KAZIMURA

PELAGIC FUR SEAL INVESTIGATIONS CALIFORNIA-OREGON WASHINGTON

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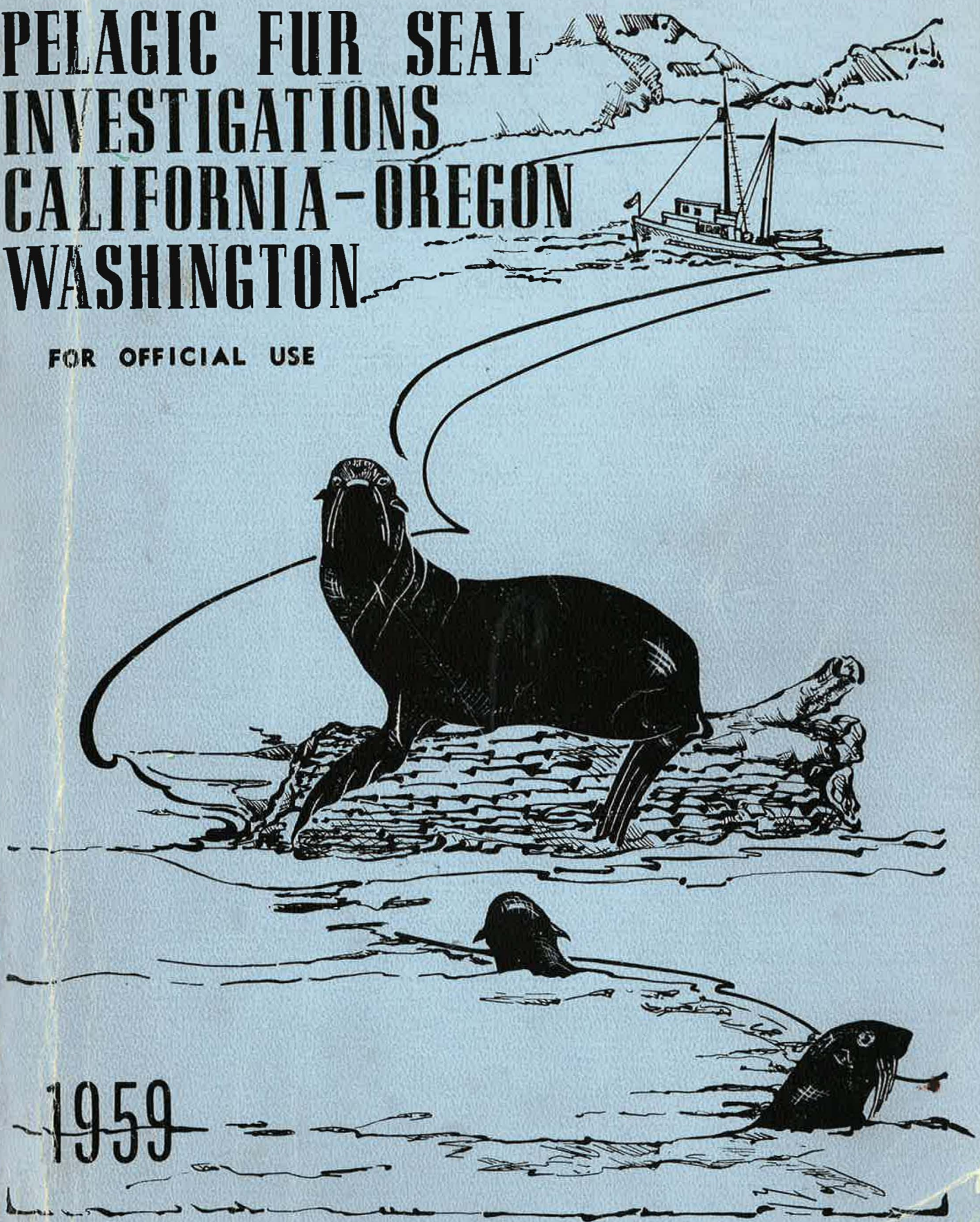

1959

PELAGIC FUR SEAL INVESTIGATIONS

CALIFORNIA, OREGON, AND WASHINGTON

1959

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CONTENTS

Figures

Page

Appendix figures

Tables

SUMMARY

The second year of pelagic fur seal research was carried out in 1959, under the terms of the Interim Convention on Conservation of North Pacific Fur Seals.

Three vessels were chartered by the United States for the field operations which began in January among the northern Channel Islands, California, and ended in April off Washington near the Strait of Juan de Fuca. Seal populations from Point Conception to Point Sur and Cape Mendocino to Point St. George were intensively sampled in 1959. Little work was done in these areas in 1958. Seal concentrations were observed west of Point Buchon, south to Point Sur, and in the vicinity of the Farallon Islands. No concentrations were encountered north of Point Arena.

Collecting was done south of Point Arena, California, until early April and in northern California, Oregon, and Washington waters from early March through 26 April, the termination date.

A total of 5,919 seals were seen and 1,548 were collected. Of these, 1,511 were females and 37 were males. The proportion of individuals (both sexes combined) in each year class ranged from 1.7 percent yearlings to a high of 10.8 percent 8-year-old seals, and fell away to 0.1 percent at ages 23 to 26.

Ages of seals were determined by the count of annual growth lines in the dentine layer of canine teeth and by comparing with teeth from tagged seals of known age. Year class proportions tend to verify the 1958 conclusion that females over 18 years old disappear more rapidly from the population than was assumed in earlier population estimates.

Nineteen tagged seals were recovered in 1959, ranging from one to 10 years of age. The number of recovered tags was very low in relation to recoveries from the same age classes on the Pribilof Islands. It is suggested that this is caused by inadequate sampling.

The pregnancy rate for 1,058 seals, 4 years and older, was 75 percent. According to genital tract examinations, 10 percent fetal mortality occurred between the period of impregnation and time of collection. Fetal mortality occurred in 10 percent of the multiparous animals, and in only 0.9 percent of primiparous seals. Part of the apparent fetal loss may result from misinterpretation during genital tract examinations.

The pregnancy rate is low in 4-year-old females (4 percent), increases rapidly toward ages 9 to 13, then gradually decreases until ages 16 to 18, when a sharp decrease in pregnancy occurs. Only a few animals are pregnant in the year classes 19 to 26.

On two occasions pregnant seals carrying twin fetuses were collected.

Seals were taken in waters with surface temperature ranging from 9 to 16 degrees centigrade. As in previous studies, no relation was found between seal abundance and water temperature. Seal distribution is related to availability of food, rather than a preference for water of certain temperature range.

Anchovy, hake, squid, and saury were principal food items, and made up 90 percent of the food of the seals collected in California waters. Anchovy alone accounted for 59 percent of the total. In Oregon, hake, rockfish, squid, and saury comprised 83 percent of food. Rockfish, sablefish, herring, and salmon were the most important food items taken off Washington, making up 85 percent of the food. Salmon occurred in 15 seal stomachs collected off Washington in 1959 and represented 1.1 percent of the total stomach contents.

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INTRODUCTION

This is a report on the second year of pelagic fur seal research carried on by the United States as agreed in the Interim Convention on Conservation of North Pacific Fur Seals (item 4 of the Schedule). A proposal for research operations to be carried out in 1959 was presented at the meeting of the North Pacific Fur Seal Commission in December 1958 and approved by that body.

It was found to be possible to follow the plan closely. The fur seal collection for 1959 was made between the Channel Islands off California and the Strait of Juan de Fuca between Washington and British Columbia. Less collecting was done in the immediate Channel Islands area than planned because of the scarcity of seals and interference by other activities. This is the principal exception to the plan as proposed.

The ocean area covered and the fur seal population are both much too large to be adequately represented by the sample of 1,548 seals collected or the larger number observed. Because of the necessity of reaching the quota of 1,250 to 1,750 seals scheduled in the Interim Convention, the collecting cannot be random as is desirable in a distribution study. There exists, always, the problem of satisfactorily relating abundance and visibility conditions at sea.

Concentration of collecting effort off the coasts of California, Oregon, and Washington in 1959 has considerably improved knowledge of fur seal distribution, age segregation, and feeding habits in this area, especially on the wintering grounds off south-central California between Monterey Bay and Point Conception, and off Cape Mendocino to Point St. George in northern California.

METHODS, EQUIPMENT, AND PERSONNEL

Vessels and Boats

Three vessels were chartered for the 1959 pelagic sealing

operations: M/V Tacoma -- a purse seiner, registered length 71.5 fe cruising speed 9 knots; M/V Harmony -- a purse seiner, registered length 70.5 feet, cruising speed 9 knots; M/V Morning Star -- a patro vessel, registered length 104 feet, cruising speed 12 knots. All vesse were required to have the following listed equipment: (1) Loran navigating equipment and/or a radio direction finder, (2) ship-to-shore a ship-to-ship radio, (3) radar, and (4) fathometer.

Each vessel carried a crew consisting of captain, engineer, cook, and deckhand and three Fish and Wildlife Service biologists or biological aids. Two small boats carried by the vessels were used for hunting during periods of good weather where seal concentrations occurred. The boats were powered with ten-horsepower outboard motors. On days when the small boats were used, they would account for about 50 percent of the seals collected for that day. Because of weather conditions the use of small boats is limited but, in view of the increased collections on days when their use is possible, it is considered worth-while to have them available.

The length of the average cruise during the past season was, as usual, dependent on weather conditions. Trips of five to seven day were commonly made and on a few occasions longer trips were possib The working day at sea was usually about twelve hours, or, in the earlier part of the season, from dawn to dark. While on the hunting grounds, the usual procedure was to stop about 6 p.m. or dark and drift until sunrise. Gill nets were frequently fished while the boat wa drifting, for the purpose of collecting a sample of fish in the area where the seals were collected. By drifting on the grounds during the night, long runs to and from port and the hunting grounds were elimi-nated. Radio schedules were maintained between vessels to coordinat movements and compare information on sealing conditions.

Hunting Methods

Hunting methods described in 1958 (Wilke et al) were used aga in 1959. Practically all of the seals were collected with twelve-gauge shotguns loaded with 00-buckshot (9 pellets) or 0-buckshot (12 pellets) There was no noticeable difference in killing power between the two loads. Rifles of .243-caliber were occasionally used.

Records were kept by each vessel of total seals sighted, seals collected, seals wounded and lost, and seals killed and lost. The tota are:

Seals sighted	5,919
Seals collected	1,548 (26.2 percent of seals sighted)
Seals wounded and lost	316 (5.3 " " " "
Seals killed and lost	286 (4.8 " " " "
Total	2,150 (36.3 percent of seals sighted were collected, wounded, or killed and lost.)

The actual numbers of seals wounded-lost and killed-lost is probably slightly higher than shown above. The seal was not recorded as wounded unless blood was actually seen, and some seals that are hit escape without being seen again. Some of these die later. Several seals with buckshot wounds were seen in the Pribilof Islands kill in 1959. They may have been wounded in the collecting off either America or Asia.

The method of processing seals aboard the vessels, with minor changes, was the same as described in the 1958 report. Only skins from animals falling within certain size limits (appendix F) were saved for processing and shipment to the contracting processor (Fouke Fur Company) in St. Louis.

Laboratory Methods

Age Determination

The method of counting annuli (annual growth lines) in the dentine layer of a canine tooth to determine age was adopted in 1958. Some changes were made in the techniques used in preparing and aging teeth in 1959.

In the field, the snout of each seal was cut off (fig. 1) and placed in a cloth bag with a metal tag corresponding to the collection number of the seal. When a number of snouts had accumulated, they were boiled to loosen the teeth. The upper right canine was extracted from the snout, cleaned, and saved.

In the laboratory, the tooth was placed in a vise and a cut was made down along the longitudinal plane to about the midline, using a Stanley Surform rasp (fig. 2). Rasp blades which produced the best results were the "regular-cut, flat, No. 294B" blade. The tooth was then ground down, as nearly as possible, to the exact midline on an

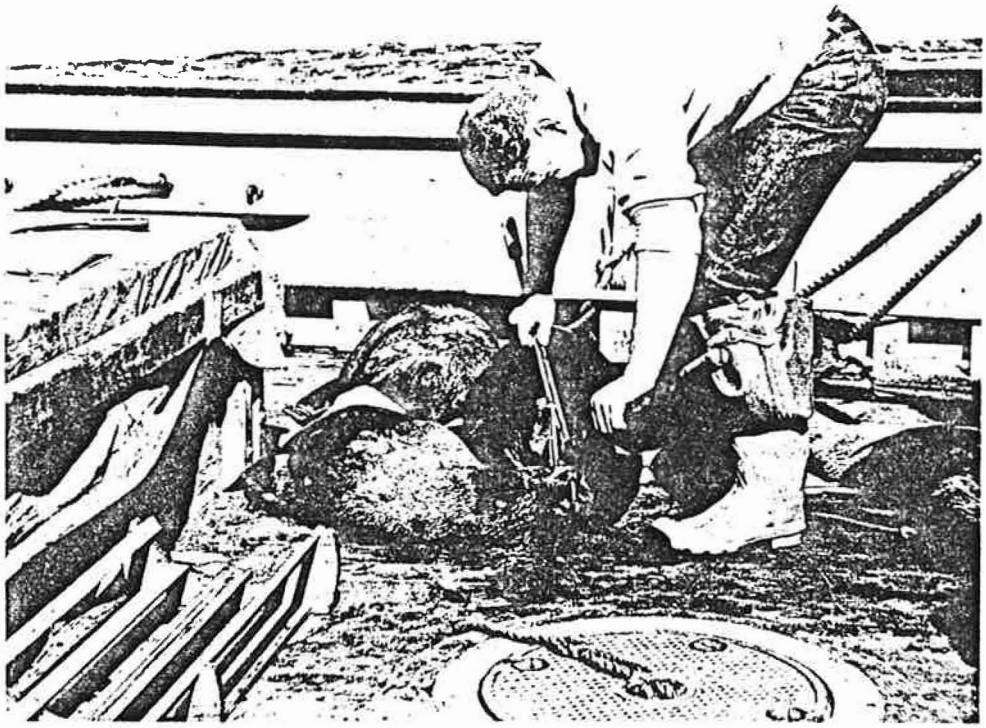

Figure 1. -- Cutting off snout for removal of canine tooth.

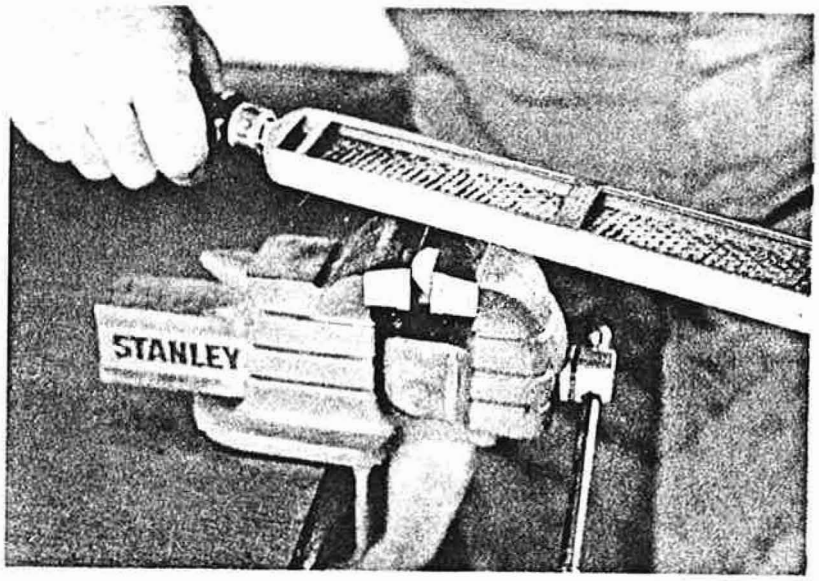

Figure 2. --Cutting a seal tooth with a rasp.

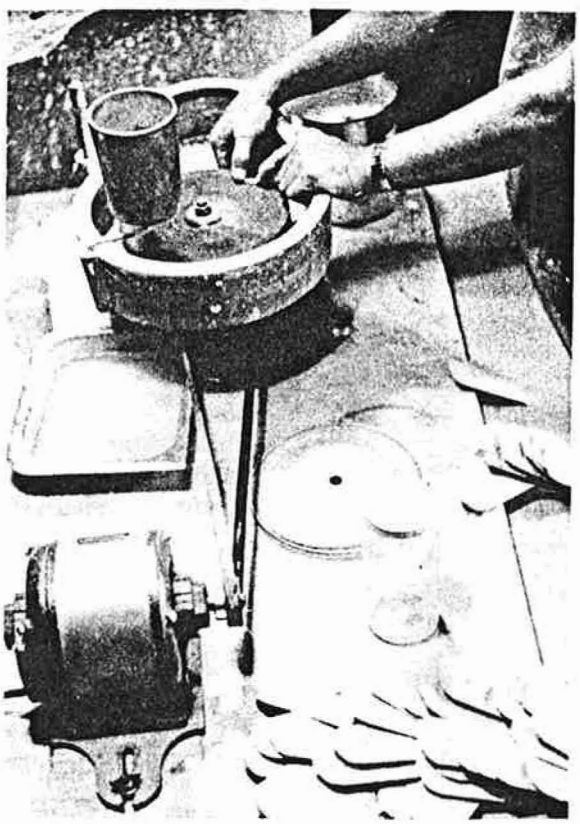

Figure 3. --Machine used to polish tooth sections.

8-inch silicon-carbide grinding wheel (fig. 3). The grinding wheel was then removed and a felt polishing wheel set in place. Polishing compound was applied to the wheel and the tooth was polished until all mark of grinding had disappeared. The carbide grinding wheel and felt polis ing wheel are part of a commercially-made gem-making set (Craftsma Sears, Roebuck and Company).

The teeth were then ready for aging (figs. 4 and 5). Binocular loops (Magni-Focuser, Model 7 - Edroy Products Company) were used to enlarge details in the teeth. The tooth was held in the hand over a light (Universal Illuminator, Model 359 - American Optical Company) to bring out the growth lines (annuli) which appear as a series of light and dark areas under illumination and, as the count was made, the toot could be turned to show the annuli to the best advantage.

Each tooth was read by three men. Results were compared and where differences of opinion occurred, the teeth were re-examined before a final age was determined. Teeth from known-age (tagged) seals were prepared for comparison with teeth from untagged seals.

Stomach Examinations

The stomach was removed from the seal during the normal processing aboard the vessel. Both ends of the stomach were tied off and the stomach was injected with 10 percent formalin solution (fig. 6). The amount of formalin injected depended upon the size and volume of the stomach. The stomach was then placed in a barrel containing formalin solution until ready for examination at the laboratory.

In the laboratory, the contents were removed from the stomach Weight and volume of stomach contents were taken. The contents were sorted by species and counts were made of the number of times each food item occurred. The percentage of the total volume represented by each food item was calculated by dividing the volume of each food item by the total volume of food contents for the entire collection or for specific areas.

Identification of food items appearing in the stomachs was made from various published keys, other literature (see bibliography), and from the collection of specimens, skeletons, and other material in the laboratory in Seattle. Some specimens were sent to the U. S. National Museum for identification, or to verify tentative identifications made in the laboratory.

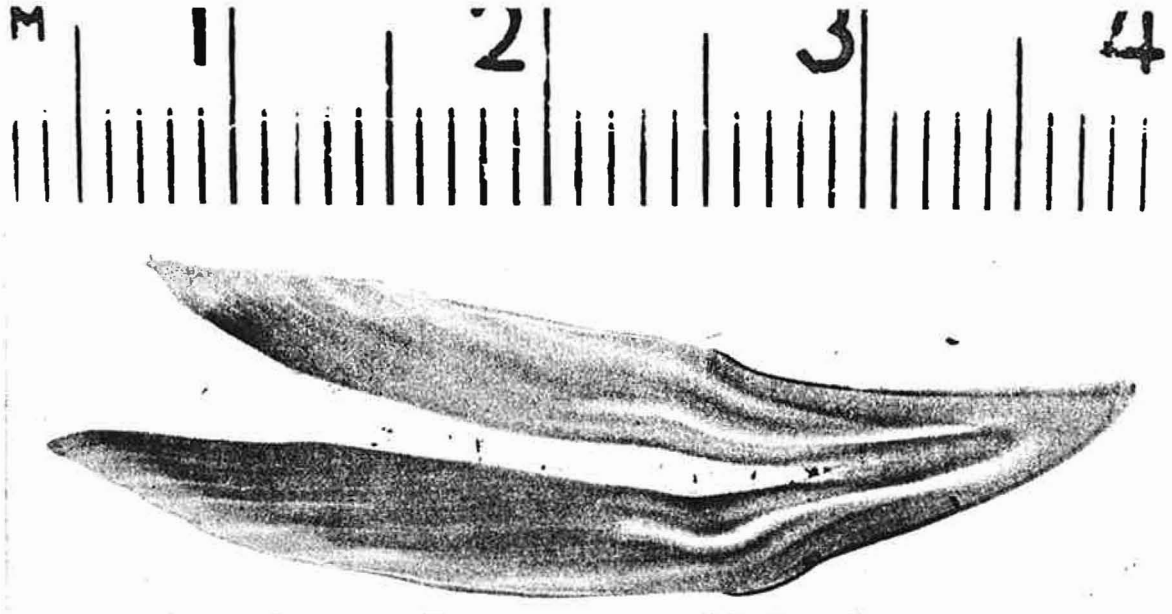

Figure 4. --Upper right canine from 7-year-old female, US59-1632; tagged (E 10561) as pup in September 1952, at St. Paul, Pribilof Islands; collected 25 April 1959 off Washington.

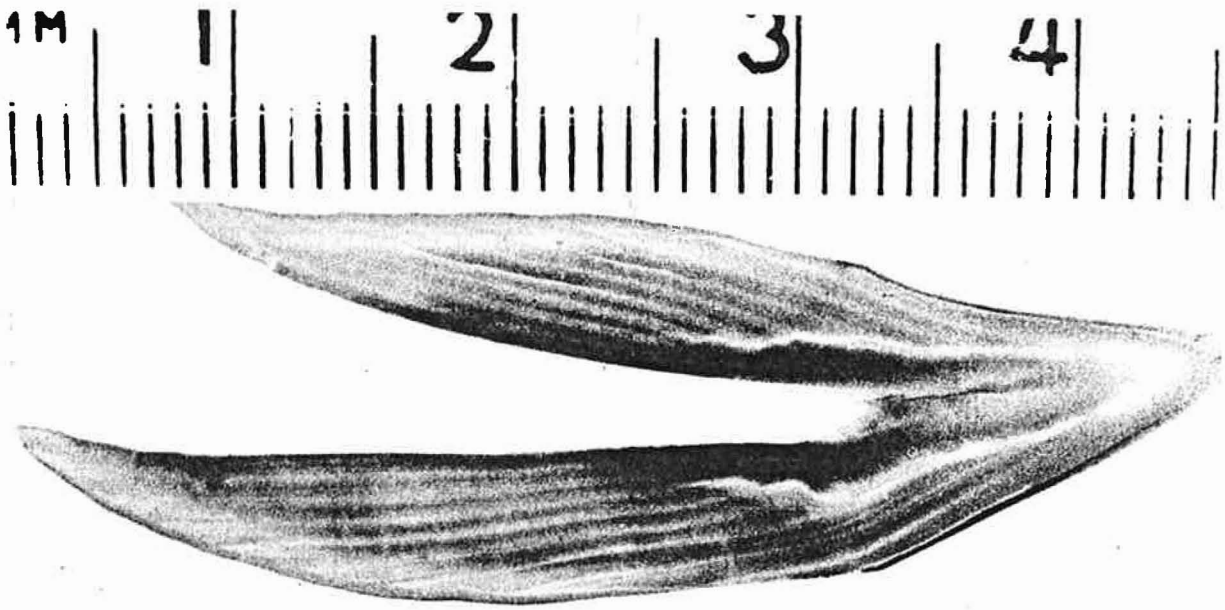

Figure 5. --Upper right canine from 9-year-old male, US58-737; tagged (CS 12714) as pup in September 1949, at St. Paul, Pribilof Islands; collected 21 April 1958 off Yakutat, Alaska.

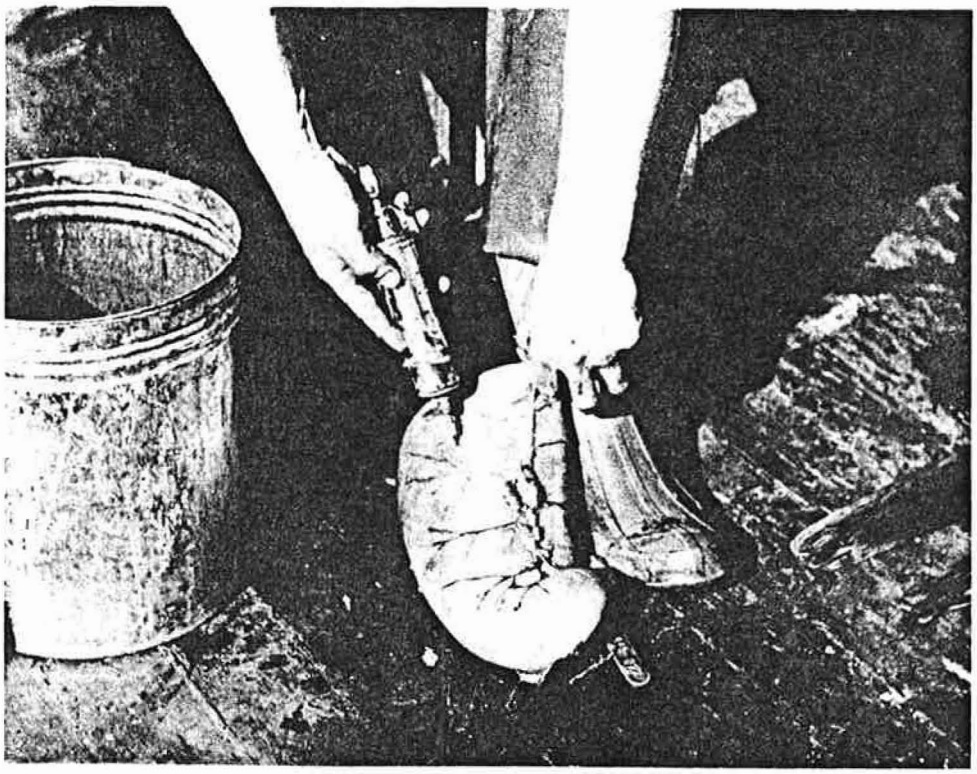

Figure 6. -- Injection of stomach with 10 percent formalin solution.

