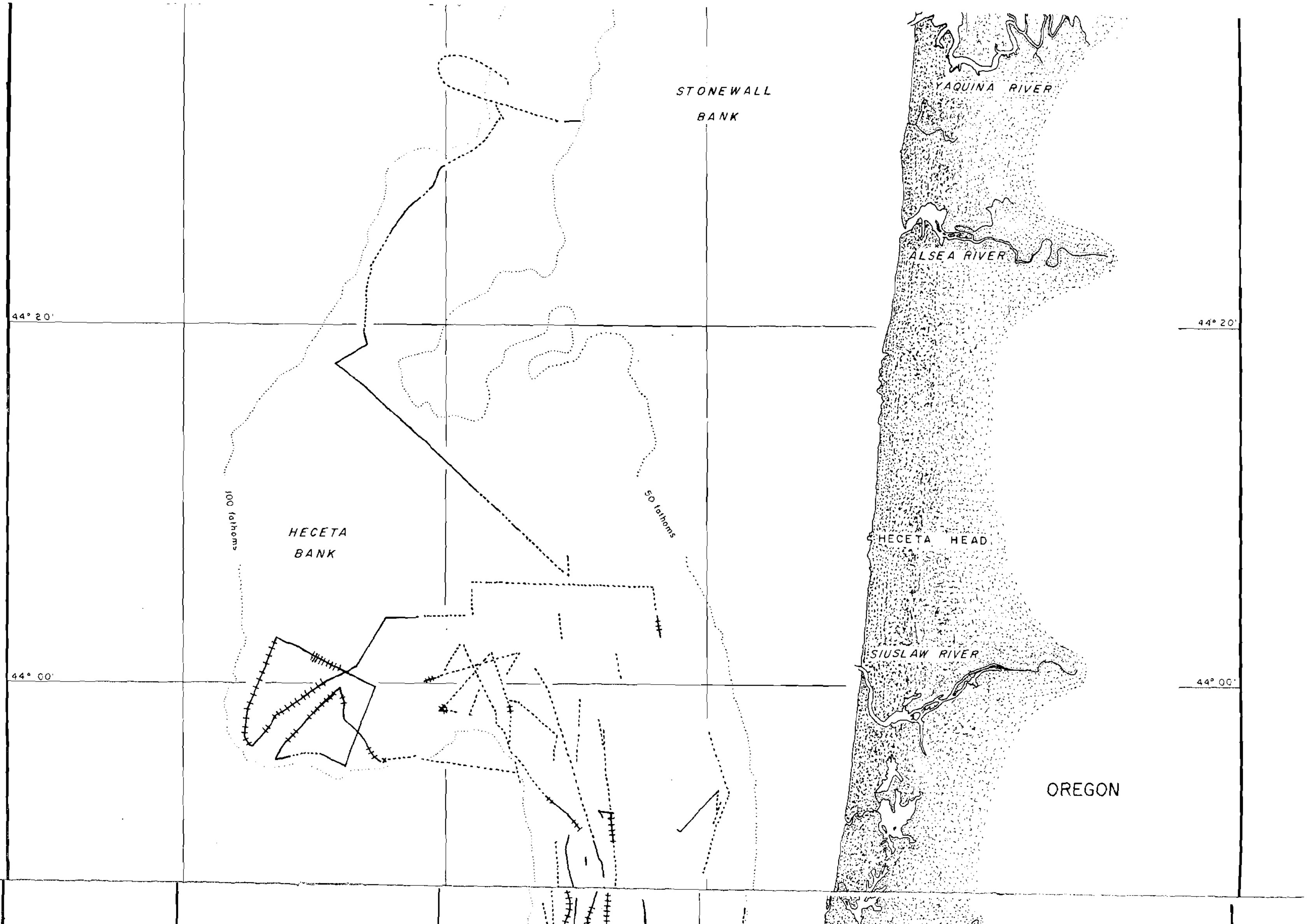
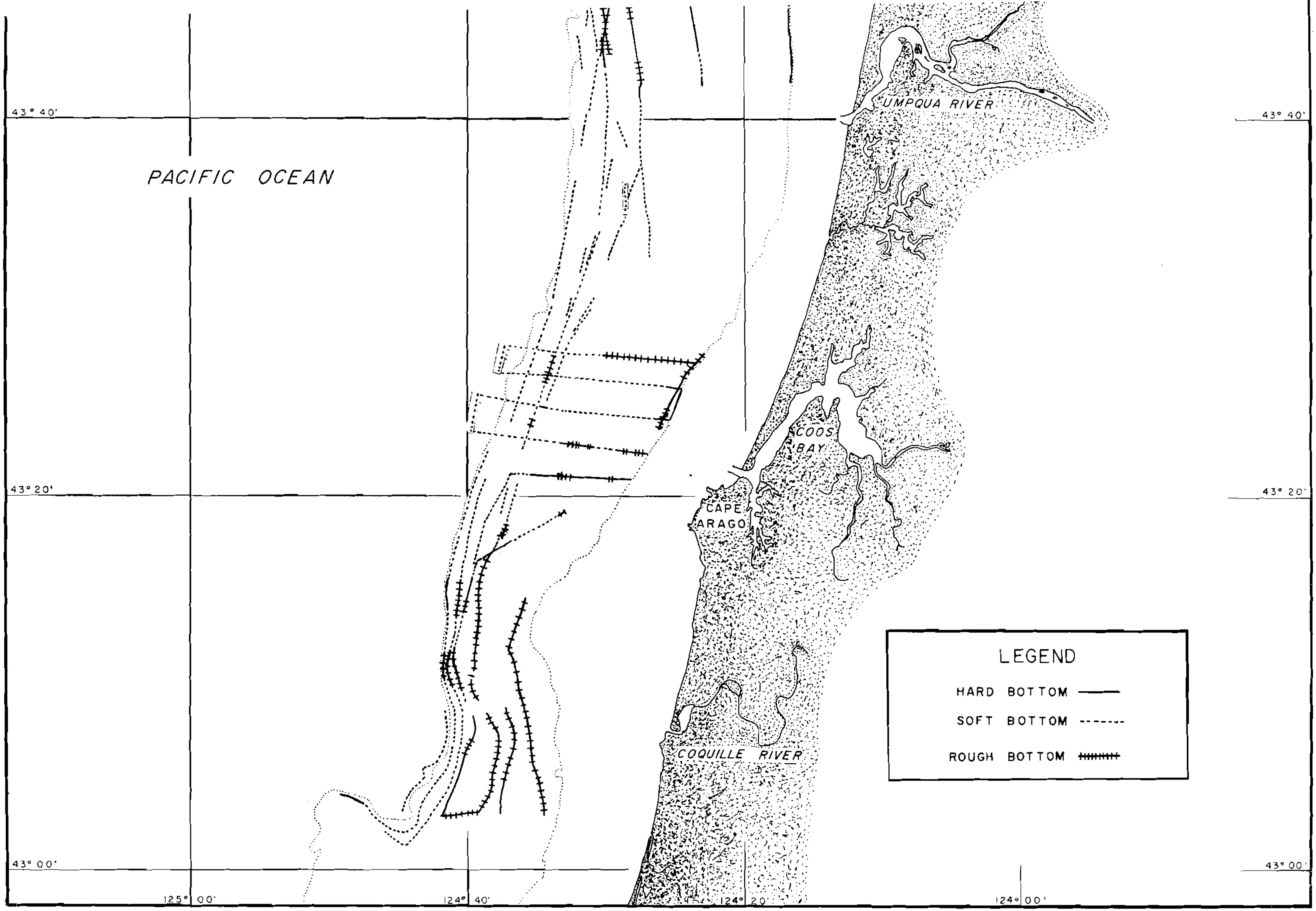


FIGURE 2. LOCATION OF SOUNDING TRANSECTS OFF THE OREGON COAST.



PACIFIC OCEAN
UMPQUA RIVER
COOS BAY
CAPE ARAGO
COQUILLE RIVER
43° 40'
43° 20'
43° 00'
125° 00'
124° 40'
124° 20'
124° 00'
LEGEND
HARD BOTTOM
SOFT BOTTOM
ROUGH BOTTOM

Johnson, and Pruter, 1961). Throughout a sounding transect, the echo sounder records a permanent "tracing" which shows the bottom configuration and indicates whether the bottom is hard or soft. At the start and end of every sounding transect, and when a major change in the bottom type or gradient occurred, the echo sounder recording was marked and the boat's position plotted. By compiling this information on a navigational chart, it was possible to delineate trawlable areas (Figure 2). The first few sounding transects were made following a course directly toward or away from shore. Because the depth and bottom conditions changed rapidly, this method proved impractical as it was impossible to position accurately the soft, hard, or rough areas. A more effective method, utilized throughout the remainder of the cruise, was to follow a given depth contour, plotting the bottom changes as mentioned above.

When a trawlable area was defined, the shrimp trawl was fished over this same ground. Not all trawlable bottom was fished, but random tows were made in these areas as time and weather permitted. By spacing drags at varying depth intervals between 50 and 105 fathoms, it was possible to determine general abundance trends of the shrimp by depth. For each drag the total pounds of shrimp taken was recorded.

Biological

For every drag in which sufficient shrimp were taken, the catch was analyzed for the number of shrimp per pound (heads-on count), length frequency by sex, and the percentage of gravid females. Length-frequency measurements were also taken for some of the commercial species of fish caught.

Pink shrimp are protandric hermaphrodites; that is, they function sexually first as maturing males and then as females during their life cycle. After spawning during October to December, the eggs are carried on the abdominal appendages of the female until they hatch in February or March. The shrimp mature, for the first time, as males at approximately 18 months. In the next year they change from mature males to mature females and are termed transitionals during the transformation period. The remainder of their life cycle is spent as mature females. Occasionally the young shrimp will bypass the male phase and mature as females.

Sex is determined by close examination of the endopodite of the first pleopod (Tegelberg and Smith, 1957). The first pleopod is the most anterior appendage posterior to the legs (first abdominal segment), and the endopodite of this appendage is a small lanceolate to elliptic form protruding from the second joint. The shape of this endopodite signifies whether the shrimp is a male, female, or in a transitional stage from male to female. Figure 3 illustrates these endopodites in their most ideal form; however, an infinite number of variations are possible in the transposing process.

Sex can be readily determined when the shrimp are fresh, but after they have been held for a period of time a slight pressure on the appendage is necessary to cause the endopodite to assert its full dimension. This procedure is particularly important in distinguishing advanced transitionals.

All shrimp measurements referred to in this report are carapace lengths —the distance from the indentation on the carapace at the base of the eyestalk to the dorsal posterior part of the carapace. To measure shrimp, a small vernier caliper calibrated to 0.1 mm. was used; lengths were recorded to the nearest 0.2 mm. Carapace length, used in this study, was found to be more reliable than standard length or total length as the carapace is less frequently damaged in handling.

EXPLORATORY FISHING RESULTS

During the cruise, seven species of shrimp were caught: *P. jordani*, *P. stenolepis*, *Crangon communis*, *C. resima*, *Spirontocaris holmesi*, *S. lamellicornis*, and *Eualus barbatus*. Only the ocean pink shrimp, *P. jordani*, was taken in commercial quantities. Catches of this species were as high as 650 pounds per ½-hour tow.

Catches of 150 pounds or more of ocean pink shrimp per ½-hour of fishing were made off the Coquille River, Cape Arago, and between the Umpqua and Siuslaw Rivers at depths from 70-99 fathoms. A total of 54 drags was made in the exploration area, at a depth range of 50-105 fathoms (Table 1). For convenience of discussion, the explored area has been divided into 3 regions: off the Coquille River; Cape Arago to the Umpqua River; and Umpqua River to the Yaquina River (Figure 1).

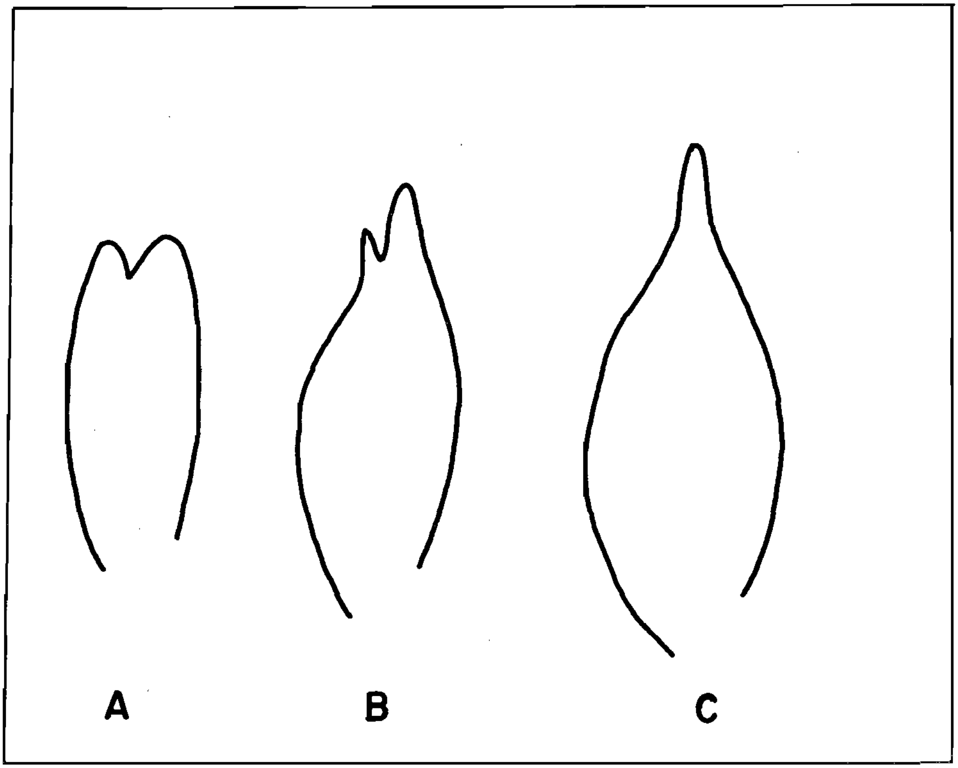


FIGURE 3. DIAGRAMMATIC SKETCH OF THE ENDOPODITE OF THE FIRST PLEOPOD IN *PANDALUS JORDANI* AT DIFFERENT STAGES OF DEVELOPMENT. (A) IS TYPICAL OF MALES, (B) OF TRANSITIONALS, AND (C) OF FEMALES.