Personnel

The following personnel took part in the pelagic fur-seal investigations in 1959:

Permanent employees: Ford Wilke, Supervisory Biologist; Karl Niggol, Biologist; Clifford H. Fiscus, Jr., Biologist.

Temporary employees: Gary A. Baines, Biologist; Harold L. Hansen, Biologist; Thomas P. O'Brien, Biologist; Paul J. Struhsaker, Biologist; Richard D. Bauer, Fishery Aid; Thomas C. Juelson, Fishery Aid; David F. Riley, Fishery Aid.

RESEARCH IN 1959

Distribution of Seals by Time, Place, and Numbers

The distribution of seals observed and collected is shown in figures 7, 8, and 9. The area through which vessels worked has been divided into a series of squares, each representing 10 square miles (nautical). The number in the upper half of the square represents the total number of seals sighted and the number in the lower half of the square represents the total number of seals collected in that area throughout the season.

Tables 1 and 2 show the numbers and relative abundance of seals seen and collected by state and 10-day periods. Appendix A is similar to table 1 but boat-hunting hours are substituted for boat-hunting days.

Grouping of seals is shown in table 3. Grouping observed in 1959 follows the pattern observed in previous years with the exception of groups containing more than 10 seals; 26 such groups were recorded. Practically all of these groups were seen when they were actively feeding in large schools of fish. When approached by the vessel or boats, the group would break up and scatter in smaller groups of one to three or four seals. From the past two seasons' observations, it seems likely that the large groups of seals are attracted and held together by the presence of schools of fish and, upon the dispersal or sounding of the fish, the group spreads and more normal grouping is resumed.

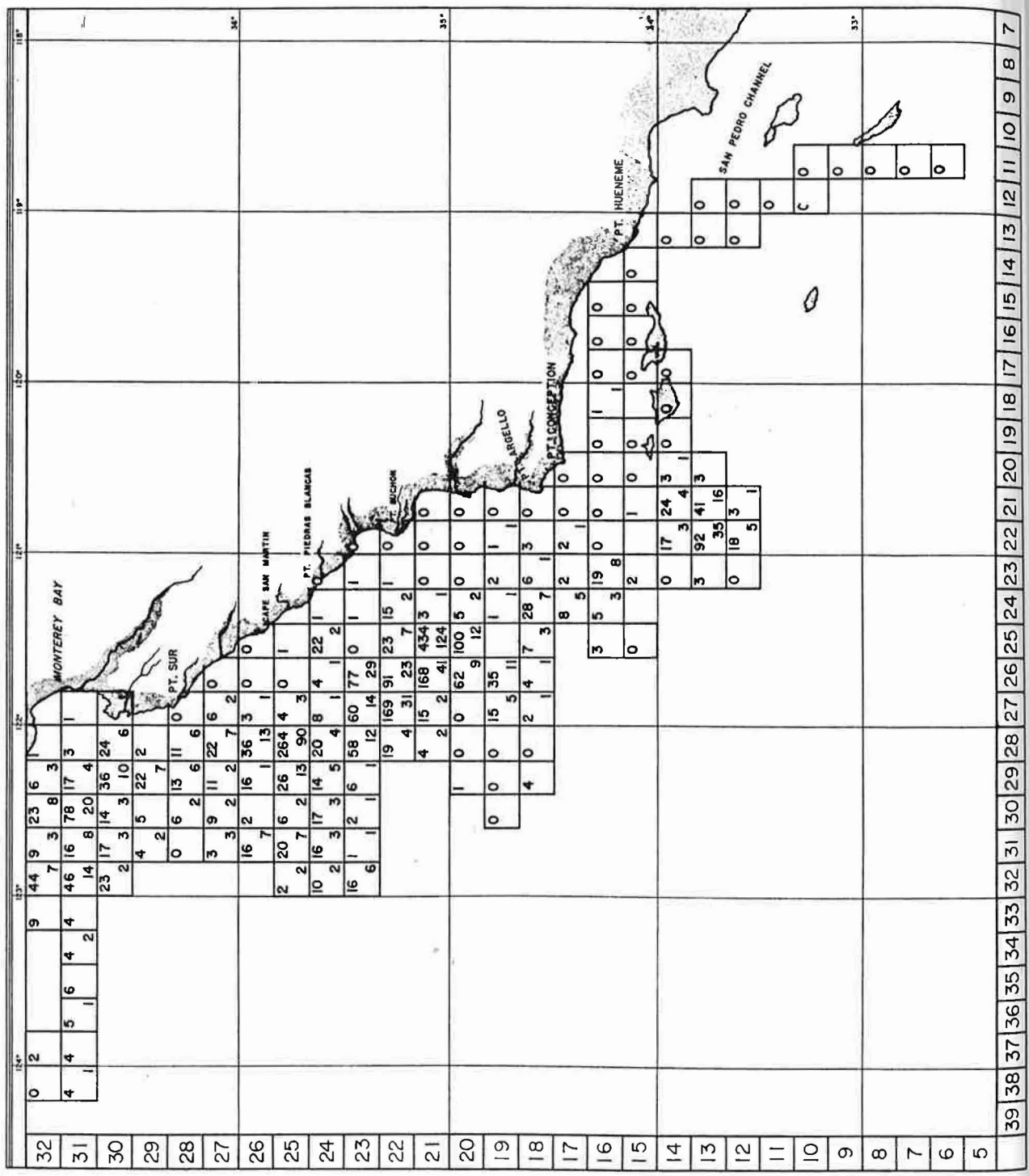

Figure 7. --Distribution of seals observed (upper number) and collected (lower number) from 32°00'N. to 37°00'N., in 1959

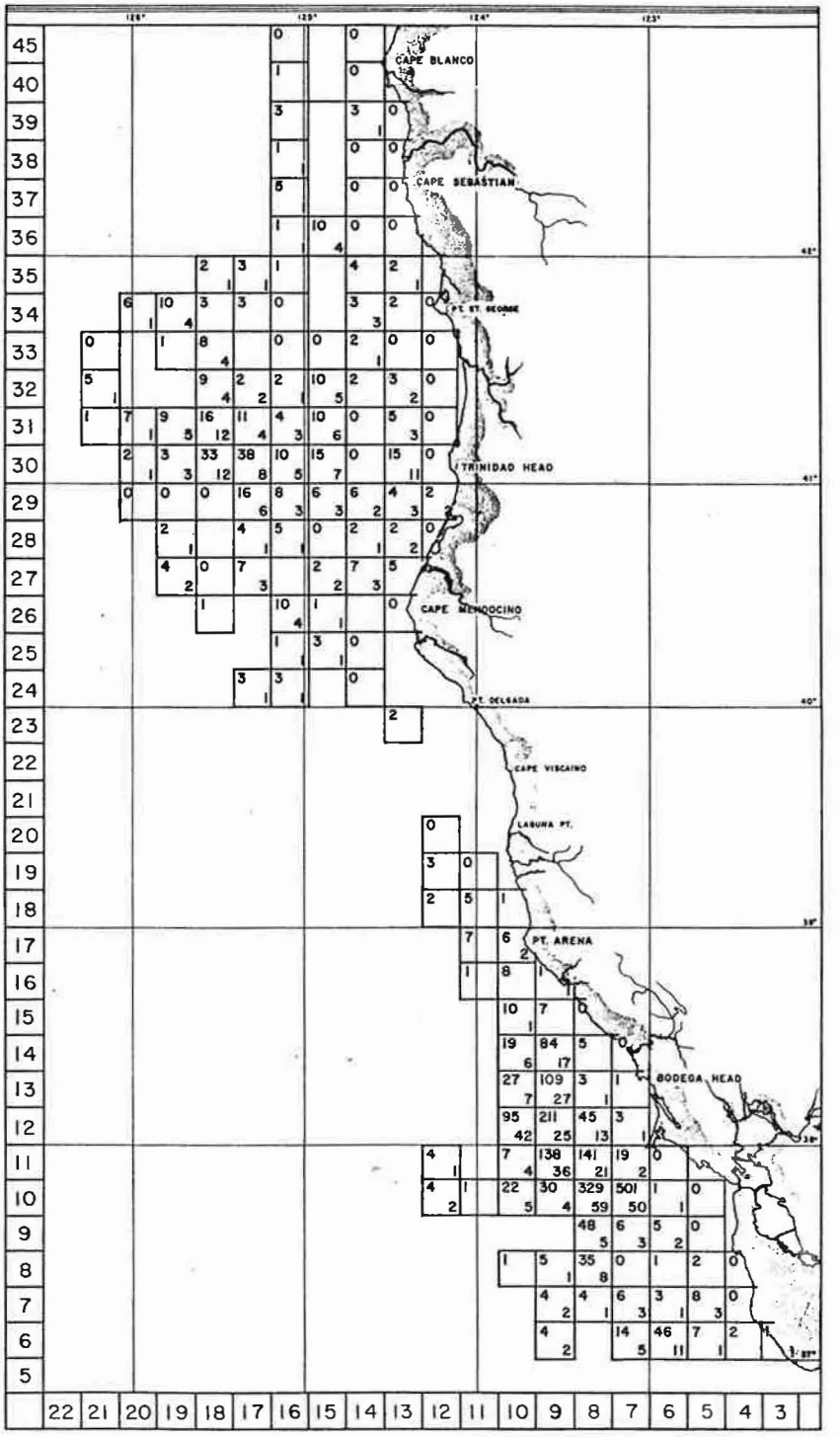

Figure 8. -- Distribution of seals observed (upper number) and collected (lower number) from 37°00'N. to 43°00'N., in 1959.

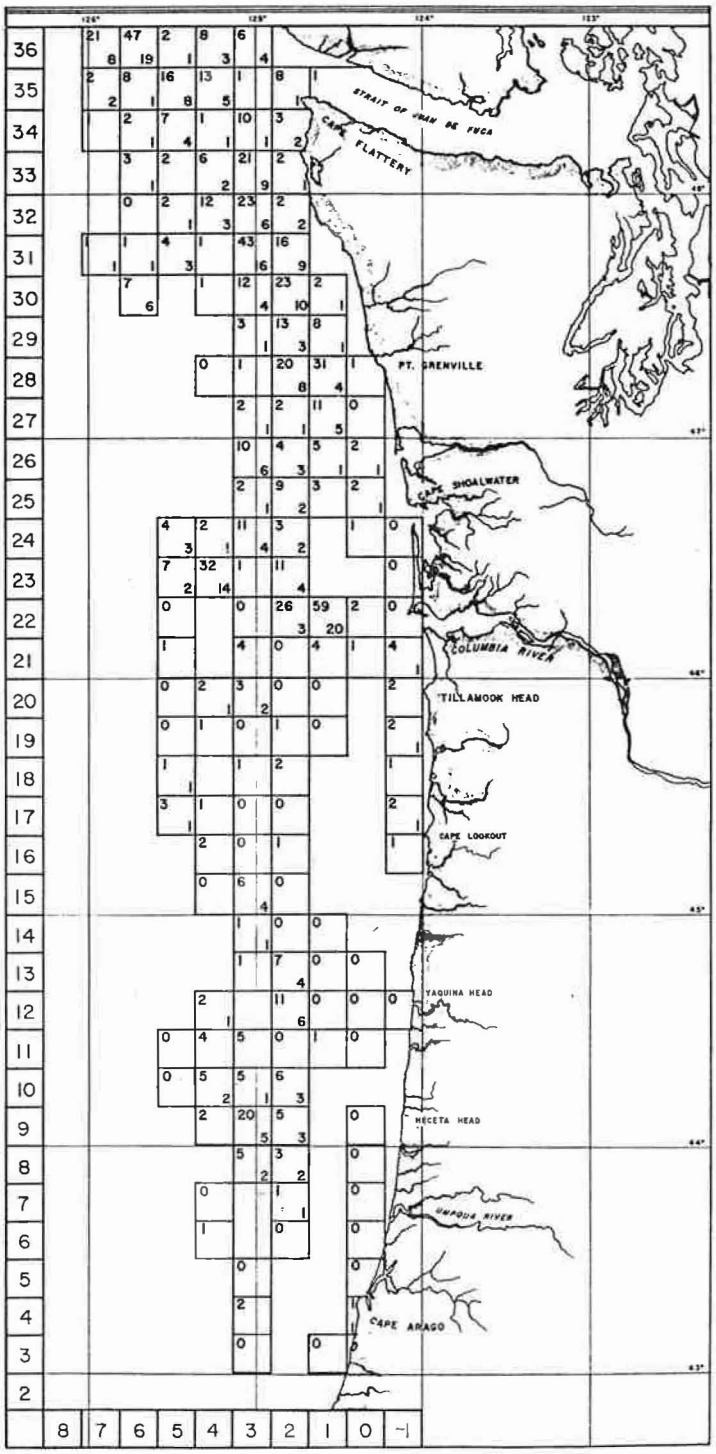

Figure 9. --Distribution of seals observed (upper number) and collected (lower number) from 43°00'N. to 48°40'N., in 1959.

Table 1. --Numbers and relative abundance of seals seen off California, Oregon, and Washington, by 10-day periods, 16 January to 26 April 1959

Period	Number of boat-hunting days	Total seals sighted	Seals seen per boat day	Percent seen in various periods
California				
16-25 January	18.25	321	17.6	6.3
26 January - 4 February	16.75	1157	69.1	22.5
5-14 February	15.00	1306	87.0	25.4
15-24 February	15.00	1067	71.1	20.8
25 February - 6 March	14.25	374	26.2	7.3
7-16 March	12.75	139	10.9	2.7
17-26 March	11.25	368	32.7	7.2
27 March - 5 April	12.75	329	25.8	6.4
6-15 April	4.00	71	17.7	1.4
Total	120.00	5132	42.8 [1/]	100.0
Oregon				
16-25 January	4.00	18	4.5	12.6
7-16 March	1.00	16	16.0	11.2
17-26 March	3.75	49	13.1	34.3
6-15 April	6.75	60	8.9	41.9
Total	15.50	143	9.2 [1/]	100.0
Washington				
16-25 January	2.75	22	8.0	3.4
17-26 March	0.25	1	4.0	0.1
27 March - 5 April	3.00	136	45.3	21.1
6-15 April	7.50	101	13.5	15.7
16-25 April	18.75	372	19.8	57.8
26 April	2.00	12	6.0	1.9
Total	34.25	644	18.8 [1/]	100.0
Grand total	169.75	5919	34.9 [1/]	

[1/] Average number of seals seen per boat day in area.

Table 2. --Numbers and relative abundance of seals collected off California, Oregon, and Washington, by 10-day periods, 16 January to 26 April 1959

Period	Number of boat-hunting days	Number of seals taken			Seals taken per boat day	Percent taken in various periods
		males	females	total		
California						
16-25 Jan.	18.25	1	83	84	4.6	6.6
26 Jan.-4 Feb.	16.75	1	170	171	10.1	13.5
5-14 Feb.	15.00	-	356	356	23.7	28.1
15-24 Feb.	15.00	-	229	229	15.3	18.1
25 Feb.-6 Mar.	14.25	-	91	91	6.4	7.2
7-16 Mar.	12.75	2	47	49	3.8	3.9
17-26 Mar.	11.25	3	115	118	10.5	9.3
27 Mar.-5 Apr.	12.75	3	126	129	10.1	10.2
6-15 Apr.	4.00	3	37	40	10.1	3.1
Total	120.00	13	1254	1267	10.6 [1/]	100.0
Oregon						
16-25 Jan.	4.00	-	5	5	1.3	9.8
7-16 Mar.	1.00	1	4	5	5.0	9.8
17-26 Mar.	3.75	1	14	15	4.0	29.4
6-15 Apr.	6.75	3	23	26	3.9	51.0
Total	15.50	5	46	51	3.3 [1/]	100.0
Washington						
16-25 Jan.	2.75	1	-	1	0.4	0.4
17-26 Mar.	0.25	-	-	-	-	-
27 Mar.-5 Apr.	3.00	1	43	44	14.7	19.1
6-15 Apr.	7.50	-	29	29	3.9	12.6
16-25 Apr.	18.75	16	138	154	8.2	67.0
26 Apr.	2.00	1	1	2	1.0	0.9
Total	34.25	19	211	230	6.7 [1/]	100.0
Grand total	169.75	37	1511	1548	6.9 [1/]	

[1/] Average number of seals collected per boat day in area.

Table 3. -- Grouping of seals sighted off California, Oregon, and Washington, 16 January to 26 April 1959,

Area	Number of seals per group											Total
	1	2	3	4	5	6	7	8	9	10	10+ 1/	
California												
No. groups	1524	499	234	103	44	37	14	14	3	11	26	2509
No. seals	1524	998	702	412	220	222	98	112	27	110	707	5132
Percent seals	29.7	19.5	13.7	8.0	4.3	4.3	1.9	2.2	0.5	2.1	13.8	100.0
Oregon												
No. groups	113	10	2	1	-	-	-	-	-	-	-	126
No. seals	113	20	6	4	-	-	-	-	-	-	-	143
Percent seals	79.0	14.0	4.2	2.8	-	-	-	-	-	-	-	100.0
Washington												
No. groups	412	81	13	2	3	-	-	1	-	-	-	512
No. seals	412	162	39	8	15	-	-	8	-	-	-	644
Percent seals	64.0	25.2	6.1	1.2	2.3	-	-	1.2	-	-	-	100.0
Grand total												
No. groups	2049	590	249	106	47	37	14	15	3	11	26	3147
No. seals	2049	1180	747	424	235	222	98	120	27	110	707 1/	5919
Percent seals	34.6	19.9	12.6	7.2	4.0	3.7	1.7	2.0	0.5	1.9	11.9	100.0

1/ Estimated group sizes for the 10+ group = 10, 12, 12, 12, 15, 15, 15, 16, 20, 20, 20, 20, 20, 20, 20, 25, 25, 30, 35, 35, 40, 40, 40, 40, 50, 100.

California

Vessel operations off California commenced 18 January and continued through 14 April 1959. Operations were confined to the waters south of Point Arena until 13 March, when work began in northern California waters.

One vessel made a trip south of Port Hueneme to the east of Cortez Bank (32°44'N., 118°42'W.) on 27-28 January. Weather conditions were poor and no seals were sighted. This was the southernmost run of the season. Two vessels worked southwest of San Miguel Island 22-24 January. Weather conditions were excellent and about 200 seals were sighted during this time. Courses were run through the Santa Barbara Channel, between San Miguel Island and Port Hueneme on 25 January, and again on 27 January. Visibility was good on both occasions but only one seal, a yearling, was sighted in the channel north of Santa Rosa Island. These three operations constituted the work accomplished south of Point Conception. It had been planned to work among these islands more intensively but military restrictions on movement within the area made it necessary to change plans in order to prevent excessive loss of time.

One or two vessels collected from Point Conception to Point Sur throughout February. Two days were spent by one vessel in the northern part of this area in mid-March. Good coverage was obtained from the shore off to about 80 miles. Most seals were found from 25 to 50 miles offshore. Seals were found in small numbers to the farthest points reached on offshore runs.

During the period 3-6 February, two vessels working west of Point Buchon located an area of seal concentration between 34°50' N. to 35°20'N. and 121°20'W. to 122°00'W. This area, about 40 miles long by 20 miles wide, lay in a northwest to southeast direction. Many schools of anchovy, the probable cause of the concentration, were present. The seals were actively feeding throughout the day and, in the larger schools of feed, groups of 10 to 20 seals were sometimes found. It was common during this time to see five or six groups of seals from the vessel at one time (see appendix F).

Feeding schools of fish could be located at a considerable distance from the vessel by the large flocks of kittiwakes (Rissa tridactyla) milling above the school. Birds commonly found in the vicinity of feeding schools were: kittiwake, rhinoceros auklet (Cerorhinca monocerata), common murre (Uria aalge), cormorant (Phalacrocorax sp.), and brown pelican (Pelecanus occidentalis californicus). In

addition to the fur seal other marine mammals seen in the area, or actively feeding on the same fish school with the fur seals, were: California sea lion (Zalophus californianus), pilot whale (Globicephala scammoni), killer whale (Grampus rectipinna), right whale dolphin (Lissodelphis borealis), Risso dolphin (Grampus griseus), Pacific striped dolphin (Lagenorhynchus obliquidens), Pacific dolphin (Delphinus bairdi), and Dall porpoise (Phocoenoides dalli).

On 13 February, another concentration of seals was located about 40 miles south of Point Sur. It apparently covered a much smaller area than the concentration off Point Buchon, although the eastern and western limits were not fully defined. This concentration was centered at about 35°45'N., 122°08'W. About 250 seals were sighted by two vessels.

The last cruise was made on 16 and 17 March when one vessel working between Point Piedras Blancas and Point Sur sighted 60 seals. It is likely that a gradual northward movement of seals began in March.

The area from Point Sur to Point Arena was hunted extensively by one or more vessels from 19 January to 8 April. Two vessels, making a southward run on 19 January, found seals evenly distributed between Point Arena and Point Sur. Weather conditions were poor and no attempt was made to work. One vessel hunted in this locality from 22 January through 8 April, with the exception of one five-day period when a trip south of Point Sur was made. Another vessel worked here from 19 February through 13 March, spending most of its time offshore between the Farallon Islands and Bodega Head. Two vessels, in early March, collected between Halfmoon Bay and Santa Cruz and offshore to Guide and Pioneer seamounts.

One vessel made an offshore run of 110 miles, 8 February, from Monterey Bay west to 36°48'N., 124°06'W. Seals were observed throughout the cruise, although in smaller numers as the outer limit of the run was approached. Small concentrations of seals were observed at different times during the season 20 to 30 miles west of Monterey. A rather stable concentration of seals was observed on the Farallon-Bodega grounds during February and seals were still present in this locality, although in smaller numbers, in April.

Groups of seals observed in the Point Sur-Point Arena area in 1959 were much larger than groups seen elsewhere along the Pacific coast in 1958 and 1959. These large groups were practically all seen in the vicinity of the Farallon Islands and on the grounds stretching from the Farallon Islands north across Cordell Bank to a point roughly parallel with Bodega Head.

Approximately 100 seals in one group were observed at 37°43'N., 123°09'W. on 2 February and several groups of 25 or more were seen 22 February in the vicinity of 37°42'N., 123°24'W, all were actively feeding in large schools of anchovy. Large flocks of birds and other marine mammals were commonly found feeding in the same schools. Pacific striped dolphin, Pacific dolphin, Dall porpoise, gray whale (Eschrichtius glaucus), California sea lion, and Steller sea lion (Eumetopias jubata) were observed in this vicinity although not all were feeding.

No work was done from Point Arena to Cape Mendocino because passages of the three vessels through this area were either at night or during periods of stormy weather.

One vessel worked between Cape Mendocino to Point St. George from 16 March through 8 April. No large concentrations of seals were observed although they were generally distributed from the vicinity of the 50-fathom curve to 100 miles offshore which was as far as the vessel ran. Total seals sighted per hour and day was much lower here than south of Point Arena. Appendix A illustrates this to a certain degree when a comparison is made between the 10-day periods, starting 26 January and ending 24 February and the periods starting 17 March and ending 5 April. Seals were seldom found in the same locations on different days, as was frequently true in the south earlier in the year. There are probably several reasons for this difference in distribution: (1) at this time of year, the seals had begun their northward migration; (2) there were no large schools of food fishes that would attract and hold seals; (3) it is likely there is no semi-permanent wintering population in this vicinity but the seals that are found here are moving south in the early winter months and north in the spring.

Oregon

For the purpose of this report, the area lying between 42°N. and 46°N. is designated as Oregon. Relatively little hunting was done off Oregon because of unfavorable weather conditions coupled with the fact that the vessels did not have unlimited time in which to wait for good sealing weather.

During the period 17-21 January, all three vessels passed south through Oregon and, although weather conditions were not favorable for either observing or hunting, seals were seen and five were collected. In March one vessel moving north (16-20 March) saw more

than 60 seals and collected 20. Another vessel, working north from 9-14 April, also saw about 60 seals and collected 25.

No concentrations of seals were seen off Oregon and, it appeared likely, during the short time spent here, that conditions were similar to those encountered off northern California. It would be desirable to have a vessel in this area for the entire season to make an investigation more nearly comparable with that made off California.

Washington

In this report, the area between 46°N. and 48°40'N. is considered Washington. A few seals were observed on the Washington coast by vessels running south to California in mid-January. One vessel hunted off Washington from 2-26 April and a second collected here from 14-26 April.

The seal population appeared to be widely scattered and erratic in distribution. One vessel worked from the Columbia River north to Cape Shoalwater during the period 2-11 April, occasionally finding seals in fair numbers. During the latter part of April, both vessels collected north of Destruction Island. Offshore areas were generally unproductive in this period. On several occasions, the vessel working the Destruction Island area would find many more seals than the vessel working La Perouse Bank but the next day conditions would be reversed. Rarely would seals be found in the same numbers in a locality from one day to the next.

In April, most older seals seen off Washington were in northward migration. This movement is best described as a series of waves, separated by intervals of one to two days. The northward movement apparently occurred at night, and daylight hours were spent in resting and, to a limited extent, in feeding.

California waters south of Point Arena can probably be considered to be the wintering area for many of the seals found south of Cape Flattery, Washington, although more thorough examination of waters off Oregon and Washington is needed before this can be definitely stated.

The study of distribution, abundance, local movements, and migration has been hampered by the necessity of obtaining a quota of seals to fulfill treaty obligations. It has been found necessary to concentrate efforts in areas where seals are found in abundance in order

to fill this quota. Repeated runs through the same area could not be made as often as is desirable for a study of this type.

Distribution by Age and Sex

Age and Sex

Of the 1,548 seals taken off California, Oregon, and Washington, 1,511 were females and 37 were males (table 4). Male seals were taken off northern California and Oregon coasts in a proportion similar to the proportion of males in the 1952 collection (Taylor, et al., 1955); none was taken here in 1958. The largest number of seals was included in the 4- to 15-year-old group; nine years was the median age. More two-year-old seals were killed in 1959 than in 1958. The oldest seal collected was a 26-year-old female killed 56 miles west of Point Arguello, California on 20 February. One 8-year-old bull was collected, 20 April, 29 miles west of Cape Flattery, Washington, far to the south of the usual range for a bull of this size and age. Older bulls, 6-year-olds and older, normally are found in the winter and spring in the Gulf of Alaska, straying south occasionally to the Sitka vicinity. See appendix B for additional information on distribution.

Tag Recoveries

Of the 1,548 seals taken, 19 (1.2 percent) were tagged (fig. 10). See also appendix C.

The tagged seals recovered were marked in various years between 1949 and 1958 (table 5, right-hand column) when from 10,000 to 50,000 pups were tagged annually.

Tag recoveries have been erratic in past pelagic samples. The number of recoveries has been less than expected as calculated from the proportion of tagged seals of various ages on the Pribilof Islands. There is no complete explanation for this nor for the discrepancy between male and female tag recoveries, low tag recoveries in the 2-year-old class, and the total absence of 1956 (3-year-old seals) tags in the samples of 1958 and 1959 (table 6). Doubtless, inadequate or nonrepresentative sampling is responsible for a part of the discrepancy between observed and expected tag recoveries. Seals are distributed over an enormous area and only a narrow strip along the coast has been touched in the pelagic sampling.

Table 4. -- Age and sex of fur seals collected off California, Oregon, and Washington in 1959

Age (years)	California 2 January to 9 April				Oregon 18 January to 15 April				Washington 20 January to 26 April				Combined areas				Combined areas males and females	
	males		females		males		females		males		females		males		females			
	number	percent	number	percent	number	percent	number	percent	number	percent	number	percent	number	percent	number	percent	number	percent
1	1	7.7	2	0.2	1	20.0	4	8.5	9	47.4	9	4.4	11	29.8	15	1.0	26	1.7
2	3	23.1	18	1.5	2	40.0	3	6.4	5	26.3	13	6.3	10	27.0	34	2.3	44	2.9
3	4	30.7	29	2.4	1	20.0	4	8.5	4	21.0	10	4.8	9	24.3	43	2.9	52	3.4
4	5	38.5	78	6.3	1	20.0	4	8.5	-	-	11	5.3	6	16.2	93	6.3	99	6.5
5	-	-	95	7.7	-	-	5	10.7	-	-	14	6.8	-	-	114	7.7	114	7.5
6	-	-	107	8.7	-	-	1	2.1	-	-	10	4.8	-	-	118	8.0	118	7.8
7	-	-	128	10.4	-	-	5	10.7	-	-	10	4.8	-	-	143	9.6	143	9.4
8	-	-	128	10.4	-	-	4	8.5	1	5.3	32	15.5	1	2.7	164	11.0	165	10.8
9	-	-	89	7.2	-	-	4	8.5	-	-	15	7.3	-	-	108	7.3	108	7.1
10	-	-	85	6.9	-	-	-	-	-	-	11	5.3	-	-	96	6.5	96	6.3
11	-	-	82	6.7	-	-	4	8.5	-	-	12	5.8	-	-	98	6.6	98	6.4
12	-	-	56	4.5	-	-	4	8.5	-	-	16	7.7	-	-	76	5.1	76	5.0
13	-	-	44	3.6	-	-	1	2.1	-	-	11	5.3	-	-	56	3.8	56	3.7
14	-	-	65	5.3	-	-	2	4.3	-	-	3	1.4	-	-	70	4.7	70	4.6
15	-	-	75	6.1	-	-	1	2.1	-	-	11	5.3	-	-	87	5.9	87	5.7
16	-	-	58	4.7	-	-	1	2.1	-	-	10	4.8	-	-	69	4.6	69	4.5
17	-	-	34	2.8	-	-	-	-	-	-	2	1.0	-	-	36	2.4	36	2.4
18	-	-	23	1.9	-	-	-	-	-	-	4	1.9	-	-	27	1.8	27	1.8
19	-	-	14	1.1	-	-	-	-	-	-	2	1.0	-	-	16	1.1	16	1.1
20	-	-	4	0.3	-	-	-	-	-	-	1	0.5	-	-	5	0.3	5	0.3
21	-	-	7	0.6	-	-	-	-	-	-	-	-	-	-	7	0.5	7	0.5
22	-	-	5	0.4	-	-	-	-	-	-	-	-	-	-	5	0.3	5	0.3
23	-	-	1	0.1	-	-	-	-	-	-	-	-	-	-	1	0.1	1	0.1
24	-	-	1	0.1	-	-	-	-	-	-	-	-	-	-	1	0.1	1	0.1
25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26	-	-	1	0.1	-	-	-	-	-	-	-	-	-	-	1	0.1	1	0.1
Total	13	100.0	1229	100.0	5	100.0	47	100.0	19	100.0	207	100.0	37	100.0	1483	100.0	1520	100.0

1,520 + 28 (unknown age) = 1,548

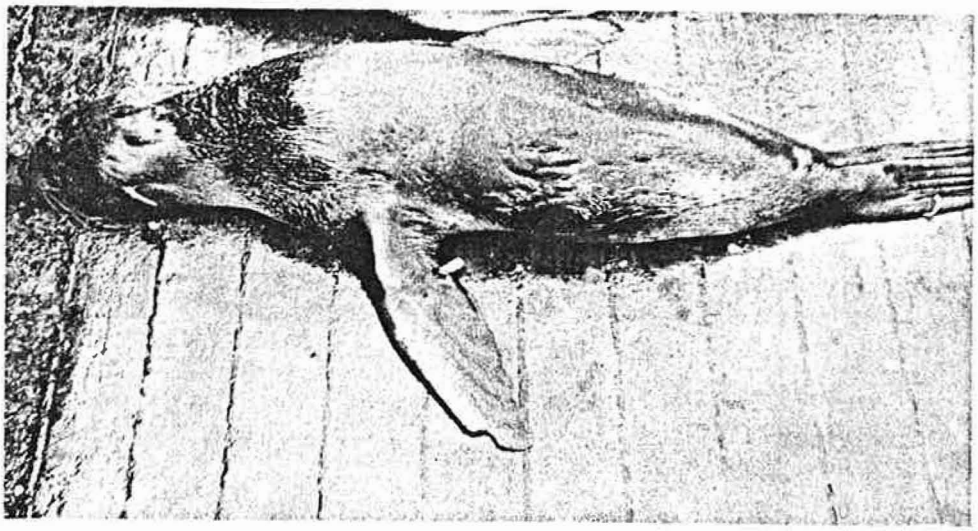

Figure 10. -- Tagged seal showing check-mark location. Tagged in 1957.

Table 5. -- Tag recoveries in pelagic sample taken off California, Oregon, and Washington in 1959

Tag series	Year attached	Age of seal	California		Oregon		Washington		Combined areas	
			male	female	male	female	male	female	male	female
A	1947	12	-	-	-	-	-	-	-	-
B	1948	11	-	-	-	-	-	-	-	-
CS	1949	10	-	1	-	-	-	1	-	2
D	1951	8	-	-	-	-	-	-	-	-
E	1952	7	-	1	-	-	-	1	-	2
F	1953	6	-	1	-	-	-	-	-	1
G	1954	5	-	4	-	1	-	-	-	5
H and no letter	1955 [1/]	4	-	4	-	-	-	1	-	5
I	1956	3	-	-	-	-	-	-	-	-
J	1957	2	-	1	1	-	-	1	1	2
K	1958	1	-	-	-	1	-	-	-	1
Total			-	12	1	2	-	4	1	18
Total tagged seals taken										19

[1/] H - Nos. 1-10,000, No letter - Nos. 10,001-50,000

Table 6. --Comparison of expected and actual numbers of Pribilof-tagged seals recovered off California, Oregon, and Washington, 1959

Year pups were tagged	Tag series	Number tagged	Estimated percentage of tagged seals in year class 1/		Number of seals of each age recovered		Number of tagged seals expected		Number of tagged seals actually recovered	
			male	female	male	female	male	female	male	female
1947	A	19,183	?	?	-	76	-	-	-	-
1948	B	19,532	?	3.00	-	98	-	2.9	-	-
1949	CS	19,960	?	3.00	-	96	-	2.9	-	2
1951	D	1,000	?	?	1	163	-	-	-	-
1952	E	19,979	3.46	4.68	-	143	-	6.7	-	2
1953	F	10,388	1.38	2.10	-	118	-	2.5	-	1
1954	G	10,000	1.23	3.69	-	115	-	4.2	-	5
1955	H 2/	49,870	6.67	12.39	6	93	0.4	11.5	-	5
1956	I	49,900	13.90	13.90	9	43	1.3	6.0	-	-
1957	J	49,842	10.00	10.00	10	34	1.0	3.4	1	2
1958	K	49,917	10.00	10.00	11	15	1.1	1.5	-	1
Total		299,571					3.8	41.6	1	18
Grand total							45.4		19	

1/ Estimated from tag recoveries on Pribilof Islands.

2/ H - Nos. 1-10,000, No letter - Nos. 10,001-50,000.

No correlation between rookery of tagging and area of recovery at sea (wintering ground) was found. The mixing of seals from various rookeries at sea was complete.

Distribution by Water Temperature

Water Temperature and Abundance of Seals

Seals were collected in water with surface temperatures ranging from 9° to 16°C. (table 7). Most collections were made in a temperature range of 12° to 14°C., off the California coast where large amounts of forage fish were available.

Large schools of forage fish were not observed in the cooler waters of 9° to 12°C., off Oregon and Washington, although weather conditions were not always favorable for such observations. If there is a conclusion to be drawn in the relationship of seal distribution to surface-water temperature, it seems reasonably apparent that distribution is regulated by the availability of food rather than the seals' preference for a certain temperature range. This is the same conclusion reached in previous investigations.

Correlation with Food Species

Although many fishes can withstand a wide range of water temperature, some are known to have definite distribution limitations because of inability to adjust to existing water temperatures. Quite probably, as in the seal, food supply also determines distribution. The fur seal shows a willingness, throughout its migration, to alter its food intake to whatever is available in the upper water layers (table 8 and fig. 11). In the warm California waters of 12° to 15°C., anchovy, squid, saury, hake, and jack mackerel were the primary species eaten. Temperatures were lower off the Oregon and Washington coasts, ranging from 10° to 12°C. Here the primary food species were rockfish, sablefish, herring, and squid. Saury and squid became less important and anchovy and jack mackerel disappeared. The seals taken off the Oregon and Washington coasts were mostly collected in shallow water of less than 100 fathoms. The survey showed that fur seals, wintering in waters of varying temperature from California to Washington, feed on most of the commonly available forage fishes and squid. As the seals migrate northward, they adjust their feeding to the species that are available.

Table 7. -- Distribution of seals collected, according to surface-water temperature, 16 January to 26 April 1959

Period	Water temperature								Mean
	9.0°C.	10.0°C.	11.0°C.	12.0°C.	13.0°C.	14.0°C.	15.0°C.	16.0°C.	
California									
16-25 Jan.	-	-	-	3	-	22	57	2	14.7
26 Jan.-4 Feb.	-	-	-	10	40	116	5	-	13.7
5-14 Feb.	-	-	-	21	15	264	57	-	14.2
15-24 Feb.	-	-	-	2	129	80	17	-	13.4
25 Feb.-6 Mar.	-	-	-	-	9	82	-	-	13.9
7-16 Mar.	-	1	8	20	16	4	-	-	12.3
17-26 Mar.	-	-	14	63	24	17	-	-	12.4
27 Mar.-5 Apr.	-	3	3	46	67	10	-	-	12.6
6-15 Apr.	-	3	10	12	15	-	-	-	11.9
Oregon									
16-25 Jan.	-	2	-	3	-	-	-	-	11.2
7-16 Mar.	-	5	-	-	-	-	-	-	10.0
17-26 Mar.	-	6	9	-	-	-	-	-	10.6
6-15 Apr.	-	8	16	2	-	-	-	-	10.8
Washington									
16-25 Jan.	1	-	-	-	-	-	-	-	9.0
17-26 Mar.	-	-	-	-	-	-	-	-	-
27 Mar.-5 Apr.	11	33	-	-	-	-	-	-	9.8
6-15 Apr.	3	22	4	-	-	-	-	-	10.0
16-25 Apr.	17	101	36	-	-	-	-	-	10.1
26 Apr.	-	2	-	-	-	-	-	-	10.0

Table 8. -- Food of fur seals, collected off California, Oregon, and Washington, 16 January to 26 April 1959, showing distribution, depth, and surface -water temperature

Food species	Percent of total food volume	Number of occurrences	Range of collections	Depth [1] (fathoms)	Surface temperature (centigrade) minimum	maximum	mean	Remarks
Anchovy	51.71	478	San Miguel Island, California to Cape Arago, Oregon	40-2000	10	16	13.8	Only five occurrences north of Point Reyes area (majority within 45 miles of shore).
Hake	22.14	329	San Miguel Island, California to Cape Flattery, Washington	40-2000	9	15	13.6	
Rockfishes	4.75	47	Pigeon Point, California to Cape Flattery, Washington	50-1000	9	15	10.2	More commonly inside 100 fathoms.
Squid	4.30	385	San Miguel Island, California to Cape Flattery, Washington	20-2200	9	15	12.6	
Saury	3.33	115	San Miguel Island, California to Grays Harbor, Washington	50-2200	10	15	12.9	Majority outside 100 fathoms.
Sablefish	2.28	16	San Francisco, California to Cape Flattery, Washington	20-500	9	13	9.5	With one exception, all were taken inside 100 fathoms.
Jack mackerel	2.08	41	Point Piedras Blancas, California to Crescent City, California	100-2000	11	14	12.8	
Herring	1.74	25	San Francisco, California to Cape Flattery, Washington	20-100	9	13	10.5	
Jack smelt	1.56	12	Point Conception, California to Cape Mendocino, California	20-500	11	15	13.0	Majority inside 100 fathoms.
Barracudinas	1.38	14	Point Conception, California to Grays Harbor, Washington	500-2200	10	14	12.1	All occurrences, with two exceptions, off Eureka, Calif. (with one exception, all outside 1000 fathoms).
Salmon	1.13	15	Cape Disappointment, Washington to Cape Flattery, Washington	20-500	9	11	9.7	More commonly inside 100 fathoms.
King-of-the-salmon	0.41	3	Point San Luis, California to Cascade Head, Oregon	600-1700	10	15	12.3	
Lanternfishes	0.32	11	Point Piedras Blancas, California to Tillamook Head, Oregon	80-1600	10	14	11.8	With one exception, all were taken outside 500 fathoms.
Northern midshipman	0.29	2	Monterey Bay, California to San Francisco, California	50-100	13	13	13.0	
Surf smelt	0.19	8	San Francisco, California to Destruction Island, Washington	20-300	11	12	11.5	

[1] Range of depths at point of collection

Note: See table 17 (page 51) for scientific names of fishes and squid.

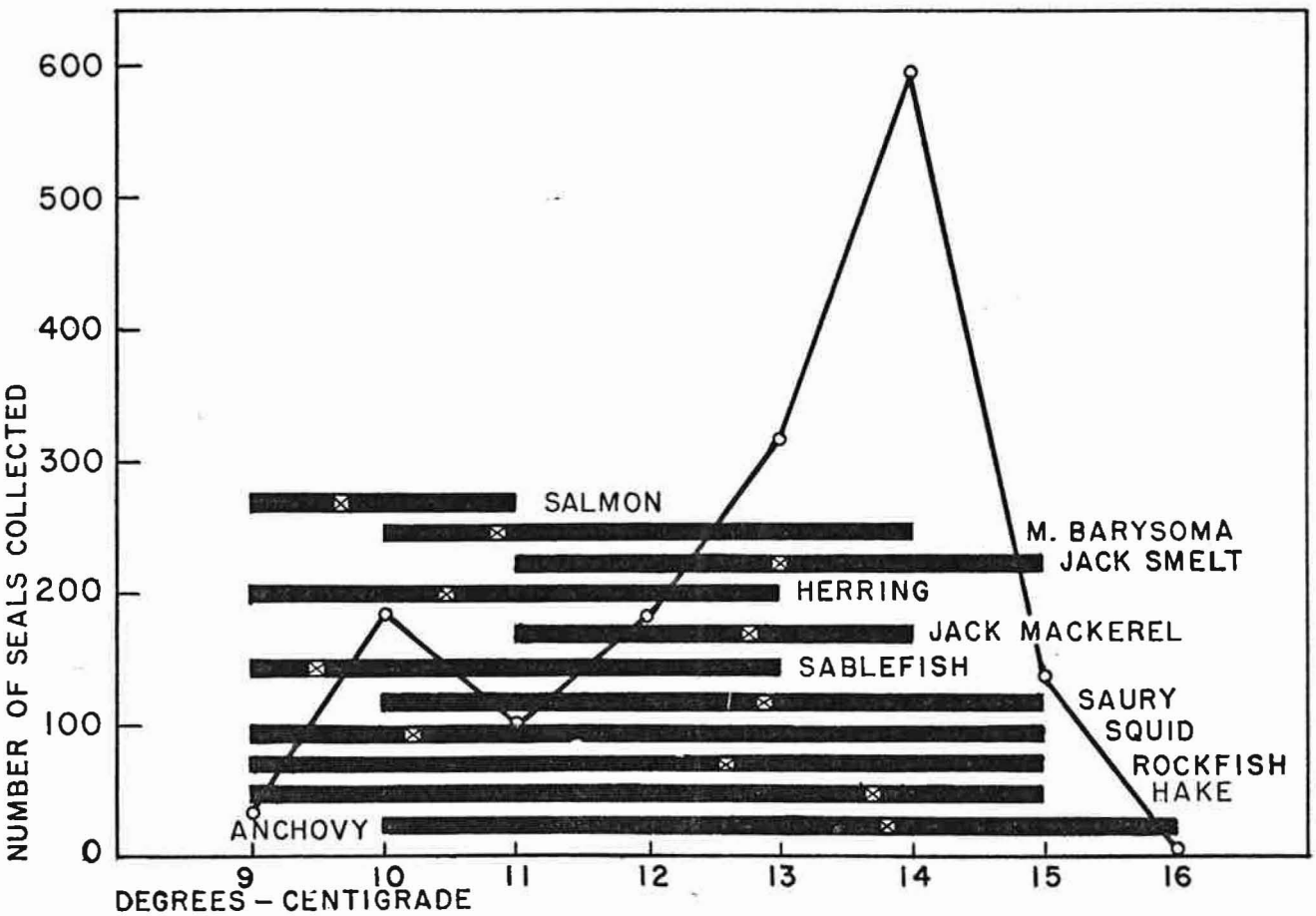

Figure 11. --Eleven fish species used as food by fur seals collected 16 January through 26 April 1959 off California, Oregon, and Washington, according to surface-water temperature. Ranked in ascending order by volume; X on bars indicate the mean temperature for each species.

Size and Reproductive Condition

Size

The length (fig. 12) and weight of male and female fur seals are similar to lengths and weights of seals of like age in the 1958 sample (tables 9 and 10). Because the collecting period extends over several months, weight changes taking place from growth and from the development of fetuses, with associated membranes and fluids, in pregnant seals are hidden in the mean weights and lengths in these tables. The increase in mean weight of pregnant seals, by 10-day periods, is shown in table 11 and appendix D. The weight of the average fetus (fig. 13) increased from 160 grams to 2,360 grams, or almost 1,400 (1,388) percent in 90 days. The growth rates for 1958 and 1959 are comparable and there is no suggestion that feeding conditions for the pregnant females were more favorable in one of the two years.

Taylor et al. (1955) first recorded that pregnant fur seals are slightly longer than nonpregnant seals of the same age. This difference which is most noticeable in seals under 10 years old, has been observed in almost all later collections including the 1959 pelagic collection. The only explanation offered is that the larger size is often associated with early sexual maturity and consistent functioning of the reproductive organs.

Reproductive Condition

The impregnation rate (percent of seals of breeding age with corpus luteum) of 1,195 female fur seals, taken in 1959, was high: 76.9 percent of all primiparous, and 97.0 percent of all multiparous seals had apparently been impregnated during their stay on the rookeries in 1958, and were pregnant during some time in the season.

The ovaries of all collected female seals were inspected for a corpus luteum and corpus albicans. The percentage of obviously gravid females dropped steadily from the time of impregnation to the time of collection (July to May). In other words, there was a steady mortality of blastocysts and fetuses as a result of abortion or resorption.

Reproduction according to age. --Information on fur-seal reproduction is derived from 2,804 seals collected during the 1958 (1,321)

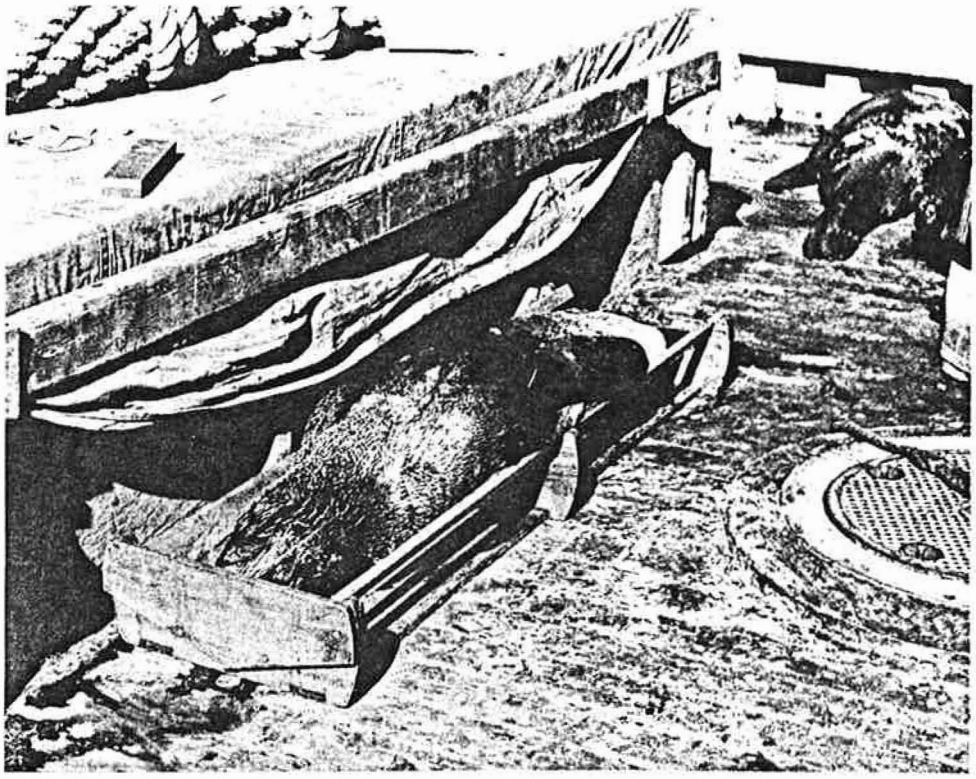

Figure 12. --Fur seal in measuring cradle.

Table 9. -- Length and weight of male and nonpregnant female seals collected off California, Oregon, and Washington, by age and sex, 16 January to 26 April 1959

Age (years)	Number measured	Length (centimeters) mean	range	standard deviation	Number weighed	Weight (kilograms) mean	range	standard deviation
Males								
1	11	81.5	74.0-88.0	3.96	11	11.0	8.5-13.5	1.52
2	10	92.0	81.0-101.0	6.19	10	14.1	9.0-16.5	2.39
3	9	105.6	92.0-114.0	6.14	9	20.0	16.0-24.0	2.40
4	6	113.5	105.0-120.0	5.09	6	24.0	20.0-26.0	2.17
5	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-
8	1	184.0	-	-	1	92.0	-	-
Total	37				37			
Females								
1	15	75.3	67.0-79.0	3.28	15	8.7	5.5-12.0	1.80
2	34	87.8	75.0-97.0	5.62	34	12.8	7.0-18.0	2.50
3	43	98.2	76.0-116.0	7.13	43	16.2	11.0-20.5	2.41
4	87	106.4	79.0-121.0	5.97	87	21.2	13.0-29.0	2.83
5	51	111.9	95.0-119.0	4.93	51	24.6	19.0-32.0	2.88
6	28	115.9	104.0-128.0	6.84	28	26.9	21.0-37.5	3.83
7	36	118.2	108.0-128.0	5.41	36	26.9	22.0-34.0	3.37
8	22	121.7	109.0-132.0	5.11	22	28.8	20.0-36.0	4.07
9	11	120.3	116.0-129.0	4.45	11	29.4	26.5-33.0	2.01
10	14	122.4	117.0-128.0	3.36	14	32.3	26.0-39.5	3.57
11	10	123.9	116.0-136.0	7.23	10	30.7	22.0-36.0	4.65
12	9	123.6	118.0-128.0	3.20	9	32.2	28.0-35.0	3.09
13	6	127.7	122.0-132.0	4.27	6	35.4	28.0-42.0	5.16
14	11	125.8	119.0-130.0	3.31	11	36.3	26.0-45.0	5.87
15	10	124.6	117.0-141.0	8.28	10	36.0	26.0-50.0	7.37
16	17	127.3	115.0-138.0	6.43	17	38.5	32.5-49.0	4.37
17	7	127.7	122.0-135.0	5.96	7	35.9	27.0-42.0	6.00
18	4	127.5	119.0-135.0	6.61	4	36.0	27.5-45.0	7.63
19	3	130.0	124.0-137.0	7.72	3	44.7	43.0-48.0	2.89
20	3	128.7	127.0-131.0	2.04	3	41.7	41.0-43.0	1.16
21	1	137.0	-	-	1	54.0	-	-
22	3	128.7	124.0-131.0	4.04	3	38.3	28.0-45.0	9.07
23	1	119.0	-	-	1	32.5	-	-
24	1	131.0	-	-	1	34.0	-	-
25	-	-	-	-	-	-	-	-
26	1	128.0	-	-	1	35.0	-	-
Total	428				428			

Table 10.--Length and weight, by age, of pregnant seals collected off California, Oregon, and Washington in 1959

Age (years)	Length (centimeters)				Weight (kilograms)			
	Number measured	mean	range	standard deviation	Number weighed	mean	range	standard deviation
4	6	111.5	105.0-119.0	5.96	6	24.6	22.5-27.0	1.73
5	63	118.2	109.0-127.0	4.79	63	28.4	21.0-38.0	4.07
6	90	118.9	108.0-131.0	5.10	90	29.5	22.5-42.0	4.93
7	107	121.5	109.0-132.0	5.42	107	30.9	24.0-42.0	7.57
8	142	121.5	105.0-137.0	5.49	142	32.4	23.0-46.0	4.44
9	97	123.1	111.0-137.0	5.37	97	33.9	28.0-42.5	3.28
10	82	124.1	111.0-134.0	4.78	82	34.9	25.0-43.0	3.98
11	88	124.8	116.0-139.0	5.36	88	36.0	26.5-49.0	4.63
12	67	127.0	110.0-151.0	6.34	67	37.7	30.0-52.0	4.63
13	50	126.2	119.0-140.0	5.13	50	37.3	24.0-48.0	4.80
14	59	126.6	116.0-138.0	5.38	59	37.6	29.5-47.5	4.06
15	77	129.0	119.0-139.0	4.78	77	39.9	22.5-55.5	5.14
16	52	128.0	117.0-138.0	5.31	52	40.1	32.0-52.5	4.62
17	29	127.7	118.0-135.0	6.97	29	38.6	31.0-45.0	4.66
18	23	130.8	120.0-153.0	7.86	23	42.4	35.0-54.0	6.32
19	13	130.7	124.0-137.0	4.89	13	41.2	34.5-52.0	5.19
20	2	133.0	131.0-135.0	2.83	2	41.5	36.5-46.5	-
21	6	131.0	121.0-141.0	6.72	6	43.2	32.5-50.0	6.22
22	2	137.0	136.0-138.0	1.41	2	46.8	42.5-51.0	-
Total	1,055 1/				1,055 1/			

1/ Lengths and weights for 3 seals missing (1055 + 3 = 1,058).