TABLE. 1. **CATCH-DEPTH RELATIONSHIP OF PINK SHRIMP FOR ALL TOWS DURING CRUISE 48.**

Depth Range in Fathoms	*Number of Tows*	*Number of Tows Containing Shrimp*	*Shrimp Caught (Pounds)*	*Average Catch Per ½-Hour Tow (Pounds)*
50– 59	1	1	30	30
60– 69	7	5	14	2
70– 79	11	11	1,053	96
80– 89	10	10	902	90
90– 99	19	17	3,145	165
100–109	2	1	50	25
Total	50①	45	5,194	104

① Four tows were not included because the gear was snagged, torn, or not fishing properly.

Off the Coquille River

Of 7 drags made off the Coquille River at depths of 89-105 fathoms, five (numbers 13, 14, 15, 16, and 19) between 89 and 99 fathoms produced shrimp at a rate of 150 pounds or more per ½-hour tow (Figure 1 and Table 2).

Drag number 14 in 94-95 fathoms produced 520 pounds of shrimp, the largest catch in this area. The size of these shrimp ranged from 89 to 123 heads-on shrimp per pound and averaged 108. No snags were encountered with the net, but tracings made during the sounding transects indicated that in shallower water off the Coquille River (55-88 fathoms) the bottom was untrawlable (Figure 2).

TABLE. 2. **CATCH-DEPTH RELATIONSHIP OF PINK SHRIMP TAKEN OFF THE COQUILLE RIVER.**

Depth Range in Fathoms	*Number of Tows*	*Number of Tows Containing Shrimp*	*Shrimp Caught (Pounds)*	*Average Catch Per ½-Hour Tow (Pounds)*
90– 99	6	5	1,520	253
100–109	1	0	0	0
Total	7	5	1,520	217

Cape Arago to Umpqua River

A total of 20 drags was made in the Cape Arago to Umpqua River area at depths between 70 and 92 fathoms (Table 3). Four (numbers 2, 20, 21, and 39) produced shrimp at a rate of 150 pounds or more per ½-hour fished (Figure 1).

TABLE 3. **CATCH-DEPTH RELATIONSHIP OF PINK SHRIMP TAKEN IN THE CAPE ARAGO TO UMPQUA RIVER AREA.**

Depth Range in Fathoms	*Number of Tows*	*Number of Tows Containing Shrimp*	*Shrimp Caught (Pounds)*	*Average Catch Per ½-Hour Tow (Pounds)*
70– 79	6	6	384	64
80– 89	7	7	414	59
90– 99	7	7	495	71
Total	20	20	1,293	65

Drag number 39 (71-74 fathoms) yielded a catch of 250 pounds. The heads-on count of pink shrimp taken in this region ranged from 72 to 133 and averaged 95 per pound. One snag was encountered with the net during drag number 12 (Figure 1), and sounding transect "traces" revealed other untrawlable areas (Figure 2).

Umpqua River to Yaquina River

In the Umpqua River to Yaquina River area all except one drag, number 54, were made between the Umpqua River and Heceta Head (Figure 1). Of the 27 drags made at depths from 51-102 fathoms, 5 (numbers 26, 29, 30, 32, and 36) in the depth range 72-91 fathoms produced shrimp at a rate of 150 pounds or more per ½-hour tow (Table 4).

TABLE 4. **CATCH-DEPTH RELATIONSHIP OF PINK SHRIMP IN THE UMPQUA TO YAQUINA RIVER AREA.**

Depth Range in Fathoms	*Number of Tows*	*Number of Tows Containing Shrimp*	*Shrimp Caught (Pounds)*	*Average Catch Per ½-Hour Tow (Pounds)*
50– 59	1	1	30	30
60– 69	7	5	14	2
70– 79	7	6	675	112
80– 89	4	3	485	121
90– 99	7	6	1,085	155
100–109	1	1	50	50
Total	27	22	2,339	87

Drag number 29 in 89-91 fathoms resulted in the largest catch—650 pounds. The heads-on count of shrimp for this area ranged from 80 to 114 and averaged 95 shrimp per pound. A snag was encountered during drag number 48 and sounding transect "traces" showed rough untrawlable bottom on the southwest corner of Heceta Bank. Depths between 65-78 fathoms in the general area from the mouth of the Umpqua River to the Siltcoos River also appeared untrawlable (Figure 2).

Observations of Bottom Characteristics

Past experience of the Bureau's Exploratory Fishing Section has demonstrated that soft bottom usually is trawlable while hard substrata bottoms are frequently untrawlable. Two drags (numbers 23 and 24) in 51-52 and 61-63 fathoms, respectively, were made in an area indicated by interpretation of the echo sounder recordings as being hard and probably untrawlable (Figures 1 and 2). If it were not known that commercial otter trawl vessels had fished in this area, the exploratory drags would not have been made and the area would have been recorded as "probably untrawlable". Although, as shown in this instance, "hard bottom" areas are sometimes trawable, damage to nets would probably result on most of the "hard and rough bottom" areas indicated in Figure 2. Examination of Figures 1 and 2 shows that several areas of "soft bottom" were located on which no drags were made due to the lack of time. Such soft areas, as previous experience has indicated, are usually trawlable.

Size and Sex Composition

Shrimp samples were measured and sexed for 41 of the 44 shrimp-producing tows. Females accounted for 54.4 per cent of the total, males 45.3 per cent, and transitionals 0.3 per cent. Very few transitionals are usually found in the fall, but they are numerous in the commercial catch from April to September. The average length of the males caught during the cruise was 16.5 mm. (Figure 4 and Section D, Figure 5), and the females 21.0 mm.

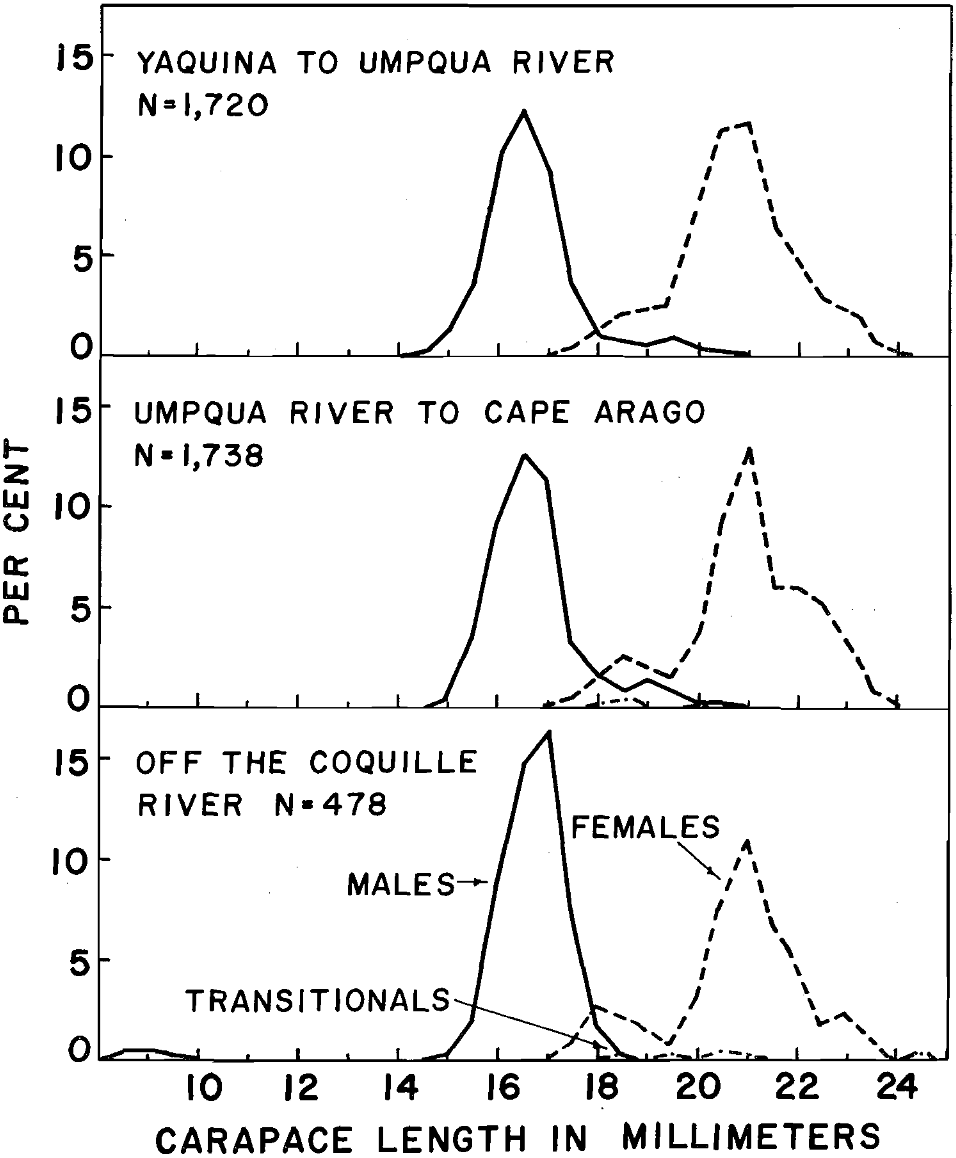


FIGURE 4. LENGTH-FREQUENCY DISTRIBUTIONS OF SHRIMP CAUGHT ON *JOHN N. COBB* CRUISE 48, SEPTEMBER-NOVEMBER, 1960.

In an effort to determine if there were differences in the sizes of shrimp caught within the cruise area, length frequencies were plotted for the three areas previously described and shown in Figure 4. No difference in average size, range of sizes, or sex composition is apparent

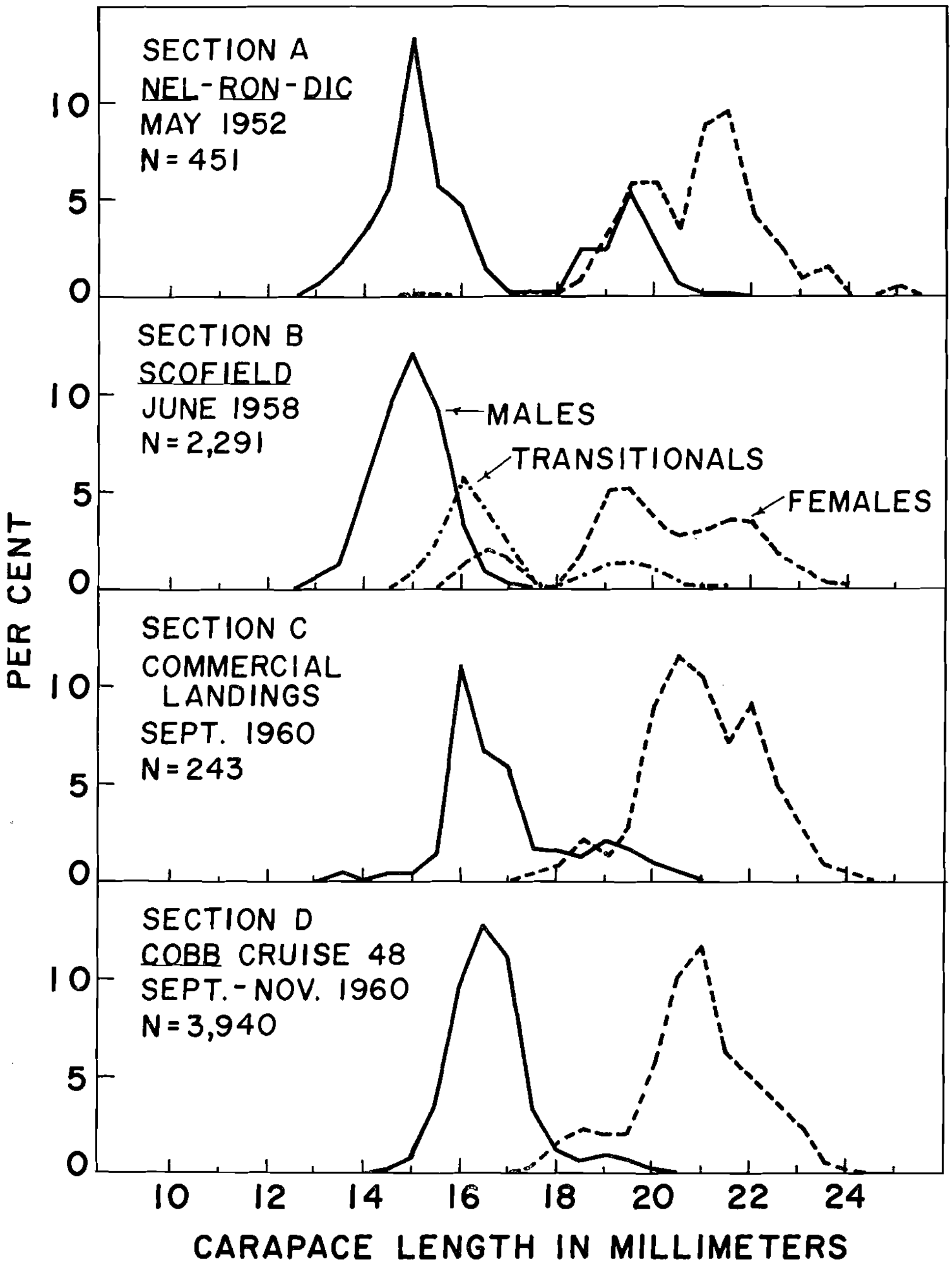


FIGURE 5. SHRIMP LENGTH-FREQUENCY DISTRIBUTIONS FROM THE COOS BAY AREA.

with the exception of the slightly higher percentage of males in the area off the Coquille River.

Figure 5 provides a comparison of shrimp length-frequency distributions from previous cruises, 1960 commercial samples, and a composite of samples taken during the *John N. Cobb* cruise. Section A is a composite of 4 tows made May 28, 1952, in 57-97 fathoms, directly off the Coos Bay spit, on a charter cruise of the trawler *Nel-Ron-Dic* by the Oregon Fish Commission. Transitionals were not recorded as such when these data were collected but were considered males. Therefore, a large percentage of the males between 18 and 21 mm. are actually transitionals. Three age or size groups are present in this graph: one at 15.0 mm., another at 19.5 mm., and a third at 21.5 mm.

A length-frequency distribution of shrimp caught off Coos Bay by the California Department of Fish and Game research vessel *N. B. Scofield* in 1958 is shown in Section B of Figure 5. Three size groups were also apparent in these samples. The smallest group (mode at 15.0 mm.) was mainly males with some transitionals and a few females. The second and third modes at 19.5 and 21.5 mm. consisted mainly of females. The size and numbers in each group compare favorably to the samples collected in 1952, 6 years previously. The size composition of the stock does not appear to have changed during the sampling interval. Very little fishing occurred during the intervening years.

Sections C and D of Figure 5 represent samples taken from the Coos Bay area in the fall of 1960 in 52-102 fathoms. Length frequencies of commercial landings are shown in Section C, while Section D is a composite of all shrimp measured from this area during the 1960 exploratory cruise of the *John N. Cobb*. The last two samples are very similar, although the modes in the commercial samples are at a slightly smaller size.

Number of Shrimp Per Pound

The size of shrimp caught during the exploratory cruise ranged from 72 to 133 heads-on-shrimp per pound. The average was 97 shrimp per pound for the 41 tows in which shrimp were measured. Pruter and Harry (1952) found that larger shrimp were captured in deeper waters while smaller shrimp were found in shallower waters. No correlation is indicated between depth and size of shrimp caught on this cruise. Table 5 shows the depths by 10-fathom intervals, the number of drags, and the average count-per-pound of the samples.

The count-per-pound, however, showed a difference to the north and south of Coos Bay. The 29 samples taken from Coos Bay north to Heceta Bank averaged 91 heads-on-shrimp per pound while the 12 samples taken from Coos Bay south to Coquille Point averaged 107 to the pound. This count-per-pound differential can be attributed to the larger percentage of males captured in the southern extremes of the cruise area (Figure 4).

Gravidness

Although many females had "head roe" (maturing ovaries visible within the carapace) at the start of the cruise, no gravid females were en-

TABLE 5. **SHRIMP COUNT PER POUND RELATED TO DEPTH OF CATCH, *JOHN N. COBB* CRUISE 48.**

Depth in Fathoms	*No. of Drags*	*Average Count Per Lb.*
50– 59	1	87.0
60– 69	3	95.0
70– 79	9	98.7
80– 89	9	94.7
90– 99	18	98.2
100–109	1	86.0

countered in the samples until October 7. An occasional gravid female was noticed in the catch as early as October 1, but due to the sample size (100 individuals) none was found in the samples. By the end of the cruise, or the first part of November, about 30 per cent of the females in the samples were gravid.

INCIDENTAL CATCHES OF FISH

Fish catches ranged from 0 to 695 pounds per drag and were taken in all areas explored. Throughout the cruise, Dover sole dominated the catches, accounting for 37 per cent of the total poundage of fish taken. Sixty per cent of the Dover sole caught by the shrimp trawl were of marketable size. Undesirable fish such as turbot, slender sole, dogfish, skate, and others accounted for 50 per cent of the total fish poundage caught, while more desirable fish such as petrale sole, sablefish, lingcod, and others accounted for about 14 per cent. A list of fish and invertebrates encountered, with their common and scientific names, is given in Appendix Table I.

SUMMARY

During September-November 1960, the U. S. Bureau of Commercial Fisheries and the Oregon Fish Commission conducted a cooperative exploratory shrimp cruise off the central Oregon coast with the Bureau's vessel *John N. Cobb.*

Trawlable grounds were located by making sounding transects with a high-resolution echo sounder, and were explored with a Gulf-of-Mexico-type shrimp trawl. From shrimp-producing tows shrimp samples were taken to determine size and age composition, sex ratio, percentage of egg-bearing females, and heads-on-shrimp per pound.

Fifty-four 30-minute drags were made between the Coquille and Yaquina Rivers. Off the Coquille River, one shrimp-producing area previously unfished was found in 90-99 fathoms. Of 7 tows made in this area, 5 produced between 150 and 520 pounds per half-hour fished. Between Cape Arago and the mouth of the Siuslaw River 20 tows were made in 70-99 fathoms, five of which produced between 140 and 250 pounds. Between the Siuslaw and Yaquina Rivers 25 tows were made in 50-99 fathoms, five of which produced from 150 to 650 pounds.

Examination of the samples showed that 54.4 per cent of the shrimp caught were females, 45.3 per cent males, and 0.3 per cent transitionals. The length frequencies for the 3 areas were very similar with no differences in average size, range of sizes, or sex composition, except for a slightly higher percentage of males taken in the area off the Coquille River.

Length frequencies of shrimp taken during the *John N. Cobb* cruise were compared with those taken by a chartered trawler in 1952, by the California Department of Fish and Game vessel *N. B. Scofield* in 1958, and from the commercial fishery near Coos Bay in 1960. The modes for the year-classes in 1952 and 1958 peaked at the same lengths while the 1960 commercial and exploratory samples peaked at a slightly greater length.

The heads-on count of the number of shrimp per pound ranged from 72 to 133 and averaged 97. No correlation was found between the size of shrimp and depth of fishing. During October egg-carrying females occurred infrequently in the catch, but by November, 30 per cent of the females in the sample were carrying eggs.

Incidental catches of fish were dominated by Dover sole, which accounted for 37 per cent of the total poundage of fish taken.

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APPENDIX TABLE I

List of Animals Taken on the *John N. Cobb* Cruise 48.

Vertebrates

Common Name	*Scientific Name*
Dover sole	*Microstomus pacificus*
Petrale sole	*Eopsetta jordani*
English sole	*Parophrys vetulus*
Rex sole	*Glyptocephalus zachirus*
Turbot	*Atheresthes stomias*
Halibut	*Hippoglossus stenolepis*
Sand dab	*Citharichthys sordidus*
Slender sole	*Lyopsetta exilis*
Flathead sole	*Hippoglossoides elassodon*
Lingcod	*Ophiodon elongatus*
Blackcod	*Anoplopoma fimbria*
Eulachon, smelt	*Thaleichthys pacificus*
Hake	*Merluccius productus*
Surf perch	Embiotocidae
Pacific Ocean perch	*Sebastodes alutus*
Black mouth rockfish	*S. crameri*
Greenstriped rockfish	*S. elongatus*
Yellowtail rockfish	*S. flavidus*
Bocaccio	*S. paucispinis*
Canary rockfish	*S. pinniger*
Red snapper	*S. ruberrimus*
Flag rockfish	*S. rubrivinctus*
Stripetail rockfish	*S. saxicola*
Shortspine channel rockfish	*Sebastolobus alascanus*
Lesser filamented sculpin	*Icelinus tenuis*
Blacktip poacher	*Xeneretmus latifrons*
Eel pout	Zoarcidae
Ratfish	*Hydrolagus colliei*
Dogfish	*Squalus acanthias*
Big skate	*Raja binoculata*
Longnose skate	*R. rhina*

Invertebrates

Crustacea

Shrimp	*Pandalus jordani*
Shrimp	*P. stenolepis*
Shrimp	*Crangon communis*
Shrimp	*C. resima*
Shrimp	*Spirontocaris holmesi*
Shrimp	*S. lamellicornis*
Shrimp	*Eualus barbatus*
Hermit crab	*Paguristes* sp.
Dungeness crab	*Cancer magister*
Box crab	*Lopholithodes foraminatus*

APPENDIX TABLE I—Continued

Common Name	Scientific Name
Echinoderms	
tarfish	*Crossaster papposus*
tarfish	*Hippasteria spinosa*
Sea Urchin	*Stronglyocentrotus drobachiensis*
Sea Cucumber	*Stichopus* sp.
Heart Urchin	*Echinocardium* sp.
Mollusks	
Snails (Shell Only)	*Argobuccinum oregonensis*
Snail	*Chrysodomus tabulatus*
Snail	*C. ithius*
Miscellaneous	
Sea Anemone	
Basket star	
Brittle star	
Brachiopod	
Starfish	
Squid	
Octopus	
Snail	
Peanut worm	

APPENDIX TABLE II

Fishing Log for *John N. Cobb* Cruise 48.

Drag Number	1	2	3	4	5	6	7	8
Date	9/29/60	9/29/60	9/29/60	9/30/60	9/30/60	9/30/60	10/1/60	10/1/60
Latitude—Start	43° 33.2′	43° 29.6′	43° 36.2′	43° 31.2′	43° 26.7′	43° 30.0′	43° 32.4′	43° 40.7′
End	43° 31.9′	43° 30.6′	43° 34.7′	43° 32.6′	43° 25.4′	43° 28.8′	43° 33.9′	43° 39.1′
Longitude—Start	124° 31.4′	124° 32.8′	124° 32.3′	124° 33.5′	124° 35.7′	124° 31.1′	124° 31.3′	124° 29.8′
End	124° 31.8′	124° 32.5′	124° 32.7′	124° 33.2′	124° 36.3′	124° 32.3′	124° 30.8′	124° 29.9′
Loran 2H4—Start	1533	1487	1568	1505	1452	1494	1522	1626
End	1517	1498	1548	1523	1436	1477	1541	1606
Depth—Start (fathoms)	87	86	95	95	96	74	85	83
Depth range (fathoms)	87–86	86–85	95	95	96	74–75	85–84	83
Bottom type①	gn.M.S.	gn.M.	gn.M.	gn.M.	gn.M.	gn.M.	gn.M.	gn.M.
Time net on bottom (minutes)	30	30	30	30	30	30	30	30
Time gear set	1213	1340	1615	1240	1425	1640	0750	1200
Remarks	....	....	....	....	....	....	....	gear not on bottom
Pink shrimp catch (pounds)	1	200	20	45	10	1	140	0
Shrimp catch hourly rate②	2 (87)	400 (80)	40 (80)	90 (77)	20 (74)	2 (81)	280 (94)	0
Food fish (pounds)③	0	38 (47%)	32 (25%)	40 (85%)	trace ④	0	29 (61%)	0
Industrial fish (pounds)	0	73	144	80	0	trace	trace	0

Drag Number	9	10	11	12	13	14	15	16
Date	10/1/60	10/3/60	10/3/60	10/3/60	10/4/60	10/4/60	10/4/60	10/5/60
Latitude—Start	43° 32.7′	43° 16.9′	43° 19.2′	43° 18.2′	43° 04.4′	43° 05.6′	43° 04.8′	43° 06.9′
End	43° 34.2′	43° 18.2′	43° 20.4′	43° 17.0′	43° 05.6′	43° 06.7′	43° 05.9′	43° 08.3′
Longitude—Start	124° 29.7′	124° 39.3′	124° 37.6′	124° 37.3′	124° 42.5′	124° 41.4′	124° 41.2′	124° 40.4′
End	124°29.0′	124° 38.9′	124° 37.2′	124° 38.2′	124° 41.4′	124° 41.0′	124° 40.7′	124° 40.3′
Loran 2H4—Start	1527	1330	1358	1345	1183	1193	1185	1210
End	1547	1346	1375	1332	1194	1208	1195	1225
Depth—Start (fathoms)	75	89	79	75	95	95	90	90
Depth range (fathoms)	75	89–85	79–80	75–76	94–96	95–94	90	90–91
Bottom type①	gn.M.	gn.M.	gn.M.	gn.M.S.	gn.M.S.	gn.M.	....	gn.M.
Time net on bottom (minutes)	30	30	30	30	30	30	30	30
Time gear set	1410	1005	1140	1232	1255	1415	1548	0855
Remarks	....	....	....	large rip in net	....	....	....	....
Pink shrimp catch (pounds)	30	40	30	3	280	520	390	180

APPENDIX TABLE II—Continued

Drag Number	9	10	11	12	13	14	15	16
Shrimp catch hourly rate②	60 (100)	80 (107)	60 (100)	6 (99)	560 (107)	1040 (123)	780 (114)	360 (107)
Food fish (pounds)③	trace	349 (85%)	308 (53%)	32 (31%)	153 (37%)	103 (51%)	126 (12%)	295 (64%)
Industrial fish (pounds)	trace	50	49	trace	31	87	trace	56