Table 11. --Mean length and weight increase of fetuses and weight increase of pregnant females, by 10-day periods, from 16 January to 26 April 1959

Date	Fetuses					Pregnant females		
	number	length (cm.)	cumulative percent increase	mean weight (kg.)	cumulative percent increase	number	mean weight (kg.)	cumulative percent increase
16-21 Jan. [1]	3	14.7	-	0.08	-	3	29.5	-
22-31 Jan.	88	18.8	27.9	0.19	129.9	88	33.5	13.6
1-10 Feb.	283 [2]	22.6	53.7	0.32	284.5	282	34.2	15.9
11-20 Feb.	171	26.3	78.9	0.53	535.9	171	35.5	20.3
21 Feb. - 2 Mar.	139 [2]	29.0	97.3	0.68	715.2	138	35.1	19.0
3-12 Mar.	39	33.3	126.5	0.96	1056.7	39	33.8	14.6
13-22 Mar.	80	36.6	149.0	1.20	1387.2	80	33.6	13.9
23 Mar. - 1 Apr.	35	39.6	169.4	1.42	1603.0	35	34.4	16.6
2-11 Apr.	134	42.2	187.1	1.79	2051.5	134	36.0	22.0
12-21 Apr.	73	46.5	216.3	2.22	2569.2	73	35.2	19.3
22-26 Apr. [3]	31	48.7	231.3	2.49	2893.4	31	36.2	22.7
Total	1,076 [4]					1,074 [4]		

[1] Period of six days.

[2] Includes one pair of twins.

[3] Period of five days.

[4] One female with resorbing fetus omitted, as well as one fetus.

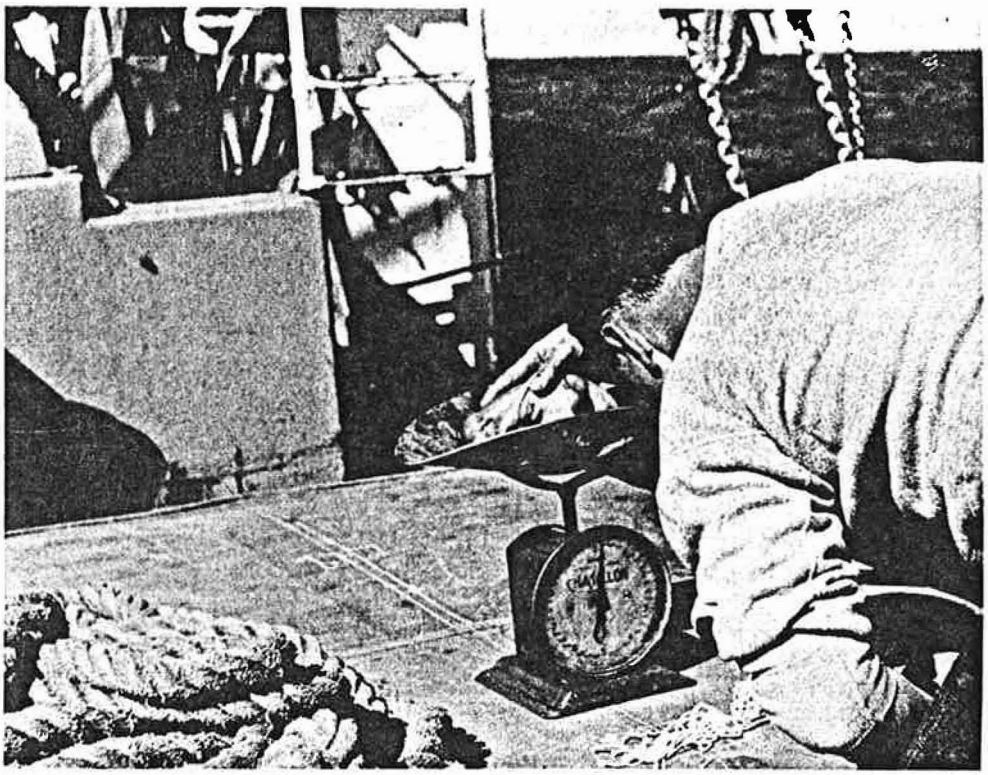

Figure 13. -- Weighing fur-seal fetus.

and 1959 (1,483) pelagic sealing (see table 12 and figs. 32, 33, and 34 i appendix D for details of the 1959 collection). Table 13 shows proportions of pregnant and nonpregnant seals taken in 1959. As in previous samples, only a few 3- and 4-year-old seals were pregnant. From a total of 300 seals, ages one to four, only eight (2.7 percent) were pregnant and one (0.3 percent) had evidently aborted. The first occurrence of pregnancy was recorded for 3-year-old females; from 82 seals examined in 1958 and 1959, two (2.4 percent) were pregnant. One carried a fetus and another had aborted. In the 4-year-old group, the pregnancy rate was slightly higher; among 135 seals inspected, six (4.4 percent) were pregnant. The pregnancy rate increased sharply in 5-year-olds and reached its culmination between ages 9 and 13. The decrease in pregnancies is not as clear as the increase. The decrease is gradual to ages 16 to 18, and then accelerates to ages 19 to 20. Thereafter, only occasional pregnant seals are encountered (table 14).

Uterine horn of pregnancy and fetal sex ratio. --The left uterine horn was the site of 51 percent of 1,075 recorded pregnancies (table 15).

The ratio of males to females was 49:51 in 1959 and 52:48 in 1958.

Abortions and resorptions. --Of all multiparous females with a corpus luteum, collected in 1959, 87.5 percent were carrying a fetus; of all primiparous females with a corpus luteum, 76.0 percent were carrying a fetus. Thus, there was a fetal mortality between the summer of 1958 and the period of observation of 10.5 percent for multiparous and 0.9 percent for primiparous females (see reproductive condition).

A number of multiparous seals may have been erroneously classified as pregnant. In some cases an apparent corpus luteum might have been actually a receding stage of corpus luteum spurium, rather than a corpus luteum of pregnancy after abortion.

The period of pregnancy is complicated by the inactive period in the morula-blastula stage which lasts about four months. During that period when the blastocyst is not embedded it may not have an affect on hormonal activity of the corpus luteum. The corpus luteum, however, is still developing and possibly reaches its maximum development about the time the implantation occurs, or three and one-half to five months after fertilization. In comparison, the human corpus luteum reaches its maximum growth in two weeks after ovulation and, if no pregnancy occurs, becomes reduced to a scar in about

Table 12. --Reproductive condition of female seals collected off California, Oregon, and Washington from 16 January to 26 April 1959

Reproductive condition	Age (years)																											Group totals		Grand total	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26		number	percent	number	percent
Nullipara																															
number	15	34	41	83	34	12	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		222	100.0	222	15.0
percent	6.7	15.3	18.5	37.4	15.3	5.4	1.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-					
Total	15	34	41	83	34	12	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		222	100.0	222	15.0
Primipara																															
Pregnant																															
number	-	-	-	5	44	30	14	11	3	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		109	76.2	109	7.3
percent	-	-	-	4.6	40.4	27.5	12.8	10.1	2.8	0.9	0.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-					
Nonpregnant																															
number	-	-	1	4	8	5	7	1	2	1	-	1	-	-	1	1	-	-	-	-	-	-	-	1	-	-		33	23.1	33	2.2
percent	-	-	3.0	12.1	24.3	15.3	21.2	3.0	6.1	3.0	-	3.0	-	-	3.0	3.0	-	-	-	-	-	-	-	3.0	-	-					
Aborted/resorbed																															
number	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		1	0.7	1	0.1
percent	-	-	-	-	-	-	-	100.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-					
Total	-	-	1	9	52	35	21	13	5	2	1	1	-	-	1	1	-	-	-	-	-	-	-	1	-	-		143	100.0	143	9.6
Multipara																															
Pregnant																															
number	-	-	-	1	20	61	95	131	93	81	87	67	50	59	77	52	29	23	13	2	6	2	-	-	-	-		949	84.9	949	64.0
percent	-	-	-	0.1	2.1	6.4	10.0	13.8	9.8	8.5	9.2	7.1	5.5	6.2	8.1	5.5	3.1	2.4	1.2	0.2	0.6	0.2	-	-	-	-					
Nonpregnant																															
number	-	-	-	-	-	1	3	9	4	1	1	2	1	3	1	5	-	-	1	-	-	1	-	-	-	-		33	2.9	33	2.2
percent	-	-	-	-	-	3.0	9.1	27.4	12.1	3.0	3.0	6.1	3.0	9.1	3.0	15.2	-	-	3.0	-	-	3.0	-	-	-	-					
Aborted/resorbed																															
number	-	-	1	-	8	9	21	11	6	12	9	6	5	8	8	11	7	4	2	3	1	2	1	-	-	1		136	12.2	136	9.2
percent	-	-	0.7	-	5.9	6.6	15.5	8.1	4.4	8.8	6.6	4.4	3.7	5.9	5.9	8.1	5.2	2.9	1.5	2.2	0.7	1.5	0.7	-	-	0.7					
Total	-	-	1	1	28	71	119	151	103	94	97	75	56	70	86	68	36	27	16	5	7	5	1	-	-	1		1118	100.0	1118	75.4
Grand total	15	34	43	93	114	118	143	164	108	96	98	76	56	70	87	69	36	27	16	5	7	5	1	1	-	1				1483	100.0
Percent	1.0	2.3	2.9	6.2	7.7	8.0	9.6	11.1	7.3	6.5	6.6	5.1	3.8	4.7	5.9	4.6	2.4	1.8	1.1	0.3	0.5	0.3	0.1	0.1	-	0.1					100.0

Table 13.--Proportion of pregnant and nonpregnant seals among 1,483 females taken off California, Oregon, and Washington from 16 January to 26 April 1959

Area	Number females	Number pregnant	Percent pregnant	Number nonpregnant	Percent nonpregnant
California	1,229	897	60.5	332	22.4
Oregon	47	26	1.8	21	1.4
Washington	207	135	9.1	72	4.8
Total	1,483	1,058	71.4	425	28.6

Table 14. -- Comparative pregnancy rate of 1,058 seals collected off California, Oregon, and Washington, by age, in 1958 and 1959

Age (years)	Number females taken		Number pregnant		Percent pregnant	
	1958	1959	1958	1959	1958	1959
3	39	43	1	-	2.6	-
4	42	93	1	6	2.4	6.4
5	70	114	32	64	45.7	56.1
6	99	118	80	91	80.8	77.1
7	103	143	92	109	89.3	76.2
8	102	164	91	142	89.2	86.6
9	81	108	78	96	96.3	88.9
10	97	96	85	82	87.6	85.4
11	113	98	104	88	92.0	89.8
12	134	76	110	67	82.1	88.2
13	110	56	91	50	82.7	89.3
14	92	70	75	59	81.5	84.3
15	71	87	56	77	78.9	88.5
16	56	69	44	52	78.6	75.4
17	36	36	20	29	55.6	80.6
18	22	27	13	23	59.1	85.2
19	14	16	4	13	28.6	81.3
20	3	5	1	2	66.7	40.0
21	1	7	1	6	100.0	85.7
22	1	5	-	2	-	40.0
23	-	1	-	-	-	-
24	-	1	-	-	-	-
25	-	-	-	-	-	-
26	-	1	-	-	-	-
Total	1,286 [1 & 2]	1,434 [2]	979	1,058	76.1	73.8

[1] Two 10+ year-old seals omitted.

[2] One- and two-year-old seals (34 in 1958 and 49 in 1959) omitted as being immature.

Table 15. --Uterine horn of pregnancy for 1,075 seals and sex of fetuses collected off California, Oregon, and Washington in 1959

Month	Uterine horn		Sex of fetus	
	left	right	male	female
January	50	44	37	56
February	314	261	294	283
March	71	84	68	88
April	115	136	128	123
Total	550	525	527	550
Grand total	1,075 [1/]		1,077 [2/]	

1/ Includes unaged female seals.

2/ Includes two pairs of twins.

two months.

Another problem in recognizing and separating the corpus luteum of pregnancy from the corpus luteum spurium is the duration of regression time and the speed at which the corpus luteum is replaced by connective tissue. In some species, the corpus luteum spurium remains over a long period of time, well developed and readily visible (McLaren, 1958).

Ovaries were preserved from 83 selected females. All of them were without a fetus but with a corpus luteum; some possessed pregnancy scars in the uterine horns. Measurements of corpora lutea (fig. 14), taken at the later date, showed two peaks (bimodal). One peak was at corpus-luteum size of 9 millimeters (diameter average 9 x 12 mm.), and the second at corpus-luteum size of 12 millimeters (average 12 x 16 mm.). From this apparent bimodality in corpus-luteum size the thesis is proposed that (1) smaller corpora lutea (9 or 10 millimeters and less) are found where fertilization or implantation did not occur; (2) larger corpora lutea (11 millimeters and over) are found where fetal mortality occurred after implantation. Present data do not prove or disprove the thesis.

If these assumptions were correct, their effect would be to reduce the number of presumed abortions.

In 1958 (Wilke et al.), a comparison was made of the age distribution of 10-year-and-older female fur seals to show their productive and total life span. This has been expanded by including the 1959 data and the comparative percentage of seals within ages 11 to 26 years is given in table 16 and figure 15.

To decrease sampling errors, 1958 and 1959 collections are combined and compared against a postulated life table and curve from Kenyon, Scheffer, and Chapman (1954). An increase in the proportion of females in year classes 16 years old and younger and decrease of older animals 17 years old and older is shown. This observation is consistent with the one made with 1958 data alone, where a crossing of the postulated curve by an observed curve suggests a more rapid disappearance of females from the population than postulated.

Anomalies. --One seal carrying twins was collected in Alaskan waters during the 1958 pelagic season. In 1959, two more seals carrying twins were collected off California. Prior to 1958, the recovery of twin fetuses had been recorded only once (Alaska Fishery and Fur-Seal Industries in 1923, U. S. Bureau of Fisheries Document

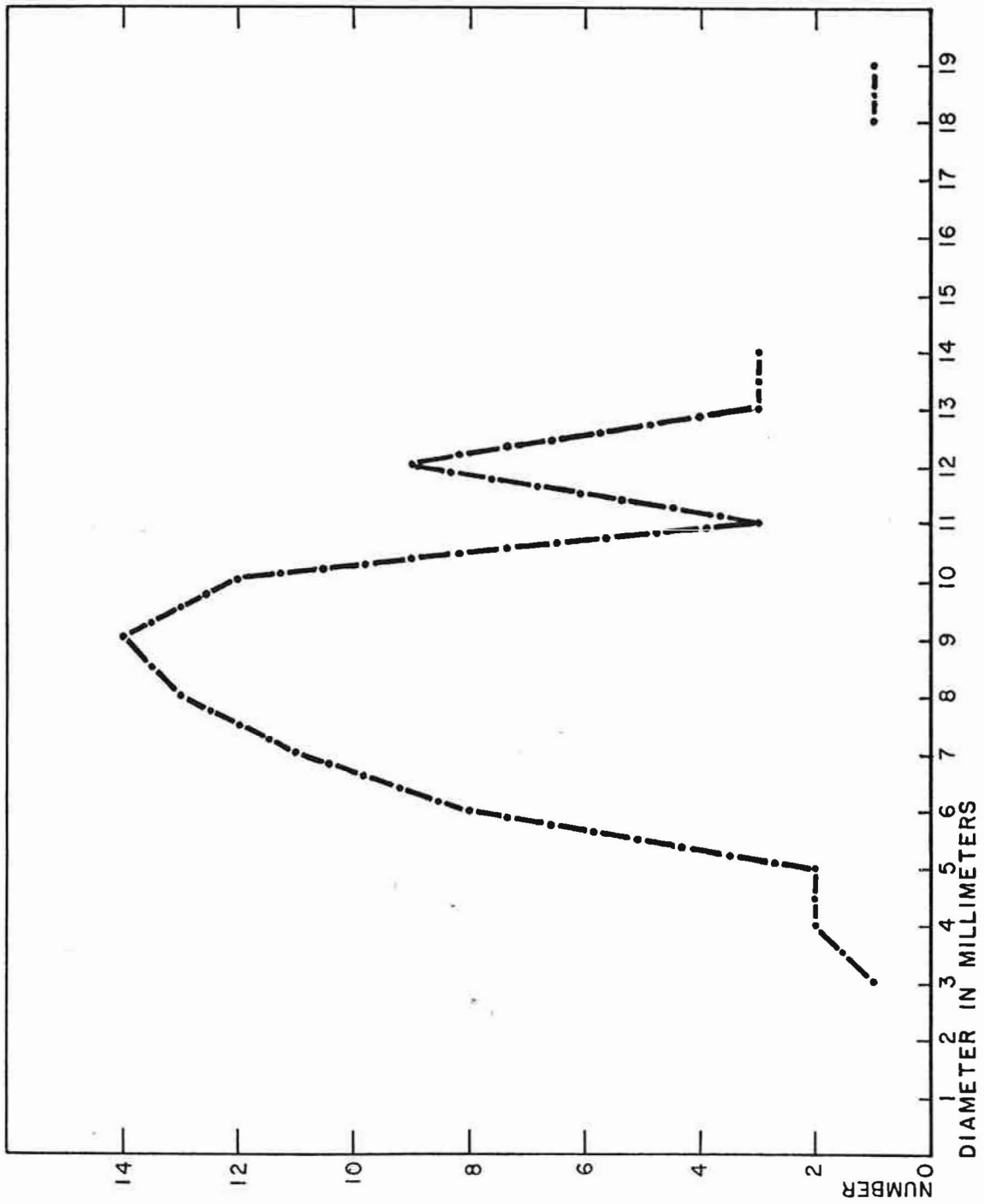

Figure 14. --Diameter of corpora lutea of 83 female fur seals collected off California, Oregon, and Washington in 1959.

Table 16. --Postulated and observed distribution of females in age group of 11 to 26 years in 1958 and 1959 combined

Age	Postulated (percent)	Observed in 1958 and 1959	
		number	percent
11	16.8	211	17.4
12	15.2	210	17.3
13	13.5	166	13.7
14	11.9	162	13.4
15	10.3	158	13.1
16	8.7	125	10.3
17	7.2	72	6.0
18	5.7	49	4.1
19	4.3	30	2.5
20	3.0	8	0.7
21	1.9	8	0.7
22	1.0	6	0.5
23	0.4	1	0.1
24	0.1	1	0.1
25	trace	-	-
26	-	1	0.1
Total	100.0	1,208	100.0

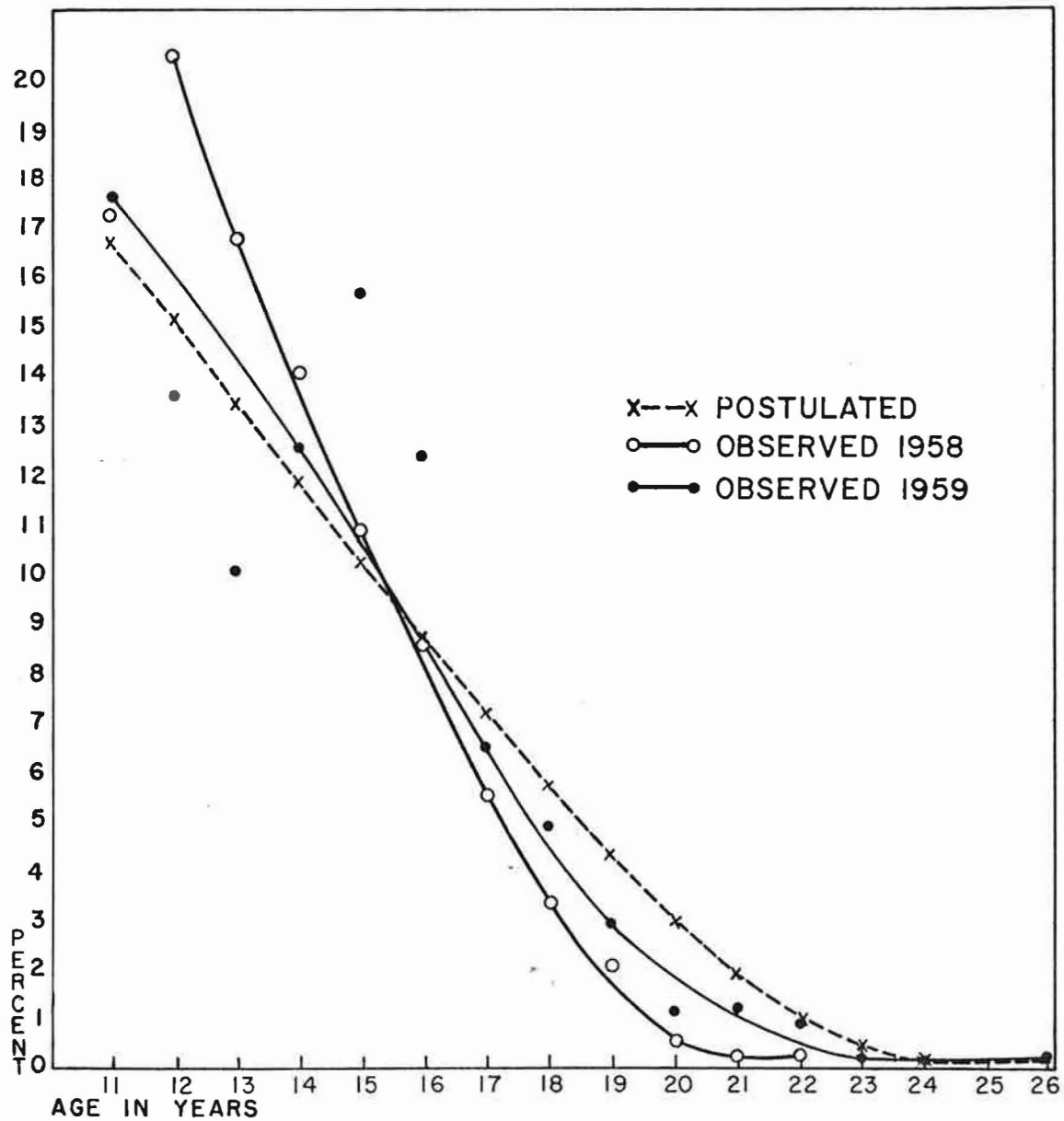

Figure 15. -- Comparison of postulated and observed age distribution among female fur seals 11 to 26 years of age, in 1958 and 1959.

703, 1925). In 1958 the twin fetuses were found in opposite horns but in 1959, in both instances, the fetuses were found in the same horn. The twins found in 1958 were both females. Both pairs of twins found in 1959 included one fetus of each sex. The male fetus, in each instance, was larger in length and weight than the corresponding female fetus.

Of the 2,178 fetuses which have been examined in the past two years only one fetus, collected in 1959, has shown a noticeable skeletal deformity. An X-ray revealed an abnormal sigma-shaped broken spinal column. The fetus had died in the uterine horn prior to collection, but its size was close to the average of this season and the skin was only slightly softened. It had, in all probability, been dead only a few days prior to collection date.

Food Habits

Fur seals feed on a large variety of fishes and squids; 26 species were identified from stomachs collected in 1959. The fish ranged in length from several inches to several feet.

When actively feeding, seals appear at the surface only long enough to take a breath of air. The length of time they remain on the surface is probably related to the depth at which they are feeding.

When seals are feeding on small fishes such as anchovy or saury, or on squids, they usually capture and consume the fish below the surface, but when larger fishes, such as hake or rockfish are taken, the seals generally bring the fish to the surface and consume it there. The smaller fishes and squids are usually found in seal stomachs undamaged except for digestive action. Fish over twelve inches in length are frequently found in the seal stomachs in chunks, or with parts of the body (most commonly the head) missing. No undamaged rockfish was found in seal stomachs in 1959 and usually the head region was missing. About 50 percent of the hake lacked heads. On numerous occasions during the past two years, seals have been observed on the surface with large fish. Ordinarily the seal grasped the fish by the head and with a series of vigorous shakes or snaps the head was parted from the body. The head was dropped and the body, which was frequently thrown 15 or 20 feet, was recovered and consumed. If the body was still too large, the "worrying process" continued until the fish was broken up into chunks small enough to swallow. Whether or not a fish is consumed at

or below the water's surface is probably determined by the size of prey the seal can take into its closed mouth. Most of the prey taken by seals is small enough to swallow entirely.

Food material in seal stomachs is found in all stages of digestion, ranging from a few vertebrae, otoliths, or squid beaks to complete undigested specimens (figs. 16 and 17). Since the seal commonly feeds upon schooling fishes, the identification of one specimen often leads to the identification of the entire stomach contents and, in many cases, to the identification of stomach contents from a series of stomachs collected in the same area.

Generally where food is abundant, stomachs contain only one or two different food items. This was particularly true in California waters in 1959 where anchovy schools were present in the collecting areas south of Point Arena. When large schools of fish are not available, seal stomachs are more likely to contain a variety of food items. To illustrate the variety of food species taken, the contents of three stomachs are given:

(1) Off Point Sur, California, total volume of stomach contents 1550 cc.; food items: 6 squid, 22 saury, 1 hake, and 1 (trace) jack mackerel.

(2) Off Point Reyes, California, total volume of stomach contents 940 cc.; food items: 2 sablefish, 27 anchovy, 1 herring, and 1 saury.

(3) Off Destruction Island, Washington, total volume of stomach contents 820 cc.; food items: 1 sablefish, 1 rockfish, 1 salmon, and 1 (trace) squid.

To illustrate contents of full stomachs from areas of food abundance, the contents of six stomachs are listed below:

(1) Off Morro Bay, California, total volume of stomach contents 5010 cc.; food items: 270 anchovy (99 percent) and 2 hake (1 percent).

(2) Off Farallon Islands, California, total volume of stomach contents 4080 cc.; food items: 158 squid (100 percent).

(3) Off Cape Elizabeth, Washington, total volume of stomach contents 4025 cc.; food items: 5 rockfish (100 percent).