Drag Number	17	18	19	20	21	22	23	24
Date	10/5/60	10/5/60	10/5/60	10/7/60	10/7/60	10/7/60	10/9/60	10/9/60
Latitude—Start	43° 03.2′	43° 02.7′	43° 01.7′	43° 22.4′	43° 20.5′	43° 18.6′	43° 47.5′	43° 42.6′
End	43° 04.5′	43° 02.1′	43° 02.8′	43° 21.6′	43° 19.4′	43° 17.5′	43° 46.2′	43° 43.4′
Longitude—Start	124° 44.7′	124° 46.3′	124° 44.0′	124° 38.5′	124° 38.9′	124° 39.7′	124° 16.5′	124° 23.1′
End	124° 43.9′	124° 45.0′	124° 42.8′	124° 39.1′	124° 39.4′	124° 40.1′	124° 16.6′	124° 23.2′
Loran 2H4—Start	1172	1169	1151	1398	1375	1352	1719	1652
End	1186	1160	1164	1388	1362	1338	1703	1663
Depth—Start (fathoms)	105	95	90	97	90	90	51	62
Depth range (fathoms)	105	95	89–91	95–97	90	89–91	51–52	61–63
Bottom type①	gn.M.S.	gy.-gn.S.	....	gn.M.	....	....	....	gy.S.
Time net on bottom (minutes)	30	30	30	30	30	30	30	30
Time gear set	1050	1321	1535	1103	1245	1405	1038	1440
Remarks	....	....	....	....	....	....	....	....
Pink shrimp catch (pounds)	0	0	150	180	150	30	30	0
Shrimp catch hourly rate②	0	0	300 (89)	360 (114)	300 (133)	60 (114)	60 (87)	0
Food fish (pounds)③	164 (17%)	200 (11%)	185 (39%)	214 (32%)	140 (84%)	211 (68%)	116 (22%)	66 (40%)
Industrial fish (pounds)	trace	63	125	70	31	26	101	61

Drag Number	25	26	27	28	29	30	31	32
Date	10/10/60	10/10/60	10/10/60	10/10/60	10/10/60	10/10/60	10/20/60	10/20/60
Latitude—Start	43° 50.6′	43° 43.7′	43° 43.6′	43° 46.8′	43° 44.7′	43° 46.7′	43° 53.6′	43° 55.7′
End	43° 49.2′	43° 44.7′	43° 44.5′	43° 45.0′	43° 45.9′	43° 47.9′	43° 54.9′	43° 57.2′
Longitude—Start	124° 31.5′	124° 30.6′	124° 31.8′	124° 31.6′	124° 30.8′	124° 31.2′	124° 27.5′	124° 31.7′
End	124° 31.3′	124° 30.8′	124° 32.0′	124° 31.4′	124° 31.0′	124° 31.3′	124° 27.7′	124° 31.5′
Loran 2H4—Start	1749	1661	1661	1701	1675	1699	1787	1812
End	1732	1676	1672	1680	1690	1715	1803	1831
Depth—Start (fathoms)	90	90	95	92	90	90	70	77
Depth range (fathoms)	88–90	88–90	93–95	92	89–91	90	70–68	77
Bottom type①	gn.M.	gn.M.	gn.M.	gn.M.	gn.M.	....	gn.M.S.	gn.M.
Time net on bottom (minutes)	30	30	30	30	30	30	30	30
Time gear set	0814	1007	1130	1305	1422	1557	0953	1136

Remarks	....	....	....	gear not on bottom for entire tow	....	....	....	....
Pink shrimp catch (pounds)	30	380	120	5	650	150	10	200
Shrimp catch hourly rate②	60 (94)	760 (104)	240 (94)	10 (94)	1300 (107)	300 (86)	20 (114)	400 (114)
Food fish (pounds)③	105 (64%)	62 (47%)	165 (45%)	trace	135 (42%)	141 (57%)	163	98
Industrial fish (pounds)	trace	49	38	trace	trace	30	92	24

Drag Number	*33*	*34*	*35*	*36*	*37*	*38*	*39*	*40*
Date	10/20/60	10/20/60	10/21/60	10/21/60	10/21/60	10/22/60	10/22/60	10/22/60
Latitude—Start	43° 56.8′	43° 59.6′	43° 55.6′	43° 57.2′	44° 00.9′	43° 34.0′	43° 35.8′	43° 38.6′
End	43° 58.3′	43° 58.4′	43° 54.4′	43° 55.8′	43° 59.7′	43° 35.6′	43° 37.5′	43° 40.0′
Longitude—Start	124° 35.0′	124° 37.4′	124° 34.6′	124° 29.7′	124° 33.0′	124° 26.8′	124° 28.3′	124° 28.5′
End	124° 34.9′	124° 38.1′	124° 34.2′	124° 29.9′	124° 32.2′	124° 27.2′	124° 27.5′	124° 29.1′
Loran 2H4—Start	1825	1856	1810	1830	1873	1542	1567	1600
End	1842	1845	1792	1813	1860	1563	1587	1617
Depth—Start (fathoms)	96	82	97	73	77	70	74	76
Depth range (fathoms)	96–90	82–83	97–102	73–72	77–76	70–71	74–71	76–77
Bottom type①	gn.M.	gn.M.	gn.M.Sh.	gn.M.S.	gn.M.	gn.M.	gn.M.	gn.M.
Time net on bottom (minutes)	30	30	30	30	30	30	30	30
Time gear set	1520	1552	0900	1044	1232	0817	0930	1040
Remarks	....	....	....	....	....	....	....	....
Pink shrimp catch (pounds)	120	75	50	400	60	50	250	50
Shrimp catch hourly rate②	240 (93)	150 (89)	100 (87)	800 (95)	120 (98)	100 (117)	500 (91)	100 (84)
Food fish (pounds)③	194	114	48	79	112	72	48	141
Industrial fish (pounds)	95	32	trace	30	32	trace	trace	trace

Drag Number	*41*	*42*	*43*	*44*	*45*	*46*	*47*	*48*
Date	10/22/60	10/22/60	10/29/60	10/29/60	10/29/60	10/29/60	10/30/60	10/30/60
Latitude—Start	43° 38.7′	43° 56.2′	43° 57.8′	44° 00.4′	44° 00.6′	44° 00.8′	43° 56.0′	43° 56.0′
End	43° 40.3′	43° 57.5′	43° 59.3′	44° 01.7′	44° 01.8′	44° 02.2′	43° 54.9′	43° 55.7′
Longitude—Start	124° 31.8′	124° 27.8′	124° 29.7′	124° 26.5′	124° 35.3′	124° 40.0′	124° 34.5′	124° 42.3′
End	124° 31.3′	124° 28.0′	124° 29.7′	124° 26.9′	124° 34.2′	124° 38.8′	124° 33.7′	124° 44.5′
Loran 2H4—Start	1600	1819	1837	1870	1870	1872	1815	1812
End	1620	1837	1855	1886	1885	1889	1800	1810
Depth—Start (fathoms)	96	68	73	68	79	74	95	90

Drag Number	*41*	*42*	*43*	*44*	*45*	*46*	*47*	*48*
Depth range (fathoms)	96–94	68–69	73–74	68	79–76	74–72	95	90–88
Bottom type①	gn.M.	gn.M.S.	gn.M.S.	gn.M.	gn.M.	gn.M.	gn.M.	gn.M.St.
Time net on bottom (minutes)	30	30	30	30	30	30	30	30
Time gear set	1230	1545	1105	1222	1356	1530	0820	1001
Remarks	....	....	....	....	....	....	....	net torn at end of tow
Pink shrimp catch (pounds)	60	trace	trace	2	2	10	40	trace
Shrimp catch hourly rate②	120 (72)	....	....	4	4	20	80 (91)	....
Food fish (pounds)③	117	122	0	73 (3%)	315 (46%)	487 (44%)	194 (81%)	251 (41%)
Industrial fish (pounds)	trace	trace	0	83	197	208	80	35

Drag Number	*49*	*50*	*51*	*52*	*53*	*54*
Date	10/30/60	10/31/60	10/31/60	11/1/60	11/1/60	11/2/60
Latitude—Start	44° 03.9′	43° 53.5′	43° 37.9′	44° 03.8′	44° 07.1′	44° 32.5′
End	44° 05.3′	43° 52.3′	43° 36.5′	44° 02.5′	44° 06.0′	44° 31.4′
Longitude—Start	124° 38.0′	124° 18.7′	124°29.6′	124° 31.4′	124° 30.7′	124° 36.3′
End	124° 38.1′	124° 19.4′	124° 30.0′	124° 31.1′	124° 30.6′	124° 35.6′
Loran 2H4—Start	1911	1790	1590	1912	1954	2265
End	1929	1775	1573	1896	1939	2250
Depth—Start (fathoms)	67	60	82	69	65	90
Depth range (fathoms)	68–66	60–59	82	69–70	65–66	90–98
Bottom type①	gn.M.	gn.M.	gn.M.S.	gn.M.S.	gn.M.S.	....
Time net on bottom (minutes)	30	30	30	30	30	30
Time gear set	1531	0758	1206	1058	1251	0751
Remarks	....	....	....	....	....	....
Pink shrimp catch (pounds)	trace	trace	3	3	2	0
Shrimp catch hourly rate②	....	....	6 (97)	6 (91)	4 (80)	0
Food fish (pounds)③	23 (44%)	trace	21 (67%)	trace	50 (50%)	trace
Industrial fish (pounds)	trace	trace	trace	trace	trace	0

① **Symbols for Types of Bottom**

gn.—green	S.—sand
gy.—gray	Sh.—shells
M.—mud	St.—stones

② Figure in parentheses indicates number of whole shrimp per pound. Absence of () indicates no count taken.
③ Figure in parentheses indicates per cent marketable.
④ Trace—less than 20 pounds of fish or 1 pound of shrimp.

Sixth Progress Report on Salmon Diet Experiments[1]

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INTRODUCTION

Beef liver has long been recognized as a desirable food component in the diet of hatchery salmon and trout (Karrick, 1948). With its high nutritive value, anti-anemic factor, and related vitamin content, it promotes good growth response when fed to salmon fingerlings. This has led to its wide use in fish diets. Beef liver for hatchery use is confined to condemned livers unfit for human consumption. The rapid expansion of state and federal fish hatchery operations has made greater demands on the supply of beef liver, while the skill of veterinarians in treating internal parasitism of beef cattle has resulted in a diminishing source of this valuable fish food.

The Seafoods Laboratory of the Oregon Agricultural Experiment Station and the Oregon Fish Commission have cooperated since 1949 in a series of studies on salmon nutrition problems and a search for beef liver substitutes. In a previous report (Jeffries *et al.*, 1954) it was demonstrated that 10 per cent fresh-frozen beef liver in diets containing whole drum-dried turbot (*Atheresthes stomias*) and hake (*Merluccius productus*) meals supported excellent growth in young spring chinook salmon (*Oncorhynchus tshawytscha*). This study also reported that drum-dried beef liver and condensed sardine solubles were satisfactory liver substitutes.

The present study employed the Oregon diet (Table 1) to evaluate sheep liver, horse liver, and yellowfin tuna (*Thunnus albacares*) liver as beef liver substitutes when used as a 10 per cent additive. In addition, drum-dried turbot meal, which proved a valuable source of protein in the diet of chinook salmon (Jeffries *et al.*, 1954), was used without the addition of beef liver. Soy bean meal, an important component of the diet of many domestic animals, was assayed using the Oregon diet.

Ten parts gelatin were added as a binding agent to each 100 parts of the mixture. The vitamin level was adjusted to be equivalent, insofar as possible, to the all-meat ration used as one of the control diets.

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TABLE 1. **COMPOSITION OF THE OREGON DIET.**①

Component	*Per Cent Completed Formulation*	
Vitamin-free casein	55	
Dextrin	18	
Corn oil	16	
Supplemental salts	6	(Phillips and Hart, 1935)
Crab meal (*Cancer magister*)	4	
Calcium carbonate	1	
Vitamin supplement②		
Total	100	

① From Jeffries *et al.*, 1954.
② Vitamin supplement comprised the following:

	Amount Milligrams Per 100 Grams of Diet Mix
Choline chloride	700.00
Inositol	250.00
B-12 Supplement (not less than 3 mgs. activity per pound)	600.00
PABA	40.00
Ascorbic acid	120.00
Thiamine hydrochloride	1.60
Riboflavin	7.20
Niacin	2.56
Biotin	.08
Calcium pantothenate	14.40
Pyridoxine hydrochloride	1.60
Folic acid	.96
Vitamin K (menadione)	.80
Vitamin A	2,000.00 I.U.
Vitamin D	200.00 I.U.

PROCEDURES

The study was conducted at the Oregon Fish Commission's Sandy Hatchery located on Cedar Creek, a tributary of the Sandy River, and Willamette Hatchery located on Salmon Creek, a tributary of the Middle Fork of the Willamette River.

This was essentially an experiment with 3 groups of fish at 2 locations. There were 8 lots of silver (*O. kisutch*) and spring chinook salmon at Sandy Hatchery and 8 lots of spring chinook salmon at Willamette Hatchery. All 3 groups were fed the same diets and each diet was fed to 1 lot of fish in each group. All diets were chemically compounded and analyzed by personnel of the Seafoods Laboratory.

The experiments began on April 29, 1953. The Willamette spring chinook and Sandy silver salmon trials were terminated on March 2-3, 1954, after a 44-week feeding period. The Sandy spring chinook trials were discontinued on October 28, 1953, after a 26-week feeding period, due to a severe outbreak of bacterial kidney disease.

The fish were fed and weighed by the same methods and techniques as those described by Jeffries *et al.* (1954). Each lot received a daily allotment of food on a dry weight basis as described by McKee *et al.* (1951). All diets were assembled on a dry weight basis and compounded to have the same proximate chemical analysis (fats, proteins, carbohydrates, vitamins, etc.) and caloric values. Water was added to diets 2 through 8 to yield the same moisture as diet 1.

The experiments were conducted using 6-foot-diameter circular firwood tanks with a water depth of 16 inches. Each tank was stocked as shown in Table 2.

TABLE 2. **INITIAL TANK STOCKING INFORMATION FOR SANDY-WILLAMETTE DIET EXPERIMENTS, 1953–54.**

Species Used and Location	*Initial Average Weight*		*Initial Weight*		
	Grams	*Fish Per Pound*	*Grams Per Tank*	*Initial Number Per Tank*	*Number of Tanks*
Sandy Silvers	.70	649	300	428	8
Sandy Chinook	1.21	375	500	413	8
Willamette Chinook..	.65	698	350	540	8

There were 3 control diets in the experiments: (1) the maximum control consisting of equal parts beef liver, hog liver, and salmon viscera plus 2 per cent salt (McKee *et al.*, 1952); (2) the Oregon diet used as the minimum control; and (3) 90 parts Oregon diet and 10 parts beef liver. The remaining 5 diets tested modifications of the minimum control diet.

The components of each diet and observational results are given in Table 3. The percentage mortality is shown in Table 4.

RESULTS AND DISCUSSION

Lot growth and weekly average water temperatures are shown in Figures 1, 2, and 3. Bacterial kidney disease afflicted all lots of fish during the course of this experiment; nevertheless, certain observations regarding the nutritional values of the components tested are presented as a guide to future experiments. The Sandy spring chinook were especially affected by kidney disease and after 26 weeks the resulting high mortality forced discontinuation of this trial. The Sandy silvers exhibited a deformity condition which was eventually fatal. All lots of silvers, including the hatchery stocks, showed this condition. The Sandy fish also showed a high incidence of infection with the metacercaria of *Troglotrema salmincola*. This parasitic trematode has been found in all stocks of fish in the Sandy River system.

The debilitated condition which developed in the fish on the turbot meal diet (Lot 7, Figures 1, 2, and 3) is worthy of comment. The symptoms displayed by the mortalities were: livers off-color (brown, tan, pale); yellow fluid in the intestinal tract; general edema and exophthalmia; anemia; colorless fluid in the body cavity; and the yellowish-green body color especially noticeable under fluorescent light.

The turbot meal used in this diet, prepared by drum-drying whole ground turbot, contained 36 per cent highly unsaturated fat. It is common knowledge that unsaturated fish oils are highly susceptible to oxidative rancidity. Mason and Hartsough (1951) and Davis and Graham (1954) have called the syndrome "yellow fat disease" resulting from the feeding of frozen rancid fish products to mink and swine. Rancidity tests of the turbot meal diet with the procedure developed by Yu and Sinnhuber (1957) confirmed that it was autoxidized and may have been responsible for the symptoms observed. Later studies of the Oregon diet confirmed these conclusions.

TABLE 3. DESCRIPTION OF DIETS AND OBSERVATIONAL RESULTS.

Lot Number	Diet	Observations
1	Maximum Control: Equal parts beef liver, hog liver, and salmon viscera plus 2% salt.	Lot growth excellent. Losses low in Willamette chinook, high in Sandy silvers and chinook. Appetite very good. Disease in Sandy silvers and chinook.
2	Minimum Control: Oregon diet.	Lot growth poor. Losses excessive in all three groups. Appetite very good. Anemia in Willamette chinook. Disease in Sandy silvers and chinook.
3	Control: Oregon diet 90%, beef liver 10%.	Lot growth fair in Sandy silvers, poor in Willamette and Sandy chinook. Losses high. Appetite very good. Anemia in Willamette chinook. Disease in all groups.
4	Oregon diet 90%, horse liver 10%.	Lot growth poor in Sandy silvers and chinook, fair in Willamette chinook. Losses excessive in all three groups. Appetite very good. Anemia in Willamette chinook. Disease in Sandy silvers and chinook.
5	Oregon diet 90%, sheep liver 10%.	Lot growth good in Sandy chinook, fair in Sandy silvers and Willamette chinook. Losses above normal in Sandy chinook, excessive in Sandy silvers and Willamette chinook. Appetite very good. Anemia in Willamette chinook. Disease in Sandy silvers and chinook.
6	Oregon diet 90%, yellowfin tuna liver 10%.	Lot growth good. Losses low in Sandy chinook, above normal in Willamette chinook, and excessive in Sandy silvers. Appetite very good. Anemia in Willamette chinook. Disease in Sandy silvers.
7	Oregon diet modified by partial replacement of the components with drum-dried turbot meal①.	Lot growth fair for first 10 weeks in both chinook lots and first 20 weeks in Sandy silvers. The fish then became sluggish. The Willamette chinook trial was discontinued after 18 weeks, Sandy silvers after 28 weeks. Losses excessive in all 3 groups. Appetite very good to very poor as experiment progressed. Anemia in all 3 groups. Disease in Sandy silvers and chinook.
8	Oregon diet modified by partial replacement of the components with commercial soybean oil meal.	The fish refused to eat the food. Because of the rising mortality rate and debilitated condition of the fish, all 3 groups were discontinued after 2 weeks on the diet.

① Drum-dried by Astoria Seafoods Laboratory.

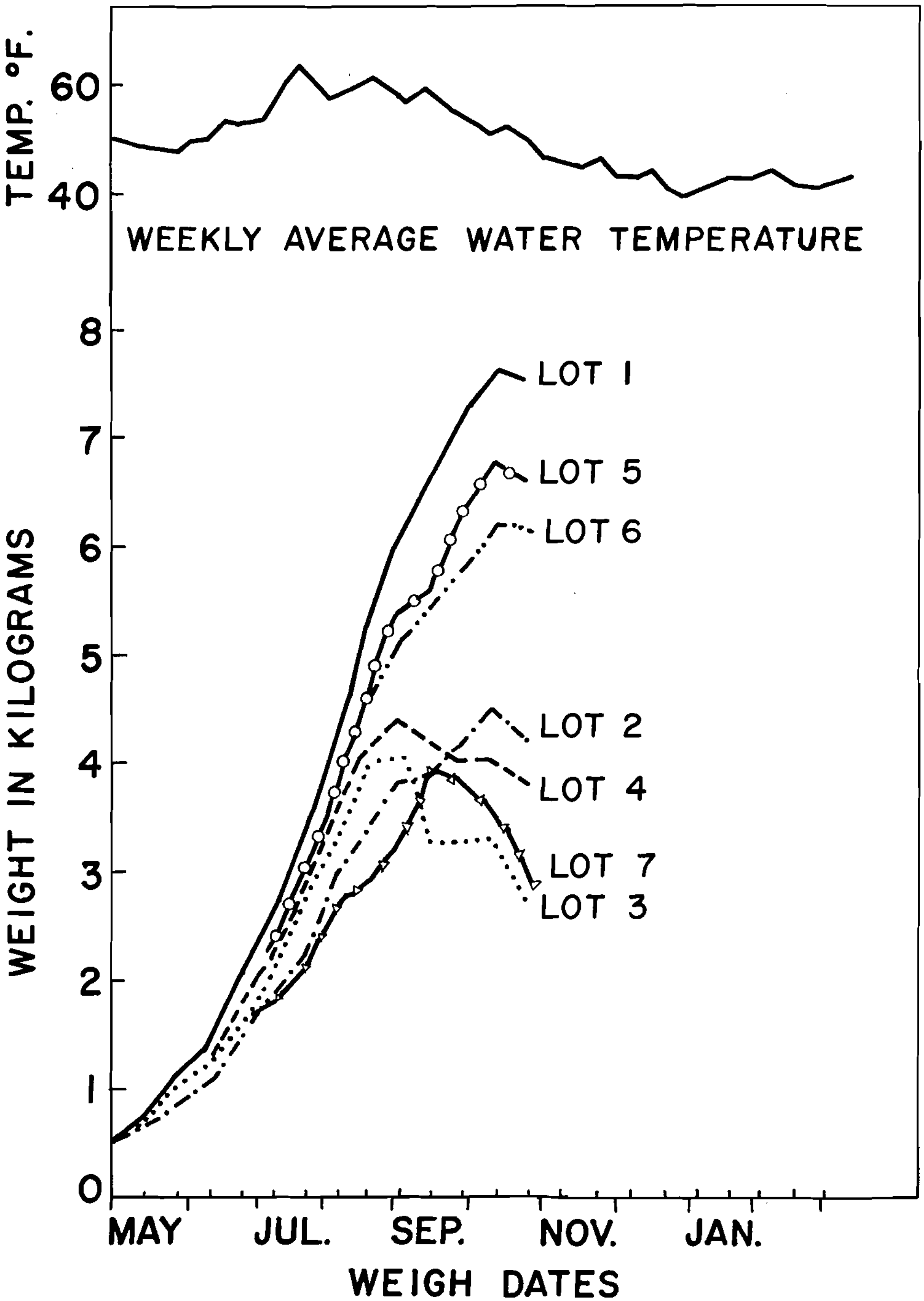

FIGURE 1. LOT GROWTH BY WEIGH DATE AND WEEKLY AVERAGE WATER TEMPERATURE, SANDY SPRING CHINOOK, 1953-54. (LOT 8 WAS DISCONTINUED AFTER 2 WEEKS.)

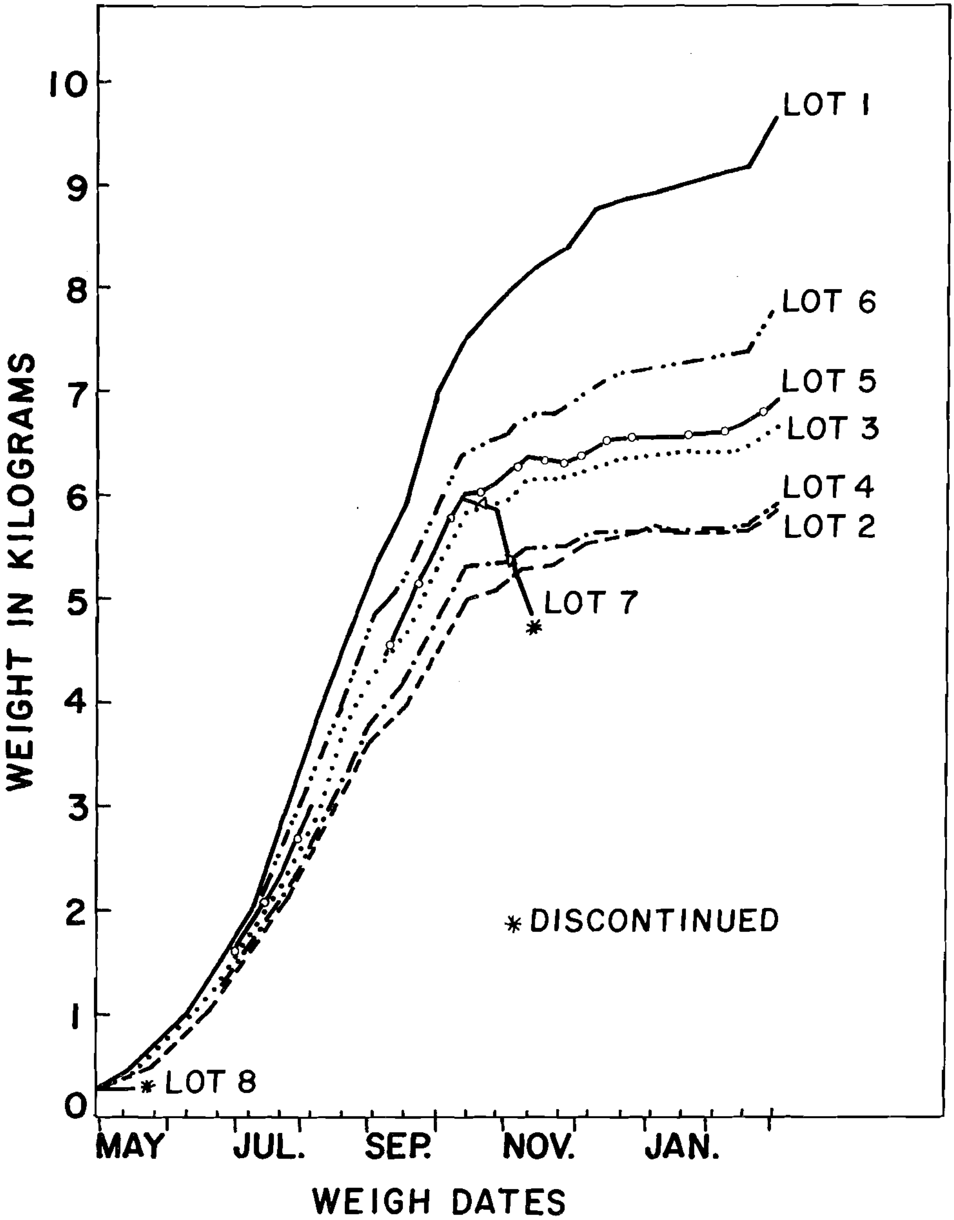

FIGURE 2. LOT GROWTH BY WEIGH DATE, SANDY SILVER SALMON, 1953-54.