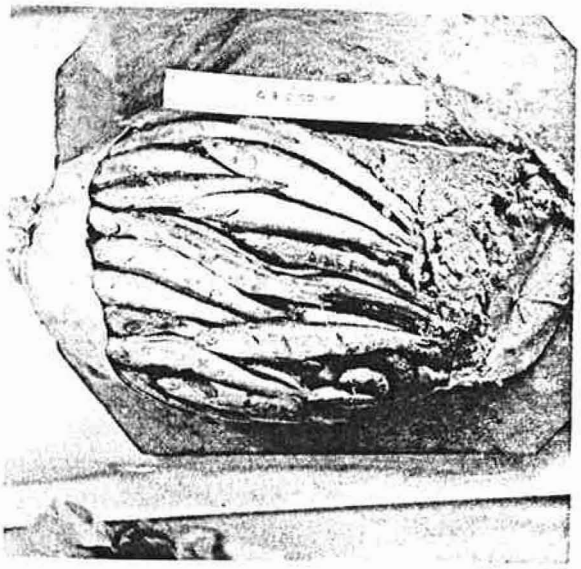

Figure 16. --A well-filled stomach containing anchovy. Contents range from well-digested material to undigested whole fish.

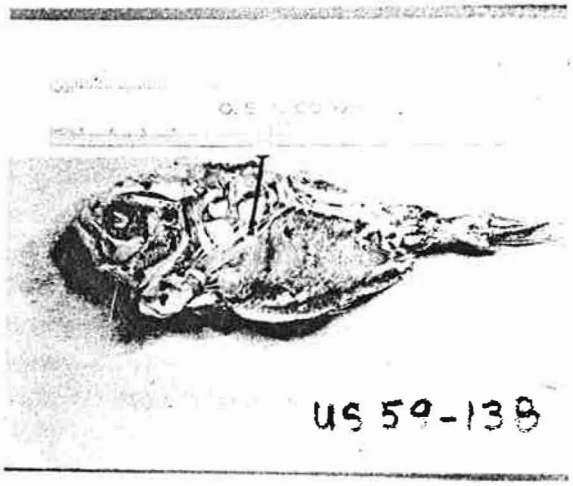

Figure 17. --Pomfret in fair condition. Digestion is just beginning.

(4) Off Farallon Islands, California, total volume of stomach contents 3940 cc.; food items: 247 anchovy (100 percent) (fig. 16).

(5) Off Point Sal, California, total volume of stomach contents 3550 cc.; food items: 6 hake (60 percent) and 55 anchovy (40 percent).

(6) Off Heceta Head, Oregon, total volume of stomach contents 3000 cc.; food items: 6 hake (100 percent).

Fur seals are considered to be primarily night and early morning feeders. The hours during midday are usually spent in rest or sleep and a gradual resumption of feeding activities occurs in the late afternoon. This has been found to be true in previous years' work and holds true for most of the areas covered in 1959. Graphs have been constructed, showing the proportions of seal stomachs containing food, a trace of food, and those that are empty, in relation to time of day (fig. 18).

Feeding activities in northern California, Oregon, and Washington, in 1959, followed the pattern found in previous years, where almost 100 percent of the stomachs contained food early in the day and there was a decrease in the number of stomachs containing food throughout the day.

In the areas south of Point Arena, California, in 1959, a large proportion of the seals were found to be feeding throughout the day and there was no decrease in numbers of stomachs containing food.

General Account of Stomach Contents

A total of 1,548 seals were collected, from which 1,542 stomachs were saved and six were lost. Over half, 67.5 percent, of the 1,542 stomachs contained food. For the three state areas, the percentage of stomachs containing food were as follows: California 70.7, Oregon 63.3 and Washington 52.2.

The stomach contents of these seals are shown in table 17. The food items are ranked, by volume, in order of decreasing importance. Figure 19 presents the eight major food items from each state by percent of volume and percent of frequency-of-occurrence. In a comparison of the 1958 and 1959 collections, we find that some changes in rank of food items have occurred; these changes will be discussed for each state.

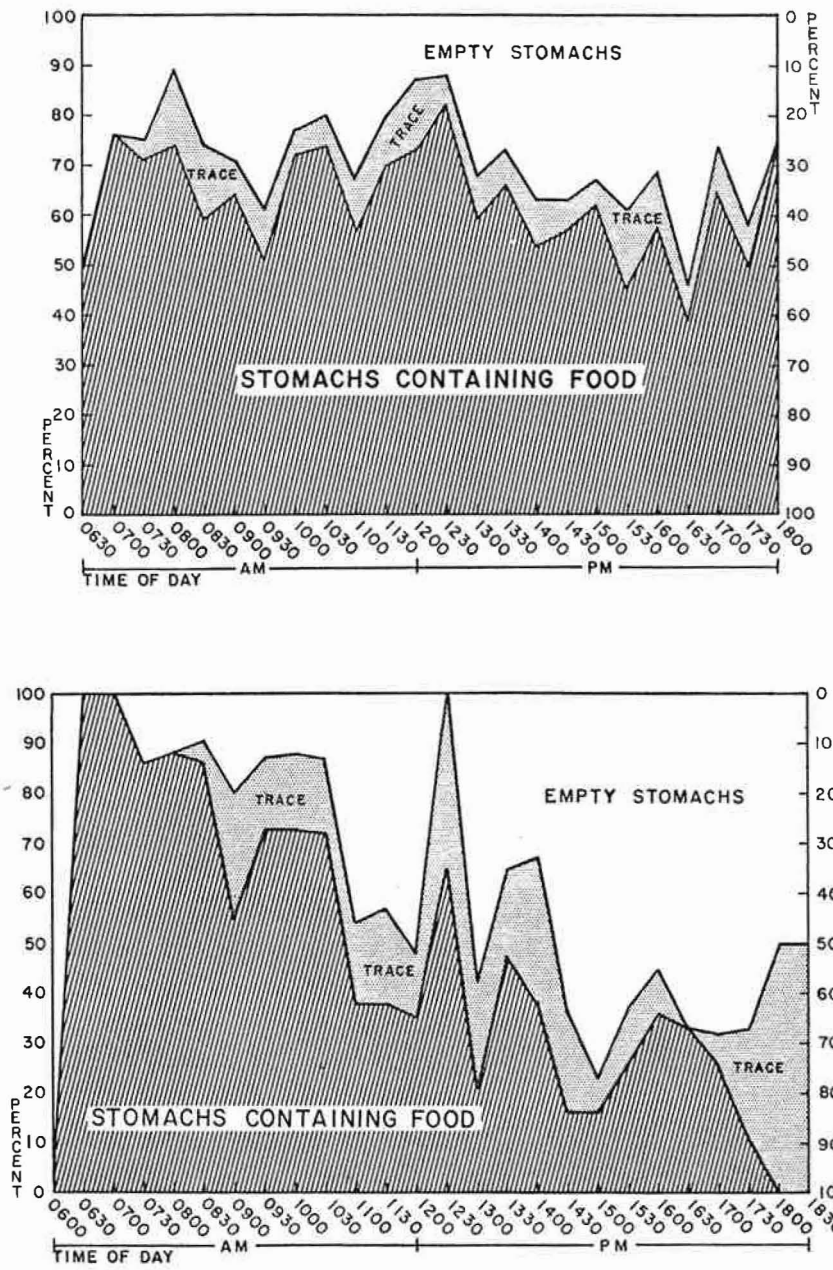

Figure 18. -- The percentage of seal stomachs containing a measurable amount of food, a trace of food, and no food, in relation to the time of day in which they were collected. Upper figure shows 1,107 seal stomachs collected off California, south of Point Arena, 21 January to 9 April 1959. Sunrise varied from 7:12 a.m. to 5:46 a.m. The lower figure shows 431 seal stomachs collected off California, north of Point Arena, Oregon, and Washington, 15 March to 26 April 1959. Sunrise varied from 6:38 a.m. to 5:16 a.m.

Table 17. --Analysis of the contents of 1,044 seal stomachs, collected off California, Oregon, and Washington, in 1959, by percent of total volume and frequency of occurrence

Food item	California 21 January - 9 April			Oregon 18-20 Jan., 16 Mar. -15 Apr.			Washington 20 January and 2-26 April			Total combined areas		
	percent of volume	frequency	frequency of trace [1]	percent of volume	frequency	frequency of trace [1]	percent of volume	frequency	frequency of trace [1]	percent of volume	frequency	frequency of trace [1]
Anchovy (Engraulis mordax)	58.97	476	10	1.47	2	-	-	-	-	51.71	478	10
Pacific hake (Merluccius productus)	24.41	318	64	34.39	3	-	0.35	8	4	22.14	329	68
Rockfishes (Sebastodes)	0.05	2	-	28.47	7	-	40.07	38	1	4.75	47	1
Squid (Loligo opalescens)	2.02	28	8	2.40	2	-	0.37	6	3	1.86	36	11
" (Onychoteuthis sp. fusiformis?)	0.63	16	3	2.02	1	-	1.14	3	-	0.71	20	3
" (Gonatus sp.)	0.07	2	-	0.08	1	-	0.15	1	-	0.08	4	-
" unidentified	1.45	264	183	11.05	21	10	1.47	42	27	1.65	327	220
Saury (Cololabis saira)	3.48	104	4	6.45	5	-	1.46	6	-	3.33	115	4
Sablefish (Anoplopoma fimbria)	0.06	1	-	0.49	1	-	21.65	14	-	2.28	16	-
Jack mackerel (Trachurus symmetricus)	2.37	41	15	-	-	-	-	-	-	2.08	41	15
Herring (Clupea pallasi)	0.34	7	-	-	-	-	14.02	18	2	1.74	25	2
Jack smelt (Atherinopsis californiensis)	1.78	12	-	-	-	-	-	-	-	1.56	12	-
Barracudinas, Paralepididae, (Magnisudis barysoma)	1.53	9	-	-	-	-	-	-	-	1.34	9	-
" " (Magnisudis barysoma?) [2]	0.04	4	-	-	-	-	0.01	1	-	0.04	5	-
Salmon (Oncorhynchus sp.)	-	-	-	-	-	-	10.95	15	1	1.13	15	1
King-of-the-Salmon (Trachypterus-rex-salmanorum)	0.37	2	1	4.45	1	-	--	-	-	0.41	3	1
Lanternfishes, Myctophidae	0.24	5	1	4.18	4	-	-	-	-	0.30	9	1
" " (Tarletonbeania crenularis)	-	-	-	0.94	2	-	-	-	-	0.02	2	-
Northern midshipman (Porichthys notatus)	0.34	3	-	-	-	-	-	-	-	0.29	3	-
Surf smelt (Hypomesus pretiosus)	0.09	7	1	-	-	-	1.06	1	-	0.19	8	1
Flatfishes, Heterosomata	-	-	-	-	-	-	0.83	1	-	0.09	1	-
" " (Lyopsetta exilis)	0.04	1	-	-	-	-	-	-	-	0.04	1	-
Pomfret (Brama raii)	0.08	3	1	-	-	-	-	-	-	0.07	3	1
Stickleback (Gasterosteus aculeatus)	-	-	-	-	-	-	0.72	6	1	0.07	6	1
--- Iniomi, (Scopelosaurus?) [2]	-	-	-	2.83	1	-	-	-	-	0.06	1	-
Shad (Alosa sapidissima)	-	-	-	-	-	-	0.47	1	-	0.05	1	-
Eulachon (Thaleichthys pacificus)	0.04	1	-	-	-	-	0.04	1	-	0.04	2	-
Arrow-fish, Stomiatidae, (Tactostoma macropus?) [2]	0.04	1	-	-	-	-	-	-	-	0.04	1	-
Pacific lamprey (Entosphenus tridentatus)	-	-	-	-	-	-	trace	1	1	trace	1	1
Fish, unidentified	1.27	40	17	0.78	3	1	5.05	19	8	1.65	62	26
Rhinoceros auklet (Cerorhinca monocerata)	0.17	3	-	-	-	-	-	-	-	0.15	3	-
Red-throated loon (Gavia stellata)	0.12	1	-	-	-	-	-	-	-	0.11	1	-
Beal petrel (Oceanodroma leucorhoa beali)	-	-	-	-	-	-	0.04	1	-	trace	1	1
Bird, unidentified	trace	-	-	-	-	-	-	-	-	trace	1	1
Stones	-	-	-	-	-	-	0.15	4	-	0.02	4	-
	100.0			100.0			100.0			100.0		
Stomachs containing food		893			31			120			1,044	
Empty stomachs		370			18			110			498	
Missing stomachs		4			2			-			6	
Total stomachs collected		1,267			51			230			1,548	

[1] Times the food item occurred as only a trace -- included in frequency totals.

[2] Identification probable but not certain.

(Trace = No volume measured, usually only a few bones, or in the case of squid, squid beaks.)

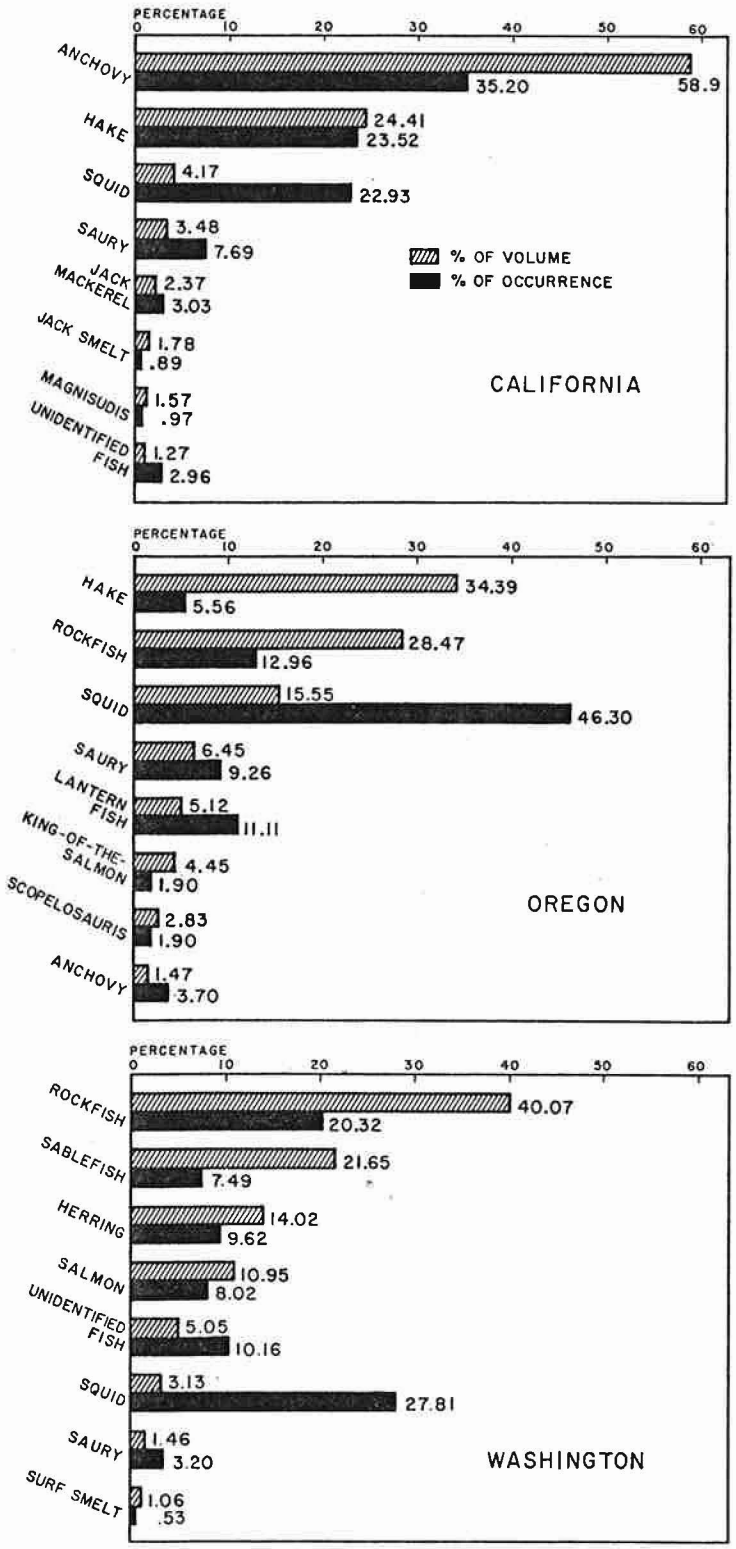

Figure 19. --Principal food of fur seals in 1959, by areas; comparing food volume and frequency-of-occurrence.

In California, the five fish taken in greatest volume by seals remained the same as in 1958. The order of importance changed. In 1958 the order was: squid 30 percent, saury 21 percent, hake 17 percent, anchovy 14 percent, and jack mackerel 5 percent. In 1959 the order was: anchovy 59 percent, hake 24 percent, squid 4 percent, saury 3 percent, and jack mackerel 2 percent. This change may be due to several factors: (1) changes in oceanographic conditions, such as water temperature, with associated changes in abundance and location of food species from year to year; (2) variation in sampling areas and length of time spent in sampling areas (in 1959 sampling was carried out over a wider area and for a longer period of time than in 1958); and (3) variation in weather conditions. The degree to which weather influences seal movements and the abundance of their food cannot be evaluated. Weather has a direct effect upon the effectiveness of vessels collecting at sea. On the average, much better weather prevailed off California in 1959 than in 1958.

Collections off the Oregon coast were small for both years. In 1958, 36 stomachs contained food and in 1959 there were 31 containing food. The first five food items ranked by percent of total volume in 1958 were: squid 59 percent, hake 18 percent, saury 12 percent, jack mackerel 7 percent, and rockfish 2 percent. In 1959 the first five items were: hake 34 percent, rockfish 28 percent, squid 15 percent, saury 6 percent, and lanternfish 5 percent. Factors affecting changes in food in California are applicable in this area also. The change in rank of rockfish from fifth in 1958 to second in 1959 can probably be attributed to the collection of seals in the vicinity of Heceta Bank in 1959. No seals were collected there in 1958. Jack mackerel, which ranked fourth in 1958, was not identified from stomachs collected in 1959. Lanternfish was identified from Oregon collections for the first time in 1959. It ranked fifth in total food volume.

In 1958, 55 stomachs containing food were collected off Washington and in 1959, 120 were collected. The first five food items ranked by percent of total volume in 1958 were: herring 51 percent, saury 13.6 percent, squid 13 percent, rockfish 12.9 percent, and smelt 3 percent. In 1959, the first five food items were: rockfish 40 percent, sablefish 21 percent, herring 14 percent, salmon 10 percent, and unidentified fish 5 percent.

A greater apparent change in food occurred in Washington than in either California or Oregon. The same factors, affecting changes in food noted for the California area, can be applied here but one additional factor must be added, depth of water at point of

collection. In 1958, seals were collected over a wide range of depths, with about 50 percent of the collection taken inside the 100-fathom curve and 50 percent taken outside. In 1959 the majority of the seals collected were taken inside the 100-fathom curve. Hunting in shallow water is probably the principal reason for rockfish and small sablefish appearing at the top of the food list in 1959. In 1958 rockfish ranked fourth and sablefish eighth in importance. Saury and squid, typically deep-water forms, ranked second and third in importance in 1958 but they dropped to seventh and sixth places, respectively, in 1959. Herring dropped in rank from first place in 1958 to fourth place in 1959. The reason for these changes is not known but is probably due to variation in abundance of these species from year to year.

Individual Food Items

Locations where food species occurred in seal stomachs are shown in figures 20, 21, 22, 23, 24, and 25. These positions indicate where the seal was collected and are probably close to where the seal captured and ate the fish or squid.

Food items are divided into three categories: those of economic importance, those of no economic importance, and miscellaneous items.

Species of economic importance. --The following species are of economic importance on the Pacific coast of North America to varying degrees:

(1) Anchovy

Anchovy was the most important food item recovered from seal stomachs in 1959. It represented 51.7 percent, by volume, of the total stomach contents. With the exception of two occurrences in Oregon waters, all recoveries were made off California.

The anchovy is probably one of the more important sources of food for the larger fishes. Merkel (1957) and Hubbs and Wisner (1953) have noted its use as a food item for salmon and marlin in California waters. Anchovy forms an important part of the diet for the wintering fur seal in California waters and, to an unknown extent, a part of the diet for other marine mammals found in California waters throughout the entire year.

The degree to which anchovy is utilized in the commercial fishery of California varies from year to year, dependent to some

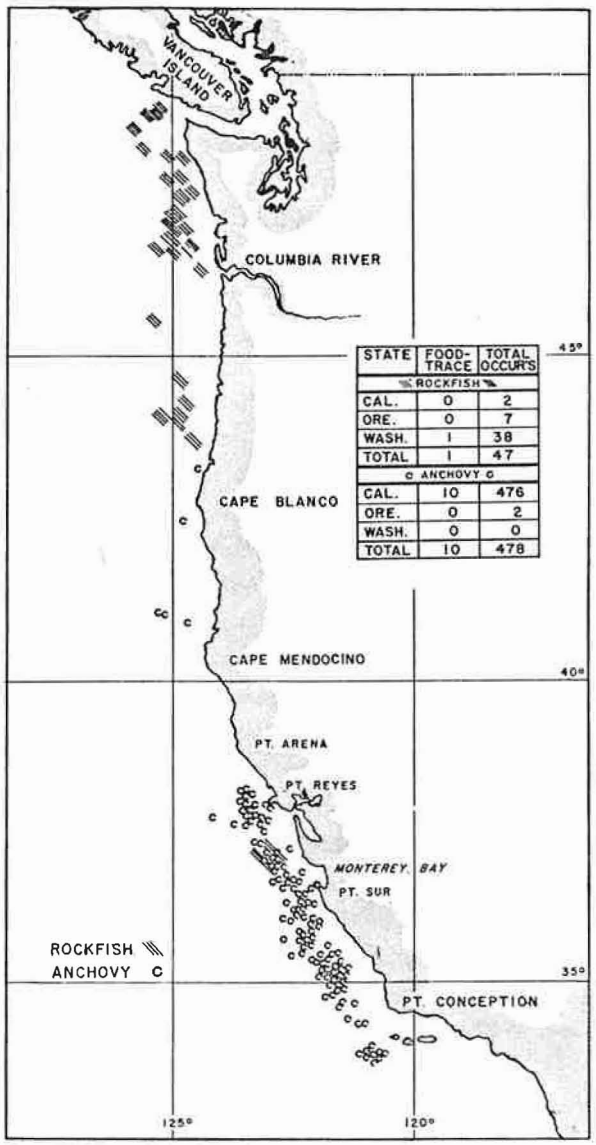

Figure 20. -- Locations where rockfish and anchovy occurred in seal stomachs collected 16 January through 26 April 1959.

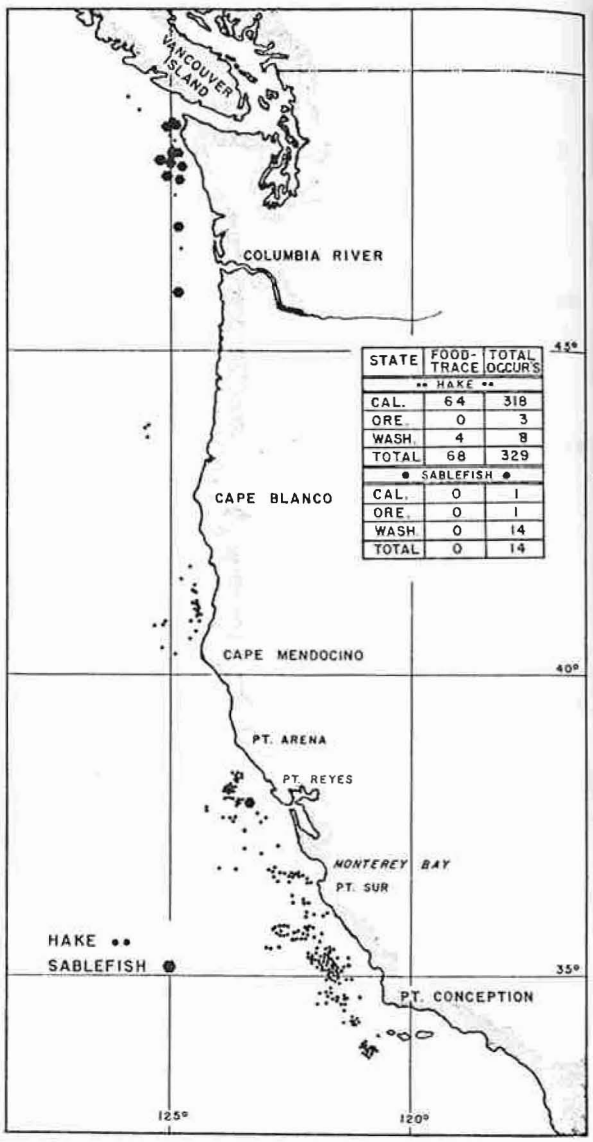

Figure 21. -- Locations where hake and sablefish occurred in seal stomachs collected 16 January through 26 April 1959.

(Food traces are defined as an unmeasured volume, usually a few bones, vertebrae, or otoliths.)

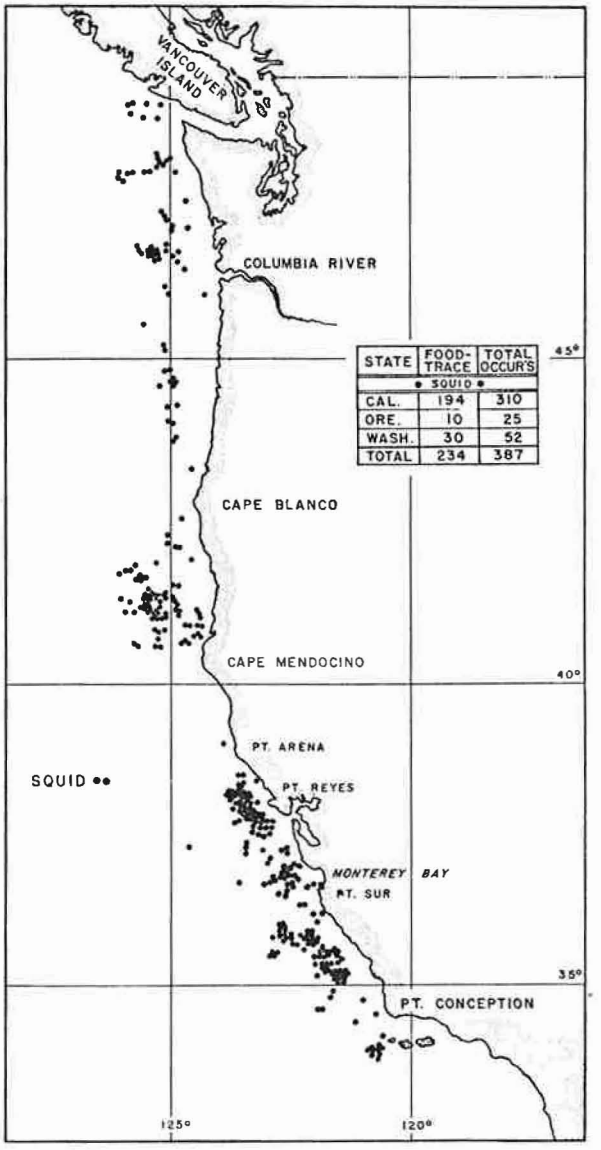

Figure 22. -- Locations where squid occurred in seal stomachs collected 16 January through 26 April 1959.