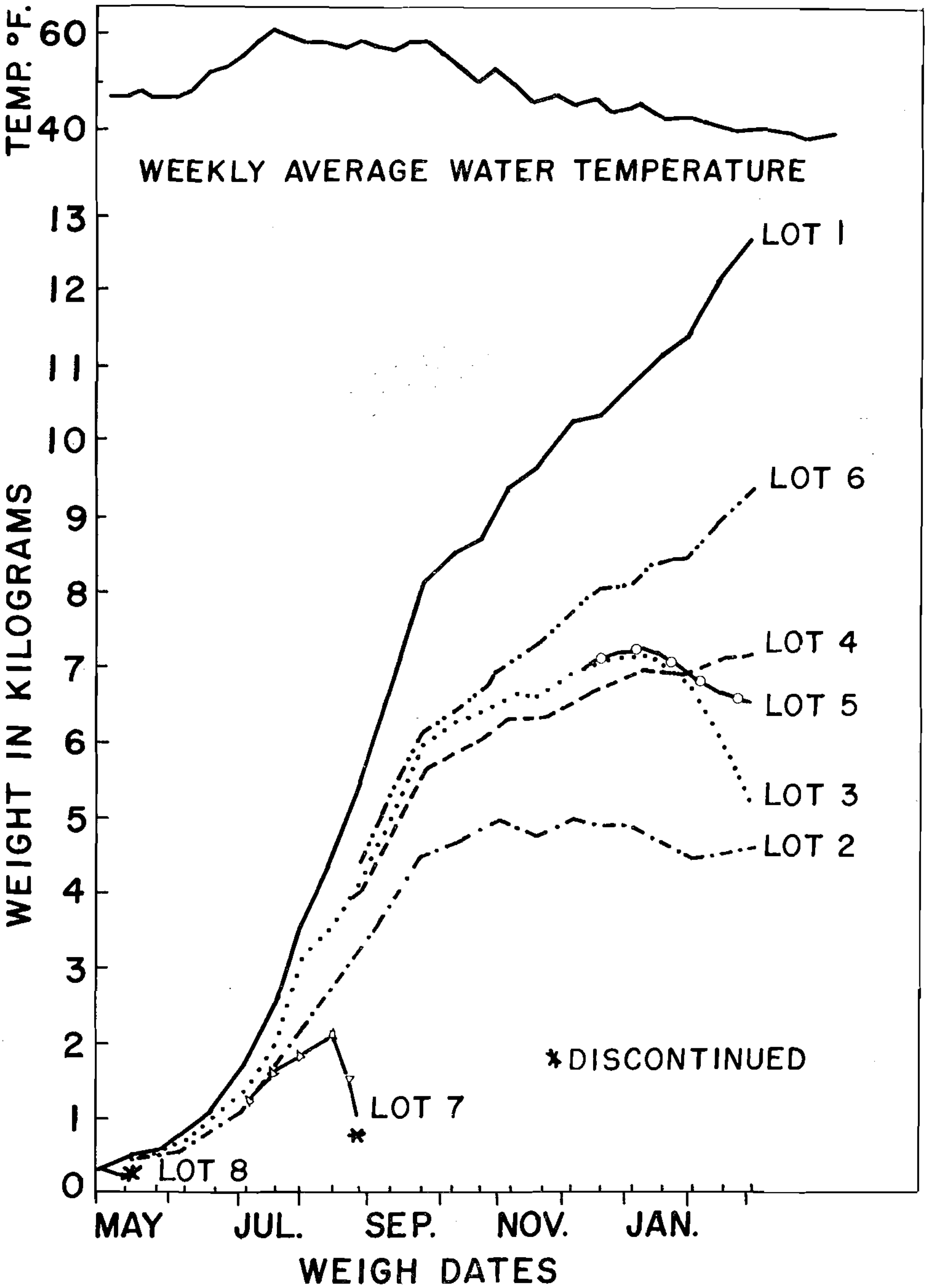

FIGURE 3. LOT GROWTH BY WEIGH DATE AND WEEKLY AVERAGE WATER TEMPERATURE, WILLAMETTE SPRING CHINOOK, 1953-54.

TABLE. 4. **MORTALITY IN SILVER AND CHINOOK SALMON DIET EXPERIMENTS AT SANDY AND WILLAMETTE HATCHERIES, 1953–54.**

	SANDY HATCHERY		*WILLAMETTE HATCHERY*
Lot Number	*Silvers (Per Cent Mortality)*	*Chinook (Per Cent Mortality)*	*Chinook (Per Cent Mortality)*
1	14	17	4
2	19	19	42
3	15	59	43
4	17	39	19
5	19	10	27
6	16	4	10
7	28	45	64
8	1	6	1

CONCLUSIONS

Definite conclusions from the observational results are difficult because of the high incidence of disease. However, the following conclusions are believed to be attributable to nutrition rather than disease.

Identical diets fed to 3 groups of fish at 2 different locations gave quite comparable results although in nutritional work spring chinook salmon appear to be a more critical test animal than silver salmon.

The various livers tested from sheep, horses, and yellowfin tuna at a 10 per cent level in the Oregon diet compared favorably with beef liver. Tuna liver appeared most promising. Based on these results, and under the conditions tested, these livers may be substituted for beef liver with satisfactory results.

Turbot meal as a partial replacement for casein and entire replacement for corn oil in the Oregon diet was not satisfactory in these trials. This is contrary to the results obtained by Jeffries *et al.* (1954). Meal rancidity was a factor in the negative results.

Soybean meal as a partial casein and dextrin replacement in the Oregon diet was not satisfactory. All lots of fish refused to eat this diet and had to be removed from the experiment after two weeks.

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Seventh Progress Report on Salmon Diet Experiments[1]

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INTRODUCTION

The salmonid fishes are one of the major natural resources of the Pacific Northwest. To aid in the conservation of this valuable resource, an expanded program of artificial propagation has been initiated by state and federal agencies but food supplies have proven inadequate. For this reason the Oregon Fish Commission and Seafoods Laboratory of Oregon State University are conducting a series of experiments designed to evaluate hatchery food components and develop economical production diets. In an initial experiment, McKee *et al.* (1951) found the Wisconsin purified diet, developed by McLaren *et al.* (1947) for trout, inadequate for spring chinook salmon (*Oncorhynchus tshawytscha*) fingerlings. By modifying the Wisconsin diet, McKee *et al.* (1952) were able to use it successfully as a test diet to evaluate a number of beef liver substitutes. Jeffries *et al* (1954) further modified the Wisconsin diet and designated it as the Oregon diet. It produced adequate growth in spring chinook salmon fingerlings at the Bonneville Hatchery and is now the standard test diet used by this research group.

The development of an adequate test diet enabled Sinnhuber *et al.* (1961) to ascribe the growth response of both silver (*O. kisutch*) and spring chinook salmon fingerlings to a number of beef liver substitutes and hatchery diet components.

This paper evaluates the growth response of silver salmon fingerlings to a group of animal protein meals not previously tested. They include the following: whale (*Balaena* sp.), Dover sole (*Microstomus pacificus*), low-temperature-dried yellowfin tuna (*Thunnus albacares*) scrap, commercial yellowfin tuna, skate-wing (*Raja* sp.), commercial meat, and Pacific herring (*Clupea harengus pallasi*). In addition, it introduces the second phase of the experimental program involving the evaluation of economical production diets compounded with commercially available ingredients. The 3 production-type diets evaluated include: ground whole turbot (*Atheresthes stomias*), hake (*Merluccius productus*), and beef liver.

PROCEDURES

The experiment, conducted at the Oregon Fish Commission's Sandy Hatchery, began on June 8, 1954, and terminated on March 1, 1955, after a 38-week feeding period. Twelve 6-foot diameter circular firwood tanks were

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used, each stocked with 400 fingerling silver salmon weighing 580 grams (1.45 grams per fish or 313 fish per pound). Each diet was fed to one lot of fish. The techniques and methods were those reported by Jeffries *et al.* (1954) with one exception: the food was formed into worm-like pellets through a modified Alemite gun. The fish were fed 7 days a week for the first month of experimental feeding, after which they were fed 6 days a week until the time of declining water temperatures in the fall. From October 1954 until the end of the experiment they were fed 5 days a week. For two weeks prior to the start of the experiment the fish were all fed the Oregon test diet. Past experience has shown that if an all-meat diet is fed until the start of the experiment, the lots fed the test diet or its modifications will lag in growth until accustomed to the new food. The change to an all-meat ration presented no problem. Each lot received a daily allotment of food on a dry weight basis as described by McKee *et al.* (1951). All diets were compounded to give the same proximate chemical composition and caloric value. The Oregon test diet and an all-meat diet served as minimum and maximum controls, respectively, and the seven other diets substituted animal protein meals for portions of the test diet. The moisture level of all diets in this series was made equivalent to the all-meat ration.

The three production-type diets were formulated by incorporating meat or fish with a dry meal mix. A moisture variation between production diets developed as a result of this method, but this affected only the bulk since the amount of food fed was calculated on a dry weight basis. Because the level of feeding production diets was based more on an appetite response, these lots received a greater food intake. The components of the 9 test and 3 production diets used are listed in Table 1.

RESULTS

Lot growth for the 9 test diets is shown in Figure 1 and for production diets in Figure 2. The weekly average water temperature for both series of experiments is shown in Figure 2. The food conversion factors, observational results, and per cent mortality for all lots are shown in Table 1.

DISCUSSION

The mortality rate by individual lots was in all cases above normal because of the presence of deformed or crippled fish. This condition was also noted by Sinnhuber *et al.* (1961). The cause has not yet been determined but since such fish occurred in all lots, and among different age groups, it is assumed that the crippling was not directly connected with the diet. In the following discussion, mortalities of this type are not considered.

Diets 3, 4, and 5 were all discontinued before the termination of the experiment. The "yellow-fat" disease symptoms exhibited by the dead and moribund fish from these lots were the same as those displayed by chinook and silver salmon fingerlings fed a diet containing turbot meal in a previous experiment (Sinnhuber *et al.*, 1961). It must be noted that the meals in the diets of fish which showed the symptoms

TABLE 1. **DESCRIPTION OF DIETS AND OBSERVATIONAL RESULTS.**

Lot Number	*Diet*	*Dry Weight Food Conversion Factor*	*Per Cent Mortality*	*Observations*
1	Maximum control: equal parts beef liver, hog liver, and salmon viscera plus 2 per cent salt.	1.23	11	Lot growth good. Losses high. Crippling disease present. Appetite very good.
2	Minimum control: Oregon test diet.[1]	1.47	14	Lot growth fair. Losses high. Appetite very good. Crippling disease present.
3	Oregon test diet modified by partial replacement with whale meal.[2]	1.73	26	Lot growth poor. Losses excessive. Appetite very good. Anemia. Crippling disease present. Diet discontinued on February 15, 1955.
4	Oregon test diet modified by partial replacement with Dover sole fillet scrap meal.[2]	1.82	21	Lot growth fair. Losses excessive. Appetite good to poor as experiment progressed. Anemia. Crippling disease present. Diet discontinued on December 12, 1954.
5	Oregon test diet modified by partial replacement with low-temperature yellowfin tuna scrap meal dried at approximately 100° F. by Seafoods Laboratory.	1.27	8	Lot growth fair. Losses above normal. Appetite very good. Anemia. Crippling disease present. Diet discontinued on February 15, 1955.
6	Oregon test diet modified by partial replacement with commercial yellowfin tuna meal.	1.17	9	Lot growth good. Losses above normal. Crippling disease present. Appetite fair.
7	Oregon test diet modified by partial replacement with skate-wing meal.[2]	1.14	8	Lot growth very good. Losses above normal. Crippling disease present. Appetite fair.
8	Oregon test diet modified by partial replacement with commercial meat meal.	1.58	13	Lot growth poor. Losses high. Crippling disease present. Appetite poor.
9	Oregon test diet modified by partial replacement with commercial herring meal.	1.24	9	Lot growth good. Losses above normal. Crippling disease present. Appetite very good.

10	Production diet 1: meal mix③ 40%, turbot 40%, yellowfin tuna liver 20%.	1.62	7	Lot growth very good. Losses above normal. Crippling disease present. Appetite good.
11	Production diet 2: meal mix④ 40%, yellowfin tuna liver 20%, hake 40%.	1.59	8	Lot growth very good. Losses above normal. Crippling disease present. Appetite good.
12	Production diet 3: meal mix⑤ 90%, beef liver 10%.	1.22	5	Lot growth good. Losses low. Crippling disease present. Appetite fair to very good.

① From Sinnhuber *et al.* (1961).

② Meals drum-dried by Astoria Seafoods Laboratory.

③ Meal mixture:

Herring meal	30%
Skim milk	26%
Linseed oil meal	26%
Corn oil	6%
Distillers solubles	8%
Crab meal	4%
Vitamin supplements	

④ Meal mixture:

Herring meal	28%
Skim milk	24%
Linseed oil meal	24%
Corn oil	12%
Distillers solubles	8%
Crab meal	4%
Vitamin supplements	

⑤ Meal mixture:

Turbot meal	38%
Tuna scrap meal	29%
Cottonseed oil meal	17%
Linseed oil meal	16%
Vitamin supplements	

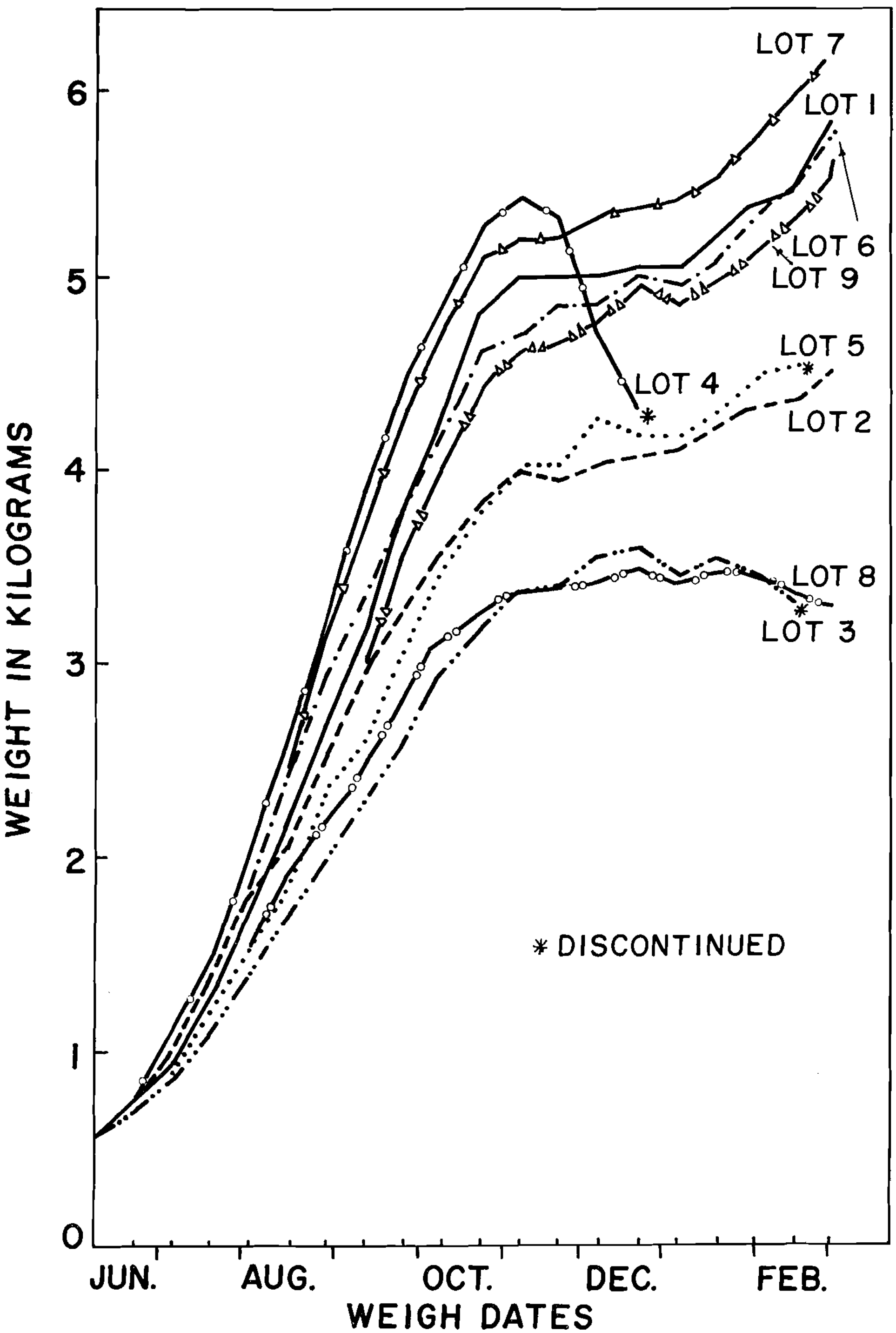

FIGURE 1. LOT GROWTH BY WEIGH DATE FOR THE TEST DIET SERIES, 1954-55.

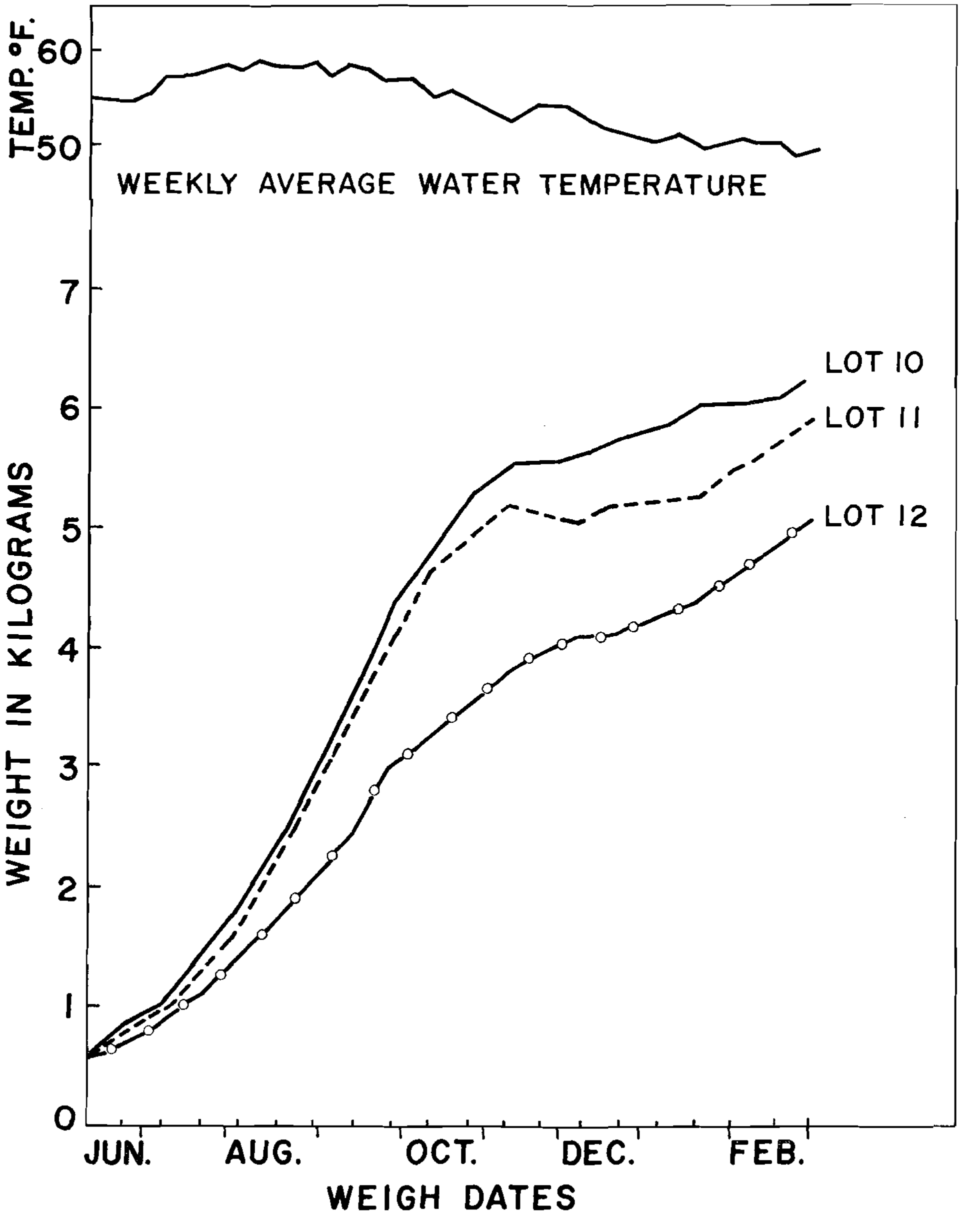

FIGURE 2. LOT GROWTH BY WEIGH DATE FOR THE PRODUCTION DIET SERIES AND WEEKLY AVERAGE WATER TEMPERATURE, 1954-55.

were all drum-dried at low temperature. In contrast, diets containing commercial meals with near-comparable fat levels produced no yellow-fat syndrome. Tests undertaken at this point verified the presence of actively oxidizing fats in the diets. One might hypothesize that the methods of drying, being less drastic than the normal commercial process, preserved the unsaturated fats inherent in the turbot, Dover sole, whale, and tuna meals. Because of their nature, these fats are highly susceptible to autoxidation, a process that catalyzes the destruction of the factors which under normal conditions prevent the yellow-fat syndrome. The rougher treatment of meals in a commercial drying process oxidizes to a large extent the unsaturated fats present. These oxidized fats do not appear to be capable of destroying the factors which prevent the yellow-fat syndrome.

Some basis for the hypothesis is found in recent diet studies of the Oregon Fish Commission: drum-dried, low-temperature meals with as low as 8 per cent unprotected fat produced good initial growth; however, after storage the same diets usually produced the yellow-fat syndrome and high mortality. In contrast, the diet containing drum-dried skate meal provided good growth and showed no yellow fat. Proximate analysis shows that skate meal made from skate wings contains less than 1 per cent fat. Further confirmation is found in the work of Sinnhuber and Yu (1958), who were able to follow autoxidative changes of the fat in tuna scrap during cold storage and demonstrated that preliminary heat treatment of the scrap lowered the peak rancidity value obtained. These workers also showed that the use of antioxidants, Tenox VI and DPPD, suppressed autoxidation in tuna scrap during frozen storage. It would appear, therefore, that preliminary oxidation of unsaturated fats in fish meals should be accomplished before diet formulation to prevent yellow fat. However, the full effect of fat oxidation on the protein quality of a meal is undetermined. Kaneda *et al.* (1955) and Matsuo (1954) report considerable toxicity in oxidized fats in experiments with rats. These results would indicate that suitable protection of the unsaturated oils is the best solution.

The fish on diet 8, the meat meal modification of the Oregon test diet, developed after 20 weeks a condition characterized by the inability to grasp food. This condition, called encephalomalacia, has been described in poultry rearing (Jungherr *et al.,* 1952) where meat meal was used as a diet component. Afflicted chicks died of starvation unless the diet was changed.

The fish fed diet 7 provided unexpectedly good results. It is well known that urea is present in unusually large amounts in the blood and tissue of elasmobranch fish. Smith (1936) detailed the role of urea in elasmobranch physiology. However, with teleost fishes, urea is considered a nitrogenous waste product to be excreted. For this reason, fingerlings fed food containing urea in above normal amounts should show poor growth. Since the converse was true in this experiment, it would appear that the excretion and osmo-regulating systems of salmon fingerlings are well able to take care of the urea content of this diet. One may therefore speculate that other elasmobranch fish, such as dogfish and other species of sharks, might provide sources of animal protein for hatchery foods.

Oil was added in production diet meals 10 and 11 and adjusted to compensate for the wet-type components used. Less oil was added to diet 10 than diet 11 since proximate analysis shows turbot contains more oil than hake. Diet 12 was designed to investigate the possibility of an all-meal diet. Ten per cent beef liver on a dry weight basis was added as a supplement and to aid in the bind during feeding. Favorable growth results were obtained with these production diets. Work on pelletization and bind has continued in order to make the production diets commercially feasible (Hublou *et al.*, 1959).

CONCLUSIONS

Seven animal protein meals were utilized as partial component replacements in the Oregon test diet to evaluate the growth response of silver salmon. These were: drum-dried whale, Dover sole, fillet scrap, and skate wing; low temperature-dried yellowfin tuna scrap; and commercial meat, herring, and yellowfin tuna.

Three production-type diets were employed to evaluate ground whole turbot, hake, and beef liver in combination with dry meals to form a moist pelleted diet.

Drum-dried whale meal produced very poor growth and excessive mortality when used as a replacement of part of the Oregon test diet. Rancidity of the meal was a factor. The diet was discontinued after 36 weeks.

Drum-dried Dover sole scrap meal produced excellent growth for the first 20 weeks, after which the mortality rate became excessive and the experiment was discontinued after 30 weeks. Again, rancidity of the meal was a factor.

Low-temperature dried yellowfin tuna scrap meal showed fair growth. The lot was discontinued after 36 weeks. Rancidity of the meal was noted.

Commercially prepared yellowfin tuna meal produced good growth and compared favorably with the diet fed the maximum control group.

The diet containing drum-dried skate meal showed very good growth. The fish made the greatest gains of any fed the replacement components.

Meat meal as a diet replacement component produced poor growth. A deficiency symptom similar to encephalomalacia in chicks was noted.

Commercially prepared herring meal as a diet replacement component produced good growth.

The three production-type diets produced good to very good growth. A diet incorporating turbot showed better growth than one including hake, while the diet composed of meals and beef liver produced the least growth of the three.

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The Percoid Fish Pseudopentaceros richardsoni From Oregon Waters

Specimens of *Pseudopentaceros richardsoni* (family Histiopteridae) from marine waters off the Oregon coast, between the Umpqua and Alsea River mouths, represent an interesting addition to the list of fishes occurring in this area. Previous North Pacific records published by Welander, Johnson, and Hajny (1957) were from oceanic localities 45° 49′ N. lat. to 49° N. lat. by 150° W. long. to 160° 03′ W. long. This source and Smith (1953) mention other occurrences of this species off the coasts of Africa and New Zealand. Smith lists several bibliographical references to *P. richardsoni.*

Three specimens of this species were taken by trawlers engaged in the rock fish *(Sebastodes* sp.*)* fishery during 1960 (Table 1).

TABLE 1. **DATA ON 3** *Pseudopentaceros richardsoni* **TAKEN IN WATERS OFF THE OREGON COAST, 1960.**

Date	*Latitude*	*Longitude*	*Depth in Fathoms*	*Vessel*
March 4	44° 25′ N.	124° 46′ W.	96	*Tom & Al*
March 7	43° 46′ N.	124° 34′ W.	80–90	*Empire II*
June 16	44° 20′ N.	124° 46′ W.	110	*Oregonian*

The depth at which these specimens were taken indicates they were on the continental shelf and might be considered among the first of this species to be collected from North American waters.

One specimen was sent to the Scripps Institution of Oceanography. Two are in the collection of fishes of the Department of Fish and Game Management at Oregon State University. Data on the latter are presented in Table 2. In general, these specimens fit closely the descriptions given by Welander *et al.* (1957) and Smith (1953).