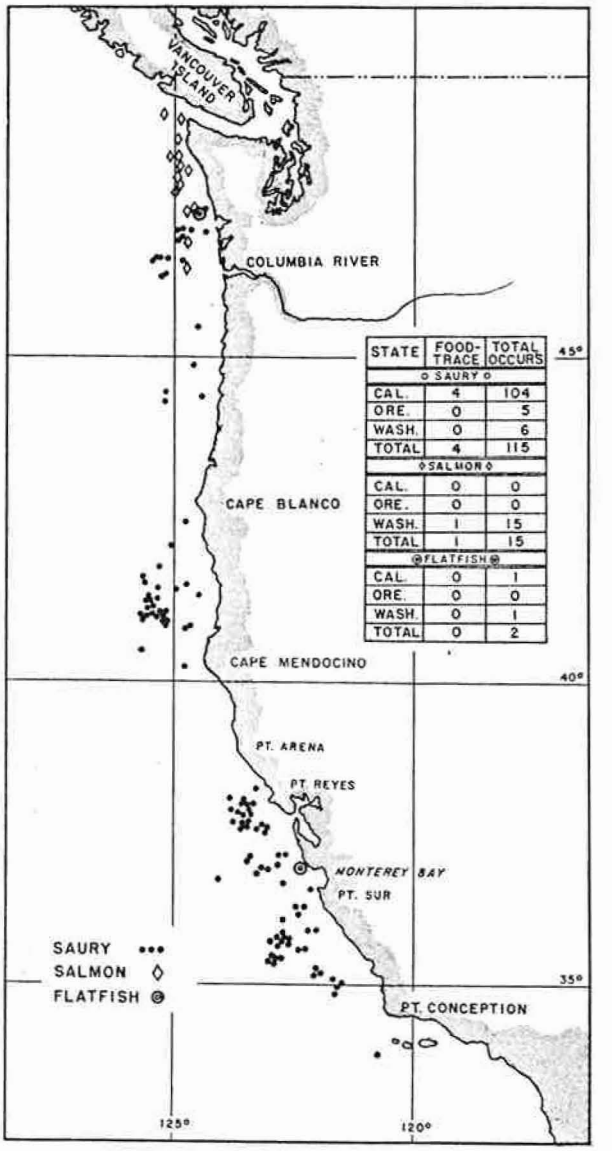

Figure 23. -- Locations where saury, salmon, and flatfish occurred in seal stomachs collected 16 January through 26 April 1959.

(Food traces are defined as an unmeasured volume, usually a few bones, vertebrae, or otoliths (pens, beaks, or eye lenses of squid).)

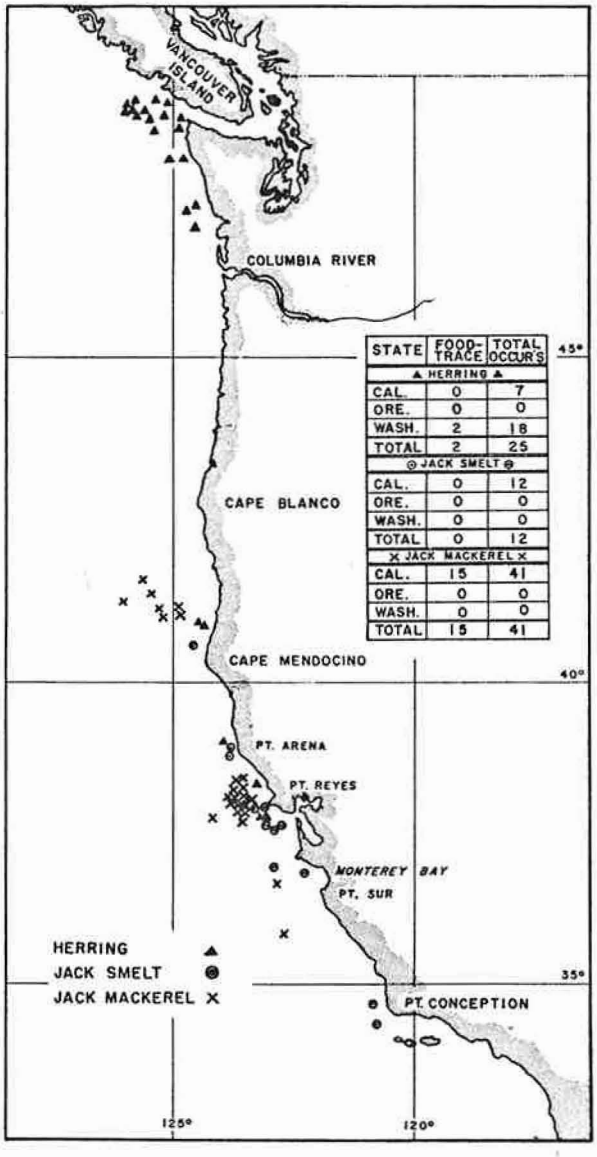

Figure 24. -- Locations where herring, jack smelt, and jack mackerel occurred in seal stomachs collected 16 January through 26 April 1959.

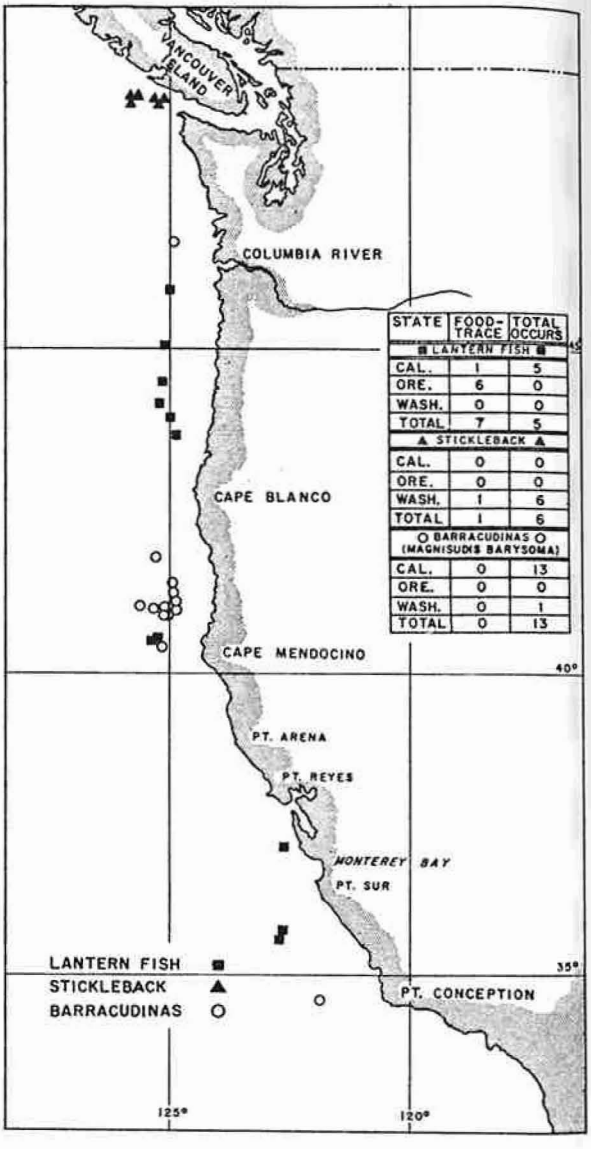

Figure 25. -- Locations where lanternfish, stickleback, and barracudinas occurred in seal stomachs collected 16 January through 26 April 1959.

(Food traced are defined as an unmeasured volume, usually a few bones, vertebrae, or otoliths.)

extent upon the availability of more desirable species of fish and market conditions. The California Department of Fish and Game publication, Fish Bulletin No. 105, lists the anchovy fishery for 1955 and 1956 as tenth in value among California fisheries. Over 70 percent of the anchovy landings are made south of the principal range of fur seals.

(2) Rockfishes

The rockfishes, 4.75 percent, by volume, of total food, occurred 47 times in 1,044 stomachs. No identifications as to species could be made, mainly because of the seals' habit of tearing off the head and eating only the body of the fish. Differences in structure of the vertebral column, between species of Sebastodes, are not considered sufficient to allow species identification. Identifiable remains of the rockfish (Sebastodes diploproa) were recovered from a Steller sea lion stomach collected off Halfmoon Bay, California, and one vessel recovered a rockfish (Sebastodes entomelas) on Heceta Bank off Oregon. This fish had been brought to the surface and was being consumed by a fur seal. The fur seal spends relatively little time in shallow water where rockfishes are available to it as a source of food.

(3) Squid

Squid was found over the entire range of the collection and comprised 4.3 percent, by volume, of the total food. Because the soft parts of squid are easily and rapidly digested, it may be more accurate to use frequency-of-occurrence rather than a percent-of-volume as an indicator of squid abundance in the sample. If frequency-of-occurrence is used, squid becomes almost equal in importance to anchovy and hake as a food item in California waters and the most important food in Oregon and Washington waters. The squid, principally Loligo opalescens, is of minor commercial importance in California but it is not taken commercially in Oregon or Washington. The size and extent of the fishery in California in 1955 and 1956 is shown in various tables in Fish Bulletin No. 105, published by the California Department of Fish and Game. A description of the 1957-58 squid fishery is given in the Commercial Fisheries Review, 21(5):19-20.

Squid identification was based mainly upon the work of Berry (1912). No significant scientific study has been made of the west coast squids since Berry's work and, although this paper is now known to be incomplete and at times erroneous, it is the best available reference source on the subject.

Over half, by volume, of the squid and squid remains were identified in 1959 but, by frequency-of-occurrence, only about 15 percent were identified. Three familes were found to be represented in the collection: Loliginidae, Gonatidae, and Onychoteuthidae. One species of the family Loliginidae, Loligo opalescens, was found. Almost half of the identified squid were of this species and it is quite likely that a similar proportion of the unidentified squid were also of this same species. The family Onychoteuthidae was also represented by one species which has been listed as Onychoteuthis (fusiformis?). The onychoteuthids found most closely resembled O. fusiformis, but the identification is open to question because a good description of the west coast onychoteuthids is not available.

The family Gonatidae was apparently represented in the collection by two species, neither of which agrees with the description of the one described west coast species, Gonatus fabricii, although they resemble it in some respects. For this reason, all specimens in this family were grouped and listed under the genus Gonatus only.

Of the identified squids, Loligo was found over the entire range of collection and much closer to the shore than Onychoteuthis or Gonatus. Both Onychoteuthis and Gonatus were found throughout the north-south range of collections but ranged farther offshore than Loligo -- Gonatus being found, in general, at a greater distance offshore than Onychoteuthis.

The three genera of squid which were identified belong to three different families. Considerable differences in morphology exist between these groups and, by careful study of structural differences of the shell (pen) and mandibles (where little or no digestive action has occurred), positive generic identification was relatively simple. It was found that these three genera could also be separated by differences in beak characteristics.

(4) Sablefish

Sablefish was found in one stomach from California, one stomach from Oregon, and in 14 stomachs from Washington. Sablefish represented less than one percent of total food, by volume, from California and Oregon but made up 21.6 percent of the food items off Washington.

(5) Jack mackerel

The jack mackerel, recorded as a fur-seal food for

the first time in 1958, was found in seal stomachs from Point St. George, California, southward; the majority of the occurrences being found off Point Reyes. Areas of collection were about the same in both 1958 and 1959 and frequency-of-occurrence was similar. Jack mackerel made up about two percent of the total food volume in both 1958 and 1959.

(6) Herring

Herring formed less than two percent of total food, by volume, in 1959. It was taken principally off Washington and there were a few occurrences in California.

(7) Jack smelt

Jack smelt was found in 12 stomachs collected off California, making up less than two percent of the food items for this area.

(8) Salmon

Salmon occurred 15 times in seal stomachs collected off Washington and formed about 11 percent, by volume, of the food in Washington waters. However, salmon composed a little over one percent of the total food for the three-state area. Identification as to species could not be made from skeletal remains.

(9) Surf smelt

Eight occurrences of surf smelt, mostly from California, making up less than 0.2 percent, by volume, of total food, were recorded in 1959.

(10) Flatfishes

Flatfishes were identified twice in 1959 and made up less than 0.2 percent, by volume, of total food. One flatfish was identified as Lyopsetta exilis (slender sole).

(11) Shad

Shad was identified from one stomach in 1959. In 1958 shad occurred seven times.

(12) Eulachon

Eulachon was identified from two stomachs in 1959.

Species of no economic importance. --The following species are of no economic importance in the area of collection:

(1) Hake

This fish ranked second in importance to anchovy as a fur-seal food in 1959. It made up over 22 percent of the total food, by volume, for the three-state area. Hake is of negligible importance in the fresh- and frozen-fish markets but, in recent years, has been utilized to some extent in the animal-food fishery of California (Best, 1959).

(2) Saury

The saury occurred in 115 stomachs and formed over three percent, by volume, of the total stomach contents. In California waters it dropped from over 20 percent of total volume in 1958 to 3-1/2 percent in 1959.

(3) Magnisudis barysoma (Harry)

One of the barracudinas was identified from fur-seal stomachs for the first time in 1959. Specific identification was made by Dr. Arthur D. Welander. Magnisudis barysoma, the only known species in the genus, is easily distinguished from the other members of the family Paralepididae by the usual external features. Positive identification can be made from the enlarged lateral-line scales, which are much larger than surrounding scales, and from the anal and pectoral fin-ray counts. See Harry (April 1953 and December 1953) for a complete description of the fish. We know of no published information on the skeletal structures of the barracudinas. The following counts were made from material recovered from seal stomachs. Total vertebrae: 68 (4), 69 (3), 70 (1). The first haemal arch and spine are on the same vertebrae: 34 (5), 35 (4). The vertebrae are distinctive and, once recognized, cannot be easily confused with those of fish from other families.

Magnisudis barysoma (Harry) was identified in 14 seal stomachs but as skeletal material was not available for comparison with other genera in the family, five of these occurrences have been listed as Magnisudis barysoma?. In these five cases, identification was made from vertebrae only. Three of the identifications occurred in the area off Eureka, California, where nine positive identifications were made,

one was collected off Point Conception, California, and one was collected off Grays Harbor, Washington. Magnisudis represented slightly over one percent of the total stomach contents.

(4) King-of-the-salmon

This trachipterid was identified in two stomachs from California and one from Oregon. One whole specimen was recovered off Washington. A fur seal had brought the fish to the surface and was in the process of eating it when the seal was surprised by the hunting vessel and the fish recovered. This fish is of incidental occurrence in fur-seal stomachs.

(5) Lanternfishes

Lanternfishes were identified for the first time in fur-seal stomachs, from California and Oregon waters, in 1959. Hanna observed fur seals taking lanternfishes off San Francisco in April 1950 (Hanna 1951). Lanternfishes form an important part of the fur seal's diet in the western Pacific but form only an insignificant part of the diet of seals taken in the past two years in the eastern Pacific. Lanternfishes were identified in five stomachs from California and in six stomachs from Oregon. The species Tarletonbeania crenularis was identified from undigested specimens in two of the six stomachs from Oregon.

(6) Northern midshipman

Midshipman was identified from three stomachs collected in California waters. Midshipman was also reported from California in 1958.

(7) Pomfret

Pomfret made its appearance, for the first time, on the list of fur-seal food from California (fig. 17). Canadian investigators reported pomfret in a fur-seal stomach collected 200 miles off Estevan Point, British Columbia in 1958 (Pike, Spalding, MacAskie, and Velsen, 1958).

(8) Stickleback

Stickleback was found in six stomachs collected off Washington. In 1958, Canadian investigators reported stickleback in fur-seal stomachs from this same general area (Pike et al. 1958).

(9) Lamprey

The Pacific lamprey was found in one stomach collected off Washington.

(10) Other fishes

Tentative identifications were made by Daniel M. Cohen, Ichthyological Laboratory, U. S. National Museum, of the contents of two stomachs. One stomach contained fish thought to be Tactostoma macropus and the other stomach contained a fish tentatively identified as Scopelosaurus. Both of these fishes represent deep-sea forms; Tactostoma is said to be abyssal. Points of collection for the two forms were: Tactostoma - 1 March 1959, 35°28'N., 122°51'W., 67 miles southwest of Point Sur, California, depth 1,800 fathoms; Scopelosaurus - 13 April 1959, 45°09'N., 125°06'W., 48 miles west of Cascade Head, Oregon, depth 700 fathoms.

Miscellaneous items. --The following are miscellaneous items found in fur-seal stomachs:

(1) Birds

Birds have frequently been reported from fur-seal stomachs, although they are by no means of common occurrence. No birds were found during the examination of stomachs in 1958 but six occurrences were recorded in 1959. The presence of large numbers of birds, in addition to large numbers of marine mammals, feeding on schools of anchovy has been commented on earlier in the report and it is of interest that all four identified birds, from California waters, were birds that dive to secure their food. This suggests the possibility that seals capture these birds beneath the water's surface, perhaps directly in the school of fish. McHugh (1952) reported a seaman's observation of a fur seal taking a black-footed albatross from the surface. Beal petrel, taken off Washington, was identified by the Bird and Mammal Laboratory, Washington, D. C.

(2) Stones

Stones were found in the stomachs of four seals taken in Washington waters: two of the stomachs each contained only one stone and no food; two of the stomachs contained food, with stones making up a small part of the total volume. The largest stone recovered measured about 2 x 4 centimeters.

Relation of Fur Seals to Commercial Fisheries

In the report of the United States for 1958, it was stated that only a brief appraisal of the direct effects of fur seals on commercial fisheries was as yet possible. This continues to be true. The following comments apply exclusively to the areas where collecting was done in 1959.

Anchovy, hake, squid, and saury again made up over 80 percent of the diet of fur seals in California. Although there was a greater proportion of anchovy and a lesser proportion of saury taken than in 1958, this change did not alter the conclusion that the fur seal is not competing seriously here with commercial fishermen under present conditions in the Pacific coast commercial fisheries.

Utilization of the anchovy for canning or bait has never reached the point where it is more than trivial as compared with the extensive foraging on anchovy by a variety of cetaceans, seals, sea lions, marine birds, and a wide range of fish and squid. Obviously, the fur seal alone is responsible for a small part of the total predation on the anchovy.

Hake and the small sauries, usually occurring off California, are practically ignored by commercial fishermen. The take of squid does not approach complete utilization for the one species, Loligo opalescens that is marketed.

The only fishes taken by fur seals off Oregon, that are of commercial value at the present time, are the rockfishes, making up 28 percent of the food, by volume, from this area. Some species of rockfish are important commercially and some are not utilized. If frequency-of-occurrence is used instead of volume as a measure of food importance, rockfishes make up 13 percent of the food fishes in this area. Oregon waters are used mainly during migration and the effect the fur seal has upon the fish population is probably negligible.

Rockfishes, sablefish, herring, and salmon, all fishes of commercial value, made up 85 percent, by volume, of the total food in Washington waters. On a frequency-of-occurrence basis, these four fishes made up 44 percent of the total fish occurrences in the state.

No commercial-size sablefish was found in the collection. The number of herring taken by the fur seal is probably unimportant compared to the number of herring taken by other predators that remain

in Washington waters throughout the entire year. Species identification of rockfish could not be determined so the percentage of commercially valuable rockfish in the sample is not known. Salmon are found off the Washington coast in considerable numbers during the early spring and summer and are taken by the fur seal migrating northward. Appraisal of the amount of predation on salmon will be helped by Canadian research collections in the area.

The bulk of the fur-seal population that migrates south to Oregon and California passes Washington far offshore in early winter, returning on the northward migration in March and April. A small population, composed mainly of one- and two-year-old animals, remains in the area for longer periods of time. The fact that the collection for Washington in 1959 was obtained mainly inside the 100-fathom curve accounts in part for the high percentage of commercially valuable fish in the sample.

Predators and Mortality at Sea

No new evidence was obtained of predation on seals. The killer whale is considered a potential predator. No attacks on fur seals by killer whales were observed in 1959.

On one occasion, 85 miles west of Point Arguello, California, three killer whales were observed in close proximity to two fur seals. The seals left the locality and were not seen again but, whether this was due to the presence of killer whales or the hunting vessel is not known. On 28 March 1959 off Eureka, California, three killer whales were observed in a large patch of bloody water. The only visible remnant of their kill was the lobe of a lung. This was salvaged but its size alone ruled out the possibility of a fur-seal kill.

Another potential seal predator is the great white shark (Carcharodon carcharias). Other large sharks may also prey on seals. Collection of a number of killer whales and large predatory sharks in areas where fur seals occur would be the only way to verify predation.

Further evidence of yearling mortality at sea, due, supposedly, to heavy winter storms and accompanying unfavorable feeding conditions was reported. On a short stretch of beach south of the Columbia River mouth, six dead yearlings were found in March (see appendix C). All six were emaciated. Mortality has been observed in previous years

when, because of heavy and prolonged winter storms, numerous dead seals were found along the Oregon and Washington coasts (Scheffer, 1950). Many disintegrate and sink before reaching shore.

The total loss at sea from various causes, up to age three, of a single year class of seals probably exceeds 250,000.

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Appendix A

Appendix table 1. --Numbers and relative abundance of seals seen off California, Oregon, and Washington, by 10-day periods, 16 January to 26 April 1959

Period	Number of boat-hunting hours	Total seals sighted	Seals seen per boat hour	Percent seen in various periods
California				
16-25 January	187.25	321	1.7	6.3
26 January - 4 February	175.00	1157	6.6	22.5
5-14 February	165.50	1306	7.9	25.4
15-24 February	148.75	1067	7.2	20.8
25 February - 6 March	138.00	374	2.7	7.3
7-16 March	105.75	139	1.3	2.7
17-26 March	116.50	368	3.2	7.2
27 March - 5 April	127.50	329	2.6	6.4
6-15 April	40.00	71	1.8	1.4
Total	1204.25	5132		100.0
			4.3 1/	
Oregon				
16-25 January	40.25	18	0.4	12.6
7-16 March	9.50	16	1.7	11.2
17-26 March	35.25	49	1.4	34.3
6-15 April	70.00	60	0.9	41.9
Total	155.00	143		100.0
			0.9 1/	
Washington				
16-25 January	32.75	22	0.7	3.4
17-26 March	0.75	1	1.3	0.1
27 March - 5 April	29.00	136	4.7	21.1
6-15 April	74.00	101	1.4	15.7
16-25 April	188.00	372	2.0	57.8
26 April	18.00	12	0.7	1.9
Total	342.50	644		100.0
			1.9 1/	
Grand total	1701.75	5919		
			3.5 1/	

1/ Average number of seals seen per boat hour in area.

Appendix B

DISTRIBUTION OF SEALS BY AGE AND DEGREE OF LATITUDE

The range of the fur seal along the west coast of North America extends from the central Bering Sea in the north to about the California-Mexican border (32°30'N.) in the south. Only the southern part of this range between 33°N. and 49°N. is pertinent here.

One of the most important published reports of seal observations for our purposes is that of Townsend (1899). A map in Townsend's report gives monthly locations of pelagic sealing operations in the North Pacific for the years 1883 through 1897. Nothing is shown for the months of October or November.

Pelagic sealing was carried on off California during the months of December through April. January, February, and March were the months of most intense hunting. Sealing occurred mainly to the north of San Miguel Island. The southernmost location was off San Nicolas Island, where one day's sealing was reported in January. Pelagic sealing off Oregon was recorded for the months of January through April, with the majority of records occurring during the months of March and April. Sealing off Washington was recorded for January through May. March and April were the months when most hunting took place.

The first important scientific collection of fur seals from this area was made in 1952 (Taylor et al., 1955) when 199 seals were taken in California waters, and 99 were taken in the waters off Oregon and Washington. At that time the age of seals 10 years old and older could not be determined so the 1952 data is not fully applicable.

In 1958, ages were determined for 596 seals from the three-state area, and in 1959, 1,520 seals from the same area were aged. The aging technique used the first time in 1958, made possible a determination of age for seals of all ages (Wilke et al., 1958).

In previous reports (Taylor et al., 1955; Wilke et al., 1958)

and in the present report, the age and sex of fur seals collected has been shown for large areas encompassing several degrees of latitude (table 4 of text); the area covered off California extends through nine degrees of latitude (540 nautical miles). Changes in the age composition of seals collected from north to south, tend to become obscured when data for a large area is combined.

The figures and tables in this appendix present the age composition of seals collected in 1958 and 1959 without separating sexes, because the collection in these waters is made up predominantly of female seals. A degree of latitude as used in appendix B, is defined as 00' to and including 59'. For example, all seals collected between 33°00'N. and 33°59'N. are included under the heading 33°N.

Figures 26, 27, 28, and 29 show the age composition of seals collected in 1959, for each degree of latitude, as a percentage of the total sample (appendix table 2). Changes in age can be easily seen in the figures. The samples taken in 42°N., 43°N., and 45°N. are inadequate in size.

Appendix table 2 and figures 26, 27, 28, and 29 do not make allowance for two important factors; time of year when collections were made and amount of hunting effort used in making the collection. Figure 30 and appendix table 3 show the average age of seals collected in each degree of latitude, the actual number of seals collected, and the number of hunting days, by month, spent in each degree of latitude for the years 1958 and 1959.