TABLE 2. **EXTERNAL CHARACTERISTICS OF 2** *Pseudopentaceros richardsoni* **FROM THE OREGON COAST.**

Specimen number	OSU 482	OSU 483
Standard length	250 mm.	338 mm.
Body depth	93 mm.	159 mm.
Depth of caudal peduncle	23 mm.	35 mm.
Head length	80 mm.	112 mm.
Length of caudal peduncle	40 mm.	53 mm.
Dorsal fin rays	XIV, 9	XIV, 9
Pectoral fin rays (total count)	18–18	18–18
Anal fin rays	IV, 8	IV, 8
Caudal fin rays (principal rays)	17	17
Pelvic fin rays	I, 5	I, 5
Scales in lateral line	69	72
Scale rows along lateral line	70	74

P. richardsoni (Figure 1) can be distinguished from other fish found in Oregon waters by its striated head bones (Figure 2), which are easily visible just under the skin; the four anal spines; and the heterocanth condition of the median fin spines, alternating slightly right and left of the midline. All fin spines are heavy and striated. In addition, the scales on the ventral surface are thickened and placed in a mosaic which forms a hard but rather smooth armor.

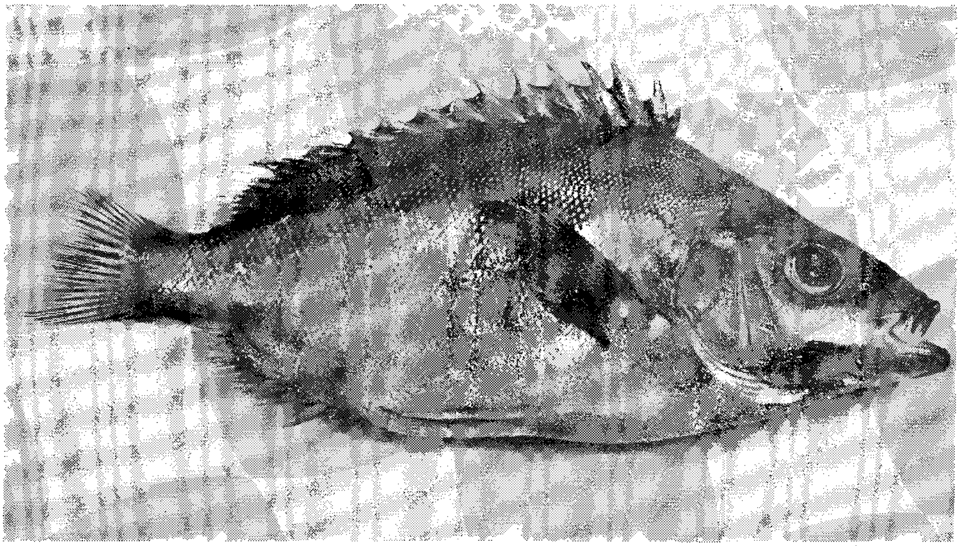

FIGURE 1. THE PERCOID FISH, *Pseudopentaceros richardsoni.*

Examination of scales suggested the smaller specimen (250 mm.) was in its 6th year of life and the larger (338 mm.) in its 11th year.

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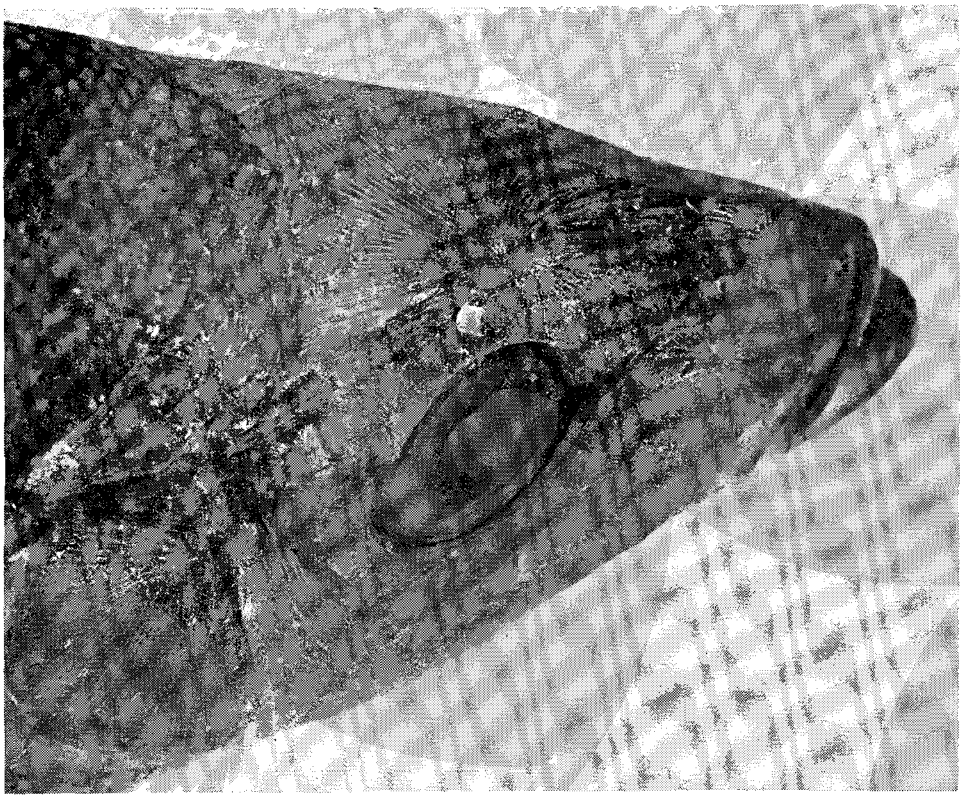

FIGURE 2. *P. richardsoni* SHOWING VISIBLE STRIATED HEAD BONES JUST UNDER SKIN.

Occurrence of the California Halibut in Oregon Waters

The range of the California halibut (*Paralichthys californicus,* Ayres) was given by Roedel (1953) as Central California south into the Gulf of California. Gunderson (1960) extended the range to 4 to 6 miles north of Redding Rock, California, longitude 41° 20.5′, latitude 124° 10.5′.

Two California halibut were brought to the Oregon Fish Commission in December 1960 for identification. The first fish was taken by Hugo Lilienthal on the trawler *Nel-Ron-Dic* between Tenmile Creek (latitude 43° 33.8′, longitude 124° 14.0′) and the Umpqua River entrance (latitude 43° 40.1′, longitude 124° 13.1′) in 36 fathoms on December 6, 1960. Mr. Lilienthal reported having taken two more of these fish at an earlier date. The second fish (Figure 1) was caught December 7, 1960, by Warren Harrison on the trawler *Ruth Ellen* in 17 to 50 fathoms off the Alsea River entrance (latitude 44° 26.3′, longitude 124° 2.5′). The fish captured off the Alsea River entrance represents an extension of the northern range of this species by approximately 180 miles over that reported by Gunderson. Identification of the fish was verified by Professor Carl E. Bond of the Department of Fish and Game Management, Oregon State University and this specimen is now in its collection of fishes. The California halibut caught between Tenmile Creek and the Umpqua River entrance is in the collection of the Oregon Fish Commission Research Laboratory, Charleston, Oregon. Meristic counts and measurements for the two fish appear in Table 1.

TABLE 1. **MERISTIC COUNTS AND MEASUREMENTS OF 2 CALIFORNIA HALIBUT** (*Paralichthys californicus*) **CAPTURED OFF THE OREGON COAST IN 1960.**

*Measurements*①	*Tenmile–Umpqua Specimen*	*Alsea Specimen*
Standard length	348 mm.	343 mm.
Total length	114.1 per cent	117.8 per cent
Head length	24.1	25.7
Snout length	5.7	5.8
Orbit length	2.6	3.5
Maxillary length	11.2	9.0
Body length	39.1	38.5
Dorsal rays	71	72
Anal rays	53	54
Ventral rays—Right	6	6
Left	6	6
Pectoral rays—Right	11	11
Left	11	11
Principal caudal rays	17	17
Gill rakers		
Lower limb	21	23
Upper limb	7	9
Scales in lateral line	96–98	95–99

① Standard length given in millimeters; all other measurements presented as percentages of standard length.

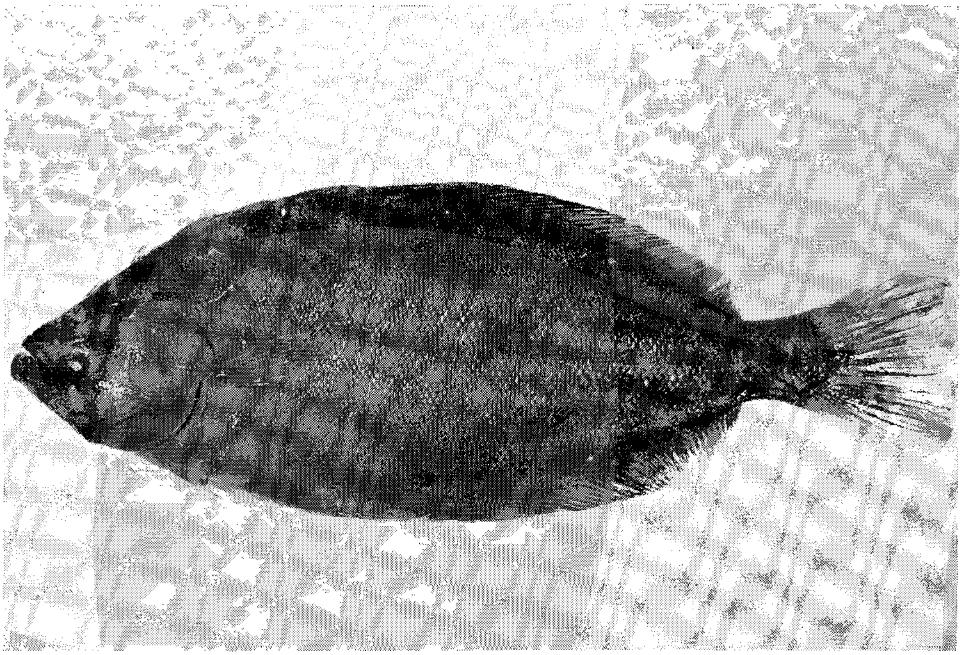

FIGURE 1. CALIFORNIA HALIBUT, *Paralichthys californicus.*

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Two Diseases New to Adult Pacific Salmon

The protozoan *Ichthyopthirius multifilis,* commonly known as "Ich", has been found on adult spring chinook salmon (*Oncorhynchus tshawytscha*) returning to the Middle Fork of the Willamette River each year since 1953. The disease first becomes apparent approximately three months after the fish enter fresh water. Mortality resulting from the infection is of an unknown magnitude but is thought to be low or inconsequential. However, in 1953 the disease caused severe losses to young steelhead trout (*Salmo gairdneri*) following the feeding of ground fresh adult chinook carcasses, indicating that the protozoan was transmitted to the steelhead ponds in the feed.

Furunculosis was diagnosed in adult spring chinook salmon returning to the South Santiam and Middle Fork of the Willamette Rivers in 1958. Identification was made by morphological and cultural tests. The causative agent *Aeromonas salmonicida* was isolated in pure culture on standard furunculosis agar medium from kidney tissue and characteristic external lesions of infected fish. External lesions associated with the disease were typically soft, blister-like necrotic areas filled with blood just beneath the skin. Characteristic lesions were also observed on adult fall chinook salmon in 1958 on the spawning grounds in the main stem of the Snake River in Idaho. No attempt at isolation of the causative agents was made to confirm this observation. Losses resulting from furunculosis in the above instances are of unknown magnitude.

No reference in the literature surveyed was found on the occurrence of the two diseases in adult Pacific salmon.

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Unusual White Sturgeon Diet

On May 7 1956, an unusually large white sturgeon (*Acipenser transmontanus*) was caught in the Willamette River below Willamette Falls at Oregon City by O. H. Cromwell of Portland, Oregon. The fish weighed 45 pounds and was 54 inches in length. It was caught in the mouth on a salmon spinner while trolling.

Examination of the stomach revealed that the fish had recently ingested 14 recognizable salmonids. Nine of these were rainbow trout or small steelhead (*Salmo gairdneri*), ranging in size from 5½ to 11½ inches fork length; 4 were chinook salmon (*Oncorhynchus tshawytscha*) 4 to 4½ inches in length; and 1 was an unidentified salmonid about 6 inches in length. Two of the largest trout were in fresh condition and the other fish were slightly digested.

The largest trout had a large, puncture-type wound running from the origin of the dorsal fin anteriorly through the body cavity. None of the other fish showed any obvious signs of injuries or disease.

It could not be determined if the sturgeon had captured the fish alive or had scavenged them after their death. However, the latter is the most likely since mortality to downstream migrants is known to occur at industrial plants at Willamette Falls, and sturgeon are notable scavengers.

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Chinook and Silver Salmon Spawning Together

An unusual spawning occurrence was observed on January 29, 1960 on a silver salmon spawning ground survey of Hatchery Creek, tributary of Johnson Creek which is a tributary of Tenmile Lakes. This is a small stream with a flow of about 6 c.f.s.

At a time when most salmon have finished spawning, a bright female chinook salmon (*Oncorhynchus tshawytscha*), weighing about 20 pounds, was observed actively spawning with a normal-sized (8-10 pounds) male silver or coho salmon (*O. kisutch*). Spawning activity was observed for about five minutes with both fish apparently performing their normal functions. Such spawning, if viable eggs and young are produced, could account for the occasional specimens observed in the fisheries that appear to have some characteristics of both species of salmon.

This occurrence was unusual because the spawning act was performed by fish of two different species; it was the first record of a chinook salmon in this stream; and represented very late spawning for a chinook. Color photos are on file at the Charleston Laboratory of the Oregon Fish Commission.

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