The following conclusions can be made in regard to the data presented in this appendix:

1. The fur-seal population in the southern part of the area studied is mainly composed of mature animals during January through March. In 1959, 55 percent of the seals collected in latitudes 33°N., 34°N., and 35°N., were 10 years old or older. Only 27 seals (5 percent) from a total collection of 582 seals were under five years of age. In the area between 36°N. and 39°N., 37 percent of 501 seals collected during January through April were 10 years old or older; 16 percent were under five years of age. The area between 33°N. and 39°N. can be considered as the main wintering area for the fur seals found south of 49°N. Apparently during January through March, a fairly stable wintering population occupies this area although shifting about locally in search of food. Some southward migration into the area occurs into February, when the forerunners of the northward

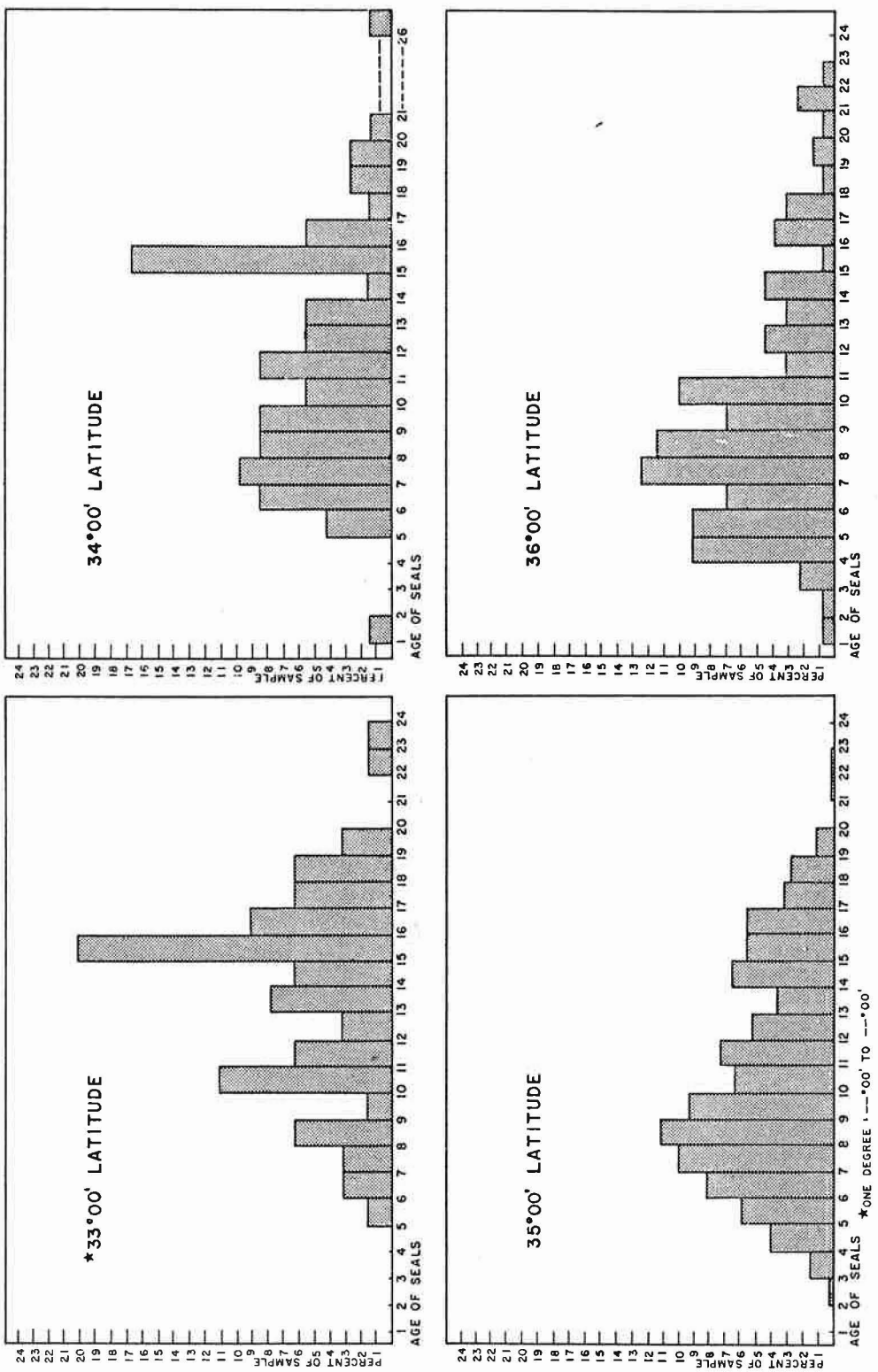

Figure 26. --Percent of seals collected, by age, in latitudes 33° to 36°N., in 1959.

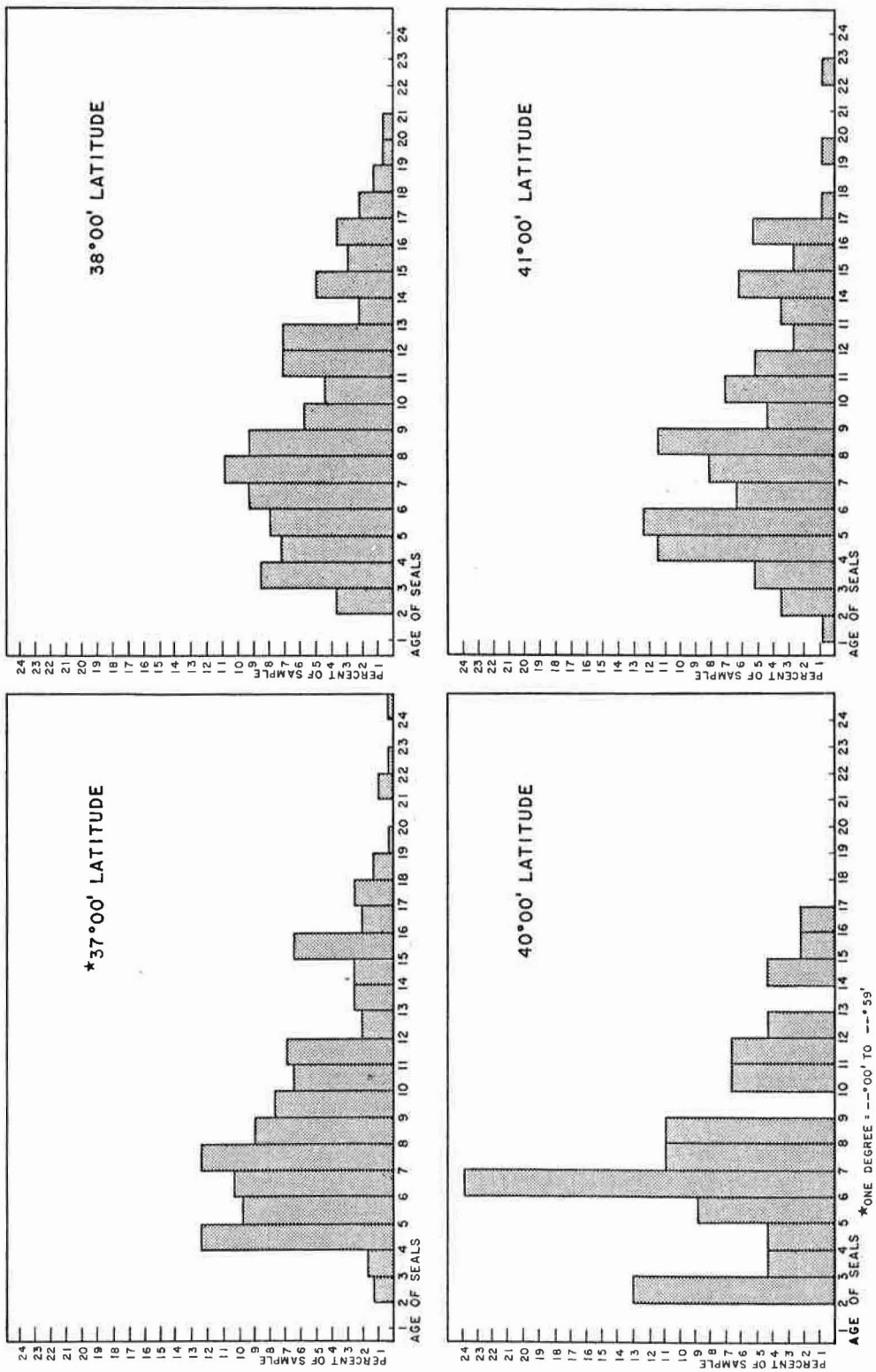

Figure 27. --Percent of seals collected, by age, in latitudes 37°, 38°, 40°, and 41°N., in 1959.

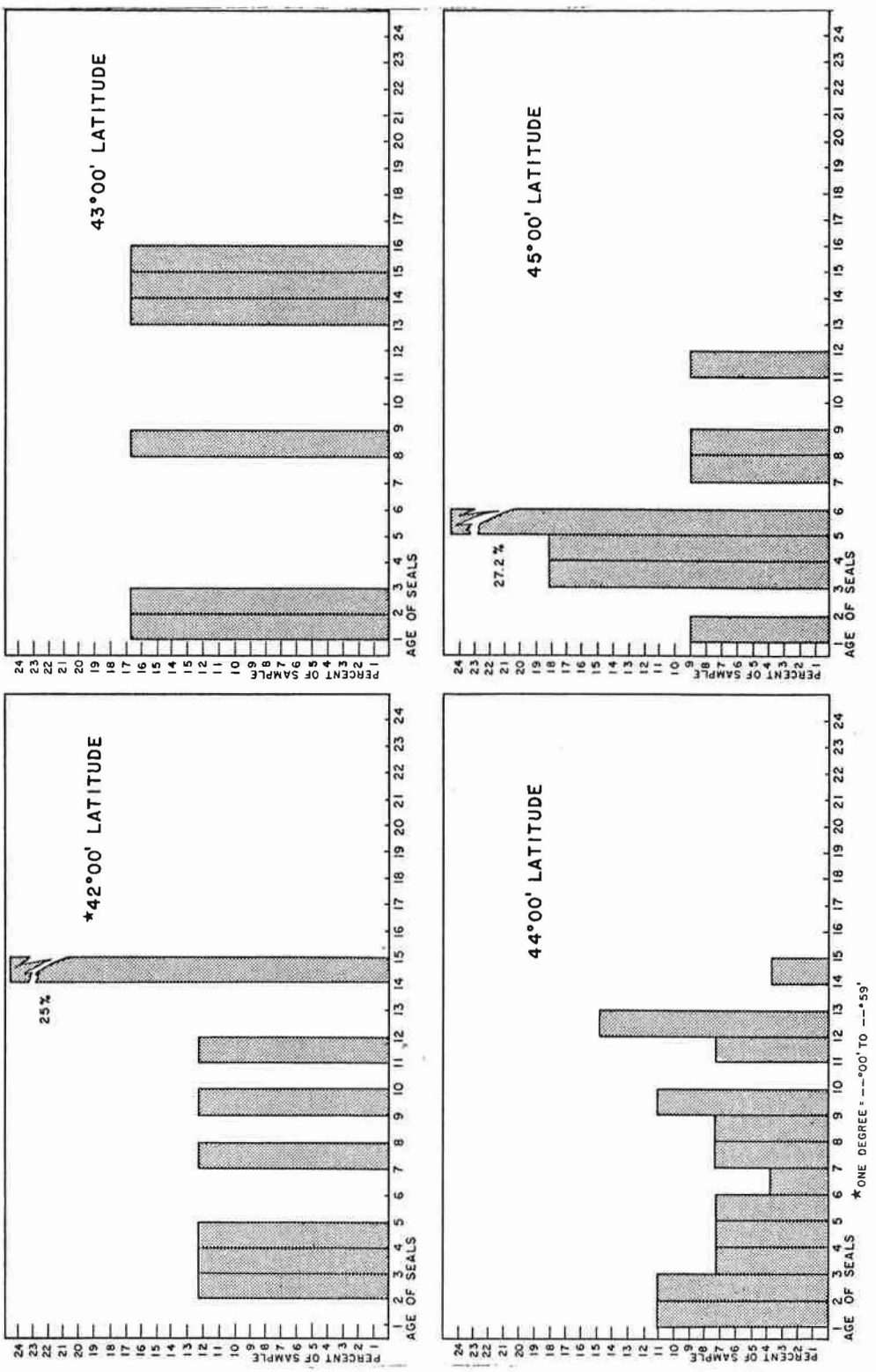

Figure 28. --Percent of seals collected, by age, in latitudes 42° to 45°N., in 1959.

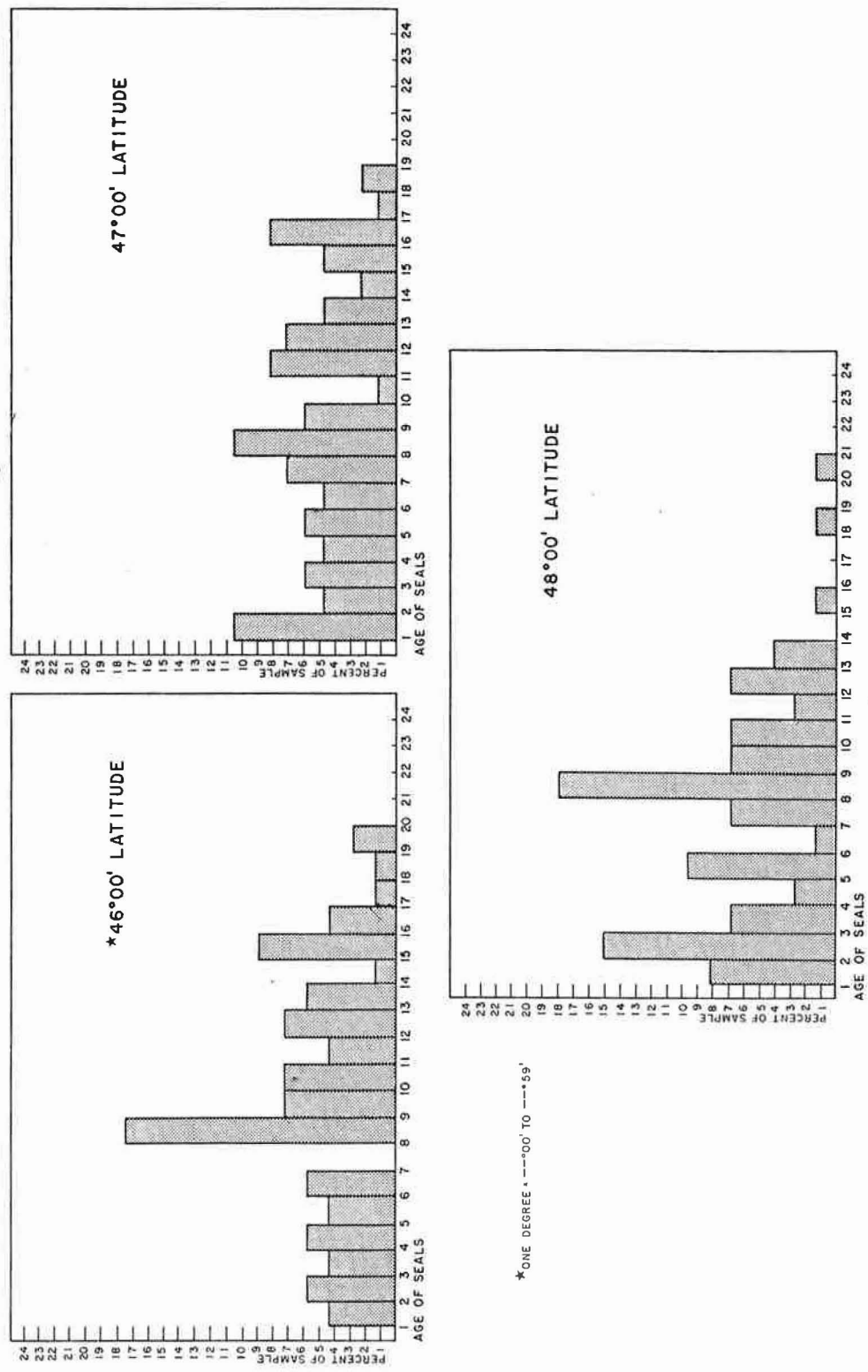

Figure 29. --Percent of seals collected, by age, in latitudes 46° to 48°N., in 1959.

Appendix table 2.--Ages of seals collected in 1959, by degrees of latitude

Degree of latitude 1/	Age in years																										
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	Total
33°	-	-	-	-	1	2	2	4	1	7	4	2	5	4	13	6	4	4	2	-	-	1	1	-	-	-	63
34°	1	-	-	-	3	6	7	6	6	4	6	4	4	1	12	4	-	1	2	2	1	-	-	-	-	1	71
35°	-	1	7	18	26	36	45	50	42	29	33	25	18	31	26	26	16	12	5	-	1	1	-	-	-	-	448
36°	1	1	3	12	12	9	16	15	9	13	4	6	4	6	1	5	4	1	2	1	3	1	-	-	-	-	129
37°	-	3	4	29	23	24	29	21	18	15	16	5	6	6	15	5	6	3	1	-	2	1	-	1	-	-	233
38°	-	5	12	10	11	13	15	13	8	6	10	10	3	7	4	5	3	2	1	1	-	-	-	-	-	-	139
39°	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
40°	-	6	2	2	4	11	5	5	-	3	3	1	-	2	1	1	-	-	-	-	-	-	-	-	-	-	46
41°	1	4	6	13	14	7	9	13	5	8	6	3	4	7	3	6	1	-	1	-	-	1	-	-	-	-	112
42°	-	1	1	1	-	-	1	-	1	-	1	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	8
43°	1	1	-	-	-	-	-	1	-	-	-	-	1	1	1	-	-	-	-	-	-	-	-	-	-	-	6
44°	3	3	2	2	2	1	2	2	3	-	2	4	-	1	-	-	-	-	-	-	-	-	-	-	-	-	27
45°	1	-	2	2	3	-	1	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11
46°	3	4	3	4	3	4	-	12	5	5	3	5	4	1	6	3	1	1	2	-	-	-	-	-	-	-	69
47°	9	4	5	4	5	4	6	9	5	1	7	6	4	2	4	7	1	2	-	-	-	-	-	-	-	-	85
48°	6	11	5	2	7	1	5	13	5	5	2	5	3	-	1	-	-	1	-	1	-	-	-	-	-	-	73
Total	26	44	52	99	114	118	143	165	108	96	98	76	56	71	87	68	36	27	16	5	7	5	1	1	0	1	1520 2/

1/ A degree of latitude is defined as 00' to and including 59'.

2/ 1,520 + 28 (unknown age) = 1,548.

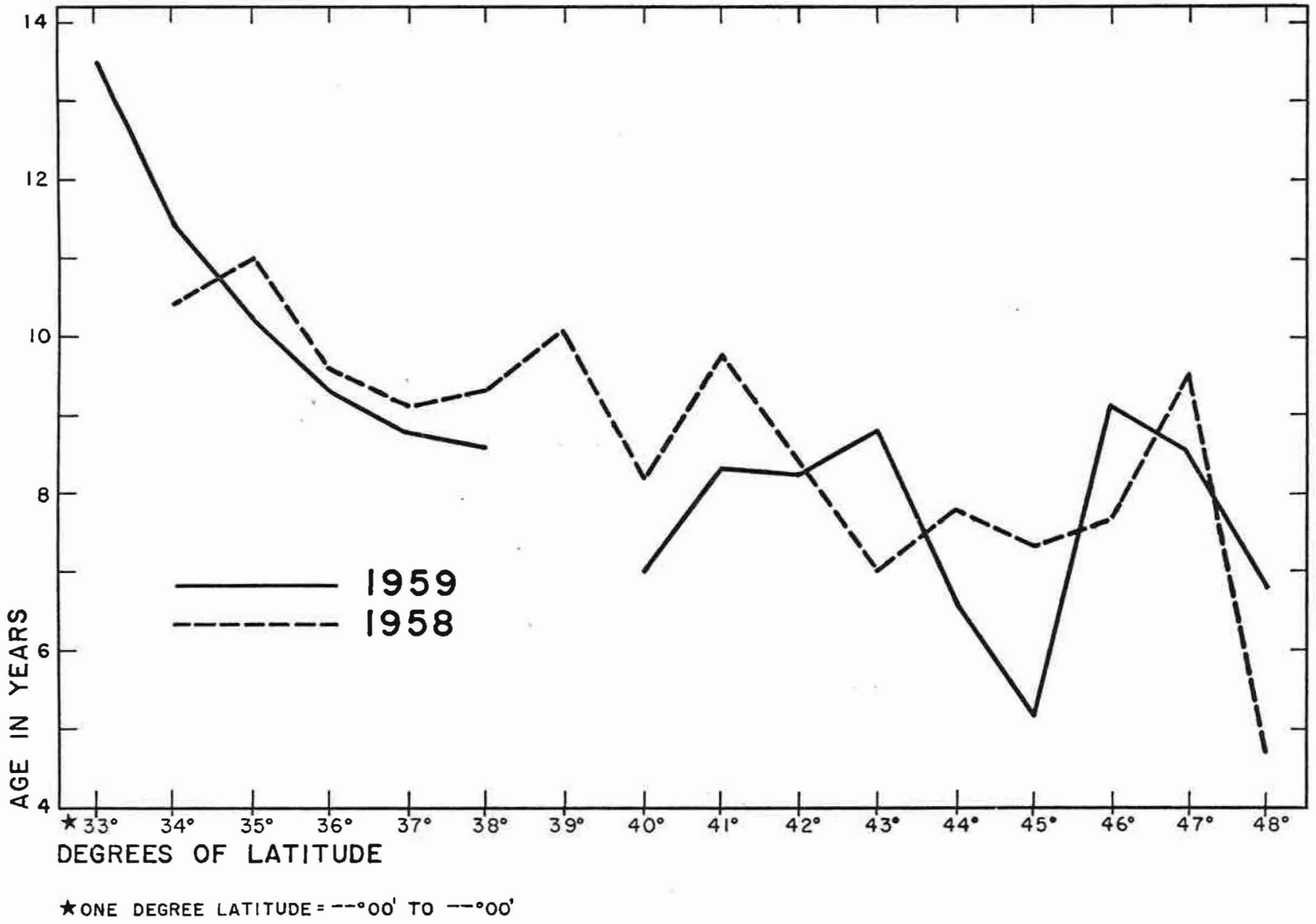

Figure 30.--Average age of seals collected in each degree of latitude in 1958 and 1959.

Appendix table 3. --Number of seals collected and number of hunting days by month in each degree of latitude, in 1958 and 1959.

Year	Degrees of latitude															
	33°	34°	35°	36°	37°	38°	39°	40°	41°	42°	43°	44°	45°	46°	47°	48°
Number of seals collected																
1959	63	71	448	129	233	139	-	46	112	8	6	27	11	69	85	73
1958	-	40	59	118	188	13	11	14	17	8	16	11	18	26	20	38
Number of days when seals were collected																
January																
1959	4	2	1	4	3	1	-	-	-	1	-	-	1	1	-	-
1958	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
February																
1959	-	7	14	9	11	2	-	-	-	-	-	-	-	-	-	-
1958	-	-	3	7	8	-	-	2	2	-	-	-	-	-	-	1
March																
1959	-	-	4	12	7	3	-	8	8	1	1	2	-	-	-	-
1958	-	2	5	9	12	2	-	2	-	-	-	-	-	-	-	-
April																
1959	-	-	-	-	2	6	-	5	5	-	2	2	3	9	10	9
1958	-	-	-	-	1	1	1	1	3	3	3	1	1	3	4	4

migration probably begin to move north. The southern limit of the main population of fur seals varies from year to year but 34°N. can probably be considered as the limit in most years.

2. Observations and collections from 40°N. to 49°N. have been made almost entirely during the months of March and April when the majority of the seals are in northward migration. A modest downward trend in average age is still apparent. It is illustrated in a comparison of the 1959 collections from 40° and 41°N. with those from 47° and 48°N.; the sample size was 158 seals in both areas. Percentages show proportion of total sample.

Age of seals	Latitudes	
	40° and 41°N.	47° and 48°N.
	percent	percent
Under 5 years old	22	29
5-9 years old	46	38
Over 9 years old	32	33

Seals of less than five years of age do not go as far to the south as the older animals. Young (1- and 2-year-olds) are found in greater numbers north of 39°N. than they are south of this latitude and they commonly linger in 47°N. and 48°N. after most of the older seals have moved on north.

The investigators believe the sample is reasonably representative for the period of collection. North of 42°N. it would be desirable to extend the period of sampling over several months and increase the sample size.

Appendix C

RECOVERIES OF TAGGED FUR SEALS REPORTED IN 1958 AND 1959

Fur seals tagged as pups on the Pribilof Islands are recovered on the islands during the commercial kill in large numbers and a much smaller number are taken at sea during pelagic investigations. A third source of tag recovery is from dead seals washed ashore and the occasional capture and release of a tagged seal. Figure 31 illustrates this third source of tag returns for the years 1958 and 1959.

Reports of untagged seals are also received. In January 1958, young seals (five to six months old) were reported as being numerous in Knight and Smith Inlets, British Columbia. Two tagged pups were found there. Fifteen dead pups were reported from the Long Beach area just south of Willapa Bay, Washington, on 8 March 1959.

The majority of tag returns in 1958 were from the inside waters of southeastern Alaska and British Columbia during the months of December, 1957, and January, 1958. Only a few tags were reported from the Washington and Oregon ocean beaches. In 1959 the majority of tags recovered came from ocean beaches. Most recoveries were made in January, February, and March. Two tagged pups were found in Puget Sound.

Only three seals older than one year of age were reported in 1958 and 1959.

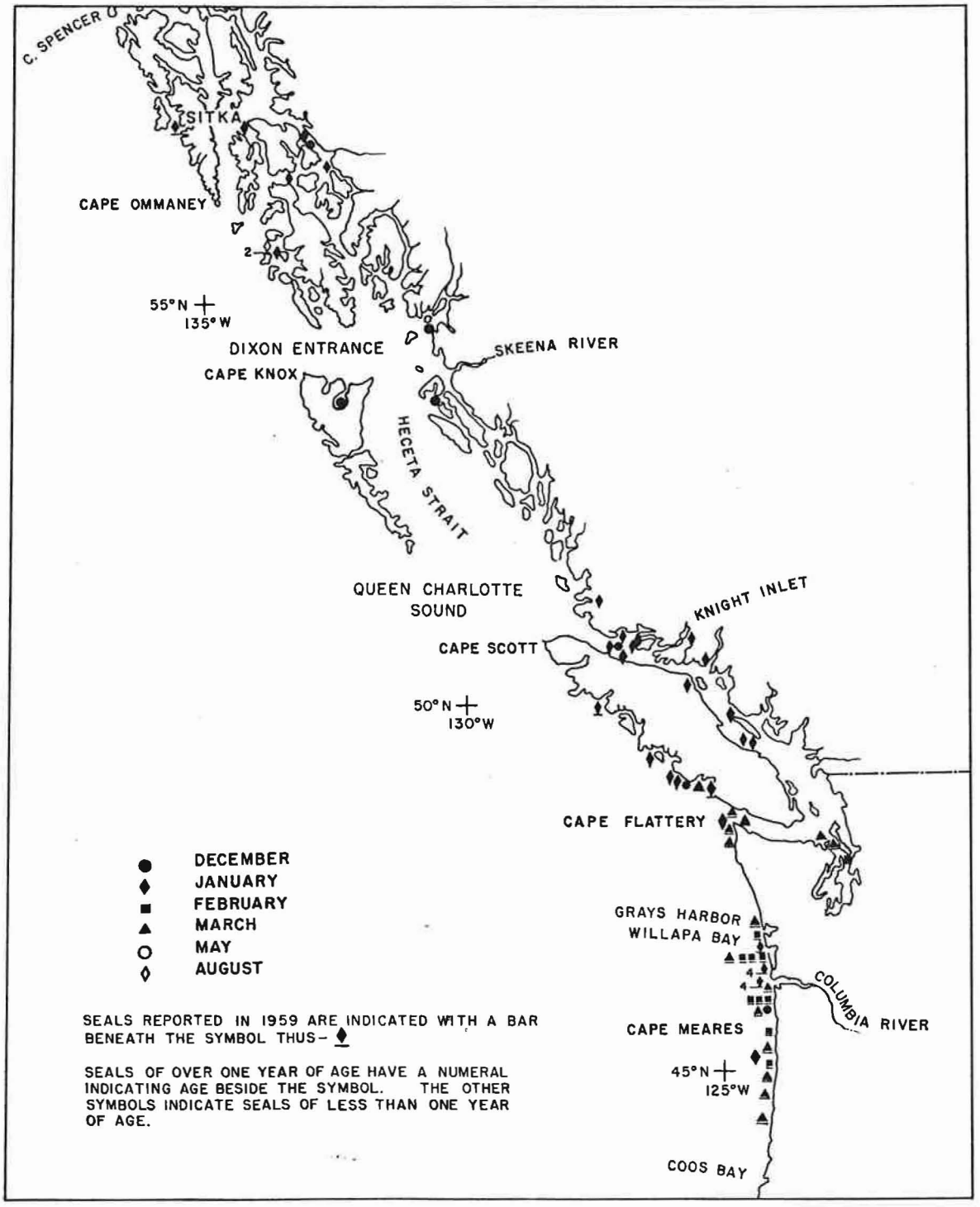

Figure 31. --Fur-seal tag recoveries reported in 1958 and 1959 from Alaska, British Columbia, Washington, and Oregon. The symbols indicate place, month, and year of recovery. Most tag recoveries were made from dead seals that had drifted ashore.

Appendix D

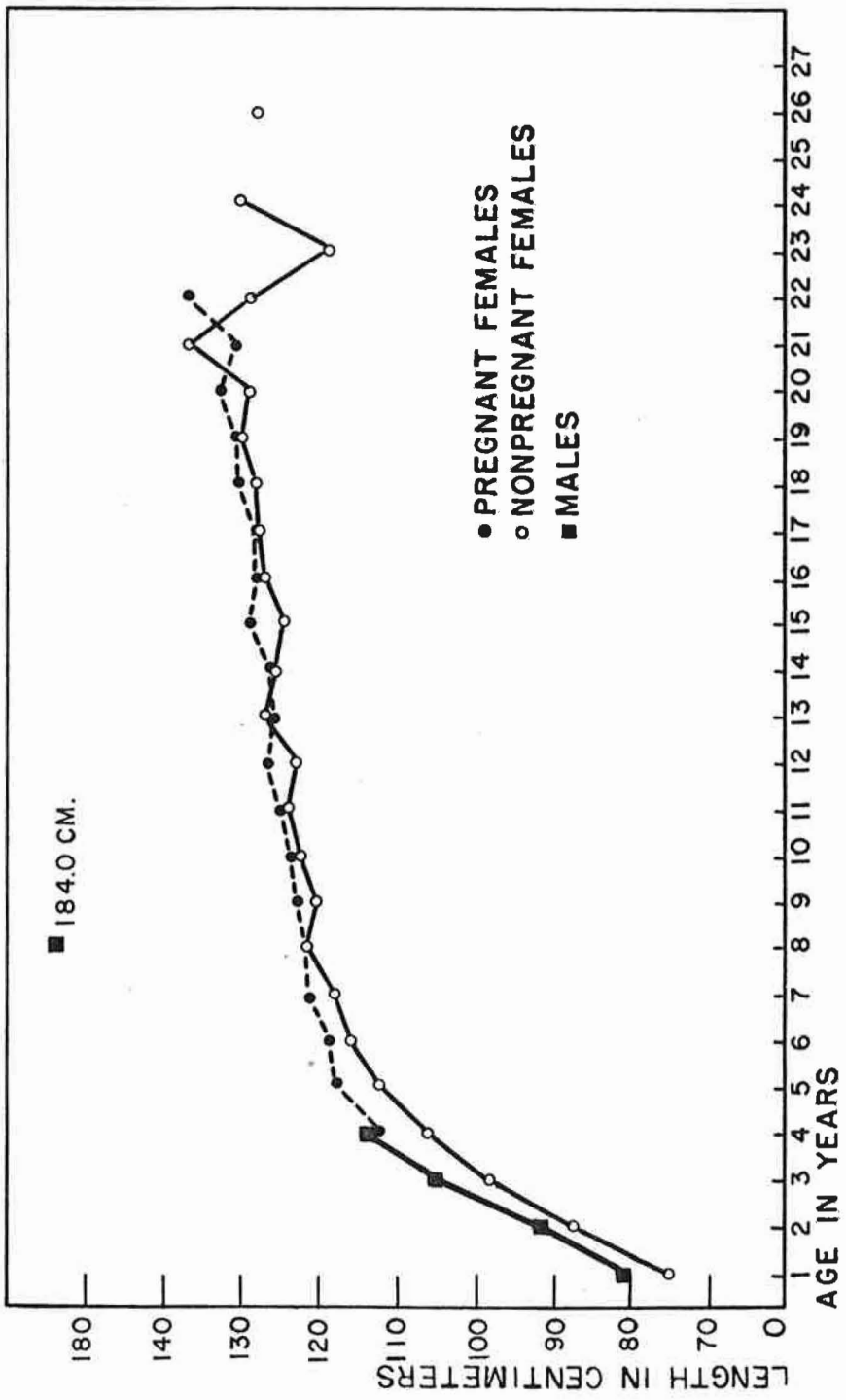

Figure 32. --Mean length of fur seals collected off California, Oregon, and Washington in 1959.

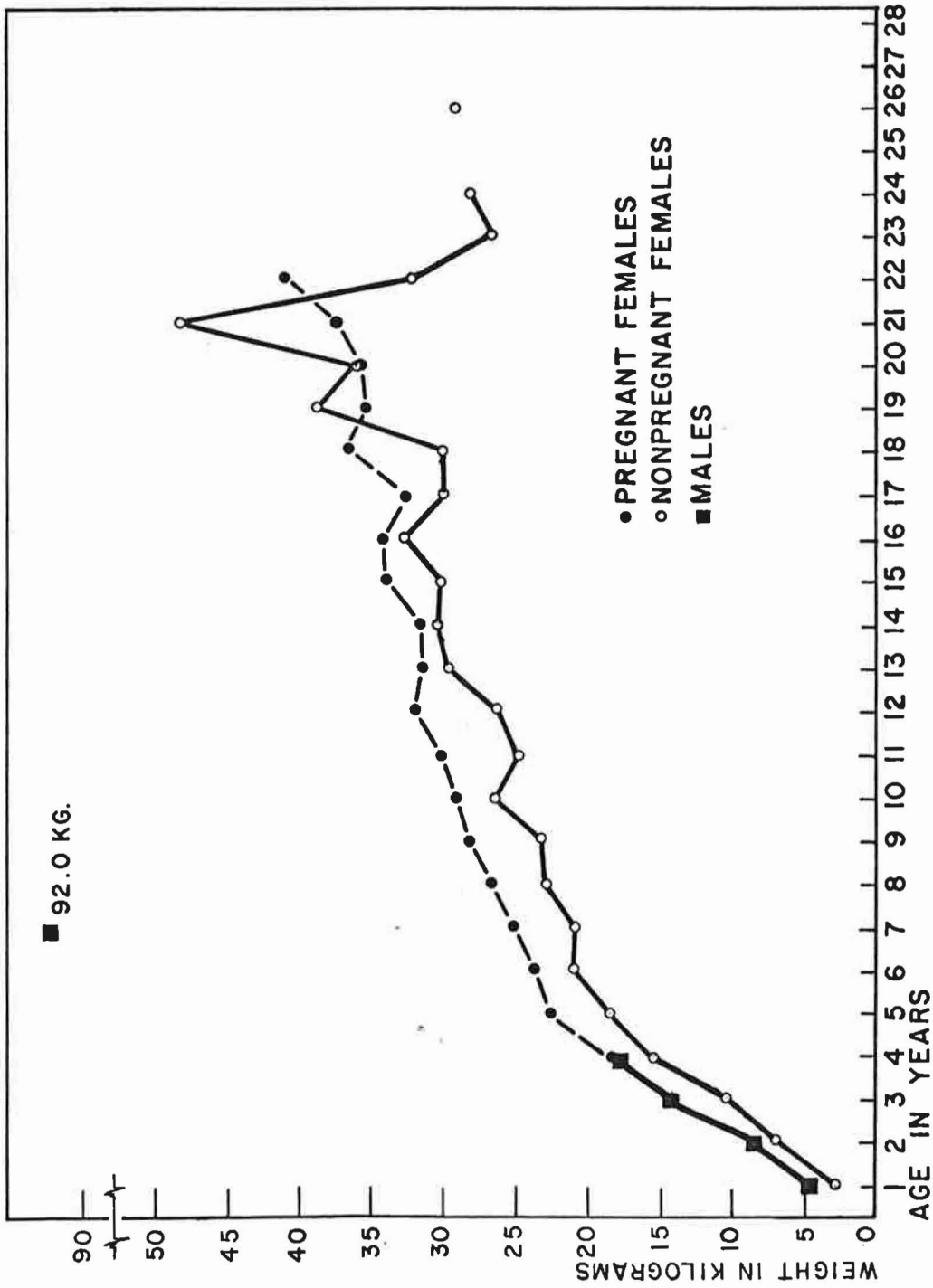

Figure 33. --Mean weight of fur seals collected off California, Oregon, and Washington in 1959.

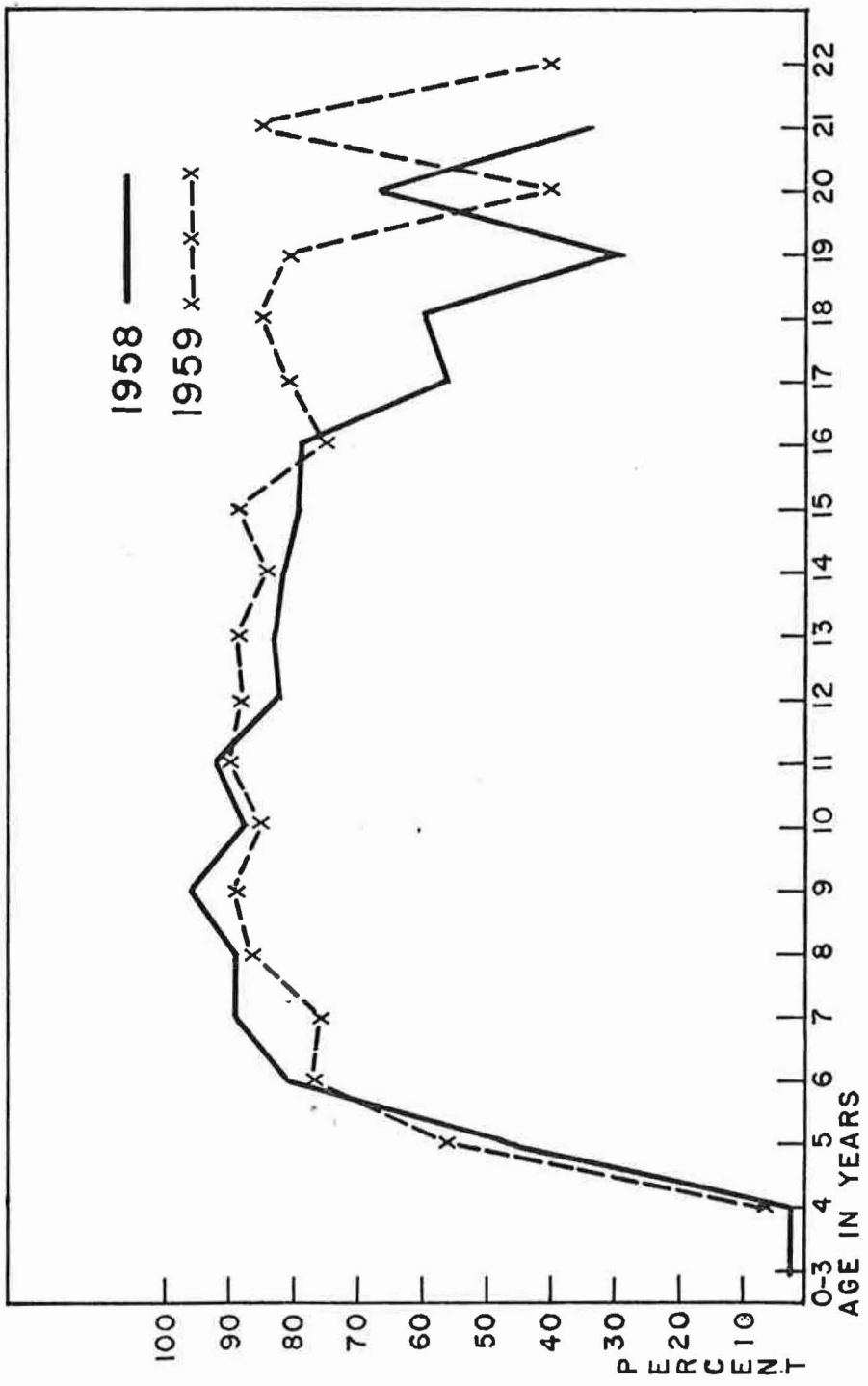

Figure 34. --Percent of pregnant seals, by age, taken off California, Oregon, and Washington coasts in 1958 and 1959.

Appendix E

POPULATION DENSITY ESTIMATES

Various methods have been used to indicate density of seals at sea. The method used here is that used by Canadian investigators (Pike et al., 1958).

The formula used: $D = \frac{S}{M} \times VF$

D = Number of seals per square mile
S = Number of seals seen
M = Number of miles run
VF = Visibility factor

The visibility factor is a means of indicating distance seen, according to varying conditions at sea.

Visibility factor:

1	=	1	mile	band	extending	1/2	mile	on	each	side	of vessel
2	=	1/2	"	"	"	1/4	"	"	"	"	"
4	=	1/4	"	"	"	1/8	"	"	"	"	"
8	=	1/8	"	"	"	1/16	"	"	"	"	"
16	=	1/16	"	"	"	1/32	"	"	"	"	"

In seal concentrations, where the boat is moving within a relatively small area, the number of miles a boat travels can only be estimated.

Example 1. --Density in an area of concentration.

An area off Morro Bay, California, where a concentration of seals was located has been selected for this example. The area, about 20 by 40 miles in size was located between 45°50'N. to 35°20'N. and 121°20'W. to 122°00'W. Densities were calculated separately for each chart square for each vessel (fig. 35). A vessel would occasionally spend considerable time hunting in one chart square and, in these cases, miles run is estimated from an assumed consistent speed of three miles per hour. This area, which includes all or parts of 16 chart squares[1/], was hunted 3-7 February 1959 by two vessels. Twelve

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1/ Chart squares: Figure 7 of text -- V23-H26, 27, 28; V22-H24, 25, 26, 27, 28; V21-H24, 25, 26, 27, 28; V20-H24, 25, 26. Squares in which no hunting occurred are underlined.

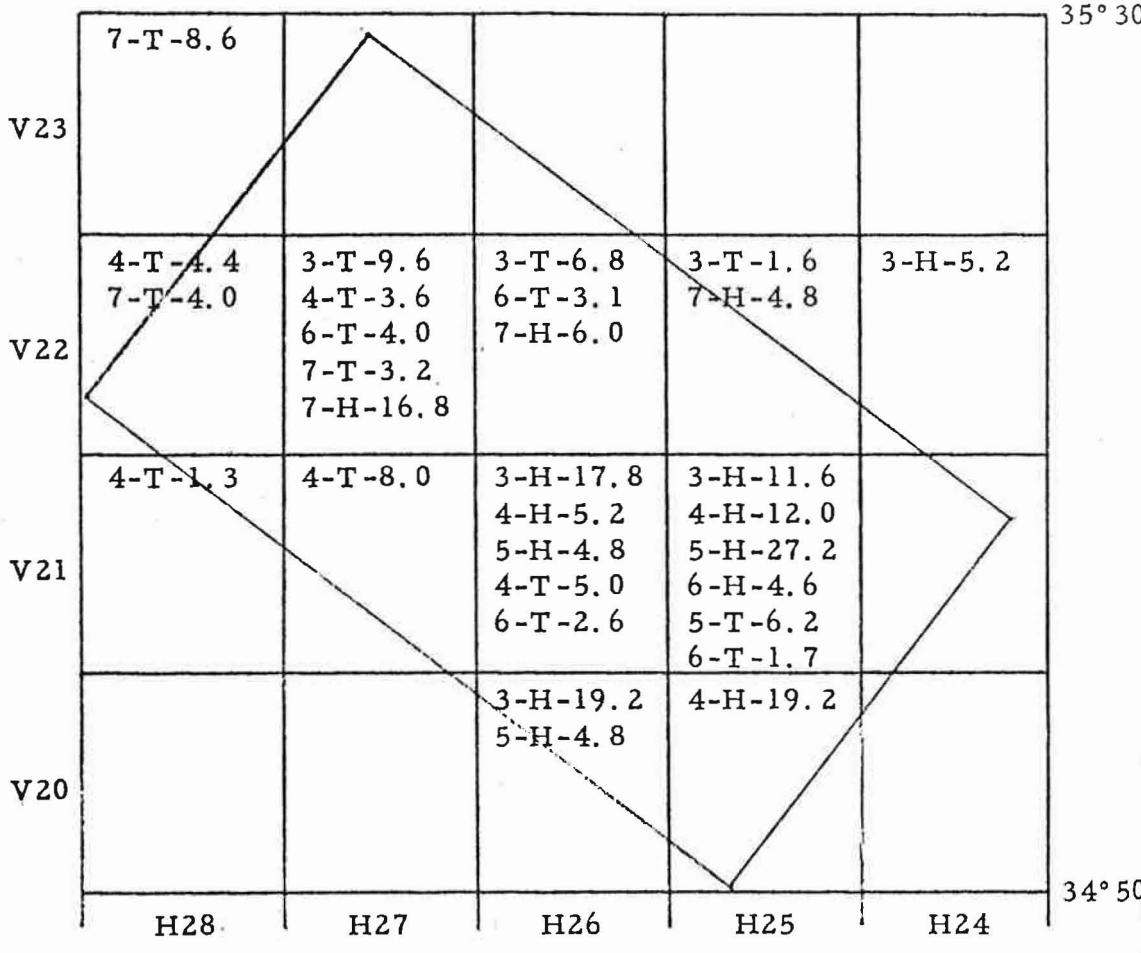

Figure 35. --Seals per square mile, in area of seal concentration, ob
served by M/V Tacoma and M/V Harmony, 3-7 Februa
1959.

of the 16 squares were hunted by the vessels and 1,031 seals were seen. Within the 12 squares hunted, 30 density values were calculated, ranging from 1.3 to 27.2 seals per square mile. The average number of seals seen per square mile is: (the total) 232.9 ÷ 30 = 7.8. The area 20 by 40 miles comprises 800 square miles: 800 x 7.8 = 6,240, the total number of seals in the area of concentration. The three most hunted squares, each hunted on four different days, had density values of 7.4, 7.1, and 10.5 seals sighted per square mile.

Example 2. --Density in an area of average distribution.

The area discussed in example 1 was revisited on 23 February by one vessel and 27 seals were seen in seven squares hunted[2/]. Three of the squares which had values of 7.4, 7.1, and 10.5 seals per square mile, when intensively hunted during the period 3-7 February, had changed on 23 February to values of 2.0, 2.0, and 4.0, respectively. The average number of seals seen per square mile for all seven squares was 1.5. At this density, the 700 square-mile area would have a population of 1,050 seals.

Example 3. --Density on an offshore run.

On 17 March, a vessel starting from a point 47 miles west-northwest of Eureka, California, ran offshore to a point 97 miles west-northwest of Eureka, then ran north-northeast to a point 86 miles west of Crescent City, California. The vessel sighted 49 seals, the largest number seen in any one day during the 25 days that the vessel worked in the Eureka area. The vessel traveled through nine chart squares[3/]; their density values, working offshore, are as follows: 0.0, 5.6, 4.4, 4.0, 3.6, 1.2, 0.4, 1.2, 0.0 seals per square mile. The last four values occurred in squares over 80 miles from shore. The average number of seals per square mile, for all nine chart squares, was 2.3, giving a seal population of 2,070 seals for an area of 900 square miles.

2/ Chart squares: Figure 7 of text -- V23-H27; V22-H23, 24, 27; V21-H24, 25, 26.

3/ Chart squares: Figure 8 of text -- V30-H16, 17, 18; V31-H18, 19, 20, 21; V32-H21; V33-H21.

Example 4. --Density on a coastwise run.

On 13 April, a vessel ran from a point 45 miles west of Cascade Head, Oregon, northwest to about 70 miles offshore, then ran northeast to a point 45 miles west of Tillamook Head, Oregon. The vessel sighted 11 seals. The vessel worked through nine chart squares[4] Working offshore and then to the north, density values were as follows: 2.0, 0.8, 3.2, 0.8, 0.0, 1.3, 2.6, 0.0, 1.6 seals per square mile. There is little difference in density values according to the distance offshore. The average number of seals, for all chart squares, was 1.4 seals per square mile and the estimated population for the area of 900 square miles was 1,220 seals. In an area located between 37°40'N. to 38°30'N. and 123°00'W. to 123°53'W., off San Francisco consisting of 20 ten-mile squares[5], hunting occurred regularly from 19 January through 8 April (31 of a total of 79 days). There was a wide range in density values in this area (0.0 to 76.8 seals per square mile), because of the large groups of seals encountered here. Seals were found consistently, although the numbers began to decrease in the last two weeks. A sample of 318 seals was collected in this area. A study was made of age in relation to time to see if segregation according to year class occurred. Results were inconclusive because the collections were not evenly distributed by time and sample sizes in some periods were too small to be of value. The indications are that no segregation by year class occurred during the time of the study.

Summary

No attempt has been made to arrive at density values for the entire area covered during the 1959 sealing operations.

The four examples given illustrate density values under different conditions that occurred during the working season and are fairly representative of the season and areas covered. It is obvious that where an average of several values was obtained over a period of several days a better estimate of seal density resulted than where the estimate was made from a single value.

4/ Chart squares: Figure 9 of text -- V15-H3; V16-H4; V17-H4, 5; V18-H5; V19-H4, 5; V20-H3, 4.

5/ Chart squares: Figure 8 of text -- V10-H7, 8, 9, 10; V11-H7, 8, 9, 10; V12-H7, 8, 9, 10; V13-H7, 8, 9, 10; V14-H7, 8, 9, 10.

A comparison of examples 1 and 2 demonstrates the population change in an area in a period of about two weeks. The change in density shown in example 3 is one that is normally met with in any offshore run in the area covered during the 1959 operations. Seals are usually scarce near shore, become most numerous at 30 to 70 miles offshore and then decline in density beyond 70 to 80 miles offshore. Density values in example 4 indicate the erratic distribution of seals frequently encountered at this time of year when seals are in northward migration along Oregon and Washington.

Examples 2, 3, and 4 with density values of 1.5, 2.3, and 1.4 seals per square mile may closely approach the actual numbers of seals found at sea in the areas covered during the 1959 pelagic sealing research.

Occasional runs were made by vessels, throughout the season, when few or no seals were sighted. If the vessels had been able to sail more systematic courses, without attempting to remain in areas of seal concentration, a better estimate of density and distribution would have been obtained.

Appendix F

SALVAGE OF FUR-SEAL SKINS, FOR COMMERCIAL USE, FROM PELAGIC COLLECTIONS

Because of difficulties experienced in the processing of female fur-seal skins and in order to reduce the work load on the collecting vessels, only skins from seals in the following size ranges were saved: males, 38 to 50 inches (965 to 1,270 mm.) in length; females, 38 to 45-1/2 inches (965 to 1,149 mm.) in length.

Length measurements were standard -- from the tip of the nose to the tip of the tail flesh.

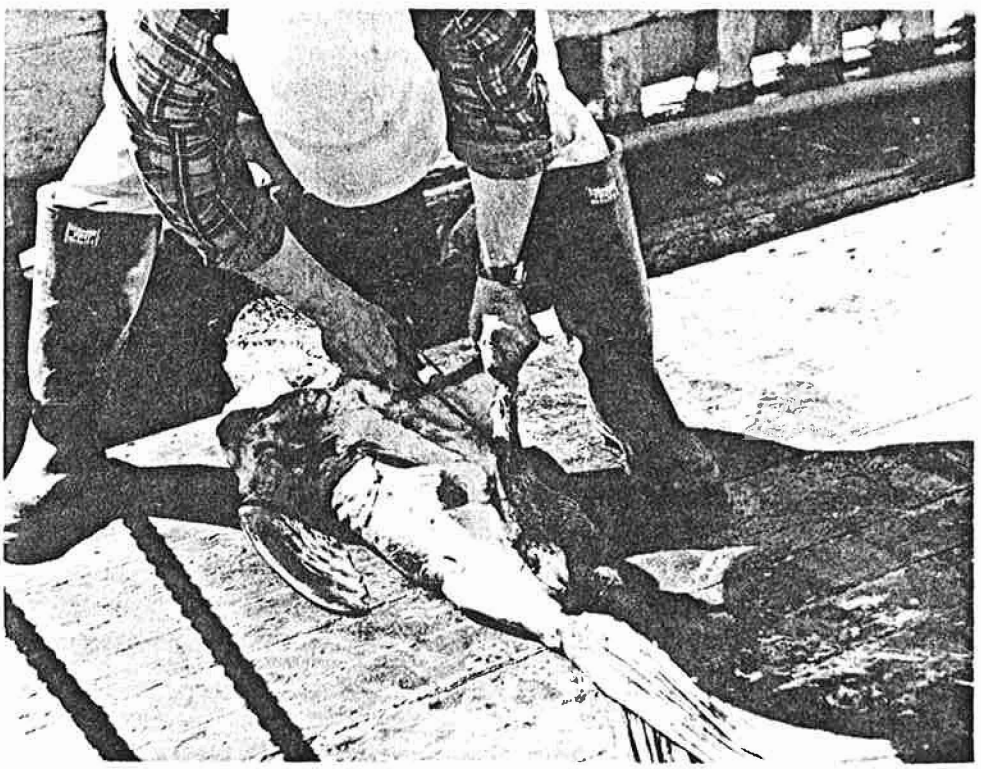

Figure 36. --Removing skin from fur seal aboard collecting vessel.